Each unit within this chapter is introduced here using an engaging image and supported by text and questions. Discussions around the image, text and/or questions should assist teachers to ascertain prior knowledge and provide students with an idea of where the chapter is heading. This is designed to promote an inquiry approach to learning and reduce the 'why?' questions.

Curriculum guidance

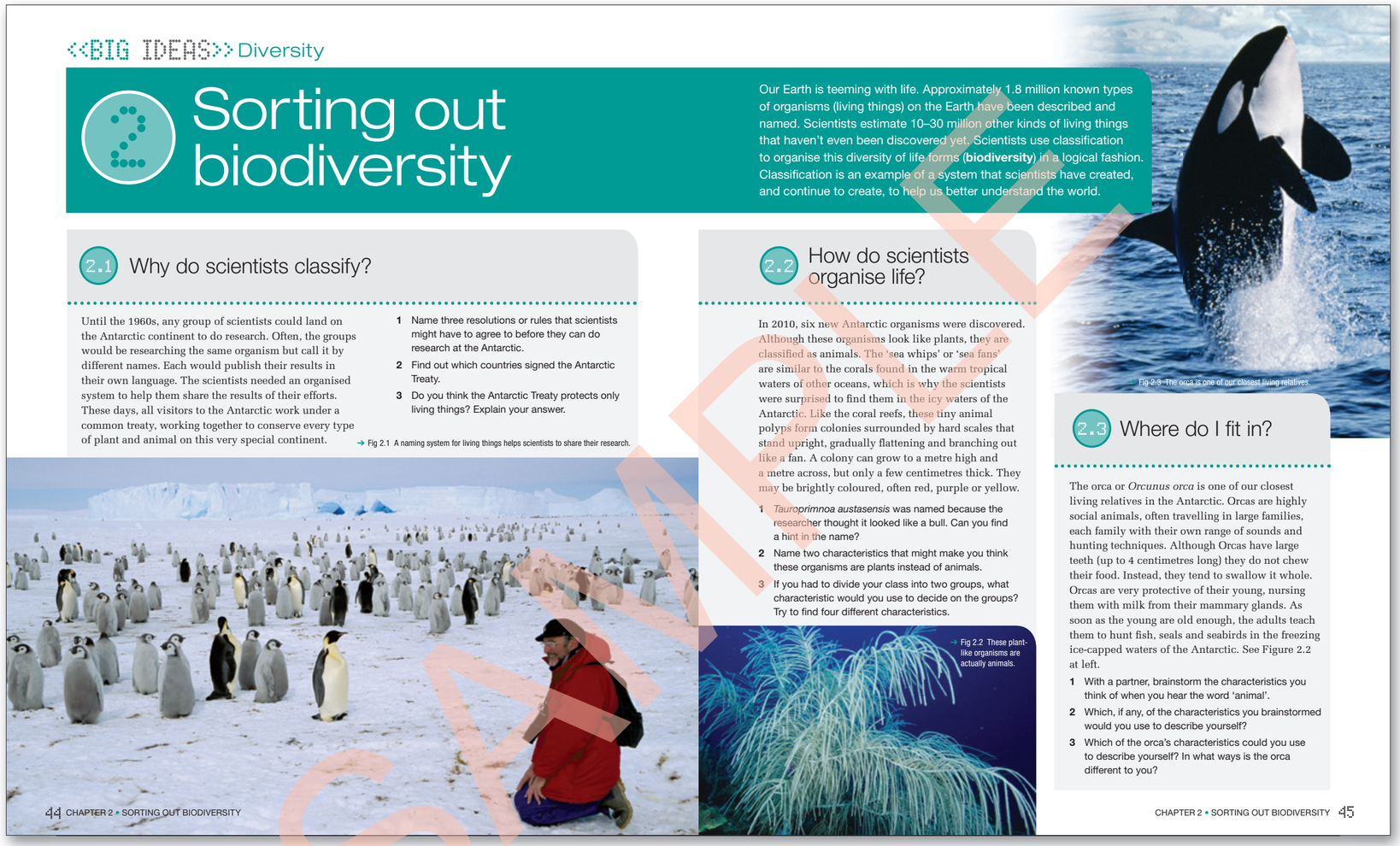
Big Idea	Previous curriculum content	Year 7 curriculum content
Diversity and Evolution: a diverse range of living things have evolved on Earth over hundreds of millions of years	The growth and survival of living things are affected by the physical conditions of their environment (Year 6)	There are differences within and between groups of organisms; classification helps organise this diversity

Big Ideas

The idea of classification should be approached as a human construct that is attempting to bring order and understanding to a complex world. Therefore there are great opportunities for a large emphasis on the area of science as a human endeavour and inquiry skills. It is important to emphasise that evidence for evolution was largely through the idea of differences 'within and between species'. Therefore there should be an emphasis on the differences within species, rather than using this chapter as a 'methods of classification' section. Opportunities linking to the work of Darwin and other 'early' biologists exist here, as they will enhance the link to the evolution aspect of the Big Idea in Year 10. This topic also allows specific references to adaptations which may well have been introduced in Year 6, and also the idea that different species or groups are found in different habitats.

Summary

Differences between living things can be observed and this helps classify organisms at a range of different levels. This diversity has arisen from evolution over time and classification can help to provide evidence for this evolution.



Answers

2.1 Why do scientists classify?

1 Three regulations or rules scientists might have to agree to before undertaking research in the Antarctic would include (students may suggest other plausible options):
   - a Abide by the treaty; use the Antarctic for peaceful purposes
   - b Share the results of their work; freedom of scientific investigation
   - c Undertake an assessment of planned activities under the 'scientific research' umbrella of the treaty.

2 The treaty has been signed by 48 countries including: Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, Poland, South Africa, Russia, United Kingdom and the United States of America.

3 The Antarctic Treaty protects every type of plant and animal and therefore all resources these organisms need to survive.

2.2 How do scientists organise life?

1 *Taurus* is a Latin word meaning 'bull', which would explain the researchers' name for the organism.

2 Two characteristics that make *Tauroprimnoa austasensis* seem to be plants are:
   - a They have branches.
   - b They lay roots into the sea bed.

3 To divide a class the characteristic used could be:
   - a Sex (male/female)
   - b Ethnicity
   - c Hair colour
   - d Eye colour.

2.3 Where do I fit in?

1 Qualities or features of animals may include:
   - respiration
   - movement
   - cellular
   - reproduce
   - respond to stimuli
   - grow
   - excrete
   - require nutrition.

2 All characteristics of living things will link to humans as humans are considered to be animals.

3 Orca characteristics which are similar to human characteristics include:
   - they are social
   - they communicate
   - they have teeth
   - they are protective of their young
   - they nurse their young with mammary glands
   - the adults teach their young.

   Orcas are different to humans in that:
   - they do not chew their food
   - they travel in large families
   - each family has their own range of sounds and hunting techniques
   - they live in different environments to humans.

obook
ID02.01 Weblink: Antarctic Treaty classroom resources

<<DISCOVERING IDEAS>>

Who am I?

This activity is designed to promote thinking about the various ways information can be communicated. The development of cameras and video has significantly improved levels of accuracy in the communication of classification-related data. Prior to photographs, illustrations were used. The quality of the illustration varied greatly depending on the skills of the artist, and the information was often based on an animal that had already disappeared from sight. Alternatively, specimens were collected. Dead animals rarely resemble their living counterparts in as fine detail; often changing colour with time.

1 Word descriptions and drawings can be quite useful in communicating specific information about new species as they allow scientists to give detailed information about organisms.
2 The problems with this method of identification are that the description may not be totally accurate because:
   - The situation in which you are viewing the animal or may be misleading. For example, saying a bear stands on two legs is misleading as it doesn't always do so
   - The use of nuances or uncommon language may cause confusion
   - Organisms may be described at different stages of life and will differ.
3 In more recent times, these problems have been overcome by the use of photographs or video to record the organism.

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.

Early classification methods

ICT

A wide variety of examples of early 'encyclopaedia' illustrations are available to view on the Internet. Students could search for the following titles to expand their understanding of early classification:

- Al Jahiz – *Kitāb al-Hayawān*
- Aristotle – *Scala Naturae*
- Carolus Linnaeus – *Biblioteca Britannica*
- Andrea Caesalpino – *De Plantis Libris XVI*
- Conrad Gessner – *Historiae animalium.*

obook

ID02.02 Video link: Early work of Charles Linnaeus

Video describing the early work of Charles Linnaeus. Suitable as an introduction to the concept of classification.

Early classification methods

Critical and creative thinking; Literacy

Ask students to carefully examine Figure 2.7, which shows a section of Linnaeus' classification system.
A more complete version could also be obtained.

The language used in this document is Latin, but students might be able to recognise certain terms.

Ask the students to comment on the structure and organisation of this system. They could also comment on a classification system that is hand-written on a single, large page.

