1

CURIOSITY, WONDER AND QUESTIONING

The word 'explore' can mean many things: *discover, investigate, question, inquire, search* or *study*. Science is exploration, whether it is done by a scientist or at school or university. But science isn't something that happens only inside a classroom or a laboratory—science is everywhere and it informs almost everything we do. This chapter includes some tools to help you with your own exploration of the big ideas of science.

QUESTIONING IN SCIENCE 1.1

Science is not just a subject at school but it is also a way of thinking and a collection of skills. All scientific discovery starts with a question. But good scientists don't just start experimenting blind—they make predictions based on what they already know and then design experiments to test those predictions.

Students:

- identify questions that can be tested or researched and make predictions based on existing knowledge

EXPLORING SCIENCE SAFELY 1.2

Experiments are one of the greatest tools of science, but it is important that the experiments performed use the appropriate equipment otherwise the results may not have any real meaning. It is also important to understand how to use scientific equipment in a safe manner.

Students:

- collaboratively and individually follow instructions to safely undertake investigations

SCIENCE SKILLS AND ACCURACY 1.3

Scientific discoveries can make huge impacts on the lives of people, so it is important that the results are accurate and relevant to the aim of the experiment. These discoveries must also be shared in a manner so that everyone can understand and agree on the results.

Students:

- collaboratively and individually plan to investigate questions and problems
- process and analyse data to identify trends, patterns and relationships and draw conclusions
- present scientific ideas and information in appropriate scientific language, text and representations

1.1 QUESTIONING IN SCIENCE

Have you asked a question today? A large part of science is asking questions, being curious about the world, and using that curiosity to find answers. It is human nature to be curious—many of the greatest discoveries and inventions in our history have been inspired purely by human curiosity. As a science student, you possess three important tools: curiosity, wonder and questioning.

CURIOSITY, WONDER AND QUESTIONING

Young children are naturally curious and they ask questions to learn about new experiences. Asking questions is good—questions help us to understand things.

As we get older, we sometimes feel self-conscious or scared to ask what we might think is a 'silly question'. A scientist would say that there is no such thing as a silly question, and that all questions lead us towards a better understanding of the world. Questions are one of the most important tools of a scientist—they help scientists to make decisions, solve problems, invent things, and change and improve our lives.

Figure 1.1 Scientists ask a lot of questions to better understand the world.

Curiosity through history

Many scientific discoveries start with one person who is curious about something. Our world would be a very different place without people wondering, 'How does this work?' or 'Why is this so?'

Sometimes, curiosity comes from necessity. To survive, the first humans had to discover, through trial and error, which foods were edible and which were poisonous. This was curiosity with life-and-death results! The information was then passed from person to person to benefit many more people.

Curiosity can also come from the desire to find things out. In ancient Greece, there was much curiosity about the stars, the sun, the moon and our own planet. Early scientists weren't called scientists at all—they were called natural philosophers because of their interest in studying nature. **Philosopher** means 'lover of knowledge'. Natural philosophers used their observations to develop calendars, to locate the Earth in the universe and to prove that the Earth is round and not flat, as previously thought.

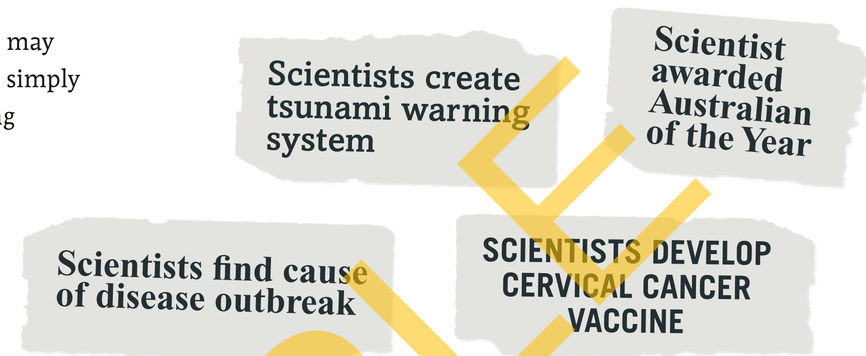
Finding answers to problems that affect people and society is another result of curiosity. Many of the great advances in medicine, such as vaccinations and the discovery of antibiotics, are the result of years of research. They have changed our lives immensely, and mostly for the better.

Curiosity today

Science is in the news every day. Some of the issues that scientists are curious about right now are alternative energy sources, clean drinking water and food for a growing world population, and new cures for diseases. Science is an ongoing process that is never 'finished'—it is always changing.

Science and technology work well together. As new technology is developed, it enables scientists to discover new information. This new information may be a brand new discovery, or it may simply confirm theories or build on existing knowledge and understanding.

For example, the invention of microscopes allowed cells to be seen for the first time. Now as microscope technology improves, the detail in which we can view cells also improves. Scientists can build on their knowledge of cell structure and function as the new technology enables new discoveries. One day we may have microscopes powerful enough to allow us to see atoms and even the subatomic particles that make them up!



ACTIVITY 1.1.1: BUBBLEOLOGY

What you need: bubble mix (100 mL glycerine, 100 mL dishwashing liquid, 850 mL water), straw, plastic ruler

1. Pour a little bubble mixture onto a clean bench surface.
2. Put the end of the straw in the bubble mix.
3. Blow gently through the straw. Caution: Do not suck on the straw.
4. Use the ruler to measure each bubble as you blow it and record your results in a table.

Trial	Height (cm)	Width (cm)
1		
2		
3		
4		
5		

5. Gently touch a bubble with a wet finger and observe what happens.
6. Gently touch a bubble with a dry finger and observe what happens.
   - Try to explain why wet and dry fingers affect the bubbles differently.
   - What is the widest bubble that you made?
   - What is the tallest bubble that you made?
   - What is inside the bubbles?
   - Why do you need to blow gently through the straw?
   - What might happen if some of the bubble mixture came up the straw into your mouth?

DEEPER UNDERSTANDING

Figure 1.2 The golden toad of Costa Rica was last seen in 1989.

Why did the golden toad disappear?

Professor Tim Flannery is a prominent Australian scientist who became Australian of the Year in 2007. In addition to his work with mammals and dinosaurs, he has become particularly well known for his research into global warming. In 1981, Professor Flannery was in Papua New Guinea, climbing Mt Albert Edward, when he noticed that the forest stretched further up the mountain than on his previous visit. He was troubled by the observation and asked himself the question, 'Why are the forests expanding?' He wondered whether the temperature had increased and whether this had allowed the forest to expand. From this first question he started to think about the impacts of climate change, and to devote his life to investigating the effects of global warming. Professor Flannery has found out that climate change is not good for frogs: they are very sensitive to changes in their environment. In his book *The Weather Makers*, Professor Flannery writes about the disappearance of the spectacular golden toad in Costa Rica. Unable to breed, as the weather got drier, the toads died in just a few years. Now, they are extinct. This is just one example of the impact of global warming, and it is evidence of our changing world.

Professor Flannery is a passionate Australian scientist whose work today stems from his curiosity and questioning back in 1981.

Figure 1.3 Professor Tim Flannery.

QUESTIONS 1.1.1: CURIOSITY, WONDER AND QUESTIONING

Remember

1 Have you ever been too self-conscious to put up your hand and ask a question in the classroom? Describe why you felt this way.

2 Identify what early scientists were called.

3 Explain why curiosity, wonder and questioning are important in science.

4 Explain what you think all scientists have in common.

Apply

5 Discuss how Professor Flannery used curiosity, wonder and questioning.

6 Have you ever heard of the saying 'necessity is the mother of invention'? Evaluate whether you agree with this.

7 Explain what else, apart from necessity, encourages invention.

8 Identify an example of a discovery by scientists that wasn't good. Was it the discovery itself, or the way people used it that wasn't good?

9 Ask an adult friend or family member if they can recall one thing that has changed in their lifetime due to science. Identify something that has changed in your lifetime due to science.

Evaluate

10 It is often said that science is never 'finished'. Evaluate this statement with a few specific examples.

DIFFERENT TYPES OF QUESTION

We ask each other questions every day: 'What time is it?', 'Should I use a red pen or a blue pen?', 'How much does it cost?' Some questions are found in textbooks and your teachers give you questions to answer: 'Is a sea sponge part of the animal or plant family?', 'What is an adjective?', '45 ÷ 5 = ?'

These are all simple questions, which you can answer in a couple of words or with a number. These types of question are useful and help us to gather basic information and facts. A 'big' question, however, is a question that scientists (and non-scientists) ask when they are really curious about a more complex topic, such as 'How did the universe begin?'

Imagine that your teacher asks you to do a project on whales. The first thing you would do is to make a list of questions or topics that you want to research and write about. Questions that you might come up with are:

- Where do whales live?
- What do whales eat?
- Who hunts whales?
- What is the *Sea Shepherd?*

These questions are good, but they aren't really big questions because they have simple answers: whales live in the sea; whales eat plankton, krill and other small animals (depending on the type of whale); more than ten countries still conduct whaling on a large scale; the *Sea Shepherd* is a ship whose crew protest against whaling. Bigger questions will help you to understand whales and the bigger system that whales fit into.

The questions in the second column of Table 1.1 are much bigger. Researching these bigger questions would help you to understand whales and the system of living things. These questions help make connections with what you already know. Asking and answering bigger questions can help you to do more than make a long list of facts. Bigger questions can help you to better understand the topic discussed.

Table 1.1 Simple questions and big questions have different purposes.

Simple questions	Big questions
Where do whales live?	What kind of environment do whales live in?
What do whales eat?	Where do whales fit into the food chain of the sea?
Who hunts whales?	Why are whales an endangered animal?
What is the *Sea Shepherd?*	How do humans protect endangered animals?

QUESTIONS 1.1.2: DIFFERENT TYPES OF QUESTION

Remember

1 Define the term 'simple question'.

2 What is the main difference between a big question and a simple question?

Understand

3 Identify which of the following questions are simple and which are big.

  a How far is the moon from the Earth?

  b What kind of environment do we live in?

  c How is climate change affecting the Earth?

  d What is the highest temperature ever recorded in Australia?

4 For the simple questions that you have identified in question 3, re-write them as big questions.

5 Write an example of a simple question and an example of a big question about any topic you are interested in.

6 Re-read your answers to question 5. Explain which question you think is more interesting.

Apply

7 Examine Figure 1.4. Identify what sorts of question a scientist might ask to find out more about this animal. Write down two simple and two big questions.

8 There are many weird and wonderful animals that may never have seen or heard of, like the aye-aye pictured in Figure 1.4. Do an Internet search using the phrase 'weird animal' and select three examples of these animals. For each animal:

  a Identify the animal.

  b Write down the first three questions that come to mind when you see the picture of the animal.

  c Determine which of your questions are simple and which are big questions.

  d Rewrite your simple questions as big questions.

  e Research your weird animals to find some answers to your big questions.

  f Present the information as a poster or a flyer for each of your animals.

9 Think back to Activity 1.1.1. Outline:

  a What small questions can you ask about bubbles?

  b What big questions can you ask about bubbles?

Figure 1.4 The rare aye-aye.

WHO'S ASKING THE QUESTIONS?

As informed and responsible citizens, we should all be asking questions about the world we live in. **Scientists** have jobs that focus on asking questions and finding answers.

All sorts of people are scientists: men, women, young people and older people. Scientists work in all kinds of fascinating places: in Antarctica, in space, near volcanoes and under the sea. Although some science happens in the laboratory, a lot happens in other places. Scientists work alone or in teams, using their curiosity to ask questions. They answer questions by observing, recording and interpreting what they find. Later in this chapter, when you start to do your own experiments, you'll find out more about how scientists work.

Scientists in the world

There are four main branches of science: biology, physics, chemistry and geology. All the other names given to science fields and scientists can be classified into one of these four main branches. As you can see in Table 1.2 (on the next page), different scientists do lots of different and useful things. Each type of scientist is an expert in their field. Many scientists work in teams with different experts when the questions they are researching are relevant across different topics.

Sometimes it is tempting to think that we already know everything and that there's nothing left to discover, but this is not so! Science is an ever-expanding search for knowledge and there is still a lot to find out.

