CLASSIFICATION 5

5.1 Classification organises our world

5.2 Living organisms have characteristics in common

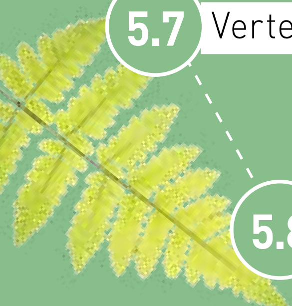
5.3 Classification keys are visual tools

5.4 The classification system continues to change

5.5 All organisms can be divided into five kingdoms

5.6 Animals that have no skeleton are called invertebrates

5.7 Vertebrates can be organised into five classes



5.8 Plants can be classified according to their characteristics

5.9 The first Australian scientists classified their environment

What if?

Identifying animals

What you need:

paper, pencil

What to do:

1. Work in pairs. Describe an animal to your partner – without using the animal's name. Can your partner draw the animal you describe?
2. Now draw an animal while your partner tries to guess what it is. How quickly did they guess your animal?

What if?

» What if you had code words that described several features of an animal at once? For example 'mammal' could mean four limbs, covered in fur and feeds their baby with milk. How would this affect the way you communicate?

5.1 Classification organises our world

Early scientists did not have photography or computers to record and catalogue images of the curious new plants and animals they discovered. Instead, they needed to rely on hand-drawn pictures and worded descriptions. Classification systems were developed to help scientists communicate with each other despite their different locations and languages.

Figure 5.1 The mature pine tree looks very different from its sapling.

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) studied and put into a group. Some plants were found to help sick people and others were poisonous. Some animals could produce food (e.g. milk and eggs). Each generation of scientists worked to improve how these groups were classified.

Common names or scientific names

Scientists try to communicate with each other regularly to help with their research. Before the existence of photographs or computers, scientists would have to draw creatures, for example birds, by hand and describe them in as much detail as they could. This was difficult, as the photographs of the American magpie and the Australian magpie (Figure 5.2) show. Both birds look so similar they have been given the same common name, 'magpie'. However, their scientific names are different. The name *Cracticus tibicen* for the Australian magpie means the same to scientists in every country around the world.

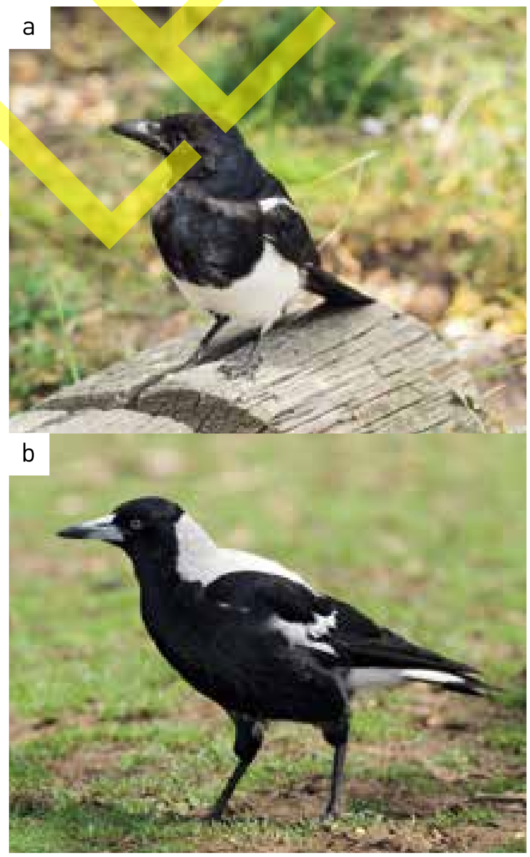


Figure 5.2 The American magpie *Pica hudsonia* (top) and the Australian magpie *Cracticus tibicen* (bottom)

Aristotle (384–322 BCE) sent his students out to gather local samples and stories. He ordered the samples and stories from least important (rocks) to the most important (wild animals, men, kings, fallen angels, angels and God).

Andrea Cesalpino (1519–1603) suggested classifying plants into groups according to their trunks and fruits.

John Ray (1627–1705) suggested that organisms needed to be observed over the whole of their lifespans.

Augustus Quirinus Rivinus (1652–1723) and Joseph Pitton de Tournefort (1656–1708) suggested using a hierarchy of names. Each organism had a long Latin name that described the characteristics of each level of the hierarchy.

CHALLENGE 5.1: DEPARTMENT STORE CLASSIFICATION
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The Linnaean classification system

The Greek philosopher Aristotle (384–322 BC) was the first scientist to start using systems to describe plants and animals. By the 17th century the early classification systems used a hierarchy of names, starting with large general groups (e.g. plants, animals) and making subsequent groups smaller and smaller depending on their characteristics. Each organism ended up with a long Latin name that described the characteristics of each level of the hierarchy. Carl 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.

Finding new species

Small groups of scientists are trying to find undiscovered plants in Brazilian rainforests before they are destroyed by logging and farming. Often the scientists 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.

Figure 5.3 Part of Linnaeus's classification system

Check your learning 5.1

Remember and understand

1. Why did Carl Linnaeus simplify the classification system used by previous scientists?
2. Give two reasons scientists still classify organisms today.

Analyse and apply

3. Why would it be difficult to classify frogs and tadpoles using the early methods of classification?

Evaluate and create

4. 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?
5. Aristotle was one of the first scientists to try to gather information from wide regions. What method might he have used to tell the differences between a horse and a fly?

Figure 5.4 The rainforests of Brazil contain many undiscovered plant species.

Figure 5.5 Carl Linnaeus

Carl Linnaeus (1707–1778) introduced the Linnaean classification system.

Carl Woese (1990) suggested that the bacterial kingdom Monera be split into two domains, and the third domain contain all other organisms.