Discovery of microworlds

Critical and creative thinking; Literacy

Ask students to think about a world in which you are completely unaware of any microscopic organisms. They could consider the following questions:

1 What aspects of your life rely on an understanding of microorganisms?
2 What explanations could you suggest for infectious diseases?
3 Do you need to understand the microorganisms in order to control them? Or do you just need to have an idea of their effects?
4 What do you do everyday that is reducing the number of microorganisms with which you come in contact?

→ Fig 2.7 Part of Linnaeus's classification system.

Discovery of microworlds

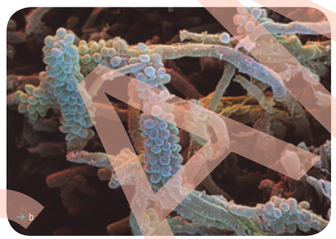
After the invention of the first crude microscopes in the 17th and 18th centuries, science took off in a new direction. Fascinating tiny creatures that nobody had ever seen before were being discovered all over the world. New systems were needed to make room for these organisms.

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.

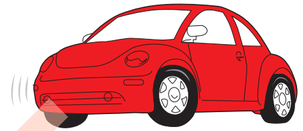
Finding new species

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.

Finding new species

Literacy

Students will most likely have learned the term 'species' prior to Year 7. It may be appropriate, however, to remind them of the definition.

A **species** is the basic unit for classification—each species will have its own classification. Organisms within a species are capable of successfully interbreeding to produce fertile and viable offspring.

This term could be linked to the theory of evolution, in which scientists explain the diversity of species on Earth. Evolutionary theory also provides explanations for changes within and between species, in the past and in the future.

PRACTIVITY 2.1

The great Guzzlemobile debate

Students may come up with additional ideas, however these are some examples.

1 Arguments for living—moves, requires nutrition in the way of fuel, responds to stimuli, exchanges gases with the environment.
2 Arguments for non-living—doesn't have ALL the characteristics for a living thing, and those it theoretically does have it can't do by itself.

Answers

What do you know about the history of classification?

1 Earliest scientists would have passed on their information verbally. The accuracy would have been questionable as verbal details often change as information is passed along.
2 Aristotle used an order of least important (rocks) to most important (wild animals, man, etc.), and then divided this into animals with blood (dogs, cats, etc.) and those he thought had no blood (insects, worms, etc.).
3 Carl Linnaeus simplified the classification system previously used because he found the descriptions too long and decided there needed to be a simpler system.
4 An 'animalcule' is a tiny (microscopic) organism named by Antonie van Leeuwenhoek to describe the microbes he saw in his water supply.
5 Scientists still classify animals today in order to organise life forms in a logical fashion. This helps us to better understand the world.

obook

ID02.03 Weblink: Leeuwenhoek's discoveries
Includes pictures and letters written by the scientist.
ID02.04 Video link: Scientists in the field discovering new species
National Geographic video explores the concept of new species being discovered all the time. Suitable for demonstrating science occurring in the field with emphasis on Australia.

Living and non-living

Students should examine the images that represent the eight characteristics of living things in Figures 2.11–2.18.

While some of these characteristics are straight forward, several will require discussion for clarification and to dispel students' misconceptions. For example, students regularly struggle with the idea of plants moving. Ask students what wastes they think plants get rid of through their leaves.

Students should attempt to provide alternative examples for each characteristic to reinforce their understanding. Prompts are provided in the captions.

Movement

Plant movements need to be clarified for many students. Simply blowing in the wind is not considered to be movement as the plant is not in control. Movement is generally through the action of chemicals (plant hormones) that control the growth of cells on one side of a stem or another to cause the stem to bend. Similarly, growth in certain areas of a plant can result in the plant reaching towards sunlight due to warmth triggering hormone production. Movement in plants is not necessarily for travel, but often in response to environmental stimuli.

Microorganisms are capable of movement due to the action, in many cases of cilia or flagella. Cilia are tiny hairs that line the external surface of the microbe and 'flutter' to propel the organism; flagella are whip-like 'tails' that can flick or move in a spiral manner to act like a rotor on a motor boat.

Reproduction

Reproduction is covered in Year 8; however, certain examples provided here will reinforce the variability of reproductive strategies employed by living things.

Plants can reproduce through the action of seeds, but many also produce spores (ferns) or are able to generate new plants through vegetative reproduction. This last form involves parts of the plant 'breaking off' to form a new plant, for example bulbs that can be split or runners that put down new root systems.

Microbes generally use *binary fission* which translates to 'splitting in two'. All the contents of the organism (cell) need to be doubled before this occurs so that the new cells are identical to the original parent cell.

Students may find it interesting to research examples of reproduction by animals.

Nutrition

When asked why they eat, many students are likely to refer only to food as a source of energy. Students should be asked to think of all the other reasons food is required by living things. Growth, repair, defence, and reproduction are just a few, not to mention the healthy functioning of muscles, bones and other organs.

Growth

Students should be aware that growth is not simply 'getting bigger'. Many organisms change throughout their life cycles, and this can be significant or minimal. Examples of each should be explored.

Response

Responding to the environment is an essential defence mechanism of all organisms. A response may be fast-acting or slow-acting and will depend on the potential consequences of the stimulus. Burning yourself needs a fast response to minimise damage, while feeling warm can be suffered for longer before you eventually decide to remove a jumper, have a cold drink or open a window.

Plants are generally incapable of quick responses; however, *nastic* responses are similar to our nervous system's reflexes. Nastic responses can be seen with plants such as the Venus flytrap that snaps shut when hairs are stimulated by insects, and *Mimosa pudica* that curls its leaves when the hairs are brushed to avoid predation.

Exchange gases

The function or purpose of the gases may be mentioned: oxygen is responsible for releasing energy from food through a chemical reaction called *respiration*, while carbon dioxide is responsible for producing food in plants and some microbes through *photosynthesis*.

Wastes

All substances are potentially toxic to organisms if they occur in large enough amounts. A system for monitoring the amounts of substances and removing them accordingly is therefore required by all organisms.

Carbon dioxide is a waste product of respiration in both plants and animals; plants can use this carbon dioxide in photosynthesis, while animals need to remove it through exhalation.

Oxygen is a waste produce of photosynthesis, and again plants are able to use it in respiration.

Water

The importance of water in a healthy organism is something on which students could elaborate. When a person is dehydrated, they are often tired, grumpy and have a headache. We often mistake thirst for hunger. Additionally, controlling the growth of microbes in our homes can be done simply by keeping surfaces dry. Ask students to consider these points.

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?

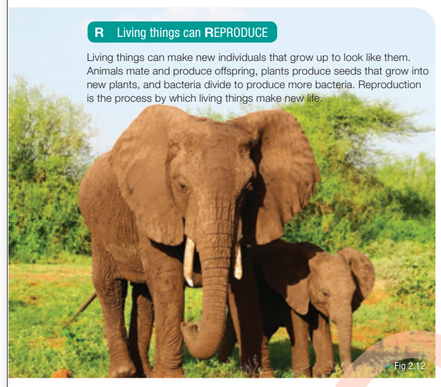
Characteristics of living things

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 **M**OVE 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



R Living things can **R**EPRODUCE

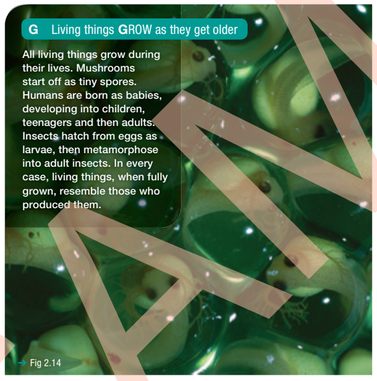
Living things can make new individuals that grow up to look like them. Animals mate and produce offspring, plants produce seeds that grow into new plants, and bacteria divide to produce more bacteria. Reproduction is the process by which living things make new life.

→ Fig 2.12

N Living things need **N**UTRITION

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.

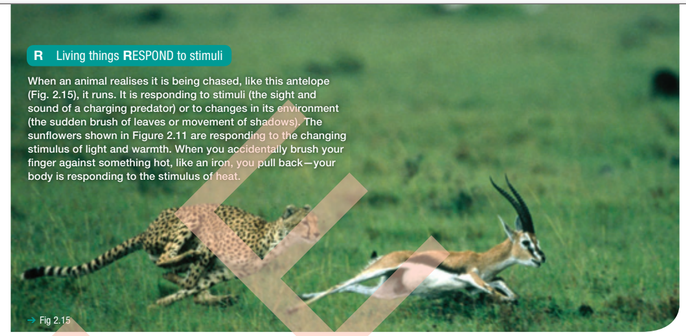
→ Fig 2.13



G Living things **G**ROW 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.

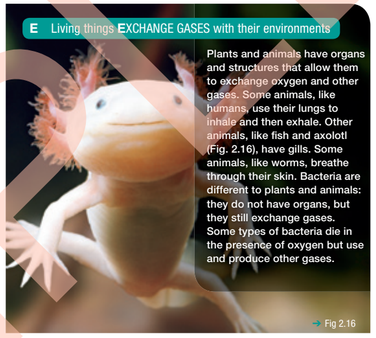
→ Fig 2.14



R Living things **R**ESPOND 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 **E**XCHANGE 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 produce **W**ASTES

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

W Living things require **W**ATER

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

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.