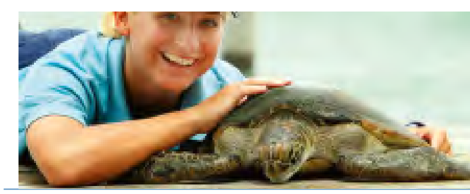
ACTIVITY 1.1.2: QUESTIONS IN DIFFERENT PROFESSIONS

Consider some questions a farmer might ask: 'What should I feed my livestock? When will I water my crops?' An accountant might ask a customer how much they earn or whether they have bought any new equipment. Simple questions are quite straightforward, with a definite answer at the end. Scientists ask simple questions, too, but often they do this to help them find answers to big questions. Sometimes big questions do not have an answer!

Looking at the four images, discuss the following questions in small groups, and then share your thoughts with the rest of the class.

- What questions might someone doing each of these jobs ask?
- Are the questions different for each job, or do some jobs have questions in common?

Table 1.2 Types of scientist and questions they might ask.

Scientist	What they investigate	Questions they might ask
Pharmacologist 	Medicines and drugs	What is the best way to treat different cancers?
Environmental scientist 	The environment	How is climate change affecting the Earth?
Astronomer 	Planets, stars and the universe	How did the universe begin?
Geneticist 	Features of living things, such as hair colour, which are passed from parents to offspring	How can we predict genetic disorders?
Palaeontologist 	Prehistoric life	Why did the dinosaurs die out?
Meteorologist 	The atmosphere and weather patterns	How can we accurately predict cyclones?
Marine biologist 	Life in the oceans and seas	How are coral reefs essential to ocean food chains?
Nanotechnologist 	Substances at the atomic (very small) scale	Can we design drugs to target individual cells?

DEEPER UNDERSTANDING

Asking questions

There are a lot of fascinating questions in the world—some big, some small. Read these questions and answers and look at the pictures to get your own curiosity bubbling.

Q How do Aboriginal trackers find missing people?

A Highly skilled Aboriginal trackers can 'read' both human and animal footprints and other signs of human presence. Usually the older people, with a deep understanding of the land and its wildlife, notice things that others cannot. Police say that the best trackers usually have more than 30 years of experience. Aboriginal trackers can help find escaped prisoners or look for missing persons. Sometimes people have a car accident in a remote area and then go wandering away from their car when they are injured and in a daze. Trackers are brought in to help find them. Yuendumu man Teddy Egan is a well-known Aboriginal tracker. In 2000, he helped the Northern Territory police to track and then recapture an escaped prisoner. He was one of four trackers employed by police in 2001 to find missing English tourist Peter Falconio. Teddy Egan says that tracking humans is much easier than tracking animals because 'people make too much mess'.

Figure 1.5 Aboriginal trackers can use their knowledge of the land to save lives.

Q Can people breathe fire?

A No, not really. But a circus trick called fire-breathing is performed for entertainment. Fire-breathing requires a lot of scientific knowledge. The experienced performer sprays a type of fuel from their mouth into a flame. The performer might hold the flames in their mouth for just a few seconds before blowing the flame away with a large exhalation (breathing out). The exhalation has to be continuous; if the performer inhales (breathes in), they will be seriously injured, with burns, collapsed lungs and even a heart attack from the shock. Fire-breathing is extremely dangerous, even for the experts, who often put up with minor injuries, such as blistered lips and tongues. Fire-breathers never perform in windy conditions and must have years of experience and understanding of the science of fire. Never play with fire!

Figure 1.6 Fire-breathing.

Q Are we really related to monkeys?

A Monkeys are not your cousins—perhaps cousins many times removed is a better description. Scientists have spent a long time trying to work out how humans came to be on the Earth. They're still trying to pinpoint the beginning of life here, but most scientists agree that life on Earth began at least 3 billion years ago. They think that the first living things were microscopic and put oxygen into the atmosphere. Over the next billion or so years, life continued to evolve. The first fish could be found about 500 million years ago. Birds and mammals only

Figure 1.7 Is this your cousin?

Figure 1.8 Many scientists think that the universe began with a Big Bang.

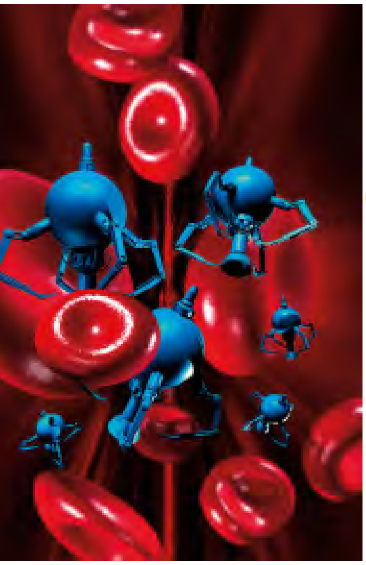


Figure 1.9 Nanobots may one day be used to repair cells.

evolved around 200 million years ago. All mammals that exist today have evolved from the first mammals. The current theory suggests the ancestor we have in common with modern apes lived about 2.5 million years ago.

Q How did the Universe begin?

A This is one of the biggest questions in science and no one really knows the full answer. Cosmologists, scientists who study the universe, think that the universe started with an event called the Big Bang. This is based on the idea that our universe (stars, planets, suns—everything) started as a 'ball' in dark, lifeless, empty space. Billions of years ago, an enormous explosion inside this ball in space created a huge amount of energy and flung all the bits and pieces of 'stuff' (gases, solids and liquids) that make up our universe all around space. Over billions of years, some of this 'stuff' joined together to form stars, like our sun, and planets, like the Earth. The Big Bang idea is being increasingly supported by evidence collected by cosmologists.

Q What is nanotechnology?

A Nanotechnology is an amazing area of science. Nanotechnology is all about scale—a very small scale. Nanotechnologists work with things that are one-billionth of a metre, which is one ten-thousandth of the width of a human hair. Push your thumb and first finger together really hard. Can you see a gap? If you could shrink yourself down small enough, there is a whole nanometre between your two fingers—this gap is huge in nano terms. Studying things at this very small scale means that scientists can change the way things are programmed. Imagine a future with nanotechnology: paint that repairs itself when it gets chipped; tiny nano-robots, called nanobots, that can enter your body and repair a damaged cell; self-cleaning glass and smart clothing that protects you from the sun, resists water and even irons itself! Nanotechnology might be small science but its possibilities are huge.

Q Will the snubfin dolphin become extinct in my lifetime?

A In August 2007, the Yangtze River dolphin, found only in the Yangtze River in China, was declared extinct. This means that there are no more of these dolphins left on our planet, and there never will be again. This event marks the first cetacean (dolphin, whale or porpoise) to be driven to extinction by humans. Do you think something like this can only happen in China? The rare snubfin dolphin, found in the Pacific Ocean off the coast of Townsville, is thought to be endangered but there is not sufficient data to support this claim. The dolphins are hard to track down and therefore difficult to study, but there could fewer than 1000 left. Until more is known about these rare mammals, they will not be listed as endangered and thus receive no government funding for work to help their survival. The dolphins are thought to be threatened by things such as overfishing of their food source and damage to their habitat.

Figure 1.10 The snubfin dolphin is thought to be critically endangered.

Pseudoscience

Scientists are reliable sources of information because of the way they test their ideas. Unfortunately, some people use the language of science to promote unscientific information. This is called **pseudoscience**. 'Pseudo' (seoo-doe) means 'false'. Have you ever seen advertisements for weight loss or hair growth 'miracles' or 'miraculous' wrinkle treatments? Although some of these products may have been partly developed by scientists, the results are usually less fabulous than they claim. Real science is based on logic and evidence, and the results can be repeated by others. The Australian Government has regulations about many of the products sold in Australia. However, not all types of product are covered.

Figure 1.11 'Miracle' products are often found to be the result of pseudoscience.

ACTIVITY 1.1.3: ASTROLOGY: SCIENCE OR PSEUDOSCIENCE?

Your teacher will provide you with a set of last week's horoscopes. They will be randomly numbered and the dates and star signs removed.

1. Decide which horoscope from last week best fits you.
2. Collate all of the horoscope numbers and class members' names on the board.
3. Your teacher will list the corresponding star signs for each number.
   - Identify how many horoscopes were correct.
   - Explain what this tells you about astrology.
   - Discuss if astrology is a science or a pseudoscience.
   - Write down two new things that you learned from this activity.

QUESTIONS 1.1.3: WHO'S ASKING THE QUESTIONS?

Remember

1. Identify the four main branches of science.
2. Identify what kind of people scientists are.
3. Identify the type of scientist who would work on developing new medicines.
4. Outline where science happens.
5. Explain how pseudoscience is different from science.

Understand

6. Explain why science is important.
7. Explain what pseudoscience is.

Apply

8. Have you been in a situation where somebody tried to convince you or someone you know to believe his or her story? Describe what happened.
9. Research the following types of scientist to find out what they study, and then write a question that each of them might ask.
   a. herpetologist
   b. taxonomist
   c. forensic scientist
10. The names of what scientists study often come from Latin names. Complete an Internet search to determine the meaning of palaeontology. Explain the relevance of this name.
11. What might a biochemist study? How about a biophysicist?

MAKING PREDICTIONS

All scientific research starts with questions. But before any experiments begin, scientists use what they already know to make predictions about what they think will happen. The experiment is designed to test that prediction.

Water boils at 100°C. But what if we changed something? Could we change the temperature at which water boils? Start with a question, and then make a prediction.

***Question**: What if salt was added to boiling water?*

***Prediction**: The temperature at which water boils will increase.*

When this prediction tries to explain a cause and effect relationship, scientists call it a **hypothesis**. A hypothesis is always written as an 'If ... then ...' statement that describes what happens if something is changed. You can use your question and your prediction to write a hypothesis.

*~~What~~ If salt was added to boiling water? **then** the temperature at which water boils will increase.*

***Hypothesis**: If salt was added to boiling water, then the temperature at which water boils will increase.*

You then test your hypothesis with an experiment. If your hypothesis is not correct, that does not mean that you are a failed scientist! You just need to find out more information. Talk to people, ask for advice or look up some information to help you predict what will happen. Then, using your new knowledge, make another hypothesis, modify your experiment and try again.

Scientists find answers to questions in the same way. Like you, they do experiments and then think and talk about the results. When scientists make a new discovery, the results are usually presented at meetings and published in scientific journals or magazines. Other scientists can then read these results and agree with the explanations or perhaps suggest alternative hypotheses. New scientific research and experiments are often based on the results of old experiments. Especially when the results are not what was expected. Experiments that 'go wrong' are often the starting place for new and exciting research.

You school library will probably have some scientific journals for you to look through.

Figure 1.12 Making a ping pong ball bounce sideways.

ACTIVITY 1.1.4: SIDEWAYS PING PONG

What you need: ping pong ball

1. Working in pairs, drop a ping pong ball from a height of 1.5 m above the ground. Your job is to investigate how far it will travel sideways after it bounces. You can only drop the ball or roll it out of a tube. Do not throw or flick it. You can spin the ball, provided it does not go forward while it is falling.
2. Test as many ideas as you can. Some ideas that you could test include the effect of the colour of the ball, temperature of the ball, type of floor covering and whether the ball has holes drilled in it.
3. Before each test, make a prediction about how the ball will move and write it down as a hypothesis (an 'If ... then ...' statement).
4. In your notebook, describe what you tried and the distance of the sideways bounce.
   - What did you find was the best way to make the ping pong ball bounce sideways?
5. Draw a conclusion based on your results.

QUESTIONS 1.1.4: MAKING PREDICTIONS

Remember

1 Define the term 'hypothesis'.

2 Outline why scientists do experiments.

3 How would you find background information for an investigation? Identify at least three places that you could look.

Apply

4 Identify the following statements as either a prediction or a hypothesis.

- **a** The plant will grow faster.
- **b** If the angle of the tube is steeper, then the ping pong ball will bounce further sideways.
- **c** If more detergent is added to the bubble mix, then bigger bubbles can be blown.
- **d** The flame will change colour.

5 Rewrite the predictions from the previous question as hypotheses. You will have to make a possible question to do so.

6 Would it be easier to work in a group, in pairs or by yourself when conduction scientific experiments? Explain your answer.

7 Construct a hypothesis for the following actions:

- **a** adding blue dye to a bucket of water with a white shirt soaking in it
- **b** putting a chocolate bar in the sun
- **c** putting an ice tray of water into a freezer.

8 Describe the advice you would give to a fellow scientist whose experiment did not support their hypothesis. Are they a failed scientist? What should they do?

