CHAPTER 1

Working scientifically

Have you ever wondered …

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

LS

After completing this chapter you should be able to:

- describe how science and technology impact society
- identify equipment appropriate to a task
- use diagrams to simplify situations
- describe how regulations on wearing seatbelts and safety helmets developed from scientific observations
- evaluate data to support or reject a hypothesis
- draw conclusions based on evidence
- construct and use tables, spreadsheets, graphs, keys and models
- describe patterns in data
- collaboratively plan how to investigate a problem
- identify controlled, dependent and independent variables
- compare data collected from different sources
- evaluate investigation methods and compare with others
- describe how different branches of science work together

AB 1.1

Chapter overview

In this chapter students are introduced to science as a separate subject and to basic experimental methods. This chapter is an early introduction to science and includes identification of terms, laboratory skills and safety rules, experimental methods, and team investigation. Curriculum notes: this chapter addresses many Science Inquiry Skill elaborations, some of which are listed here.

It also addresses the Australian Curriculum and Victorian Curriculum. SHE:

> *Science and technology contribute to finding solutions to a range of contemporary issues. These solutions may impact on other areas of society and involve ethical considerations; for example, relating regulations about wearing seatbelts or safety helmets to knowledge of forces and motion.*

Pre-prep

Investigations such as Prac 2 in Module 1.2 allow students to practise performing practicals as well as taking measurements. Most practicals are simple to perform and set up. The Planning your own investigation activity in Module 1.4 may require some preplanning.

Chapter duration: 3 to 4 weeks.

Pre-quiz

Content differentiation

Ask students to individually write down the answers to the following questions. Write these down for them to see as well as reading them out aloud. The responses to the answers will help you determine which students should choose the alternative extension activities listed below.

1. List the parts of a science report.
   purpose, hypothesis, materials, procedure, results, discussion, conclusion
2. Explain what the term *variable* means.
   It can be changed.
3. Identify some of the branches of science.
   Geology, biology, astronomy, physics, chemistry, ecology, psychology …

Connect

4. Why is science important in the world in which we live?
5. How has science influenced the law? Give an example.

PEARSON science 7 RESOURCES

Activity Book

1.1 *Knowledge preview* enables insight into student prior knowledge of key content and ideas.

Weblinks

A selection of weblinks and descriptions to support the development and application of content and skills in this chapter is accessible via your eBook.

Activity Book Toolkit

The Activity Book Toolkit on page xv contains a section on *Learning styles* which includes a series of questions to help students become aware of their preferred method of learning.

What's coming up

Understandings

- A variety of branches of science practised in the world.
- Science is a human endeavour.
- Science and the law are linked.

Knowledge

- The steps involved in experiments
- The fair test
- Units that relate to measurements.

Skills

- Design and perform an experiment
- Take measurements.

Vocabulary preview

biology
branches
Bunsen burner
chemistry
cross-section
ecology
geology
hotplate
laboratory
mass
meniscus
physics
psychology
safety flame
toxic

STEM 4 fun

Can you create a phone?

HINTS AND SUGGESTIONS

If students have trouble with their phones, tell them to pull the twine or cotton tight. This allows it to carry the vibrations from the speaking end along the twine to the receiver end.

As the students will only be 3 metres apart, they will need to whisper into their phone and the listener should have one ear up against their cup and perhaps block their other ear.

LOOKING FORWARD

Students should reflect on their activity through the questions. Answers will depend on their experience and prior knowledge. Discuss how what they did helped the phone work better or what could have improved their design.

MODULE 1.1

Science and the laboratory

Scientists study the world around them to find out how it works. They investigate the living world of animals, plants, bugs and germs, and they study the planet and environments they live on and in. They investigate the physical world of substances like plastics and metals, and chemicals like water and acids. They explore forms of energy such as heat, light and sound. They even study things that are out of this world, like other planets, stars and galaxies.

STEM 4 fun

Can you create a phone?

YES

PROBLEM

Create a phone that allows you to have a conversation when standing three metres apart.

SUPPLIES foam cups, plastic cups, paper cups, empty tins, wool, wire, cotton, cardboard, foil, twine

PLAN AND DESIGN Design the solution—what information do you need to solve the problem? Draw a diagram. Make a list of materials you will need and steps you will take.

CREATE Follow your plan. Construct your solution to the problem.

IMPROVE What works? What doesn't? How do you know it solves the problem? What could work better? Modify your design to make it better. Test it out.