Thomas Cavalier-Smith (1998) suggested the kingdom Plantae be split into two kingdoms because of differences in their cells.

5.2 Living organisms have characteristics in common

Biology is the study of living organisms and what it means to be alive. Both plants and animals are considered to be alive. They share many characteristics that apply only to organisms.

Figure 5.6 Living things move. Sunflowers turn to follow the Sun as it moves across the sky.

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 such as bacteria – have in common. To remember all eight characteristics, just remember MR N GREWW.

M Living things can MOVE by themselves

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.

R Living things can REPRODUCE

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

N Living things need NUTRITION

All living things need nutrients to survive. Animals obtain most of their nutrients by eating food and drinking. Plants absorb nutrients through their roots and fungi feed on decaying organisms. Plants are **autotrophs**, which means that they make their own food. Animals and fungi are **heterotrophs** – they rely on other living things for food.

G Living things GROW as they get older

All living things grow during their lives. Mushrooms start off as tiny spores. Humans are born as babies and develop 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 their parents.

Figure 5.7 Living things reproduce.

Figure 5.8 Living things need nutrients to survive.

Figure 5.9 Living things grow during their lives. These larvae will grow into mosquitoes.

Figure 5.10 Living things respond to change.

R Living things RESPOND to change

When an animal realises it is being chased, like the antelope in Figure 5.10, 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 5.6 are responding to the changing stimuli of light and warmth.

E Living things EXCHANGE GASES with their environment

Plants and animals have organs and structures that allow them to exchange oxygen and other gases. Some animals, such as humans, use their lungs to inhale and then exhale. Other animals, such as fish and the axolotl (Figure 5.11), have gills. Some animals, such as worms, breathe through their skin.

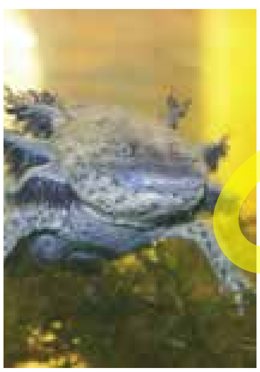

Figure 5.11 The axolotl has gills to exchange gases with its environment.

Figure 5.12 Sweating is one way humans get rid of waste products from their bodies.

W Living things produce WASTES

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

W Living things require WATER

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

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, has *never* had these characteristics.

Check your learning 5.2

Remember and understand

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

Apply and analyse

2 Consider the things listed below.

Eucalypt tree, water, paper, robot, leather belt, wombat, roast chicken, chair

- a With a partner or by yourself, decide whether each of the items meets the requirement to be classified as a living thing.
- b Decide whether each should be classified as living or non-living.

3 Are any of the items listed in question 2 dead? Explain your answer.

Evaluate and create

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

5 Is a bushfire alive? Explain your answer.

Figure 5.13 The human body uses water for many jobs, including maintaining body temperature.

5.3 Classification keys are visual tools

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 see how a particular member of the group fits in with all the rest. 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. 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.

Figure 5.14 Dr Redback's family

Using dichotomous keys

One common type of key is called the **dichotomous key** (pronounced 'dye-COT-o-muss') because 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 to an existing key.

Dr Redback's family

Dr Redback loved to send out Christmas cards with a family photo on the front. One year, just for fun, he included two dichotomous keys to help everyone identify all his family and pets.

Use the picture of Dr Redback's family and one of the dichotomous keys provided (Figure 5.15) to work out who is who.

Tabular keys

If a scientist is going out into the bush to study plants and animals, a large drawing like the one on the left in Figure 5.15 may not be useful. Instead, a field guide or tabular key, such as that shown on the right of Figure 5.15, can be used. This is used in the same way as the diagram version. Two choices are offered at each stage. When a decision is made, the scientist is led to the next characteristic choice.

CHALLENGE 5.3: DICHOTOMOUS KEY
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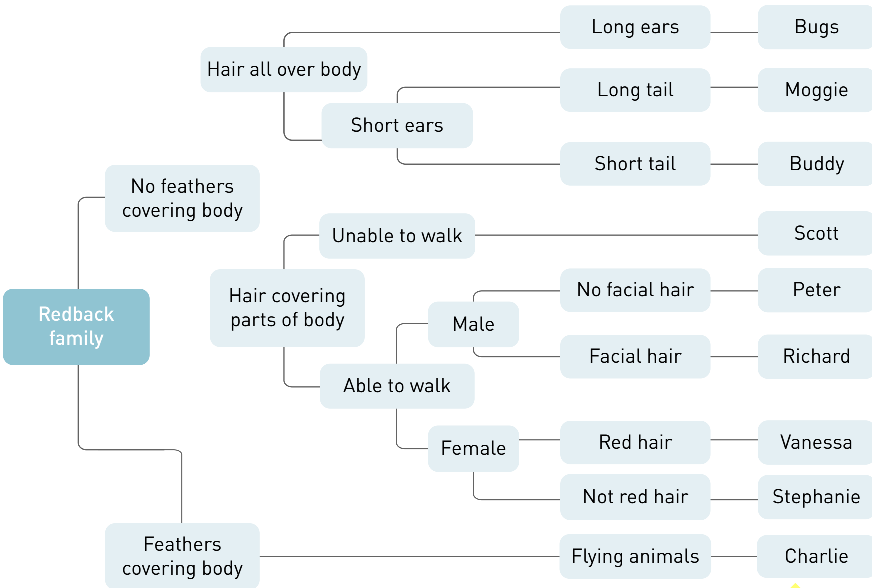

1	No feathers covering body	Go to 2
	Feathers covering body	Go to 9
2	Hair all over body	Go to 3
	Hair covering parts of body	Go to 4
3	Short ears	Go to 5
	Long ears	Bugs
4	Unable to walk	Scott
	Able to walk	Go to 6
5	Long tail	Moggie
	Short tail	Buddy
6	Male	Go to 8
	Female	Go to 7
7	Red hair	Vanessa
	Not red hair	Stephanie
8	No facial hair	Peter
	Facial hair	Richard
9	Flying animals	Charlie

Figure 5.15 Dichotomous keys for Dr Redback's family. The key on the right is the tabular key for the diagram on the left.

