2
CLASSIFICATION

The Earth is teeming with life. Approximately 1.8 million known types of organism (living thing) on the Earth have been described and named. Scientists estimate there are 10–30 million other kinds of living things that haven't even been discovered yet. Scientists use classification to organise this diversity of life forms (biodiversity) in a logical fashion. Classification is an example of a system that scientists have created, and continue to develop, to help us better understand the world.

CLASSIFYING LIVING THINGS 2.1

Classifying is a tool that is not restricted to the study of science. You probably classify things every day without really being aware of it. Classification is the process of separating items based on similarities and differences.

Students:

» Identify the purpose of classification
» Classify living things based on structural similarities and differences
» Explain how features of some Australian plants and animals are adaptations for survival and reproduction

USING KEYS AS TOOLS FOR CLASSIFICATION 2.2

Once items have been classified, we can work backwards using what we already know to identify unknown items or organisms.

Students:

» Use the Linnaean classification system to name organisms (additional)
» Use keys to identify plants and animals
» Construct simple identification keys (additional)
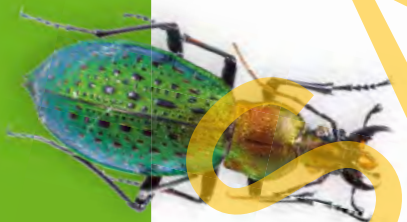
CLASSIFICATION TODAY 2.3

All known living things have already been classified. Using this information, new species that are discovered can also be classified based on the key features they have in common with known species. How life is classified can change as new scientific discoveries are made.

Students:

» Outline the features used to group plants, animals, fungi and bacteria
» Identify groups of microorganisms
» Identify where classification has changed because of new evidence (additional)

2.1 CLASSIFYING LIVING THINGS

Every year, scientists are discovering plants and animals that have never been seen before. What if you were to find a new organism at your school? How would you know that no one else had discovered it? Could you describe it so that people on the other side of the world understood what it looked like and how it behaved? How would you know if it was alive?

THE PURPOSE OF CLASSIFICATION

Classification is the process of organising objects or living things based on their similarities or differences in characteristics. Classification allows us to better understand the living world by helping us to:

- identify living things
- understand the history of living things on Earth
- show what is similar and different among living things
- communicate precisely, accurately and more easily.

The features, or criteria, we use to group living things are very important to the usefulness of a classification system. Biologists study the structures and functions of organisms. They also investigate how organisms reproduce. These features are used in classification.

For example, **botanists**, scientists who study plants, use the structure of flowers to group them—this feature is important to the reproduction and distribution of many land plants. **Zoologists**, scientists who study animals, describe a group of mammals that give birth to live young in a relatively developed state as placental mammals. Humans are one example of a placental mammal.

ACTIVITY 2.1.1: WHO AM I?

Choose a partner to work with. Describe an animal to your partner—make sure you don't use the animal's name. Your partner should try to draw the animal you describe. How accurate are they? Now your partner draws an animal while you try to guess what it is. How quickly did they guess your animal?

- How effective are word descriptions and drawings for communicating specific information about new species?
- What are the problems you can identify?
- How might some of these problems have been overcome in more recent times?

Early classification

Early scientists didn't have the technologies to make or send exact images of their discoveries. Most of their communication was written as papers or letters, sent around the world to other scientists. They had to make illustrations and written descriptions of the plants and animals that they saw, and not all of them were great artists. Often, without knowing it, two scientists described the same organism that was at different stages of its life. Imagine finding a tadpole and a frog for the first time—how would you know they were the same animal?

Figure 2.1 Early scientists used illustrations to help them communicate.

Figure 2.2 The 25–30 mm juvenile Eastern Blue Groper (a) could easily have been originally classified as a different type of fish to the 1.2 m adult (b).

To devise a useful classification system, scientists had to find a way to communicate that would make misunderstandings less likely. They needed to agree on common words they could use to describe certain characteristics, common languages for scientific papers and common processes for finding, describing and communicating their work.

The Greek philosopher Aristotle (384–322 BC) is considered by many to be the grandfather of classification. He found that each small township near his home had its own list of favourite plants and animals, described and ordered for its own purposes. He decided that this information should be shared and he set about finding a logical way to collect it. He sent his students out to gather local samples and stories. More than 500 types of plant and animal were collected and arranged in order of importance, according to where they lived and their shapes. Aristotle ordered them from what he thought was least important (rocks) to the most important (wild animals, men, kings, fallen angels, angels and God). He divided animals into those with blood (cats and dogs) and those that he thought had no blood (insects, worms and shelled animals).

For many years, other scientists used Aristotle's classification system. Nearly 2000 years later, early explorers travelling to new lands found more new and different species—too many to fit into Aristotle's 500 classification groups. They also questioned some of the groupings—were rocks alive and should angels and God be included in this system? Over the next hundred years a number of scientists developed new ways of describing and grouping living things.

Table 2.1 Scientists' contributions to the classification system throughout history.

Scientist	Improvement to classification
Andrea Cesalpino (1519–1603)	Classified plants into groups according to their trunks and fruits.
John Ray (1627–1705)	Suggested that each scientist needed to observe an organism over the whole of its lifespan.
Augustus Quirinus Rivinus (1652–1723) and Joseph Pitton de Tournefort (1656–1708)	Suggested using a hierarchy of names. This meant starting with large general groups (like plants and animals) and then making each group smaller and smaller depending on its characteristics. Each organism had a long Latin name that described the characteristics of each level of the hierarchy. For example, a human would be described as an animal that breathes air, lives on land, has two legs and two arms, can give birth (if female) to live young that drink milk from their mother, has body hair, stands upright, uses tools and can speak.
Carolus Linnaeus (1707–1778)	Changed the descriptions to single words and reduced the number of classification groups to seven. His system is still used today. It is occasionally modified as new organisms are discovered and as we learn more about the organisms we already know.

Discovery of microworlds

After the invention of the first crude microscopes in the 17th and 18th centuries, science took off in a new direction. Fascinating tiny creatures that nobody had ever seen before were being discovered all over the world. New classification systems were needed to make room for these organisms.

The first person to discover microscopic organisms was a Dutch scientist named Antonie van Leeuwenhoek (pronounced Lay-ven-hock) in the late 17th century. His first discoveries gave him quite a shock.

One day, van Leeuwenhoek noticed that his local water supply looked greenish and had begun to smell. He decided to look at a drop of the water with the microscope he had just made. At first, he saw plant-like things containing long strands and tiny green globules floating gently about. But mixed in among the globules were a host of tiny creatures (that he named 'animalcules') darting to and fro. No doubt he began to wonder what he had been drinking every day!

'If these tiny creatures lived in water', he thought, 'I wonder if they live inside us?' He then examined the plaque between his own teeth. He also collected plaque from some other people (including one man who had never cleaned his teeth in his life). If the water-borne organisms looked frightening, imagine how van Leeuwenhoek felt when he saw enormous numbers of tiny organisms swimming around in the material taken from his own mouth. Van Leeuwenhoek is thought to be the first person ever to see **bacteria**.

The development of the microscope also led to another important discovery—all living things are made up of **cells**. You will learn more about cells in chapter 3.
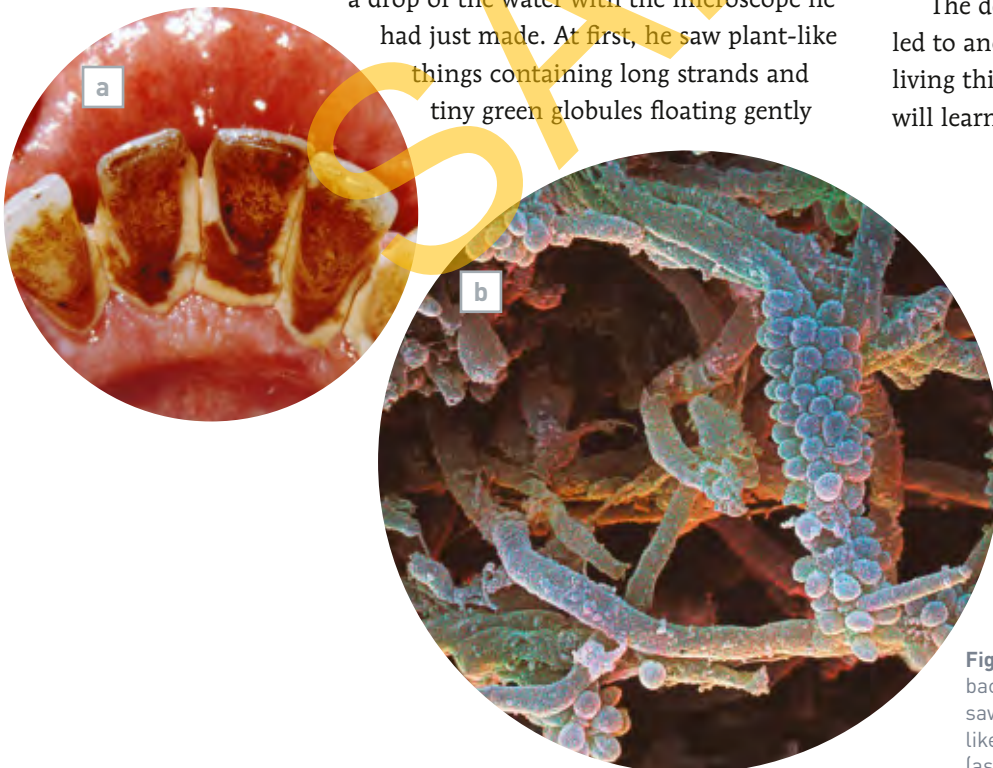
Figure 2.3 (a) Dental plaque contains bacteria. (b) What van Leeuwenhoek saw that gave him nightmares: bacteria like these were living in his own mouth (as they do in yours).

Use a light microscope set up by your teacher and prepared slides to look at a range of microorganisms such as yeast and algae. Observe the differences between cells. Draw at least two different types of cells as accurately as you can, including any key structural differences. Label your diagrams. If you do not know the name of a particular structure, make one up for this exercise. Your teacher will give you its correct name later.

Write a brief description of each type of cell that you drew next to the appropriate diagram.

Compare your diagram and your written description with others in your class. Can you tell if you have drawn and described the same type of cells?

- What are some of the difficulties of using drawings and written descriptions to classify living things?
- Did you and your classmates use the same names for the cell structures? How does this affect communication between scientists?
- How could modern technology improve communication about classification?

Discovering new living things

You might think that scientists have identified all living things by now. They've been actively finding and classifying new organisms for hundreds of years. In fact, we will possibly never stop finding new types of organism, which is wonderful when you consider the benefits of such **biodiversity**.

Small groups of scientists are trying to find undiscovered plants in Brazilian rainforests before they are destroyed by logging and farming. Often large pharmaceutical companies from other countries support them. Why would companies on the other side of the world be interested in saving plants and animals in the rainforest? One reason is that we may one day need these undiscovered organisms. Many of the medications we currently use come from organisms. The antibiotic penicillin was discovered from a type of mould; aspirin comes from a substance in the bark of willow trees. The next painkiller could come from a small fungus in a rainforest, or from an insect that relies on the fungus for food.

Remember

1 Define the term 'classification'.
2 Aristotle was one of the first scientists to try to gather information from wide regions. Describe what method he used to organise all the observations from his observers.
3 Describe what an 'animalcule' is, based on van Leeuwenhoek's observations.

Apply

4 The earliest scientists did not have pens or paper. Hypothesise how they might have passed on the information they received. How accurate would it have been?
5 Investigate why Carolus Linnaeus simplified the classification system used by previous scientists.
6 Outline two reasons why scientists still classify organisms today.
7 Describe places where you see everyday examples of classification.
8 Explain why classification is useful.

Figure 2.4 The rainforests of Brazil contain many undiscovered plant species.

CLASSIFICATION OF LIVING THINGS

One of the first decisions most scientists have to make when classifying something for the first time is if it is alive. What does it mean to be alive? What is the difference between us and the chairs we sit on? Both plants and animals are considered to be alive. What do we have in common that makes us alive? Living things are more properly called **organisms**.

Characteristics of living things

It has taken many years of observation and discussion for scientists to develop eight characteristics that all organisms—plants, animals and even microorganisms like bacteria—have in common. To remember all eight characteristics, just remember the mnemonic (a memory trick to help you remember information) MR N GREWW.

Non-living things may have some of the characteristics of organisms, but will not have all eight, or will not be able to do some of them by themselves. For example, a steam train can move on its own and requires coal for its energy, but trains do not grow over time or make baby trains! So a train is a non-living thing.

M ORGANISMS CAN MOVE BY THEMSELVES

Cats chase mice, birds flap their wings as they fly and fish swish their tails as they swim. Animal movements are easy to see. But do plants move? Look at the leaves on an indoor plant—they usually face the window (a source of light). Turn the plant around so that the leaves face into a darker part of the room. In a few days, the leaves will again be facing the window. The leaves have moved by themselves. The sunflowers in Figure 2.5 turn their heads to follow the sun as it moves across the sky each day and carnivorous plants such as Venus flytraps will move to trap insects.

Figure 2.5

R ORGANISMS CAN REPRODUCE

Organisms can make new individuals that grow up to look like them. Animals like the elephants in Figure 2.6 mate and produce offspring, plants produce seeds that grow into new plants, and bacteria divide to produce more bacteria. Reproduction is the process by which living things make new life.

Figure 2.6

N ORGANISMS NEED NUTRITION

Organisms need nutrients to survive. Animals obtain most of their nutrients by eating food and drinking. Plants absorb nutrients through their roots and fungi feed on decaying organisms. Plants are **autotrophs**, which means that they make their own food using the energy from sunlight in a process called photosynthesis. Animals and fungi are **heterotrophs**—they rely on other living things for food like the snake in Figure 2.7.
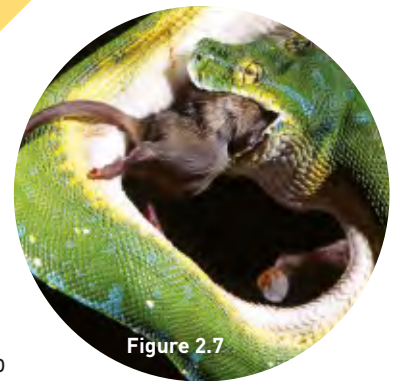

Figure 2.7

G ORGANISMS GROW AS THEY GET OLDER

All organisms grow during their lives. Mushrooms start off as tiny spores. Humans are born as babies, developing into children, teenagers and then adults. The tadpoles in Figure 2.8, will hatch from their eggs then metamorphose into adult frogs. In every case, living things, when fully grown, resemble those adults who produced them.
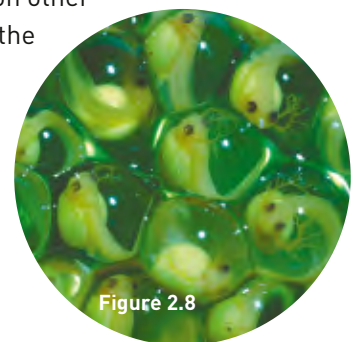

Figure 2.8

R ORGANISMS RESPOND TO STIMULI

When an animal realises it is being chased, like the antelope in Figure 2.9, it runs. It is responding to stimuli (the sight and sound of a charging predator) or to changes in its environment (the sudden brush of leaves or movement of shadows). The sunflowers shown in Figure 2.5 are responding to the changing stimulus of light and warmth. When you accidentally brush your finger against something hot, like an iron, you pull back—your body is responding to the stimulus of heat.

E ORGANISMS EXCHANGE GASES WITH THEIR ENVIRONMENTS

Plants and animals have organs and structures that allow them to exchange oxygen and other gases. Some animals, like humans, use their lungs to inhale and then exhale. Other animals, like fish and axolotls (Figure 2.10), have gills. Some animals, like worms, breathe through their skin. Bacteria are different to plants and animals: they do not have organs, but they still exchange gases. Some types of bacteria die in the presence of oxygen but use and produce other gases.

Figure 2.9

W ORGANISMS REQUIRE WATER

All organisms need water; it is required for many functions. For example, it transports substances in our bodies to where they are needed and it is involved in many important chemical reactions. In animals such as humans, it helps maintain body temperature. No wonder a large proportion of our body is water!