REFLECTION

1 What area of STEM did you work in today?
2 In what career do these activities connect?
3 How did you use mathematics in this task?

Science is important

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

Developments in science have also caused argument and debate. Cloning, the use of stem cells to repair damage in the body, and genetically modified food have all been developed from scientific discovery. Society has split into those who support the use of these new discoveries and those who do not. Climate change, and what we as humans should do to control it, has also split society into those who believe that it is happening and those who do not. There is even debate among those who do believe it is happening: some believe that it is caused by human activity, while others believe it could be part of a natural cycle.

Learning strategies

Literacy strategy

FORMATIVE ASSESSMENT

Quiz – Hinge question

MI: Verbal/Linguistic

For more information about Hinge Questions, see page xx. Tell students you will quiz them after reading the content of this unit. Devise a series of multiple-choice questions that can be used for this quiz. Try to put in some common misconceptions in these questions to tease these out. After they have read the content, ask the students to vote for what they think is the right answer for each question i.e. A, B, C or D. Make sure they do this in silence as you want to see each individual's thinking and current knowledge.

Catering for diversity of learners

First class

MI: Visual/Spatial, Verbal/Linguistic

In the first lesson, welcome students to your science lab. Ask them what they notice about the room. What makes it different from other classrooms? What is science? Move around the class, giving each student the opportunity to provide the name of a type of scientist or a branch of science.

Using visuals

Identifying equipment

MI: Visual/Spatial

To help identify prior knowledge, give students pictures of a variety of equipment and ask them to identify and explain their use.

PEARSON science 7 RESOURCES

Untamed Science Video

What Is Science, Anyway?

Suze visits a science fair to learn what students think about science. Access this video via your eBook.

Whatever its cause, glaciers like the one in Figure 1.1.1 are melting at a higher-than-normal rate. Older issues, such as whether nuclear power should be used in Australia, are being debated again because of our increasing energy needs. As a future adult and voter you will need an understanding of science to help you decide what we should do about these issues and any new issues that arise. To make good decisions about our future, you will need an understanding of science.

FIGURE 1.1.1 Climate change: do we believe the evidence that temperatures are rising because of human activity or do we reject it based on other evidence?

The branches of science

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

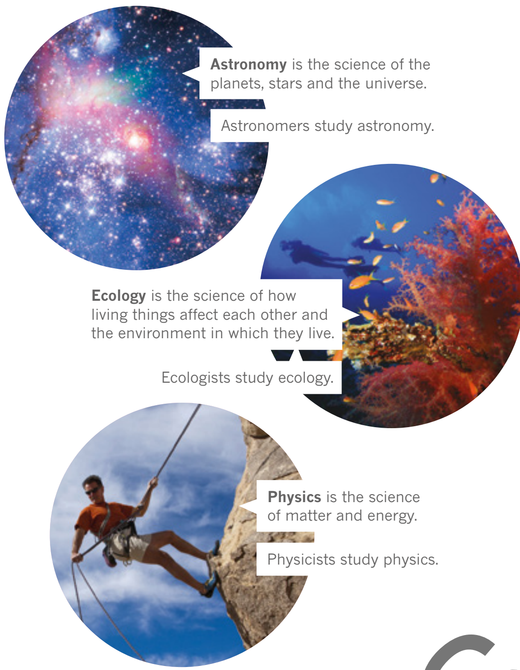



FIGURE 1.1.2 The main branches of science

Home learning activity

PRODUCT DIFFERENTIATION

A real scientist

MI: Visual/Spatial, Verbal/Linguistic

Ask students to investigate a living scientist. It may be a parent, friend or someone students can make contact with via email (universities are a good place to start). Ask students to find answers to the following questions.

1. What got the scientist interested in science?
2. What branch of science is their work in?
3. What work they do and what equipment do they use?

Alternative extension activity

Famous scientists

MI: Visual/Spatial, Verbal/Linguistic

Ask the extension students to complete the following activity instead.

Investigate a famous scientist that you would like to know more about.

1. What do you think led them to science?
2. What area did they specialise in?
3. What were some of their achievements?
4. How has what they achieved influenced the world today?

It may be possible to have a practising scientist come into your class and discuss their work. Check the CSIRO list of scientists.

Using visuals

PROCESS DIFFERENTIATION

Draw science

MI: Visual/Spatial, Intrapersonal

1. Have students sketch a picture of what they think science is.

Extend students with the following extra activity.

2. Have students sketch a picture showing how science links to the world they live in. Words and pictures can be used.

Place all pictures on display and discuss with students what they think science is about.