1.1 CHECKPOINT

QUESTIONING IN SCIENCE

Remember and understand

1 Explain why asking questions is good. [1 mark]

2 Explain what a big question is and give an example of a big question in a field of science that you are interested in. [2 marks]

3 Outline some qualities a scientist should have. [1 mark]

4 Explain why scientists often work in teams. [1 mark]

5 In your own words, explain the difference between a simple question and a big question. [1 mark]

6 Demonstrate three things that you know about:

a scientists [1 mark]

b the history of science [1 mark]

c the future of science [1 mark]

Apply

7 Change these simple questions into big questions:

a What do crocodiles eat? [1 mark]

b Where do crocodiles live? [1 mark]

c What can we do to stop crocodiles from being hunted for their skin? [1 mark]

8 Use the Internet, library or other research tools to examine what the following types of scientist do:

a entomologist [1 mark]

b seismologist [1 mark]

c botanist [1 mark]

9 Do you know of any famous scientists? Research the life and times of one scientist. Describe when and where they lived, what questions they asked and how they explored science. [2 marks]

10 The following observations can be turned into questions that can then be investigated.

Observations:

i The temperature is very hot today.

ii The ice seems to melt faster when it is warmer.

iii A kilogram of feathers seem to take up more room than a kilogram of coins.

iv In autumn, only some trees tend to lose their leaves.

a Write the question that can be investigated. [4 marks]

b Identify some sources that can be used to investigate the questions. [2 marks]

Analyse and evaluate

11 Choose one of the questions from the Deeper Understanding box: Answering questions on pages 11–12. Draw up a KWLH (Know–Want–Learned–How) chart. Identify and write what you know about the topic already (column 1), what you want to know (column 2), what you have learned (column 3) and how you found out this information (column 4). [4 marks]

12 Imagine you are a judge at the court of pseudoscience. Today's case is about Casper White. Casper studied science at school and at university. He now has his own business as a ghost hunter. He charges $400 an hour to look for signs of ghosts in people's homes. He has a business card that reads 'Dr Casper White, Professional Ghostologist'. Is Casper a scientist or a pseudoscientist? Explain your answer. [2 marks]

Critical and creative thinking

13 In this section, you have read about several different animals that are endangered or extinct. The gastric brooding frog is an Australian frog thought to be extinct. Investigate this frog and present your findings in a creative format. [4 marks]

14 Describe and explain one action that could cause a species of animal to become extinct and one action that could prevent this. [2 marks]

Figure 1.13 The gastric brooding frog.

TOTAL MARKS
[/35]

EXPLORING SCIENCE SAFELY

1.2

An important part of exploring science is knowing how to conduct experiments safely and successfully. An experiment is a way to solve a problem or to find the answer to a question. Only through experimentation can some of the truly big questions of science be answered. You need to know about three important things before you can start experimenting: equipment, general safety in the laboratory and how to use one of the most useful pieces of laboratory equipment, the Bunsen burner.

ACTIVITY 1.2.1: USING THE RIGHT EQUIPMENT

Working with a partner, list as many situations as you can from your daily lives that require specialist equipment. For example, to bake a great cake you would use a proper cake tin of the correct size and an oven set to just the right temperature.

For each situation you think of, note whether there are alternatives to the equipment and, if so, how they might affect the results.

Finally, consider how the choice of equipment affects investigations done in a science laboratory. Would plastic test tubes and beakers work as well as glass laboratory equipment? Never? Sometimes? Does it matter if scientists in other parts of the world have different equipment from that of scientists in Australia? Discuss your thoughts with others in the class.

Figure 1.14 Could plastic containers be used in a laboratory?

SCIENTIFIC EQUIPMENT

Equipment is the name given to the beakers, burners, flasks, stands and other items used in the laboratory. The equipment helps us to do experiments and to do them safely. Commonly used equipment is shown in Figure 1.16. Some of the names might sound unfamiliar to you but you will soon learn what each piece of equipment is called and how it is used. The equipment in your school laboratory may look slightly different because each laboratory has its own types of equipment. Some items of equipment can be used together in an experiment. Equipment placed together for an experiment is called **apparatus**.

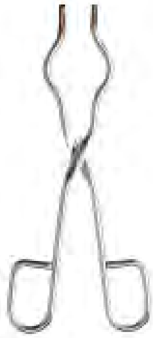
Scientific diagrams

To show others how to set up an experiment, scientists write a list of the equipment needed and drawings that show how it is set up. But imagine how long this would take if every picture was as beautiful and realistic as the painting in Figure 1.15! Even if you didn't use paints, and just sketched with a pencil, it would still take a long time to draw the equipment.

Scientists have a quick and simple way to show scientific equipment. They use drawings called **scientific diagrams**. Using scientific diagrams means you don't have to be an artist to be a good scientist and you have more time to do the experiments.

Figure 1.15 This still-life picture of science equipment looks great, but it is not practical for science experiments.

Retort stand with boss head and clamp. Used to hold up equipment.

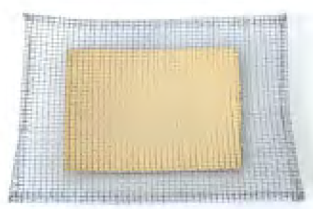


Crucible tongs. Used to hold crucibles or hot material.

Tripod stand. Used to hold up equipment.

Bunsen burner. Used to heat up chemicals.

Measuring cylinder. Used to measure quantities of liquid.



Gauze mat. Used to evenly disperse heat from a Bunsen burner when heating substances.

Test tube holder. Used to hold test tubes when heating.

Test tube rack. Used to hold test tubes.

Conical flask. Used to hold solutions.

Evaporating dish. Used to hold substances to evaporate.

Watch glass. Used to hold small amounts of substances.

Beaker. Used to hold solutions.

Filter funnel. Used to help pour solutions into smaller containers or to filter solutions.

Test tube. Used to hold solutions.

Stirring rod. Used to stir substances.

Spatula. Used to obtain chemicals.

Thermometer. Used to measure temperature.

Figure 1.16 Types of equipment used in the laboratory.

The procedure for drawing scientific diagrams is as follows:

1. Draw clearly and neatly.
2. Use a sharp pencil.
3. Draw the equipment from the side view.
4. Don't show any detail, just a simple outline with no shading.
5. Draw lines using a ruler.
6. Print labels neatly and connect them to the diagram with a line or arrow.
7. Spell labels correctly. Incorrect spelling makes good science look bad!
8. Diagrams should be between 6 and 10 centimetres high.

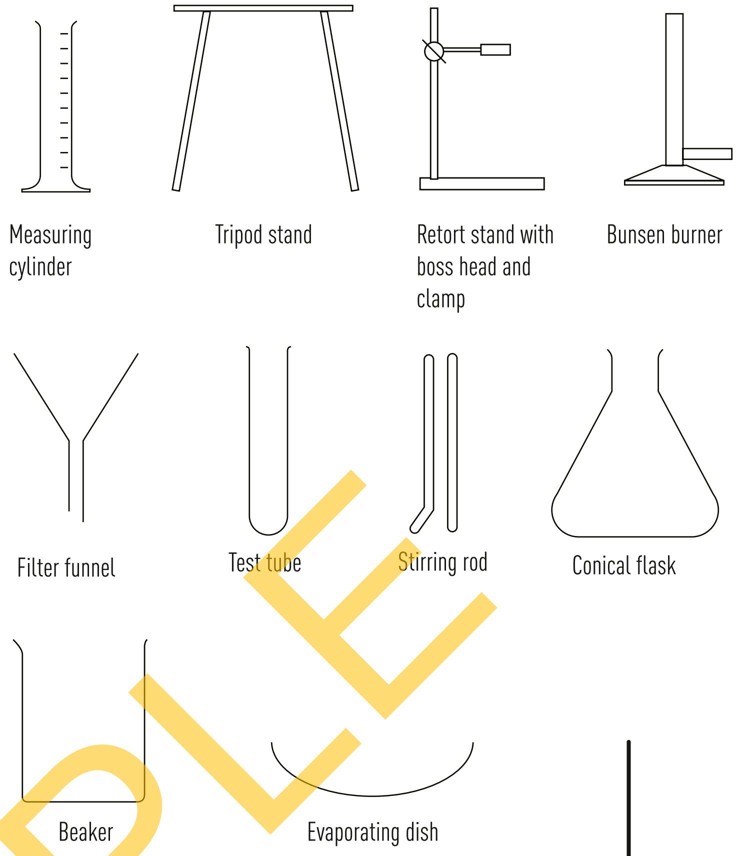


Figure 1.17 Scientific diagrams of laboratory equipment.

Equipment to wear

Labfab: Notes from the fashion labwalk

Welcome to our fabulous fashion show for the label that is taking the fashion world by storm—*Labfab*.

Olivia is wearing our new designer lab coat, which has three- and four-button options. Note that the buttons are worn done up. This versatile coat is now available in colours other than white, for our science fashionistas.

Lab coats are going to be loose this year for stylish comfort during those tricky experiments. And this year, knee length is *the* length, to protect you from stray chemicals (we had a few glitches with last year's range).

Safety glasses are hot and big. Top model and scientist Corey is modelling a pair from the new range, which are hipper than the latest sunglasses. If you already wear glasses you may not need to wear safety glasses, but style leaders everywhere will be wearing them on top of their usual specs.

This year, laboratory shoes are solid—no tootsies please! Solid and sensible, they scream 'enduring style'.

Finally, you can never have too many accessories. The latest in latex—a cheeky take on rubber—is our fabulous range of disposable gloves. They are available in a range of high-style colours to suit your every experimental mood.

Figure 1.18 The lab fashionistas.

ACTIVITY 1.2.2: SCIENTIFIC DRAWING

Your teacher will assign half of the class to station 1 while the other half work at station 2. Swap stations halfway through the class time.

Station 1

What you need: 5 boxes (each containing five different pieces of equipment), grey pencil, ruler, piece of plain A4 paper

1. Share a box with a partner. Without using this textbook, write down the name of each piece of equipment in the box and complete a scientific diagram of each in pencil. When you have finished, return the box and collect a different one.
2. Check your answers and diagrams (and spelling!) for the pieces of equipment from Figures 1.16 and 1.17. Correct any mistakes.
3. Look at your list of equipment. On a sheet of plain paper, divide the list into groups according to use. For example, you might put all pouring equipment together, or all heating equipment, or all safety equipment. Decide on categories first and then allocate the equipment.

Station 2

What you need: large conical flask, retort stand, boss head, clamp, funnel, small beaker

1. Set up the stand with the boss head and clamp, placing the boss head about two-thirds of the way up the stand.
2. Carefully place the flask neck into the clamp and tighten the clamp so the flask is secure. (The flask should be about 10 cm above the bench, not resting on it.)
3. Predict and write down how many beakers of water you think will fill the flask.
4. Fill the beaker with water. Use the funnel to transfer the water into the flask.
   - How many beakers full do you need to completely fill the flask?
   - Was your prediction correct?
5. Draw a scientific diagram of what you have set up, labelling all equipment.
6. Take apart the apparatus and place each piece of equipment in its correct cupboard.
   - Which piece of equipment was the most difficult to draw? Which did you find the easiest?
   - Identify up to five pieces of equipment that you had not seen before and list their uses in a laboratory.
   - Identify two pieces of equipment that can be used for:
     - holding things
     - mixing chemicals
     - pouring
   - Where in your laboratory do you find:
     - safety equipment?
     - test tubes?
     - Bunsen burners?
     - tongs?
     - retort stands?
     - test tube racks?
     - heating mats?
     - a rubbish bin?
     - beakers?

ACTIVITY 1.2.3: MEMORY GAME

1 Your class will divide into two teams and revise Figure 1.16. Spend 2 minutes reminding yourself of the correct names for the pieces of equipment.
2 Your teacher will uncover a mystery tray containing 16 items of equipment. You will be able to view the tray for 60 seconds, and then it will be re-covered.
3 Write down the names of all the pieces of equipment you can remember.
4 When you check answers, score two points for each piece remembered and spelled correctly; score one point if the spelling is incorrect.
5 Add up the points for each team—the team with the most points wins.

Bonus round:

6 Your teacher will prepare a different tray of 10 pieces of equipment. You will be able to view the tray for 60 seconds, and then it will be recovered.
7 Draw the scientific diagram of all the pieces of equipment you can remember.
8 Score 1 point for every correctly drawn diagram.
9 Add up the points for each team – the team with the most points wins.