Check your learning 5.3

Remember and understand

1 What is a dichotomous key?
2 Why is it called 'dichotomous'?
3 What does the term 'classifying' mean?

Apply and analyse

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
   d has a broken leg
   e is sitting on the ground

Evaluate and create

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 Use the dichotomous key in Figure 5.16 to help with the following tasks.
   a Identify and name the four beetles in Figure 5.17.
   b Draw a simple sketch of the following:
      i frope beetle   ii gring beetle
      iii gripe beetle   iv frong beetle

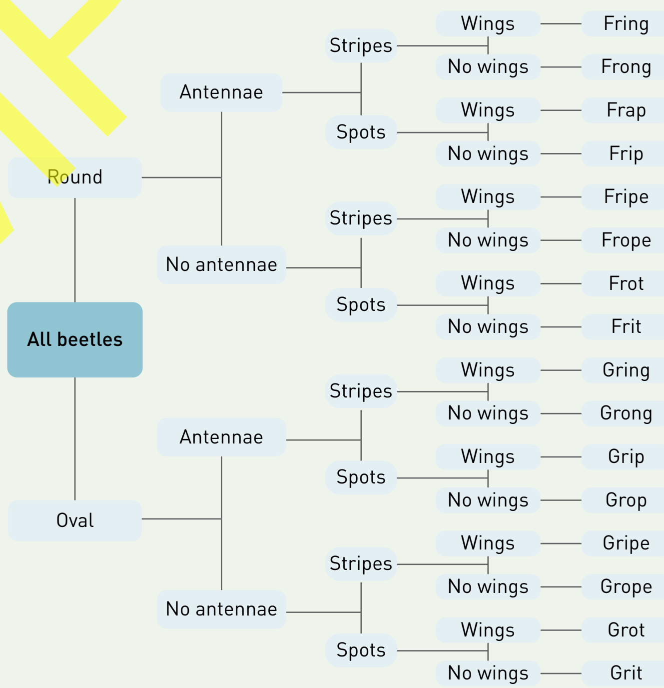

Figure 5.16 A dichotomous key to help identify 16 different types of beetle.

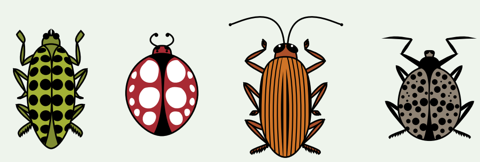

Figure 5.17

5.4 The classification system continues to change

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

Giving organisms a precise name

When trying find your house on Google Earth, you first find Australia, then the state you live in. Each time you narrow your search closer–to your town, your suburb, your street–until you finally find your house.

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'.)

KINGDOM: Animalia
e.g. insect, fish, bird, lizard, kangaroo, fox, lion, jungle cat, domestic cat

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

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

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

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

GENUS: *Felis*
e.g. jungle cat, domestic cat

SPECIES: *catus*
domestic cat

Figure 5.18 The Linnaean classification system uses seven different levels. It is used to give names to living things such as the domestic cat, Felis catus.

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 names given to every living thing using the Linnaean classification system.

Our homes can easily be found by using only the two smallest groups in an address (the street and the suburb). The information about the bigger groups, like the Earth and the country, 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 (or **binomial**) **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).

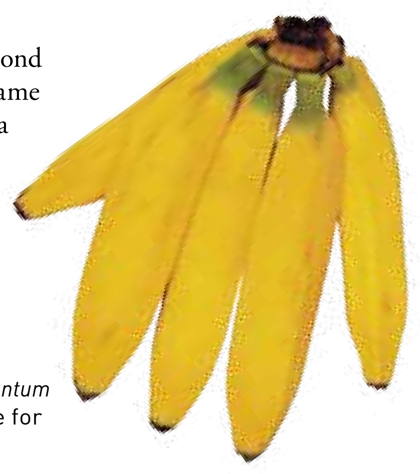

Figure 5.19 *Musa sapientum* is the Linnaean name for a banana.

CHALLENGE 5.4: CAN YOU UNDERSTAND SCIENTIFIC NAMES?
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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.

The changing face of science

After 250 years, scientists are still testing and modifying the Linnaean classification system. 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. The genetic material (DNA) of these organisms was different from that of other bacteria. This led to the suggestion that a sixth kingdom, Archaea, was needed. Scientists are currently testing this idea and comparing it with 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.

Figure 5.20 (a) Biologist collecting Archaea samples in the hot springs of the Obsidian Pool in Yellowstone National Park, USA (b) A magnified view of a clump of Archaean organisms

Check your learning 5.4

Remember and understand

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

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

3 How do you know if two organisms are members of the same species?

Apply and analyse

4 Select three species of animal. For each species:

a describe its appearance

b give its common and scientific names.

Evaluate and create

5 How has an understanding of genetic material changed classification?

5.5 All organisms can be divided into five kingdoms

Taxonomists have been classifying all living things into five kingdoms for over 250 years. The comparison of genetic material may cause changes to this system in the future. That is the very nature of science – to change and develop as new evidence becomes available.

Figure 5.21 Simple animal (top), plant (middle) and bacterial (bottom) cells.

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. Any living thing with more than one cell is **multicellular**. Many living things, such as bacteria, consist of only one cell. These are single-celled or **unicellular** organisms.