CHECKPOINT

Students can now answer Module 1.1 Review questions 2, 3, 4, 8, 9, 13, 14, 16 and 19.

Teaching strategy

Bushfire and climate scientist

The Working with Science profiles highlight a range of career opportunities that use many of the skills and subject knowledge developed during this topic. Careers are selected to inspire students with a diverse range of interests and skill sets and to shine a spotlight on careers that students may not be aware of, are new or future careers in this field and have a STEM focus.

WORKING WITH SCIENCE ANSWERS

Bushfire and climate scientist

1. In order to prepare for and manage bushfires, we need to understand where and when they are likely to occur and how severe they will be. By analysing data from past bushfires and climate patterns, scientists can better understand future bushfires. This is becoming more important because scientists predict that climate change will cause more severe weather events, such as bushfires, in the future.
2. Scientists often apply their knowledge and scientific findings by working with people who use this knowledge to do their jobs (e.g. firefighters and weather forecasters). By communicating their findings, scientists can help to improve the practices used by people in these jobs and improve outcomes for and services to the community.

Skills in practice

Branches of science

MI: Verbal/Linguistic

Continue the discussion with students about branches of science and what is studied in each branch. Students can be directed to the information on pages 3 and 4 of the text.

Working with Science

BUSHFIRE AND CLIMATE SCIENTIST

Dr Sarah Harris

Understanding climate and bushfire patterns is an important part of predicting where and when bushfires might occur. By using this knowledge, firefighters can be more prepared and better equipped to manage bushfires. Bushfire and climate scientists use geology, biology, chemistry and mathematics to study, map and model fire and weather trends.

FIGURE 1.1.3 Dr Sarah Harris

Dr Sarah Harris is a bushfire and climate scientist at Monash University (Figure 1.1.3). In her work, she models climate and bushfires to forecast when bushfires might happen, to understand the impact of bushfires and to map planned burns. Dr Harris works with fire and emergency services, the Bureau of Meteorology and other government departments to work out the best ways to prepare for and manage bushfires to minimise their impact.

Bushfires in Australia are frequent and severe. Scientists predict that climate change will increase extreme weather events such as drought and heatwaves. For this reason, bushfire and climate research will continue to be an important field of study. To become a bushfire or climate scientist, you will need a Bachelor of Science, majoring in environmental management or earth sciences. After your degree, you can continue studying to become a research scientist, or work for government departments. You might like this job if you enjoy working in teams, analysing data, observing patterns and using your knowledge to solve environmental problems.

Review

1. Why do you think bushfire and climate scientists are important?
2. Why do you think it is important that scientists work with the community and government departments?

Sub-branches of science

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

Likewise, physicists might specialise in acoustics (sound), optics (light) or mechanics (forces and energy) and chemists might specialise in organic, inorganic, analytical or physical chemistry.

There are so many types of living things that biologists specialise in the study of only one type of living thing, such as animals (zoologists study zoology), plants (botanists study botany) or germs (microbiologists study microbiology) (Figure 1.1.4). Even sub-branches are sometimes too big. For example, zoology covers so many different types of animals that it is split into smaller sub-branches such as insects (entomologists study entomology), spiders (arachnologists study arachnology) and fish (ichthyologists study ichthyology).

Prac 1 p. 11

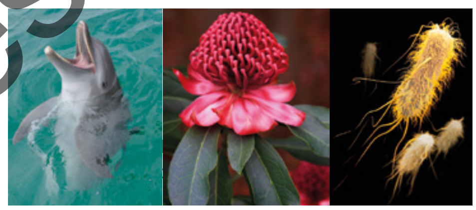


FIGURE 1.1.4 Some of the sub-branches of biology (left to to right): zoology, botany, microbiology

SciFile

The many branches of science

There are lots of other very specific sub-branches of science. Some more examples include teuthology (the study of octopuses), mycology (the study of fungi), chiropterology (the study of bats), carpology (the study of fruits and seeds) and oology (the study of eggs).

Definitions

Objective

MI: Verbal/Linguistic

At some stage it may be worth clearly explaining what it means to be objective.

Description: To be objective is to be able to put aside bias or preconceived expectations, even a hypothesis, and have the experiment speak for itself. Predictions and hypotheses must be able to be tested and dismissed, if necessary, once the data is shown to be accurate. The purpose of experiments should be to test hypotheses or predictions, not to prove they are correct.

