

# 1

# Investigating science

## HAVE YOU EVER WONDERED...

- why science is taught in schools?
- why scientists run experiments?
- why laboratories have rules?

## After completing this chapter students should be able to:

- apply correct scientific terms
- identify where science has been used to make claims about products
- apply specific skills and safety rules
- assess situations and develop safety rules that should apply
- construct tables and graphs to display data
- identify the correct units for a measurement
- identify controlled, dependent and independent variables
- work as a team to investigate a problem.

# 1.1

## A subject called science



Scientists study the world around them to find out how it works. They investigate the living world of animals, plants, bugs and micro-organisms, and they investigate the planet and environments they live on and in. They investigate the physical

world of substances like plastics and metals, and chemicals like water and acids. They investigate forms of energy such as heat, light and sound. They even study things that are out of this world, like other planets, stars and galaxies.

### Science is important

The world is very complex and is becoming more complex every day. New technology is constantly developing and new issues are constantly hitting the headlines. For example, HD televisions, Blu-ray, iPods and Wii players were not around ten years ago. Laptop computers, mobile phones, email and internet are only a little older. Likewise the issues of climate change were not heard of until relatively recently.

Developments in science have also caused argument and debate. Cloning, the use of stem cells to repair damage in the body, and genetically modified food have all developed from scientific discovery, and society has split into those who support their use and those

who don't. Climate change, and what we as humans should do to control it, has also split society into those who believe that it is happening and those who don't. There is even debate among those who do believe it is happening: some believe that it is caused by human activity, while others believe it is just a natural cycle. Whatever its cause, glaciers like the one in Figure 1.1.1 are melting at a higher-than-normal rate. Older issues, such as whether nuclear power should be used in Australia, are being debated again because of our increasing energy needs. As a future adult and voter you will need an understanding of science to help you decide what we should do about these issues and any new issues that arise. To make good decisions about our future, you will need an understanding of science.



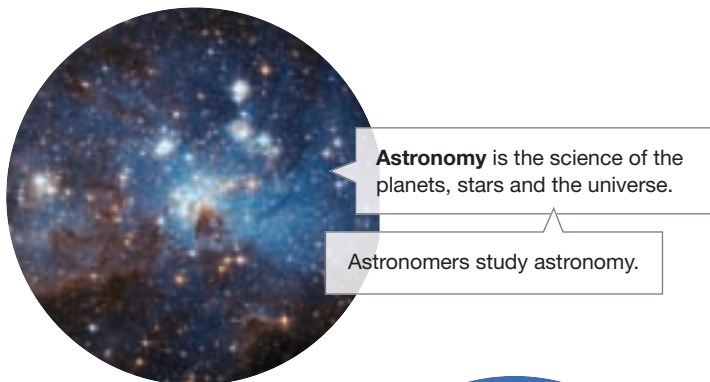


**Figure 1.1.1**

Climate change: do we believe the evidence that temperatures are rising because of human activity or do we reject it based on other evidence?

## The branches of science

The subject of science covers many different areas, ranging from acids to aardvarks, electricity to emus, rats to rocks, Venus to viruses, and much, much more. Science covers so many different areas that it must be split into different **branches** as shown in Figure 1.1.2. Scientists tend to work in one particular branch of science. This allows them to explore it in detail and develop a deep understanding of it without being distracted by what is going on in the other branches.



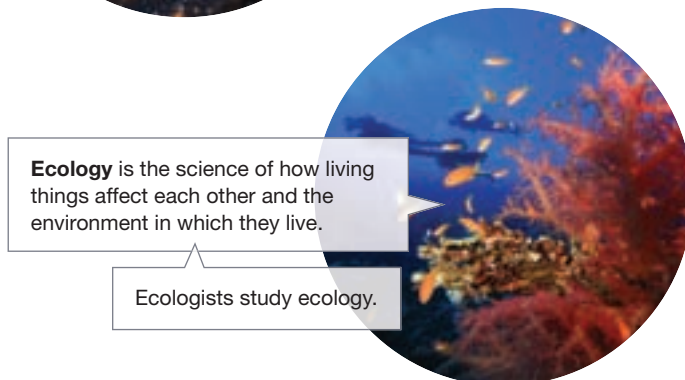
**Astronomy** is the science of the planets, stars and the universe.

Astronomers study astronomy.



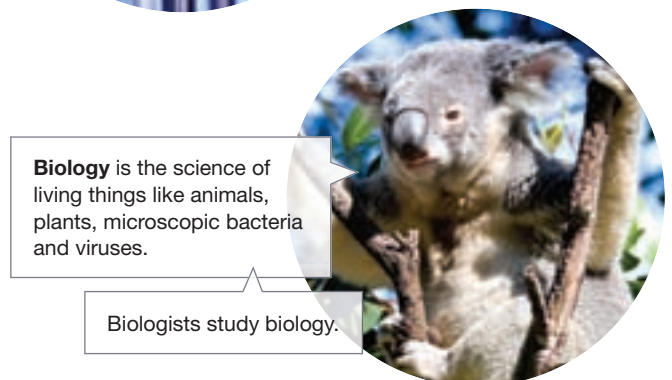
**Chemistry** is the science of materials, chemicals and chemical reactions and how they might be used.

Chemists study chemistry.



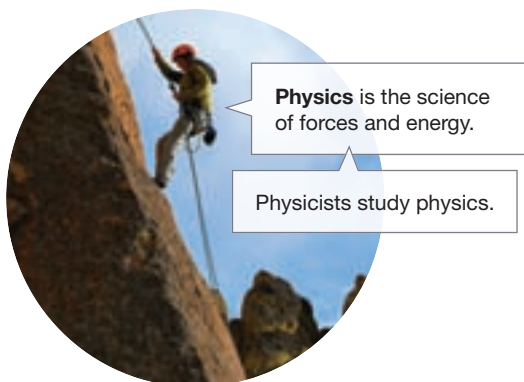
**Ecology** is the science of how living things affect each other and the environment in which they live.

Ecologists study ecology.



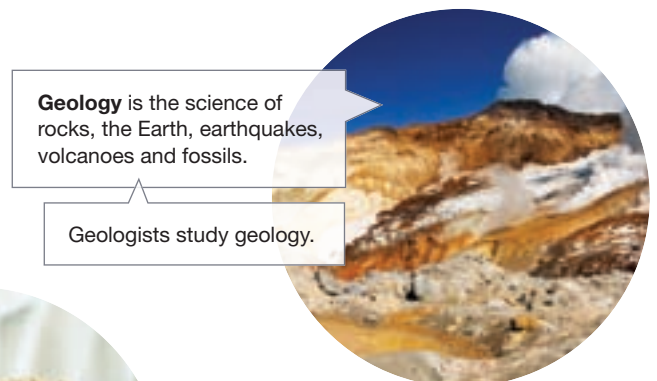
**Biology** is the science of living things like animals, plants, microscopic bacteria and viruses.

Biologists study biology.



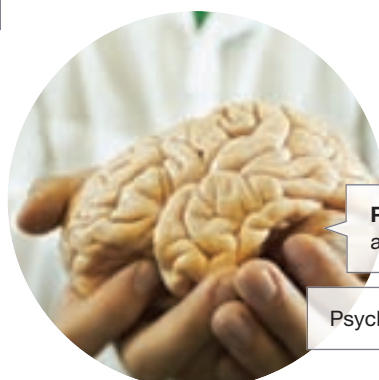
**Physics** is the science of forces and energy.

Physicists study physics.



**Geology** is the science of rocks, the Earth, earthquakes, volcanoes and fossils.

Geologists study geology.



**Psychology** is the science of how and why we behave the way we do.

Psychologists study psychology.

**Figure 1.1.2**

The main branches of science

## Sub-branches of science

The branches of science are so broad that they are split into smaller sub-branches. Geology, for example, covers so much material that a geologist would find it impossible to study it all. Instead geologists tend to specialise by working in a sub-branch like petrology (the study of rocks), palaeontology (fossils), vulcanology (volcanoes) or seismology (earthquakes).

Likewise, there are so many types of living things that biologists specialise in the study of only one type of living thing, for example, animals (zoologists study zoology), plants (botanists study botany) or germs (microbiologists study microbiology). Even sub-branches are sometimes too big: for example, zoology covers so many different types of animals that it is split into smaller sub-branches such as insects (entomologists study entomology), spiders (arachnologists study arachnology) and fish (ichthyologists study ichthyology), as shown in Figure 1.1.3.

## Some common tasks

There are many different branches and sub-branches of science but they are all similar in the basic tasks that their scientists need to carry out. All scientists:

- make observations and measurements
- classify objects into groups of similar things
- make inferences and predictions about what is happening and what might happen in the future
- analyse their measurements, plotting graphs, making calculations and looking for patterns
- make models to help them understand what is happening.

You will learn more about all these tasks later in the book. Most importantly, scientists work as part of a team. You will do this too, especially during practical activities. Teamwork is what's happening in Figure 1.1.4.

### The science of poo

There are lots of other very specific sub-branches of science. Some are teuthology (the study of the octopus), mycology (the study of fungi), carpology (the study of fruits and seeds) and oology (the study of eggs). Even the scientific study of poo has its own sub-branch: scatology!

SciFile

Figure 1.1.3

The branches of science are split into smaller sub-branches. Some of these are then split into even smaller sub-branches.

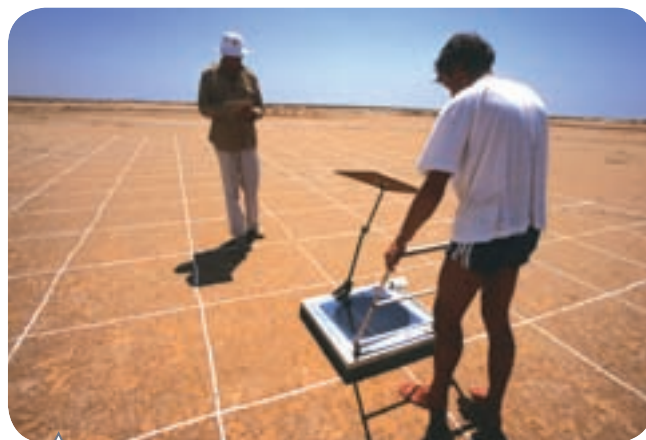
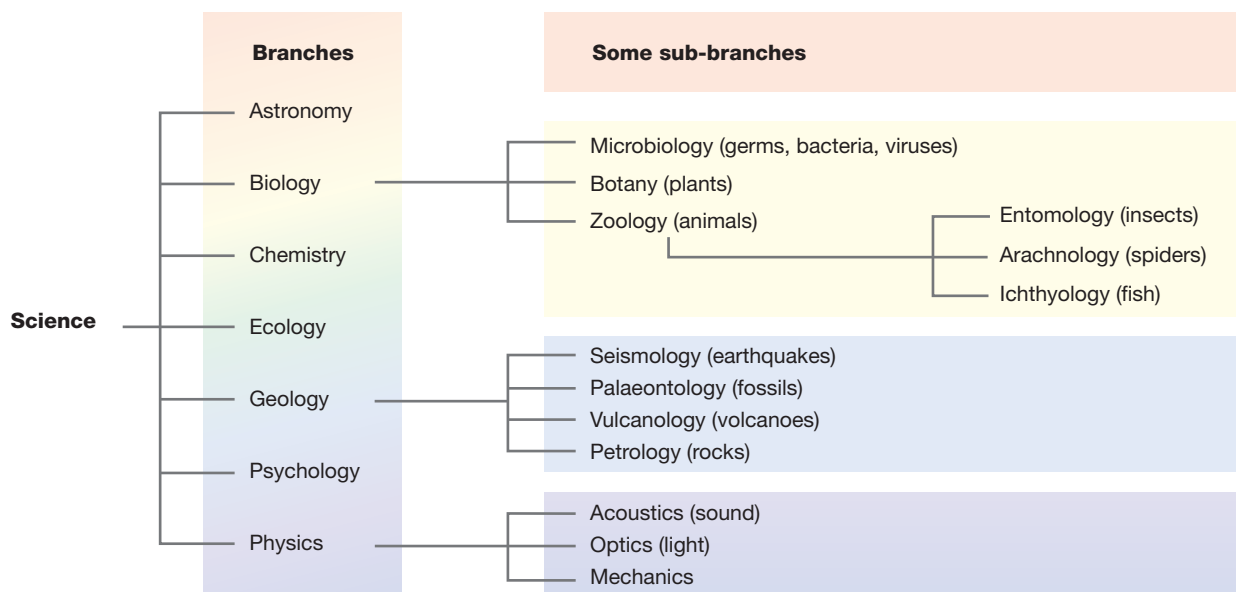


Figure 1.1.4

Everyone is good at something and not so good at something else. By working as part of a team, scientists can share their skills.





# SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

## Science and the law

Laws make you wear a bike helmet because science has shown that helmets can protect you from serious head and brain injury.

Figure  
1.1.5



The observations that scientists gather and the conclusions they make form the basis of many of the laws and regulations that we all must follow every day.

For example, scientific evidence on car and bike crashes has led to speed limits, and laws that make us wear seat belts in cars and helmets when riding a bike or motorbike. In a similar way, scientific evidence on bushfires has led to laws determining days of total fire ban and the types of houses that are built in areas of high bushfire risk.

Scientific evidence has also been used to form laws and regulations that:

- make car manufacturers include airbags, crumple zones and crash-resistant fuel tanks
- control the type of houses built in areas at risk of floods or cyclones
- determine which drugs should be illegal, which should be available on prescription and which can be bought at the supermarket
- control the type of additives that can be put in food

- control how long food can be sold for ('use by' and 'best before' dates)
- determine unsafe levels of sound, chemicals and dust for workers
- control the type and amount of pollutants that can be released into rivers, soil and atmosphere
- preserve animals, plants and landscapes at risk of being lost forever.

