2 Sorting out biodiversity

Our Earth is teeming with life. Approximately 1.8 million known types of organisms (living things) on the Earth have been described and named. Scientists estimate 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 create, to help us better understand the world.

2.1 Why do scientists classify?

Until the 1960s, any group of scientists could land on the Antarctic continent to do research. Often, the groups would be researching the same organism but call it by different names. Each would publish their results in their own language. The scientists needed an organised system to help them share the results of their efforts. These days, all visitors to the Antarctic work under a common treaty, working together to conserve every type of plant and animal on this very special continent.

1. Name three resolutions or rules that scientists might have to agree to before they can do research at the Antarctic.
2. Find out which countries signed the Antarctic Treaty.
3. Do you think the Antarctic Treaty protects only living things? Explain your answer.

→ Fig 2.1 A naming system for living things helps scientists to share their research.

2.2 How do scientists organise life?

In 2010, six new Antarctic organisms were discovered. Although these organisms look like plants, they are classified as animals. The 'sea whips' or 'sea fans' are similar to the corals found in the warm tropical waters of other oceans, which is why the scientists were surprised to find them in the icy waters of the Antarctic. Like the coral reefs, these tiny animal polyps form colonies surrounded by hard scales that stand upright, gradually flattening and branching out like a fan. A colony can grow to a metre high and a metre across, but only a few centimetres thick. They may be brightly coloured, often red, purple or yellow.

1. *Tauroprimnoa austasensis* was named because the researcher thought it looked like a bull. Can you find a hint in the name?
2. Name two characteristics that might make you think these organisms are plants instead of animals.
3. If you had to divide your class into two groups, what characteristic would you use to decide on the groups? Try to find four different characteristics.

→ Fig 2.2 These plant-like organisms are actually animals.

→ Fig 2.3 The orca is one of our closest living relatives.

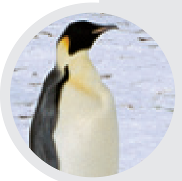
2.3 Where do I fit in?

The orca or *Orcunus orca* is one of our closest living relatives in the Antarctic. Orcas are highly social animals, often travelling in large families, each family with their own range of sounds and hunting techniques. Although Orcas have large teeth (up to 4 centimetres long) they do not chew their food. Instead, they tend to swallow it whole. Orcas are very protective of their young, nursing them with milk from their mammary glands. As soon as the young are old enough, the adults teach them to hunt fish, seals and seabirds in the freezing ice-capped waters of the Antarctic. See Figure 2.2 at left.

1. With a partner, brainstorm the characteristics you think of when you hear the word 'animal'.
2. Which, if any, of the characteristics you brainstormed would you use to describe yourself?
3. Which of the orca's characteristics could you use to describe yourself? In what ways is the orca different to you?

2.1

Why do scientists classify?



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 before you? 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?

<<DISCOVERING IDEAS>>

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 draw an animal while your partner tries to guess what it is. How quickly did they guess your animal?

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

→ Fig 2.4 Early scientists used illustrations to help them communicate.

The history of 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. Many scientists communicated in Latin, the ancient language from which many European languages have come. 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? 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.

Early classification methods

Early humans first classified plants by learning which plants were edible and which were poisonous. A new plant or animal discovered by humans was (and still is) tested and put into a group. Some plants were found to help sick people and others were poisonous. Some animals could produce foods (e.g. milk and eggs). Each generation of scientists worked to improve how these groups were classified.

The Greek philosopher Aristotle (384–322 BCE) 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. Over 500 types of plant and animal were collected and arranged in order of importance, according to where they lived and the shapes of their bodies. 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 organisms. Each scientist would publish their ideas in letters or books for other scientists to see.

Andrea Caesalpino (1519–1603) suggested classifying plants into groups according to their trunks and fruits. John Ray (1627–1705) pointed out that some plants looked very different when they were saplings than when they were large trees.

→ Fig 2.5 The mature pine tree looks very different from its sapling.

He 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) both 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. All this would have been written in Latin and the classification used by all educated people in the 17th century.

→ Fig 2.6 Carolus Linnaeus.

Carolus Linnaeus (1707–1778) tried these classification systems but found their descriptions to be too long. He decided a simpler system was needed. He changed the descriptions to single words and reduced the number of classification groups to seven.

Linnaeus's 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.

→ Fig 2.7 Part of Linnaeus's classification system.

Discovery of microworlds

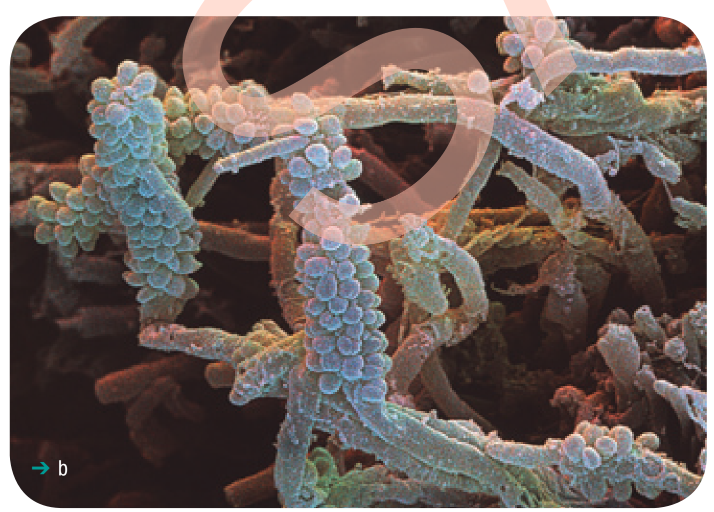
After the invention of the first crude microscopes in the 17th and 18th centuries, science took off in a new direction. Fascinating tiny creatures that nobody had ever seen before were being discovered all over the world. New systems were needed to make room for these organisms.

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.

→ Fig 2.8 (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).



→ Fig 2.9 The rainforests of Brazil contain many undiscovered plant species.

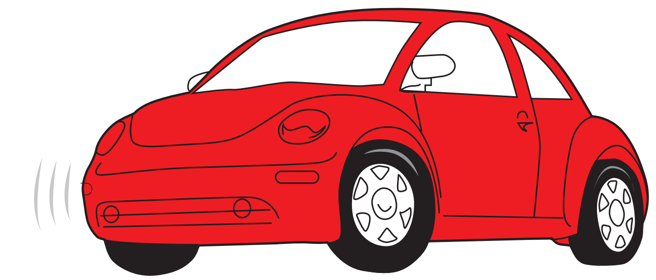
Finding new species

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, and this is really good 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 they are supported by large pharmaceutical companies from other countries. 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 the rainforest, or from an insect that relies on the fungus for food.

PRACTIVITY 2.1

The great Guzzlemobile debate



→ Fig 2.10 A Guzzlemobile.

A Guzzlemobile has been found on a planet similar to the Earth. Two groups of scientists are arguing about whether it is alive or not.

1 Work in a group of four, divided into pairs. One pair has to argue in favour of a Guzzlemobile being a living creature. 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 the Guzzlemobile is living or not.
3 When the time is up, have a class discussion about whether this new 'creature' is alive or not.

What do you know about the history of classification?

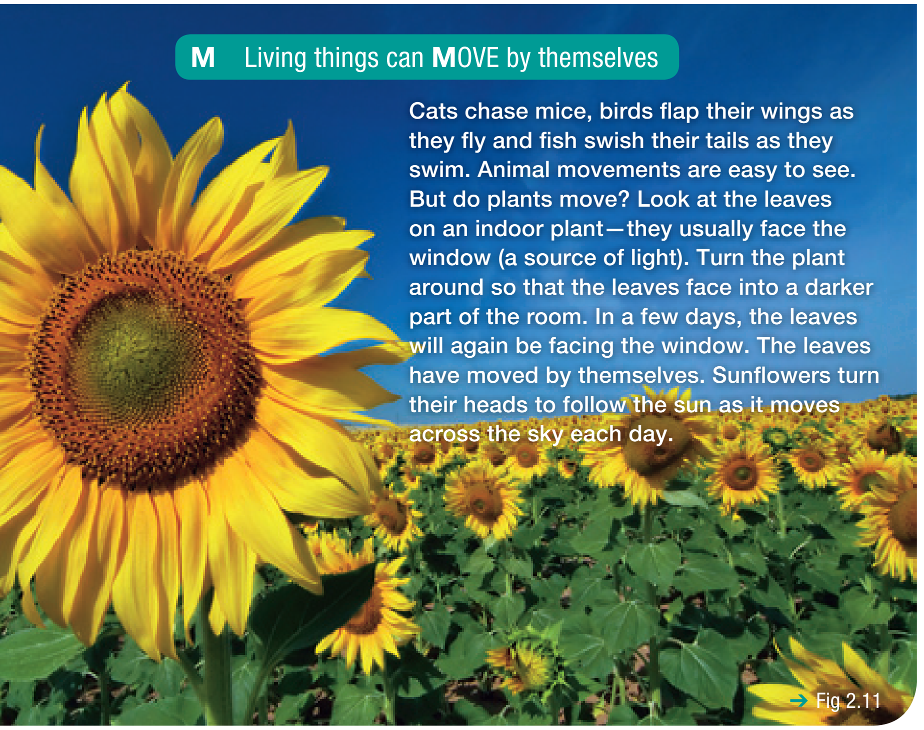
1 The earliest scientists did not have pens or paper. How would they have passed on the information they received? How accurate would it have been?
2 Aristotle was one of the first scientists to try to gather information from wide regions. What method did he use to organise all the observations from his observers?
3 Why did Carl Linnaeus simplify the classification system used by previous scientists?
4 What is an 'animalcule'?
5 Give two reasons scientists still classify organisms today.

Living and non-living

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?

Characteristics of living things

It has taken many years of observation and discussion for scientists to develop eight characteristics that all living things—plants, animals and even microorganisms like bacteria—have in common. To remember all eight characteristics, just remember MR N GREWW.



M Living things can MOVE by themselves

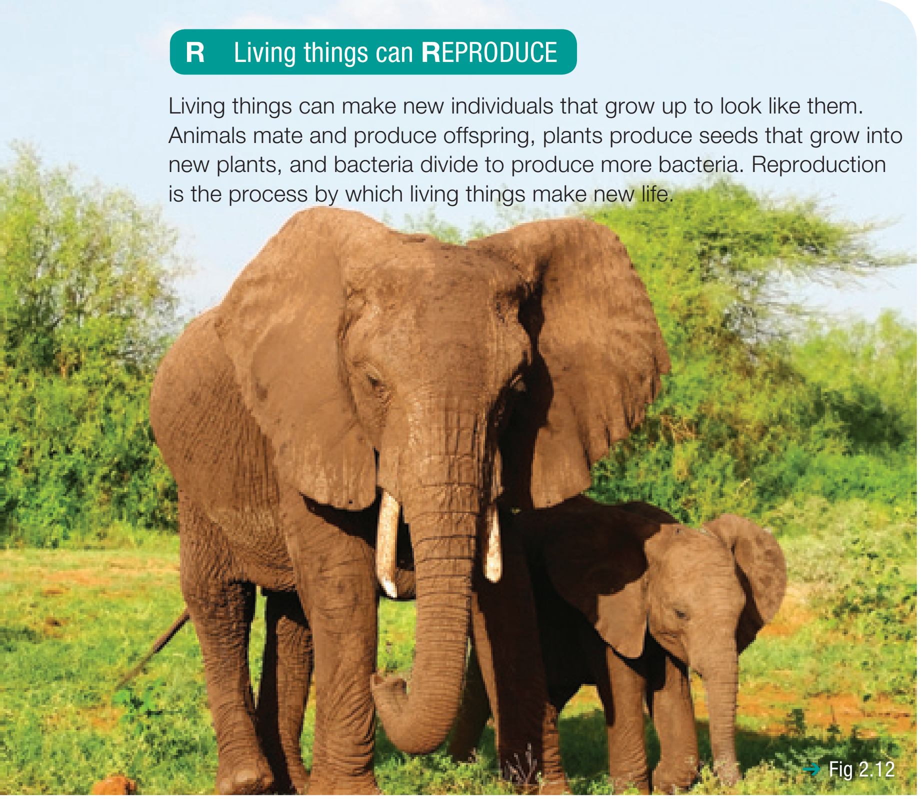
Cats chase mice, birds flap their wings as they fly and fish swish their tails as they swim. Animal movements are easy to see. But do plants move? Look at the leaves on an indoor plant—they usually face the window (a source of light). Turn the plant around so that the leaves face into a darker part of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

Fig 2.11

N Living things need NUTRITION

All living things 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. Animals and fungi are heterotrophs—they rely on other living things for food.