QUESTIONS 1.2.1: SCIENTIFIC EQUIPMENT

Remember

1 Match each piece of equipment with the correct label.

a filter funnel b beaker c measuring cylinder

2 Explain the difference between a drawing and a scientific diagram.
3 Match each word with its meaning.

equipment	use equipment and apparatus to answer a problem
apparatus	place with equipment and apparatus in it
laboratory	equipment that is put together to do an experiment
experiment	beakers, stands and other items used for experiments

Apply

4 Examine Figure 1.19. Identify two right and two wrong things about the way the students are dressed.
5 Draw the equipment set up required to:
  a heat water in a beaker
  b fill a conical flask with water

Figure 1.19

LABORATORY SAFETY

Scientists may be exposed to a variety of hazards in their work. In unfamiliar environments, such as out in the field, there are many safety hazards they cannot control. In a laboratory, safety issues are easier to manage. Working in teams can make the control of certain hazards easier; good communication between team members is essential. You should be aware of safety for yourself and other students.

As a science student you need to be familiar with your laboratory, what the warning signs mean and what to do in an emergency. Remember, most safety is common sense, which can prevent many dangerous situations.

Safety symbols

Safety symbols are used in a lot of different settings. You may have seen the ones in Figure 1.20 on building sites, at entrances to buildings, at school or on roads. Your laboratory may already have some of these symbols displayed.

Symbols are often simple drawings, although sometimes words are used as well. If a picture can show a message clearly, words may not be needed.

Laboratory safety rules

Good laboratories have many features so that they are safe places to work. A class laboratory is not like a normal classroom—there are additional rules to follow. It is a place where people are learning to be better scientists, but who don't always get it right the first time. You will notice your science skills improving as you do more and more experiments carefully in the laboratory.


Figure 1.20 What do you think each of these symbols mean?

ACTIVITY 1.2.4: CREATING LABORATORY SAFETY RULES

Figure 1.21 Can you see the potentially dangerous activities?

Look at Figure 1.21.

- How many potentially dangerous activities can you identify in this picture?
- Explain the rules that might be needed to prevent potential danger.
- Create a list of rules you think might be needed in your science laboratory.
- Compare your list of rules to the tips listed next.
- Type up your list on a computer, print it out and stick it on the inside front cover of your workbook.

Twenty ways to improve your lab life

TIPS

Do:

- Wear a lab coat for practical work.
- Keep your workbooks and paper away from heating equipment, chemicals and flames.
- Tie long hair back whenever you use a Bunsen burner.
- Wear safety glasses while mixing or heating substances.
- Tell your teacher immediately if you cut or burn yourself.
- Tell your teacher immediately if you break any glassware or spill chemicals.
- Wash your hands after any experiments.
- Listen to and follow the teacher's instructions.
- Light Bunsen burners with matches, never with paper or other materials.
- Wear gloves when your teacher instructs you to.

Don't:

- Run in a laboratory.
- Push others or behave roughly in a laboratory.
- Eat in a laboratory.
- Drink from glassware or laboratory taps.
- Look down into a container or point it at a neighbour when heating or mixing chemicals.
- Smell gases or mixtures of chemicals directly. Instead, waft them near your nose, and only when instructed.
- Mix chemicals at random.
- Put matches, paper or other substances down the sink.
- Carry large bottles by the neck.
- Enter a preparation room without your teacher's permission.

QUESTIONS 1.2.2: LABORATORY SAFETY

Remember

1 Identify the three safety symbols shown. What does each one stand for?

2 Identify three items of protective clothing you might wear in the laboratory. Explain why should you wear them.

3 Outline five things you should do to remain safe in the laboratory.

4 Outline five things you shouldn't do in the laboratory.

Apply

5 With a partner, take turns to mime a safety rule for your partner to guess.

6 Discuss why it is dangerous to drink from laboratory glassware.

Create

7 Create an A4 poster of a rule in science.

USING A BUNSEN BURNER

A **Bunsen burner** is one of the most useful pieces of equipment you will use in the laboratory. The Bunsen burner is used to heat things in the laboratory, so it needs to be hot. In the right conditions, the hottest part of a Bunsen burner flame can be have a temperature of more than 1500°C.

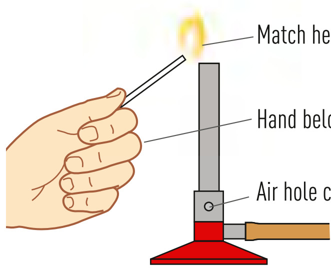


Figure 1.22 The correct way to light a Bunsen burner.

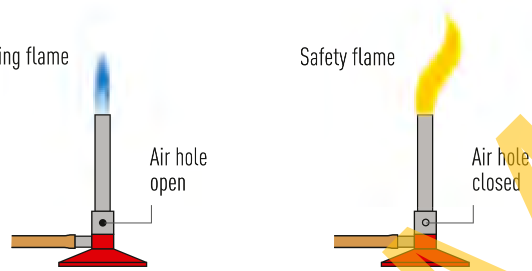


Figure 1.23 Blue (heating) and yellow (safety) flames on the Bunsen burner.

The Bunsen burner has a collar that can be turned to open or close the air hole. The position of the air hole controls how much air can enter the burner and, therefore, how hot the flame is. The Bunsen burner has two flame settings: the yellow safety flame and the blue heating flame.

A mixture of petroleum gas and air is used to produce a good flame for heating. This is the blue or heating flame and is produced by leaving the air hole open. The blue flame has a darker blue on its outside, which is the hottest part, and a lighter blue on the inner part, which is cooler, but will still burn you! The blue flame is often difficult to see.

When alight but not being used for heating, the Bunsen burner should be left on the yellow (safety) flame, which is not as hot and is easy to see. The safety flame is always used when lighting the burner. The flame will be yellow when the air hole is closed.

The safety flame doesn't mean that you can leave your flame unattended though! Make sure someone is looking after the experiment at all times.


Figure 1.24 A scalded hand.

WARNING

TREATING SCALDS AND BURNS

1. Immediately run cold tap water on the scald or burn for at least 15 minutes. Do not use ice or very cold water because this can harm the skin.
2. Ask another student to tell your teacher about the scald or burn.
3. Remove nearby clothing (unless it is stuck to the burnt area) and jewellery, such as watches, rings and bracelets, because burnt areas can swell quickly.
4. Try to handle the area as little as possible because skin will be damaged and may peel off. Do not use any creams.
5. Seek medical attention if necessary. On the way, use a spray bottle or loose wet dressing to keep the area wet.


Figure 1.25 A burnt hand.

WARNING

IF THERE IS A FIRE IN THE LABORATORY

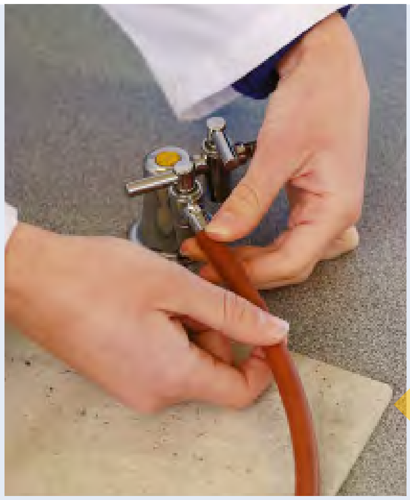
1. Let the teacher know immediately. (They will turn off the main gas tap if gas is involved.)
2. The class fire officer should take a message to the school administration as quickly as possible.
3. Evacuate the area in an orderly manner.
4. If the fire is small, the teacher will use a fire extinguisher.
5. Check that everyone is safe.

SCIENCE SKILLS

Lighting a Bunsen burner

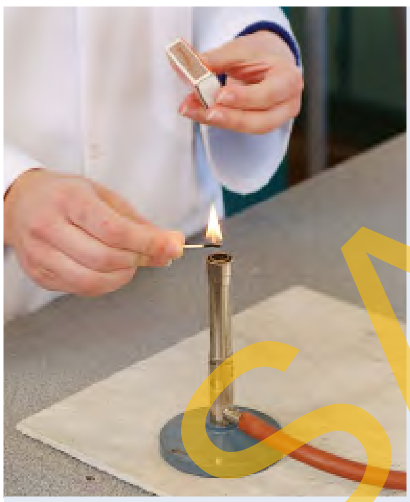
Lighting a Bunsen burner is done in five steps:

1 Place the Bunsen burner on a heating mat.

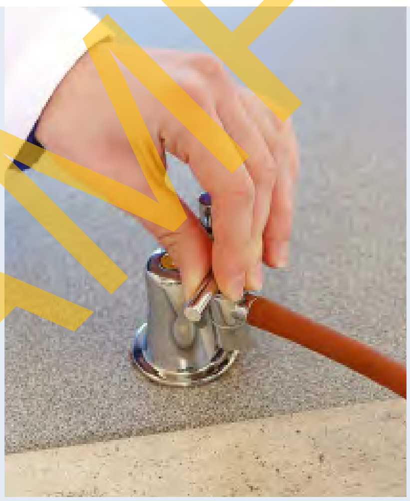


2 Connect the rubber hosing firmly to the gas tap.

3 Close the air hole by turning the collar.



4 Light a match and place it just above the top of the barrel, with your hand below the flame.



5 Open the gas tap fully.

After you have followed these steps, the Bunsen burner will have a yellow (safety) flame.

Now that you have learned about equipment and safety, it is time to do your first formal science experiment. After you have successfully accomplished this skill, your teacher will give you your Bunsen burner licence.

EXPERIMENT 1.2.1: GETTING TO KNOW YOUR BUNSEN BURNER

Aim (what you are trying to find out)

To learn how to light a Bunsen burner and explore how a Bunsen burner heats objects.

Materials (what you need)

- Bunsen burner
- 2 pieces of white ceramic or porcelain
- Matches
- Metal tongs
- Coloured pencils and grey pencil
- Notebook
- Heatproof mat

WARNING

> Wear safety goggles and a lab coat.
> Keep your hand below the flame.
> You will be drawing in your notebook during this experiment. Keep it well away from the Bunsen burner (on a nearby bench or further up the bench).
> The porcelain you heat will remain very hot for a long time. Do not pick it up with your fingers; use tongs.

Method (clear step-by-step instructions of how to do the experiment)

A question is to be answered or a diagram is to be drawn for each step. Put these in your notebook as you go. They will be the results of your experiment.

1. Draw a picture of the gas tap in the 'off' position (90 degrees to the outlet). Follow steps 1–5 of the Science Skills activity carefully to light the Bunsen burner.
2. Write down the colour of the flame. Change the flame to a blue flame by opening the air hole on the collar.
3. Write down the three changes that have just occurred. Keeping the blue flame, slowly turn the gas tap towards the 'off' position.
4. Relight the Bunsen burner safely. Observe and record what happens when the collar is in the following positions: fully closed, half opened, fully opened.
5. Draw the coloured flame when the air hole is closed, half open and fully open. Return to the safety flame by adjusting the air hole.
6. Using tongs, hold a piece of porcelain in the top of the yellow flame for a minute. Place the hot porcelain on the heatproof mat when you have finished. Describe what happens to the porcelain and draw it.
7. Hold the other piece of porcelain with the tongs. Change the flame to blue and heat for 1 minute. Describe what happens to this piece of porcelain and draw it.

Figure 1.26 Which of these pieces of porcelain was heated in the yellow flame of a Bunsen burner?

Results (diagrams, tables, graphs and statements about what happened)

Include diagrams of the:

- gas tap in the 'off' position
- Bunsen burner with flame colour labelled when the air hole is open
- Bunsen burner with flame colour labelled when the air hole is closed.

Include descriptions of:

- changes to the flame when the gas tap was slowly turned off
- how the flame was different when the air hole was half open
- changes to the porcelain when placed in the yellow and blue flames.

Discussion (questions to help you analyse and explain your results)

1 Why do you think the yellow flame is called the safety flame? Give at least two reasons.

2 Which flame is the noisiest: blue or yellow? Why is this helpful to know?

3 Which flame leaves a sooty carbon black deposit on whatever object it heats?

4 Which flame is the 'clean' flame for heating?

5 Give as many reasons as you can for using a blue flame for heating in an experiment.

6 When is the best time to use a safety flame?

Conclusion (a statement to sum up your experiment and explain what you have learnt/discovered)

- What are the main differences between a yellow and blue flame?
- Why do you think a Bunsen burner has two flames?
- Write a sentence that refers back to the aim.