Sometimes, scientific evidence leads to changes in global laws. For example, chemicals called chlorofluorocarbons were destroying the ozone layer, putting us all at greater risk of skin cancer. Governments across the world have since banned the use of chlorofluorocarbons in everyday products like deodorants and hair sprays and in fridges. Similar laws will be required to limit the release of carbon dioxide to minimise global climate change.

# 1.1

## Unit review

### Remembering

- 1 **Name:**
  - a devices that have only been around in the last ten years
  - b a scientific issue that has arisen in the last ten years.
- 2 **List** seven important branches of science.
- 3 **List** four sub-branches for each of:
  - a biology
  - b geology
  - c physics.

### Understanding

- 4 **Explain** why everyone needs to have an understanding of science.
- 5 A biologist usually specialises in one sub-branch of biology. **Explain** why.

### Applying

- 6 **Identify** the branches of science that are being studied below.
  - a Amanda is measuring the amount of pollution in a lake.
  - b Sarah is making a video of a volcano erupting.
  - c Brian is studying the movement of the planets.
  - d Yang is measuring the speed of sound.
  - e Joe is testing what an acid does to metal.
- 7 For each of the following investigations, **identify** the branch and sub-branch that is being studied.
  - a Abdul is counting how many eggs a cockroach has laid.
  - b Hon is studying the crystals embedded in a rock.
  - c Travis is investigating how light bends as it passes through glass.
  - d Lisa is photographing the bones of a dinosaur.
  - e Francesca is measuring the growth of a seedling.

### Analysing

- 8 **Compare** the similarities and differences between the types of work done by a detective and a scientist.
- 9 Refer to the contents pages (pages v–vii) and **classify** each of the chapters as biology, chemistry, physics, geology or astronomy (space).

### Evaluating

- 10 Some branches of science cover two or more other branches. **Propose** what two branches of science are studied in biochemistry.

### Inquiring

- 1 Search available resources such as textbooks, encyclopedias and the internet, to construct a short biography of the life and scientific achievements of the Australian scientist David Unaipon (Figure 1.1.6).



**Figure 1.1.6**

David Unaipon was an Australian scientist and inventor. He is shown on the \$50 bill.

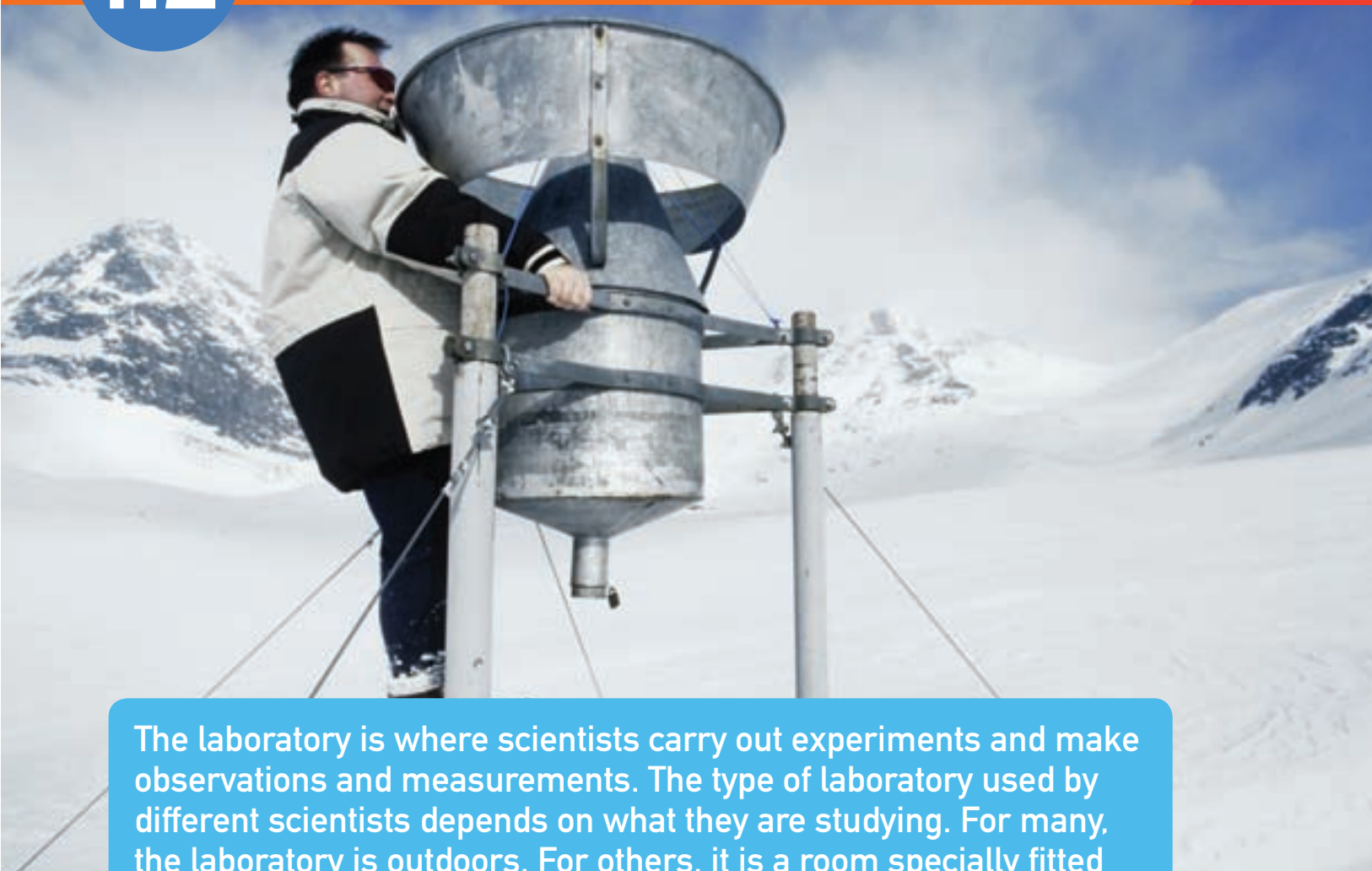
- 2 Go to the website for *The New Inventors* and watch a video of this week's inventions.
- 3 Advertising frequently uses scientific 'evidence' that the product works or that it is better than its competitors. The ad might present scientific evidence on the action of a new additive to a shampoo, deodorant or detergent or discuss which grains are better for your health. Ads for home gym equipment frequently display infrared images showing which muscles are working hard, while some car ads show images of crash-test dummies and anti-skid brake systems.

Find an advertisement on TV, on a billboard, on the internet or in a magazine or newspaper that uses science to help sell the product.

- a Describe how science is used to make the product appear attractive and worth buying.
- b Assess whether the science used is relevant to the product or not.

# 1.2

## The laboratory



The laboratory is where scientists carry out experiments and make observations and measurements. The type of laboratory used by different scientists depends on what they are studying. For many, the laboratory is outdoors. For others, it is a room specially fitted for their experiments. Whatever laboratory and whatever branch of science they work in, scientists use equipment and follow strict rules regarding safety. As a beginning scientist, so will you.

### Different laboratories for different scientists

A scientist works in a **laboratory**. Laboratories are where scientists run most of their experiments and make most of their observations, measurements and discoveries. Your idea of a laboratory is probably a large room equipped with Bunsen burners, sinks, glassware, balances and chemicals and occupied by people in white coats and safety glasses. This is the type of laboratory that chemists tend to work in and the type of laboratory that you will eventually work in at school. It might look something like Figure 1.2.1.



Figure 1.2.1

To most of us, the laboratory is a place full of Bunsen burners, glassware and white coats.



Different scientists have very different ideas about what a laboratory is. For marine biologists, the laboratory could be a coral reef. The laboratory of a zoologist might be a rainforest, and a laptop computer and video camera could be their most important equipment. The laboratory of an astronomer will be wherever their telescope is mounted. Figure 1.2.2 shows a palaeontologist at work in his laboratory. Scientists like him will usually have another laboratory in which they can test the samples they collected outdoors. An ecologist, for example, might collect samples of polluted water from a creek but then analyse them back in their other laboratory.



**Figure 1.2.2** For palaeontologists, the laboratory could be the site at which a dinosaur skeleton has been found. Their equipment is likely to be a spade and brushes to clear the soil away from around the bones. Sturdy boots, a sunhat and overalls will be far more important to them than white coats.

## Equipment

Tools and **equipment** are a necessary part of most jobs. A builder uses power drills and saws, nail guns and measuring tapes, while a chef uses ovens, pots and pans, sieves and measuring spoons. Scientists use equipment too, to help them carry out experiments and to help them describe what they observe more accurately. Each branch of science uses its own specific tools and equipment. An astronomer will not see much without a telescope, and a microbiologist needs a microscope to see bacteria that are invisible to the naked eye. Physicists need ammeters and voltmeters to measure electrical current, and ecologists need pH meters to determine how acidic creek water is. There is, however, a set of equipment common to most laboratories, including the ones at school.

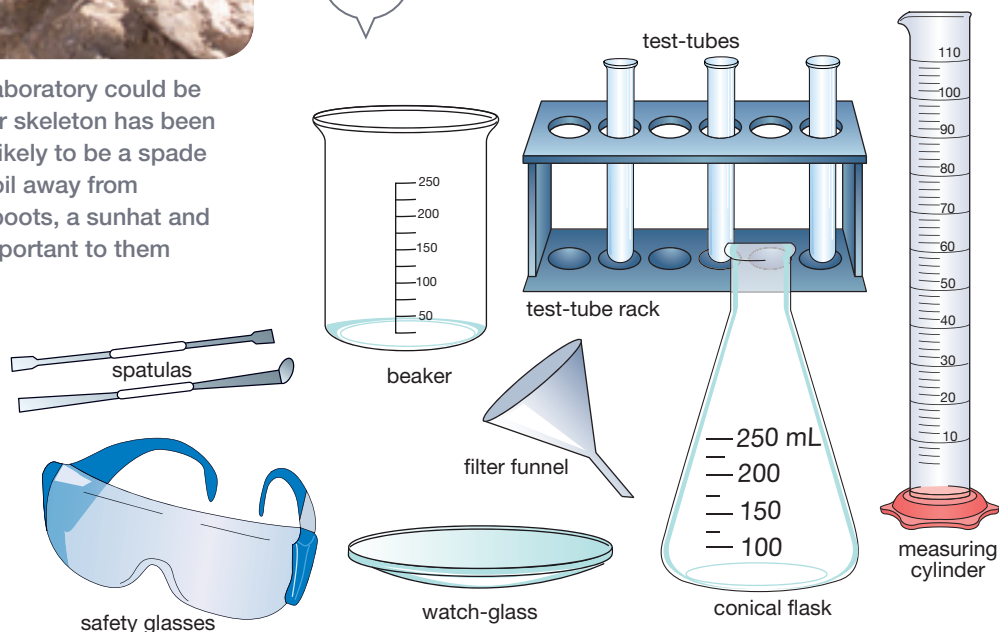
## Glassware

Glassware such as beakers, conical flasks, test-tubes and watch-glasses allows you to mix and heat chemicals. Most glassware in the laboratory is made of Pyrex, a special type of glass that is less likely than normal glass to crack when it is heated or cooled. Some common items of glassware are shown in Figure 1.2.3.

Beakers and conical flasks usually have markings up their sides, but the markings only indicate rough volumes. You would use a measuring cylinder to measure more accurate volumes. Volume is normally measured in the laboratory in millilitres (unit symbol mL). Larger volumes are measured in litres (unit symbol L).

**Figure 1.2.3**

Equipment commonly used in the laboratory

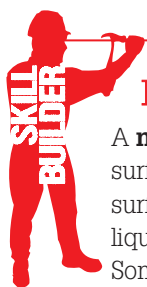


## Eating a Vulcano

Sometimes laboratories go wrong! In 2009, a Swiss laboratory accidentally discovered how to make chocolate that won't melt on a hot day or in your pocket. It's code-named Vulcano.

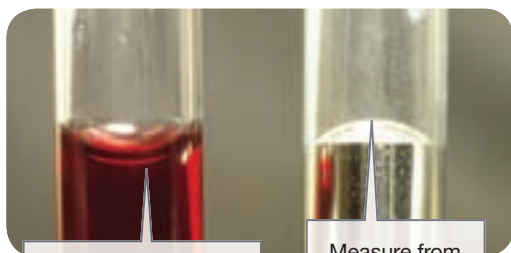
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## Reading a meniscus

A **meniscus** is the curved shape formed by the surface of a liquid where it contacts another surface. The meniscus is easy to see when the liquid is in a tube such as a measuring cylinder. Sometimes the meniscus curves upwards and sometimes it curves downwards. This could make measuring volumes a little difficult. Figure 1.2.4 shows how scientists measure the volume when a meniscus is present.



Measure from the bottom of the meniscus if it curves downwards.

Measure from the top of the meniscus if it curves upwards.

Figure 1.2.4

The surface of a liquid in a measuring cylinder forms a curve called a meniscus.

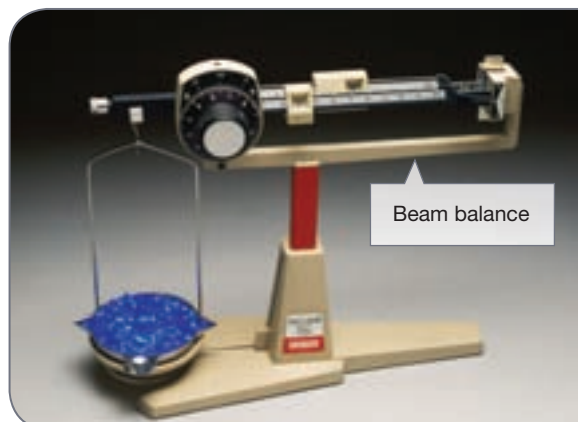
## Balances

The beam balances, electronic balances and spring balances shown in Figure 1.2.5 can all be used to measure the **mass** of an object. Mass is a measure of how much matter there is in an object.