Scientists are human, so there is often bias in results; however, scientists should strive to keep their opinions aside until the experiment either disproves or provides evidence for what is predicted.

PEARSON science 7 RESOURCES

Practical investigation

Prac 1, page 11, introduces how to run an experiment, including following safety instructions.

Weblinks

There are several weblinks provided that you may like to use to investigate careers in science.

Career links

Multiple branches of science

MI: Logical/Mathematical

Ask students to think about and list other career paths that require an understanding of multiple branches of science.

Responses may include other environmental scientists like the example in the Working with science, any role in biochemistry, biophysics, geophysics and so on.

Discuss how many scientists do not just specialise in only one branch of science, and also need an understanding of mathematics (such as statistics), computing (for simulations and record keeping) and great communication.

The laboratory

A scientist works in a **laboratory**. Laboratories are where scientists run most of their experiments and make most of their observations, measurements and discoveries. Your idea of a laboratory is probably a large room equipped with Bunsen burners, sinks, glassware, balances and chemicals that is occupied by people in white coats and safety glasses. This is the type of laboratory that chemists tend to work in and the type of laboratory that you will eventually work in at school. It might look something like Figure 1.1.5.

FIGURE 1.1.5 To most of us, the laboratory is a place full of Bunsen burners, glassware and people in white coats.

Different scientists have very different ideas about what a laboratory is. For marine biologists, the laboratory could be a coral reef. The laboratory of a zoologist might be a rainforest, and a laptop computer and video camera could be their most important equipment. The laboratory of an astronomer will be wherever their telescope is mounted. Figure 1.1.6 shows a palaeontologist at work in her laboratory. Her equipment is most likely a spade and brushes to clear the soil away from around the fossil. Sturdy boots, overalls and a hat will be far more important to her than a white coat. Scientists like her will usually have another laboratory in which they can test the samples they collected outdoors. For example, an ecologist might collect samples of polluted water from a creek but then analyse them back in their other laboratory.

FIGURE 1.1.6 For palaeontologists, the laboratory could be the place in which a dinosaur fossil has been found.

Equipment

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

Technology also plays an important role. Devices like smartphones and tablets provide the ability to photograph and record video of investigations. Digital probes and sensors can be connected to devices to collect a range of data. Software enables scientists to work with the data they collect, create models, and share and engage with scientific research. However, there is a set of basic scientific equipment common to most laboratories, including the ones at school.

Using visuals

Laboratory equipment

MI: Visual/Spatial

Go to cupboards around the lab where pieces of equipment are kept and bring out pieces one at a time. Ask students what they think the name of the piece of equipment might be and what could be its use. This will teach them what the equipment is and where they can find it. (If equipment is not kept in the laboratory, organise for some to be available, but keep it out of sight until you want the students to identify it.)

Literacy strategy

PROCESS DIFFERENTIATION

Pictures and words

MI: Visual/Spatial, Verbal/Linguistic

This chapter refers to a lot of diagrams and pieces of equipment that have new names. Have students construct a table with two columns as shown below. Each time a new piece of equipment is mentioned, have students add it to their table. Allow time for them to do this.

Name and diagram	What it is used for? (write or draw)
Beaker	Measuring chemicals (though not as accurate as the measuring cylinder), mixing chemicals, heating chemicals

Applying skills

Equipment bingo

MI: Visual/Spatial, Verbal/Linguistic

Make up a series of bingo cards using equipment names, and have a tray of equipment available to pull out one at a time in order to play equipment bingo. Make plenty of cards, and swap cards around for an extended game. Use prizes as a reward.

Using visuals

ENVIRONMENT DIFFERENTIATION

Common equipment

MI: Visual/Spatial

Set up some experiments using common equipment. Have students in mixed ability groups move to each set-up and identify each piece of equipment being used. Ask students to predict what they think the experimental set-up could be used for. They can also practise sketching each set-up. Simple experiments you could demonstrate include measuring the boiling point of water, making solutions, dissolving substances in test-tubes, separating oil and water using a separating funnel, decomposition by heating in a crucible, filtration, and making carbon dioxide with acid and marble chips while collecting the gas underwater in an inverted test-tube.

Applying skills

Meniscus

MI: Logical/Mathematical, Visual/Spatial

Have students look at test-tubes with different liquids that have a meniscus. Mention this is the introduction to problems that can also occur with parallax error (not looking directly on). Ensure students look directly at the test-tube and carefully identify the direction of the meniscus and where the result should be measured. If time is permitted, have students use the internet to investigate some common liquids and find out if they expect the meniscus to curve upwards or downwards for each liquid. Investigate in class any liquids you have available.