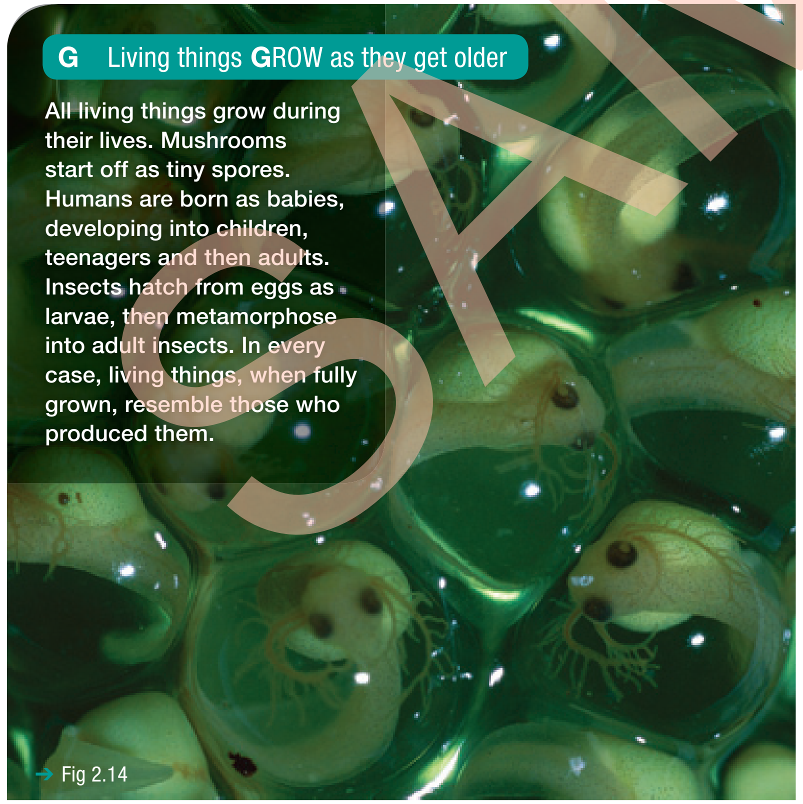
Fig 2.13



R Living things can REPRODUCE

Living things can make new individuals that grow up to look like them. Animals 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.

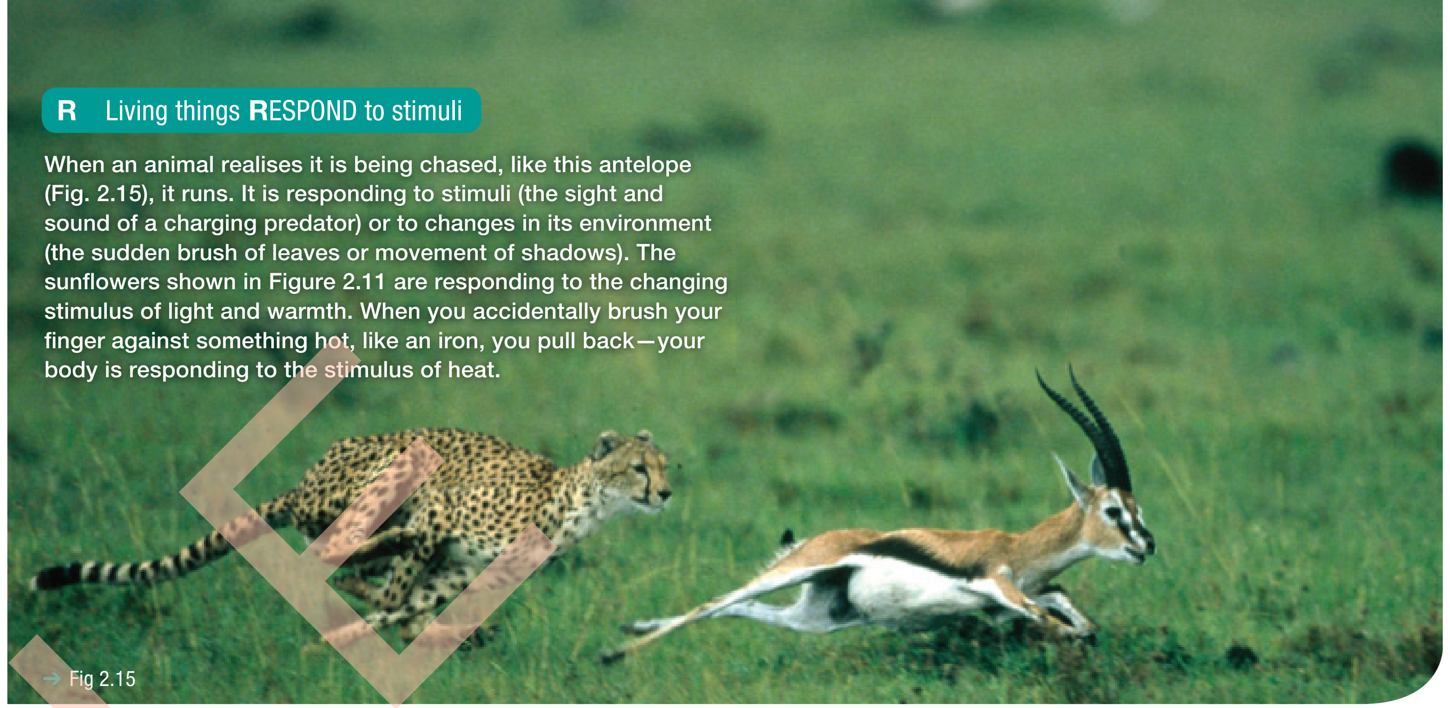
Fig 2.12



G Living things GROW as they get older

All living things grow during their lives. Mushrooms start off as tiny spores. Humans are born as babies, developing into children, teenagers and then adults. Insects hatch from eggs as larvae, then metamorphose into adult insects. In every case, living things, when fully grown, resemble those who produced them.

Fig 2.14



R Living things RESPOND to stimuli

When an animal realises it is being chased, like this antelope (Fig. 2.15), 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 2.11 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.

Fig 2.15

E Living things EXCHANGE GASES with their environments

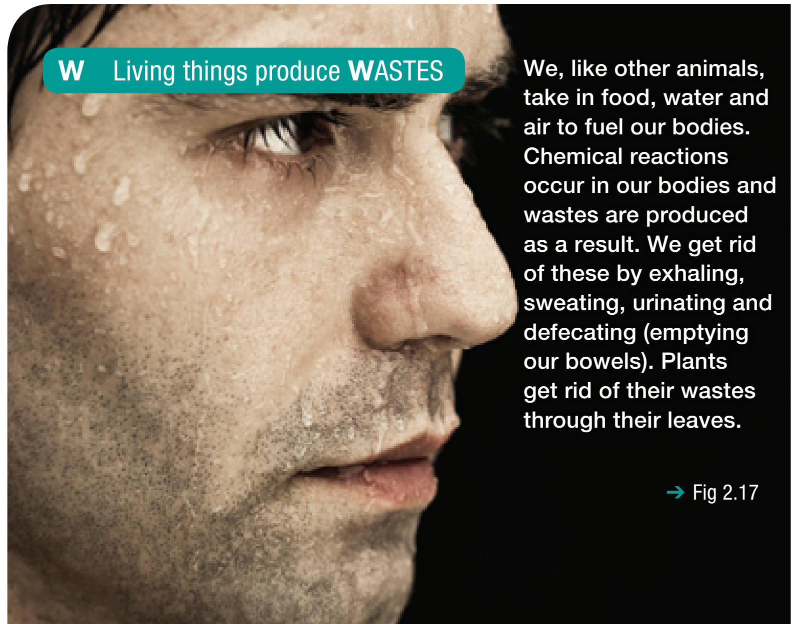
Plants and animals have organs and structures that allow them to exchange oxygen and other gases. Some animals, like humans, use their lungs to inhale and then exhale. Other animals, like fish and axolotl (Fig. 2.16), have gills. Some animals, like worms, breathe through their skin. Bacteria are different 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.

Fig 2.16

W Living things require WATER

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

Fig 2.18



W Living things 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, urinating and defecating (emptying our bowels). Plants get rid of their wastes through their leaves.

Fig 2.17

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. But, 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.

What do you know about living and non-living?

1 The system scientists use to group things divides them first into two groups. What are the two groups?

2 Consider Table 2.1.

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.

→ Table 2.1

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

3 Are any of the items in Table 2.1 dead? Explain your answer.

4 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.

Write 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.

5 Use the characteristics of a living thing to describe a bushfire.

6 Is a bushfire alive? Explain your answer.

ZOOMING IN

Encyclopedia of Life

Imagine how useful it would be to have a list of every single living species on the Earth. Now imagine how long this list would take to compile given that there are nearly 2 million known species on our planet.

This seemingly impossible task has now been taken on by Edward O. Wilson, one of the world's most well known biologists. 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 for scientists but also for students, teachers and the public to gain a better understanding of all life on the Earth. Many people are saying that this is the most significant development in the life sciences for more than 250 years. The EOL will be a global tool and will be used by people across the planet. The richness of life will only be one click away!

→ Fig 2.19

2.1 Why do scientists classify?

Remember and understand

1 List the eight characteristics of living things.
2 What is an organism?
3 What is meant by the term 'dead'?
4 Give an example of plants moving by themselves.
5 What type of nutrition does a living plant need?
6 Why is it important for scientists to use a common system to group all living things on the Earth?
7 Plants are described as living because they have all eight of the characteristics of living things. What gases do plants exchange with their environment?

Apply

8 'Biodiversity' is the word used by scientists to describe a variety of different organisms in the same region. Why is it important to preserve a large biodiversity of plants and animals in the world?
9 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.
10 Drawing accurate scientific diagrams of plants and animals is time consuming and difficult. What method would be used by scientists today to show what an organism looks like?
11 Copy the table shown below. Place the items in the following list 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*.

Living		Non-living
Currently living	Dead	

Analyse and evaluate

12 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 create a species list and map for the area in which you live.
a What is the most frequently seen animal in your area?
b What is the most frequently seen plant in your area?

→ Fig 2.20

13 Look at Table 2.2, showing the number of living things on the Earth.

→ Table 2.2 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 a backbone (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 (Monera)	35 351	>1 200 500	11%
Algae and protozoa (Protista)	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 edn, September 2009

a How many species of plant are estimated to be on the Earth?
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). Are you surprised with the result? Explain.