Parts of a cell

Taxonomists ask three questions when they are trying to classify the cells of an organism.

1. Does the cell keep all its genetic material (called DNA) inside a **nucleus**? The nucleus protects the DNA that carries all the instructions for staying alive.
2. Does the cell have a **cell wall** around it for extra support?
3. Does the cell use sunlight to make its own nutrients (autotroph)? Plant cells can do this, but fungi (like mushrooms) need to absorb their nutrients from other living things (heterotroph).

It is the correct combination of these three features that help divide all living things into the first big group called kingdoms.

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.

Kingdom Plantae

Plants include trees, vines, bushes, ferns, mosses, weeds and grasses. They all gain energy by making their own food from sunlight

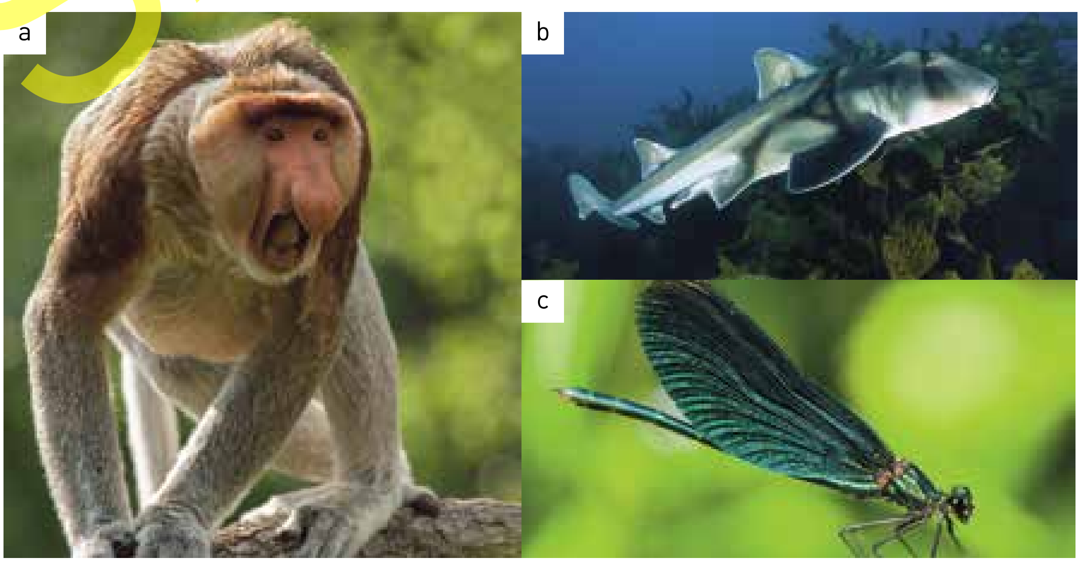

Figure 5.22 Kingdom Animalia: (a) the proboscis monkey (*Nasalis larvatus*), which has the biggest nose; (b) the Port Jackson shark; and (c) the damselfly.

CHALLENGE 5.5: CLASSIFYING LIVING THINGS
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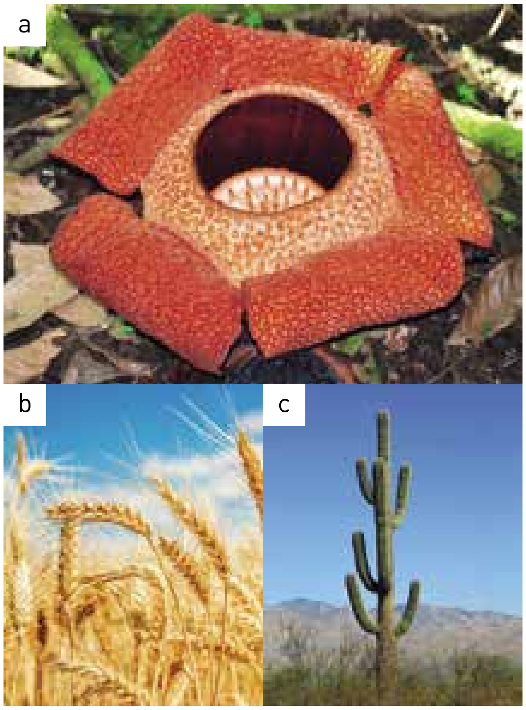

Figure 5.23 Kingdom Plantae. (a) The smelliest plant, the *Rafflesia*, is found in South-East Asia. Its flower can measure up to 90 centimetres across and weigh about 11 kilograms. It gives off a rotten meat odour when it blossoms to attract insects (b) Wheat (c) Cactus.

Figure 5.24 Kingdom Fungi: (a) mushrooms; (b) mould.

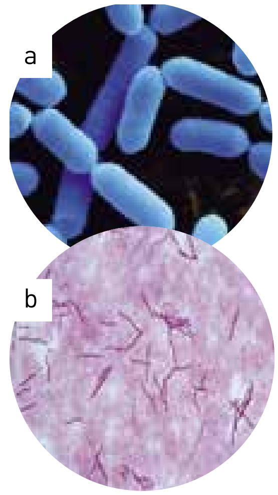

Figure 5.25 Kingdom Monera, as seen under a microscope: (a) *Lactobacillus casei*; and (b) *Spirillum volutans*.

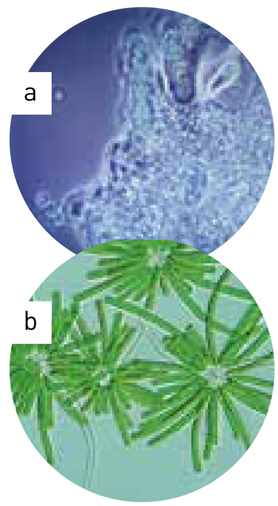

Figure 5.26 Kingdom Protista, as seen under a microscope: (a) amoeba; and (b) *Giardia lamblia*.