Answers

What do you know about living and non-living?

1 The two groups scientists divide all things into are Living and Non-Living.
2 See the table at the bottom of this page.
3 The roast chicken is dead because it once had all the characteristics of a living thing.
4 Students will create their own mnemonics.
5 A bushfire contains all the characteristics of living things except 'requires water'.
6 A bushfire is non-living as is does not require water. If water is applied to fire it will extinguish the fire and thus 'kill' it.

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.

52 CHAPTER 2 • SORTING OUT BIODIVERSITY

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

UNIT 2.1 • WHY DO SCIENTISTS CLASSIFY? 53

2

	Eucalypt tree	Water	Paper	Robot	Leather belt	Wombat	Roast chicken
Moves by itself	Y	N	N	N	N	Y	N
Reproduces itself	Y	N	N	N	N	Y	N
Requires nutrition	Y	N	N	N	N	Y	N
Grows as it gets older	Y	N	N	N	N	Y	N
Responds to change in its environment	Y	Y	N	N	N	Y	N
Exchanges gases (e.g. oxygen)	Y	Y	N	N	N	Y	N
Produces wastes	Y	N	N	N	N	Y	N
Requires water	Y	Y	N	N	N	Y	N
Living or non-living?	**L**	**NL**	**NL**	**NL**	**NL**	**L**	**NL**

ZOOMING IN

Encyclopedia of Life

Students could investigate the website of the Encyclopedia of Life. They could comment on the information they discover and suggest the intended audience for the project.

Comparisons could be made with similar projects such as:

- Atlas of Living Australia
- Tree of Life
- Catalogue of Life
- Global Biodiversity Information Facility
- ZooKeys.

obook
ID02.05 Weblink: Encyclopedia of Life
Database of life on Earth. Suitable for research/interest.

BIG IDEAS

2.1 Why do scientists classify?

Remember and understand

1 The eight characteristics of living things are:
   a Movement
   b Reproduce
   c Nutrition needed
   d Grow as they get older
   e Respond to stimuli
   f Exchange gases with their environment
   g Wastes produced
   h Water required.
2 An organism is a living thing that has (or can develop) the ability to act or function independently. It can react to stimuli, reproduce, grow and maintain homeostasis. It can be a virus, bacterium, protist, fungus, plant or animal.
3 'Dead' refers to something that was once living.
4 Examples of plants moving by themselves:
   - Sunflowers turn their heads to follow the sun
   - Leaves face the sunlight.
5 A living plant needs nutrition such as sunlight, water and adequate soil including nitrogen, potassium and phosphorus.
6 It is important for scientists to use a common system to group all living things because they may inadvertently identify the same organism. It is also easier for scientists to infer something about one species when they have another species classified that is similar.
7 Plants exchange oxygen and carbon dioxide with their environment during photosynthesis.

Apply

8 It is important to preserve a large biodiversity of plants and animals as it is a measure of the health of an ecosystem. A diverse ecosystem is more likely to be able to recover from a random event such as a bushfire or flood. We are continually finding new species and need to preserve biodiversity to do so. Biodiversity also provides support for pharmaceutical discoveries and the availability of medicinal resources such as penicillin and aspirin.
9 In order for scientists to decide if something is living or non-living, they need to identify whether it has all the characteristics of a living thing such as whether it breathes, moves by itself, needs nutrition, can reproduce, grows as it gets older, respond to stimuli, exchange gases with the environment, produce wastes and require water. (Two of these would be require.)
10 Today, scientists commonly use photography or videos to show what an organism looks like.
11

Living		Non-living
Currently living	Dead	
Daffodil bulb	Stewed apple	iPod
Your teacher	Shark's tooth	DVD
Germs	Dinosaur skeleton	Hairs in your brush
Your pet		Soft drink bottle
		Silver chain

Analyse and evaluate

12 Answers will vary depending on the area you live in.
13 Refer to Table 2.2
   a It is estimated there is in excess of 10 927 630 species on Earth.
   b Answers will vary. Some students will be surprised, others won't. Animals on Earth—1 424 153; Plants on Earth—297 857.
14 Answers will vary – some interesting animals are the eyelash mite, penis fish, vampire bat, echidna, platypus, etc.

Critical and creative thinking

15 Answers will vary—students could do an experiment in which plants are planted and faced away from light so the leaves turn to face the light. They could also investigate how plants respond to different amounts of watering daily.

<<CONNECTING IDEAS>>

16 The invention of the microscope was important to the development of the classification system because it had great impact on scientific thinking. Very small organisms were discovered that did not fit into either of the plant/animal groups. It also meant a more systematic approach was needed to ensure all species could be included as the number of organisms requiring identification, classification and communication increased dramatically.

obook
ID02.06 Interactive activity: Classifying living, non-living and dead
ID02.07 Weblink: Atlas of Living Australia

<<DISCOVERING IDEAS>>

Department store design

Responses will vary significantly for this activity. Students should identify the benefits of grouping objects according to function more than appearance. For example, nail polish and a hacky sack might both be red, but grouping them according to colour makes little sense. Grouping nail polish with perfume would be a more logical combination, as would grouping a hacky sack with a cricket ball.

Discussions could centre on department stores and supermarkets familiar to the students. They would most likely be aware of grouping electrical goods, clothing, laundry products and fresh produce. Students could suggest aspects of this organisation that are beneficial and aspects that they would modify.

Similarities could be drawn with the organisation of files on computers, in particular, the organisation of students' iTunes libraries or similar.

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.

<<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?

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.

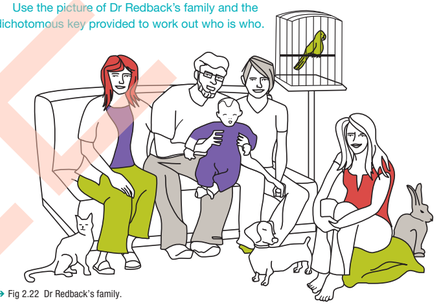
One common type of key is called the **dichotomous key** (pronounced 'dye-COT-o-muss') as the branches always split into two (*di* = 'two'). Scientists use this type of key to make simple 'yes' or 'no' decisions at each branch. For example, does the animal have fur (yes/no)? Does it have scales (yes/no)? 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.

PRACTIVITY 2.2

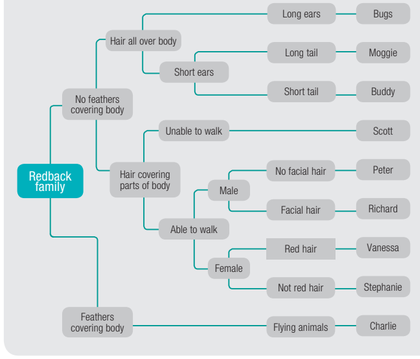
Dr Redback's family

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.

PRACTIVITY 2.2

Dr Redback's family

- Bugs – Rabbit
- Moggie – Cat
- Buddy – Dog
- Scott – Baby son
- Peter – Elder son
- Richard – Dr Redback
- Vanessa – His wife
- Stephanie – His daughter
- Charlie – Bird

Students might benefit from using their fingers to trace the path they take on the key.

Students could be challenged to work backwards from the name of the family member to identify the correct person or animal in the illustration.

Students could be asked to write down the characteristics of each person or animal. These characteristics could be assessed to decide whether they were the most appropriate feature to use for grouping, and whether the feature would be appropriate in a larger group of people and animals.

obook
ID02.08 Interactive activity: Using a dichotomous key

Answers

What do you know about using keys?

1 A dichotomous key is a visual tool used in the classification of organisms. Scientists use this type of key to make simple 'yes' or 'no' decisions at each branch. Each answer leads to another branch and another question.

2 It is called a 'dichotomous' key because the branches always split into two.

3 The term 'classifying' means to divide or group something based on certain characteristics.

4 Classifying groups of birds:
- a Is eating bird seed—bad because it doesn't describe a characteristic, it describes a behaviour that many birds will display
- b Has a blue stripe above the eye—good because it describes something the bird can be identified by
- c Has a wing span of 32 centimetres—good but would need to be accompanied with other information (juvenile/adult, colour etc.)
- d Has a broken leg—bad because it describes something that is not permanent
- e Is sitting on the ground—bad because it is a behaviour that all birds will display
- f Has a high-pitched, bell-like song—good because not all birds have the same song
- g Has brown tail feathers—good as it describes characteristics the bird holds.

5 Answers will vary—students are likely to group the equipment by size first, however they could also start by grouping according to whether the equipment is used to measure or for another use.

6 Answers will vary depending on which dinosaurs are researched.

7 a i Grot
ii Frap
iii Grope
iv Frip

b Students' drawings should have the following elements:
- i Frope—round, no antennae, stripes, no wings
- ii Gring—oval, antennae, stripes, wings
- iii Gripe—oval, no antennae, stripes, wings
- iv Frong—round, antennae, stripes, no wings.