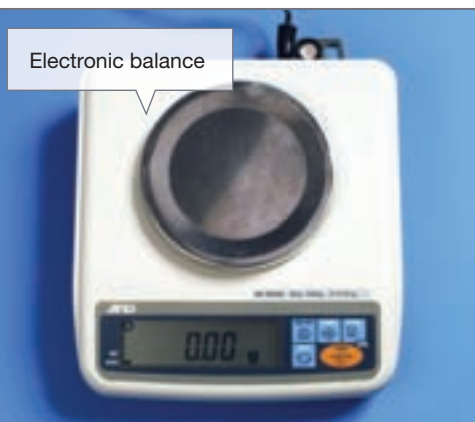
In the laboratory, mass is usually measured in grams (unit symbol g) or kilograms (kg).

Figure 1.2.5

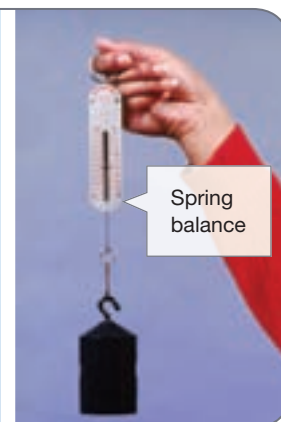
Different balances can be used to measure the mass of an object. Mass is sometimes incorrectly called weight.



Beam balance



Electronic balance



Spring balance

## Heating equipment

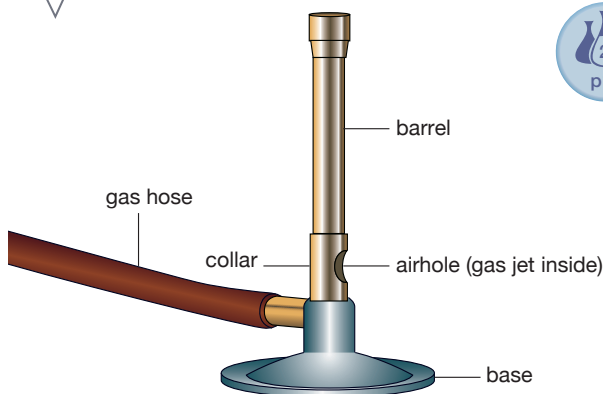
**Hotplates** and **Bunsen burners** are some of the most important and dangerous pieces of equipment that you will use in the school laboratory. Both get extremely hot and so can burn you seriously if you treat them incorrectly.

### Parts of the Bunsen burner

Figure 1.2.6 shows the parts of the Bunsen burner. The collar controls the amount of air that enters the burner and controls the heat and colour of the flame. If you *shut* the airhole, very little air is able to mix with the gas. The gas does not burn well and it produces a pale yellow flame that is easily visible and relatively cool. This is shown in Figure 1.2.7 on page 10. For these reasons, the yellow flame is called the **safety flame**. It is also a dirty flame, because it leaves a layer of black carbon soot on anything that is heated in it.

Figure 1.2.6

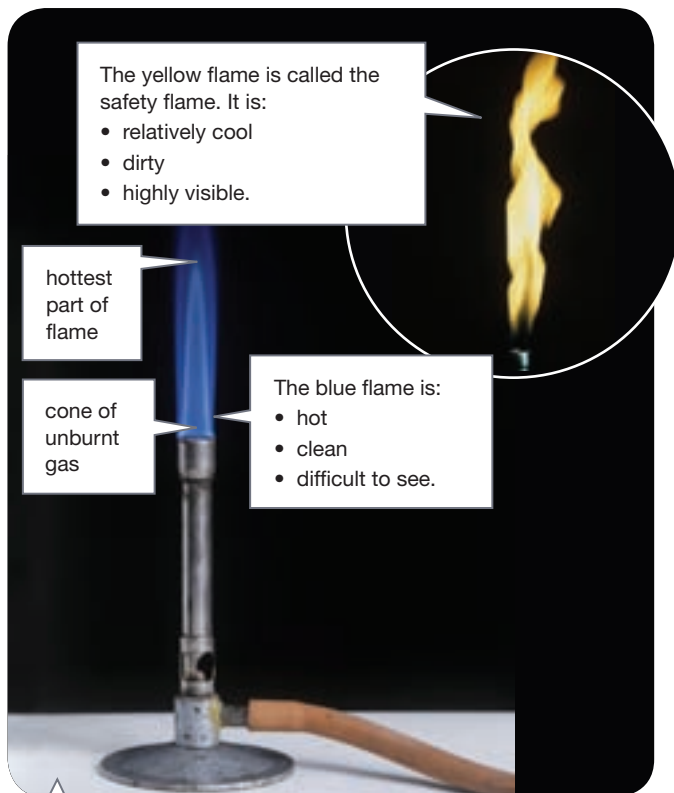
The Bunsen burner



p14

p15

If you *open* the airhole, then a lot of air will enter. The gas will burn efficiently with no smoke, and will be extremely hot (about 1500°C). This flame is noisy. It has a blue colour and is sometimes difficult to see. At the very base of the flame, there is a small cone of unburnt gas. As Figure 1.2.7 on page 10 shows, the hottest part of the flame is just above this cone.



**Figure 1.2.7** The yellow flame is easy to see and relatively cool. The blue flame is much hotter and almost invisible. This makes it much more dangerous.

### Other equipment used for heating

A kitchen stove isn't very useful unless you have frying pans, saucepans, tongs and stirring spoons to help you cook the food safely. A Bunsen burner also needs additional equipment to help you heat objects and to keep you safe. Some of this equipment is shown in Figure 1.2.8.

Clay triangle: used to support a crucible

Crucible and lid: used to burn small samples of solid

Evaporating dish: used to evaporate off the solvent from a solution, leaving crystals behind

Bench mat: used to protect the bench

Tongs and pegs: allow you to pick up hot objects

Gauze mat: used to spread the heat

Retort stand, bosshead and clamps: used to hold other equipment

Tripod: used to hold beakers above the flame

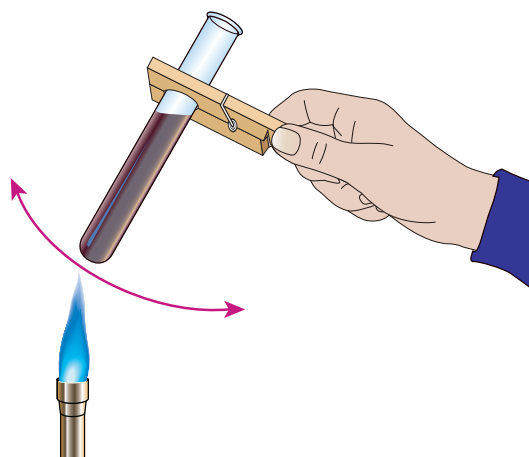
**Figure 1.2.8** The hotplate and Bunsen burner need additional equipment to make them useful.



### Heating a test-tube

Test-tubes can spit out their contents if you heat them incorrectly. They can also break.

- 1 Use a peg or test-tube holder to hold the test-tube near its open end.
- 2 Point the test-tube away from everyone, including yourself.
- 3 Heat the bottom gently, moving it back and forth through the flame as shown in Figure 1.2.9.

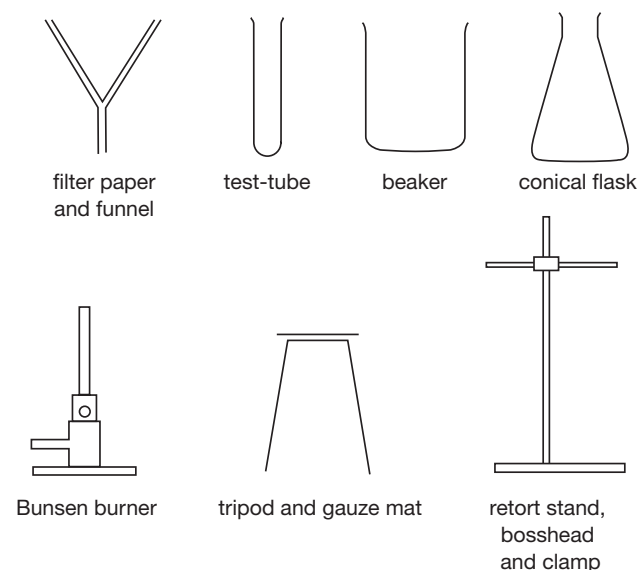


**Figure 1.2.9** Never leave a test-tube in the one spot in a flame for too long.

## Drawing equipment

Scientists do not draw equipment realistically but as simple two-dimensional (2D) line-drawings, 'splitting' the equipment down the middle to show its **cross-section**.

Figure 1.2.10 shows how scientists draw some of the most common equipment used in the laboratory.



**Figure 1.2.10** Scientists draw scientific equipment as simple, two-dimensional cross-sections.



## Safety

Science can be fun. Experiments are part of that fun, but they can also be very dangerous. Hotplates and Bunsen burners can burn, and Bunsen flames can set clothes or hair on fire. Acids are corrosive and can burn badly, especially if splashed into your eyes. Many other chemicals are **toxic** and are poisonous if you sniff or taste them. Broken glassware can cut, and small fragments can easily enter your eyes.

### Safety rules

The laboratory can be dangerous, but can be safe if we all follow some simple rules. Although each school, each laboratory and each teacher will have their own set of rules that you must follow, some rules are common to all laboratories:

- Always follow instructions from your teacher or laboratory technician.
- Move about the lab in a safe way. Do not run, push or shove.

- Always wear safety glasses when using chemicals.
- Unless instructed to do so by your teacher or lab technician, do not eat, taste, drink or sniff anything in the lab.
- Always tell your teacher if you break something or if you are unsure about what to do.
- Turn on the tap before placing any glassware under it. Otherwise the water might crack the glass of whatever you are holding.

Your teacher and school will give you a list of any other rules that you need to follow in your laboratory.

Other rules apply when you are heating something:

- Always tie back long hair; otherwise it's a fire risk.
- If you need to leave a Bunsen burner on, turn it to a visible yellow safety flame.
- Only use matches to light Bunsen burners.
- Always use tongs to pick up objects that have been heated.
- When you are heating a test-tube, ensure that it is pointed away from everyone (including you).
- Hotplates and Bunsen burners, tripods and gauze mats remain hot for a long time. Allow them to cool before you pack them away.

Safety in the laboratory is really just common sense. If something has the potential to hurt someone then *don't do it!*



## Your local experts

If you are confused about equipment, safety, or what you are supposed to do in a laboratory, then there are usually two experts who you can turn to:

- Your science teacher is trained in science and has probably specialised in one particular branch of science, such as biology, chemistry or physics.
- Your laboratory technician (lab tech) will usually be found working behind the scenes in a science department. He or she may come into your laboratory to help your science teacher out, especially if an experiment is particularly dangerous. Your lab tech is trained in safety, the laboratory, its equipment and chemicals.



# 1.2

## Unit review

### Remembering

- 1 **Name** an essential piece of equipment for:
  - a a microbiologist
  - b an astronomer.
- 2 **Name** the special type of glass from which most laboratory glassware is made.
- 3 **Specify** the temperature that a Bunsen burner flame can reach.
- 4 **List** four dangers that you will meet in the laboratory.
- 5 Find the **names** of the two experts you can turn to in the laboratory.

### Understanding

- 6 **Define** the term *cross-section*.
- 7 a The markings on beakers and conical flasks cannot be used to measure out volumes accurately. **Explain** why.  
b **Name** the piece of equipment used to measure volumes accurately.
- 8 All laboratories are different. **Explain** how.
- 9 A yellow flame will burn you if you are careless, but it is called the safety flame. **Explain** why.

### Applying

- 10 **Identify** the volumes indicated in Figure 1.2.11.

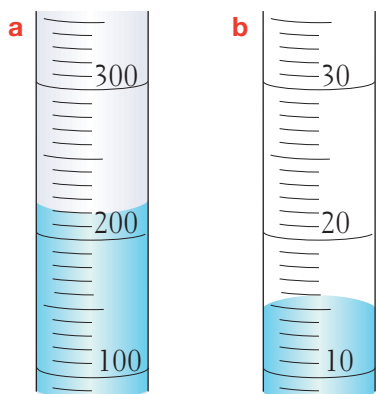


Figure 1.2.11

- 11 **Identify** whether the following observations would be made of a yellow Bunsen burner flame or a blue Bunsen burner flame:
  - a dirty
  - b noisy
  - c almost invisible
  - d extremely hot
  - e closed airhole.

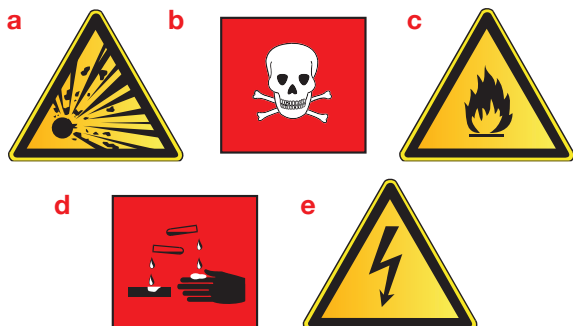
- 12 **Identify** what the students in Figure 1.2.12 are doing right or are doing wrong.



Figure 1.2.12

## Analysing

13 **Assess** what the following safety signs are saying.



14 **Compare** a beaker with a conical flask.

## Evaluating

15 In the laboratory, **propose** a way you could:

- a protect your eyes
- b avoid slipping while moving around.

16 **Propose** reasons why:

- a you should light a match before you turn on the gas to the Bunsen burner
- b long hair should be tied back when you are using the Bunsen burner
- c eating and drinking is banned in the laboratory
- d you should turn a Bunsen burner to a yellow flame if you need to leave it.