Figure 2.11

W ORGANISMS PRODUCE WASTES

We, like other animals, take in food, water and air to fuel our bodies. Chemical reactions occur in our bodies and wastes are produced as a result. We get rid of these by exhaling, sweating (Figure 2.12), urinating and defecating (emptying our bowels). Plants get rid of their wastes through their leaves.

If an organism could not get rid of its wastes, they would build up, become toxic and eventually cause the organism to die.

Figure 2.10

Figure 2.12

ACTIVITY 2.1.4: THE FIRE

Is a bushfire alive or not?

1   Work in a group of four, divided into pairs. One pair has to argue in favour of a fire being alive. The other pair has to argue that it is not alive.

2   Each pair has 5 minutes to come up with a list of characteristics that support whether a fire is living or not.

3   When the time is up, have a class discussion about whether a fire is alive or not, and perhaps whether other characteristics for classifying 'alive' may be required.

Non-living or dead?

Something classified as **living** needs nutrition and water, and is able to move by itself, reproduce, exchange gases, grow, respond to stimuli and produce wastes. If something doesn't have these characteristics it would seem logical to assume that the thing is non-living.

What about something that is dead? Something **dead**, such as a dried flower or an Egyptian mummy, was once living; when it was alive it did have the characteristics of a living thing. Something that is **non-living**, such as a computer or your watch, never had these characteristics.

All living things are made up of cells. Once that living thing dies, the cells remain, but they are no longer functioning. Dead things are usually distinguished from non-living things in that they are still made up of cells. The wood of a desk, for example, was once a living tree. If you were to examine the wood under a microscope, you would see that it is still made up of cells. A plastic chair contains no cells; it is made up of molecules of plastic. It is a non-living object. You will learn more about cells in chapter 3.

ACTIVITY 2.1.5: DEAD OR ALIVE?

Bakers use yeast (a type of microorganism) to help their bread to rise. The yeast cells use the sugar in the dough as nutrients and produce carbon dioxide, which causes the dough to rise. Yeast can also be bought as a dry powder.

Design an experiment to determine whether or not dried yeast is still alive.

• What key features of living things can you test for?

• What variables should you keep the same (controlled variables) to ensure you have designed a fair test?

• Discuss your method and results.

• Is dried yeast a living thing? How do you know?

• When you have finished, your teacher may give you a few research questions to complete.

DEEPER UNDERSTANDING

Encyclopedia of Life

Edward O. Wilson, one of the world's most well-known biologists, has taken on the seemingly impossible task of compiling a list of the nearly 2 million known species on our planet. He is developing an online database of all life on the Earth. The Encyclopedia of Life (EOL) aims to make all knowledge of the world's known species freely available to all. The initiative was launched on 9 May 2007. As new species are discovered they will be added to the database. Every species will have its own page, with links to all known information about that species.

The EOL will be a tool not only for scientists but also for students, teachers and the public to gain a better understanding of all life on the Earth.

Remember

1 The system scientists use to group things divides them first into two groups. Identify these two groups.

2 Apart from the eight characteristics of life, identify one other thing that all living things have in common.

3 Explain how to distinguish a non-living object from something that is dead, and how to distinguish a living thing from a dead thing.

Apply

4 Consider Table 2.2.

Table 2.2 Living or non-living?

	Eucalypt tree	Water	Paper	Robot	Leather belt	Wombat	Roast chicken	Computer virus
Moves by itself								
Reproduces itself								
Requires nutrition								
Grows as it gets older								
Responds to changes in its environment								
Exchanges gas (e.g. oxygen)								
Produces wastes								
Requires water								
Living or non-living?								

a With a partner or by yourself, decide if each of the items meets the requirement to be classified as a living thing.

b Decide if each should be classified as living or non-living.

5 Are any of the items in Table 2.2 dead? Explain your answer.

6 A mnemonic (pronounced nem-on-ic) is a memory aid. It is an especially good way to remember a list. A mnemonic takes the first letter of each word in a list and uses the letters to start words in a phrase. For example, the colours of the rainbow (red, orange, yellow, green, blue, indigo and violet) could be remembered using the phrase Rich Old Yankees Go Bowling In Vienna. Construct a new mnemonic to help you remember the eight characteristics of living things. You may change the order of the characteristics to help you make a phrase.

7 Apply the characteristics of a living thing to describe a bushfire.

8 Is a bushfire alive? Justify your answer.

9 Which characteristic is the most essential for an organism to be classified as living? Justify your answer.

10 Is there another characteristic you would include in determining alive versus non-alive? Explain your answer.

ADAPTATIONS FOR SURVIVAL AND REPRODUCTION

Plants and animals need to be suited to the area where they live if they are to have the best chance of survival. The survival of a species relies not only on the individuals of the population living healthy lives, but also their ability to reproduce healthy offspring. We say that they are adapted to live in these areas. The features that help them survive are called **adaptations**. Adaptations are key features of an organism and are often used to classify and identify them.

Adaptations can be physical, like the thick fur on a platypus's body to keep it warm, or behavioural, such as foraging for food at night to avoid predators. Adaptations can be to do with successful mating or rearing of offspring. Most adaptations help an organism to function more effectively or efficiently in some way.

ACTIVITY 2.1.6: DESIGNING AN ANIMAL

Design an animal that fits the following description. Try not to base your animal on any that you already know—consider this an alien. Present a labelled diagram to the class, explaining how the various features of your animal make it suited to its lifestyle.

Waking as the sun goes down, this small animal climbs nimbly through the trees, trying to avoid detection by making sure it doesn't rustle leaves. It cleverly taps the bark of tree trunks, checking for hollow spots where it is most likely to find insect nests hidden beneath the surface. With skill and agility, it creates an opening and sucks the insects out, feasting for several minutes before moving on. As the sun begins to return, this animal becomes invisible to the predators of the day.

Animal adaptations

The echidna has strong claws, which it uses to dig for termites and ants. Its snout can smell and feel for its prey, and its sticky tongue catches the termites and ants inside their nests. Having no teeth, the echidna instead crushes its food between the roof of its mouth and the base of its tongue. The soil drawn in with the termites and ants also helps with the crushing.

Echidnas have two types of hair: the obvious type being sharp spines for defence against predators, the other is fur-like hair for insulation. The echidna lays eggs like birds and reptiles but carries them in a pouch like a marsupial. This adaptation allows the female echidna to continue foraging for food while incubating eggs and caring for the immature young.

The long snouts, sticky tongues, toothless mouths, claws for digging, spines for defence and egg laying are all physical adaptations that increase the echidnas' chance of survival in their environment.

The water-holding frog of central Australia lives in an environment where rainfall is unpredictable and the climate is harsh. It wraps itself in a cocoon of dead skin cells and buries itself underground. Water is stored in the bladder or in pockets under the skin. The frog can spend up to seven years underground without water. After heavy rain, the frog comes to the surface, refills its water supplies, mates, feeds and then burrows again until the next rains.

Several animals demonstrate very interesting behavioural adaptations. Male emperor penguins huddle in large groups to protect themselves from the extremely cold winds in Antarctica. They take turns being on the outside to give everyone the best chance of survival. Many of these penguins hold an egg on top of their feet at the same time, protecting it from the freezing temperature of the ice below.

Figure 2.13 Echidnas are adapted to eating ants and termites.

Figure 2.14 The water-holding frog can survive without rain for up to seven years.

Figure 2.15 Emperor penguins huddle together to stay warm.

Plant adaptations

Plants also have many adaptations. Many rainforest plants have shiny, waxy leaves with a 'drip tip' on the end to drain the rainwater quickly. The rainforest soil is usually shallow, so the bigger trees have buttress roots to help prevent them from being blown over in a strong wind. Desert plants need to lose as little water as possible during the hot days but gain as much water as possible when it rains. Some desert plants have small, rolled-up leaves, which do not get as hot as large, flat leaves. Other desert plants have spiky leaves or leaves covered with small hairs. These physical adaptations prevent the leaves from getting too hot and from losing too much water.

Perhaps the most spectacular adaptation is that of Australian plants to the dry conditions in Australia. Plants can neither run nor hide from fire as it comes sweeping through the bush. Their ability to handle fire sets them apart from plants of other regions in the world. Not only are some of our plants adapted to fire, some plants cannot exist without it.

Many eucalypt trees can reshoot after damage by fire. The trees shoot from buds that are found just below the bark called epicormic buds. They can also shoot from large underground rootstock called lignotubers. Other Australian plants, like the woollybush of Western Australia, have fire resistant seeds. While the adult trees burn, the seeds are protected. They sprout after the next heavy rains and germinate in soil that is very fertile thanks to the ashes of the previous generation. Banksia seeds often cannot germinate (sprout) unless they have been exposed to the extreme heat of a bushfire. However, these plants often take many years to mature. So if there is another fire before they are old enough to produce their own seeds, that species may be wiped out in that area.

Figure 2.16 The blue quandong has buttress roots to help prevent it from being blown over.

Figure 2.17 Cactus plants have spikes or hairy leaves to prevent them from losing too much water.

Figure 2.18 These eucalypts have resprouted after fire from epicormic buds under their bark.

ACTIVITY 2.1.7: EUCALYPT ADAPTATIONS

What you need: nuts, leaves and bark of a eucalypt

1. Place the nuts in a 40°C oven for 24 hours to open and shed their seeds. Each of these thick woody capsules contains hundreds of tiny seeds.
   - Why is the seed of the gumnut protected with such a thick external capsule?
   - What might trigger the release of the seed from the gumnut?
2. Feel the leaves of the eucalypt. They have a thick cuticle that is effective in preventing water loss.
   - Why would this be an advantage to the plant?
3. Hold a leaf up to the light or under a binocular microscope. Notice the numerous small dots. These are oil glands in the leaf.
   - What is the function of the oil glands in a eucalypt leaf?
4. Have a close look at the bark of the tree. In a lot of eucalypt trees it is thick and fibrous.
   - What are some of the functions of bark?
   - Explain how all of these adaptations you have examined help the eucalypt to survive in Australian climates.

Figure 2.19 A Wollemi pine in the Wollemi National Park.

Living fossils

Environments can change naturally, and they can be changed by humans. This places new environmental conditions on existing adaptations. Changing environmental conditions may no longer suit the adaptations of an organism, which may cause the organism to die. If no members of the population or species are suited to their new environments then the whole species might become extinct. However, some isolated habitats might remain favourable so that some organisms of a species can survive, even though everywhere else around has changed.

During 1994, material was collected from a strange-looking tree growing in a deep gorge within Wollemi National Park in the Blue Mountains in New South Wales. The total population of 40 adult trees and 130 seedlings all existed in this one gorge. The tree turned out to be a very old species, which was named the Wollemi pine. It is one of the oldest and rarest plants, dating back to the time of the dinosaurs. The Wollemi pine shows that some isolated animals and plants can survive almost unchanged if the conditions they are living in don't change.
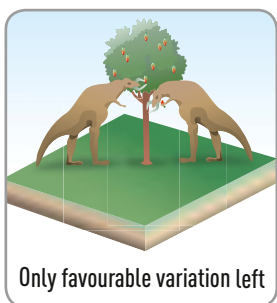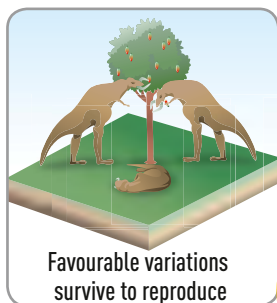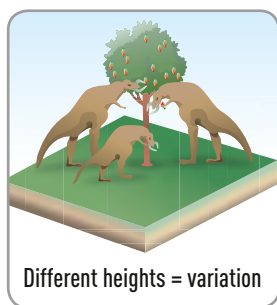
How adaptations arise

Physical adaptations rely on variation already existing in a population. If food was running out and there was the possibility of getting food from the top of a tree, an animal might be able to teach itself to climb but it certainly couldn't just grow longer legs or a longer neck.

You might have heard of the phrase 'survival of the fittest'. This has very little to do with being able to run a race. In this phrase, being 'fit' means 'suited to the environmental conditions'. Looking around your classroom, you will notice that even though you're all human and about the same age, you're all slightly different. This is a really good thing because it means you all have strengths and weaknesses in different ways. The same applies to all organisms.

In a population of animals that are all of slightly different heights, perhaps some will be able to reach the food at the top of a tree. This might mean that everyone gets to eat or it might mean that only those that are tall enough to reach this food get to eat. Either way, if you eat, you live long enough to reproduce, passing your features to the next generation. If you don't eat, you probably won't live long enough to reproduce and your particular features may be lost from the population. Over time, if the food availability stays the same, the population is likely to become taller because only the tall members of the species are reproducing.

Physical adaptations may take a long time to happen and so many species face extinction if their population doesn't adapt fast enough.

Different heights = variation

Favourable variations survive to reproduce

Only favourable variation left

Figure 2.20 Variations provide options for species when environments change.

Figure 2.21 No two individuals within a species are exactly the same.

Thinkers' keys

Thinkers' Keys (by Tom Ryan) are strategies that challenge us to think in different ways. Try using the Thinkers' Keys approach to think differently about life on the Earth.

The reverse listing key

Name ten things that a non-living thing could never do.

The 'what if' key

What if living things did not exist? What would the Earth be like?

The question key

The answer is 'single-celled organism'. Think of five questions that give only that answer.

The construction key

Use materials from around your classroom to construct your own type of classification key.

The combination key

Make a list of all of the attributes of plants and animals. Combine the attributes of these two things to create a new and better type of organism.

The disadvantages key

Make a list of the possible disadvantages of classifying things into groups. Suggest ways to correct or eliminate each disadvantage.

The prediction key

Predict what types of organism might be discovered in the next 20 years.

The alphabet key

Prepare a list of words from A to Z that describe things that a living thing can do.

The commonality key

What do living things and non-living things have in common?

QUESTIONS 2.1.3: ADAPTATIONS FOR SURVIVAL AND REPRODUCTION

Remember

1 Explain what 'adaptation' means.
2 Identify some features of desert plants that are adaptations.
3 Identify the differences between behaviour adaptations and physical adaptations.
4 Define the term 'lignotubers'.

Apply

5 Explain how adaptations help an animal to survive.
6 Investigate how these adaptations of a bilby are useful:
    a nocturnal
    b lives in a burrow
    c large ears
    d very concentrated urine.
7 Suggest reasons to explain why a species or population with a long life cycle is likely to take much longer to physically adapt to an environmental change than the same one with a short life cycle.
8 Tabulate all the adaptations mentioned in this section, ensuring that you identify each adaptation as either chemical, behavioural, structural or otherwise.

Research

9 Research some other examples of living fossils. Present your research in the form of a pamphlet.

CLASSIFYING LIVING THINGS

Remember and understand

1 Identify the eight characteristics of living things. [1 mark]

2 Define organism. [1 mark]

3 Outline the key differences between something that is dead (i.e. once living) and something that is non-living. [1 mark]

4 Describe an example of plant movement. [1 mark]

5 Recall what a living plant needs to survive. [1 mark]

6 Explain why it is important for scientists to use a common system to group all living things on the Earth. [1 mark]

7 Recall some adaptations that eucalypts have to help them survive fires. [1 mark]

8 Copy the table shown. Classify the items in the following list by placing them in the correct columns: *stewed apple, iPod, daffodil bulb, DVD, hairs in your brush, your teacher, shark's tooth, germs, soft drink bottle, your pet, silver chain, dinosaur skeleton* [3 marks]

Living		Non-living
Currently living	*Dead*	

Figure 2.23

Figure 2.22

Apply

9 Plants are autotrophs (i.e. they make their own food), so why do they need other nutrients? Explain your answer. [2 marks]

10 Possums (Figure 2.22) come out at night and move around in trees. Identify what type of adaptation this is. Examine what other examples of adaptation they might have to support their survival. [2 marks]

11 Imagine that an unknown organism was discovered during a space mission and brought back to Earth. Briefly outline two different methods that scientists could use to decide if it was living or non-living. [2 marks]

12 Drawing accurate scientific diagrams of plants and animals is time consuming and difficult. Describe what method scientists would use today to show what an organism looks like. [1 mark]

13 A tapeworm (Figure 2.23) has many unusual adaptations. Suggest a reason for the following adaptations:

   a hooks around its 'head' [1 mark]

   b suckers [1 mark]

   c its flat body [1 mark]

Analyse and evaluate

14 Suggest at least two reasons why we need to classify living things. [2 marks]

15 Explain how adapting to the environment helps a species reproduce and survive. [2 marks]

16 Look at Table 2.3, showing the number of living things on the Earth.

a Identify how many species of plant are estimated to be on the Earth. [1 mark]

b Compare the number of known plant species with the total number of known animal species (add animals without a backbone and animals with a backbone together). Why do you think this might be the case? Explain your reasoning. [2 marks]

Table 2.3 Types and numbers of living things on the Earth.