Teacher demonstration

Lighting a Bunsen burner

MI: Visual/Spatial

Show students the correct way to light a match (striking it away from you) and keeping your wrist lower than the match flame.

Indicate the parts of a Bunsen burner, including removing the collar (when the burner is not lit) to show them where the gas would come out.

Balances

The beam balances, electronic balances and spring balances shown in Figure 1.1.7 can all be used to measure the **mass** of an object. Mass is a measure of how much matter there is in an object.

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

FIGURE 1.1.7 Different balances can be used to measure the mass of an object.

Glassware

Glassware such as beakers, conical flasks, test-tubes and watch-glasses allows you to mix and heat chemicals. Most glassware in the laboratory is made of Pyrex, a special type of glass that is less likely than normal glass to crack when it is heated to high temperatures or cooled quickly. Some common pieces of equipment are shown in Figure 1.1.8.

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

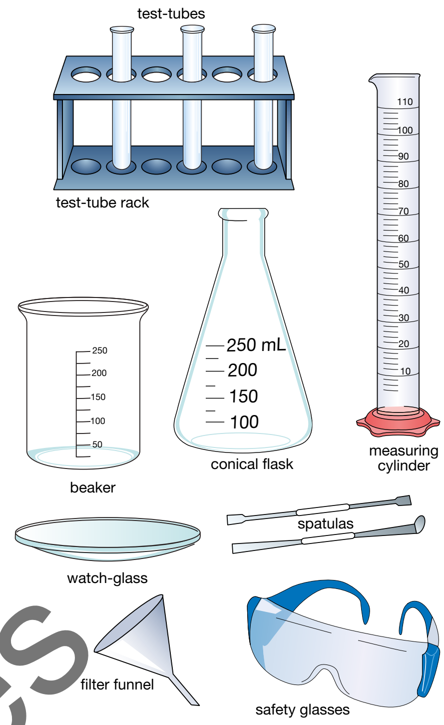


FIGURE 1.1.8 Equipment commonly used in the laboratory

AB 1.3

Heating equipment

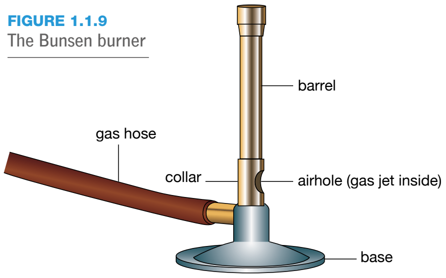
Hotplates and **Bunsen burners** are some of the most important and dangerous pieces of equipment that you will use in the school laboratory. Both get extremely hot and can cause serious burn injuries if you use them incorrectly.

The Bunsen burner

Prac 2 p. 12 Prac 3 p. 13

Figure 1.1.9 shows the parts of the Bunsen burner. The collar controls the amount of air that enters the burner as well as controlling the heat and colour of the flame. When you *shut* the airhole, very little air is able to mix with the gas. The gas does not burn well as it is the oxygen in air that is needed for fire to burn. It produces a pale yellow flame that is easily visible and relatively cool. This is shown in Figure 1.1.10. For these reasons, the yellow flame is called the **safety flame**. It is also a dirty flame, because it leaves a layer of black carbon soot on anything that is heated in it.

FIGURE 1.1.9
The Bunsen burner



If you *open* the airhole, then a lot of air will enter, which means a lot more oxygen is able to enter. The gas will burn with no smoke, and will be extremely hot (about 1500°C). This flame is noisy. It has a blue colour and is sometimes difficult to see. At the very base of the flame, there is a small cone of unburnt gas. As Figure 1.1.10 shows, the hottest part of the flame is just above this cone.

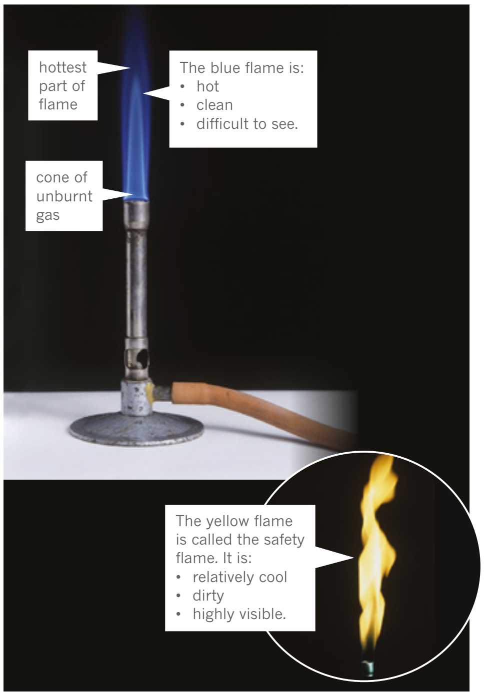


FIGURE 1.1.10 The yellow flame is easy to see and relatively cool. The blue flame is much hotter and almost invisible. This makes it much more dangerous.