## Creating

17 You are using a Bunsen burner to heat water in a beaker. **Construct** a scientific diagram to show how your equipment looks.

18 **Create** a sign that warns people that Bunsen burners are hot. Your sign must be in two colours only and use no words.

## Inquiring

- 1 Investigate what an eyewash is and how to use it.
- 2 Find out what first aid should be applied if you come across someone who has burnt themselves.

- 3 Find out what a fire blanket is, what it is made of, and how to use it.
- 4 Research who Bunsen was and what he had to do with the burner named after him.



## Fake wounds

Can you fake an injury?



### Collect this ...

- small ball of coloured dough from your teacher
- small amount of bright red food dye
- spatula or bamboo skewer
- small twigs, cotton wool and bandages

### Do this ...

- 1 Pat your lump of dough until it is flat.
- 2 Pat it onto your skin and blend it in to your skin by squashing its edges down with your fingers.
- 3 Use the edge of a spatula or skewer to make a fake 'cut' in the surface of the dough.
- 4 Make the wound look more realistic by inserting a small twig into the 'cut' and by dribbling some red food dye into it.
- 5 Use paper towelling, cotton wool or bandages to disguise the edges of the dough.

### Record this ...

**Describe** what the cut looked like. Did it look realistic?

**Explain** what you should do if someone really cuts themselves in the laboratory.

# 1.2

## Practical activities

### 1 The Bunsen burner

#### Purpose

To light a Bunsen burner and produce a yellow and blue flame.

#### Materials

- Bunsen burner, bench mat and matches
- pin



#### Procedure

##### Part A: Lighting the Bunsen burner

- 1 Follow the instructions in the skill builder to light a Bunsen burner.
- 2 Turn the collar to open and shut the airhole. Observe what colour flames are produced.
- 3 Turn off the Bunsen burner and allow it to cool.

#### SAFETY

Tie long hair back.  
Turn Bunsen flame to yellow if you need to leave the burner at any time.  
Allow all equipment to cool before packing it away.

##### Part B: Unburnt gas

- 4 Push a pin through the wood near the top of an unlit match. Balance the match on the top of the Bunsen burner so that the match head is in the centre of its barrel.
- 5 Light the Bunsen burner as usual and quickly turn it to a blue flame. Figure 1.2.13 shows the correct set-up.

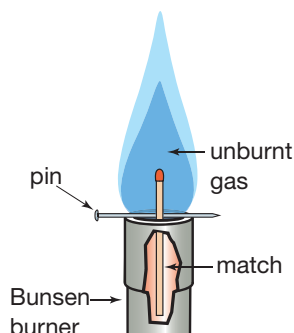


Figure 1.2.13

#### Results

Record all your observations in a table like the one shown below.

Airhole	Was the flame noisy or quiet?	Flame colour	Other observations
Closed			
Half-closed			
Open			

#### Discussion

- 1 **Propose** a reason why the airhole should be closed when you light a Bunsen burner.
- 2 **Describe** what happened to the match in the barrel of the Bunsen burner.
- 3 **Explain** your observations.



#### Lighting the Bunsen burner

- 1 Place the Bunsen burner on a heatproof bench mat and connect it to the gas jet.
- 2 Turn the collar of the Bunsen burner so that the airhole is completely closed.
- 3 Light a match.
- 4 Turn on the gas at the gas tap.
- 5 Hold the lit match about 1 cm over the top of the barrel.
- 6 If the match blows out then immediately turn the gas off and start again.
- 7 When lit, the Bunsen burner should produce a bright yellow flame.
- 8 To obtain a blue flame, turn the collar so that the airhole is opened.
- 9 This sometimes causes the flame to blow out. If it does, turn off the Bunsen burner and follow the steps above to light it again. Then, to obtain a blue flame, adjust the airhole so that it is not completely open.



## 2 Investigating the flame

### Purpose

To determine which flame is hot, which is cool, which is dirty and which is clean.

### Materials

- Bunsen burner, bench mat and matches
- old, 'bald' gauze mat
- small piece of broken white porcelain
- tongs



### Procedure

#### Part A: Hot or cool?

- 1 Set up and light the Bunsen burner.
- 2 Set it to a yellow flame.
- 3 With tongs, hold the gauze mat vertically in the flame so that it touches the top of the burner as shown in Figure 1.2.14.
- 4 Set the flame to blue and repeat step 3.
- 5 Carefully draw diagrams of any heat markings that you see.

**SAFETY**

Tie long hair back.  
Turn Bunsen flame to yellow if you need to leave the burner at any time.  
Allow all equipment to cool before packing it away.

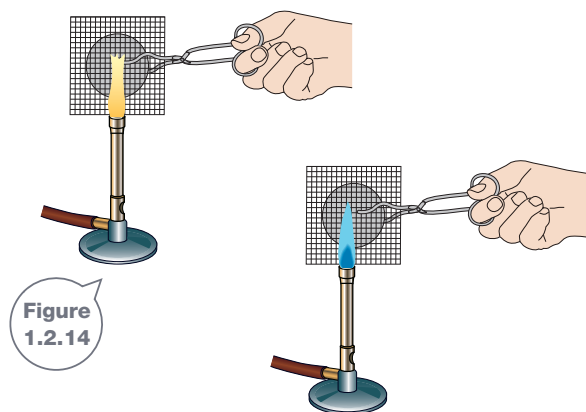


Figure 1.2.14

#### Part B: Clean or dirty?

- 6 With tongs, hold the small piece of porcelain in a blue flame and record your observations.
- 7 Set the flame to yellow and repeat step 6.

### Discussion

#### Part A

- 1 The wire of the gauze mat will glow red if it is really hot. **Identify** which flame (yellow or blue) made the wire glow red.
- 2 **Describe** the markings caused by the blue flame.
- 3 **State** where the flame was the hottest and where it was the 'coolest'.

#### Part B

- 4 **Compare** what happened to the porcelain in the yellow flame and the blue flame.
- 5 **Identify** which flame could be called 'dirty'.
- 6 **State** whether this was the hot flame or the cool flame.

# 1.3

## Experiments

Scientists carry out experiments to find out something about the world around them or to test a little bit of it. They record their observations and measurements and analyse them so that patterns and trends become clear. They can then make a logical inference about what happened and why. Inferences lead to predictions of what might happen in the future or in experiments under different conditions.



INQUIRY

science 4 fun

### Magic candles

Can you relight a candle from a distance?



#### Collect this ...

- candle
- saucer or Petri dish
- matches

#### Do this ...

- 1 Stand the candle upright on the saucer or Petri dish. Melting a little of its base will help it stick.
- 2 Light the candle and use all your senses except taste to make as many different observations as possible. (Michael Faraday, a nineteenth century scientist, made 53!)
- 3 Gently blow the candle out and attempt to relight it by moving a lit match down the smoke trail as shown.



#### SAFETY

Ensure the bench is clear.

Make sure that your candle can't topple over.

#### Record this ...

**Describe** what happened.

**Explain** why you think this happened.

## Practical activities

An **experiment** or **practical activity** is a test on a small part of the world around us. It might test the temperatures at which different metals melt, or it might test how Bogong moths know when to migrate to the alpine regions of New South Wales and Victoria. It might test the intelligence of dolphins, how to make building materials fireproof, why some people are allergic to peanuts, why solar eclipses occur, or how chocolate can be made even tastier.

Scientists either design their own experiments or follow the instructions of other scientists who have performed them already. You will be doing this too. You will be given instructions for most practical activities, but some will require you and your group to plan and carry out your own investigations.

## Observations and measurements

Although scientists use all of their five senses to make **observations**, sight is probably the sense that gives them the most information. This is the sense being used in Figure 1.3.1. Scientists make either qualitative or quantitative observations.



**Figure 1.3.1**

The main sense a scientist uses is sight. They will also use hearing, smell, taste and touch, although often it will be far too dangerous to use some of these.

## Qualitative observations

**Qualitative observations** are descriptive. They are recorded as diagrams or written down in words.

Qualitative observations would be made about the noise a bird makes, the colour of its feathers, what it eats, and how it acts throughout the day. The appearance of shaving foam and the shape of a crab are qualitative observations too, as is the taste of the food in Figure 1.3.2.



**Figure 1.3.2**

The look, smell and taste of food are qualitative observations.

1.5

## Quantitative observations

Describing a day as hot (a qualitative observation) doesn't really give an idea of how hot it is. There is no uncertainty about how hot the day is if you specify the temperature it reached: 43°C is hot in anyone's language! Measurements like this are **quantitative observations**. They are written as numbers and allow scientists to be more detailed and accurate in their observations. Distance, mass, time, temperature and volume are quantitative observations, since all can be written as numbers. For example, chips come in 200 gram bags, cans of soft drink hold 375 mL, water boils at 100°C, and it takes 60 minutes to fly from Melbourne to Sydney, a distance of 881 km.

1.6

1.7

Sometimes an optical illusion like the one shown in Figure 1.3.3 on page 18 will trick your senses into making qualitative observations that are incorrect. Measurement will usually indicate whether your senses were correct or not.





**Figure 1.3.3**

An optical illusion makes the floors (orange) of this building in Melbourne's Docklands look as if they are at sloping at different angles. Measurement of the distance between the floors proves that they are all horizontal.

### Moonface!

The Moon often looks huge as it rises in the east but it is really just the same size as when it is somewhere else in the sky. Check this out by holding your hand out and using your fingers to measure its width as it moves across the sky. The illusion is shown in Figure 1.3.4.

SciFile



**Figure 1.3.4**

An optical illusion causes the Moon to look huge when it rises.

## Units

Measurements are useless unless the units of measurement are included. Scientists use units from the metric system for their measurements.

- Distances, lengths and heights are measured in millimetres (mm), centimetres (cm), metres (m) or kilometres (km).
- Small masses are measured in grams (unit symbol g). Heavier masses are measured in kilograms (kg) or tonnes (t).
- Volume is measured in millilitres (mL) or litres (L).

Other non-metric units are used as well. For example:

- time is measured in seconds (s), minutes (min) or hours (h)
- temperature is measured in degrees Celsius (°C).

The above units together form a system of units called *Système Internationale* (otherwise known as SI units). Each unit has its own symbol and there is a correct way of writing each symbol. For example, the symbol for millilitres is mL and not ML (which means a million litres). Likewise, the symbol for kilograms is kg, not Kg, KG or kgs.

## Taking accurate measurements

Measurements are only worthwhile if they are accurate. So that your measurements are as accurate as possible, make sure that:

- everyone in your laboratory team takes their own measurement. You can then calculate the average of everyone's values
- you keep your eye level with the measurement (like in Figure 1.3.5)
- the measuring device starts at zero.

Mistakes are often made when measurements are recorded but you can avoid this if you take enough care. Reduce the chance of recording measurements wrongly by:

- writing down measurements (with their units) as soon as you take them. Do not try to remember measurements
- avoiding fractions like  $\frac{1}{2}$  or  $\frac{1}{4}$  in measurements. Use decimals instead. 9.5 kg is fine,  $9\frac{1}{2}$  kg is not
- making sure that everyone in the group has a copy of the results before you leave the laboratory.





Figure 1.3.5

Keep your eyes level with your measurement.

## Inferring and predicting

From your observations and measurements, you can sometimes make an **inference**, or logical explanation, about what happened and why it happened. You may then be able to predict how it could work in the future or if the experiment was run in a different way. A **prediction** must be logical and must be based on the observations you made in your experiments. Every day you make observations, inferences and predictions, probably without even knowing it!

**Observation:** Everyone is packing up.

**Inference:** It must be nearing the end of the lesson.

**Prediction:** The bell will ring soon.

In science, you might start with an observation from an experiment:

**Observation:** Cubes of sugar dissolve in tea faster when they are broken into smaller pieces.

**Inference:** Smaller pieces mix better with the water than larger lumps, making them dissolve faster.

**Prediction:** If the sugar is crushed even finer, then it will dissolve even faster.

## INQUIRY science 4 fun

### The eyes have it

What is the most accurate way of making observations?



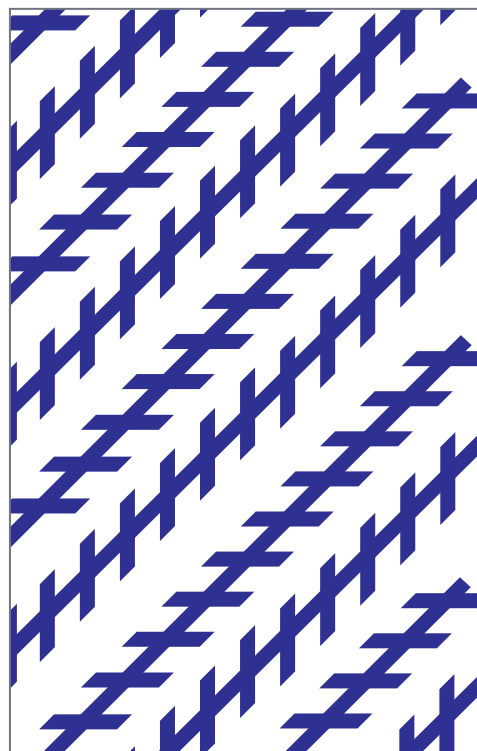
#### Collect this ...

- a ruler

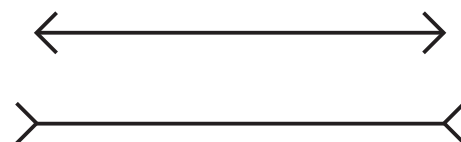
#### Do this ...

- 1 Look at the following diagrams and describe them.

a



b



- 2 Now measure the distance between the lines in diagram a.

- 3 Measure the length of the lines in diagram b.