Group	Number of species described	Number of species estimated to exist	Percentage of total estimated number of living things (%)
Animals with internal backbones (vertebrates)	64 788	80 500	0.7
Animals without backbones (invertebrates)	1 359 365	6 755 830	61.8
Plants	297 857	390 800	3.6
Fungi	98 998	1 500 000	13.7
Bacteria (monerans)	35 351	>1 200 500	11
Algae and protozoa (protists)	28 871	>1 000 000	9.2
Total number of species	1 885 230	>10 927 630	100

Source: Chapman, A.D., *Numbers of Living Species in Australia and the World*, 2nd ed., September 2009

Research

17 Do an Internet search for an image of a recently discovered species. Can you use the Internet to find how scientists classified the species (i.e. its scientific name)? [1 mark]

18 One of the main contributors to the *Encyclopedia of Life* is the *Atlas of Living Australia*. Do an Internet search for the *Atlas of Living Australia* and click on 'Explore'. From this page you can construct a species list and map for the area in which you live.

a Investigate the most frequently seen animal in your area. [1 mark]

b Identify the most frequently seen plant in your area. [1 mark]

Critical and creative thinking

19 Design an experiment to show that plants are living things that respond to stimuli. Choose one stimulus only (such as reaction to light or to lack of water) to investigate. This stimulus is the experimental variable, so you will need to change the variable in some way and control the rest of the variables in the experiment. Make a list of the equipment you would need. Describe any safety guidelines you need to follow. [5 marks]

20 Write a short story of 500 words to describe the chaos in a large library that operated with no system of classification. Try to make it humorous. [5 marks]

Making connections

21 Investigate why the invention of the microscope was important to the development of the classification system. How did it change the number of organisms for identification, classification and communication? [5 mark]

2.2 USING KEYS AS TOOLS FOR CLASSIFICATION

Scientists group or classify the millions of living things on the Earth so that they can see similarities and differences between organisms. This system helps scientists to communicate with each other when describing the characteristics and behaviour of living things. Once these levels of classification have been described, they can be used to identify an unknown organism.

THE LINNAEAN CLASSIFICATION SYSTEM

When you were younger, did you ever send a letter to a friend with your address on the back of the envelope written like Figure 2.24?

If you read this address from the bottom up—from 'The Universe' to the house number—each line is like a level of classification. As you go up each level, the classification becomes more specific and the recipient becomes easier to locate. It is a bit like focusing in on your house on Google Earth.

Figure 2.24 Did you ever address a letter like this?

You may start with the whole country, but each country has states, then towns, suburbs and, finally, streets and buildings.

Giving organisms a precise name

While many taxonomists developed different methods of classifying living things, it is the work of Swedish scientist Carolus Linnaeus from the mid-1700s that is still used today. The Linnaean Classification Hierarchy works in a similar way to the address in Figure 2.24. While the levels of the Linnaean Classification Hierarchy are relatively unchanged, the numbers of groups within each level and their defining characteristics have been and continue to be refined as research and technology improves.

The Linnaean system for classifying all living things starts with large groups called **kingdoms**, and then divides into smaller groups called **phyla** (singular: phylum). Each phylum has several classes. The classes have **orders**, and so on. There are seven different levels to get to the final name of each organism. They are kingdom, phylum, class, order, family, genus and species, with each level having fewer types of organisms that belong in them.

Figure 2.25 Carolus Linnaeus

ACTIVITY 2.2.1: GROUPING ANIMALS

Locate, print and cut out the images of 20 very different animals.

Decide on the most appropriate features for grouping these animals. For example, fat and thin tends to be related to lifestyle rather than the type of animal, so it is not a good feature to use in classification.

Use these groupings to come up with a key for your animals.

Did anyone in the class use similar characteristics to you when grouping their animals? How do you think this is similar or different to the way scientists would work? Do you think your levels of classification match Linnaeus' classification hierarchy?

Linnaeus's double-name system

Have you eaten a *Musa sapientum* lately? And did you pat your *Canis familiaris* this morning? These are the kinds of double name given to every living thing using the Linnaean classification system.

Our homes can easily be found by using only the two smallest groups in the address (the street and the suburb). The information about the bigger groups, like the Earth and the Universe, is not really necessary. In much the same way, an organism can also be named from the two last groupings on the Linnaean dichotomous key—the **genus** and the **species**.

In the double-name system, the genus group name always starts with a capital letter. The second word is the species name and it does not have a capital letter. The double name is always written using italics (sloping letters), or underlined when written by hand.

A species is a group of organisms that have similar characteristics to each other. When they breed in natural conditions, their offspring are fertile (they can also breed). All domestic dogs belong to the one species because, even though they look very different, they can breed together and have puppies.

More than 500 000 organisms have already been given a double name (also called a **binomial name**) and can be easily found in the Linnaean classification system.
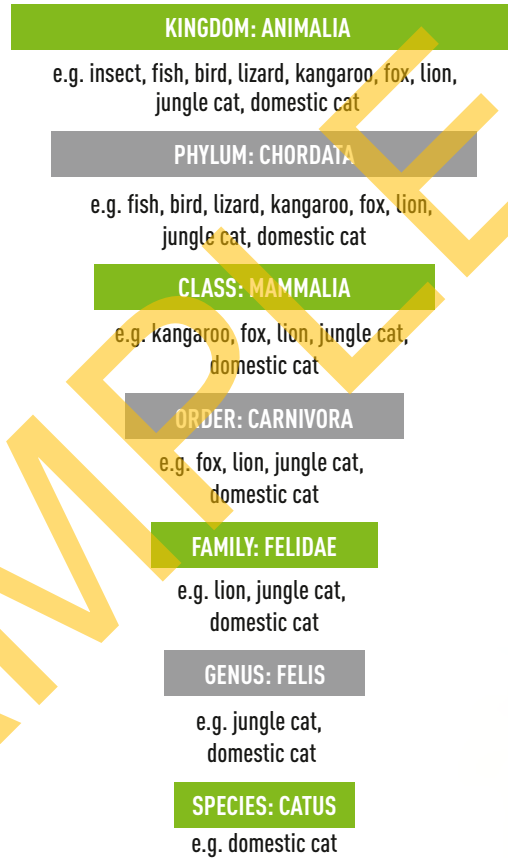
KINGDOM: ANIMALIA
e.g. insect, fish, bird, lizard, kangaroo, fox, lion, jungle cat, domestic cat

PHYLUM: CHORDATA
e.g. fish, bird, lizard, kangaroo, fox, lion, jungle cat, domestic cat

CLASS: MAMMALIA
e.g. kangaroo, fox, lion, jungle cat, domestic cat

ORDER: CARNIVORA
e.g. fox, lion, jungle cat, domestic cat

FAMILY: FELIDAE
e.g. lion, jungle cat, domestic cat

GENUS: FELIS
e.g. jungle cat, domestic cat

SPECIES: CATUS
e.g. domestic cat

Figure 2.26 The Linnaean classification system uses seven different levels. It is used to give scientific names to living things such as the domestic cat, *Felis catus*.

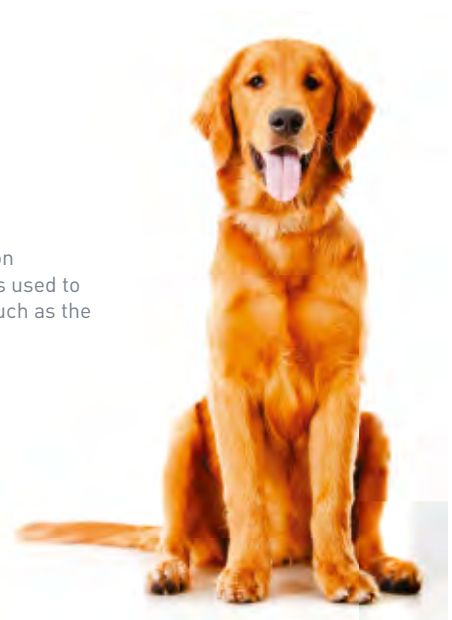**Figure 2.27** *Musa sapientum* is the Linnaean binomial name for a banana.

Figure 2.28 *Canis familiaris* is the scientific name for the domestic dog.

Understanding scientific names

The scientific names of most living things usually come from Latin (and sometimes Greek) words. Why use Latin? The language of science for many centuries was Latin. This enabled scientists who lived in different countries and spoke different languages to use a common language to communicate their work and discoveries.

The words used describe physical features, behaviours and even colours of organisms. Some basic understanding of Greek and Latin will help you to interpret scientific names. Table 2.4 contains some examples.

Table 2.4 Some scientific words and their meanings.

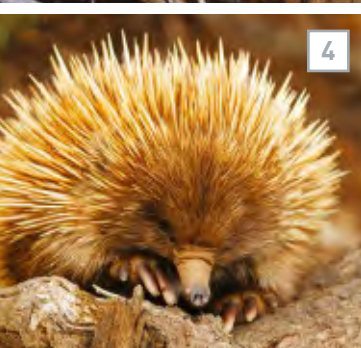| Latin/Greek root word	English meaning
Aculeat	Spiny
Ornitho	Bird
Arctus	Bear
Phascol	Pouch
Anatinus	Duck-like
Pus	Foot
Cinereus	Grey
Rufus	Red
Gloss	Tongue
Tachy	Fast
Rhynchus	Snout
Chlamy	Caped
Macro	Large
Saurus	Lizard

Figure 2.29
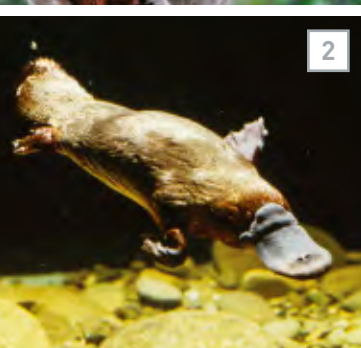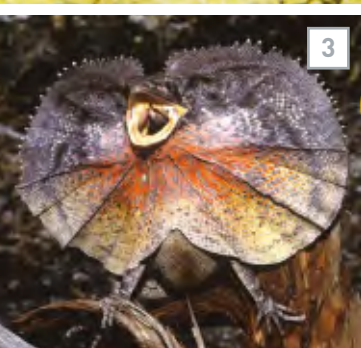
QUESTIONS 2.2.1: THE LINNAEAN CLASSIFICATION SYSTEM

Remember

1 Identify who invented the naming system that is still used today to name living things.

2 Identify the first level of the Linnaean classification system under 'All living things'.

3 Mnemonics are often used to help you remember things. Create your own to remember the seven levels of classification.

4 Define the term 'species'.

Apply

5 Apply the information in Table 2.4 to match the scientific names of these Australian animals with their pictures in Figure 2.29.

    a *Macropus rufus*

    b *Tachyglossus aculeatus*

    c *Phascolarctus cinereus*

    d *Ornithorhynchus anatinus*

    e *Chlamydosaurus kingie*

6 What do you think a *Macroglossus aculeatus* might look like? Sketch this imaginary animal, using Table 2.4 to help.

7 Explain why giving your address as 'John Campbell, Southern Hemisphere, The Earth' would not be a good way to get many letters.

8 With the same idea from question 7, explain why taxonomists need a very detailed system like the Linnaean classification system to group living things.

9 Research the scientific names for three different animals. For each:

    a Work out their full classification

    b Describe their appearance

    c Determine what their scientific name means (some are more obvious than others) and whether this suits.

USING KEYS FOR IDENTIFICATION

When you visit an outdoor market, you may wander around for some time before you find what you want. An online store is more organised, with similar items grouped together in a menu. If you were looking for the latest movie to buy, you would first locate the entertainment section. In that section you will often find all the games, music and movies together. There might be several submenus of movies and the one you want might be in a section for latest releases. Scientists use classification systems to group objects or organisms together based on similar characteristics. Classification makes the names and descriptions of organisms easier to find.

Circular keys

Circular keys can also be used to separate and classify different things. With a circular key, you start off in the centre of the circle and follow the path that correctly identifies the features that you can see. Rather than the branches seen in dichotomous keys, circular keys contain everything within the circle. Each level of a circular key determines the next step that you will follow.
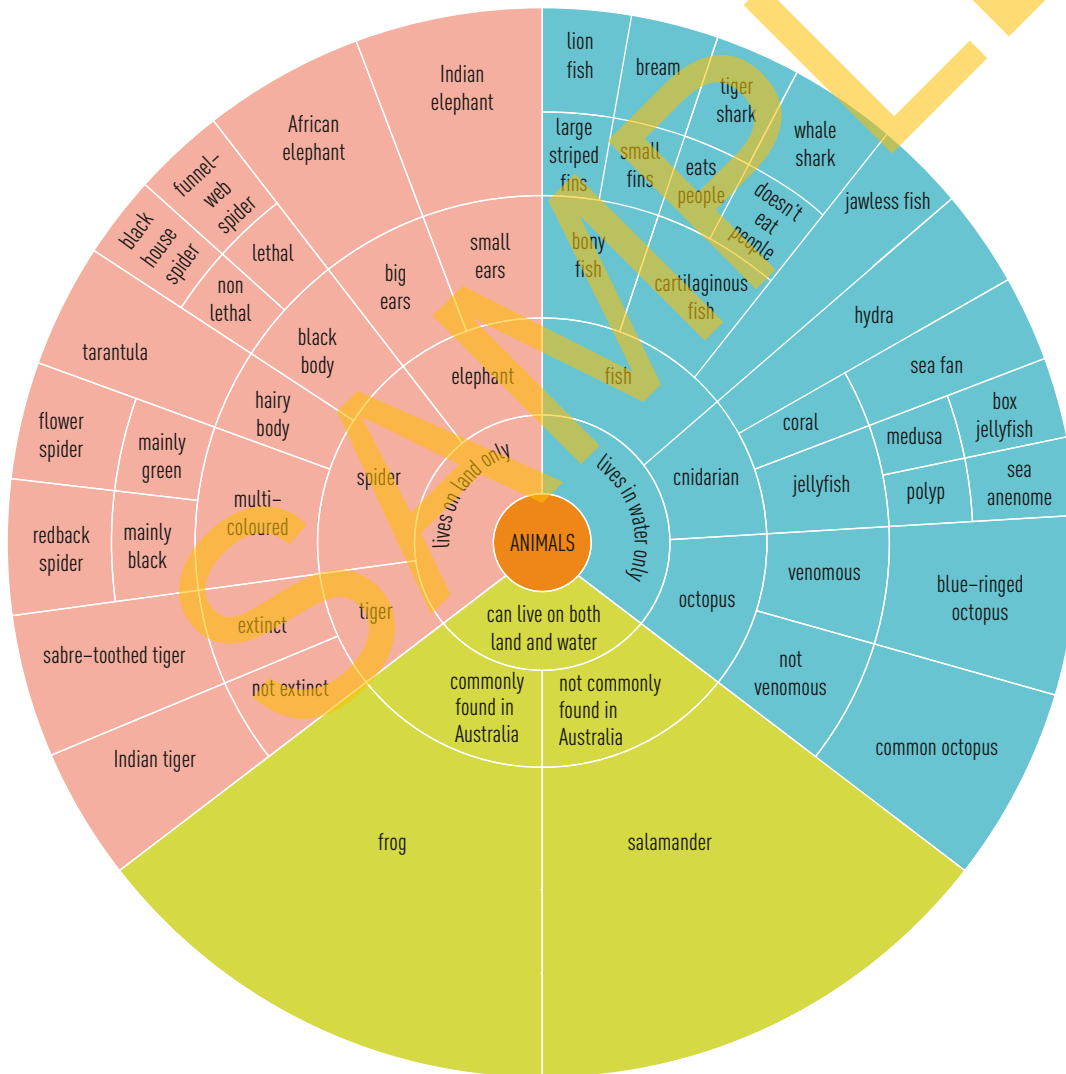

Figure 2.30 A circular key is another tool for classification.