(autotrophs). They are multicellular and 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 store their genetic material in a nucleus and 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.

Kingdom Monera

This kingdom is made up of the simplest and smallest living things. There are approximately 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 food, such as cheese and yoghurt.

Microbiologists are the scientists who study microorganisms in Kingdoms Monera and Protista.

Kingdom Protista

There are approximately 55 000 species of protists. Their cell structure is more complex than that of the 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). They do all have one feature in common: they store their genetic material in a nucleus. **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.

Check your learning 5.5

Remember and understand

1 Name four features that all animals have in common.
2 Name four features of Kingdom Fungi.
3 Name an organism made up of just one cell.

Apply and analyse

4 How is a protist different from a bacterium?
5 What is the difference between cells in Kingdom Plantae and Kingdom Fungi?

Evaluate and create

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

5.6 Animals that have no skeleton are called invertebrates

Kingdom Animalia contains approximately 35 phyla. Most commonly scientists break them into two main groups: vertebrates and invertebrates.

Figure 5.27 The giant squid is an invertebrate.

Internal or external skeleton?

In the same way as when 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 along 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.

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. As well as enormous animals such as the giant squid, thousands of tiny insects and other creatures belong to the invertebrate group.

Identifying invertebrates

In the same way that vertebrates are classified, invertebrates are grouped into six main groups or phyla on the basis of 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 Table 5.1 can be used to place an organism in a particular phylum.

Table 5.1 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**

EXPERIMENT 5.6: DISSECTING SKELETONS
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CHALLENGE 5.6: IDENTIFYING INVERTEBRATES
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Arthropods

> segmented bodies
> paired and jointed legs
> exoskeleton

Examples: insect, spider, centipede, scorpion

Poriferans

> spongy body with holes
> found in water, attached to rocks

Examples: breadcrumb sponge, glass sponge

Molluscs

> soft body
> usually have a protective shell

Examples: snail, octopus, oyster

Cnidarians

> soft, hollow body
> live in water
> tentacles

Examples: coral, sea jelly, anemone

Nematodes, platyhelminths 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 the sea

Examples: sea urchin, sea cucumber, brittle star

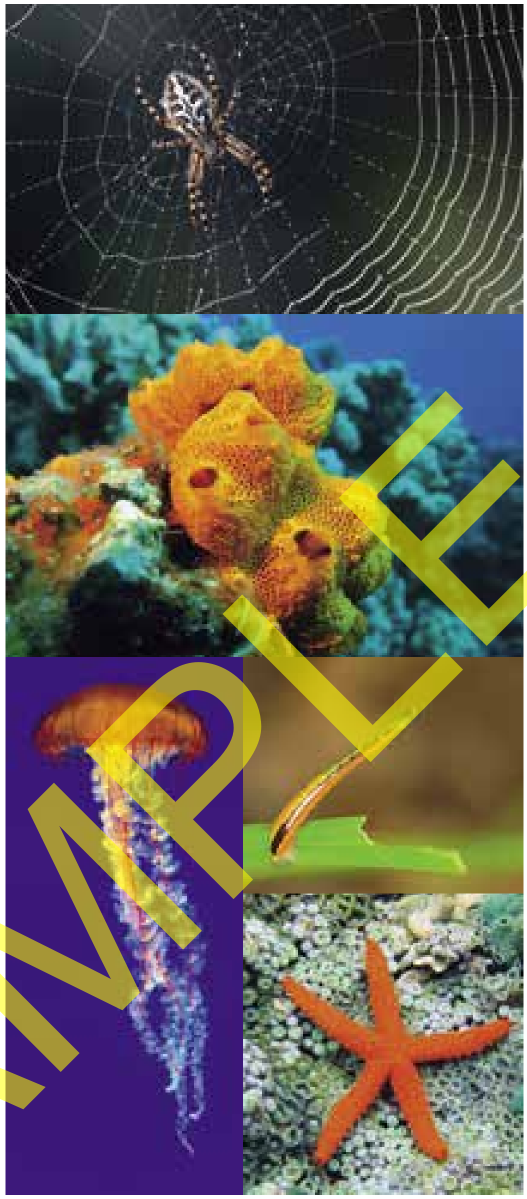

Figure 5.28 Some commonly found invertebrate phyla

Check your learning 5.6

Remember and understand

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 What percentage of animals are invertebrates?
3 Give two examples of animals with an exoskeleton.
4 Give two examples of animals with no skeleton at all.

Apply and analyse

5 Beetles have segmented bodies and jointed legs. To which phylum do they belong?

Evaluate and create

6 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.

5.7 Vertebrates can be organised into five classes

Vertebrates are animals with a spine or backbone. Vertebrates as a group can be broken down into further subgroups called classes based on their body covering, how their young are born, and their body temperature. Vertebrates either have a constant body temperature (and are called **endotherms**) or a body temperature that changes with the environment (**ectotherms**).

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 5.29. The main feature used to separate mammals is the way in which their young develop.

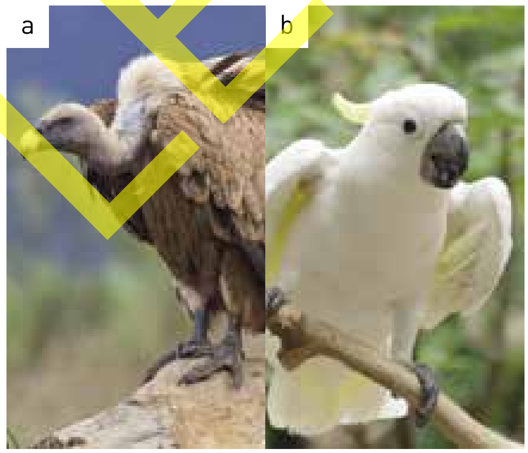

Figure 5.30 Class Aves: (a) a vulture; and (b) a cockatoo

Class Aves

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

Figure 5.29 The three subgroups of mammals: monotremes, marsupials and placentals.