14 Do an Internet search for an image of an 'interesting animal'. Can you use the Internet to find how scientists classified the animal (i.e. its scientific name)?

Critical and creative thinking

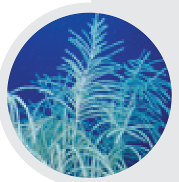
15 Design an experiment to show that plants are living things that respond to stimuli. Choose one stimulus only (such as reaction to light or to lack of water) to investigate. This stimulus is the experimental variable, so you will need to change the variable in some way and control the rest of the variables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

CONNECTING IDEAS Diversity

16 Why was the invention of the microscope important to the development of the classification system? How did it change the number of organisms for identification, classification and communication?

2.2

How do scientists organise life?



Scientists group 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. What characteristics do scientists use to divide the different animals into groups? How big are the groups? How do scientists classify living things?

Using keys

When you visit an outdoor market, you may wander around for some time before you find what you want. A department store is more organised, with similar items grouped together. If you were looking for the latest movie on DVD, you would first locate the electronics section. In that section you will often find the recordings counter with all the games and movies sitting on shelves. There might be several shelves of movies and the one you want might be on a shelf of latest releases.

Scientists use a system similar to this to sort things into groups, or classify them. The system makes the names and descriptions of organisms easier to find.

Using dichotomous keys

A **key** is a visual tool used in the classification of organisms. A key is often more useful than a list of characteristics and similarities of each group. A **branched key** (it looks like a tree) helps us to see how a particular member of the group fits in with all the rest.

One common type of key is called the **dichotomous key** (pronounced 'dye-COT-o-muss') as the branches always split into two (*di* = 'two'). Scientists use this type of key to make simple 'yes' or 'no' decisions at each branch. 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 the animal has already been identified by someone else. A newly discovered organism would need to be studied first and then new branches added.

<<DISCOVERING IDEAS>>

→ Fig 2.21

Department store design

1 With a partner, divide the items listed below into six department store groupings of your choice. Justify your choices.

   snowboard, CD, 'miracle' moisturiser, waterproof tent, golf balls, jeans, mountain bike, T-shirt, atlas, cricket bat, Hacky Sack, laptop computer, sleeping bag, nail polish, digital alarm clock, TV celebrity poster, backpack, surfing magazine, ultrashine lip gloss, plasma TV, winter coat, wetsuit, R&B CD box set, glitter eye shadow, perfume, swimming costume, MP3 player, travel book, CD player, hoodie jumper

2 Divide the products in your six departments into smaller groups or 'subdepartments'.

3 Draw a plan of your department store layout. Think carefully about what departments you will put next to each other and why.

4 Join up with another pair and 'take them on a tour' through your department store.

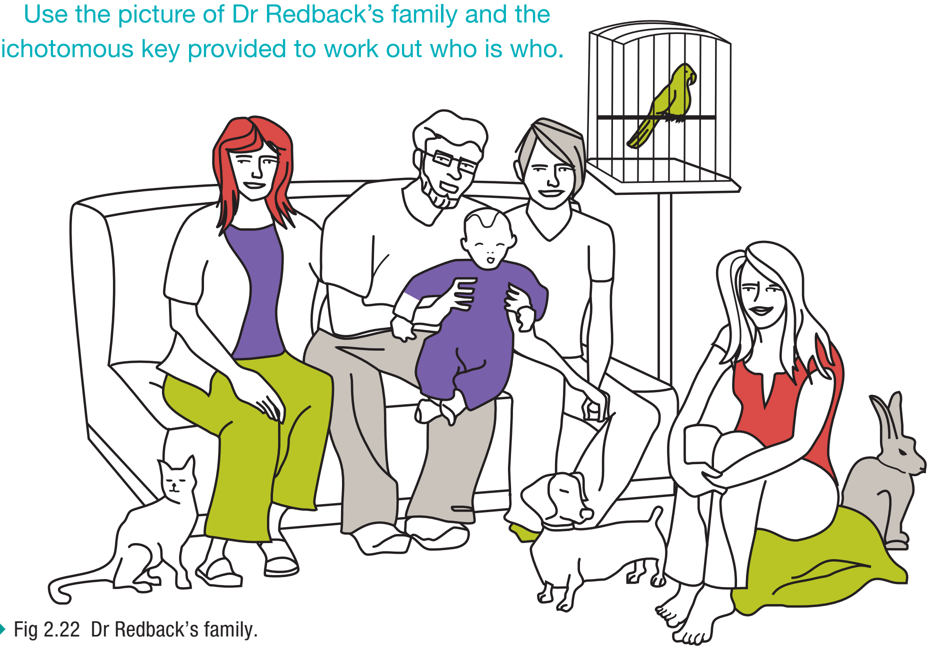
- Was it difficult to decide on your six departments? Why or why not?
- Which items did you have trouble placing into departments? Why?
- How did you end up agreeing on a department for the difficult-to-place items?
- Do you think a customer visiting your store would find products easily?
- How was the layout of your store different from that of the other group?
- Did the other group find your department store plan easy to follow? What improvements could you have made?

PRACTIVITY 2.2

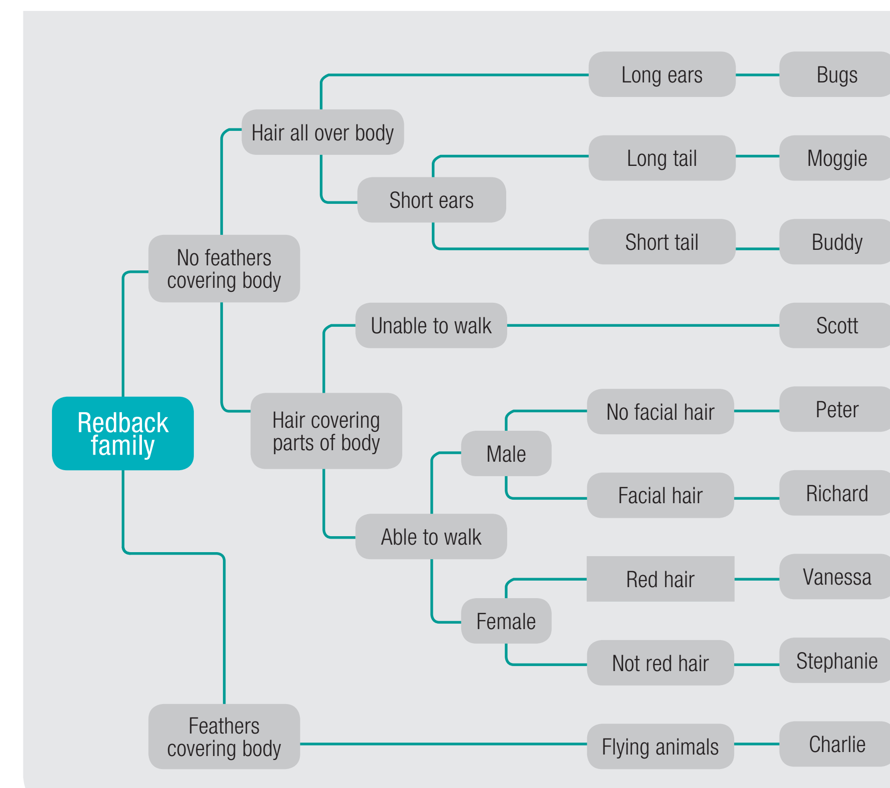
Dr Redback's family

Dr Redback loved 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.



→ Fig 2.22 Dr Redback's family.



→ Fig 2.23 Dichotomous key for Dr Redback's family.

Dichotomous keys

DESIGN YOUR OWN...

→ Fig 2.24

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 and conducting

- What similarities or differences can you find to separate the objects into two groups?
- What other similarities or differences can you find to separate them into further groups? 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?

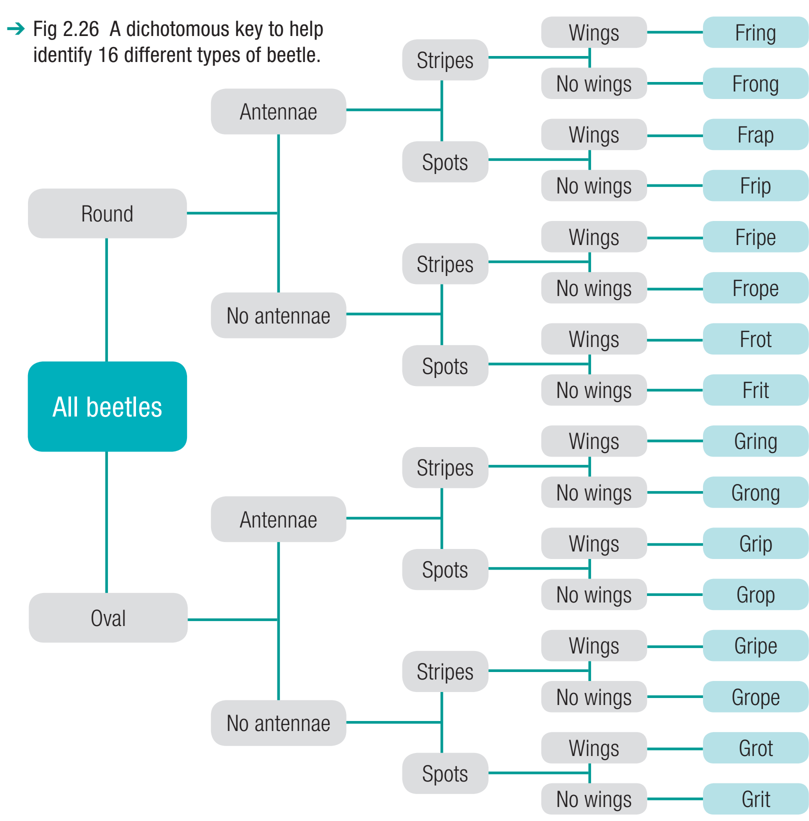
Communicating

Swap your dichotomous key with another group. How effectively have they constructed a dichotomous key? Ask them to evaluate your key. Which was the best dichotomous key designed in your class? What features made it the best key?

What do you know about using keys?

1 What is a dichotomous key?
2 Why is it called 'dichotomous'?
3 What does the term 'classifying' mean?
4 Which of the following descriptions would be good to use to classify a group of birds in a dichotomous key? Give a reason 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 wing span 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 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. Make up a table of their common characteristics and look for common ones you could use to build a dichotomous key for classifying them. Include the names and pictures of the dinosaurs on the key.
7 Use the dichotomous key in Figure 2.26 to help with the following tasks.
   a Identify and name the four beetles in Figure 2.25.
   b Draw a simple sketch of the following:
      i frope beetle
      ii gring beetle
      iii gripe beetle
      iv frong beetle

→ Fig 2.25



→ Fig 2.26 A dichotomous key to help identify 16 different types of beetle.

<<OVERARCHING IDEAS>>

Finding the key

Patterns, order and organisation

As you no doubt found out in the Discovering Ideas activity (page 56), it is quite possible to use different systems to classify or group similar things. One system is not necessarily better than another, just different. Scientists use the same types of method to classify living things—they group together living things that have similar characteristics.

Thinkers Keys

Thinkers Keys were first introduced by Australian educator Tony Ryan in the 1980s. Thinkers Keys introduce different ways of higher order thinking by challenging 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 a plant cell and animal cell. 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 twenty 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?