Dichotomous keys

A **key** is a visual tool used in the identification of organisms. A key is often more useful than a list of characteristics and similarities of each group. One common type of key is called the **dichotomous key** (pronounced dye-COT-o-muss), named because the branches always split into two (di means two). Scientists use this type of key to make simple 'yes' or 'no' decisions. For example, does the animal have fur (yes/no)? Does it have scales (yes/no)? Each answer leads to another branch and another question. This key only works if someone else has already classified the animal. A newly discovered organism would need to be studied first and then new branches added to the key if appropriate branches do not already exist.

Dichotomous keys can be presented in various ways. A **branched key** (like a tree) helps us to see how a particular member of a group fits in with all the rest. The yes/no decision is made at the junction of the branches, and the endpoint is the name of the organism. Tabular keys contain the same information as branched keys but they are set out in a table or numbered list where you read through the numbered options in order. Each item presents two options, and more information is given at each step. Eventually the organism can be identified.

ACTIVITY 2.2.2: DR REDBACK'S FAMILY

Dr Redback loves to send out Christmas cards with the family photo on the front. One year, just for fun, he included a dichotomous key to help everyone identify all his family and pets. Use the picture of Dr Redback's family and the dichotomous key provided to work out who is who.
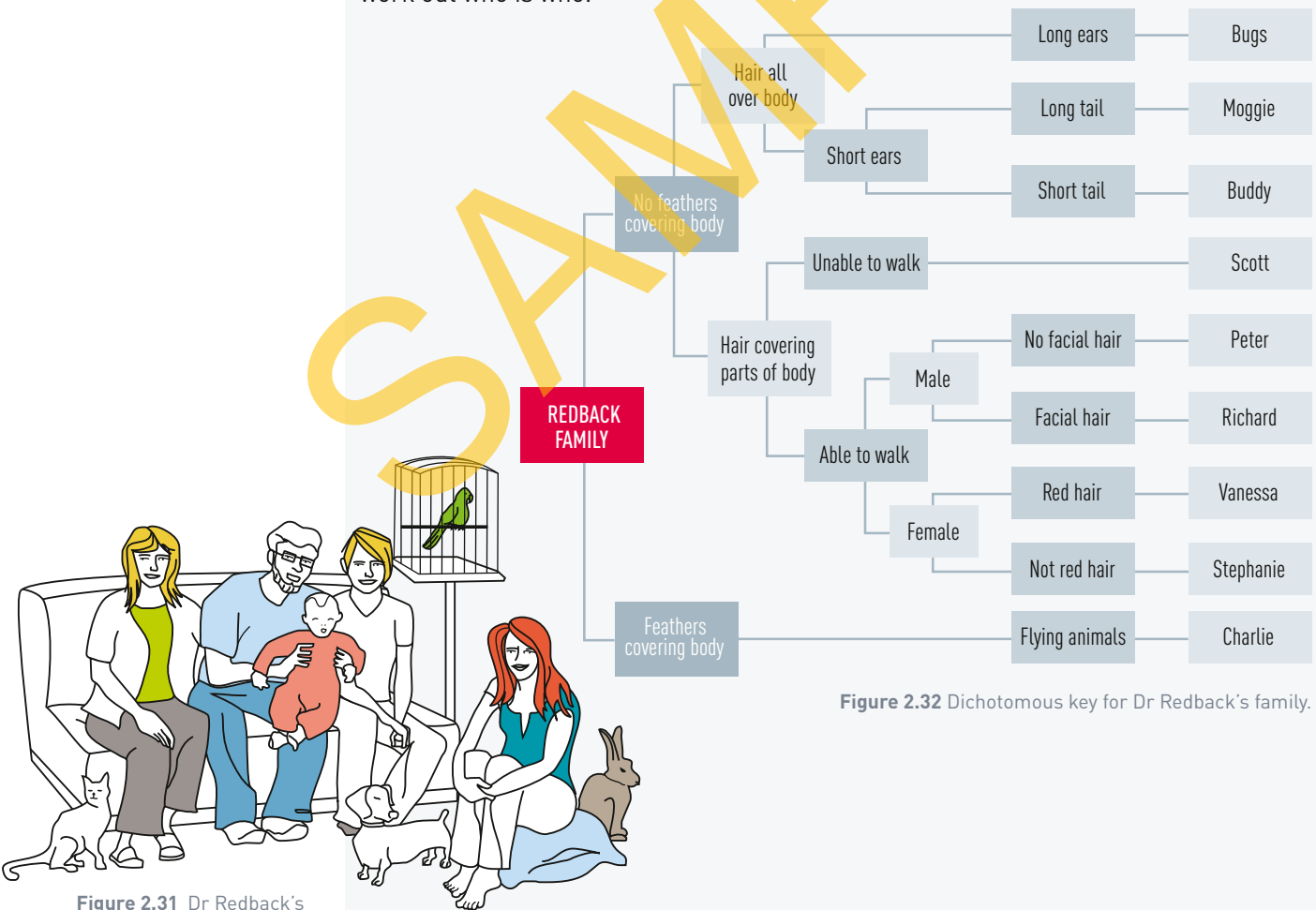

Figure 2.32 Dichotomous key for Dr Redback's family.


Figure 2.31 Dr Redback's family.

ACTIVITY 2.2.3: MAKING A TABULAR DICHOTOMOUS KEY

Scientists often use tabular dichotomous keys to determine the group to which an animal or plant belongs.

1 Use the following tabular key to identify the class of each of the animals shown.

1	Feathers present	Birds
	No feathers present	Go to 2
2	Hair or fur present	Mammals
	No hair or fur	Go to 3
3	Fins present	Fish
	No fins present	Go to 4
4	Has moist skin, no scales	Amphibians
	Has scales	Reptiles

2 Use the information given about Dr Redback's family in Activity 2.2.2 to create your own tabular dichotomous key.
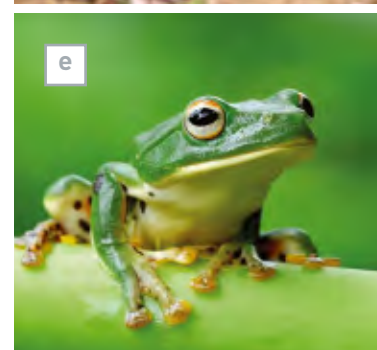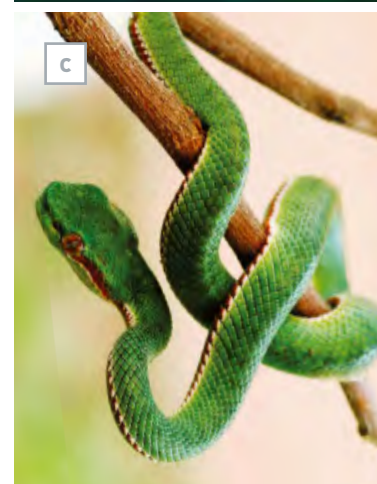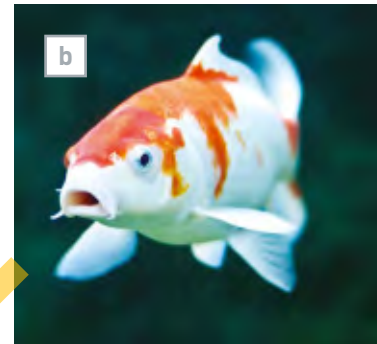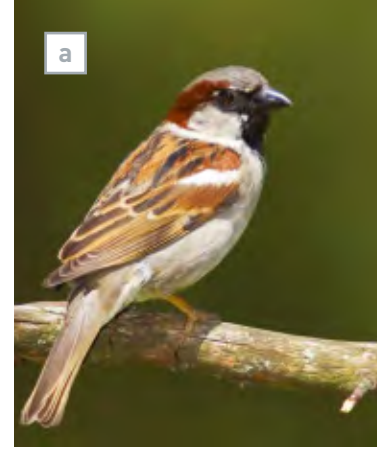
STUDENT DESIGN TASK

Dichotomous keys

Challenge

Using what you have discovered about the characteristics of living things, design your own dichotomous key.

Questioning and predicting

Think about objects that could be sorted into two groups. For example, you might like to use snack foods such as corn chips, flavoured chips or plain chips.

Planning

What similarities or differences can you find to separate the objects into two groups?

Conducting

What other similarities or differences can you find to separate the objects further? Keep dividing into two groups until each item is on its own.

Processing, analysing and evaluating

1 Draw a dichotomous key to show how you grouped the objects.
2 How hard was it to divide your objects into different groups? Could you have used a better group of objects?

Communicating

1 Swap your dichotomous key with another group.
2 How effectively have they constructed a dichotomous key? Ask them to evaluate your key.
3 Which was the best dichotomous key designed in your class?
4 What features made it the best key?
5 Groups may have come up with different keys to separate the same objects. Explain how this might have occurred.

Remember

1 Recall the definition of a dichotomous key.

2 Explain what 'dichotomous' refers to.

3 Suggest a reason why dichotomous keys may be presented as a table.

Apply

4 Which of the following descriptions would be good to use to identify a group of birds in a dichotomous key? Justify why each one is or is not a good method of classification:

a is eating bird seed

b has a blue stripe above the eye

c has a wingspan of 32 cm

d has a broken leg

e is sitting on the ground

f has a high-pitched, bell-like song

g has brown tail feathers

5 Draw a circular key that could be used to identify laboratory equipment. Include these items: tripod stand, Bunsen burner, gauze mat, 50 mL beaker, 150 mL beaker, 100 mL measuring cylinder, 10 mL measuring cylinder, 500 mL beaker, 500 mL measuring cylinder, retort stand, clamp.

6 Design a dichotomous key to identify dinosaurs. You should research at least ten dinosaurs of the Jurassic period (find out when this was), find drawings of them and identify characteristics that could be used to classify them. Construct a table of their common characteristics and look for common ones you could use to build a dichotomous key for identifying them. Include the names and pictures of the dinosaurs on the key.
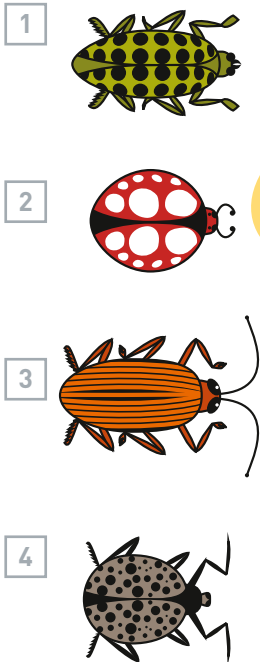
7 Use the dichotomous key in Figure 2.34 to help with the following tasks:

a Identify and name the four beetles in Figure 2.33.

b Draw a simple sketch of the following:

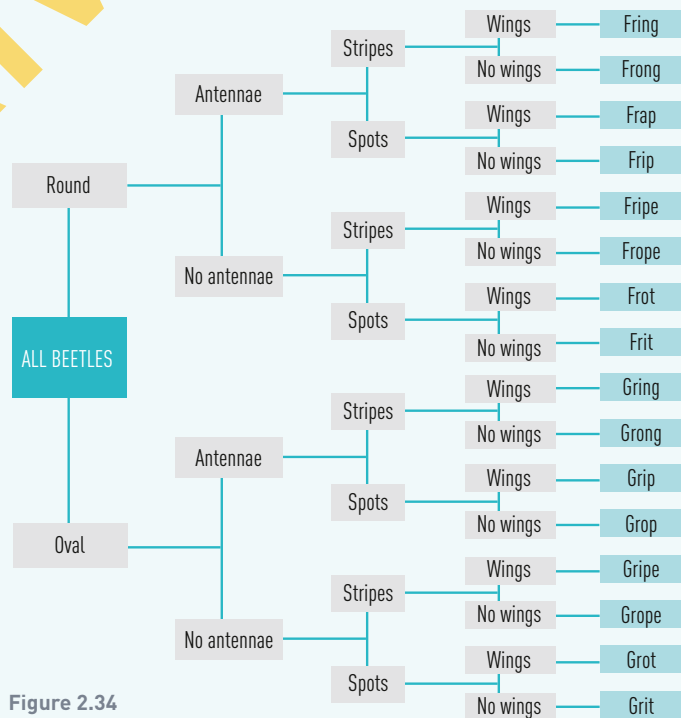i frope beetle

ii gring beetle

iii gripe beetle

iv frong beetle

Figure 2.33

Figure 2.34

USING KEYS AS TOOLS FOR CLASSIFICATION

Remember and understand

1 You have a family name and a given name. Compare the way people are named with Linnaeus's double-name system. [1 mark]

2 Explain why most keys are dichotomous. [1 mark]

3 Identify why classification is important. [1 mark]

4 Explain why some features are not appropriate to use as features to use in a dichotomous key. Use at least two examples in your answer. [2 marks]

5 Explain why scientific names are often in Latin or Greek. [1 mark]

6 Outline the advantages of using a dichotomous key. [1 mark]

Apply

7 Arrange these terms in order from the level that contains the most number of organisms to the level that contains the least number of organisms: *family*, *kingdom*, *species*, *class*, *phylum*, *genus*, *order*. [1 mark]

8 Refer back to Activity 2.2.2 about Dr Redback's family. Demonstrate how you might adjust the dichotomous key if: his 'family' included his sister, Melinda, and mother, Frances; he had two daughters, Stef and Gemma (Stef wears glasses); and he had a pet lizard named Stealth and not a bird named Charlie. [3 marks]

9 Empty your school bag or pencil case and design a dichotomous key of its contents. [3 marks]

Analyse and evaluate

10 Identify some of the difficulties of using your dichotomous key on the contents of someone else's bag or pencil case. [1 mark]

11 Download a copy of the collection of insects in Figure 2.35 from your obook, or photocopy and enlarge the figure from your book.

   a Cut out the pictures of the insects so you can move them around on your desk.

   b Working on your own, sort the insects into groups based on some aspect of their appearance. Justify your system of classification. [1 mark]

   c Compare your groupings with those of a partner. Between the two of you, can you think of other ways to classify the insects? [1 mark]

   d With your partner, construct a dichotomous key for this group of insects. [3 marks]

12 Discuss the limitations of a dichotomous key. [2 marks]

13 Discuss why the invention of the dichotomous key was important to the development of the classification system. [1 mark]

Critical and creative thinking

14 Propose a new system of classification for organising life on the Earth. Which kingdom would you be in? [2 marks]
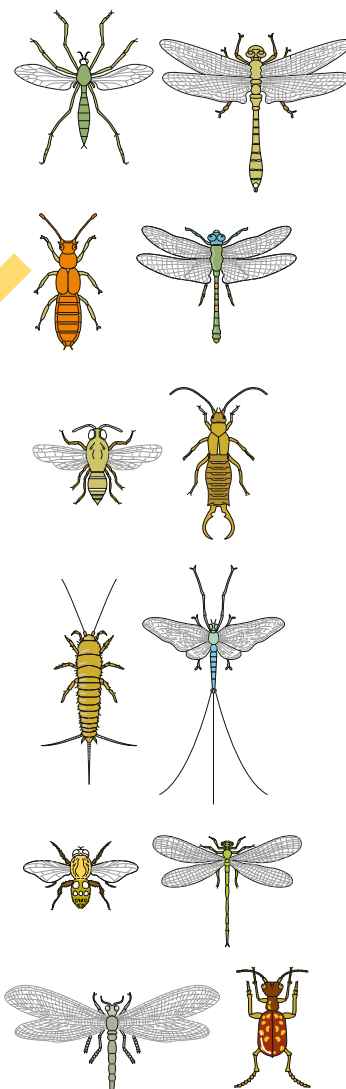

Figure 2.35

TOTAL MARKS
[/25]

2.3 CLASSIFICATION TODAY

The animal kingdom contains a large range of organisms: from the tiniest fairy fly, where 50 could fit within 1 millimetre, to the giant blue whale, which is up to 33 metres long—about the size of a house. Size is not a very suitable characteristic for classifying animals, especially because most grow over time. So what characteristics are chosen to group animals? And where do humans fit in this system?

KINGDOMS

The earliest **taxonomists** (scientists who classify living things) divided all living things into two groups: plants and animals. As new technology such as microscopes developed, very small organisms were discovered that did not fit into either of these groups. Scientists began to question the classification of other organisms such as mushrooms: did they really belong to the plant group? After all, they looked different under the microscope and they didn't produce their own food.

These days, scientists generally agree on classifying living things into five large kingdoms based on:

- the features of their cells (small structures that make up the organism)
- how they obtain nutrients
- their general appearance.