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 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.

Turtles also belong to this class. Many people become confused by the hard outer shell of turtles and tortoises, thinking it is an exoskeleton. Underneath the shell there is a hard backbone with a nerve cord running through it.

CHALLENGE 5.7: WHO ARE THE VERTEBRATES?
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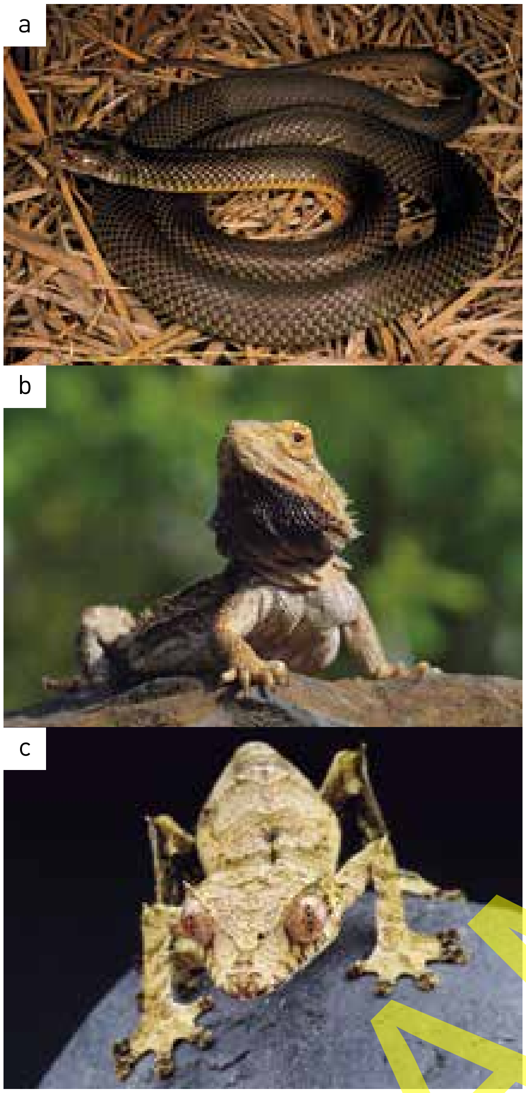

Figure 5.31 Class Reptilia: (a) a king brown snake; (b) a bearded dragon; and (c) a gecko

Figure 5.32 Despite having a hard outer shell, turtles and tortoises have a hard backbone with a nerve cord running through it.

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 land. The only remaining group of amphibians in Australia is frogs. In other parts of the world, caecilians and salamanders may be found.

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 to breathe. Fish are further grouped according to their skeleton. Sharks, rays and skates have a skeleton made entirely of cartilage, whereas all other fish have bony skeletons.

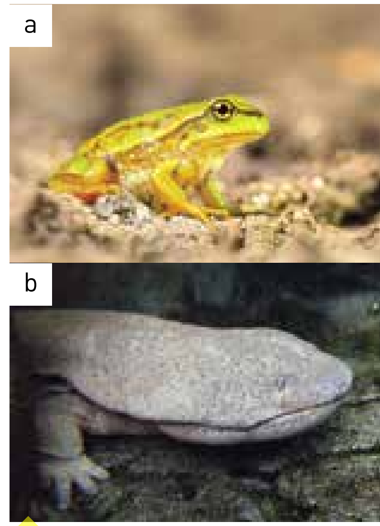

Figure 5.33 Class Amphibia: (a) a growling grass frog; and (b) a Chinese giant salamander

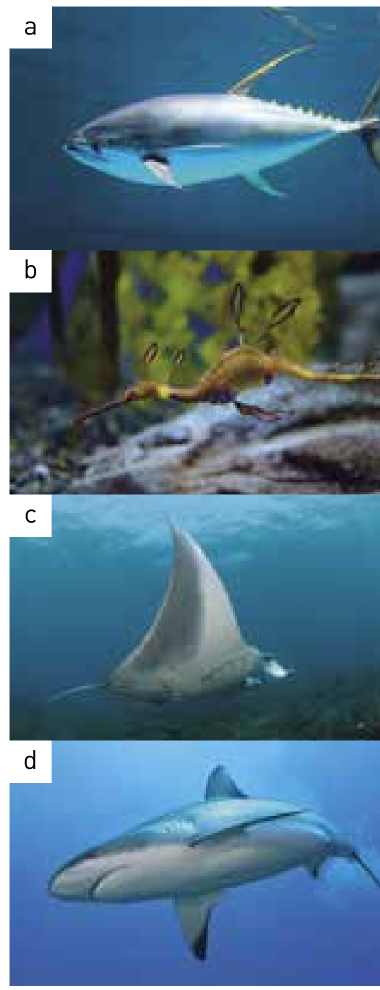

Figure 5.34 Class Pisces: (a) tuna; (b) weedy seadragon; (c) manta ray; and (d) reef shark

Check your learning 5.7

Remember and understand

1 What are the main characteristics of mammals?

Apply and analyse

2 A dolphin lives in the ocean and has fins. It breathes air, gives birth to live young and feeds them milk. 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 does a placental mammal look like when it is born? How does this differ from monotremes and marsupials?

Evaluate and create

5 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, is endothermic and breathes air, to which class of vertebrate does it belong?