DESIGN YOUR OWN...

Dichotomous keys

→ 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?

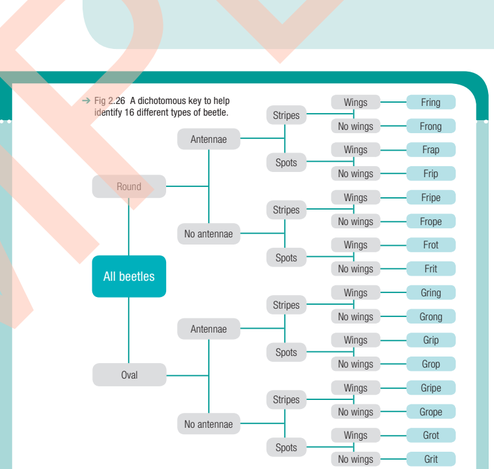
1 What is a dichotomous key?
2 Why is it called 'dichotomous'?
3 What does the term 'classifying' mean?
4 Which of the following descriptions would be good to use to classify a group of birds in a dichotomous key? Give a reason why each one is or is not a good method of classification:
- a is eating 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.

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?

OVERARCHING IDEAS

Finding the key

The reverse listing key—a non-living thing could never: move, feed, reproduce, grow, respond, exchange gases, produce wastes, require water, think, sense the world (sight, hear etc.).

The 'what-if' key—if living things did not exist there wouldn't be much variation. Earth would be a very still and quiet place.

The question key—Suggestions include:
- What is a unicellular organism?
- What are bacteria?
- What is the opposite of multicellular?

Construction key—answers will vary depending on classroom resources.

Combination key—new organism will vary depending on student:
- attributes of an animal cell—cell membrane, flexible, nucleus with genetic material
- attributes of a plant cell—cell wall, rigid, nucleus with genetic material.

Disadvantages key—suggestions include:
- We may not identify the species correctly due to lack of information
- Confusion could occur, for example, it is often debated whether viruses are living or non-living. To correct this, there could be an extra classification group, Archaea, as suggested recently and update the classification as new information is discovered.

Prediction key—invertebrates are likely to be discovered in the next 20 years. Students may like to be more specific than this.

Alphabet key—students are likely to have things such as respiration, respond, nutrition, water, wastes, exchange gases, reproduce etc.

Commonality key—both have a mass/weight, both take up space, made of cells, require all the characteristics of living things, driven by laws such as law of gravity and contain genetic material.

The Linnaean classification system

Literacy; ICT

To reinforce the hierarchy described by Linnaeus, ask students to examine the series of names used to classify the domestic cat in Figure 2.28.

Students could be asked to select three animals or plants and create a similar classification tree for each. They could present their research in the form of a poster that includes an image of the organism and the common name, where appropriate. Students should represent the binomial name using the scientific conventions:

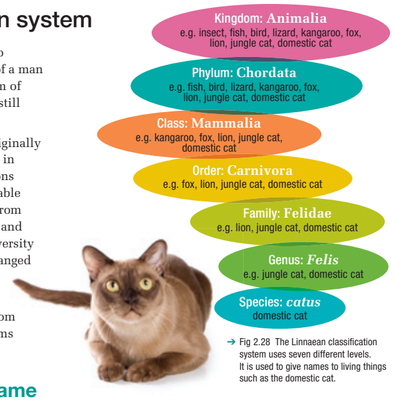
- genus and species
- all italics
- genus with capital, species with lowercase.

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

→ Fig 2.27 Did you ever address a letter like this?

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?

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

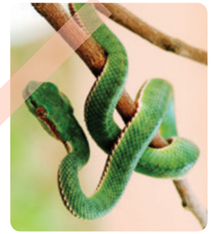
Making a field guide

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

PRACTIVITY 2.3

Making a field guide

The animals in the images fit the following classes from top left, clockwise: Aves, Mammalia, Pisces, Amphibia, Reptilia.

A tabular key for Dr Redback's family should resemble the following:

1	No feathers covering body	Go to 2
	Feathers covering body	Flying animals (Charlie)
2	Hair all over body	Go to 3
	Hair covering parts of body	Go to 5
3	Long ears	Bugs
	Short ears	Go to 4
4	Long tail	Moggie
	Short tail	Buddy
5	Unable to walk	Scott
	Able to walk	Go to 6
6	Male	Go to 7
	Female	Go to 8
7	No facial hair	Peter
	Facial hair	Richard
8	Red hair	Vanessa
	Not red hair	Stephanie

Understanding scientific names

Critical and creative thinking; Literacy

Students could use Table 2.3 to create their own combinations of Latin and Greek root words. They could form 'new' binomial names, then attempt to describe or draw their creatures.

Illustrations with names could be displayed around the room. Alternatively, students could swap unlabelled drawings with classmates and ask them to work out what the name of the creature might be.

obook

ID02.09 Weblink: Activity classifying organisms from kingdom to species
Interactive activity to classify organisms from kingdom to species level. Suitable for students to demonstrate their understanding of how to classify.

Answers

What do you know about the Linnaean classification system?

1 Identification of species using Latin name:
   a *Macropus rufus* – Red kangaroo
   b *Tachyglossus aculeatus* – Short-beaked Echidna
   c *Phascolarctus cinereus* – Koala
   d *Ornithorhynchus anatinus* – Platypus
   e *Chlamydosaurus kingii* – Frill necked lizard.
2 A *Macroglossus aculeatus* would, by name, be a large-tongued spiny creature.
3 Carl Linnaeus invented the naming system that is still used today to name living things.
4 The seven groups living things are divided into are: Kingdom, Phylum, Class, Order, Family, Genus, Species.
5 Giving your address as 'John Campbell, Southern Hemisphere, The Earth' is too general. It doesn't provide enough information in order for someone to locate you to deliver the letters.
6 Taxonomists need very detailed systems, as they allow them to make sense of all the organisms studied and identify a specific species in a simple and practical manner. Every species can be given a unique name, as compared with common names that are often neither consistent nor unique.
7 The first level of the Linnaean classification system is Kingdom.
8 Species means a group of organisms that look similar to each other.
9 Answers will vary depending on animals chosen.

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.

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**.

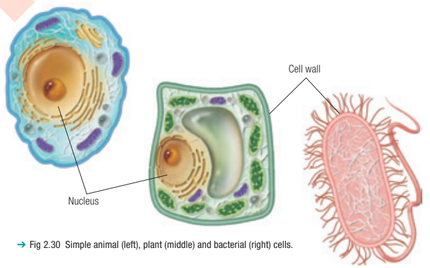
Cells can usually only be seen through a microscope. Some are so tiny that 20 000 of them, placed end to end, would only be 1 centimetre long. Giant squid have nerve cells that are up to 12 metres long!

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.

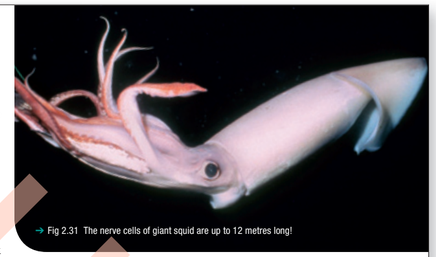
Parts of a cell

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.



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

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?

Cells in living things

Literacy

Cells are not officially taught until Year 8 in the Australian Curriculum. A very brief overview is given here to demonstrate the changing nature of the classification system and the additional level of detail available to taxonomists since the invention of the microscope.

Students should be aware that:

- tiny building blocks make up multicellular organisms, and unicellular organisms are made of only one of these blocks
- animal and plant cells are similar in complexity
- the cells of unicellular organisms tend to be very basic in structure but may have external additions to aid mobility or other purpose.

Answers

What do you know about cells in living things?

1 Characteristics of a plant cell are:
   - Cell wall
   - Use sunlight to make their own nutrients
   - Some students may also answer – chlorophyll or chloroplasts and vacuole.
2 A nucleus is where the genetic material such as DNA is in a cell.
3 The role of a cell wall is to provide extra support for the plant cell. It enables the plant cells to remain rigid in place of a spine like some animals.
4 An example of an organism containing just one cell is bacteria.
5 Multicellular means more than one cell.
6 Unicellular means single-celled.
7 The invention of the microscope was important to our understanding of things as it allowed us to view life previously unseen. It changed the classification system as scientists could consider smaller details when grouping organisms according to features.

BIG IDEAS

2.2 How do scientists organise life?

Remember and understand

1 The largest cell is the ostrich egg, which is about as big as an apple.
2 Most keys are dichotomous because scientists can make simple 'yes' or 'no' decisions at each branch.
3 Most animals are multicellular as they require more than one cell to carry out the functions needed to survive.
4 The advantages of using a dichotomous key are that it requires simple 'yes' or 'no' decisions, each answer leads to another branch and another question, and it is often simple to follow and understand.
5 Two characteristics that would divide a class into two groups of equal size could be: gender; hair colour; eye colour.
6 Students' own responses.