The Linnaean classification system

Deciding to use an enormous dichotomous key to classify every living thing was largely the work of a man named Carolus Linnaeus (1707–1778). His system of classification, called the **Linnaean taxonomy**, is still used today.

Linnaeus was born in Sweden in 1707 and he originally studied medicine. However, his real interest was in collecting plants and he went on many expeditions to other countries to collect native plants. To be able to make sense of all the plants he had collected from around the world, he designed a system to order and name them. He worked as a professor at the University of Uppsala in Sweden and, in his spare time, arranged all the plants in the university garden according to his new system of classification.

Linnaeus's classification system was extended from just grouping plants to classifying all the kingdoms of living organisms.

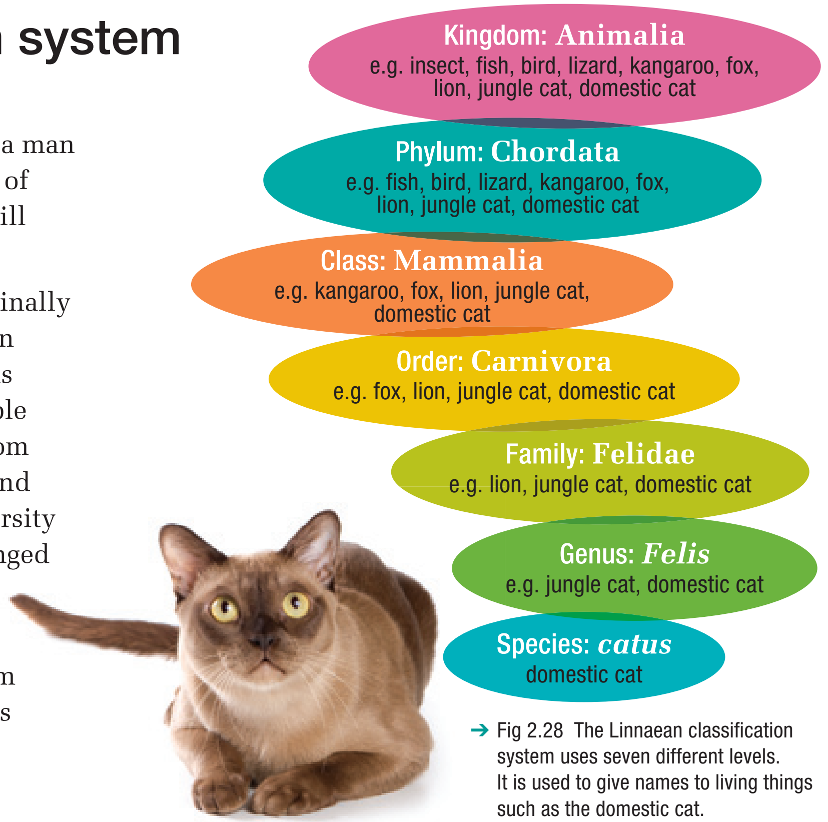


Fig 2.28 The Linnaean classification system uses seven different levels. It is used to give names to living things such as the domestic cat.

Giving organisms a precise name

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 2.27?

Fig 2.27 Did you ever address a letter like this?

If you read this address from the bottom up—from 'The Universe' to the house number—it is a bit like a classification key. As you go up each level, it becomes easier to locate the sender. It is a bit like focusing in on your house on Google Earth. You may start with the whole country, but each country has states, then towns, suburbs and, finally, streets and buildings.

The Linnaean dichotomous key for all living things works in a similar way. It starts with large groups called kingdoms, and then divides into smaller groups called phyla. 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*, *species*. (Tip: Some people use the following mnemonic to remember the Linnaean system: '**K**ing **P**hillip **C**rawled **O**ver **F**our **G**ooey **S**nails'.)

Linnaeus's double-name system

Have you eaten a *Musa sapientum* lately or have they been too expensive to buy? 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).

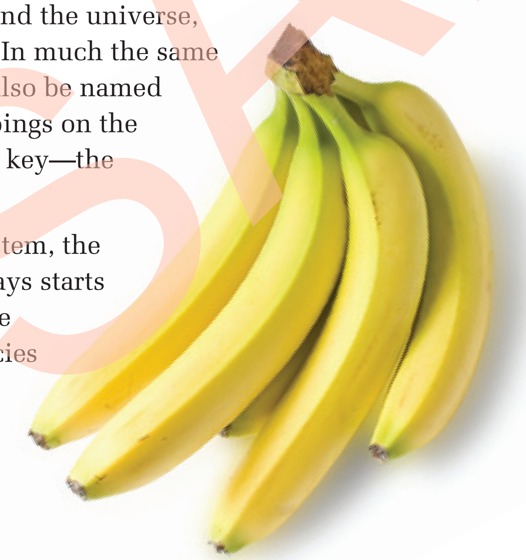


Fig 2.29 *Musa sapientum* is the Linnaean name for a banana.

PRACTIVITY 2.3

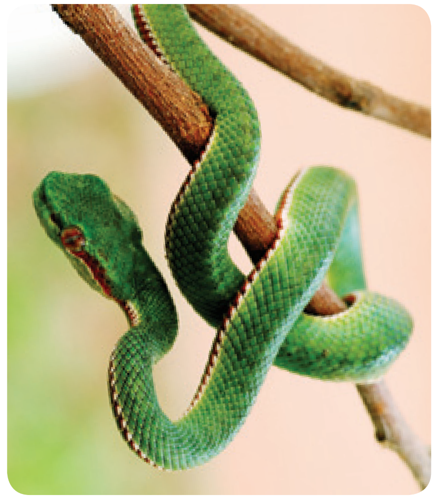
Making a field guide

Scientists often use field guides to determine the group to which an animal belongs. These guides are set out in a tabular key where you read through the numbered options in order. Each item presents two options, and more information is given at each step. Eventually the animal can be identified.

1 Use the information given to identify the class of each of the animals shown.

1	Feathers present No feathers present	Aves Go to 2
2	Hair or fur present No hair or fur	Mammalia Go to 3
3	Fins present No fins present	Pisces Go to 4
4	Has moist skin, no scales Has scales	Amphibia Reptilia

2 Use the information given about Dr Redback's family in Practivity 2.2 on page 57 to create your own field guide or tabular key.



A **species** is a group of organisms that look similar to each other. When they breed in natural conditions, their offspring are fertile (in other words, they can also breed). Domestic cats belong to the one species because they can breed together and have kittens.

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.

Understanding scientific names

The scientific names of animals 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 2.3 contains some examples.

Table 2.3 Some scientific words and their meanings

Latin/Greek root word	English meaning	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
Hynchus	Snout	*Chlamy*	Caped
Macro	Large	*Saurus*	Lizard

What do you know about the Linnaean classification system?

1 Use the information in Table 2.3 to match the scientific names of the Australian animals with their pictures.

   a *Macropus rufus*

   b *Tachyglossus aculeatus*

   c *Phascolarctus cinereus*

   d *Ornithorhynchus anatinus*

   e *Chlamydosaurus kingii*

2 What do you think a *Macroglossus aculeatus* might look like? Sketch this imaginary animal, using Table 2.3 to help.

3 Who invented the naming system that is still used today to name living things?

4 What are the seven groups that living things are divided into? Write them in order from largest to smallest level of organisation.

5 Why would giving your address as 'John Campbell, Southern Hemisphere, The Earth' not be a good way to get many letters?

6 With the same idea in mind, why do taxonomists need a very detailed system like the Linnaean classification system to group living things?

7 What is the first level of the Linnaean classification system under 'All living things'?

8 What does the word 'species' mean?

9 Select three species of animal. For each animal:

   a describe its appearance

   b give its common and scientific name.

Cells in living things

The discovery of microscopes changed the classification system. Instead of grouping only the large plants and animals, scientists now had to include all the tiny living things they saw under a microscope. They could also consider much smaller details when grouping organisms according to features.

→ Fig 2.31 The nerve cells of giant squid are up to 12 metres long!

Building blocks of life

Cells are often called the building blocks of life. Think of the way bricks are used to build a house. Cells build living things in a similar way. However, there are usually many more cells in living things than bricks in a house: an adult human body is made up of about 10 trillion (10 000 000 000 000) cells. Elephants have even more. Any living thing with more than one cell is **multicellular**. As van Leeuwenhoek discovered, many living things, such as bacteria, consist of only one cell. These are single-celled or **unicellular**.

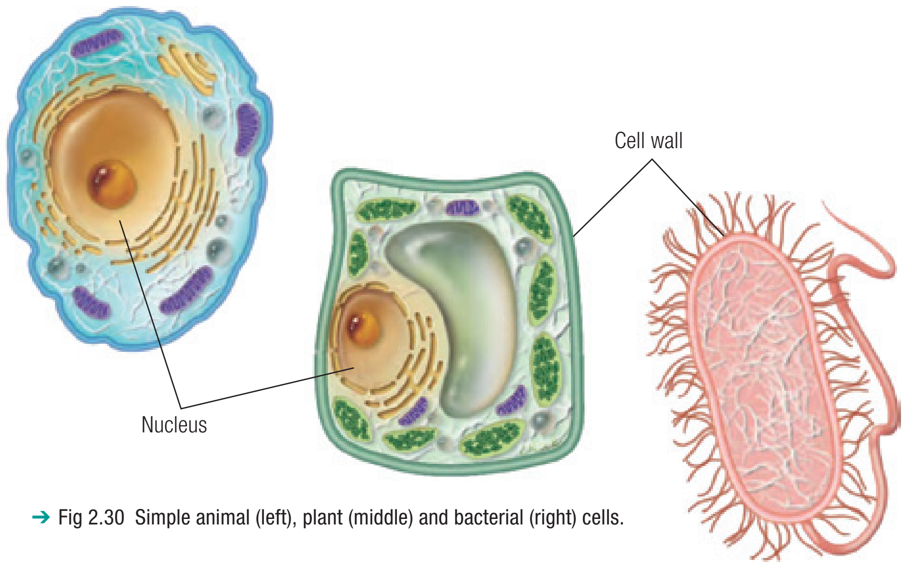
Cells can usually only be seen through a microscope. Some are so tiny that 20 000 of them, placed end to end, would only be 1 centimetre long. Giant squid have nerve cells that are up to 12 metres long!

Armed with a new and bigger picture of life, scientists set about the task of working out dichotomous keys for a system that would include all living things.

Parts of a cell

Although the cells of different organisms might at first appear quite different in shape, if you look closer at the parts that make them up, cells are actually quite similar. All cells have genetic material called **DNA**, which carries all the instructions for staying alive. Often (but not always) this genetic material is packaged into a small part of the cell called a **nucleus**. Each cell of an animal or plant has a nucleus. All cells without a nucleus (like bacteria) are in a separate group. Plant cells have a special **cell wall** around them for extra support, while animal cells do not. This is one way scientists distinguish between plants and animals. Another way to distinguish between cells is whether they use sunlight to make their own nutrients (**autotroph**). Plant cells can do this, but fungi (like mushrooms) need to absorb their nutrients from other living things (**heterotroph**). The structures inside the cells give us information about how they work.

It is these small details that are used to divide up all living things in the first big groups called kingdoms.



→ Fig 2.30 Simple animal (left), plant (middle) and bacterial (right) cells.

What do you know about cells in living things?

1 Name two characteristics of a plant cell.

2 What is a nucleus?

3 What is the role of a cell wall?

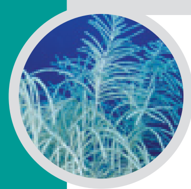
4 Name an organism made up of just one cell.