QUESTIONS 1.2.3: USING A BUNSEN BURNER

Remember

1 Identify the colour of a Bunsen burner's safety flame.

2 Identify the colour of the heating flame.

3 Describe how you get a heating flame with your Bunsen burner.

4 Summarise the steps of how to safely light a Bunsen burner.

5 Identify at least three differences between the safety and the heating flame of a Bunsen burner.

Apply

6 Outline the three safety tips to remember when lighting a Bunsen burner.

7 Outline how you should you treat a scald.

8 Justify how the safety flame got its name.

1.2
CHECKPOINT

EXPLORING SCIENCE SAFELY

Remember and understand

1 Draw a diagram of a:

- **a** conical flask [1 mark]
- **b** tripod stand [1 mark]
- **c** test tube [1 mark]

2 Explain what this safety sign means. [1 mark]

3 When using a Bunsen burner, the air hole is sometimes open and sometimes closed. Complete Table 1.3. [3 marks]

Table 1.3 Using a Bunsen burner.

Use	Should air hole be open or closed?
Being lit	
Heating	
Turned on but not heating	

4 Write a poem to help you remember that an open air hole results in a hot, blue flame and a closed air hole results in a cooler, yellow flame. [1 mark]

5 Outline the steps you would take if:

- **a** there is a fire [1 mark]
- **b** you burn yourself. [1 mark]

6 Explain how a science classroom is different from another classroom by making a list of the things that are the same in both classrooms and the things that are unique to a science classroom. [2 marks]

7 Outline the difference between the terms 'equipment' and 'apparatus'. [1 mark]

8 Explain why symbols are sometimes used instead of words to warn people of danger in the laboratory. [1 mark]

9 Identify why the Bunsen safety flame is important. [1 mark]

10 Explain how you get a safety flame with your Bunsen burner. [1 mark]

11 The safety flame is not good for heating. Outline two reasons for this. [1 mark]

12 Identify which part of the blue flame is best for heating. [1 mark]

13 There are five steps to lighting a Bunsen burner. Put these words that summarise the process in the correct order: open, connect, light, place, close, gas. [2 mark]

Apply

14 Design your own safety symbols for the following: no dogs allowed, wear sunscreen, no bikes allowed inside, walking only, slippery floor, poison. [3 marks]

Analyse and evaluate

15 Burn injuries are not the only type of laboratory injury. Eye injuries can also occur in a science classroom. Construct a list of some ways that your eyes could be injured. Next to each, write a safety tip to help avoid the injury. [3 marks]

Critical and creative thinking

16 Design an improvement for the lab coat you wear in your science classroom. Make sure you think about fabric, materials, function and comfort. Use your imagination to make your coat unique.

- **a** Draw a labelled diagram of the new coat. [1 mark]
- **b** Identify three reasons why your design is an improvement. [3 marks]
- **c** If you were to produce this new lab coat, how might you go about testing it to see if it was successful? Outline in a paragraph what you would do. [2 marks]

17 How would you design a sign to warn students in 500 years' time of a danger that is still present? Think about how you could possibly interpret danger signs now. Would those representations be relevant in 500 years' time? [3 marks]

TOTAL MARKS
[/35]

SCIENCE SKILLS AND ACCURACY

1.3

So far, you have seen that science involves asking questions and working safely in a laboratory. Laboratory safety is only one part of doing experiments. Scientists collect information during their experiments and they record what they did and what they found out. They follow an experimental method, use all of their senses to make observations, collect information and display their findings in reports, set out in a standard scientific way. They think about and try to control things that might affect their results. Effective science relies on properly collecting and recording information.

INVESTIGATING SCIENCE

Science is about finding answers to questions and solutions to problems. In this section, you are going to be an active scientist and collect scientific information. You will do a number of simple activities in which you investigate questions you probably don't know the answers to. You need to make predictions or hypotheses before each experiment to improve and test your scientific knowledge and understanding.

ACTIVITY 1.3.1: SCIENTISTS PREPARING FOR SCIENCE

Look carefully at the photo of the scientist with gorillas and write down your opinion for the following questions:

What is the scientist trying to find out about the gorillas? Does he need to be this close to get his answers? Is this the first and only time he would spend with the gorillas? Does he have some idea of the answers he is likely to get? Would he have done any special research or training before getting so close to these wild animals? Was his clothing chosen carefully for his investigation?

Discuss your opinions with a small group and then share them with the class.

Figure 1.27

Variables and fair tests

When doing an experiment, factors or variables should all be kept the same, except for the one that is being tested. A **variable** is anything that can change and something that can affect the results of an experiment. Controlling these variables ensures that the experiment is fair.

The factor or variable we change intentionally to test how it affects the results is called the **experimental variable** or **independent variable**. The independent variable will affect the results, which are known as the **dependent variables**. Every other variable should be kept exactly the same so that it cannot influence the results in any way. These are called **controlled variables** or **controls**.

It may be easier to think of variables as causes and effects.

A hypothesis may be stated as 'If salt was added to boiling water, then the temperature at which the water boils will increase'. There is a cause and effect relationship in the statement, i.e., the salt will cause the effect of increased temperature of boiling.

In this case, the salt is the independent variable (or the cause) whilst the boiling temperature of the water is the dependent variable (or the effect).

Figure 1.28 Microbiologists need to control several variables in their experimental environment. They must be very careful not to contaminate their samples.

Fair tests ensure that experimental results can be used to make the right decisions. When we consider the results of an experiment and try to draw some conclusions, we need to consider the following questions:

- Did we control every variable, except the one we were changing on purpose, so that the conditions of the different trials were exactly the same?
- Were there any variables in the environment that we couldn't control?
- If we did exactly the same experiment again, would we expect the results to be exactly the same?
- Did we estimate any measurements during the experiment?

Repetition of experiments is very important. If you perform an experiment and achieve certain results, you would conclude that the results are correct. But what if you did the experiment a second time and the results were slightly different? Did you do something slightly differently? Were the conditions slightly different? Did you use the same materials from the same source? Earlier in the chapter you learned about pseudoscience. One of the biggest differences between science and pseudoscience is that scientists control and repeat their experiments.

When similar results are collected when an experiment is repeated, the results are said to be **reliable**. Performing an experiment several times will give you greater confidence in your results. If other people repeat your experiment and achieve the same results, then your results are supported even more.

ACTIVITY 1.3.2: GETTING RELIABLE RESULTS

What you need: crushed ice, large ice blocks, plastic bowl, metal bowl, lamp or light source (optional), stopwatch

1. Tip the crushed ice into the plastic bowl.
2. Tip the large ice blocks into the metal bowl.
3. Place each of the bowls on the window ledge in the sun and begin the stopwatch. (A lamp can be used in place of sunlight if necessary.)
4. Check the bowls every 2 minutes and record any changes you notice.

- Which ice mixture melted the fastest?
- Did both bowls provide the same conditions for the ice?
- Did both bowls contain the same ingredients?
- Did everyone in the class obtain the same results?
- Would someone else be able to reproduce this experiment exactly and achieve the same results?
- Are these results reliable? Why? Why not?
- Do you think this activity represents a fair test? Why? Why not?

Figure 1.29

ACTIVITY 1.3.3: CONTROLLED AND EXPERIMENTAL VARIABLES

Read the following experiment descriptions and, for each one, identify all the controlled variables and the dependent and independent variables.

Experiment 1

Blocks of milk, dark and white chocolate (250 g each) were broken into pieces and placed in three glass bowls of the same size. All bowls were covered with cling film and placed on a windowsill in direct sunlight. They were observed at 5-minute intervals to determine how long the chocolate would take to melt. Results were recorded in words and with photographs.

Experiment 2

A skateboard was released from the top of a 3 m ramp and the total distance it travelled was recorded. The skateboard then had a 1 kg weight attached to it and the experiment was repeated. Weights of 2 kg, 5 kg and 10 kg were also tested to determine whether they affected the distance travelled by the skateboard.

QUESTIONS 1.3.1: INVESTIGATING SCIENCE

Remember

1 Describe a 'variable' in your own words.

2 Explain why most variables need to be controlled.

3 Identify the name given to the factor that is being tested, and therefore changed on purpose.

4 Suggest some synonyms for the word 'reliable'. Why would you want your results to be reliable?

Apply

5 Justin decided to conduct an experiment to find out whether his cats preferred full-cream or low-fat milk. He gave one cat a small bowl of full-cream milk and the other a saucer of low-fat milk. He then left them alone because they were fussy cats that didn't like to be watched while they were feeding. When he returned an hour later, the low-fat milk was gone and there was a small amount of full-cream milk in the bowl. Justin concluded that his cats preferred low-fat milk.

- **a** Do you agree with Justin's conclusion?
- **b** Do you think he conducted a fair test?
- **c** What was the experimental variable in this experiment?
- **d** What were the variables that needed to be controlled? Were they controlled? How might they have affected the results?
- **e** Explain how you would improve Justin's experimental method so that his results were more reliable. Write this as a numbered, step-by-step set of instructions.

OBSERVATION AND INFERENCE

To be good at investigating and solving problems, you need to be observant and notice things around you. All of your senses—sight, taste, hearing, smell and touch—send information to your brain. Most of the results of experiments are collected by making **observations**. Good observers make accurate observations and achieve accurate results.

Observations can be either quantitative or qualitative.

Quantitative observations use measurement—they are quantities or 'amounts' and are normally written using numbers. Specialised equipment is often used to make quantitative observations, like scales, stopwatches and light meters.

The numerical measurements are usually accompanied by units, for example 2.7 metres or 23.4°C. **Metres** are a measure of distance and **Celsius** is a measure of temperature, so they are both quantitative.

The units of measurements are very important. If they are not included it can be very difficult to understand what the scientist is trying to say. Imagine an experiment that looked at plant growth. If the results simply said 'The plant grew 3', you wouldn't really know what happened. 3 what? 3 leaves? 3 cm? 3 cm per day? It is the units that tell us exactly what was being measured. Units also allow us to compare results easily. Comparing Plant A, that grew 3 cm with Plant B that grew 5 cm, it is easy to see that that Plant B grew more than the first. But if the results were recorded in different units, Plant A grew 30 mm and Plant B grew 5 cm it can be a little confusing. A good experiment will use the same unit for all the trials.

Qualitative observations use words to describe anything that is not an 'amount'. The sense organs of the human body are essential for qualitative observations. What you see, hear, smell, taste or feel are generally qualitative observations. 'Rough', 'sour' and 'yellow' are all words describing qualitative observations.

The more detail provided in qualitative observations, the better. Photographs and videos can also be used to record qualitative observations.

Scientists need to be good at **inference** as well as observation. An inference is a likely explanation of an observation. It is how you explain your observation. An inference doesn't necessarily guarantee that something is true, but it is likely to be true.

Before a scientist can infer anything about their results, they must ensure that the results are reliable. Good experiments should repeated to make sure they always achieve similar results. The more similar the results and more repeats or trials of an experiment, the greater the reliability of the results and the more confident a scientist can be about their inference.

Table 1.4 contains examples of observations, paired with possible inferences.

Table 1.4 Some observations and inferences.

Observation	Inference
Your house smells like cooked onions when you get home from school	You are probably having cooked onions with dinner
A fabric feels like satin	The fabric is either satin or something that feels very much like satin
You see a man running down the street	The man is running either away from something or to something
You hear a house alarm ringing	Someone has entered the house
Lemon juice tastes sour	Lemons contain an acid

ACTIVITY 1.3.4: TESTING YOUR SENSES

The secret to being observant is to use your senses. These activities will make you more aware of your senses. In some of these activities you will need a blindfold. It is best to use safety glasses that have been painted black or covered with dark paper. You will not test your fifth sense, taste, because it is not good safety practice to eat in the laboratory.

Smell

Your teacher has some test tubes (wrapped in paper) lined up in a test tube rack. Gently smell each one by wafting the smell towards your nose with your hand. See if you can name the smell. They might be the odour of paint, banana peel, a piece of cake, leaves from a lemon tree or something else. Try to recognise each substance by its smell.

WARNING

> Never smell things in a science laboratory unless your teacher instructs you to

Touch

Wearing your blindfold, feel some common objects. They might be fruit, fabric, sandpaper, plastic or something else. Describe the feel of each one and try to recognise each substance.