Apply

7 Order of Linnaean classification system is: Kingdom, Phylum, Class, Order, Family, Genus/Group, Species.
8 Students' own responses.
9 Students may opt to:
- Change the 'feathers covering body' to 'scales covering body' to include the pet lizard
- Add 'immediate family members' and 'other family members' to include his sister and mother
- Add another branch for females under 20 to separate the daughters
- Remove the facial hair branches as Dr Redback will now be the only male
- Remove the able/unable to walk branches as all family members are able to walk.

Analyse and evaluate

10 Students' own responses.
11 Other types of classification keys are:
- Tabular
- Circular
- Polychotomous keys which offer several choices at each step.

12 Students' own responses.

Critical and creative thinking

13 Students' own responses.
14 Students' own responses.

<<CONNECTING IDEAS>>

15 a The dichotomous key was important to the development of the classification system as it provided scientists with a simple way to identify and group species based on what they observed.

b The limitations of a dichotomous key include:
- Only species already discovered and named by someone else can be identified
- Assumptions are sometimes involved when making the yes/no decision
- The organism being observed must be included in the dichotomous key.

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?

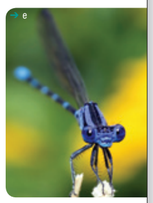
Kingdoms

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.

<<DISCOVERING IDEAS>>

Grouping animals

Responses will vary significantly. Students might discuss the difficulties or challenges associated with grouping organisms with which they are not familiar. They might also evaluate classification systems that are based purely on appearance, rather than examining an organism in its natural habitat.

Kingdoms

Literacy

As students read through the information about the various kingdoms, they could be encouraged to prepare lists of the features that separate the groups. This information will assist them with Practivity 2.4 and the questions on page 68, as well as providing a quick reference. All the information they require is provided in short paragraphs.

The images selected to represent each kingdom highlight the variation within the kingdoms. For example, Kingdom Animalia includes four of the five classes of vertebrates and one invertebrate.

Critical and creative thinking

What does the word 'kingdom' mean outside of science? Students will no doubt be familiar with the idea of a kingdom being a societal structure controlled by a king.

Ask the students to identify the levels of power in a kingdom. They can then use this structure to assist them in understanding the application of kingdoms to classifying living things.

obook

ID02.10 Figure 2.31 Collection of insects
ID02.11 Weblink: Museum Victoria, interactive activities and exhibition information
Museum Victoria site that includes interactive activities (using a dichotomous key to identify animals). Further links to the animals on exhibition at the museum and their status. Identifies animals according to biogeographic regions. Suitable for pre excursion stimuli or virtual tour if excursions can't be arranged.
ID02.12 Weblink: Interactive timeline on when the different kingdoms first appeared on Earth
Interactive timeline that briefly shows when the different kingdoms first appeared on Earth. Suitable for introduction to evolution.

Kingdom Plantae

Critical and creative thinking

Figure 2.33 provides students with examples of five significant groups of plants. Additional examples could be found for each group. Similarities and differences within and between the groups could then be made to highlight the characteristics used to group organisms and simultaneously highlight the diversity within each group, both at Kingdom level and below.

Kingdom Fungi

Critical and creative thinking

Reinforce the key concept of diversity for students by examining the wide range of organisms that comprise the Fungi kingdom.

Within the mushroom group, students may be familiar with the range on offer at local supermarkets and green grocers, particularly due the influence of Asian cooking. Additionally, students are likely to have seen fungal growth on dead and decaying logs and trees. Plate fungi can grow to enormous sizes, while other fungi are microscopic. Sifting through soil under leaf litter may uncover white root-like structures that are the hyphae of fungi as they spread.

Fungi can be associated with causing and curing diseases. Athlete's foot and penicillin are two such examples. Students could investigate these and other applications of fungi.

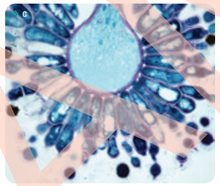
→ Fig 2.33 Kingdom Plantae: (a) The smelliest plant, the *Rafflesia*, is found in South-East Asia. Its flower can measure up to 90 centimetres across and weigh about 11 kilograms. It gives off a rotten meat odour when it blossoms, to attract insects. (b) Flowering gum. (c) Wheat. (d) Nepenthe. (e) Cactus.

Kingdom 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.

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.

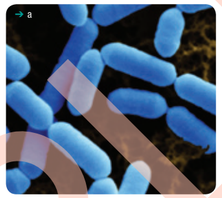


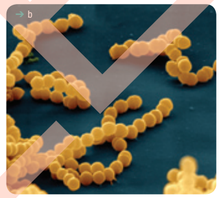
→ Fig 2.34 Kingdom Fungi: (a) Mushrooms. (b) Mould. (c) *Aspergillus conidiophores* as seen under a microscope.

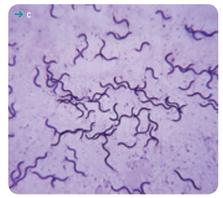
Kingdom Monera

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.



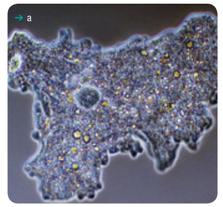


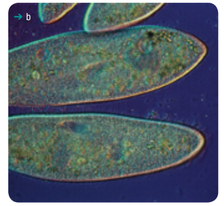


→ Fig 2.35 Kingdom Monera, as seen under a microscope: (a) *Lactobacillus casei*. (b) *Streptococcus pyogenes*. (c) *Spirillum volutans*.

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*.

Kingdom Monera

Critical and creative thinking

Kingdom Monera is made up of bacteria and blue-green algae (cyanobacteria). These organisms are all prokaryotic, which means they have no membrane-bound organelles and so their genetic material is uncontained within the cell.

Some sources claim that a 3-domain system is now in effect. This system groups organisms into Archaea, Bacteria and Eukaryota. The Bacteria domain would therefore be comprised of the Monera kingdom, while plants, animals and fungi would fit into Eukaryota and protists into Archaea.

We have chosen not to use this system in order to simplify the delivery of the content to students and highlight the diversity without delving into the cellular structures that inform the 3-domain system.

Kingdom Protista

Critical and creative thinking

Protists are regularly referred to as 'the leftovers' or 'miscellaneous group'. Ask students to consider the reasons behind placing organisms in this group.

A major deciding factor is lack of knowledge and understanding of the organisms. Similarly, the massive number of organisms on the planet requires time and energy to identify characteristics for classification purposes. This in turn requires someone to be interested in carrying out such a task, and others financing the project.

obook
ID02.13 Interactive activity: Kingdoms

PRACTIVITY 2.4

Classifying living things

- Seaweed – Plantae
- Shark – Animal
- Sea monkey – Animal
- Sea jelly – Animal
- Robot and ice crystals are non-living.

Students could add other living things into their columns and could aim to have a certain number of organisms.

Answers

What do you know about Kingdoms?

1 Four features of animals could include:
- multicellular
- genetic material in a nucleus
- gain energy from other living things
- cells don't have a cell wall.

2 Four features of Kingdom Monera include:
- simplest and smallest living things
- unicellular
- cells have a cell wall
- no nucleus.

3 A protest cell structure is more complex than that of a bacterium.

4 Kingdom Plantae gain energy by making their own food from sunlight, whereas Kingdom Fungi do not.

ZOOMING IN

Giant squid dissection released on the web

Online dissections are sometimes a non-confronting way for students to learn about the internal structure of organisms.

Students could access the Melbourne Museum website to find additional information about giant squids.

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

EXPERIMENT 2.1

Examining skeletons

Discussion

1 a The skeleton of the fish in inside its body.
  b This type of skeleton is called an endoskeleton.
2 a The skeleton of the prawn is outside its body.
  b This type of skeleton is called an exoskeleton.
3 A squid does not have a skeleton; however, it has an internal gladius to support the mantle.
4 Fish – vertebrate; prawn – vertebrate; squid – invertebrate.
5 Humans are vertebrates and have an endoskeleton.

Conclusion

Two types of skeleton are possible – internal (endo) and external (exo). Squids, however, have no skeleton.

Lab tech notes

Fish shops and markets, if given time, will supply whole squid, whole or filleted fish, and prawns.

Class clean up

- Dirty scalpels to be collected and kept separate from other dissection equipment to avoid cuts. Ask the lab tech to clean.
- All other equipment should be washed in hot soapy water. Ensure sinks are free from specimen parts, as they will smell.
- Wrap all specimens and dirty gloves in newspaper, place in and sealed bag, and bin.

Safety

The use of vinyl gloves is recommended, as latex has been known to cause allergic and anaphylaxis reactions.

obook

ID02.14a Video demonstration: Using dissection tools—Flower dissection
ID02.14b Video demonstration: Squid dissection
ID02.15 Video link: Giant squid dissection
Museum Victoria demonstration of squid dissection. Introduces the concept of how these organisms evolved. Suitable for demonstrating scientists at work.

Answers

What do you know about Kingdom Animalia?