5 What does 'multicellular' mean?

6 What does 'unicellular' mean?

7 Why was the invention of the microscope important to our understanding of living things?

2.2 How do scientists organise life?



Remember and understand

1 Where do you find the largest cell? How big is it?
2 Why are most keys dichotomous?
3 Are most animals unicellular or multicellular? Explain your choice.
4 What are the advantages of using a dichotomous key?
5 List two characteristics that would divide your science class into two groups of approximately equal size.
6 Empty your school bag or pencil case and design a dichotomous key of its contents.

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*.
8 Make up a new mnemonic to remember the levels of classification.
9 Refer to Figure 2.22 (page 57) showing Dr Redback's family. How might you 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?

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.
11 Research other types of classification key that can be used to identify organisms.
12 Download a copy of the collection of insects in Figure 2.31 from your **obook**.
   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.
   c Compare your groupings with those of a partner. Between the two of you, can you think of other ways to classify the insects?
   d With your partner, create a dichotomous key for this group of insects.

Critical and creative thinking

13 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.
14 Propose a new system of classification for organising life on the Earth. Which kingdom would you be in?

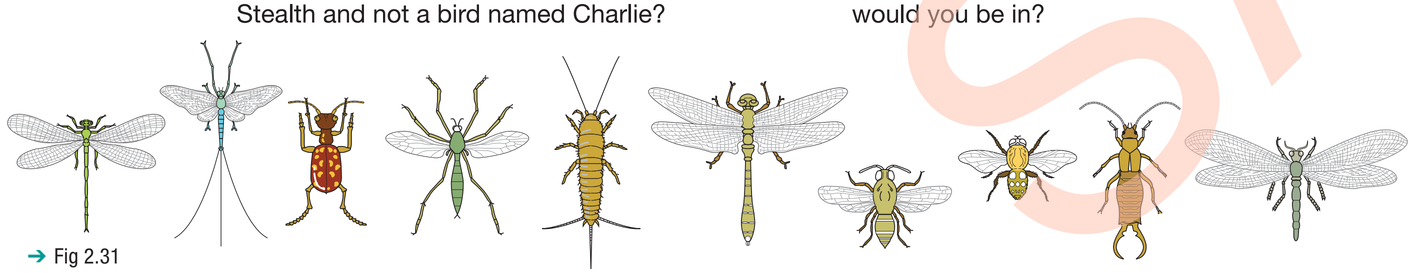


Fig 2.31

<<CONNECTING IDEAS>> Diversity

15 a Why was the invention of the dichotomous key important to the development of the classification system?
   b What are the limitations of a dichotomous key?

2.3 Where do I fit in?

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 m long—about the size of a house. Size is not a very suitable characteristic for classifying animals into groups, especially because most grow over time. So what characteristics are chosen to group animals? And where do humans fit in this system?

<<DISCOVERING IDEAS>>

Grouping animals

Type the word 'animal' into a search engine for images. Print and cut out the images of 30 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.

Use these groupings to come up with a dichotomous 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?

Kingdoms

The earliest **taxonomists** (scientists that 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.

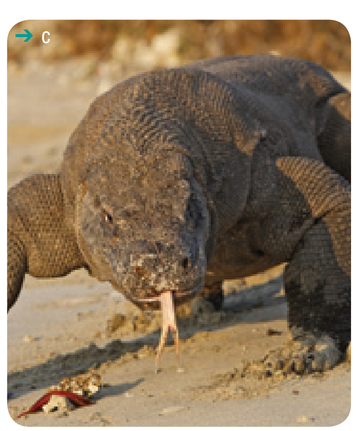
These days, scientists generally agree on classifying living things into five large **kingdoms** based on:

- the structure of their cells
- how they obtain nutrients
- their general appearance.

Kingdom Animalia

All organisms in this kingdom are multicellular. Each cell stores its genetic material in a nucleus but doesn't have a cell wall. Animals gain energy from other living things. We belong in this kingdom. Zoologists are the scientists who study animals.





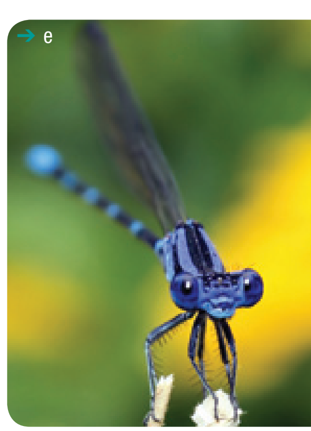


Fig 2.32 Kingdom Animalia: (a) The proboscis monkey (*Nasalis larvatus*) has the biggest nose. (b) Pangolin. (c) Goanna. (d) Port Jackson shark. (e) Damselfly.

Kingdom Plantae

Plants include trees, vines, bushes, ferns, mosses, weeds and grasses. They all gain energy by making their own food from sunlight (autotrophs). They are multicellular, but their cells have a cell wall around the outside of the cell, as well as a nucleus inside the cell. **Botanists** are the scientists who study the plant kingdom.

→ Fig 2.33 Kingdom Plantae: (a) 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. It gives off a rotten meat odour when it blossoms, to attract insects. (b) Flowering gum. (c) Wheat. (d) Nepenthe. (e) Cactus.

Kingdom Fungi

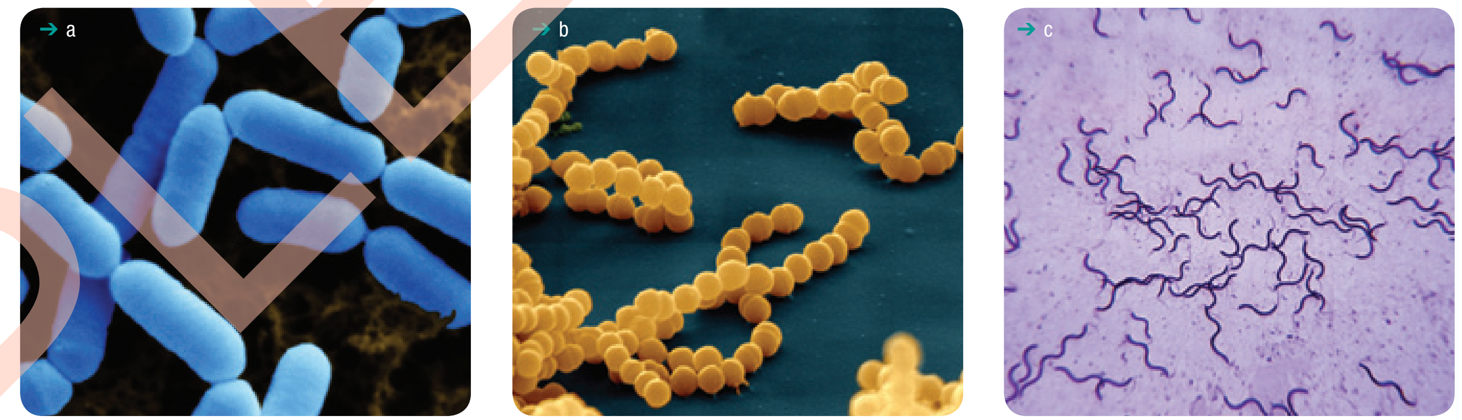
Kingdom Fungi includes mushrooms, toadstools, yeasts, puffballs, moulds and truffles. Some fungi grow in wood and in soil and develop from tiny spores. Fungi do not make their own food. Instead, they feed on the remains of dead animals and plants. Some fungi can cause diseases, such as tinea (athlete's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

→ Fig 2.34 Kingdom Fungi: (a) Mushrooms. (b) Mould. (c) *Aspergillus conidiophores* as seen under a microscope.

Kingdom Monera

This kingdom is made up of the simplest and smallest living things. There are about 75 000 different organisms in Kingdom Monera and they are all unicellular, and have a cell wall but no nucleus. **Bacteria** are the most common 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, we would be surrounded by mountains of smelly rubbish. Bacteria have been put to use by humans to make foods, such as cheese and yoghurt.

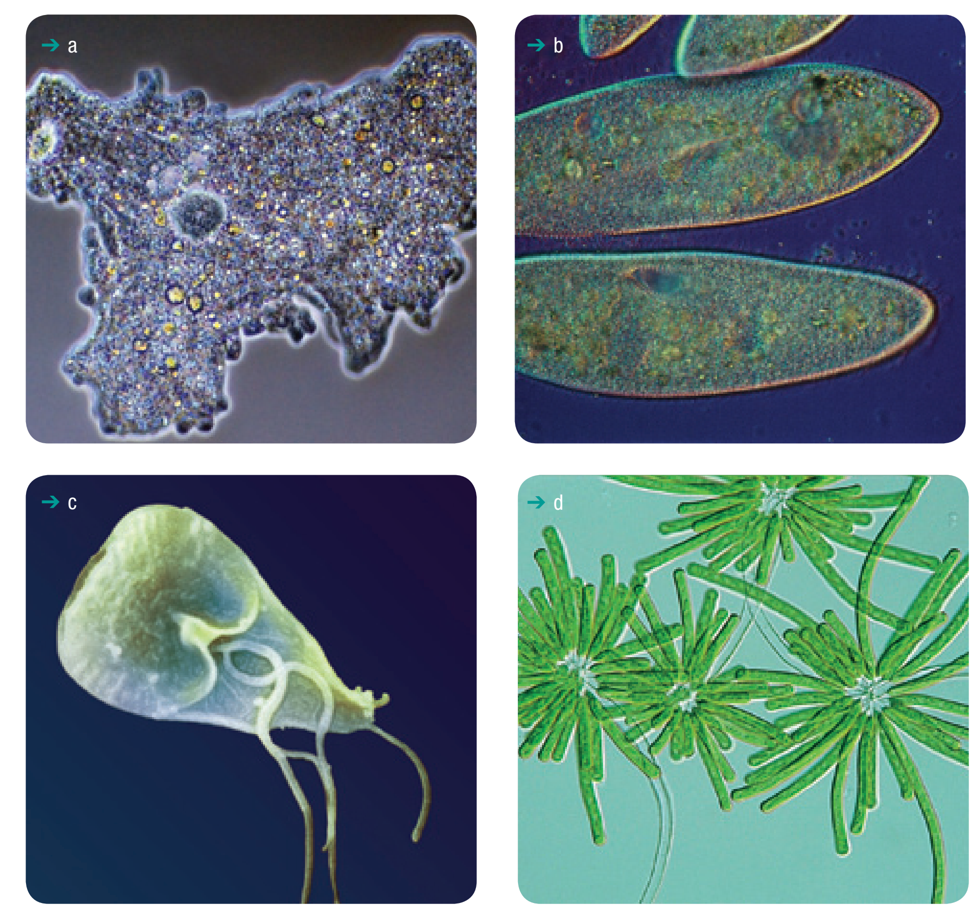
Microbiologists are the scientists that study microorganisms in kingdoms Monera and Protista.



→ Fig 2.35 Kingdom Monera, as seen under a microscope: (a) *Lactobacillus casei*. (b) *Streptococcus pyogenes*. (c) *Spirillum volutans*.

Kingdom Protista

There are about 55 000 species of protist. Their cell structure is more complex than Monera. Often, organisms that don't fit into any other kingdom will belong in Protista. They may 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. ***Amoeba***, microscopic organisms that change their shape to trap their food, also belong to this group.



→ Fig 2.36 Kingdom Protista, as seen under a microscope: (a) *Amoeba*. (b) Paramecium. (c) *Giardia lamblia* (d) *Ophiocytium arbuscula*.