Animalia

All organisms in this kingdom are **multicellular**, that is, they are made up of many cells. Each cell stores its genetic material (**DNA**) in a small internal structure called the **nucleus**. Animal cells do not have a **cell wall**. Animals gain energy from other living things. We belong in this kingdom. Scientists who study animals are generally called **zoologists**.

Figure 2.36 Animal kingdom: (a) The proboscis monkey (*Nasalis larvatus*) has the biggest nose. (b) Port Jackson shark. (c) Pangolin. (d) Damselfly. (e) Goanna.
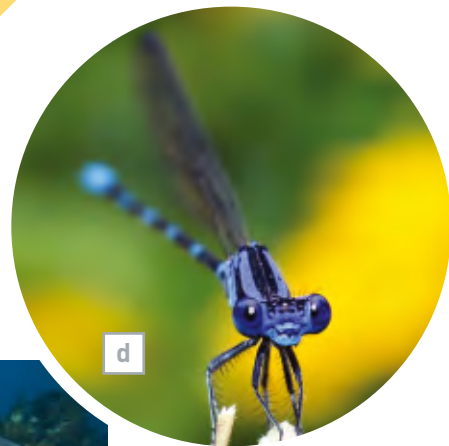
Plantae

Plants include trees, vines, bushes, ferns, mosses, weeds and grasses. They are autotrophs, that is, they make their own food from sunlight. Plants are multicellular and their cells contain DNA in a nucleus, but their cells have a cell wall around the outside of the cell. Scientists who study plants are called **botanists**.

Fungi

Fungi include mushrooms, toadstools, yeasts, puffballs, moulds and truffles. Some fungi grow in wood and in soil, and develop from tiny spores. Fungi do not make their own food. Instead they feed on the remains of dead animals and plants. Some fungi can cause diseases, such as tinea (athlete's foot). Scientists who study fungi are called **mycologists**.

Fungi and the following two kingdoms consist of many organisms that are **unicellular** (only have one cell). They are usually so small they cannot be seen without a microscope and as such are also called **microorganisms**. There are three main types of fungi: mushrooms, yeasts and moulds. The types of fungi are classified based on the way in which they reproduce.

The visible part of most fungi, mushrooms in particular, is really just the part that produces spores for reproduction. Much of the fungus is not visible to the naked eye but consists of very fine hair-like projections that spread throughout the soil or host organism. Some fungi, monerans and protists also become visible to the naked eye when they grow in large colonies, which are made up of large groups of individual, self-sufficient cells living together.

Figure 2.37 Plant kingdom: (a) Flowering gum. (b) Moss. (c) The smelliest plant, the *Rafflesia*, is found in South-East Asia. Its flower can measure up to 90 centimetres across and weigh about 11 kilograms. To attract insects when it blooms it gives off a rotten meat odour. (d) Cactus. (e) Wheat.
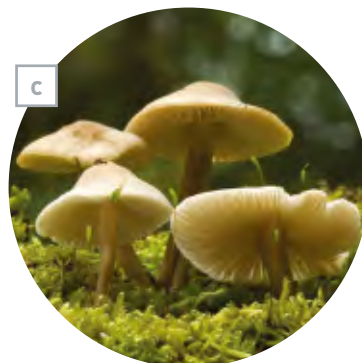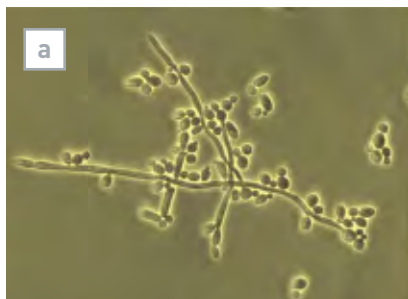
Figure 2.38 Fungi kingdom: (a) The hair-like filaments of the yeast *Candida albicans* as seen under a microscope. (b) Mould. (c) Mushrooms.

Monera

This kingdom is made up of the smallest living things. There are about 75 000 named different types of organism in the Monera kingdom and they are all unicellular. They have a cell wall, but it is made from a different chemical to plant cell walls. Bacteria do have DNA, but no nucleus. This is the key feature of this kingdom, and cells without a nucleus or membrane-bound organelles are called **prokaryotes**. Organisms from all other kingdoms are made from cells that have a true nucleus and membrane bound organelles, like mitochondria, which you will learn about in chapter 3. These types of cells are called **eukaryotes**.

Bacteria are the most common organisms in this kingdom. Many people think of bacteria as harmful to humans, but this is not always true. Bacteria in the soil break down rubbish and wastes produced by animals (especially us). Without bacteria, mountains of smelly rubbish would surround us. Bacteria have been put to use by humans to make foods, such as cheese and yoghurt.

Bacteria are classified based on a number of different characteristics such as shape, organisation and the stain patterns from particular dyes. Bacterial cells can be round (cocci), rod-shaped (bacilli) or spiral shaped (spirilla).

The cells are then classified based on how they are organised; individuals, in pairs (diplo), in chains (strepto) and in clusters (staphylo) are some examples.

Figure 2.39 Bacteria as seen under a microscope:
(a) *Spirillum volutans.*
(b) *Lactobacillus casei.*
(c) *Streptococcus pyogenes.*

The shape and organisation of the cells often helps name the species. Looking at Figure 2.39, what does the name *Streptococcus pyogenes* say about the shape and organisation of the bacteria cells?

Protista

There are about 55 000 known species of Protista. Their cell structure is more complex than Monera. Often, organisms that don't fit into any other kingdom will belong in the Protista kingdom. Scientists still debate whether some groups of algae belong here or with plants. Protists range in size from single-celled organisms to much larger ones like kelp (seaweed). **Plankton**, the tiny sea creatures eaten in their millions by whales, are part of this kingdom. **Amoebas**, microscopic organisms that change their shape to trap their food, also belong to this group.

Scientists who study microorganisms in the Monera and Protista kingdoms are called **microbiologists**.

The Protista kingdom is one of the most difficult to classify because of the huge range of diverse organisms. Taxonomists are still arguing about how to classify the organisms within this varied group. Many believe the kingdom should be classified further based on cellular structures, like the presence of chloroplasts, flagella and their methods of gathering nutrition. Research continues in this area and the classification of this kingdom will continue to change as more information and evidence is found.
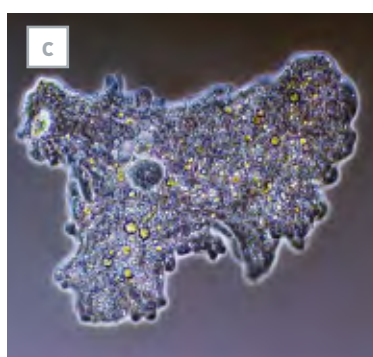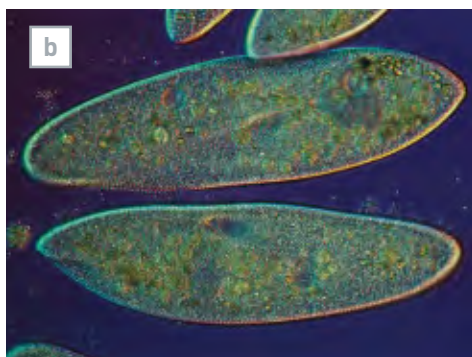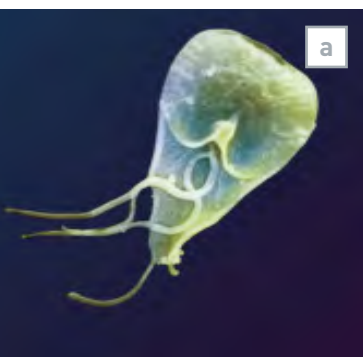

Figure 2.40 Protists as seen under a microscope: (a) *Giardia lamblia.*
(b) *Paramecium.* (c) *Amoeba.* (d) *Ophiocytium arbuscula.*

The scientist whose main role is to classify living things is known as a taxonomist. In this activity, you become the taxonomist.

What you need: 'Classifying into Kingdoms' worksheet from your obook or A3 card/paper, scissors, glue.

1 Download the 'Classifying into Kingdoms' worksheet from your obook. (Alternatively, this activity can be done online.)

2 Use a double-page spread of your workbook (or a sheet of A3 card or paper) to draw up a table with four columns.

3 Label the columns 'Animal', 'Plant', 'Fungi' and 'Other (Monera and Protista)'. (You don't need to distinguish between the Monera and Protista kingdoms.)

4 Cut out each organism from the worksheet and paste it into the correct column.

QUESTIONS 2.3.1: KINGDOMS

Remember

1 Recall the five kingdoms.

2 Recall four features of animals.

3 Recall four features of the Monera kingdom.

4 Define the characteristics that make up a protist.

5 Draw a table to identify the names of scientists who study organisms within each kingdom.

Apply

6 Explain how a protist is different from a bacterium.

7 Describe the difference between cells in the Plantae and Fungi kingdoms.

8 A bacterial species was classified as *Staphylobacillus*. What would you expect the cells to look like under a microscope?

9 A new organism was found to contain a cell wall but no nucleus. It photosynthesised and was microscopic. Suggest which kingdom it best fits in and explain your answer.

10 Describe the key structural features you would look for to distinguish between prokaryotic and eukaryotic organisms.

Research

11 The five-kingdom system has a few problems, especially with the classification of Protista. There are now suggestions that three domains should be used over the five-kingdom system. Research the current use of these domains (Archaea, Prokarya and Eukarya). See the section on the Changing face of classification on page 91 for more information.

CLASSIFYING ANIMALS

Vertebrate or invertebrate?

In the same way as creating any kind of dichotomous key, classifying the animal kingdom first requires a question. The system scientists use to classify animals is based on their structure. The question is: 'Does this animal have an internal backbone or not?'

Animals such as cats, humans and birds, with an internal skeleton (**endoskeleton**) are put in a group called **vertebrates**. Because these animals often have a spinal cord that usually threads its way between the vertebrate bones, the phylum is called **Chordata**. Other animals with an external skeleton (**exoskeleton**), such as beetles and crabs, and those with no skeleton at all, such as slugs, are known as **invertebrates**.

The kingdom Animalia is divided into up to 36 different phyla (plural of phylum) depending on which taxonomist you speak to. However, nine of these phyla contain the vast majority of all animal species. Only one of these, Chordata, contains vertebrate animals.

All the rest of the phyla contain invertebrate animals.

Giant squid dissection released on the web

By Matthew Moore, 5:19PM BST, 18 Jul 2008

Figure 2.41 The giant squid is an invertebrate.

A giant squid has been dissected live on the Internet for the first time—and the gory 90-minute clip has been released for public download.

The 39 st [nearly 250 kilogram] creature was carved up by biologists in front of hundreds of onlookers and thousands of web viewers at Melbourne Museum in Victoria, Australia.

The team of scientists provided a running commentary as they revealed the squid's internal organs, including its three hearts and doughnut-shaped brain.

They also established the squid was a female, and cut into her stomach in an unsuccessful attempt to discover her final meal.

Many people in the audience held handkerchiefs in front of their faces because of the revolting smell.

The rare creature was caught up in fishing nets in May, but this was the first detailed inspection of its body. The corpse took three days to thaw.

Stretching to 40 ft [over 12 metres] in length, it was the longest giant squid ever captured in Australian waters.

But calamari connoisseurs hoping for a feast will be disappointed; female squids are not fit for human consumption because of the amount of ammonia in their bodies.

After tests on the squid are complete it will be sewn back together and put on display in an ethanol solution at the museum.

The full video of the dissection is available to view and download from the Melbourne Museum website.

Source: www.telegraph.co.uk/earth/ earthnews/3347540/Giant-squid-dissection- released-on-the-web.html

EXPERIMENT 2.3.1: EXAMINING SKELETONS

Aim
To examine the skeletal structures of three marine organisms.

Materials
- 1 fish (whole)
- 1 prawn
- 1 squid
- Newspaper
- Dissecting board
- Dissecting kit
- Vinyl or latex gloves
- Always wear gloves when handling the animals.
- The animals must always be on the dissecting board when handling and dissecting.

WARNING
> Scalpels are extremely sharp. Use with great care.
> If cut, remove gloves and wash the cut under clean water. Apply antiseptic to the cut and cover with dressing. Tell your teacher.

Method
1 Observe the external features of the fish.
2 Carefully cut the fish in half lengthways so you can see the internal skeleton.
3 Observe the skeleton of the fish.
4 Feel the outside of the prawn and then peel it.
5 Cut the prawn in half and observe the inside.
6 Feel the outside of the squid and then cut it in half.
7 Observe the inside of the squid.

Results
- Draw labelled diagrams of each specimen's skeleton.

Discussion
1 Consider the fish.
   a Where is the skeleton of the fish located?
   b What is this type of skeleton called?
2 Consider the prawn.
   a Where is the skeleton of the prawn located?
   b What is this type of skeleton called?
3 Does the squid have a skeleton?
4 In which group of animals (vertebrate or invertebrate) would you place each of the organisms observed? Why?
5 What are you: a vertebrate or an invertebrate?

Conclusion
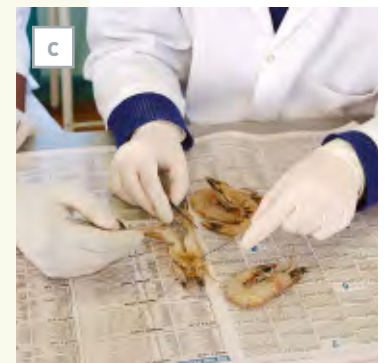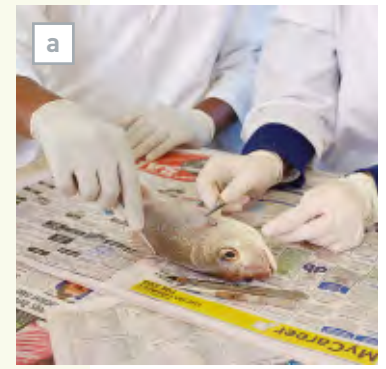What types of skeleton are possible? Write a sentence to address the aim.

Figure 2.42 (a) Observe external features of the fish. (b) Observe the skeleton of the fish. (c) Cut the prawn in half. (d) Observe the outside of the squid.

Remember

1 Animals are divided into two main groups.
   a Identify the names of the groups.
   b Explain what the names of these two groups mean.
2 Identify two examples of animals with an exoskeleton.
3 Identify two examples of animals with no skeleton at all.

Apply

4 Explain why invertebrates are such a dominant group among animals.
5 Draw a diagram of the world's biggest invertebrate and write down its dimensions, for example, its length and weight.
6 Why do you think dissecting a giant squid live on the Internet was so interesting to so many people? Do you find it interesting? Explain.
7 Classify the following animals as vertebrates or invertebrates and copy and complete the table.

Vertebrate (endoskeleton)	Invertebrate	
	Exoskeleton	No skeleton

Lizard

Cow

Sea sponge

Galah

Sting ray

Praying mantis

Snail

Sea star

Sea anemone

Lobster

Bumblebee

Redback spider
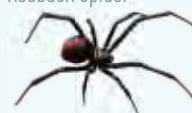
Earth worm

Research

8 Use the Internet to determine the nine biggest animal phyla. Record their scientific and common names and list at least three animals from each phylum.
9 There are some animals included in the Chordata phylum that are very strange, including tunicates and hagfish. Find out a little more about them and explain why they have been placed in the Chordata phylum.

CLASSIFYING VERTEBRATES

Vertebrates are animals with a spine or backbone. Vertebrates as a group can be broken down into further subgroups called classes. Scientists group vertebrates according to:

- their body covering
- how they obtain oxygen (gills/lungs)
- how their young are born
- how they control their body temperature.

Vertebrates can either generate their own body heat or rely on absorbing heat from their environment. Those that generate their own heat are called **endotherms** and tend to have a constant body temperature. Those that rely on absorbing heat from their surroundings are called **ectotherms**. They often have behaviours such as 'sunning' themselves to raise their body temperature sufficiently so they can become active.

Class Mammalia

Mammalia is a class of vertebrates well known to many people. Many of our pets belong to this class: horses, dogs, cats, rabbits, guinea pigs and mice. We belong to this class too. Mammals are animals with hair or fur and they have a relatively constant body temperature. But this class gets its name from mammary glands, which produce milk. It is usually the females that produce the milk to feed their young, but all mammals have mammary glands.