1 Animals are divided into two main groups
   - Endoskeleton – meaning internal skeleton
   - Exoskeleton – meaning external skeleton
2 Examples of animals with an exoskeleton include: beetles, crabs, grasshoppers, cockroaches etc.
3 Examples of animals with no skeleton include: worms, snails, slugs, jellyfish, starfish, leeches etc.
4 About 96% of all animals are invertebrates.
5 Invertebrates are such a dominant group because of their size. Their size allows them to occupy a wide variety of habitats as well as many microhabitats, which may not be visible to the eye.
6 The world's biggest known invertebrate is the giant squid.
7 Students' own responses.
8 Dissecting a giant squid live on the Internet was interesting to so many people as it is a rare creature. Most people have not seen something this big before, nor have they seen a dissection done in such a way. Additionally, the running commentary allowed viewers to understand what was going on.

Class Mammalia

Critical and creative thinking

Students may be interested in the phenomenon of diapauses. Essentially, this involves marsupials and some other animals 'pausing' pregnancies until the conditions are suitable. Additionally, some marsupials are known for being 'prematurely' pregnant.

Students could consider the pros and cons of these strategies. They may also endeavour to explain how this may be possible.

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**).

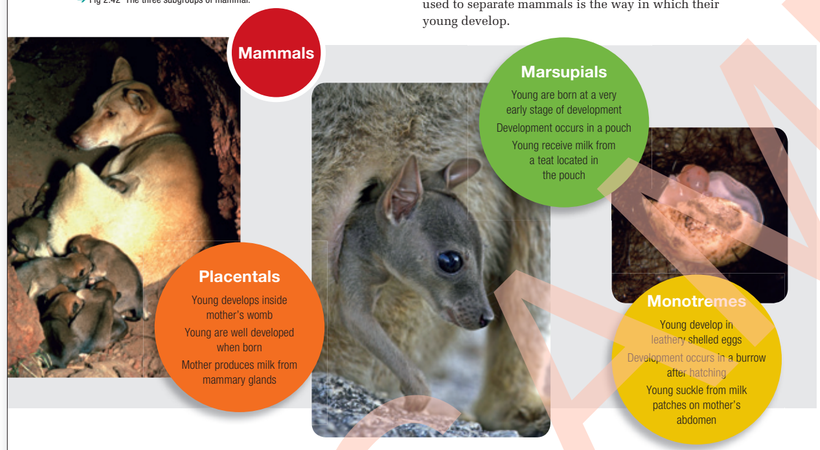
Class Mammalia

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.

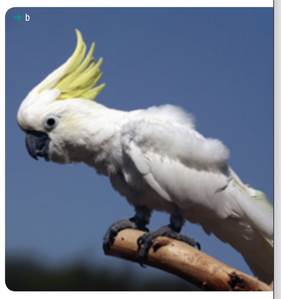
... Australians have adopted the short-beaked echidna as a national mascot of sorts ... The echidna's total numbers are unknown ... Concerned that their future welfare is not assured, Australia has officially listed them as a protected species.

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.

LITERACY LAB

The enigma of the echidna

1 Two different types of echidna are:
   - Short-beaked echidna – lives in Australia
   - Long-beaked echidna – lives in Papua New Guinea.

   The differences between these echidnas are:
   - Short-beaked will grow longer fur between the spines as the mountains get cold
   - Size of the beak
   - Diet of the short-beaked is mainly ants and termites, whereas the long-beaked feeds on earthworms and insects.
2 Echidnas can be considered weird, as they are mammals that lay eggs like a reptile, have a beak like a bird, spines like a hedgehog and the pouch of a marsupial.
3 If scientists hadn't seen an echidna for themselves they are likely to have thought the pictures were false due to the oddities of the echidna's physical appearance.

obook

ID02.16 Interactive activity: Vertebrate classes
ID02.17 Video link: Enigma of the echidna
Video to support the enigma of the echidna textbox. Website also provides links to other stories/videos of living things. Suitable for general background information.

Class Reptilia

ICT

Some reptile populations are affected by temperature-dependent gender determination. This means that the gender of offspring is determined by the temperature of the eggs during incubation.

Students could undertake research to find out to which groups of reptiles this phenomenon applies. Does warmer mean female or male? How does an egg's position in a nest affect temperature? Why might global warming cause extinctions for reptiles that are affected?

Class Amphibia and Class Pisces

Critical and creative thinking

Amphibians and fish are mostly external fertilisers. The female will lay eggs directly into the water, often near a protective structure like a log, crevice or among seaweeds. The male will then spray large amounts of sperm over the eggs to fertilise them.

Students could consider the following questions:

- Why would large numbers of eggs be more common than smaller numbers? (increased likelihood of some surviving)
- Why might external fertilisation be easier than mating? (less energy required for courtship; saves time waiting for a mate)
- What dangers would the eggs face in the environment? (predation and drying out or being washed away).

Students could research examples of external fertilisation and describe the successes and failures of the strategy. Protection of the eggs during incubation and parenting after hatching could be investigated as strategies to increase the success.

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.

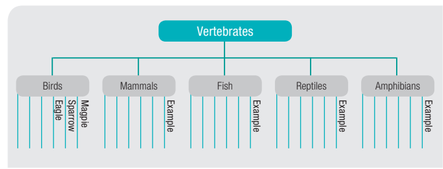
1 Divide the class into five groups, each of which will be allocated one class of vertebrate.
2 Label an A3 sheet of paper with the name of your class of vertebrate.
3 Write the letters of the alphabet down the left-hand side of the page.
4 For each letter, write the name of an animal that fits this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



PRACTIVITY 2.5

Who are the vertebrates?

Vertebrate alphabet graffiti

Students may need to conduct some research to complete all letters of the alphabet. They may also like to research some of the more interesting species.

Jellyfish organiser for vertebrates

This could be done as a whole class activity or students could rotate around the classroom to different vertebrate groups.

Answers

What do you know about classes of vertebrate?

1 a Seals give birth to live young, often on land.
b Seals belong to the Mammalia class of vertebrates.
2 Dolphins belong in the class Mammalia as they give birth to live young and feed their young with their own milk.
3 Flying foxes, although similar in structure to birds, belong to the class Mammalia as they give birth to live young and feed their young with their own milk.
4 The main characteristics of mammals are:
- They give birth to live young
- They feed their young with their own milk.

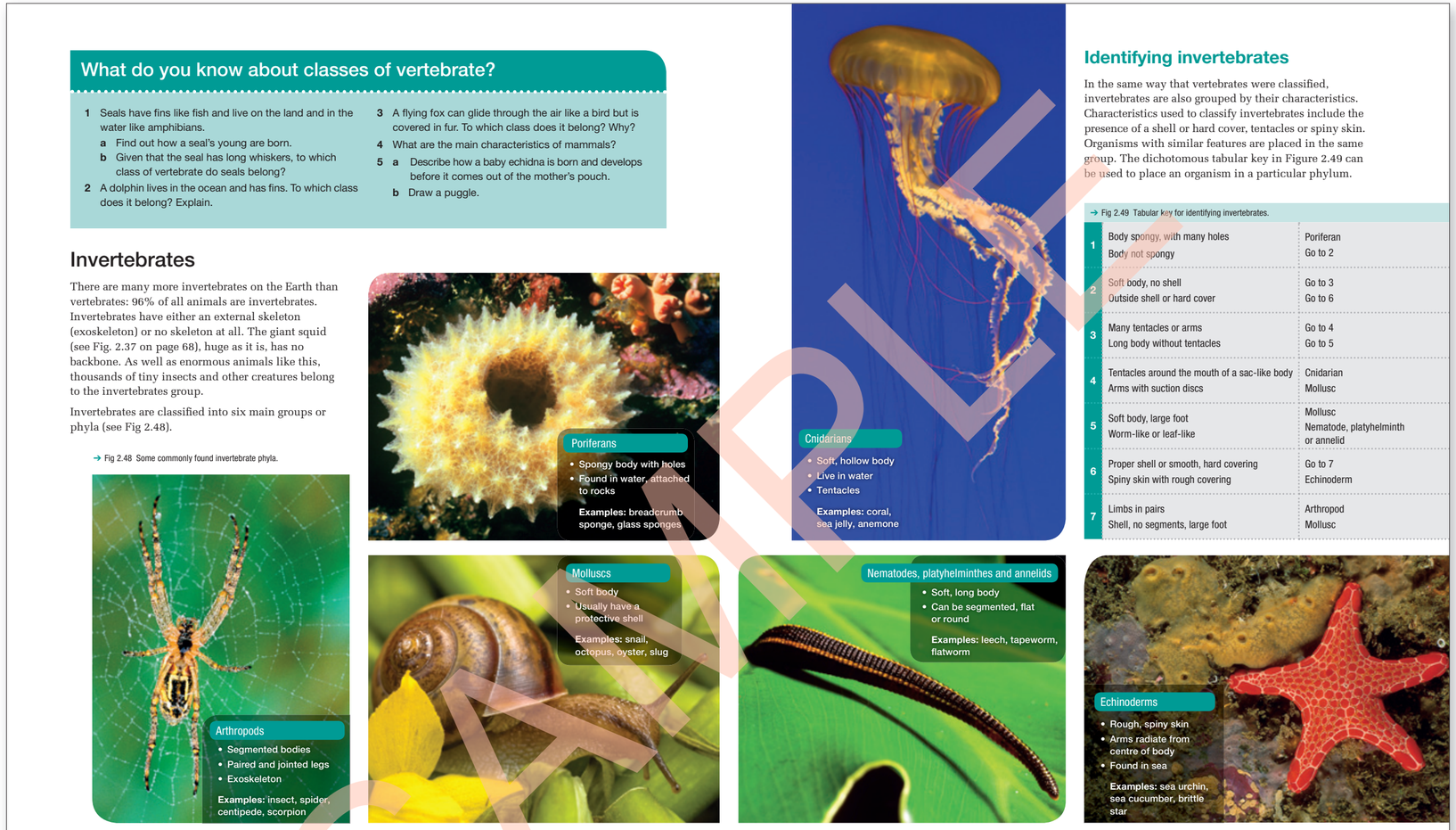
5 a The echidna egg is laid into a backward opening pouch and ten days later it hatches into the pouch. Hatchings are about 1.5 cm and are known as Puggles. After hatching they attach themselves to the mother's areolae (monotremes lack nipples) to feed on the milk. Juveniles are evicted from the pouch at about 3 months old, however, they will often be left in the nest while the mother is foraging from when the juvenile starts to develop spines. Weaning occurs at about 6 months of age and they leave the burrow at about this time. The mother and young don't have contact after this.
b Students' own drawings. The puggles should be small, spineless and blind.