PRACTIVITY 2.4

Classifying living things

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

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

1 Download the 'Sorting into Kingdoms' worksheet. (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 mark up a table with four columns.
3 Label the columns 'Animalia', 'Plantae', 'Fungi' and 'Other (Monera and Protista)'. (Don't try to distinguish between Monera and Protista.)
4 Cut out each organism from the worksheet and paste it into the correct column.

What do you know about kingdoms?

1 Name four features of animals.
2 Name four features of Kingdom Monera.
3 How is a protist different to a bacterium?
4 What is the difference between cells in Kingdom Plantae and Kingdom Fungi?

Kingdom Animalia

Internal or external skeleton?

In the same way as creating any kind of dichotomous key, dividing the animal kingdom into groups first requires a question. The system scientists use to divide animals into groups is based on their structure. The question is: 'Does this animal have an internal or external skeleton?'

Animals such as cats, humans and birds with an internal skeleton (called an **endoskeleton**) are put in a group called **vertebrates**. Because these animals often have a spinal cord that 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**. Invertebrates dominate the animal kingdom.

ZOOMING IN

Giant squid dissection released on the web

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

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.

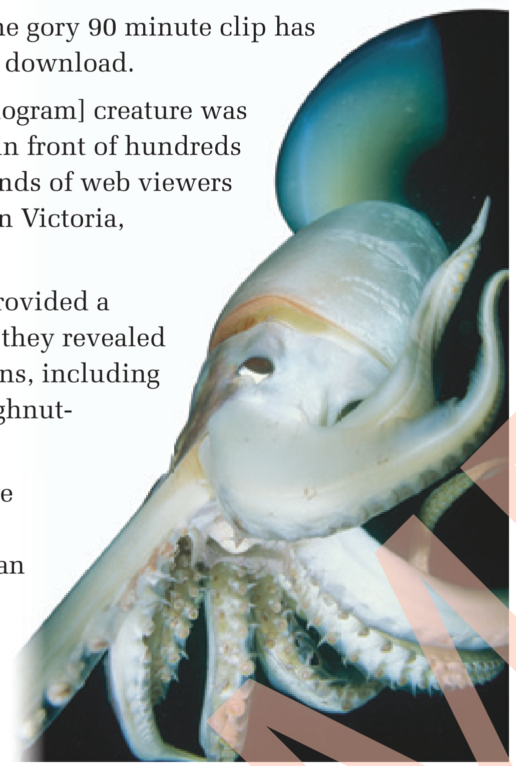


Fig 2.37 The giant squid is an invertebrate.

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 2.1

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
pair of vinyl or latex gloves

- Always wear gloves when handling the animals.
- The animals must always be on the dissecting board when handling and dissecting.
- 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 insides.
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?

Fig 2.38

Fig 2.39

Fig 2.40

Fig 2.41

What do you know about Kingdom Animalia?

1 Animals are divided into two main groups.
   a What are the names of the groups?
   b What do the names of these two groups mean?
2 Give two examples of animals with an exoskeleton.
3 Give two examples of animals with no skeleton at all.
4 What percentage of animals are invertebrates?
5 Why do you think invertebrates are such a dominant group among animals?
6 What is the world's biggest known invertebrate?
7 Draw a sketch of the world's biggest invertebrate and write down its dimensions, for example its length and weight.
8 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.

Classes of vertebrate

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 their young are born
- their body temperature.

Vertebrates either have a constant body temperature (**endotherm**) or a body temperature that changes with the environment (**ectotherm**).

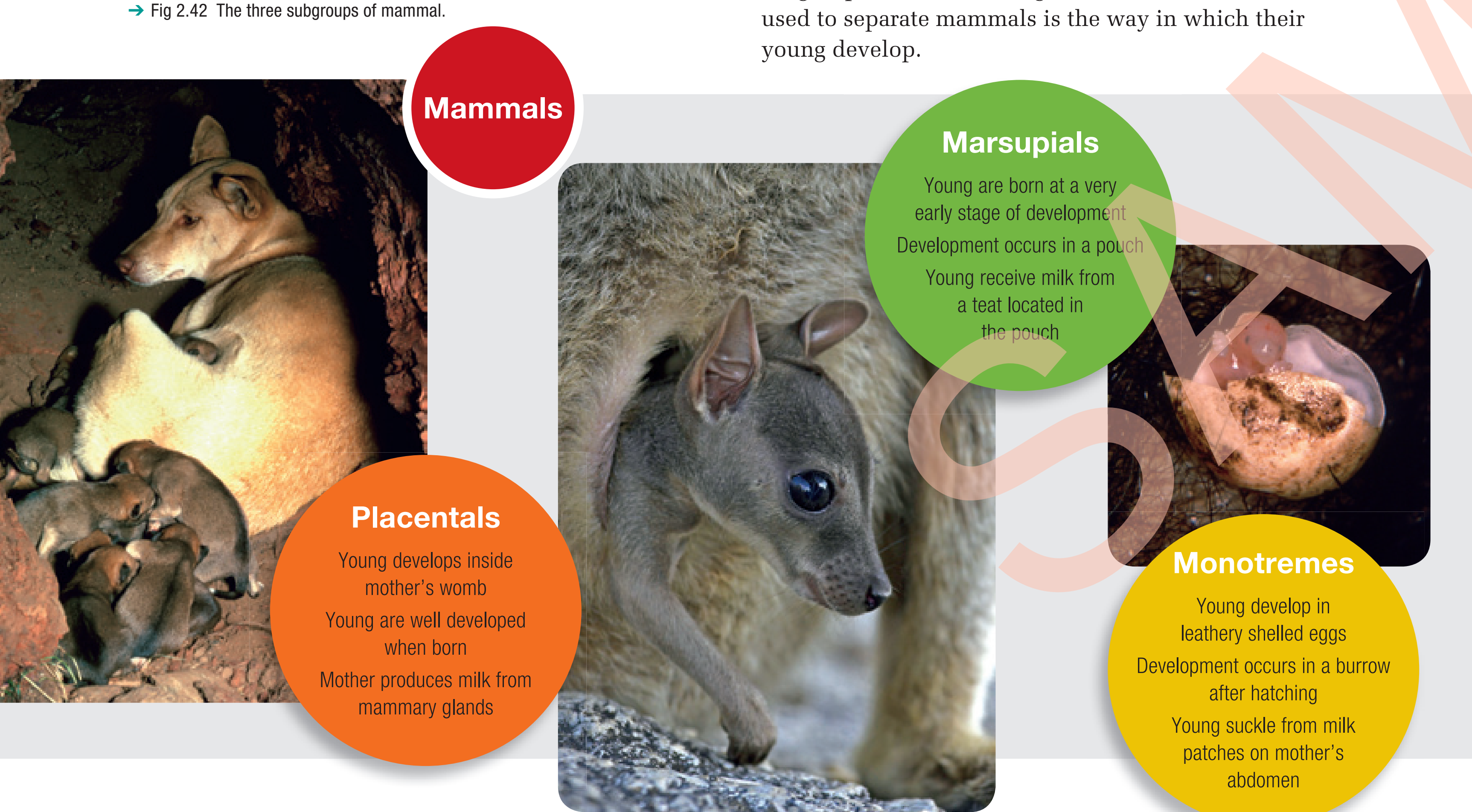
Class Mammalia

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 constant body temperature. Female mammals give birth to live young and feed their young with their own milk.

Class Mammalia can be further broken down into three subgroups, as shown in Figure 2.42. The main feature used to separate mammals is the way in which their young develop.

→ Fig 2.42 The three subgroups of mammal.



LITERACY LAB

The 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 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/The-Enigma-of-the-Echidna

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 an echidna for themselves might have believed pictures to be false?

Class Aves

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

→ Fig 2.43 Class Aves: (a) Vulture. (b) Cockatoo.

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 (sea snakes). These animals are also ectotherms—we 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.

→ Fig 2.44 Class Reptilia: (a) King brown snake. (b) Bearded dragon. (c) 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.

→ Fig 2.45 Class Amphibia: (a) Growling grass frog. (b) Chinese giant salamander.

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.

→ Fig 2.46 Class Pisces: (a) Tuna. (b) Weedy seadragon. (c) Reef shark. (d) Manta ray.

PRACTIVITY 2.5

Who are the vertebrates?

Vertebrate alphabet graffiti

Note: Alternatively, this task could be completed as a webpage, with images and links to further information about each animal.

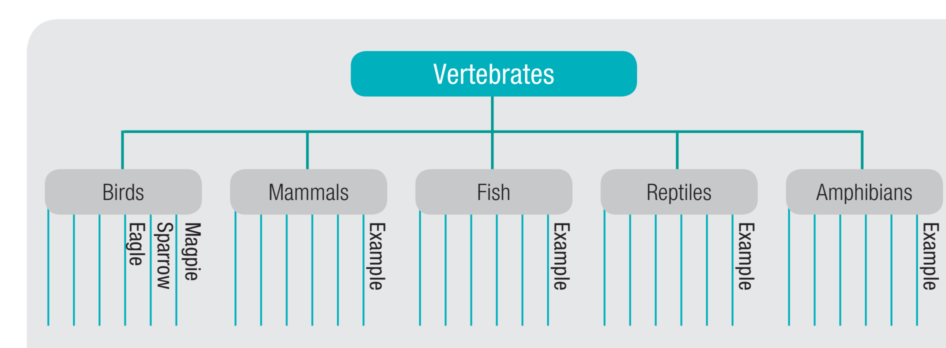
1 Divide the class into five groups, each of which will be allocated one class of vertebrate.
2 Label an A3 sheet of paper with the name of your class of vertebrate.
3 Write the letters of the alphabet down the left-hand side of the page.
4 For each letter, write the name of an animal that fits this 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 2.47.
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.

→ Fig 2.47 A jellyfish organiser for vertebrates.



What do you know about classes of vertebrate?

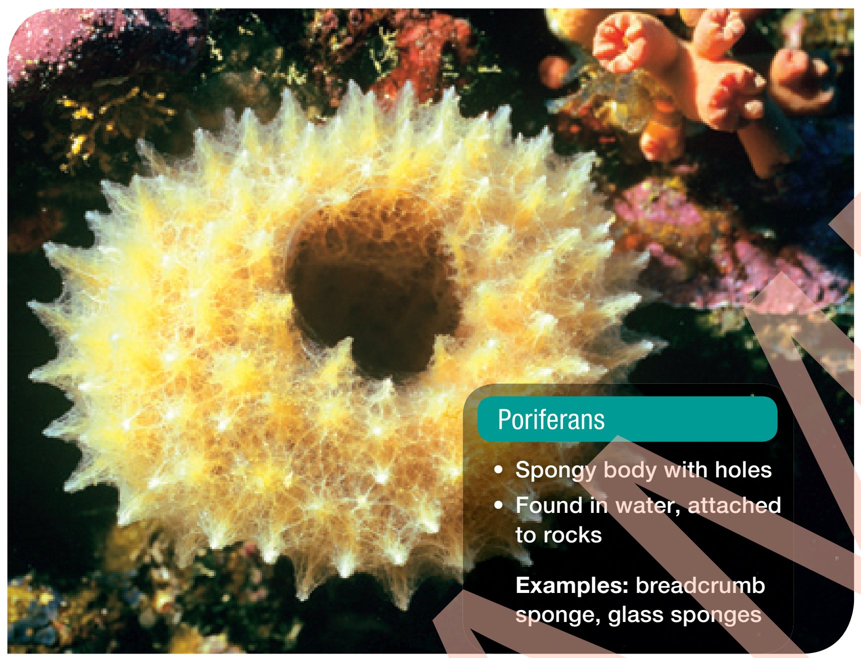
1 Seals have fins like fish and live on the land and in the water like amphibians.
   a Find out how a seal's young are born.
   b Given that the seal has long whiskers, to which class of vertebrate do seals belong?
2 A dolphin lives in the ocean and has fins. To which class does it belong? Explain.
3 A flying fox can glide through the air like a bird but is covered in fur. To which class does it belong? Why?
4 What are the main characteristics of mammals?
5 a Describe how a baby echidna is born and develops before it comes out of the mother's pouch.
   b Draw a puggle.