#### Record this ...

**Describe** the observation that was most accurate.

**Explain** why you think this happened.

# 1.3

## Unit review

### Remembering

- 1 **List** your five senses.
- 2 **List** three observations about each of the following:
  - a a candle
  - b molten (melted) candle wax
  - c a candle flame
  - d the smoke from a candle that has been blown out.
- 3 **State** the measurements shown in each of the measuring devices in Figure 1.3.6.

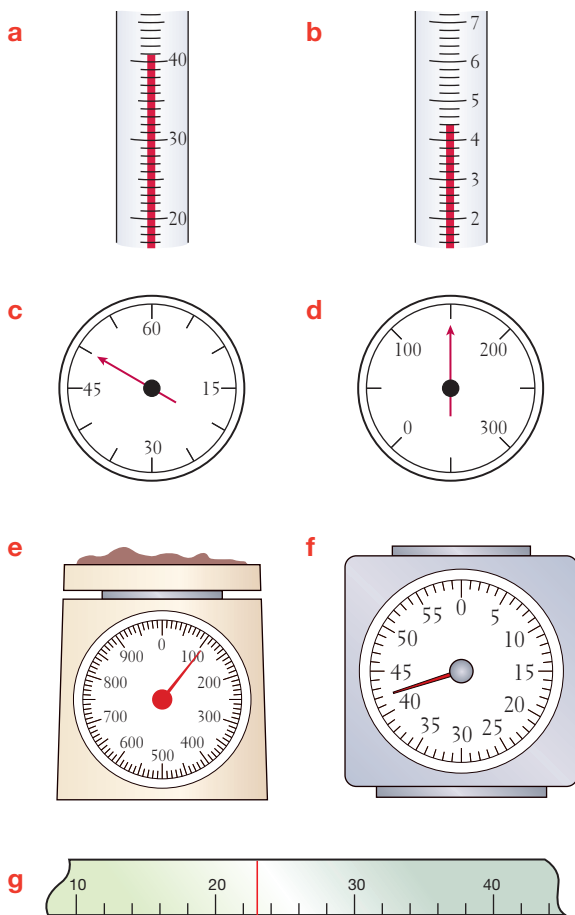


Figure 1.3.6

- 4 **State** which of the abbreviations below are correct for these units:

- a gram
 

A gm	B gms
C G	D g
- b kilogram
 

A kilo	B kg
C Kg	D KG
- c millimetre
 

A mms	B mm
C Mm	D mL
- d litre
 

A lt	B mL
C lit	D L
- e minutes
 

A min	B m
C mins	D ms

### Understanding

- 5 **Explain** what advantages quantitative observations have over qualitative observations.
- 6 Give an example to **explain** how optical illusions can lead you to make faulty observations.

### Applying

- 7 **Identify** the best metric unit to use to measure the length of:
  - a a bull-ant
  - b the length of a cricket field
  - c the distance between Brisbane and Cairns.
- 8 **Identify** the best SI unit to measure the:
  - a mass of a mouse
  - b time it takes to sneeze
  - c temperature of a sick dog
  - d mass of a person
  - e volume of a swimming pool.
- 9 **Identify** what is wrong with the way these measurements have been recorded.
  - a The mass of a mouse =  $150\frac{1}{4}$  g.
  - b The car was travelling at 100.
  - c A full bottle of soft drink contained 1.25 mL.



- 10 Sometimes it is too dangerous to use some of our senses. **Identify** which senses you would and would not use in the following experiments.

Activity	Senses that would be safe to use	The sense that would give you the most information	Senses that would be unsafe to use
Testing a new rat poison			
Testing whether minced steak is OK to eat or is 'off'			
Testing the lava flowing from a volcano			
Testing how dangerous an acid is			
Testing whether tomatoes are ripe			

- 11 In each part of this question there is an observation, an inference and a prediction.

**Identify** which is which.

- a**
- i** Dinner is being cooked.
  - ii** Food smells are coming from the kitchen.
  - iii** Dinner will be in half an hour.
- b**
- i** The colours of a felt-tip pen ran when they got wet.
  - ii** Washing should get the stain of a felt-tip pen out of my shirt.
  - iii** The inks used in a felt-tip pen can dissolve in water.
- c**
- i** The soup is hot.
  - ii** Steam is rising from the soup.
  - iii** I'll need to wait a while before I can start.

- c** It's a gas.
- d** It's one of the chemicals produced by chemical reactions in your body.
- e** If gas stops coming out, then you will soon be dead.

## Creating

- 15 **Design** a way of measuring the:

- a** mass of a Smartie or an M&M without using any weighing device
- b** thickness of a piece of A4 paper with a normal ruler
- c** average number of your heartbeats in a minute.

## Analysing

- 12 **Contrast** qualitative with quantitative observations.

- 13 **Classify** the following observations as qualitative or quantitative.

- a** The night was dark.
- b** There were 68 people in the hall.
- c** It took 15 minutes to walk to school.

- 14 The following are statements about the gas you breathe out. **Classify** each statement as an observation, an inference or a prediction.

- a** It's hot, moist, colourless and clear.
- b** It's carbon dioxide.

## Inquiring

- 1 Search the internet for images and video of optical illusions such as the Zolner illusion.
- 2 Write a short history of the metric system.
- 3 Find the years in which Australia adopted the metric system.
- 4 Some chemicals used in a laboratory are thrown in the bin, some are washed down the sink and others have very special requirements for their disposal. It all depends on how dangerous they are. Find out what happens to different chemicals used in the laboratory after an experiment.

# 1.3

## Practical activities

### 1 Hot, hotter, hottest

#### Purpose

To compare qualitative with quantitative measurements.

#### Materials

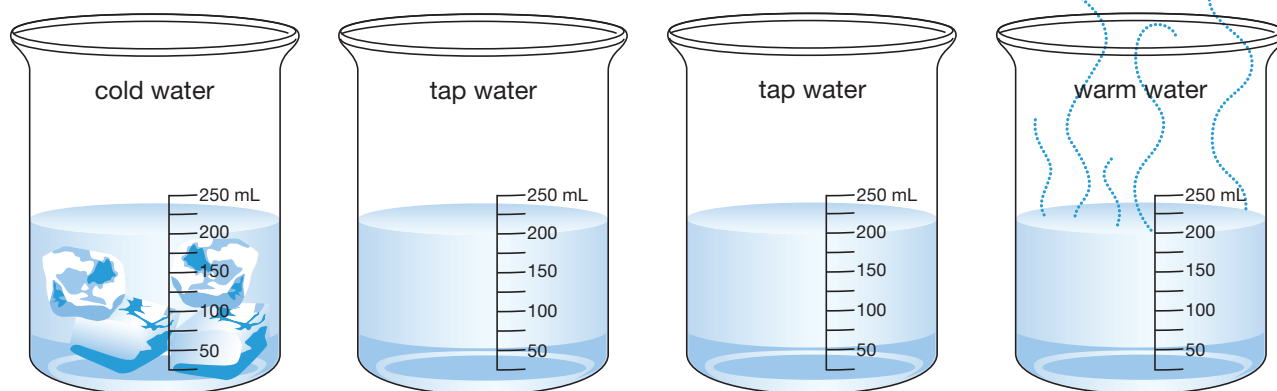
- 4 × 250 mL beakers or identical tubs
- thermometer
- ice
- warm water



#### Procedure

- 1 Fill four beakers and arrange them as shown in Figure 1.3.7.
- 2 Immerse (place) your left hand in the beaker containing cold water and your right hand in the beaker containing warm water. Leave your hands in the water for 30 seconds or so.
- 3 Remove your hands and put each hand into a beaker containing tap water.
- 4 Leave them there for 30 seconds or so. Does the water feel the same to both hands, or does one feel hotter?

Figure 1.3.7



#### Results

- 1 Copy out the table below into your workbook.

Beaker	Actual temperature (°C)	What it felt like (very hot, hot, cool, cold)
Water-ice mixture		
Tap water 1		
Tap water 2		
Warm water		

- 2 Rate what the temperature of each beaker felt like: very hot, hot, cool or cold. Record your ratings in the table.
- 3 Check the accuracy of your ratings by measuring the actual temperature of each beaker with the thermometer. Record each temperature in the table.

#### Discussion

- 1 **Identify** the quantitative observations you took in this activity.
- 2 **Identify** your qualitative observations.
- 3 **State** whether your qualitative observations agreed with your quantitative ones.
- 4 Quantitative observations can be trusted more than qualitative observations. **Explain** why.

## 2 Taking measurements

### Purpose

To observe that not everyone takes the same measurement.

### Materials

- access to a range of equipment that shows different quantities (such as a 250 mL beaker, 100 mL conical flask or a 100 mL measuring cylinder containing different quantities of water, a beam or electronic balance with a mass on it, a sheet of paper with a ruler to measure its length)
- A4 sheet of paper next to each piece of equipment

### Procedure

Move around the laboratory and read the measurement for each piece of equipment.

### Results

- 1 Construct a table similar to the one below in your workbook.

Name of equipment	Measurement	Units

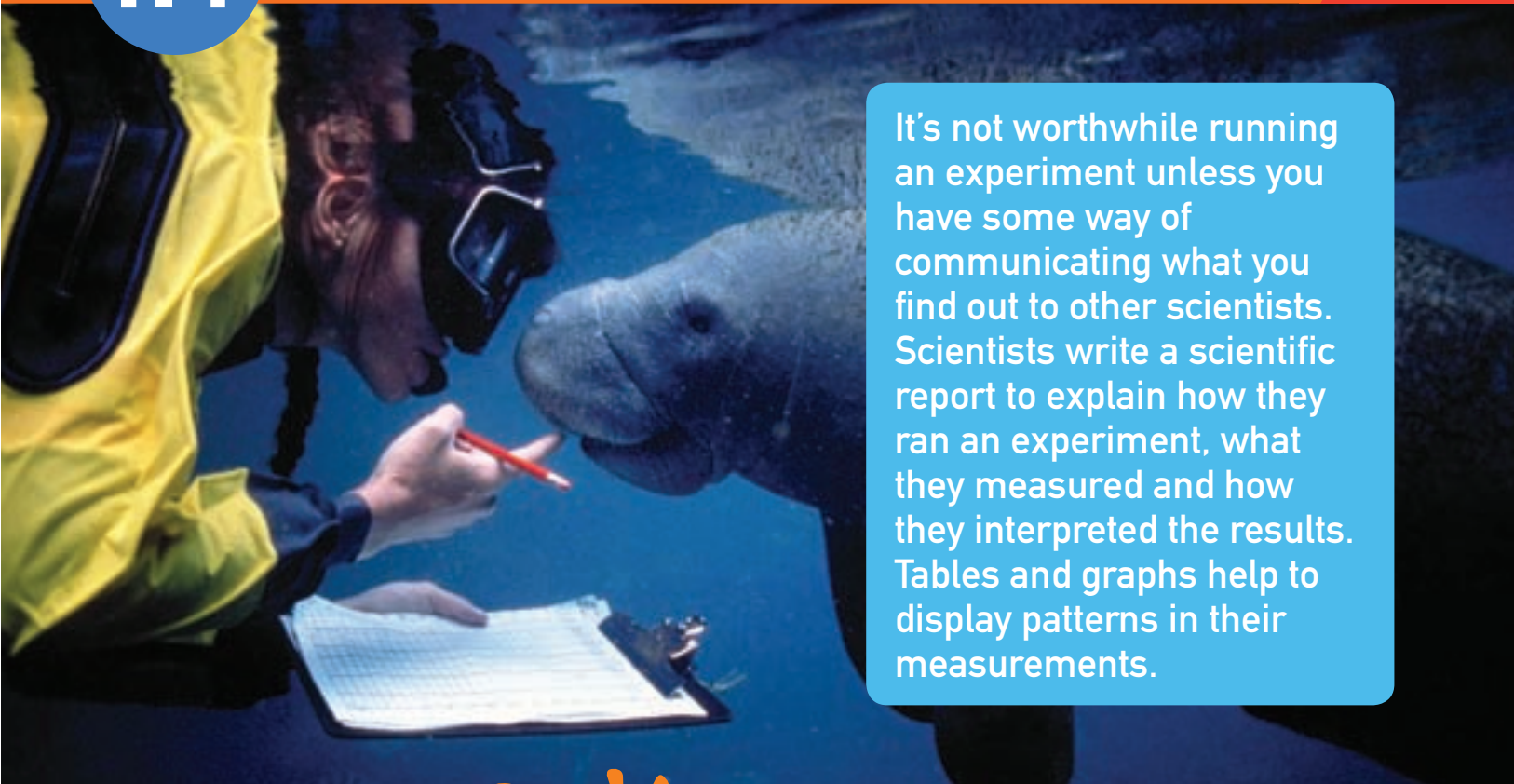
- 2 Record your measurement in the table and on the paper next to each piece of equipment.
- 3 After you finish, check all the measurements written on the pieces of paper and determine if they are all exactly the same.

### Discussion

- 1 Everyone in a team will take slightly different measurements, even when measuring exactly the same thing. **Propose** reasons why.
- 2 **Describe** a way of using all the results on the paper to obtain an even better result.







It's not worthwhile running an experiment unless you have some way of communicating what you find out to other scientists. Scientists write a scientific report to explain how they ran an experiment, what they measured and how they interpreted the results. Tables and graphs help to display patterns in their measurements.

INQUIRY

## science 4 fun

### Broken whispers

Can a group communicate a piece of information accurately without writing it down?



#### Do this ...

- 1 As a class or in a group, sit around in a circle.
- 2 One of you is to construct a short story that takes no more than two sentences to tell.
- 3 The story is to be passed on around your group by one person whispering it very quietly to another.
- 4 Compare the original story with the story that it ended up being.

#### Record this ...

**Describe** what happened.

**Explain** why you think this happened.

## Tables

Measurements and observations are easier to read and analyse if they are displayed in tables. Tables also make trends (patterns) in the measurements more obvious. Each column in a table needs to have a clear heading that includes the units in which each measurement has been taken.