Invertebrates

Critical and creative thinking

The invertebrate group is varied and numerous. Several examples of each of the main phyla have been given in Figure 2.48.

Students could present these examples in large posters, presentations or web pages, highlighting the characteristics unique to each group and adding further examples.



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.

Poriferans
- Spongy body with holes
- Found in water, attached to rocks

Examples: breadcrumb sponge, glass sponges

Cnidarians
- Soft, hollow body
- Live in water
- Tentacles

Examples: coral, sea jelly, anemone

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

Nematodes, platyhelminthes and annelids
- Soft, long body
- Can be segmented, flat or round

Examples: leech, tapeworm, flatworm

Echinoderms
- Rough, spiny skin
- Arms radiate from centre of body
- Found in sea

Examples: sea urchin, sea cucumber, brittle star

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

Identifying invertebrates

Literacy

Have students use the tabular key in Figure 2.49 to systematically identify the organisms in each image from Figure 2.48.

Students could list the characteristics used in the tabular key to identify each organism, and comment on the reasoning behind including certain characteristics over others.

PRACTIVITY 2.6

Identifying invertebrates

Students may find the tabular key on page 75 inadequate for identifying the organisms they discover in their local environment. They should be encouraged to suggest whether it is possible to provide an adequate key for invertebrates given the enormous number that are involved. Obviously, such keys do exist, but the level of detail they include would not be appropriate for Year 7 students.

The invertebrates included on page 76 can be identified as follows:

a Worm
b Arthropod
c Arthropod
d Echinoderm
e Arthropod
f Poriferan
g Annelid
h Arthropod.

Answers

What do you know about invertebrates?

1 About 96% of animals are invertebrates.
2 An exoskeleton is an external skeleton. Examples of organisms with an exoskeleton include: crabs, beetles, cockroaches, grasshoppers etc
3 Beetles belong to the phylum Arthropoda as they have segmented bodies and jointed legs.
4 **a** The term arthropod means 'jointed feet', which refers to the segmented bodies and jointed legs these organisms have.
b Answers will vary depending on arthropods drawn.
5 Answers will vary based on Practivity 2.6 results.

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.

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?

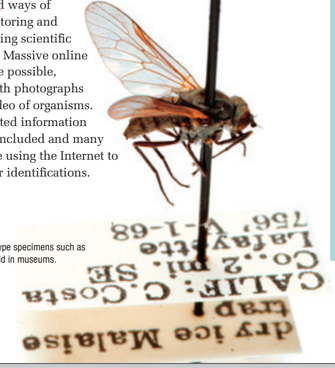
The changing face of science

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?

What do you know about the changing face of science?

1 **a** The names of the original three kingdoms were: Plants, Animals and Minerals.
b The change to five kingdoms was necessary because there were scientific advances and more information and greater detail could now be observed. (Students are likely to have different answers based on whether they actually agree with the changes or not.)
2 The understanding of genetics changed the classification system, as species that were originally considered to be related because they looked similar are actually quite different based on the genetic material each one contains.
3 A holotype specimen is an example of an organism that was used when the description for classification was decided. These are housed in museums.
4 Scientists choose a single organism to represent the species instead of trying to find a description that fits every single individual in the species, as there is variation within a species. Similar to how every human or dog looks different even though they are still part of the same species.
5 A paper system for classification can be very large and hard to sort through. Today, the Internet and online databases allow more sophisticated ways to store, organise and communicate this information.

obook

ID02.18 Video link: Mythbusters test daddy long legs myth
Mythbusters video that tests the myth that daddy long legs have the deadliest venom of all spiders. Suitable for student curiosity, how to prove/disprove theories.

BIG IDEAS

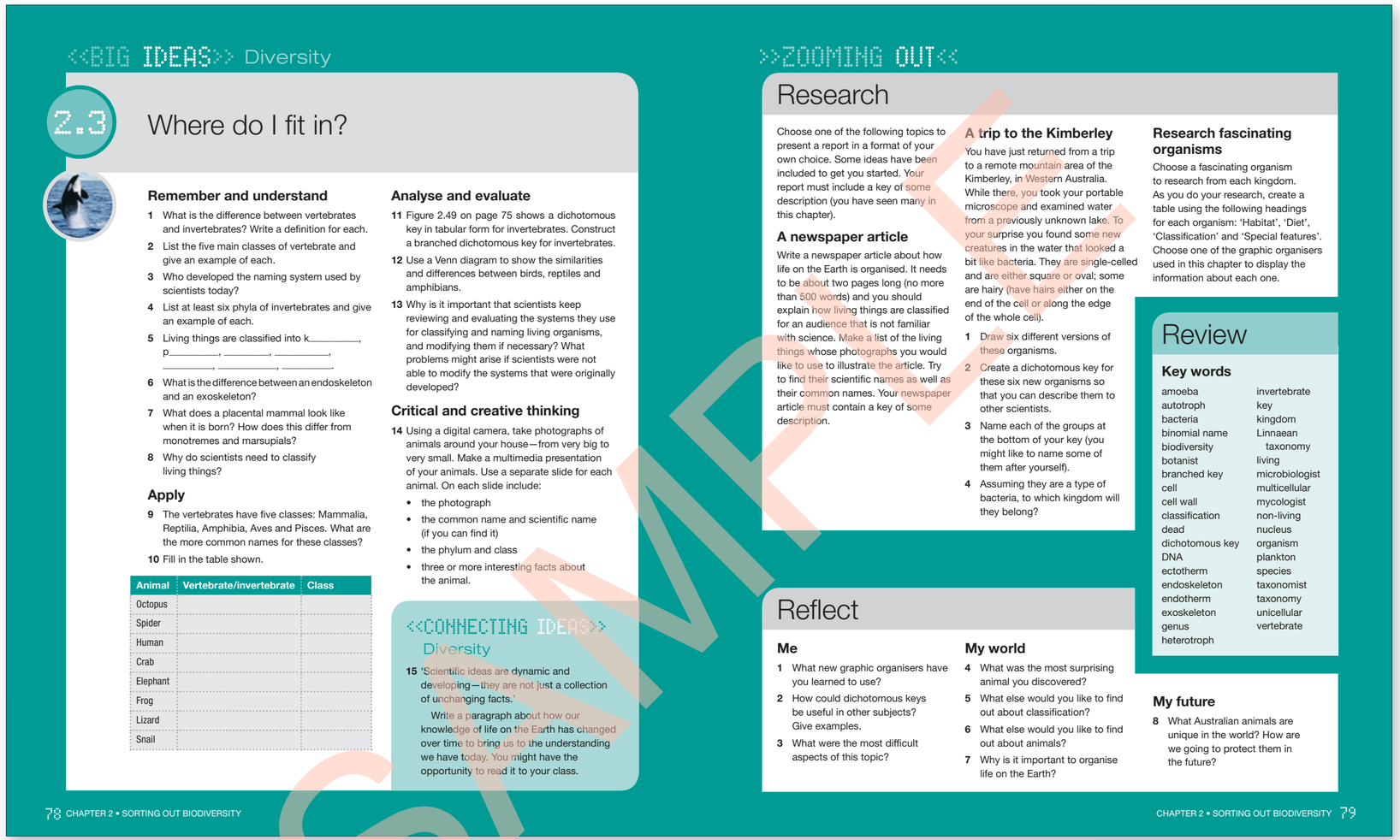
2.3 Where do I fit in?