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

5.8 Plants can be classified according to their characteristics

Plants belong in one of the five kingdoms of living things. All plants are multicellular organisms that are able to produce their own energy by using sunlight. This does not mean all plants look the same. They have a variety of different characteristics that allow us to classify them into different phyla.

Figure 5.35 Not all plants germinate from seeds. Ferns produce spores instead.

Seeds or spores

Planting a seed and watching it grow is something most people have done at some stage. But not all plants have seeds. Some plants, such as ferns, produce spores. Spores are much smaller than seeds and only contain half the genetic material needed to make a fern. They can be found clinging to the underside of a fern frond.

Vascular tissue

Plants, like all living things, need water to survive. Many plants use their roots to absorb water and transport it through tube-like structures to the leaves. This system of tubes is called the **vascular tissue** of the plant. Not all plants are so organised. Many plants, such as mosses and liverworts, need to live in damp places where they can absorb water through all parts of their structure.

Figure 5.36 Mosses and liverworts can absorb water through all parts of their structure.

The importance of flowers

Most plants you will have in your school garden produce flowers. Flowers are the way plants attract birds and insects to encourage **pollination** and therefore enable them to produce seeds. Not all plants have true flowers. Conifers have needle-like leaves and produce cones instead of flowers. Pollen from one cone is often transferred to another cone (pollination) so that a seed can produced.

Figure 5.37 Some plants use flowers or cones to produce seeds.

Figure 5.38 The number of petals on a monocot flower is always a multiple of three.

Figure 5.39 A dicot flower.

CHALLENGE 5.8: IDENTIFYING PLANTS
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Monocots and dicots

Flowering plants can be divided into two main groups. Monocotyledons (monocots) have a single leaf that grows from the seed. They can usually be recognised by the parallel veins in the leaves and by counting the number of petals in the flowers. Monocot flowers always have petals that are in multiples of three.

Dicotyledons (dicots) grow two leaves from the seed. Their leaves have veins that are reticulated (spread out from a central vein) and they tend to have four or five petals on each flower.

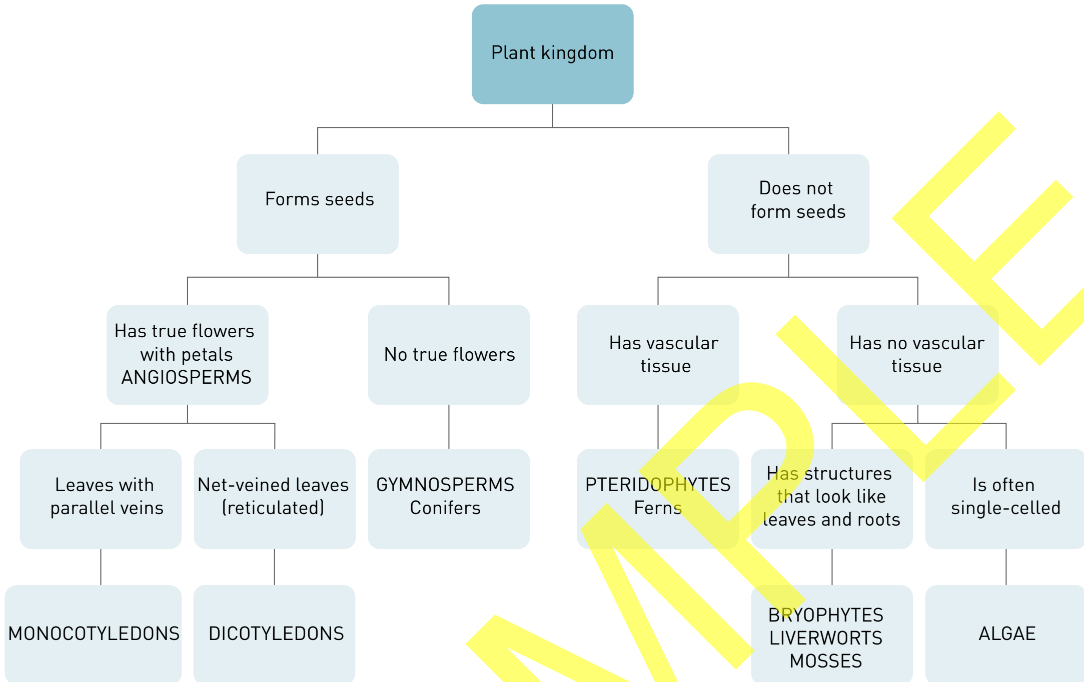

Figure 5.40 A sample plant key.

Check your learning 5.8

Remember and understand

1 What kind of plants are:
   a ferns?
   b mosses?
2 Which group do these household plants belong to?
   a fruit tree
   b palm tree
   c green weed in a fish tank
   d maidenhair fern
   e bird nest fern
   f moss on the path
   g rose bush
   h vegetables
   i pine tree
   j grass and lawn
3 How do mosses, ferns and conifers reproduce?
4 What is the difference between vascular and non-vascular plants?

Apply and analyse

5 Who am I? I am large and green. I use sunlight to make my own food. I smell nice and like to come inside at Christmas. Some people do not like me because my leaves can be prickly and needle-like. I use a cone to help me reproduce. Which plant phylum do I belong to?

Evaluate and create

6 Locate a plant in your garden.
   a Draw a labelled diagram of the plant.
   b What features could you use to classify your plant?
   c Name at least one feature that is not currently present that would help you classify your plant.