Computer programs such as Excel allow you to produce an electronic table on a computer. This type of table is known as a spreadsheet.

## Graphs

A graph shows trends in measurements even more clearly than tables do. The type of graph you draw depends on the types of observations you make.

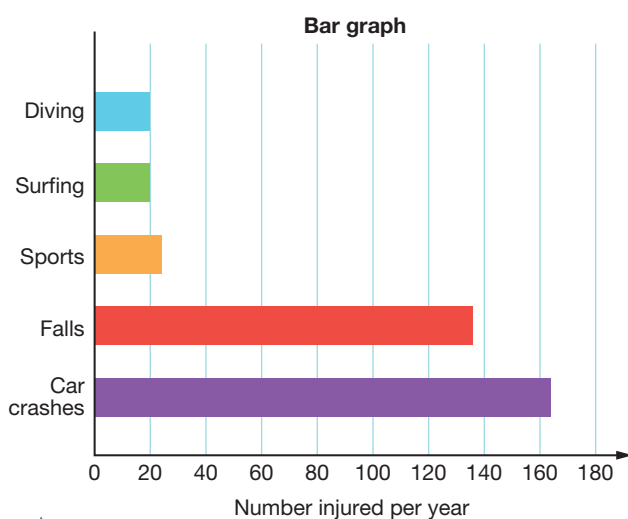
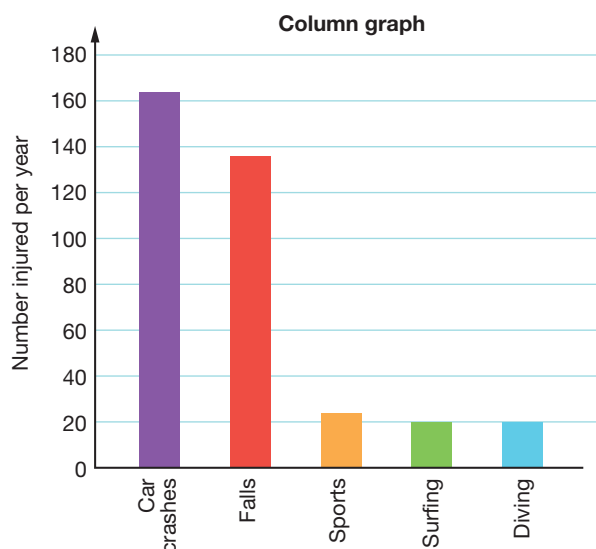
### Bar and column graphs

Some observations fall into discrete groupings. This means that all the observations can be sorted into categories and counted. Animals, for example, fall into discrete groupings like kangaroos, ants, cockatoos and

sharks. Other observations that have discrete values are makes of cars (such as Holden, Toyota, Ford, Mazda), sports (netball, football, golf, tennis), building materials (timber, brick, concrete, glass) and the sex of people (male or female).

**Bar** and **column** graphs are used when you have a set of observations that are discrete. These discrete values are displayed on one of the axes of the graph while numbers are displayed on the other axis, as shown in Figure 1.4.1. Axes are the horizontal and vertical lines 'framing' the graph.

Cause of spinal injury	Average number injured per year
Car crashes	164
Falls	136
Sports	24
Surfing	20
Diving	20

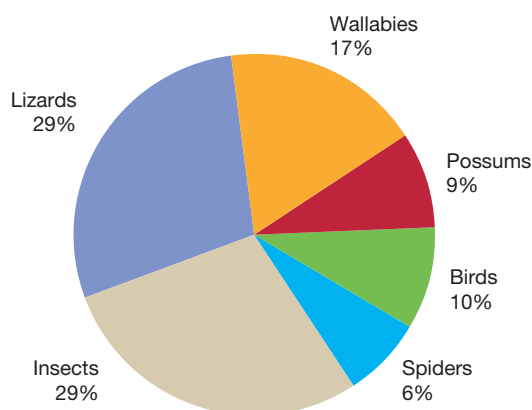


**Figure 1.4.1**

There are five main causes of injuries to the spine. These two graphs indicate how many Australians are injured on average per year.

## Pie graphs

Discrete groupings are also used to construct **pie graphs** or pie charts. A pie graph shows the proportions of each grouping within a total. In a pie graph, the whole pie represents 100%, half the pie represents 50% and a quarter-pie represents 25%. As an example, Figure 1.4.2 shows the percentages of different animals living in a nature reserve.



**Figure 1.4.2**

This pie graph shows the proportions of each animal in a nature reserve and not their real numbers.

## Line graphs

Measurements involve numbers that are not discrete but *continuous*. This means that if you choose two numbers, then you can always find other numbers in between them. For example, between 10 and 20 you will find the numbers 11, 12, 13, 14 and so on. Between them are even more numbers such as 11.4, 12.7 and 13.576362. Measurements therefore vary continuously. Continuous variation is shown in the height of humans. Imagine measuring the height of every student and teacher in your school. There would be a spread of heights from short to tall with most heights represented in between. Length, mass, time, volume and temperature measurements are continuous.

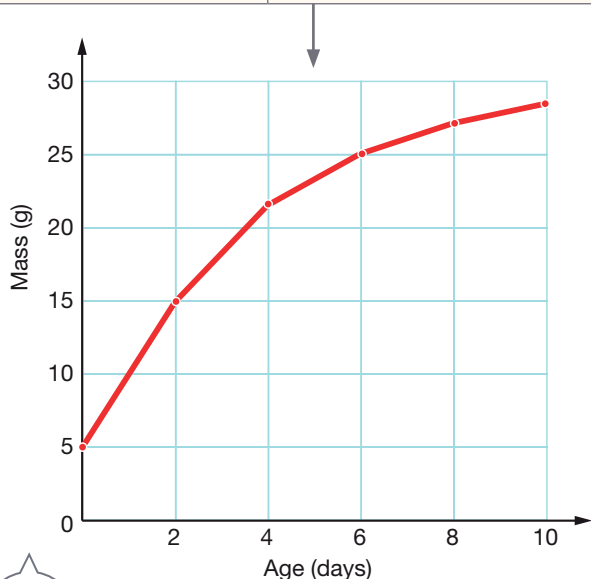
**Line graphs** require two sets of measurements, that show continuous variation. This is shown in Figure 1.4.3 on page 26.



Once you have plotted all the points on a line graph, do not connect up the points dot-to-dot. Instead, draw a straight line or a smooth curve roughly through the centre of the points you have plotted. A straight line like this is called a line of best fit while the curve is called a curve of best fit. These 'best fits' clearly show patterns that might exist in the measurements you took in the experiment. These patterns can be described as shown in Figure 1.4.4 on page 26.

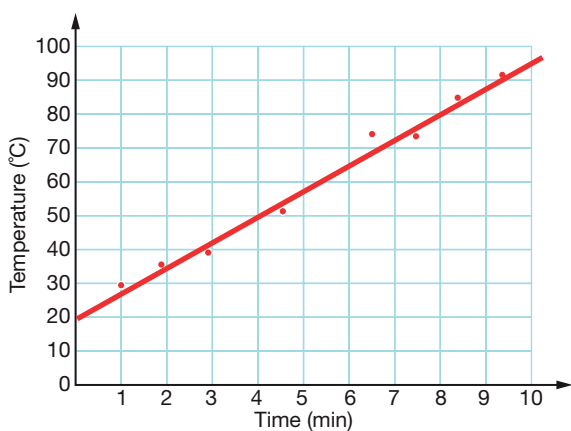


Age of mouse (days)	Mass (g)
0	5
2	15
4	22
6	25
8	27
10	28



**Figure 1.4.3**

Line graphs need two sets of numbers to plot.



**Figure 1.4.4**

A line of best fit is drawn roughly through the middle of all the points. In this way, the line of best fit shows the trend or pattern in the graph.

## Scientific reports

Scientific reports are used by scientists to communicate to other scientists how they performed an experiment and what they found out in it. If you set out your report clearly and logically, then it allows other scientists to repeat your experiment.

## Aim or purpose

The **aim** or **purpose** is what you wanted to do in an experiment or practical activity, what you wanted to show or wanted to prove.

## Hypothesis (optional)

You probably have some idea of what might happen in an experiment even before you start it. This 'educated guess' is called your **hypothesis**. A hypothesis is an inference based on what you already know. A hypothesis is not always included in a scientific report.

## Materials

This is a list of all the *important* equipment, chemicals and materials that you used. If equipment comes in different sizes, then make sure you include the size you used (for example, 250 mL beaker).

## Method or procedure

The **method** or **procedure** is a detailed list of what you did in the experiment. You must include what quantities were used (for example, 5 g, 2 spatula loads or 10 mL), and the exact order in which the steps of the experiment were performed. A diagram of the experiment is a useful way of showing what you did.

## Results

**Results** include all your observations and all your measurements, preferably displayed in a table.

## Discussion or analysis

Include in your **discussion** or **analysis**:

- answers to any questions asked in the activity
- any graphs you plotted
- an explanation about what you think your results showed about the experiment
- what you have found about the experiment from other sources such as textbooks, the internet or encyclopedias
- a description of any problems you had with the experiment and what you did to overcome them.

## Conclusion

Your **conclusion** needs to summarise what you have found out in the experiment. The conclusion should be short and must relate to the purpose.





# 1.4

## Unit review

### Remembering

- 1 **Recall** the main sections of a scientific report by matching the following:

Purpose	instructions
Hypothesis	the end
Materials	aim
Procedure	analysis
Discussion	equipment
Conclusion	educated guess

- 2 **List** the things that should be included in the following sections of a scientific report:

- a materials
- b procedure
- c discussion.

### Understanding

- 3 **Explain** why scientists would want to read what others have found out in experiments.

### Applying

- 4 Adrian ran an experiment in which he tested how much sugar would dissolve in a hot cup of tea.

**Identify** the best conclusion for his experiment.

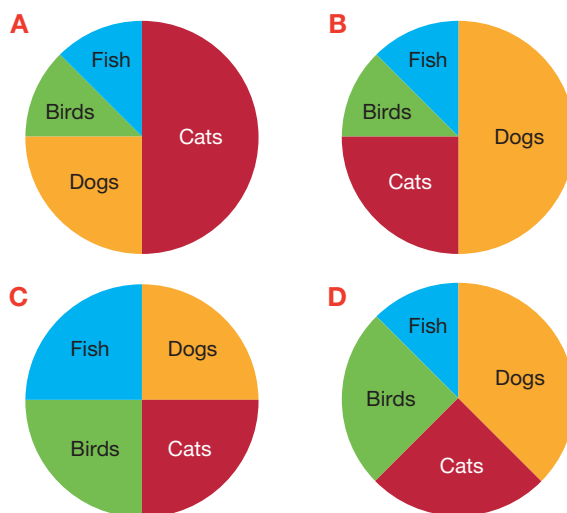
- A The experiment was fun.
- B I learnt a lot from the experiment about sugar dissolving in hot tea.
- C 3 teaspoons of sugar were able to be dissolved in a hot cup of tea.
- D Tea tastes better when there is sugar dissolved in it.

- 5 **Identify** whether a column/bar, pie or line graph would best show the following results.

- a The top speeds of different makes of cars
- b The temperature of a room throughout a winter's day
- c The types of animal with different numbers of legs
- d The percentages of your classmates who were born in Australia and overseas
- e Your height as you get older

- 6 **Identify** which of the graphs A–D best represents the results in the table.

Type of pets	Percentage (%)
Dogs	50
Cats	25
Fish	13
Birds	12



- 7 Use the key below to **identify** the term that best describes the trend shown in each of the line graphs in Figure 1.4.5.

- A constant
- B increasing
- C decreasing
- D no trend shown.

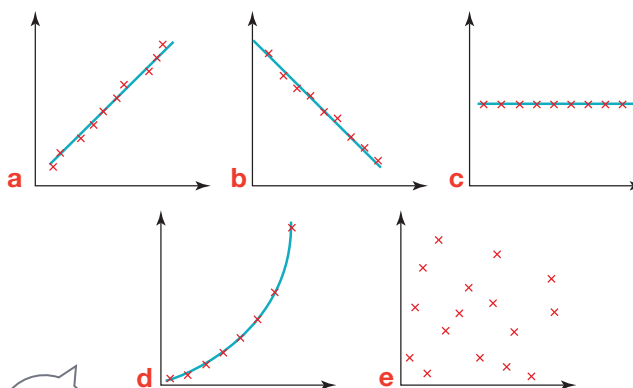


Figure 1.4.5

## 1.4 Unit review

### Analysing

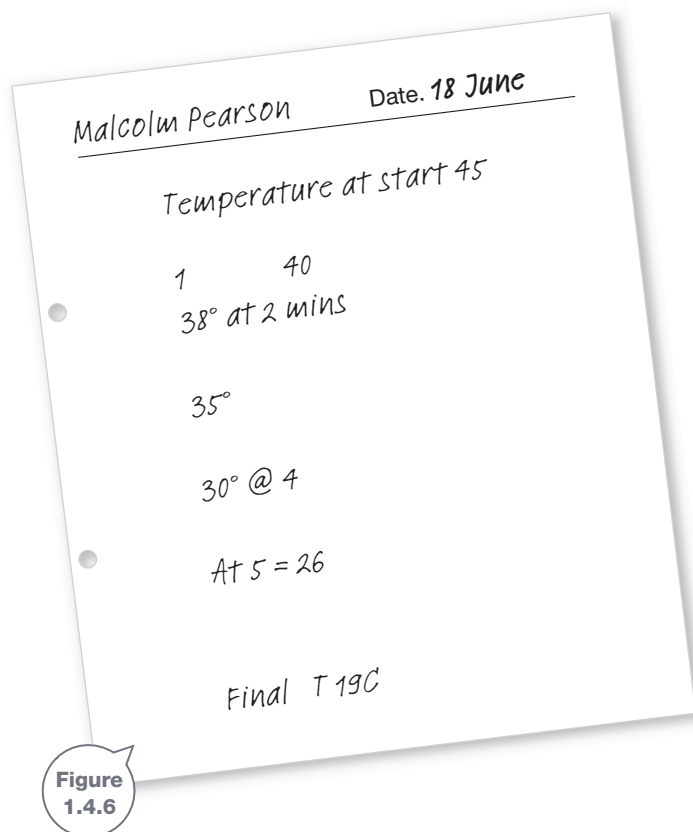
- 8 Draw simple sketches to **contrast** a column graph with a:
- a bar graph
  - b pie chart
  - c line graph.