Remember and understand

1 Vertebrates have an endoskeleton. Invertebrates have an exoskeleton or no skeleton.
2 The five main classes of vertebrates are: Mammals, Reptilia, Amphibia, Aves (birds), Pisces (fish).
3 Carolus Linnaeus invented the naming system that is still used today to name living things.
4 The six phyla of invertebrates are: Poriferan (e.g. sea sponges), Cnidaran (e.g. jellyfish, coral, anemone), Mollusc (e.g. snails, shell-covered aquatic animals, octopuses), Nematodes/annelids (worms) (e.g. leech, tapeworm, flatworm), Echinoderm (e.g. sea star, sea urchin, sea cucumber), Arthropod (e.g. spiders, insects).
5 Living things are classified into: Kingdom, Phylum, Class, Order, Family, Genus/Group and Species.
6 The difference between and an endoskeleton and exoskeleton: Endo – meaning internal – skeleton inside body; Exo – meaning external – skeleton outside body.
7 A placental mammal looks like a smaller version of the adult when it is born. Monotremes and marsupials are furless, blind and approximately 1 cm when born and travel from the birth canal to the pouch where they grow.
8 Scientists need to classify living things to make sense of all the organisms studied, and identify a specific species in a simple and practical manner. Every species can be given a unique name, as compared with common names that are often not consistent or unique.

Apply

9 More common names for vertebrate classes: Mammalia—Mammals; Reptilia—Reptiles; Amphibia—Amphibians; Aves—Birds; Pisces—Fish.



10

Animal	Vertebrate/invertebrate	Class
Octopus	Invertebrate	Mollusc
Spider	Invertebrate	Aracnid
Human	Vertebrate	Mammalia
Crab	Invertebrate	Crustacea
Elephant	Vertebrate	Mammalia
Frog	Vertebrate	Amphibia
Lizard	Vertebrate	Reptilia
Snail	Invertebrate	Mollusc

Analyse and evaluate

11 Students' own responses.
12 Students' own responses.
13 It is critical for scientists to keep reviewing, evaluating and modifying the systems they use for classifying and naming living organisms because new information may be discovered which may cause a change in the classification of a species. With the knowledge associated with genetics, we now know some species are in fact distinct and not at all related. Problems that may arise should this modification not be possible include: incorrect data, misidentification of species, some species may not be able to be classified, and new species would not be known.

Critical and creative thinking

14 Students' own responses.

<<CONNECTING IDEAS>>

15 Answers will vary, however students should mention such things as:
a Invention of things such as the microscope which lead to the identification of new species and ability to describe things in greater detail
b New species discovered and therefore new information needed to be included with the current data
c New techniques such as genetic testing allow scientists to gain a greater understanding of the species.

ZOOMING OUT

Research

Research tasks are an effective way of assessing learning and other capabilities, and can be used effectively as an assessment task in lieu of or alongside other methods of assessment. The three topics presented give students a choice based on their interests, and some control over their learning. Students could complete the research after planning the project, or be allowed to complete the research if their planning is sufficient.

Reflect

Questions in this section will vary, as it is an individual reflection, however some suggested answers follow for certain questions.

2 Dichotomous keys in other subjects might help separate ideas and help identify concepts.
7 It is important to organise life on earth to help make sense of all organisms. It can assist in identifying current species and whether a new species is discovered. It also enables scientists to understand the complex relationships and requirements of a species.
8 The Australian animals that are unique in the world inlcude: Koala, Kangaroo, Wombat, Echidna, Bilby, Tasmanian devil, Dingo, Platypus etc. To protect them in the future we need to understand what their needs are. There are laws to protect these species and conservation programs to assist in this.

obook

ID02.19 Weblink: Interactive clip classification theory/variation in species/genetic engineering. Includes quiz and links to revision notes and online test. Suitable as an extension activity understanding living things.
ID02.20 Flashcard glossary
ID02.21 Student self-test

CONNECTING IDEAS

How is life on Earth organised?

1 The Anangu lived in the central Australian desert, where the weather is extreme. It is often dry and hot, rainfall is difficult to predict and the seasons are varied. They lived a nomadic lifestyle, travelling in small family groups and surviving by hunting wildlife and gathering food from the land.
   - a Foods (animals)—honey ants, witchetty grubs, sand goanna, kangaroo, bird and lizard eggs
   - b Foods (plants)—nectar from a honey grevillea tree, bush onion, native pigweed, desert raisin, bush plum, native fig.

2 The early explorers left this environment because they were confronted by a harsh landscape and couldn't survive as they struggled to find food in the area. This is because they didn't know where to look or what plants were suitable as food, nor did they know how to hunt the native animals effectively.

3 Answers will vary, some suggestions follow:
   - a Living—Plants (students may be more specific), kangaroos, koalas, spiders, goannas, birds, lizards, snakes, insects (students may be more specific)
   - b Non-living—rocks, water, wind, soil.

4 The Anangu recognise habitats in their own way because they have a unique understanding of the relationships between the land, plants and animals. They also know when and where to find particular foods.

5 Capillary action in relation to water is the ability of it to flow against gravity where it will rise in a narrow space such as a thin tube.

6 Animals found in the Uluru-Kata Tjuta National Park:

Mammals	Reptiles	Birds	Invertebrates
Spinifex hopping mouse	Thorny devil	Crimson Chat	Ant
Rufous hare wallaby	Nocturnal desert skink	Galah	Blowfly
Bush-tailed possum	Woma python	Painted firetail	Katydid
Dingo	Perentie lizard	Wedge-tail eagle	
Red Kangaroo	Mulga snake	Crested pigeon	

7 Characteristics of amphibians which would make it difficult for them to live in an arid environment:
- Start life in water, skin slimy and moist to touch, lay eggs in water.

Other animal classes that would have difficulty living in this environment would be:
- Pisces as they require large bodies of water for their entire lifespan
- Monotremes would find it hard to breed in arid environments.

8 The bilby's pouch is rear facing as they have to dig for food and shelter and don't want their pouch full of soil.

9 Monotremes would find it hard to breed in arid environments because:
- Their young don't spend as long in the pouch and thus aren't protected from the harsh environment for as long as marsupial young. Being fully developed before entering the harsh environment enables marsupials a better chance for survival. Monotremes wouldn't have this advantage
- Echidnas are diurnal and would be out during the hottest part of the day
- Echidna mothers will leave their young for days at a time (after they've left the pouch due to spines) while they're foraging for food, so if they can't dig a proper burrow due to hard ground, that would also leave the young open to predation
- The platypus requires large bodies of water for its entire lifespan including creek or river banks for burrows.

10 Mammals found in Australia's arid environments:

Animal	Placental/ Monotreme/ Marsupial	Latin name
Spinifex hopping mouse	Placental	*Notomys alexis*
Mulgara	Marsupial	*Dasycercus cristicauda*
Bilby	Marsupial	*Macrotis lagotis*
White-striped mastiff bat	Placental	*Talarida australis*
Wongai ningaui	Marsupial	*Ningaui ridei*
Kultarr	Marsupial	*Antechinomys laniger*
Short-beaked echidna	Monotreme	*Tachyglossus aculeatus*
Western pigmy possum	Marsupial	*Cercatetus concinnus*
Fat-tailed dunnard	Marsupial	*Sminthopsis crassicaudata*

By the end of Year 7, students:

Chapter 2

They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences.

They communicate their ideas, methods and findings using scientific language and appropriate representations.

They plan fair experimental methods, identifying variables to be changed and measured.

They select equipment that improves fairness and accuracy and describe how they considered safety.

Students draw on evidence to support their conclusions.

They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods.

obook

ID02.22 Weblink: Anangu environment
ID02.23 Weblink: Mammals, reptiles, birds and invertebrates of Uluru–Kata Tjuta NP
ID02.24 Weblink: Mammals of Australia's arid environment

How is life on Earth organised?

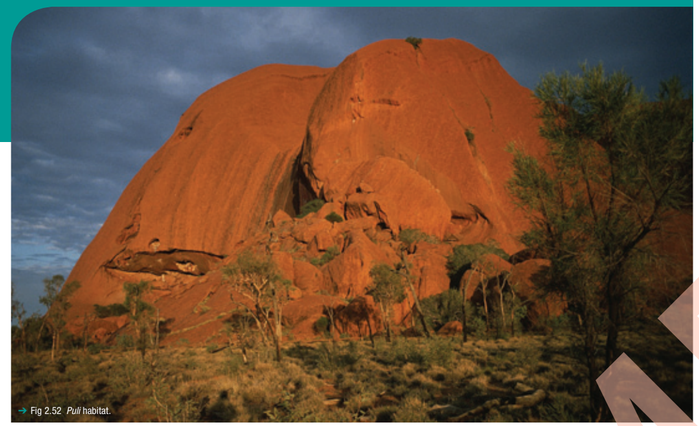


Fig 2.52 *Puli* habitat.

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.