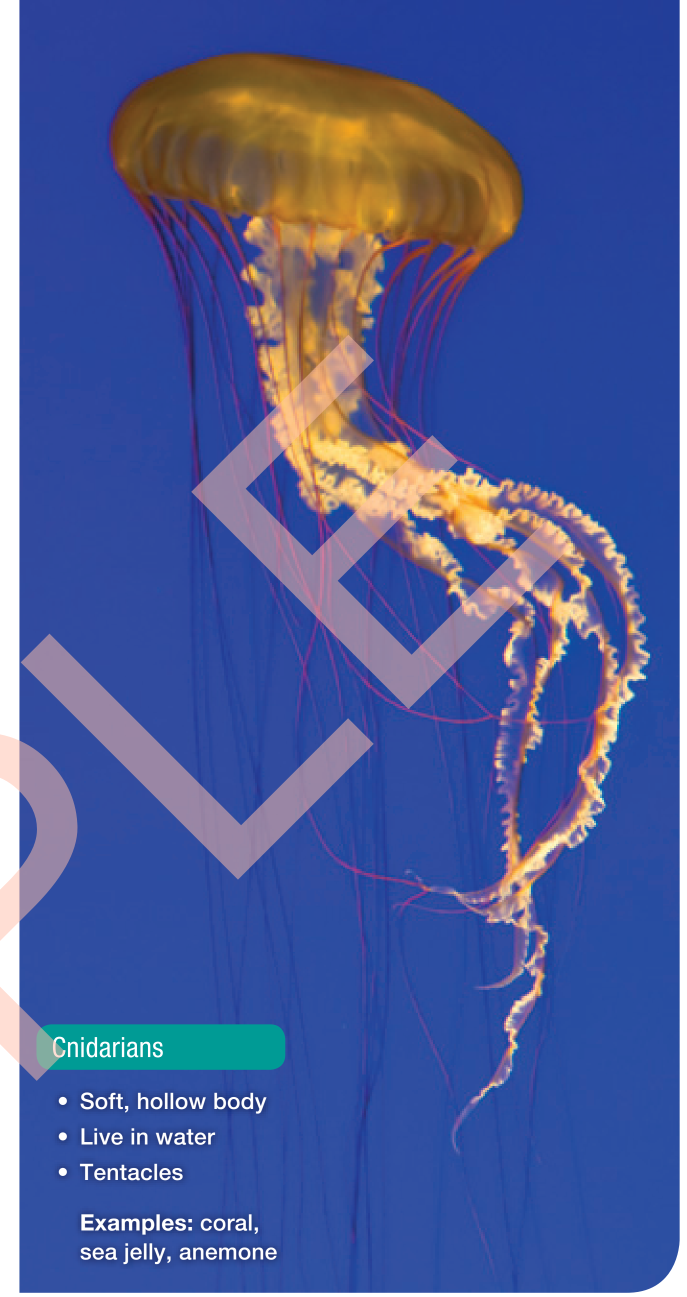
Invertebrates

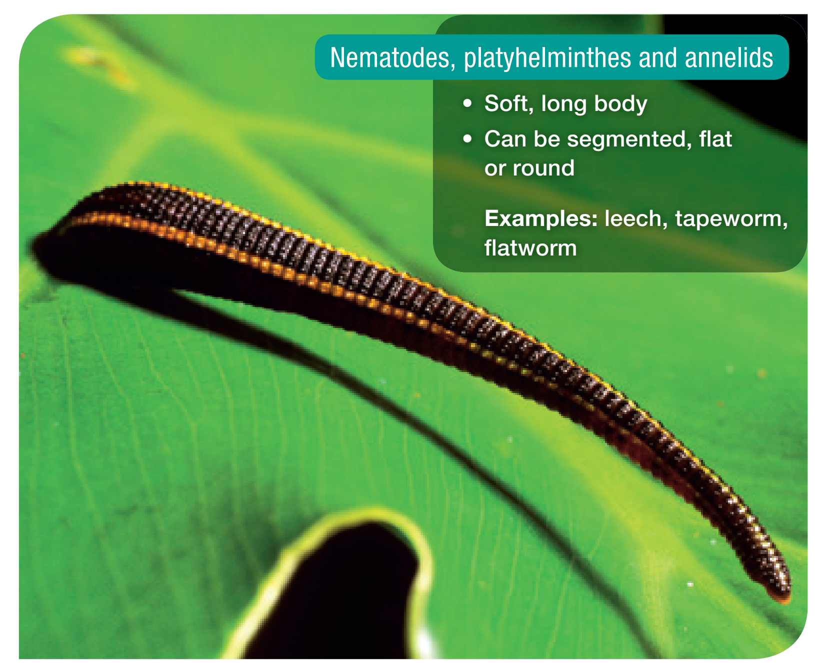
There are many more invertebrates on the Earth than vertebrates: 96% of all animals are invertebrates. Invertebrates have either an external skeleton (exoskeleton) or no skeleton at all. The giant squid (see Fig. 2.37 on page 68), huge as it is, has no backbone. As well as enormous animals like this, thousands of tiny insects and other creatures belong to the invertebrates group.

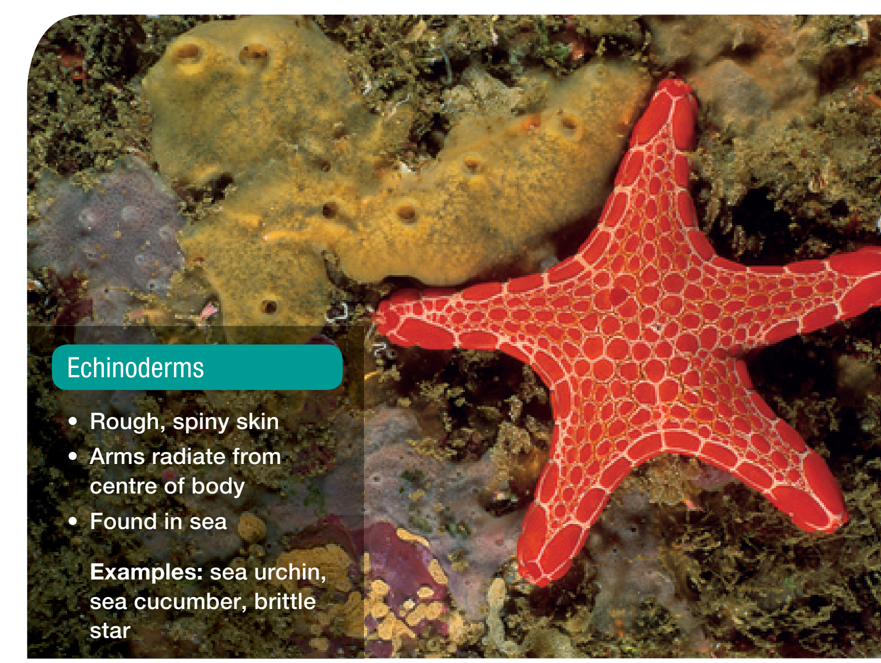
Invertebrates are classified into six main groups or phyla (see Fig 2.48).

→ Fig 2.48 Some commonly found invertebrate phyla.









Identifying invertebrates

In the same way that vertebrates were classified, invertebrates are also grouped by their characteristics. Characteristics used to classify invertebrates include the presence of a shell or hard cover, tentacles or spiny skin. Organisms with similar features are placed in the same group. The dichotomous tabular key in Figure 2.49 can be used to place an organism in a particular phylum.

→ Fig 2.49 Tabular key for identifying invertebrates.

1	Body spongy, with many holes	Poriferan
	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	Cnidarian
	Arms with suction discs	Mollusc
5	Soft body, large foot	Mollusc
	Worm-like or leaf-like	Nematode, platyhelminth or annelid
6	Proper shell or smooth, hard covering	Go to 7
	Spiny skin with rough covering	Echinoderm
7	Limbs in pairs	Arthropod
	Shell, no segments, large foot	Mollusc

PRACTIVITY 2.6

Identifying invertebrates

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

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

- 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 Wearing gloves, use tweezers to collect up to ten invertebrate specimens in separate jars.
3 Use the tabular key in Figure 2.49 to classify the invertebrates into their particular phylum.
4 Use a magnifying glass or stereomicroscope 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.

- Use the tabular key in Figure 2.49 to identify the phylum of each of the invertebrates shown.

→ a

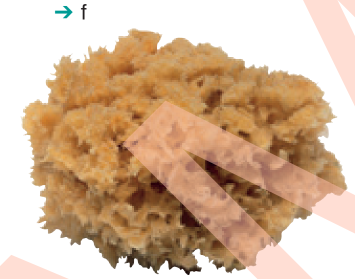
→ b

→ c

→ d

→ e

→ f



→ g

→ h

What do you know about invertebrates?

1 What percentage of animals are vertebrates?
2 What is an exoskeleton? Give an example of three organisms with an exoskeleton.
3 Beetles have segmented bodies and jointed legs. To which phylum do they belong?
4 Eighty per cent of animals on the Earth are arthropods.
   a Which characteristic does their name refer to? (Hint: 'arthritis' and 'podiatrist')
   b Draw three different arthropods and label the features that make them part of this phylum.
5 In Practivity 2.6, which phylum of invertebrates did you find in the greatest quantity? Can you explain why?

The changing face of science

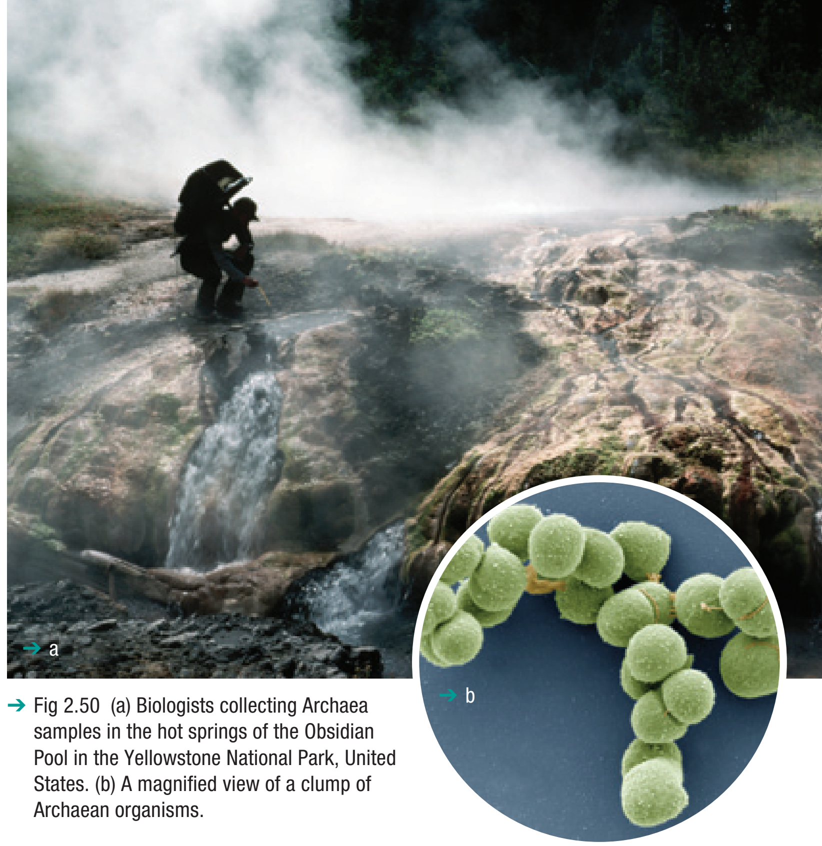
Scientists are still testing and modifying the Linnaean classification system after 250 years. The development of microscopes led to the discovery of single-celled organisms (bacteria). This led to the number of kingdoms increasing from three (plants, animals and minerals) to the current five (Plantae, 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, 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. This system suggests one super domain, Eukaryota, for the plants, animals, protists and fungi. The single-celled organisms in Kingdom Monera would then be split into two domains according to their genetic material.