### Evaluating

- 9 **Propose** reasons why a message sent around a room via whispers often ends up very wrong.

### Creating

- 10 **Construct** an appropriate conclusion for the following aims.
- a To test if fishing line is stronger than string
  - b To prove that water boils at  $100^{\circ}\text{C}$
  - c To determine how much water a sponge can hold
- 11 **Construct** a table for the poorly recorded results shown in Figure 1.4.6.



- 12 Bridie noted the speedometer reading every 5 seconds as her mum's car accelerated. At the start, the speed was 0 km/h. The speed was 20 km/h after 5 seconds, then 30, 50, 60 and 80 every 5 seconds after.
- a **Construct** a table to display her results.
  - b **Construct** a line graph to show her results.

### Inquiring

Find out about the Mars Polar Lander (Figure 1.4.7), the spacecraft that crashed into Mars as a result of poor communication between different groups of scientists.



Figure 1.4.7

An artist's impression of what the landing of the Mars Polar Lander *should* have looked like.

# 1.4

## Practical activities

### 1 Hot drinks cooling

#### Purpose

To compare the rates at which different cups of hot drink cool.

#### Materials

- beakers, cups and mugs
- hot water (from an urn or heated over the Bunsen burner or hotplate)
- one or more of tea, coffee, drinking chocolate
- milk and sugar
- teaspoon or stirring stick
- thermometer
- stopwatch, clock or watch



#### SAFETY

Do not boil the water that you are heating. It needs to be hot but not boiling.

Do not pick up any beaker with hot water with your bare hands. Use special tongs made for beakers or use insulated gloves.

Wear safety glasses at all times.

#### Procedure

- 1 You are going to measure the temperatures of two cups, mugs or beakers of tea, coffee or drinking chocolate as they cool.
- 2 Prepare at least two cups, beakers or mugs of tea, coffee and/or drinking chocolate, adding sugar and milk as desired.
- 3 Measure the temperature of each drink every 1 minute for at least 10 minutes.

#### Results

- 1 Record all your temperatures in a results table similar to the one below.

Time (min)	Cup of tea	Beaker of coffee	Mug of drinking chocolate
0 (at the start)			
1			
2			
3			
4			

- 2 Plot the results of each drink as a line graph on a similar grid to that shown in Figure 1.4.8.

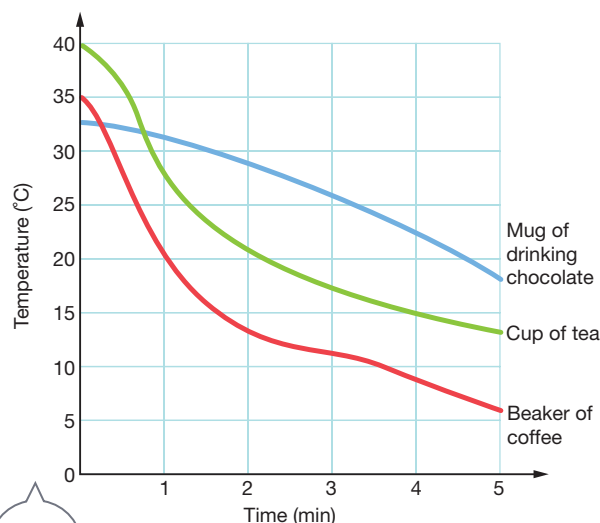


Figure 1.4.8

#### Discussion

- 1 **Describe** the trend or pattern that each graph showed. Was it increasing, decreasing, constant, unpredictable?
- 2 **Identify** which drink cooled the:
  - a fastest
  - b slowest.
- 3 **List** as many factors as you can to **explain** why the drinks cooled at different rates.
- 4 **Propose** improvements that could be made to your experiment.



## 1.4 Practical activities

### 2 Spaghetti predictions

#### Purpose

To use a graph to predict unknown measurements.

#### Materials

- 4 lengths of spaghetti
- beam balance or electronic balance
- 30 cm ruler (with 1 mm markings)

#### Procedure

- 1 Break three lengths of spaghetti into three pieces each so that you end up with nine different lengths.
- 2 Measure the length and mass of each piece of spaghetti.

#### Results

- 1 Record the lengths and masses you measure in a table like that shown below.

Length (mm)	Mass (g)

- 2 Use this information to plot a line graph. Draw a straight line so that it passes roughly through the centre of your points. An example of a line of best fit is shown in Figure 1.4.9.

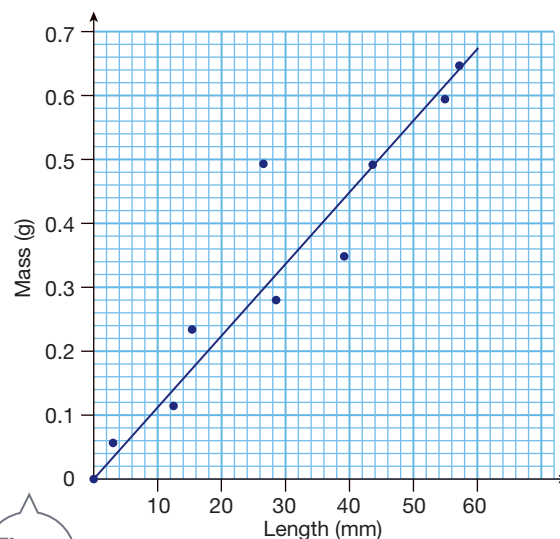


Figure 1.4.9

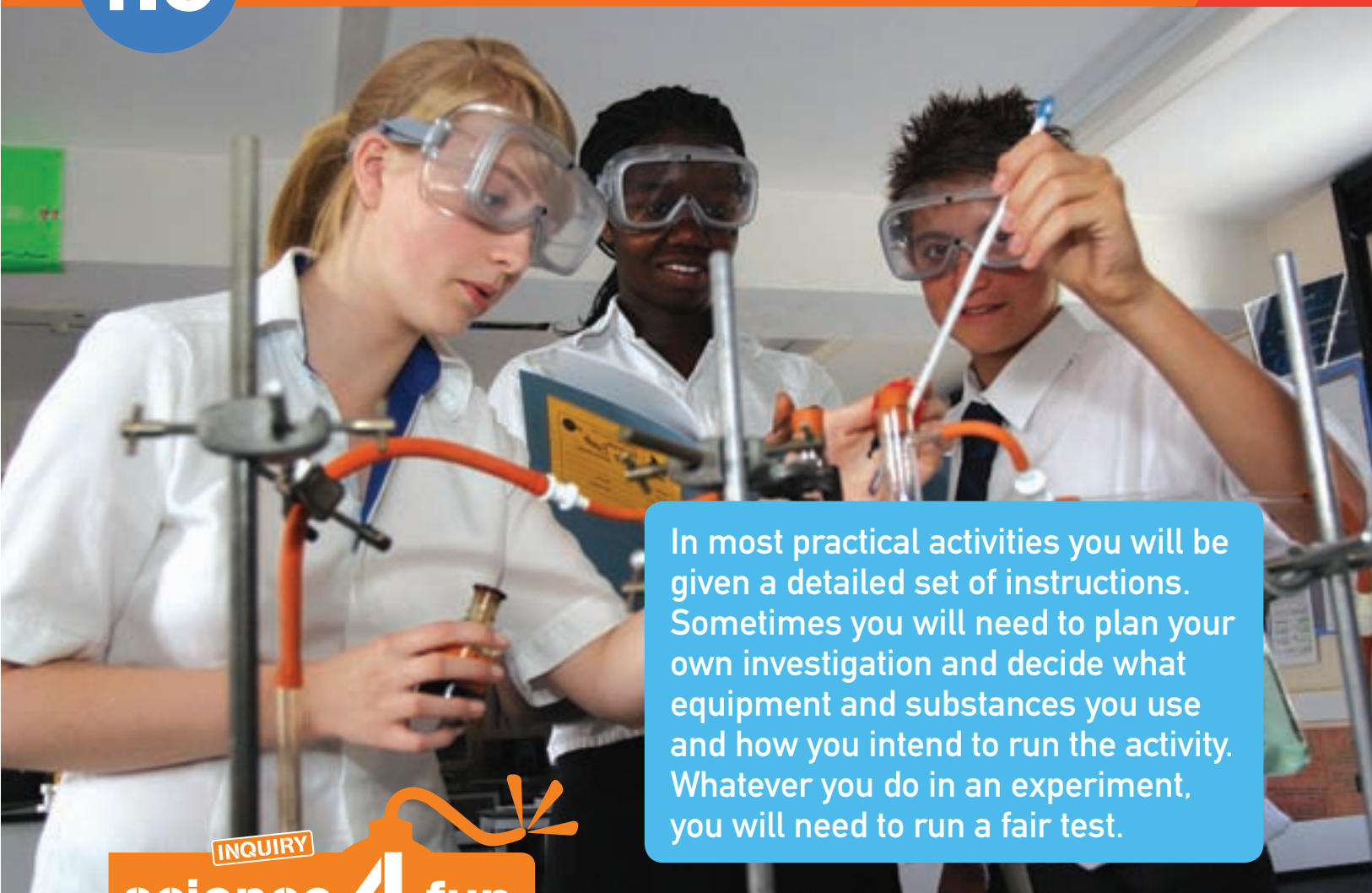
- 3 You only had nine lengths of spaghetti and there were lots of other lengths that you could not measure. Mark on your graph a length that you did not measure.
- 4 Use the graph to estimate the mass of this length.
- 5 Snap your final length of spaghetti at the length you chose in step 3 and measure its mass.
- 6 Compare its mass with your prediction in step 4.

#### Discussion

- 1 **Explain** why a line of best fit is better than joining points dot-to-dot.
- 2 **Construct** a conclusion about the link between mass and length of spaghetti.

# 1.5

## Designing your own investigation



In most practical activities you will be given a detailed set of instructions. Sometimes you will need to plan your own investigation and decide what equipment and substances you use and how you intend to run the activity. Whatever you do in an experiment, you will need to run a fair test.

INQUIRY

science 4 fun

### No-leak bags

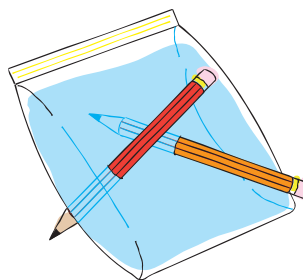
What happens when you stab a plastic bag full of water?

#### Collect this ...

- 1 zip-lock plastic bag
- pencils
- pencil sharpener
- water
- access to a sink or bucket

#### Do this ...

- 1 Sharpen the pencils so that their tips form a very sharp point.
- 2 Three-quarters fill the plastic bag with water, and zip it shut.



- 3 Hold the plastic bag above a sink or bucket (or work outside).
- 4 Stab the bag fast with a pencil so that the tip comes out the other side.
- 5 Repeat with the other pencils.

#### Record this ...

**Describe** what happened.

**Explain** why you think this happened.

## Identifying variables

Many different factors influence what happens in an experiment. In science, these factors are known as **variables**. Think of the time it takes someone to run 100 metres. The time taken will depend on many variables, such as the age, weight and fitness of the runner, the shoes being worn, the direction of the wind and whether the surface was grass, concrete or sand.

Any experiment that you carry out must be a **fair test**. To be fair, you should change only one variable at a time. Otherwise you won't be able to work out what variable caused any change. All the other variables must be controlled, being kept exactly the same.

In any experiment you should be able to identify the:

- **dependent variable:** this is what you are trying to measure. It depends on all the other variables. For the 100-metre run, the dependent variable is the time taken.
- **independent variable:** this is the variable that you want to test and is what the dependent variable depends on. Change this and what you are trying to measure will probably change too. For the 100-metre run, you might choose to test the surface run on, and so this would be the independent variable.
- **controlled variables:** these are all the other variables that you don't want to test right now. These are kept constant. In the 100-metre run, you are testing the surface, so every other variable needs to be kept the same. The age, fitness and weight of the runner, the type of shoes they are wearing and the wind direction would all need to be kept constant.



Figure 1.5.1

The type of ball and the surface it is dropped onto are two variables that will affect the height to which the ball bounces.

Figure 1.5.1 shows a ball bouncing on a racquet. When a ball is dropped onto a surface such as a racquet, many variables influence the height the ball bounces back to. The height of a bounce (bounce height) is the dependent variable because it depends on other (independent) variables. Just a few of these are the:

- type of ball that is being bounced
- type of surface it is being bounced on
- height the ball drops from (drop height).

Let's say you decide to test how the drop height of a ball affects the bounce height. Your variables are therefore:

- dependent variable: bounce height. This is what you are measuring and will be the basis of your aim.
- independent variable: drop height. This is what you are changing.
- controlled variables: the type of ball and surface. These must be kept the same throughout the experiment.