AB 1.2

Other equipment used for heating

A kitchen stove isn't very useful unless you have frying pans, saucepans, tongs and stirring spoons to help you cook the food safely. A hotplate and Bunsen burner also need additional equipment to help you heat objects safely. Some of this equipment is shown in Figure 1.1.11.

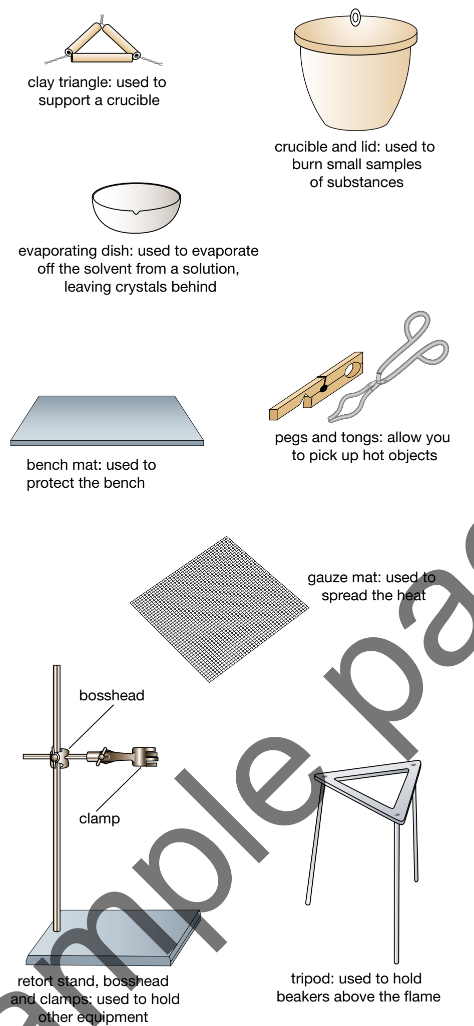


FIGURE 1.1.11 The hotplate and Bunsen burner need additional equipment to make them useful.

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Practical investigations

Prac 2, page 12, teaches students to light a Bunsen burner correctly.

Prac 3, page 13, investigates the properties of the Bunsen burner flame.

Skills support

Pearson Skills: Science and Inquiry 1 has additional support for Working in the laboratory and Heating water.

Activity Book

1.2 *The Bunsen burner* covers the identification of parts and use of this equipment.
1.3 *Identifying laboratory equipment* is a mix and match activity of sketches, 2D cross-sections and equipment names.

Weblinks

Lab safety rules
More about the Bunsen burner

Questioning

Safety

MI: Verbal/Linguistic, Logical/Mathematical

Ask students in pairs the following questions before getting into safety.

1. Why do safety rules always need to be followed in a science lab?
2. What are some features of a safe science lab?
3. What safety rules do you have at home?

Catering for diversity of learners

PROCESS DIFFERENTIATION

Role play

MI: Visual/Spatial, Verbal/Linguistic, Interpersonal, Bodily/Kinaesthetic

Divide students into groups of three and give each a role play based on something that may happen in the science lab. The audience must identify what the students are doing wrong in each role play, and create a rule to avoid this happening.

Alternative extension activity

Questions about Michael Faraday

MI: Verbal/Linguistic, Intrapersonal

Ask the extension students to complete this activity instead of the Role play activity.

Using the internet and other resources, investigate the British scientist Michael Faraday.

1. What type of scientist was he?
   Physicist and chemist
2. He also played a part in inventing the earliest form of a device used in most laboratories today. What is it?
   The Bunsen burner
3. Michael Faraday was a British physicist and chemist whose combined expertise led to the development of many of today's common technologies. List one example.
   He invented electromagnetic rotary devices that were vital in the creation of electric motors and played a key role in the development of electricity for use in technology.

CHECKPOINT

Students can now answer Module 1.1 Review questions 1, 5, 6, 7, 11, 12, 15, 17, 18, 20, 21 and 22.