Sight

We have binocular vision, which means that we have two eyes that function together. Cover one eye and then ask your partner to hold a pencil within the reach of your arm. Stretch out your arm and touch the top of the pencil with your finger. Most times you will judge the correct direction but not the correct distance. This is because you need two eyes to judge distance.

Hearing

Sit at your desk and put on your blindfold. As your partner taps on the desk or clicks their fingers, point to where you think the noise is coming from. How good are you at finding the direction of a sound?

Questions

- Based on this activity, which is your strongest sense?
- Based on this activity, which is your weakest sense?
- Did you discover anything surprising while doing this activity? If so, what was it?
- Write one thing that you have learned about your senses of smell, touch, sight and hearing.

ACTIVITY 1.3.5: OBSERVATION VERSUS INFERENCE

How good are you at making observations? Do you confuse observations with inferences? There are many things that you can observe.

1 Draw a table with two columns, one for observations and one for inferences.
2 Light a candle and list six observations of the burning candle.
3 Write down three inferences you can make from your observations.

QUESTIONS 1.3.2: OBSERVATION AND INFERENCE

Remember

1 Identify the senses that you would use to observe in the laboratory.
2 Explain why scientists don't use the sense of taste in a laboratory.
3 Define the term 'observation'. Provide an example.
4 Define the term 'inference'. Provide an example.
5 Outline the difference between a quantitative and a qualitative observation.
6 Explain why it is important to include units in all your qualitative observations.

Apply

7 Identify which of the following are observations. Identify which are inferences.
  a You smell a strong odour from a garbage bin.
  b Coffee stays hotter if you add the milk before the hot water.
  c The temperature today was 37°C.
  d It is so hot that the temperature must be 37°C.
  e There is a person in a Santa suit. It must be Christmas.
  f I can smell fish cooking.
  g This candle has a greasy feel.
  h I believe that this candle is made of special wax.
  i This soup is so hot that it hurts my teeth.
  j Shh! I can hear an animal on the roof. It must be a possum.
8 Identify which of the observations in question 7 are quantitative and which are qualitative. Explain your answer.
9 Observation and inference are very important tools for scientists. Outline why you think they are important.

Critical and creative thinking

10 You have designed an experiment to test the effectiveness of different fertilisers (A, B and C) on plant growth.
  a Make a list of at least five qualitative observations you would make during the experiment.
  b Make a list of at least five quantitative observations you would make and the units you would use.
  c If the plants fertilised with Fertiliser B grew 5 cm taller on average than all the other plants, what could you infer about Fertiliser B?
  d If most of the plants fertilised with Fertiliser C died, what could you infer about Fertiliser C?

MEASURING AND RECORDING

Whether you are always aware of it or not, you use measurements every day. You might buy milk in a 1 litre carton and ask for 200 grams of ham at the supermarket. You might walk 800 metres to school each day. If you are ill, a doctor will measure your body temperature to see if it varies from the normal 37°C. Each time you look at your watch, you are measuring time. Measurements are, and have always been, an important part of life and of science. When you do experiments, you will perform measurements and record your results.

Old ways of measuring

Gulliver is the main character in the book *Gulliver's Travels*. During his adventures, he is shipwrecked on the island of Lilliput. The people of Lilliput are tiny and think that Gulliver is a giant. After they overcome their fear of the big man and become his friends, the people decide to make Gulliver a new set of clothes.

But measuring this giant for a suit of clothes is a real problem, because the Lilliputians are so tiny. So, after checking out as many dimensions of Gulliver as they can, they decide that the distance around Gulliver's waist is probably equal to twice the distance around his neck. It is easier to measure around his neck than his large waist.

Is the distance around a waist equal to twice the distance around a neck? Use a piece of string and ruler to check. Compare your answer with those of other students.

For thousands of years, distances have been measured by comparing them to parts of the human body. The height of a horse, for instance, is still measured in hands. Some countries, such as the United States, measure distance in feet. A standard system is now used, instead of human hands and feet.

Measurement and units

The idea of having standard **units** for measurement soon spread, so that all types of measurement were included. The **metric system** is now used by scientists worldwide.

A measurement of 2.45 metres has to be the same in Sydney as in New York. A temperature of 37°C is just as hot in Calcutta as in Dubbo. Scientists often check each other's work by repeating experiments, to see if they get the same results. To do this, they need to be able to use measurements that are the same as those of the original experiment. Using a standard system of measurement, scientists everywhere can understand and build on each other's work.

Measurements of five different quantities are important when you are exploring science: volume, mass, temperature, time and length.

Figure 1.30 Measurements of mass are made at home when cooking.

Table 1.5 Measurements used in ancient civilisations.

Old unit	Civilisation	Estimated equivalent today (cm)
Royal foot	Ancient Egypt	25.4
Royal cubit	Ancient Egypt	52.4
Finger	Ancient Mesopotamia	1.9
Palm	Ancient Mesopotamia	7.5
Fathom	Ancient Mesopotamia	180
Knuckle	Ancient Greece	3.9
Lick	Ancient Greece	15.4

Figure 1.31 These cubits and a leather case are relics of ancient Egypt.

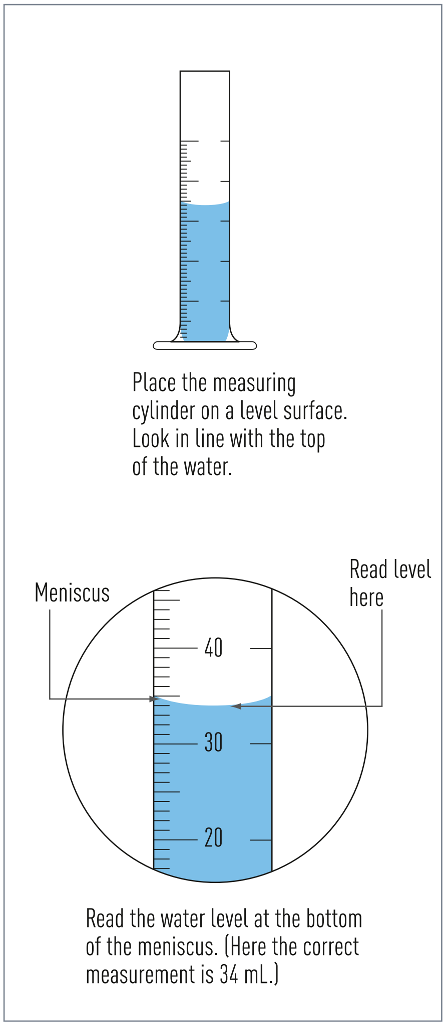
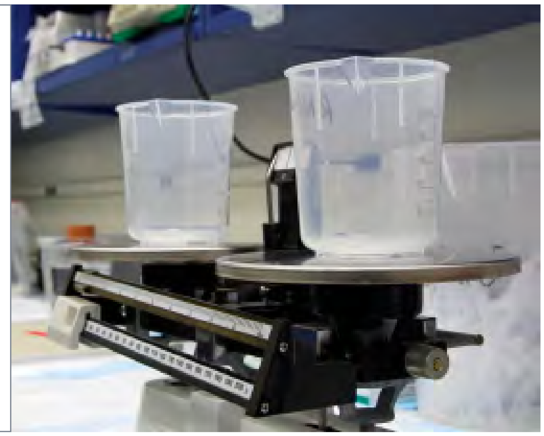


Figure 1.32 Measuring volume.

VOLUME

Volume is how much space something takes up. Measurements of liquid volumes can be shown using units called litres (L) or millilitres (mL). In science, measuring cylinders are used to measure the volume of liquids. Some beakers have a measuring scale on them, but measuring cylinders are more accurate than beakers. Beakers are only used as a basic estimation of volume. When the volume of water or any other liquid is measured in a measuring cylinder, the liquid will 'stick' to the side of the glass or plastic container and it forms a **meniscus**. To obtain an accurate measurement of volume, the reading must be made from the bottom of the meniscus (refer to the diagram). Measurements of the volume of solid objects have units such as centimetres cubed (cm^3).

Figure 1.33 The International Prototype Kilogram.



MASS

Mass is the amount of matter or substance in an object. Mass is measured in units called grams (g), kilograms (kg) and tonnes (t). Smaller masses are measured in milligrams (mg). Mass-measuring devices are called scales or balances. You are likely to use an electronic balance or a triple beam balance, similar to the one shown, to measure mass.

TEMPERATURE

Temperature is measured using a thermometer. Some thermometers have a digital scale. Measurements of temperature have the unit called degrees Celsius. Its symbol is °C.

TIME

Time is measured with a watch or clock. A watch or clock set to the correct time tells you the time of day. A stopwatch measures how much time has passed. In your experiments, measurements of time will often have the unit called seconds (s) or minutes (min).

LENGTH

Measurements of length can be shown using a unit called metres, using the symbol 'm'. For long distances, kilometres (km) are used. For small distances, centimetres (cm) or millimetres (mm) can be used. In school science, the devices we use to measure length and distance are the trundle wheel, metre rule and tape measure.

Recording measurements

All measurements have two parts: a number and a unit. For example, 5 metres is written as '5 m'. Notice that the unit does not have an 's' after it, even though it stands for 'metres'.

Measurements are usually recorded in a table or a graph so that they can be easily read, compared or used for further calculations.

Table 1.6 Some metric units of measurement.

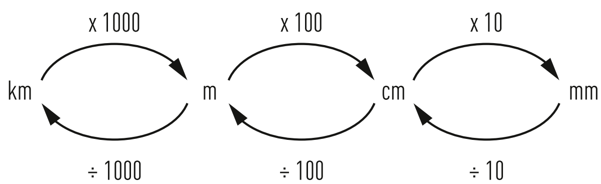
Measurement	Unit	Symbol	Typical instrument used
Distance/length	Kilometre	km	Trundle wheel
	Metre	m	Metre rule
	Centimetre	cm	Tape measure
	Millimetre	mm	Tape measure
Volume	Litre	L	Volumetric flask
	Millilitre	mL	Measuring cylinder
Mass	Tonne	t	Weighbridge
	Kilogram	kg	Beam balance
	Gram	g	Spring balance
	Milligram	mg	Electronic balance
Time	Hour	h	Clock
	Minute	min	Stopwatch
	Second	s	Stopwatch
Temperature	Degrees Celsius	°C	Thermometer

Figure 1.34 A temperature of 37°C is the same in (a) Calcutta in India and (b) Dubbo in central New South Wales.

NUMERACY BUILDER

A Converting units of length

To compare two measurements, their units must be the same. It is difficult to compare 10 000 metres to 13 kilometres—which one is longer? Comparing 10 kilometres with 13 kilometres is much easier. The metric system works in multiples of 10, so we can convert using a formula.



1 kilometre = 1000 metres

1 metre = 100 centimetres

1 centimetre = 10 millimetres

To change a larger unit (e.g. km) into a smaller unit (e.g. m) you need to *multiply*. To change a smaller unit (e.g. mm) into a larger unit (e.g. cm) you need to *divide*.

Example

Which is longer: 150 metres or 12 000 centimetres?

150 m × 100 = 15 000 cm

150 metres is longer than 12 000 centimetres.

Your turn

1 Identify which is longer: 10 000 millimetres or 500 metres.

2 Identify which is shorter: 3 kilometres or 1000 metres.

3 Convert 1 kilometre into metres, centimetres and millimetres.

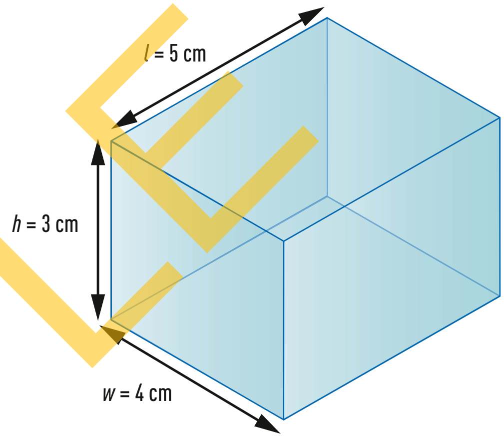
B Measuring volumes of regular solids

The volume of solid objects is often measured in centimetres cubed (cm^3). The volume of a rectangular prism can be found by multiplying length by width by height:

$V = l \times w \times h$

Example

A rectangular prism has the dimensions shown:



Calculate its volume.

$$\begin{aligned} V &= l \times w \times h \\ &= 5 \times 4 \times 3 \\ &= 60 \text{ cm}^3 \end{aligned}$$

The volume is 60 cm^3.