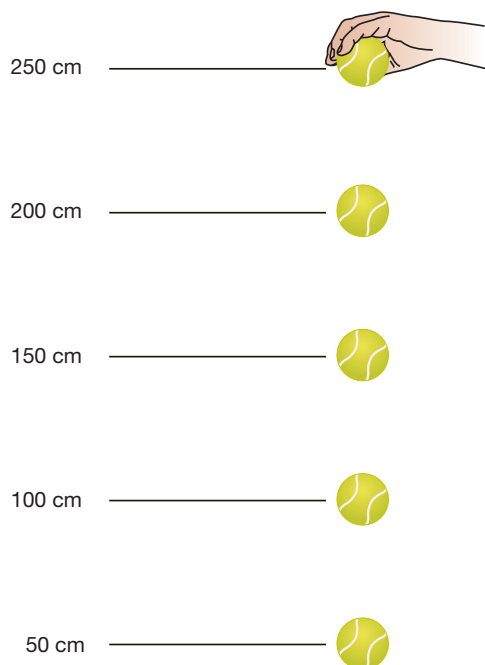
Your purpose therefore would be: *To test how drop height affects bounce height.*

## Developing a hypothesis

Think about what is likely to happen in the experiment. Write down what you think might logically happen. This is your hypothesis.

## Developing your procedure

Your procedure must test the effect of only the independent variable you chose earlier. All other variables must be kept the same. In this ball-bounce experiment, you need to test one type of ball (such as a tennis ball) and one type of surface (for example, onto a concrete path). The only thing you can change is the height you drop the ball from. Figure 1.5.2 shows how this might be done. If you want to change another variable, then you need to run a new and separate experiment.



**Figure 1.5.2**

Try to test five or more different heights and make sure they are not too close to each other. Anything less than five measurements and measurements that are too close make patterns difficult to see.

## Putting your results in a table

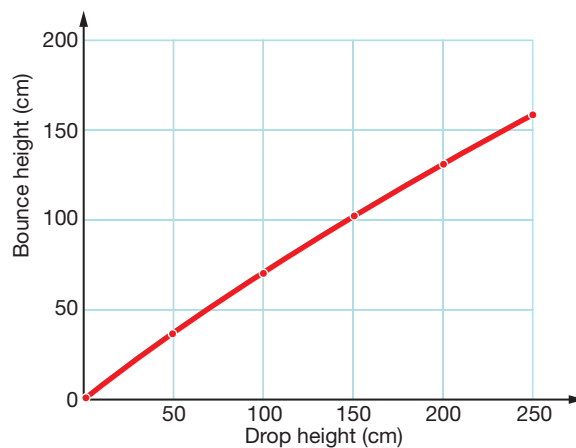
Before you start, think about the heights you might drop the ball from and the results you might obtain. Here you are measuring drop height and bounce height. An appropriate results table would look like the one shown in Table 1.5.1.

**Table 1.5.1 Results table**

Drop height cm	Bounce height (cm)
0	0
50	30
100	62
150	95
200	120
250	148

## Plotting a graph

When plotting a graph, you first need to decide which type of graph you are to plot. Line graphs like that shown in Figure 1.5.3 are used when you have two sets of continuous measurements.



**Figure 1.5.3**

Two sets of measurements require a line graph.

The results in Figure 1.5.3 have two sets of numbers and so a line graph is the most appropriate graph to plot. In this example, a column, bar or pie graph would make no sense.

Bar graphs are used when one set of results is discrete. For example, bar graphs would be a good way of showing the way bounce height changed when the type of ball or type of surface was changed.

## Your conclusion

Your conclusion must answer the purpose or aim of your experiment. Depending on what you tested, appropriate aims and conclusions would be:

*Purpose:* To test what increasing drop height does to bounce height.

*Conclusion:* Increasing drop height causes bounce height to increase.





## Remembering

- 1 **Recall** variables by matching the different terms with their definitions.

Dependent variable	Kept the same
Independent variable	Changed during the experiment
Controlled variable	What you are measuring

- 2 In the science4fun activity on page 31, sharp pencils were stabbed into a plastic bag full of water. For this activity, **state**:

- a an aim
- b a logical hypothesis.

- 3 **List** variables that are likely to affect the:

- a amount of sugar that will dissolve in a cup of tea
- b number of visitors to a swimming pool
- c growth of a plant
- d time taken to cook a potato
- e number of times you go to the toilet in a day.

## Understanding

- 4 **Explain** why only one variable should be changed in any single experiment.
- 5 **Explain** why you should try to collect five or more results in an experiment.
- 6 Georgie heard an old tale that if you want an avocado to ripen quickly, then it should be placed in a brown paper bag with a banana. She thought this sounded weird and wanted to see if it was true. **Describe** in detail how she could test if the tale was true or not.

## Applying

- 7 **Identify** which of the following sets of drop heights would give the best idea of what happens when drop height is increased.
- A 10 mm, 20 mm, 30 mm, 40 mm, 50 mm
  - B 5 cm, 10 cm, 15 cm, 20 cm, 25 cm
  - C 50 cm, 100 cm, 150 cm, 200 cm, 250 cm
  - D 10 m, 20 m, 30 m, 40 m, 50 m

- 8 **Identify** likely aims that would have led to these conclusions.

- a Tennis balls bounced the best on concrete. They did not bounce as well on short grass and bounced poorly on long grass.
- b Superballs bounced best, followed in order by tennis balls and volleyballs. Squash balls were the worst bouncers.

- 9 **Identify** the variables that are likely to affect the amount of detergent froth produced when washing the dishes.

## Evaluating

- 10 Bob ran an experiment on bouncing balls and recorded the following results.

Ball	Surface	Drop height (cm)	Bounce height (cm)
Tennis	Sand	30	1
Squash	Concrete	300	30
Golf	Gravel	100	5
Volleyball	Grass	50	10

On the basis of his results, he claimed that squash balls bounced better than tennis balls.

- a **State** the dependent variable that Bob tested.
- b **Identify** how many variables Bob changed during the experiment.
- c **Assess** whether the experiment was a fair test.
- d Do you agree with Bob's conclusion? **Justify** your answer.

## Creating

- 11 For the experiment in Question 9 or 10, **construct** a method that would test a single variable.

## Inquiring

Scientific investigations are regularly reported in the newspaper, on websites and in scientific magazines such as *Cosmos* and *Scientific American*. Find an article that discusses a scientific investigation and:

- give the names of the scientists involved
- summarise what they found out.

# 1.5

## Practical activities

### 1 Designing your own investigation

#### Purpose

To design and run an experiment that tests a single variable.



#### Materials

Choose your own, depending on your choice of topic.

#### Procedure

Design your own experiment that will test a variable that is likely to affect:

- 1 the bounce height of a ball



- 2 the amount of sugar that can be dissolved in a cup of tea



- 3 the adhesive strength of sticky tape



- 4 the stretch of an elastic band or other elastic material such as stockings



- 5 the strength of paper.



#### Discussion

- 1 **Construct** a scientific report describing what you did in your prac. In it, you should include a:
  - a table of results
  - b graph.
- 2 **Identify** other variables that would affect your experiment.

## Remembering

- 1 **Name** the branch of science that studies:
  - a living things
  - b chemicals
  - c forces and energy
  - d the mind
  - e the Earth
  - f space
  - g the environment.
- 2 **State** two metric units commonly used for:
  - a distance
  - b volume
  - c mass.
- 3 **State** which abbreviation is correct for these units.
 

a degrees Celsius	
A deg C	B deg
C °C	D C
b hour	
A hr	B h
C Hr	D H
c seconds	
A sec	B secs
C S	D s
- 4 **State** one qualitative and one quantitative observation for each of:
  - a a can of soft drink
  - b yourself.

## Understanding

- 5 **Define** the following terms.
  - a meniscus
  - b cross-section
  - c hypothesis
  - d variable
- 6 **Describe** the features of a safety flame.
- 7 **Explain** why the senses of taste and smell are rarely used in science.

## Applying

- 8 **Identify** the equipment in these jumbled words.
  - a kaeber
  - b aluspat
  - c burccile

- 9 **Identify** the best SI unit to measure the:
  - a time to run the 100 m sprint
  - b mass of a car
  - c volume of water in a sink.
- 10 **Identify** which of the following statements are observations, which are inferences and which are predictions.
  - a i One Olympian is bigger than the other.  
ii The bigger Olympian will win the event.  
iii One will lift a heavier weight than the other will.
  - b i I'll need to buy a new plant.  
ii The plant is dying.  
iii Leaves are curling up and turning brown.
- 11 **Identify** the best type of graph (bar, column, pie or line) from the clues below.
  - a It shows percentages.
  - b It has two sets of measurements.
  - c It has discrete groups along its bottom, horizontal axis.
  - d It has discrete groups along its vertical axis.

## Analysing

- 12 **Classify** the following observations as qualitative or quantitative.
  - a The cow went 'moo'.
  - b The car was travelling at 60 km/h.
  - c The Saints won by 25 points.
  - d The Sea Eagles won by a lot.

## Evaluating

- 13 **Propose** reasons why the Bunsen burner gas must be turned on after the match is lit.

## Creating

- 14 **Use** the following ten key words to **construct** a visual summary of the information presented in this chapter.

laboratory	equipment
experiment	safety
observations	measurements
units	quantitative
variables	qualitative



# Thinking scientifically

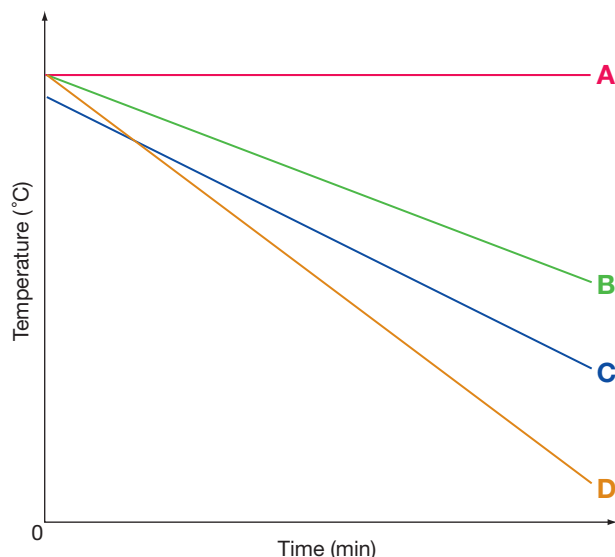
The Three Bears returned home and found someone had been eating their porridge. Being scientific bears, they were interested in how fast different-sized bowls cooled. They filled them with hot porridge and measured the temperature every minute. Their results are shown in the table.

Time (min)	Temperature of Papa Bear's porridge (°C)	Temperature of Mama Bear's porridge (°C)	Temperature of Baby Bear's porridge (°C)
0	60	58	61
1	55	48	50
2		39	48
3	45	31	30
4	40		20
5	35	18	10

**Q1** Identify which bowl cooled the fastest.

- A** Papa Bear's
- B** Mama Bear's
- C** Baby Bear's
- D** Not enough information to decide

Mama Bear then sketched line graphs to show what was happening. These are shown below.



**Q2** Identify which graph most likely represents:

- a** Papa Bear's bowl
- b** Mama Bear's bowl
- c** Baby Bear's bowl.

**Q3** Identify which of the following variables are *unlikely* to have much effect on the cooling of the porridge.

- A** size of bowl
- B** amount of porridge
- C** amount of sugar in porridge
- D** starting temperature of porridge

**Q4** Baby Bear misread his thermometer once. Identify which of his readings is probably wrong.

- A** 50°C
- B** 48°C
- C** 30°C
- D** 20°C

**Q5** Papa Bear forgot to read his thermometer once. Identify the most likely missing temperature.

- A** 31°C
- B** 53°C
- C** 50°C
- D** 18°C

**Q6** Mama Bear also forgot to read her thermometer. Identify the most likely missing temperature.

- A** 30°C
- B** 24°C
- C** 20°C
- D** 18°C



# Glossary

## Unit 1.1

**Astronomy:** the study of space

**Biology:** the study of living things

**Branches:** sub-groups of science

**Chemistry:** the study of chemicals and their reactions

**Ecology:** the study of the environment

**Geology:** the study of Earth

**Physics:** the study of forces and energy

**Psychology:** the study of behaviour



Psychology

## Unit 1.2

**Bunsen burner:** used in the laboratory to provide heat

**Cross-section:** split down the middle

**Equipment:** tools of the laboratory

**Hotplate:** heating device

**Laboratory:** where a scientist works

**Mass:** amount of matter

**Meniscus:** curved surface of liquids in narrow tubes

**Safety flame:** yellow flame

**Toxic:** poisonous



Bunsen burner

## Unit 1.3

**Experiment:** a scientific test

**Inference:** logical explanation

**Observation:** what is seen, heard, smelt, felt, tasted

**Practical activity:** experiment

**Prediction:** what might happen

**Qualitative observations:** observations in words only

**Quantitative observations:** measurements including numbers

## Unit 1.4

**Aim:** what you are trying to do

**Analysis:** looking for trends in the results

**Bar graph:** used when one set of observations is discrete. Bars are horizontal

**Column graph:** used when one set of observations is discrete. Columns are vertical

**Conclusion:** what you have found out

**Discussion:** analysis

**Hypothesis:** educated guess

**Line graph:** used when there are two sets of continuous measurements

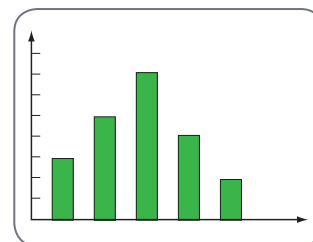
**Method:** tells how you did the experiment

**Pie graph:** used to show proportions

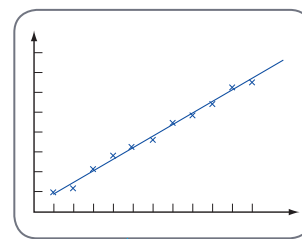
**Procedure:** tells how you did the experiment

**Purpose:** aim

**Results:** the measurements and observations made in an experiment



Column graph



Line graph

## Unit 1.5

**Controlled variables:** held constant throughout an experiment

**Dependent variable:** will change naturally as you change the other variables

**Fair test:** changing only one variable at a time

**Independent variable:** what you change in an experiment

**Variables:** factors that influence an experiment