The class Mammalia can be further broken down into three subgroups (Figure 2.43). The main feature used to separate mammals is the way in which their young develop. **Placental** mammals give birth to relatively well-developed young, **marsupial** young develop mostly in the pouch rather than in the womb and **monotremes** lay eggs. However, no matter the type of mammal, they all feed their young milk.

One type of monotreme, the platypus, caused considerable controversy when it was first scientifically studied because it seemed to have a blend of mammal, reptile and bird characteristics. For a long time it was believed that platypuses could not maintain their body temperature as did endothermic mammals. Studies by an Australian scientist, Tom Grant, have shown that even when platypuses are feeding in icy water, their body temperature remains within a small fixed range. Other scientists have done genetic studies to clarify the links that the platypus has with mammals, reptiles and birds.

MONOTREMES

- Young partially develop in leathery-shelled eggs
- Young hatch underdeveloped from the egg and require intensive nurturing in either a shallow pouch or burrow
- Young suckle from milk patches on mother's abdomen
- E.g. Platypus and echidna

MARSUPIALS

- Young are born at a very early stage of development
- Further development occurs in a pouch
- Young receive milk from a teat located in the pouch
- E.g. Wallaby

PLACENTAL MAMMALS

- Young develops inside mother's womb
- Young are well developed when born
- Mother produces milk from mammary glands
- E.g. Dingo

Figure 2.43 The three subgroups of mammal.

Enigma of the echidna

By Doug Stewart

One of the most remarkable sights that biologist Peggy Rismiller has seen in her years exploring the Australian bush is that of an echidna sunbathing. The short-beaked echidna, or spiny anteater, ordinarily resembles a spiky ball, like some kind of terrestrial sea urchin. To warm up on a cool morning, however, it will stretch out on the ground ... and lift its spines to let in sunlight. 'It's amazing to see,' Rismiller says. 'It looks like a rug with spines.'

On a continent teeming with weird mammals, the echidna is one of the weirdest. It has a beak like a bird, spines like a hedgehog, eggs like a reptile, the pouch of a marsupial and the lifespan of an elephant. Elusive and unpredictable, echidnas continue to perplex the scientific world with their oddities.

Along with the platypus, the echidna is the world's only living monotreme, an order of egg-laying mammals found solely in Australasia. ... 'Echidna' commonly refers to the short-beaked echidna, which is found across Australia. A second genus, the long-beaked echidna, lives in Papua New Guinea.

The first detailed description of the echidna was published in England in 1792. A decade later, another account included a drawing by Captain William Bligh, who had feasted on roast echidna years earlier during a stopover in Australia. Bligh had the foresight to sketch the strange animal before eating it. Not until 1884 did the scientific world learn, to its amazement, that both platypuses and echidnas laid eggs.

... After mating, an adult female lays a single egg about the size of a five-cent coin directly into her pouch. The newborn puggle (baby echidna) that hatches about ten days later stays in the pouch for several weeks to suckle from the milk its mother secretes.

... Australians have adopted the short-beaked echidna as a national mascot of sorts ... The echidna's total numbers are unknown ... Concerned that their future welfare is not assured, Australia has officially listed them as a protected species.

Source: www.nwf.org/News-and-Magazines/National-Wildlife/Animals/Archives/2003/

Questions

1 Two different types of echidna exist today. Where does each live and how are they different?
2 Do you consider the echidna to be weird? Explain.
3 Why do you think that scientists who had not seen echidnas for themselves might have believed pictures to be false?
4 Identify the two monotremes and where they can be found.

Figure 2.44 The short-beaked echidna.

Class Aves

All birds in the phylum Chordata belong in this class. Like mammals, they are endotherms (having constant body temperatures). Some of their main distinguishing characteristics (the way they differ from the other classes) include their covering of feathers and their scaly legs. All animals in this class lay eggs with a hard shell.

Figure 2.45 Class Aves: (a) Cockatoo. (b) Vulture.

Class Reptilia

The skin of reptiles, such as snakes and lizards, is usually covered in a layer of fine scales. Reptiles use lungs to breathe, even if they live under water (for example, sea snakes). These animals are also ectotherms—scientists do not use the term 'cold-blooded' to describe these animals because a lizard that has been lying in the sun has very warm blood, even though at night its blood is cool.
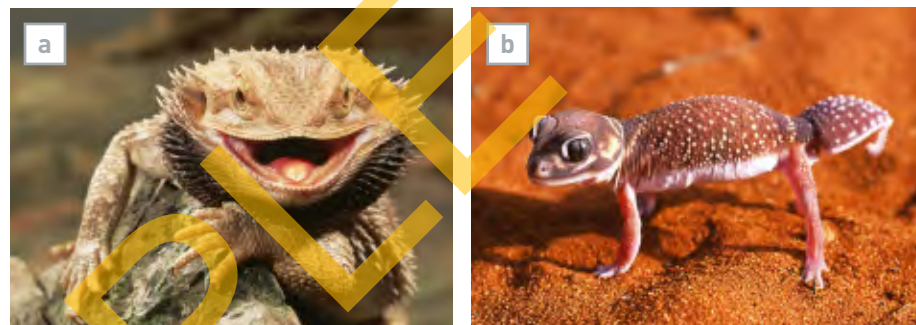
Figure 2.46 Class Reptilia: (a) Bearded dragon. (b) Gecko.

Class Amphibia

Like reptiles, amphibians are ectotherms; however, their skin is usually soft and slimy to touch. They lay their eggs, without shells, in water. For the first part of their life they have gills and live in the water. As they get older, lungs develop and they become able to live on the land. The only remaining group of amphibians in Australia is frogs. In other parts of the world, caecilians and salamanders may be found.
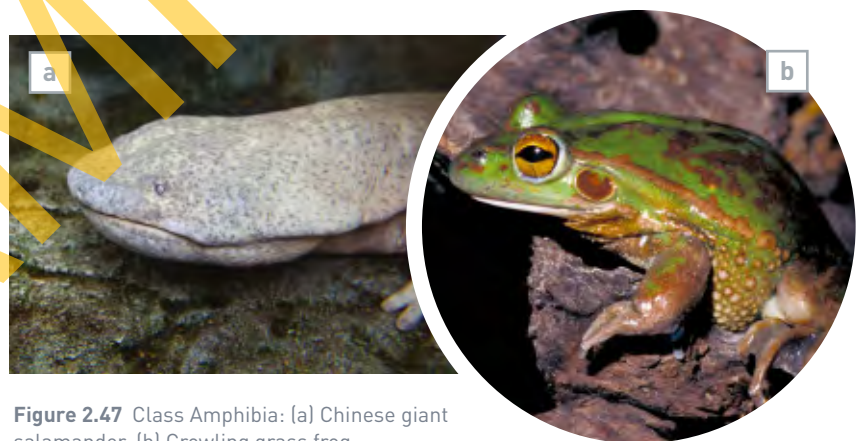
Figure 2.47 Class Amphibia: (a) Chinese giant salamander. (b) Growling grass frog.

Class Pisces

Most fish are ectotherms. They are covered in a layer of scales and most have fins. They spend all their life in water and so need gills for breathing. Fish are further grouped according to their skeleton. Sharks, rays and skates have a skeleton made entirely of cartilage, while all other fish have bony skeletons.

Figure 2.48 Class Pisces: (a) Reef shark. (b) Weedy sea dragon.

Vertebrates

Amphibians — Example _____

Reptiles — Example _____

Fish — Example _____

Mammals — Example _____

Birds — Magpie / Sparrow / Eagle _____

Figure 2.49 A jellyfish organiser for vertebrates.

Vertebrate alphabet graffiti

This task could be completed as a webpage, with images and links to further information about each animal.

1 You will be placed into one of five groups, each of which will be allocated one class of vertebrate.
2 Label an A3 sheet of paper with the name of your class of vertebrate.
3 Write the letters of the alphabet down the left-hand side of the page.
4 For each letter, write the name of an animal that fits this category.
5 When finished, you will have the names of up to 26 different vertebrates. Some categories will be harder to fill than others.
6 Put up the finished sheets around the room.

Jellyfish organiser for vertebrates
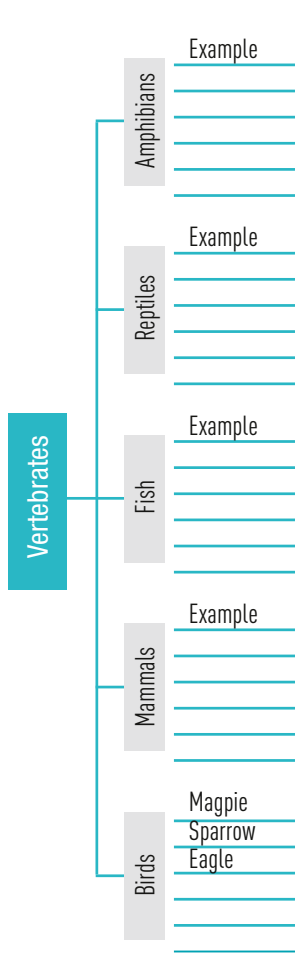
A jellyfish graphic organiser is a good way to show how subgroups make up a whole. It can also be used to list specific examples at the same time.

1 Individually, go around to each of the five sheets of vertebrates and select six animals from each class.
2 On a full page, draw five 'jellyfish' connected to the main group (vertebrates), as shown in Figure 2.49.
3 Label each jellyfish with the class names (fish, reptiles, amphibians, mammals and birds).
4 Write a description of the characteristics of each class in the appropriate body of each jellyfish.
5 Place the six animals you selected along six tentacles on each jellyfish.

QUESTIONS 2.3.3: CLASSIFYING VERTEBRATES

Remember

1 Describe the main characteristics of mammals.
2 Describe how a baby echidna is born and develops before it comes out of the mother's pouch.
3 Identify the defining characteristics of each class of mammal.

Apply

4 Seals have fins like fish and live on the land and in the water like amphibians.
   a Investigate how a seal's young are born.
   b Given that a seal has long whiskers, to which class of vertebrate do seals belong?
5 A dolphin lives in the ocean and has fins. To which class does it belong? Explain.
6 A flying fox can fly through the air like a bird but is covered in fur. To which class does it belong? Why? Explain.
7 Draw a dichotomous key to separate out the different classes of vertebrates.

CLASSIFYING INVERTEBRATES

There are many more invertebrates on the Earth than vertebrates: 96% of all animals are invertebrates. Invertebrates have either an external skeleton (exoskeleton) or no skeleton at all. The giant squid, huge as it is, has no backbone. As well as enormous animals like this, thousands of tiny insects and other creatures belong to the invertebrates group. Invertebrates are classified into several main groups or phyla.

Invertebrates are grouped by their characteristics (in the same way that vertebrates are classified). Characteristics used to classify invertebrates include the presence of a shell or hard cover, tentacles and spiny skin. Organisms with similar features are placed in the same group. The tabular dichotomous key in Table 2.5 can be used to place an organism in a particular phylum. Not all phyla of invertebrates are shown on the key.

Table 2.5 A tabular dichotomous key for classifying invertebrates.

1	Body spongy, with many holes	Porifera
	Body not spongy	Go to 2
2	Soft body, no shell	Go to 3
	Outside shell or hard cover	Go to 6
3	Many tentacles or arms	Go to 4
	Long body without tentacles	Go to 5
4	Tentacles around the mouth of a sac-like body	Cnidaria
	Arms with suction discs	Mollusca
5	Soft body, large foot	Mollusca
	Worm-like or leaf-like	Nematodata, Platyhelminthes or Annelida
6	Proper shell or smooth, hard covering	Go to 7
	Spiny skin with rough covering	Echinodermata
7	Limbs in pairs	Arthropoda
	Shell, no segments, large foot	Mollusca

ARTHROPODS

- Segmented bodies
- Paired and jointed legs
- Exoskeleton
- Examples: insect, spider, centipede, scorpion

MOLLUSCS

- Soft body
- Usually have a protective shell
- Examples: snail, octopus, oyster, slug

PORIFERANS

- Spongy body with holes
- Found in water, attached to rocks
- Examples: breadcrumb sponge, glass sponges

Invertebrates can be found in just about every different environment on the planet. They have adapted to survive in some of the most extreme conditions from the freezing depths of the ocean to the scorching heat of deserts. Most of the invertebrates we think of tend to be the small bugs, insects and the creepy crawlies. But as you saw earlier, the giant quid is one of the largest invertebrates in the world. Invertebrate Japanese spider crabs can grow to around 3.8 metres from claw to claw. Most of the larger invertebrates live in the ocean or other aquatic environments because the buoyancy of the water means there is less need for body support than is required when living on land.

NEMATODES

- Also called round worms
- Long smooth cylindrical body
- Often microscopic
- Examples: round worm, threadworm, heartworm

ANNELIDS

- Also called segmented worms
- Long cylindrical body that is separated into segments
- Examples: leeches, earthworms

PLATYHELMINTHES

- Also called flat worms
- Mostly parasitic
- Have a blind gut (mouth but no anus)
- Examples: tapeworm, blood and liver flukes
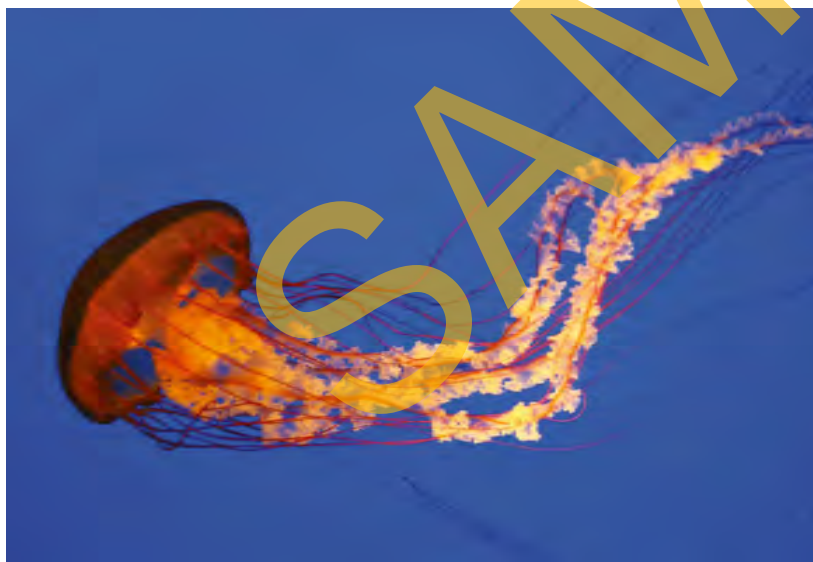
CNIDARIANS

- Soft, hollow body
- Live in water
- Tentacles
- Examples: coral, sea jelly, anemone

ECHINODERMS

- Rough, spiny skin
- Arms radiate from centre of body
- Found in sea
- Examples: sea urchin, sea cucumber, brittle star

What you need: magnifying glass or stereo microscope, Petri dishes, jars with lids, tweezers, vinyl or latex gloves, newspaper

Alternatively, your teacher may provide prepared samples for you to look at. Complete this classification exercise for each prepared sample.

WARNING
> > Do not touch any animal that might bite or sting. Check with your teacher if you are unsure.
> > Use tweezers to pick up animals.
> > Place any animal immediately in a jar and put on the lid.

1 Visit a local natural environment (e.g. a garden, beach, park or pond) and observe invertebrate specimens.
2 While wearing gloves, use tweezers to collect up to ten invertebrate specimens in separate jars.
3 Use the tabular key in Table 2.5 to identify the invertebrates to their particular phylum.
4 Use a magnifying glass or stereo microscope to help you sketch each animal. Put in the common name for the animal (if you can) and write its classification group under the drawing.
5 Return the invertebrates to their natural environment after you have finished.

QUESTIONS 2.3.4: CLASSIFYING INVERTEBRATES

Remember

1 Recall what percentage of animals are vertebrates.
2 Describe an exoskeleton. Give three examples of organisms with an exoskeleton.
3 Beetles have segmented bodies and jointed legs. Identify the phylum to which they belong.

Apply

4 Eighty per cent of animals on the Earth are arthropods.
   a Explain which characteristic their name refers to. (Hint: 'arthritis' and 'podiatrist')
   b Draw three different arthropods and label the features that make them part of this phylum.
5 In Activity 2.3.3, which phylum of invertebrates did you find in the greatest quantity? Can you explain why?
6 Transform the tabular key in Table 2.5 into a branching dichotomous key.