Your turn

1 Calculate the volume of a rectangular prism of length 10 cm, width 8 cm and height 6 cm.

2 A box has a volume of 400 cm^3. It has a length of 10 cm and width of 5 cm. What is its height?

ACTIVITY 1.3.6: MEASURING OBJECTS

Your teacher will give you some objects to measure. You will have to select the best measuring device for an accurate measurement. Record your results in a table in your notebook. Don't forget to write the units of your measurement.

Some examples are:

- volume and mass of a cup of water
- mass of a small plastic container partly filled with sand
- distance from your laboratory to where you sit at lunchtime
- thickness of a page in this book
- time a ball is in the air after it is thrown.

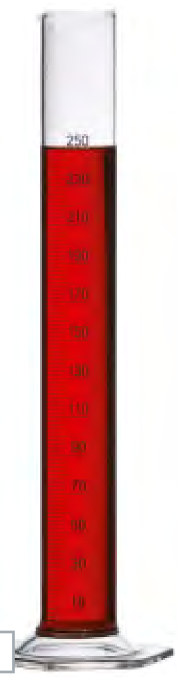
Measuring accurately

Accurate measurement in science is important so that your results are a true record of something. Comparing measurements with other scientists is useful only if your results are accurate.

You can do several things to improve your accuracy in the science laboratory. Always take your time when measuring and make sure that you write down the result straight away. When reading a scale, line up your eye directly in front of the object and the scale. Looking from above or from the side can produce different readings. This kind of error is called a **parallax error**.

Sometimes, errors in measurement are unavoidable. An **error** is different from a mistake—it can happen for various reasons, no matter how careful you are. Errors can occur if the object you are measuring falls between two markings on a scale—this will mean that you have to estimate the exact measurement. Sometimes scales can be calibrated (set up) incorrectly, which means that, no matter what you measure, you will get a slightly inaccurate result. You can minimise the effect of this kind of error by always using the same measuring device.

Whilst errors may not be eliminated, they should be minimised.



a

b

Figure 1.35 Which angle would you use (a) or (b) to get an accurate reading of the measuring cylinder? How could a reading error occur here?

QUESTIONS 1.3.3: MEASURING AND RECORDING

Remember

1 Construct a list of everything you have measured today. Think carefully—you have probably measured more things than you realise. Try to list at least five things.

2 When you measure volume of a liquid, identify what part of the meniscus is used.

3 Outline what tools you would use to measure the following things:
- **a** distance around a cricket ground
- **b** time it takes a sprinter to run 100 m
- **c** mass of a carrot
- **d** volume of water in a fish tank
- **e** volume of a square block
- **f** temperature of a swimming pool
- **g** your mass
- **h** thickness of this book

Apply

4 Outline why it is a problem to use body parts as a measuring tool.

5 In the United States, people use imperial units of measurement (foot, pound, mile) but scientists in the United States use metric units. Explain:
- **a** why the scientists use metric units
- **b** what problems might arise if scientists in the US used imperial units.

6 Would you prefer to walk 14 900 centimetres or 3 kilometres? Explain why.

7 Suggest a reason why the unit for minutes is (min) and not (m).

Analyse and evaluate

8 In Australia, we measure temperature in degrees Celsius, however there are other temperature scales which are used around the world. Investigate the different scales used for temperature and explain how to convert between them. If a recipe called for an oven to be heated to 356 Fahrenheit, how hot would it be in degrees Celsius?

Research

9 What causes the water meniscus to form? Mercury has an inverted meniscus. What does this mean? Draw how you would accurately measure 25 mL of mercury.

SCIENTIFIC REPORTS

When you do an experiment, you need to keep two things in mind: the doing and the reporting. A scientific report is an essential part of any experiment—it is where you record and present your findings. Reports usually contain two parts: a record of the equipment and method you have used, and a statement of what you observed and/or measured and what you conclude based on your observations.

Scientists use scientific reports to communicate with other scientists so that they can learn from each other. So that their reports are easy to follow, scientists write reports in a certain format, using similar language.

What is in a scientific report?

A report is a written account of what you did in an experiment. It usually has eight parts:

1 **Title**, date and partners (if you are working in a group). Don't forget to write your own name!

2 **Aim** or question—what you are trying to find out or why you are doing the experiment.

3 **Hypothesis**—your initial theory or prediction about the outcome of the experiment. (Note: Not all experiments contain a hypothesis.)

4 **Materials** or equipment—a detailed list of the equipment used.

5 **Method**—numbered, step-by-step description of how you did the experiment, including diagrams of apparatus.

6 **Results**—measurements and observations you took during the experiment. They are usually presented in a table, graph and/or diagram.

7 **Discussion**—your opportunity to discuss the findings, any problems that were encountered and suggestions for improvement or further investigation.

8 **Conclusion**—the answer to the aim or question. It should be clear, reasoned and relate very closely to the starting aim or question.

SCIENCE SKILLS

Writing in the third person

The best type of scientific report lays out the facts in clear, plain English. Writing impersonally is called writing in the third person. This is when we use words such as *they*, *he*, *she*, *it* and not *I*, *we* and *you*. If an experiment has been controlled to make it a fair test, then it shouldn't matter whether Einstein or your 15-year-old brother conducted the experiment. This is one reason that personal pronouns ('I', 'me', 'our') are usually left out of scientific reports. When you use personal pronouns, it's tempting to put in a lot of information that isn't relevant.

Read the following paragraph from the discussion section of an experiment:

> *Well, I think that our experiment went really well. We got it all done in the time we had and the teacher was happy with how we cleaned up. Xavier helped me a lot in my experiment but he was a bit clumsy. Our results showed that vinegar and bicarbonate soda make a really good volcano. They fizz and froth up to about 10 times the size before all the bubbles pop and it becomes a runny liquid again. I think that if I did this experiment again I would make sure that the measurements were all done by me or I would find a different partner to work with. This would reduce the number of errors and maybe we wouldn't smash so many pieces of glassware.*

Your turn

Re-write the paragraph in the third person, leaving out any sentences you think are unnecessary.

ACTIVITY 1.3.7: TESTING MATERIALS FOR FLAMMABILITY

Tests ordered on clothes after formaldehyde scare

21 AUGUST 2007, NEW ZEALAND

Authorities are to test a wide range of imported clothing to see if it meets New Zealand safety standards after children's clothes imported from China were found to pose a health risk.

A TV3 Target programme to air this week has found dangerously high levels of formaldehyde in Chinese-made children's clothes. The gas is commonly used in clothing manufacture, but the programme found levels up to 900 times higher than considered safe by the World Health Organization in garments it tested.

Last month, two boys suffered minor burns when their TWL pyjamas ignited.

Commonly employed as a preservative, formaldehyde is used in many industries and has been used on clothing to combat mildew and give a permanent press effect. Exposure to excess levels can create breathing problems and cause headaches.

Clinical adviser Alison Hussey said both issues showed safe clothing standards should be enforced, and that manufacturers' instructions to wash clothes before wearing should be followed.

'We advise that people choose natural fibres and that clothes, particularly sleepwear, are close fitting and that it should be washed before use. That children should be supervised around heaters is probably the most important thing.'

Imagine you have just been appointed as a scientist to the *Choice* group, who test many different products. Reading the article above will prepare you to write your first scientific report.

As a *Choice* scientist, your job is to investigate four different materials for flammability—describing how they burn—and to recommend the best one for making children's pyjamas.

None of the materials you will be testing have had formaldehyde added to them, nor have they been treated with fire-retardant chemicals.

The following model for this experiment includes a step-by-step guide to writing the report.

You will be working in pairs to conduct and assess the flammability experiment.

1 Before doing the experiment, copy the aim, materials, method and results table into your notebook.
2 Complete the experiment with a partner and fill in your results table.

WARNING

> Do this experiment in a fume cupboard if possible. Otherwise, make sure the room is well ventilated and do not breathe in any fumes from burning material. Have a large beaker of cold water next to you. If the fabric is still smoking when the flame goes out, immerse it in the water using tongs.

3 Answer the discussion questions.
4 Check back to the aim to remind you what your conclusion is about. Copy the conclusion from the example and fill in the gaps according to what you found.
5 Evaluate the design of this experiment. Do you think it is valid to draw a conclusion from only four cases? Explain.

Testing materials for flammability

DATE: 14 February 2014

NAME: Beaker Bunsen

PARTNER: Tripod Test Tube

Sets out what you are trying to discover. It is the 'question' you are asking, and will be different for each experiment.

AIM

To compare the flammability of four materials and recommend one for making children's pyjamas. (Note: This experiment does not contain a hypothesis.)

Contains a list of what you need.

MATERIALS

- Bunsen burner
- Ceramic tile
- Large beaker
- Metal tongs
- 2 heatproof mats
- Stopwatch or clock
- 2 cm square piece of four different types of material (e.g. nylon, wool, cotton drill, polyester/cotton mix)

Gives step-by-step instructions and often a diagram of equipment.

METHOD

1. Light the Bunsen burner.
2. Change to a blue flame.
3. Use tongs to hold a piece of material. Put the corner of the material in the burner until it catches alight.
4. Remove the material from the flame and immediately place it on the tile.
5. Time how long the flame takes to go out.
6. Write a careful description of how the material burns (e.g. colour changes, melting, charring).
7. Repeat with the other pieces of material.

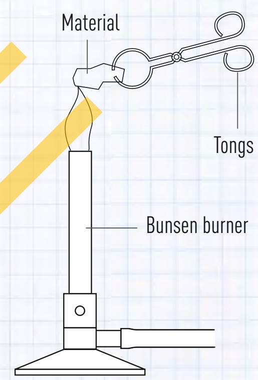


Figure 1.36 Experimental set-up.

Often includes a table to fill in the results.

RESULTS

TABLE 1.7 ....

(Hint: give the table an appropriate name)

MATERIAL	TIME TO BURN (S)	DESCRIPTION OF BURNING
< material 1 name >		
< material 2 name >		
< material 3 name >		
< material 4 name >		

Where any set questions are answered and where you describe any unusual or interesting results. This is also where you can suggest improvements for an experiment.

DISCUSSION

1 Which materials became runny during burning? Would this be good for a material worn close to the skin?

2 Which material burned the quickest?

3 Which material burned the slowest?

4 Why is knowing the length of time needed to burn helpful when considering materials for children's clothing?

5 One variable that could affect the results is the size of the piece of material. Why were all the pieces of material cut to the same size? If they had not been, how would this have affected the results?

6 Identify one other variable that could have affected the results. Was this variable controlled? Discuss.

7 Which materials could be suitable for making a lab coat and why?

8 What safety recommendations would apply to anyone trying this experiment?

CONCLUSION

Of the four materials tested, the best material to make children's pyjamas from a fire safety point of view would be __________________ because __________________.

An answer to the question you set out to investigate. Look back at the aim before writing the conclusion. Try to use one or two sentences and to write in the third person.

QUESTIONS 1.3.4: SCIENTIFIC REPORTS

Remember

1 What is a prediction called in science? In what form is it usually written?

2 Explain why results are usually presented in a table or graph format.

3 Identify the eight sections in the order they are used when writing a scientific report.

4 What is a conclusion? Why is it written at the end of an experiment?

Apply

5 Explain why it is important that scientists complete scientific reports.

6 How would a common format for all scientific reports make it easier for scientists to communicate with each other?

7 Identify a reason why personal pronouns are not used in scientific reports.

8 If you wanted to test how well different laundry powders worked, what variables would you have to keep the same? Why is this important?

Critical and creative thinking

9 An agricultural company has developed a new breed of grass that they claim increases milk production in cows that eat it. You have been asked to test this claim.

a Write an aim for your experiment.

b Make a hypothesis.

c Identify the experimental variable and the dependent variable for your experiment.

d Identify the other variables that would need to be controlled.

e Write an appropriate method for your experiment, making sure to explain how to test the dependent variable and to control all the other variables you listed in part d.