The comparison of genetic material may cause even greater changes to the classification system in the future. Species that were previously thought to be related because they looked similar are now 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 even video of organisms. Links to related information can also be included and many scientists are using the Internet to confirm their identifications.

→ Fig 2.51 Holotype specimens such as this one are held in museums.



→ Fig 2.50 (a) Biologists collecting Archaea samples in the hot springs of the Obsidian Pool in the Yellowstone National Park, United States. (b) A magnified view of a clump of Archaean organisms.

Museums currently hold most 'holotype' specimens, the organism(s) used when the description for classification was decided. This specimen is chosen because it represents 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 into the future.

What do you know about the changing face of science?

1 A 'three kingdom' system became five and then six kingdoms.
   a What are the names of these kingdoms?
   b Do you agree with the changes? Explain.
2 How has an understanding of genetics changed classification?
3 What is a holotype specimen?
4 Why do 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?
5 What problems would a paper system for classification encounter? How is this being addressed today?

2.3

Where do I fit in?

Remember and understand

1 What is the difference between vertebrates and invertebrates? Write a definition for each.

2 List the five main classes of vertebrate and give an example of each.

3 Who developed the naming system used by scientists today?

4 List at least six phyla of invertebrates and give an example of each.

5 Living things are classified into k________, p________, ________, ________, ________, ________, ________.

6 What is the difference between an endoskeleton and an exoskeleton?

7 What does a placental mammal look like when it is born? How does this differ from monotremes and marsupials?

8 Why do scientists need to classify living things?

Apply

9 The vertebrates have five classes: Mammalia, Reptilia, Amphibia, Aves and Pisces. What are the more common names for these classes?

10 Fill in the table shown.

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

Analyse and evaluate

11 Figure 2.49 on page 75 shows a dichotomous key in tabular form for invertebrates. Construct a branched dichotomous key for invertebrates.

12 Use a Venn diagram to show the similarities and differences between birds, reptiles and amphibians.

13 Why is it 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 that were originally developed?

Critical and creative thinking

14 Using a digital camera, take photographs of animals around your house—from very big to very small. Make a multimedia presentation of your animals. Use a separate slide for each animal. On each slide include:

- the photograph
- the common name and scientific name (if you can find it)
- the phylum and class
- three or more interesting facts about the animal.

<<CONNECTING IDEAS>> Diversity

15 'Scientific ideas are dynamic and developing—they are not just a collection of unchanging facts.'

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. You might have the opportunity to read it to your class.

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).

A 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.

A 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 creatures in the water that looked a bit like bacteria. They are single-celled and are either square or oval; some are hairy (have 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 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.

Review

Key words

amoeba
autotroph
bacteria
binomial name
biodiversity
botanist
branched key
cell
cell wall
classification
dead
dichotomous key
DNA
ectotherm
endoskeleton
endotherm
exoskeleton
genus
heterotroph
invertebrate
key
kingdom
Linnaean taxonomy
living
microbiologist
multicellular
mycologist
non-living
nucleus
organism
plankton
species
taxonomist
taxonomy
unicellular
vertebrate

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 animal you discovered?

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

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

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?

2 How is life on Earth organised?

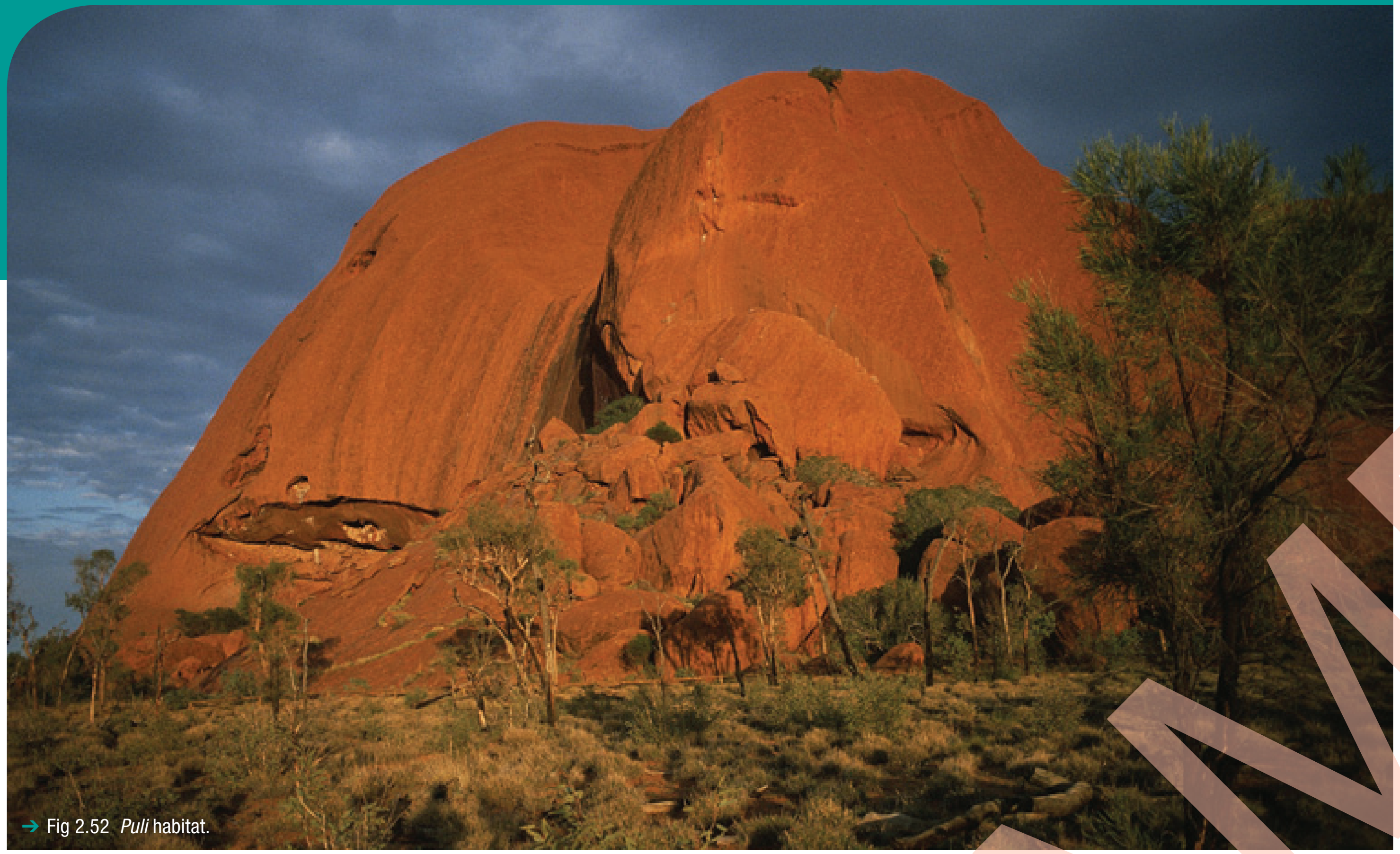


Fig 2.52 *Puli* habitat.

Have you ever visited Uluru or Kata Tjuta (the Olgas)? This area is part of Australia's arid zone, a region that receives less than 250 millimetres of rainfall per year. Australia is the second driest continent in the world. Despite the harsh climate, this area is home to hundreds of different organisms.

When early European explorers first visited this region in the 1870s they were confronted with a harsh landscape. Their initial aim was to find a route for the overland telegraph line from Adelaide to the Top End and to set up pastures for sheep and cattle grazing. They soon decided that the region was unsuitable, and left.

However, the traditional owners of the land, a group of Anangu Aboriginal people, had lived on this land for thousands of years and understood it well. They lived a nomadic life, travelling in small family groups and surviving by hunting wildlife and gathering food from the land.

The Anangu knew where to find food to survive and, more importantly, which areas were the best for hunting and gathering. The Anangu classified their environment to help them locate the precious food. They used these names:

Puli—rocky areas, gorges, stony slopes. Animals come to this area to find shelter and water.

Puti—open woodland. After the rains this area has an abundance of grass, which the kangaroos eat. Honey ants build their nests in this area.

Pila—spinifex plains, low areas between dunes. This is the best place to gather seeds to eat.

Reptiles are particularly suited to this environment. The thorny devil, like all reptiles, uses the environment to regulate its temperature. When it wants to become active it lays in the sun, but when it is too hot outside it hides in a burrow until the heat has passed.

One fascinating thing that the thorny devil can do is drink water with its feet! It places its feet in a puddle and water moves up by capillary action along grooves in its skin to the corner of its mouth.

Mammals are rarely seen during the day in Uluru–Kata Tjuta National Park. Most are nocturnal and come out in the evening, avoiding the heat of the daytime desert. The most abundant groups of mammals are the placentals (see Fig. 2.42 on page 70) and the marsupials.

Marsupials, such as the bilby, give birth to underdeveloped young but protect them by having a pouch where further development can occur. The pouch is similar to that of a kangaroo; however, it is a backward-opening pouch. When the young are fully developed they can leave the pouch and survive the harsh climate.

Fig 2.53 *Puti* habitat.

1. Follow the link on the **obook** to find out about the kind of environment that the Anangu lived in and foods they ate to survive. List at least five animals and five plants that they ate.
2. The early explorers left this environment because they couldn't survive. Why did they struggle to find food here?
3. In a group of four, use a large sheet of paper to create two collages on the one sheet, one showing living things and one showing non-living things you would expect to find in Uluru–Kata Tjuta National Park. One pair creates the 'living' collage and the other pair creates the 'non-living' collage.
4. Why do you think the Anangu devised a system of classification for the natural habitats around them?
5. Find out what 'capillary action' (in relation to water) means.
6. Follow the link on the **obook** to investigate the mammals, reptiles, birds and invertebrates found in the Uluru–Kata Tjuta National Park. Make a list of five for each category. Classify each one into its correct group.
7. One of the classes of vertebrate is Amphibia. What characteristic of amphibians would make it difficult for them to live in arid environments? What other animal classes would struggle to survive in arid environments?
8. Why do you think the bilby's pouch is rear-facing?
9. Discuss why monotremes would find it difficult to breed in arid environments.
10. Follow the link on the **obook** to investigate which mammals can be found in Australia's arid environments. Classify each of these mammals as placentals, monotremes or marsupials. List any specific Latin double names given for each animal (genus and species).

Fig 2.54 *Pila* habitat.