Research

7 The phyla classifications in invertebrates are always changing. Research about an organism called a brachiopod.
   a Which phylum does it belong in?
   b Why is it classified in that way?
   c How does it obtain its food?
   d What type of habitats does it live in?
   e How is it different from a mollusc such as a clam or scallop?

CLASSIFYING PLANTS

Plants are living things that are essential to the survival of all life on the Earth. Like animals, plants grow and need to reproduce to ensure their survival. These multicellular organisms can make their own food—they are autotrophs.

Plants can be classified in a number of different ways, based on different characteristics. When classifying according to stature (height and shape), plants are divided into mosses, herbs, ferns, shrubs, trees and vines. These groups are defined by the height of the plant and the number and type of stem (woody or herbaceous).

VINES
- Very long stems that can remain flexible or become woody
- Tend to use other plants or structures for support
- Greatly varied in height

TREES
- Typically one main woody stem (trunk)
- Over 5 m

SHRUBS
- Usually multiple woody stems branching form the base of the plant
- Between 1–5 m

FERNS
- Fronds are grown directly from and evenly around fibrous stem
- Most between 0.5–5 m, but can grow over 30 m

HERBS
- Fleshy stems
- Usually less than 1 m

MOSSES
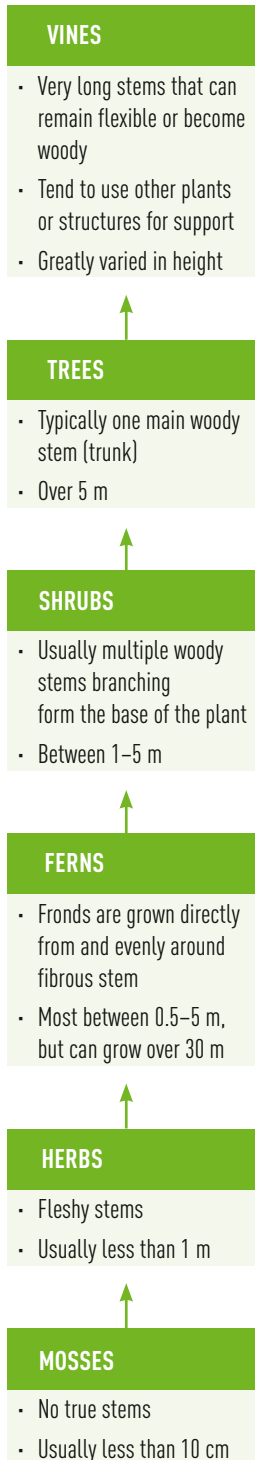- No true stems
- Usually less than 10 cm

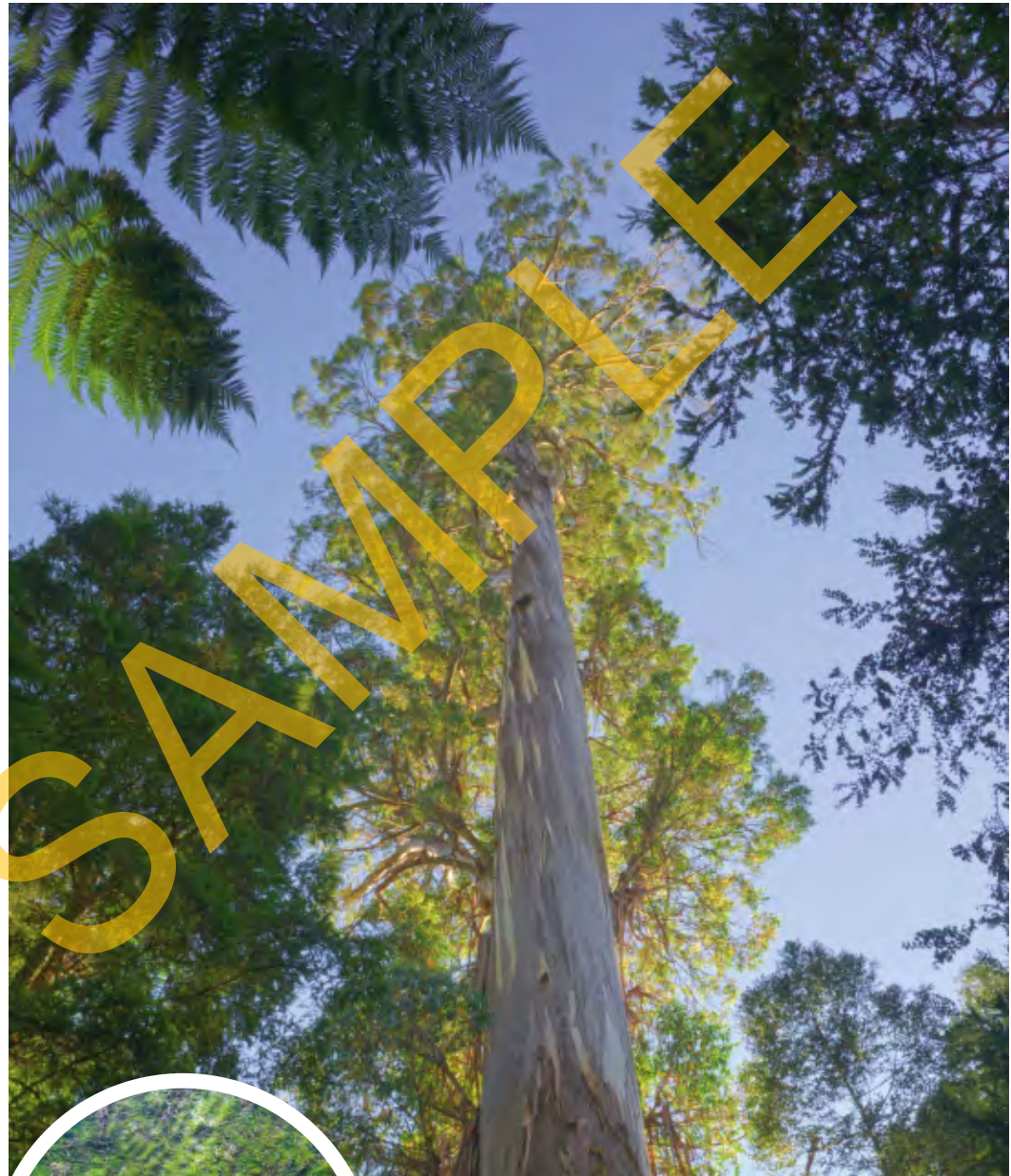**Figure 2.50** The stature classification of plants.

Figure 2.51 The mountain ash (*Eucalyptus regnans*) is a vascular plant.

Figure 2.52 Moss is a non-vascular plant.

Plants are also classified based on whether or not they have veins for efficiently conducting water and nutrients around the plants.

- **Vascular** plants, such as ferns, conifers and flowering plants, contain vein-like structures. **Xylem** carry water and minerals up from the roots and **phloem** carry food (a sugar called glucose) around the plant.

- **Non-vascular** plants, such as liverworts and mosses, do not have these veins and so must absorb their water and nutrients through the surface of their leaves. This is much more difficult and is why non-vascular plants tend to be very small and are restricted to damp environments.

Plants can also be classified into phyla using their reproductive characteristics and structural features to distinguish them. Four of the most common phyla are Bryophyta (mosses and liverworts), Pteridophyta (ferns), Coniferophyta (conifers) and Anthophyta (flowering plants).

BRYOPHYTES

- Small, non-vascular
- Need a constant supply of water to live and reproduce
- Reproduce by spores in capsules
- Thin leaf-like structures, attach to soil by thread-like structures called rhizoids
- Examples: peat moss, Marchantia

PTERIDOPHYTES

- Small- to medium-sized, vascular
- Need water for fertilisation and a complete life cycle
- Reproduce by spores on back of leaves
- Have stems, roots, leaves
- Young rolled-up leaves unroll into a feathery frond
- Examples: tree fern, fishbone fern, maidenhair fern

CONIFEROPHYTES

- Large, vascular
- Reproduce by naked seeds, often carried by the wind from a woody cone
- Needle-like leaves
- Examples: Wollemi pine, Radiata pine, White Cypress pine, cycad

ANTHOPHYTES

- Small to large, vascular
- Reproduce by flowers containing seeds that develop in the ovary after fertilisation
- Fertilised flower produces seeds and fruit
- Examples: grevillea, waratah, rose

ACTIVITY 2.3.4: IDENTIFYING PLANTS

1 Observe and collect small specimens of at least five types of plant from local bushland (not a national park or flora reserve) or your garden. Make pressed, dried specimens. Include notes about where each plant specimen was collected.

2 Make detailed observations of each plant including:

- height and width
- type of plant (tree, shrub, herbaceous, grass, perennial, annual)
- type of bark, if present (smooth, fibrous, hard, furrowed)
- shape, smell, texture, size and edge shape of the leaf
- evidence of reproduction (spores on leaf, flowers, fruit, nuts, cones).

3 Identify the features the plants have in common.

4 List some differences between your plants.

QUESTIONS 2.3.5: CLASSIFYING PLANTS

Remember

1 Compare the function of xylem and phloem in vascular plants.

2 Describe the key features that would help identify a plant as being an anthophyte.

3 Are you likely to find mosses or liverworts growing in the desert? Explain your answer.

Apply

4 Using your specimens from Activity 2.3.4, classify your plants as vascular or non-vascular.

5 Some coniferophytes produce seeds with 'wings'. Suggest a possible advantage for this adaptation.

6 Apply your knowledge from this chapter to construct a dichotomous key for the five different plant samples you collected in Activity 2.3.4. Remember to only include one variable at each step, such as:

- has flowers or seed pods OR does not have flowers or seed pods
- is a wood plant OR is a soft, fleshy plant
- has long, needle-like leaves OR does not have long, needle-like leaves.

7 Evaluate the advantages of vascular plants over non-vascular plants.

Research

8 Pollen from anthophytes can often be used for identification purposes. Observe some pictures of pollens from plants and compare them. Make a dichotomous key to separate them.

9 Tree rings can often be used to determine the ages of the plants. Investigate:

- **a** what a scientist who studies tree rings is called
- **b** how tree rings form
- **c** what can be learnt from studying tree rings.

THE CHANGING FACE OF CLASSIFICATION

Scientists are still testing and modifying the Linnaean classification system after 250 years. The development of microscopes led to the discovery of single-celled organisms (bacteria). This led to the number of kingdoms increasing from three (plants, animals and minerals) to the current five (Plantae, Animalia, Fungi, Protista and Monera).

In the 1970s a group of organisms previously thought to be bacteria was discovered to be something else: single-celled organisms that could live in extreme conditions, such as very salty or hot waters. This led to the suggestion that a sixth kingdom, **Archaea** (ancient bacteria), was needed. Scientists are currently testing this idea and comparing it to a whole new system that comes before kingdoms.

The Three-Domain system was first suggested in 1990 and inserts a new level of classification before kingdom. This system suggests one domain, Eukarya, for the plants, animals, protists and fungi. The single-celled, prokaryotic organisms in the Monera kingdom would then be split into two domains according to their DNA.

The comparison of DNA may cause even greater changes to the classification system in the future. Species that were previously thought to be related because they looked similar have now been found to have very different genetic material. That is the very nature of science—to change and develop as new evidence becomes available. This is why scientists collaborate and share ideas, to make sure we have the best possible explanation for every scientific discovery.

The Internet allows more sophisticated ways of organising, storing and communicating scientific information. Massive online databases are possible, complete with photographs and video footage of organisms. Links to related information can also be included and many scientists are using the Internet to confirm their identifications.
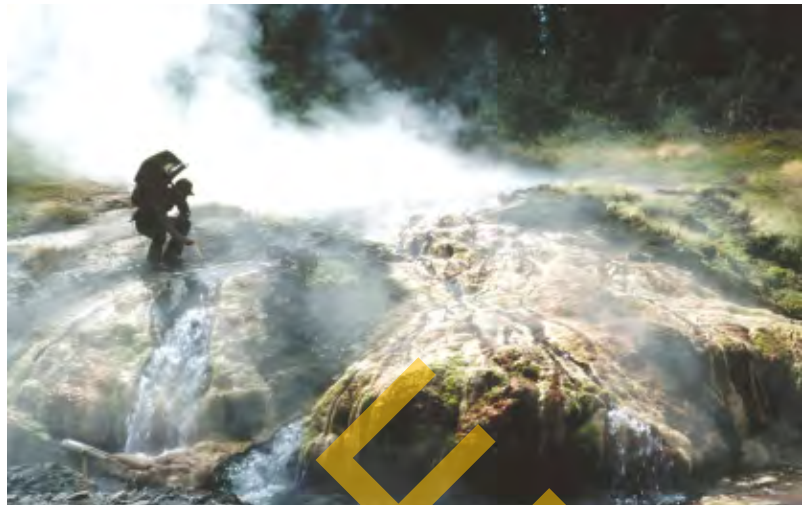

Figure 2.53 Biologists collecting Archaea samples in the hot springs of the Obsidian Pool in the Yellowstone National Park, United States.

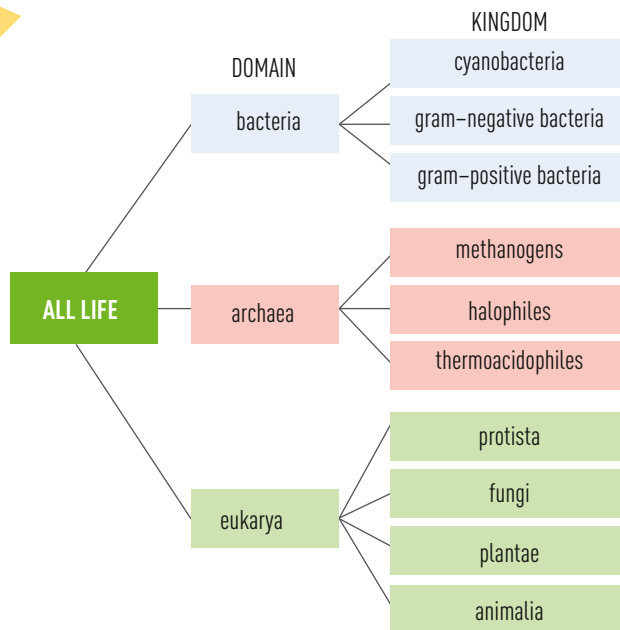**Figure 2.54** A magnified view of a clump of Archaean organisms.

Figure 2.55 The Three-Domain system of classification as proposed by Carl Woese.

Museums and herbaria currently hold most 'holotype' specimens, the organism(s) used when the description for classification was decided. These specimens are chosen because they represent the majority of organisms of the same type. Museums are likely to continue to do this, but most will need to put their data online in the future.

Figure 2.56 Holotype specimens such as this one are held in museums.

QUESTIONS 2.3.6: THE CHANGING FACE OF CLASSIFICATION

Remember

1 Fill in the gaps, using the words in the Word Bank below:
Classification of organisms is continually changing as new _____ is discovered. New _____ allows more of the planet to be explored and new _____ are being found. Advances in _____ research means that DNA is now being used to _____ how closely related species are. This new information sometimes requires a change in the way we _____ those organisms. Through the Internet and easily accessible photographic and video technology, _____ information can be shared more quickly and more frequently so _____ around the world can work together.

WORD BANK			
Classify	Evidence	Genetic	Species
Identify	Technology	Accurate	Scientists

2 A 'three-kingdom' system became five and then six kingdoms.
   a Identify the names of these kingdoms.
   b Do you agree with the changes? Explain.
3 Describe how an understanding of DNA and genetics has changed classification.
4 Describe a holotype specimen.

Apply

5 Explain why you think scientists might choose a single organism to represent its species, instead of trying to find a description that fits every single organism in the species.
6 Examine the problems a paper system for classification would encounter. How is this being addressed today?
7 Use the Internet to research and describe an example of an organism where classification has changed as a result of scientific developments such as genetics.
8 Research the definitions of halophile, thermoacidophile and methanogen.
9 Research the terms cyanobacteria, gram-negative and gram-positive. What are the key features that are used to classify these different types of bacteria?

Create

10 Using the information in this chapter and a large piece of paper, construct a branching diagram showing the five Kingdoms and the major groups or phyla within each Kingdom. Add pictures to show examples of organisms within each group. Include brief descriptions of the key characteristics that are used to classify each group.