1.3 CHECKPOINT

SCIENCE SKILLS AND ACCURACY

Remember and understand

1 Identify what a fair test is. [1 mark]

2 Explain why a standard unit of length is needed. [1 mark]

3 Identify an appropriate metric unit for:

a volume [1 mark]

b temperature [1 mark]

c mass. [1 mark]

4 Explain the purpose of controlling variables in an experiment. [1 mark]

5 Identify if the following observations are quantitative or qualitative.

a The bus is red. [1 mark]

b I am older than 12 years old. [1 mark]

c The line to the tuckshop is 4 metres long. [1 mark]

6 Explain why a measurement is not very useful if you don't include the correct units. Give an example in your answer. [2 marks]

7 Which is best for measuring volume, a measuring cylinder or a beaker? Explain why. [2 marks]

8 Identify which section of a scientific report would contain the measurements collected. [1 mark]

Apply

9 Have you ever heard the expression 'Close enough is good enough'? Identify one situation where this is true and one where the expression does not apply. [2 marks]

10 Make three observations and three inferences about:

a this textbook [2 marks]

b your own hand [2 marks]

11 If the units for measurements were different between Sydney and Melbourne, explain some problems that would be likely to arise. [1 mark]

Analyse and evaluate]

12 There are many unusual measurements. Outline the answers to these measurement questions.

a How would you find the temperature inside a furnace? [1 mark]

b How can you measure the thickness of a sheet of paper? [1 mark]

c How fast do your fingernails grow? How could you measure this? [1 mark]

Critical and creative thinking

13 Design the following experiments. Write the aim, the hypothesis and the method. Identify the variables and make sure you control all but the experimental variable. Make note of any safety issues. Set it out like one of the experiments in this book.

- An experiment to test if three types of material are waterproof or not. [4 marks]
- An experiment to see how high a rubber 'bouncy-ball' can bounce on different surfaces. [4 marks]

Making connections

14 Reflect on all the new things that you have learned about exploring science. Draw up a PMI chart. In column 1 write the 'pluses' (good things that you have learned), in column 2 write the 'minuses' (negative things that you have learned) and in column 3 write some interesting things that you have learned. One example has been done for you. [3 marks]

Plus	Minus	Interesting
In science I get to explore a lot of amazing questions	The Yangtze River dolphin is extinct	Fire-breathing requires a lot of scientific knowledge

TOTAL MARKS
[/35]

1 CHAPTER REVIEW

1 Fill in the gaps using the Word Bank below:

Science involves questioning and research based on first-hand and second-hand information. Questioning is an ______________________ part of science as it can lead to further understanding and knowledge. ______________________ questions are better to ask than small questions as they are more open and allow for more ______________________ to be determined.

Scientists were originally natural ______________________ who considered the world and determined logical explanations about how the world worked. The biggest difference between ______________________ nowadays and philosophers in the past is that scientists complete experiments and then repeat them to determine a ______________________ result.

There are many ______________________ of science. The study of living organisms is called ______________________. The study of chemicals is called ______________________, the study of motion and movement is called ______________________ and the study of the Earth and rocks is called ______________________.

When studying science, the concept of measurement is very important. It is crucial to have uniform ______________________ so that scientists all over the world know that there are no miscommunications. The measurements used in science are based on the ______________________ system.

Specific scientific equipment can be found in science ______________________, which is why there are different rules in science laboratories compared to regular classrooms. Some of these rules govern ______________________ safety, such as the most protective type of clothes to wear, whilst other rules govern class safety, such as listening to the teacher's instructions.

It is also important to use appropriate ______________________ equipment. For example, plastic beakers should ______________________ be used when heating as they will melt.

Designing an appropriate scientific experiment and reporting back the ______________________ of the experiment is also an important part of science. Experiments should include the ______________________ variable and the ______________________ variable as well as controls to ensure that the experiment is a fair test.

WORD BANK

Big	Biology	Branches	Chemistry
Dependent	Geology	Independent	Important
Information	Laboratories	Metric	Not
Personal	Philosophers	Physics	Reliable
Results	Scientific	Scientists	Units

1

CHAPTER REVIEW

TOTAL MARKS
[/35]

Identify questions that can be tested or researched and make predictions based on existing knowledge

2 Change the question 'Where do koalas live?' into a bigger question. [1 mark]

3 Explain why pseudoscience isn't 'real' science. [1 mark]

4 Propose an example of a big question that each of the following scientists might ask:

  a Meteorologist [1 mark]
  b Geneticist [1 mark]
  c Pharmacologist [1 mark]
  d Marine biologist [1 mark]

5 Are modern scientists any different from the natural philosophers of the past? Explain your answer. [1 mark]

6 'The blue Bunsen burner flame will heat the water faster than the yellow flame.' Is this statement a prediction or a hypothesis? Justify your answer. [1 mark]

Collaboratively and individually plan to investigate questions and problems

7 Define the following terms:

  a 'hypothesis' [1 mark]
  b 'variable' [1 mark]
  c 'fair test' [1 mark]

8 Explain why scientists perform experiments. [1 mark]

Collaboratively and individually follow instructions to safely undertake investigations

9 Each of the following statements contains false information. Rewrite them to make them true:

  a If the rubber hose of a Bunsen burner has a split in it, push it firmly onto the gas tap so gas won't leak from the split. [1 mark]
  b To light a Bunsen burner, open the air hole, light a match and place it just above the air hole. [1 mark]
  c If you are not using the Bunsen burner for a while, open the air hole to change the flame to the blue safety flame. [1 mark]

10 Science safety is not a fashion statement. Recommend four good tips for maintaining personal safety in the science laboratory. [2 marks]

11 A science laboratory needs to have specific rules.

  a Why are these rules necessary? [1 mark]
  b State four rules that apply in a science laboratory but not in your usual classroom. [4 marks]

Process and analyse data to identify trends, patterns and relationships and draw conclusions

12 Explain why scientists repeat experiments. [2 marks]

13 Determine if each of the following statements is qualitative or quantitative:

  a The temperature is 26°C. [1 mark]
  b The water is warm. [1 mark]
  c The surface is rough. [1 mark]
  d The sun is bright. [1 mark]
  e The lemon juice tastes sour. [1 mark]
  f Our table is about 2 metres long. [1 mark]
  g The ball reached me in 5.4 seconds. [1 mark]

Present scientific ideas and information in appropriate scientific language, text and representations

14 Explain the purpose of writing in the third person when writing scientific reports. [1 mark]

15 Draw a neat and labelled scientific diagram of a beaker on top of a tripod and gauze mat. Explain what features of your diagram make it a scientific diagram. [3 marks]

RESEARCH

Choose one of the following topics for a research project. Your job is to plan the project, rather than actually do the research. Planning is a very important tool. Place the topic in the centre of a bubble map and fill the surrounding bubbles with big questions. Make sure your questions are big enough to give you an insight into the topic and into broader issues as well. An example has been done for you in Figure 1.37.

Famous Australian scientists

What big questions do you want to explore about a notable Australian scientist? You could consider Frank Macfarlane Burnet, Gustav Nossal, Mark Oliphant, Brian Schmidt, Nancy Millis, William McBride, Struan Sutherland, Howard Florey, Barry Marshall, Peter Doherty or Suzanne Corey.

Famous scientists in history

What big questions do you want to explore about a scientist who lived long ago? You could consider Archimedes of Syracuse, Hero of Alexandria, Galileo Galilei or Isaac Newton.

Depending on variables

Variables are sometimes described as 'dependent' instead of 'controlled' and 'independent' instead of 'experimental'. How are these terms similar? How are they different? When would each be used?

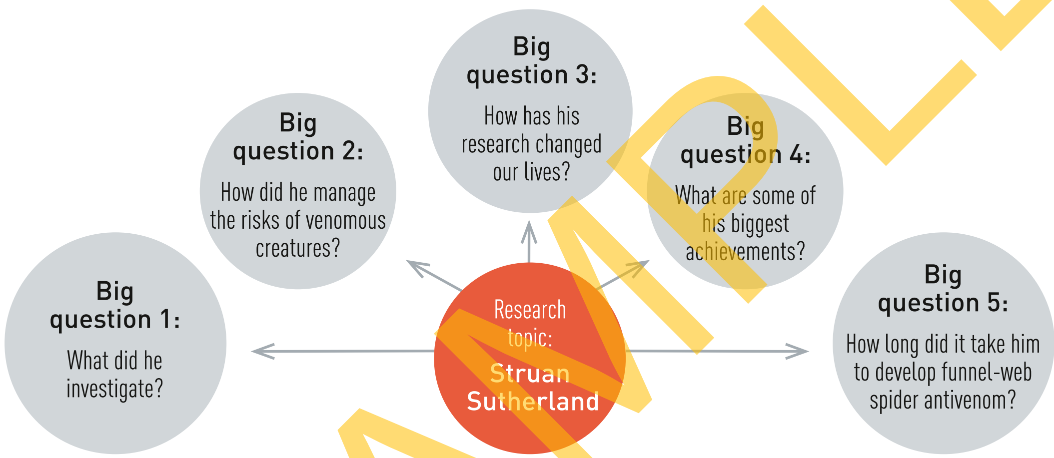


Figure 1.37 A mind map of research project planning.

KEY WORDS

aim
apparatus
Bunsen burner
Celsius
conclusion
controlled variable
controls (in terms of experiments)
dependent variable
discussion
equipment
error
experiment
experimental variable
fair test
hypothesis
independent variable
inference
meniscus
method
metres
metric system
observation
parallax error
philosopher
pseudoscience
qualitative
quantitative
reliable
results
scientific diagram
scientist
title
unit
variable

REFLECT

Me

1 What new science laboratory skills have you learned in this chapter?

2 What was the most surprising thing you found out about questioning?

3 What were the most difficult aspects of this topic?

4 How has your group work improved?

5 What could be done to improve your cooperative skills?

My world

6 Why is it important to ask questions?

7 Why is it important to make observations and inferences?

My future

8 Have you learned about any science careers that you are interested in?

9 What do you think are some of the most important issues that scientists face in the next few years?

1

MAKING CONNECTIONS

Working like a scientist

Not all experiments are a success. In fact, most scientists would agree that one success requires tens or even hundreds of 'failures' along the way. But the saying 'learn from your mistakes' is so true in the world of scientific exploration. If all scientists gave up when an experiment didn't work out, we would know very little about our world. Careful analysis of what went right and wrong, and what could be improved, is the key to successful science.

AIM

To use a selection of materials to design and construct a device that will carry a fresh egg safely to the ground when dropped from a second-storey window.

MATERIALS

1 egg

1 large plastic garbage bag

8 icy pole sticks

10 matchsticks

sticky tape (2 lengths of 40 cm)

2 large paperclips

2 large pipecleaners

1 cardboard square (20 cm × 20 cm)

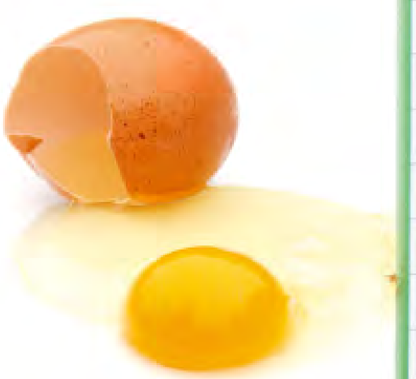
3 felt markers

1 piece of dishcloth (25 cm × 15 cm)

2 elastic bands

METHOD

1 Design and construct an egg-carrying device within 30 minutes and following these rules:
   - The egg must be fresh.
   - No materials other than those provided are to be used.
2 Place a fresh egg in the device and drop from a second-storey window onto the ground according to the following rules:
   - The egg and its device must be dropped by simply releasing the device to 'free fall'.
   - The device must not be interfered with during or at the end of its fall.
3 Inspect the egg for damage.



1 Read through the experimental report carefully and analyse the strengths and weaknesses of the experimental design.

2 Using the same constraints as listed in the materials and method, design your own egg-carrying device to demonstrate how scientists can learn from others' mistakes. Present your experiment in a formal report.

RESULTS

Figure 1.38 The egg-carrying device was designed to slow the fall and protect the egg on impact.

Figure 1.39 The egg-carrying device failed to protect the egg.

DISCUSSION

The egg-carrying device remained mostly intact upon impact with the ground; however, the egg was completely smashed within it.

During the design phase, consideration was given to the speed at which the egg would descend because a faster descent was likely to result in a harder hit. For this reason, the device had a wide, flat base but the extra material used may have increased the overall weight. Additionally, protective layers for the egg would have increased the overall weight and may have increased the speed of the descent.

Future tests might vary the amount of material used, the shape and texture of the base and the position of the egg within the device. A parachute may be incorporated into the design also.

CONCLUSION

The egg-carrying device did not carry the egg safely to the ground. Alternative designs should be considered.Are the questions different for each job, or do some jobs have questions in common?