CLASSIFICATION TODAY

Remember and understand

1 Identify the difference between vertebrates and invertebrates. Write a definition for each. [2 marks]

2 Recall the five main classes of vertebrate and give an example of each. [5 marks]

3 Recall who first developed the naming system used by scientists today. [1 mark]

4 Identify and list at least six phyla of invertebrates and give an example of each. [6 marks]

5 Explain the difference between an endoskeleton and an exoskeleton. [1 mark]

6 How are placental mammals differentiated from monotremes and marsupials? [1 mark]

7 Outline why scientists need to classify living things. [1 mark]

Apply

8 Copy and complete the table below. [4 marks]

Animal	Vertebrate/invertebrate	Class
Octopus		
Spider		
Human		
Crab		
Elephant		
Frog		
Lizard		
Snail		

Analyse and evaluate

9 Convert the tabular dichotomous key (Table 2.5) to a circular key for invertebrates. [2 marks]

10 Construct a Venn diagram to show the similarities and differences between birds, reptiles and amphibians. [2 marks]

11 Discuss why it is important that scientists keep reviewing and evaluating the systems they use for classifying and naming living organisms, and modifying them if necessary. What problems might arise if scientists were not able to modify the systems? [2 marks]

Critical and creative thinking

12 Using a digital camera, take photographs of living things around your house—from very big to very small. Construct a multimedia presentation of your living things. Use a separate slide for each organism. On each slide include:

- the photograph
- the common name and scientific name (if you can find it) or major group to which it belongs
- three or more interesting facts. [5 marks]

Making connections

13 Write a paragraph about how our knowledge of life on the Earth has changed over time to bring us to the understanding we have today. Include some specific examples of understandings that have changed. [3 marks]

TOTAL MARKS [/35]

2

CHAPTER REVIEW

1 Fill in the gaps, using the words in the Word Bank below:

_____ is the process of grouping organisms based on similarities and differences in _____ features. Classification helps ensure there are no errors in communication between scientists _____ the same organism.

The features used to classify organism are also _____ which increase the likelihood of survival and reproduction. Australia has three different types of mammals; placentals, _____ and monotremes, which are classified according to the way they _____.

The _____ Classification System classifies all life into increasingly specific levels from Kingdom, _____, Class, _____, Family, _____ to Species. Each level contains less organisms than the one before it.

Keys are used to identify organisms that have already been classified. _____ keys work as a series of steps, with only two options at each step, while _____ keys give more choices per step.

There are five different kingdoms: _____, Plantae, Fungi, _____ and Protista. Microorganisms can be found in the kingdoms _____, Monera and Protista. Cellular structures are used to classify microorganisms. For example, organisms from Monera do not store their DNA in a nucleus and plants have a _____ while animals do not.

WORD BANK			
Animalia	Cell wall	Genus	Order
Adaptations	Describing	Marsupials	Phylum
Circular	Dichotomous	Monera	Reproduce
Classification	Fungi	Linnaean	Structural

The purpose of classification

2 Identify three reasons why classifying living things is important. [3 marks]

3 Outline one technological advance that has changed the classification of living things. [1 mark]

Classifying based on structural similarities and differences

4 Explain how the water-holding frog meets the eight criteria of living things. [3 marks]

5 Imagine you are one animal from a phylum of invertebrates (such as molluscs, arthropods, annelids, nematodes, echinoderms, etc.). Write a diary entry explaining the key events in your day, explaining how you demonstrate at least four of the characteristics of living things. [4 marks]

6 Research why the Three-Domain system of classification was suggested. (Hint: what do organisms within each domain have in common, and what makes them different from each other?) [2 marks]

Use keys to identify plants and animals

7 Construct a jellyfish diagram to summarise the classification of the four main phyla of plants. Which group is best adapted to living in a range of Australian environments? Explain your answer. [3 marks]

8 Use the following tabular dichotomous key to identify the animals shown in Figure 2.57. [2 marks]

1	Gills present	Go to 2
	Blow hole present	Go to 3
2	Scales present	Tuna
	Rough skin	Shark
3	Less than 3 m long	Dolphin
	Longer than 3 m	Go to 4
4	Teeth present	Toothed whale
	No teeth present	Baleen whale

Identify groups of microorganisms

9 Draw a table to help identify the different names used to identify the different shapes of bacteria. [2 marks]

10 Identify the names of the five kingdoms of classification of living things. [2 marks]

11 Imagine you were van Leeuwenhoek, seeing bacteria for the first time. He asked the question 'If these tiny creatures live in water, I wonder if they live inside us?' Propose three other questions he could have asked and then investigated. [3 marks]

12 Suggest a reason why bacteria are classified by their appearance and not, say for example, by how they produce young. [1 mark]

Outline features used to group plants, animals, fungi and bacteria

13 For each of the five main classes of vertebrates, explain the advantages and disadvantages of their different body coverings, i.e. moist skin (amphibians), scales (fish and reptiles), feathers (birds), hair and fur (mammals). [4 marks]

14 Construct a table to summarise the key features that help to classify and identify plants, animals, fungi and bacteria. [2 marks]

Figure 2.57 Identify these animals using the tabular dichotomous key.

Explain Australian plant and animal adaptations

15 Identify one ectothermic and one endothermic Australian animal and describe one adaptation of each animal. [2 marks]

16 Use information in this chapter to construct a comprehensive table that includes the physical and behavioural adaptations of the echidna and how they help it survive and reproduce successfully. Which of these features (and any others) are useful for classifying the echidna? [3 marks]

17 Design a plant that is well suited to living in an area that is exposed to frequent droughts and bushfires. Explain how its adaptations help it survive in its environment. [3 marks]

18 Evaluate whether or not the Wollemi pine is well adapted to Australian conditions. Explain your answer. [2 marks]

Identify where classification has changed (additional)

19 Identify the reasons why organisms belonging to the group the Archaea are classified differently to bacteria. [2 marks]

Constructing simple identification keys (additional)

20 Construct a 'What am I?' list of clues to a phylum or other major group of organisms. See how many clues your classmates need before they guess the name of the group. [2 marks]

21 Using the link provided by your teacher (or in your obook), view the slide show, made in Canada, of 35 slides of living things. Construct your own version to emphasise the classification and diversity of Australian species. [5 marks]

Use the Linnaean classification system (additional)

22 Research the Wollemi pine. What is its full scientific name (from kingdom to species)? To what group of plants does it belongs (vascular or non-vascular)? How does it reproduce? [4 marks]

RESEARCH

Choose one of the following topics to present a report in a format of your own choice. Some ideas have been included to get you started. Your report must include a key of some description (you have seen many in this chapter).

Newspaper article

Write a newspaper article about how life on the Earth is organised. It needs to be about two pages long (no more than 500 words) and you should explain how living things are classified for an audience that is not familiar with science. Make a list of the living things whose photographs you would like to use to illustrate the article. Try to find their scientific names as well as their common names. Your newspaper article must contain a key of some description.

Trip to the Kimberley

You have just returned from a trip to a remote mountain area of the Kimberley, in Western Australia. While there, you took your portable microscope and examined water from a previously unknown lake. To your surprise you found some new organisms in the water that looked a bit like bacteria. They were single-celled and either square or oval; some were hairy (had hairs either on the end of the cell or along the edge of the whole cell).

1 Draw six different versions of these organisms.

2 Create a dichotomous key for these six new organisms so that you can describe them to other scientists.

3 Name each of the groups at the bottom of your key (you might like to name some of them after yourself).

4 Assuming they are a type of bacteria, to which kingdom will they belong?

Research on fascinating organisms

Choose a fascinating organism to research from each kingdom. As you do your research, create a table using the following headings for each organism: 'Habitat', 'Diet', 'Classification' and 'Special features'. Choose one of the graphic organisers used in this chapter to display the information about each one. Keep a list of the sources of your information.

REFLECT

Me

1 What new graphic organisers have you learned to use?

2 How could dichotomous keys be useful in other subjects? Give examples.

3 What were the most difficult aspects of this topic?

My world

4 What was the most surprising organism you discovered?

5 What else would you like to find out about classification?

6 What else would you like to find out about organisms?

7 Why is it important to organise life on the Earth?

My future

8 What Australian animals are unique in the world? How are we going to protect them in the future?

KEY WORDS

adaptations	dead	living	phylum
amoeba	dichotomous key	marsupial	placental
Archaea	DNA	microbiologist	plankton
autotroph	ectotherm	microorganism	prokaryote
bacteria	endoskeleton	monotreme	species
binomial name	endotherm	multicellular	taxonomist
biodiversity	eukaryote	mycologist	unicellular
botanist	exoskeleton	non-living	vascular
branched key	genus	non-vascular	vertebrate
cell	heterotroph	nucleus	xylem
cell wall	invertebrate	order	zoologist
Chordata	key	organism	
classification	kingdom	phloem	

Extreme communities

Black smokers

In 1977, two scientists and a pilot crammed into an extreme submarine, ALVIN, and headed nearly 3000 metres under the sea, near the Galapagos Islands. They predicted that the chains of underwater volcanoes, called mid-ocean ridges, would have hot springs a lot like deep undersea versions of the hot springs of Yellowstone National Park. Until then, no deep-sea volcanic vents had ever been found.

The scientists found the first hot water deep-sea vent, just as they predicted, but they were surprised to also find diverse communities of living organisms. Hot water rich in minerals gushed out of the chimney-like vents and mixed with the cold ocean water, reacting to form dense clouds of tiny black minerals. These chimneys are called 'black smokers'.

New research

This discovery opened up a whole new area of research. Oceanographers had to develop new technologies to explore these deep-sea environments. Biologists discovered, classified and investigated a whole new range of microorganisms, invertebrates and vertebrates. Geologists studied the rock formations and composition of the minerals and vented water. So far, only 1% of the ocean floor has been mapped, so there is much more to learn. There is still more to understand about the impact of these vents on the chemistry of the whole ocean.

Exploitation

Deep-sea vents are rich in valuable mineral ores. Mineral exploration companies are at work and mining operations similar to offshore oil and gas rigs have already been trialled.

Darkness

There is no natural sunlight in the deep-sea environment, and only a few places where there is the red glow from lava oozing out of cracks in the rocks.

Pressure

We all experience the 'popping' of our ears with a change of pressure. This is nothing compared to the changes in pressure involved in travelling to the ocean depths. The pressure experienced is about 300 times the air pressure experienced at sea level. This would feel like having a mass of 300 kilograms resting on your fingernail.

Temperature

The high-pressure environment increases the boiling point of the water. Superheated water at these depths can reach temperatures of 400°C. In contrast, the water temperature away from the vent is 2°C.

Apart from the darkness, pressure and temperature variations, there are other reasons why the waters here are not ideal for most life. These include high salinity and acidity. The water is about as acidic as vinegar.

Communities

The basis of these deep-sea communities is the bacteria that feed off hydrogen sulfide or methane. These bacteria have been described as 'extremophiles' because they survive the extremes of these deep parts of the ocean. Amphipods and copepods feed off thick mats of bacteria. Snails, shrimp, mussels, clams, anemones, crabs, tube worms, eels and octopuses can also be found in this environment. Life down in the deep sea does not depend on the sun.

Some of the interesting animals that live at these depths include the Pompeii worm, *Alvinella pompejana*, which withstands temperatures up to 80°C, and the scaly-foot gastropod, *Crysomallon squamiferum*, which has a reinforcing of iron and organic materials on its foot. Others are giant tube worms, *Riftia pachyptila*, which grow up to 2 metres in length but lack a mouth and digestive system.

The mysterious giant tube worm

How the giant tube worm obtained food greatly puzzled biologists until a graduate student, Colleen Cavanaugh, was observing a dissection of a giant tube worm and observed an organ, called a trophosome, being sliced up. This organ was the main internal organ and it was noted that it sometimes contained crystals of sulfur. The possible functions of this strange organ were being discussed. Cavanaugh jumped up to share her inspiration. She thought the tissues in the organ contain sulfur-eating bacteria that provide food for the tube worm. The tube worm extracts the sulfur substances from the water to keep the bacteria on the job. Research has since proved her inspiration to be correct.

1   Explain why plants don't live in the communities around deep-sea vents.

2   How has the discovery of deep-sea vent communities changed our understanding of the diversity of living things?

3   Many of the animals found near deep-sea vents are blind. Explain why you think this might be.

4   Examine how the discovery of the deep-sea vent communities has changed the classification of living things.

5   Construct a paragraph arguing why ongoing research into deep-sea vents is worthwhile.

6   Science is often divided into the areas of biology, chemistry, physics and geology.

   a   Explain why you think the two scientists that went on the initial exploration in ALVIN were geologists.

   b   Why do you think that scientific research like the exploration of deep-sea vents depends on collaboration?

7   Write an advertisement for a scientist to join a team to explore the deep-sea hydrothermal vents.

8   Is advancement in science based on inspiration or perspiration? Use the example of the discovery of how the giant tube worm gets its nutrition to explain your answer.

9   Photosynthesis is the term given to organisms that use light to produce their nutrients and energy. The organisms found on deep sea ocean vents do not use light but instead use chemicals. Suggest an appropriate name to describe how these organisms obtain their nutrients and energy.

10   Design a dichotomous key to distinguish and identify five 'black smoker' species. For each species, identify one adaptation that helps it to survive in its environment.
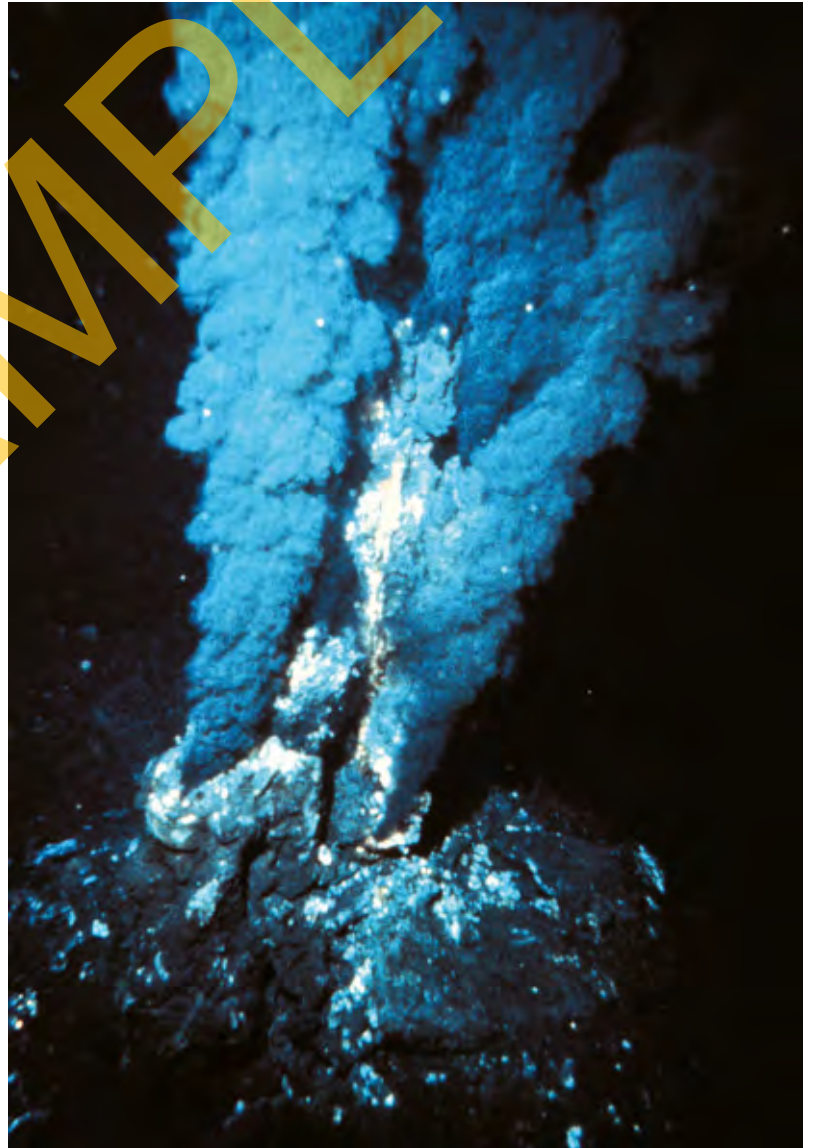

Figure 2.58 A black smoker.