//SCIENCE AS A HUMAN ENDEAVOUR//

5.9 The first Australian scientists classified their environment

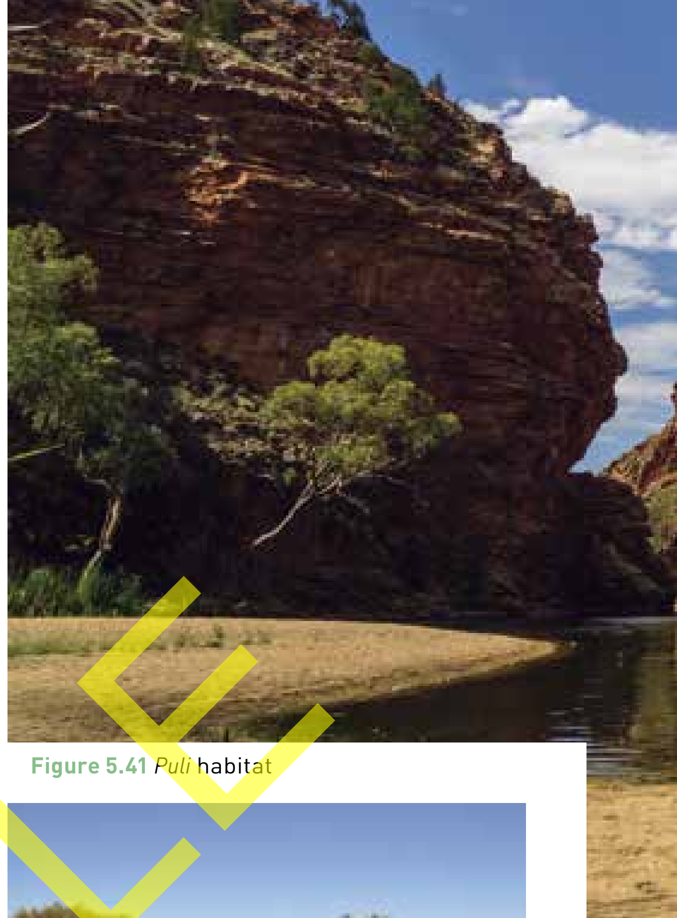

Figure 5.41 *Puli* habitat

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.

The Australian environment

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, the Anangu 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, and honey ants build their nests in this area

Figure 5.42 *Puti* habitat

Figure 5.43 *Pila* habitat

- *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 lies in the sun; but, when it is too hot outside, it hides in a burrow until the heat has passed.

One fascinating thing 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 Figure 5.29) and the marsupials.

Marsupials, such as the bilby, give birth to underdeveloped young but protect them by having a pouch in which further development can occur. The pouch is similar to that of a kangaroo; the bilby's pouch however, opens backwards. When the young are fully developed, they can leave the pouch and survive the harsh climate.

Extend your understanding 5.9

1. Find out about the kind of environment that the Anangu lived in and the foods they ate to survive. List at least five animals and five plants 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 should create the 'living' collage and the other should create the 'non-living' collage.
4. Why do you think the Anangu devised a system of classification for the natural habitats around them?
5. Investigate the mammals, reptiles, birds and invertebrates found in Uluru–Kata Tjuta National Park. Make a list of five for each category. Classify each one into its correct group.
6. 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?
7. Why do you think the bilby's pouch is rear facing?
8. Discuss why monotremes would find it difficult to breed in arid environments.
9. Investigate which mammals can be found in Australia's arid environments. Classify each of these mammals as placentals, monotremes or marsupials. List any Linnaen double names (genus and species) given for each animal.

Remember and understand

1 What is an organism?

2 Give an example of plants moving by themselves.

3 What are the advantages of using a dichotomous key?

4 Why is it important for scientists to use a common system to group all living things on the Earth?

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

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

7 List at least five phyla of invertebrates and give an example of each.

Apply and analyse

8 'Biodiversity' is the word used by scientists to describe a variety of different organisms in the same region. Why is it important to preserve a large biodiversity of plants and animals in the world?

9 Imagine that an unknown organism was discovered during a space mission and brought back to Earth. Briefly outline two different methods that scientists could use to decide whether it was living or non-living.

10 Refer to Figure 5.14 showing Dr Redback's family. How might you adjust the dichotomous key in Figure 5.15 if his 'family' included his sister, Melinda; his mother, Frances; he had two daughters, Stef and Gemma (Stef wears glasses); and he had a pet lizard named Stealth but not a bird named Charlie?

11 Place the items in the following list in the correct columns in Table 5.2: *stewed apple*, *iPod*, *daffodil bulb*, *DVD*, *hairs in your brush*, *your teacher*, *shark's tooth*, *germs*, *soft drink bottle*, *your pet*, *silver chain*, *dinosaur skeleton*.

Table 5.2

LIVING		NON-LIVING
CURRENTLY LIVING	DEAD	

Evaluate and create

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

a What is the most frequently seen animal in your area?

b What is the most frequently seen plant in your area?

Figure 5.44

13 Look at Table 5.3, showing the number of living things on the Earth.

Table 5.3 Types and numbers of living things on the Earth

GROUP	NUMBER OF SPECIES DESCRIBED	NUMBER OF SPECIES ESTIMATED TO EXIST	PERCENTAGE OF TOTAL ESTIMATED NUMBER OF LIVING THINGS
Animals with internal backbones (vertebrates)	64 788	80 500	0.7%
Animals without a backbone (invertebrates)	1 359 365	6 755 830	61.8%
Plants	297 857	390 800	3.6%
Fungi	98 998	1 500 000	13.7%
Bacteria (Monera)	35 351	>1 200 500	11%
Algae and protozoa (Protista)	28 871	>1 000 000	9.2%
Total number of species	1 885 230	>10 927 630	100%

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

a How many species of plant are estimated to be on the Earth?

b Compare the number of *known* plant species with the total number of *known* animal species (add animals without a backbone and animals with a backbone together). Are you surprised with the result? Explain.

14 Download a copy of the collection of insects in Figure 5.45 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.

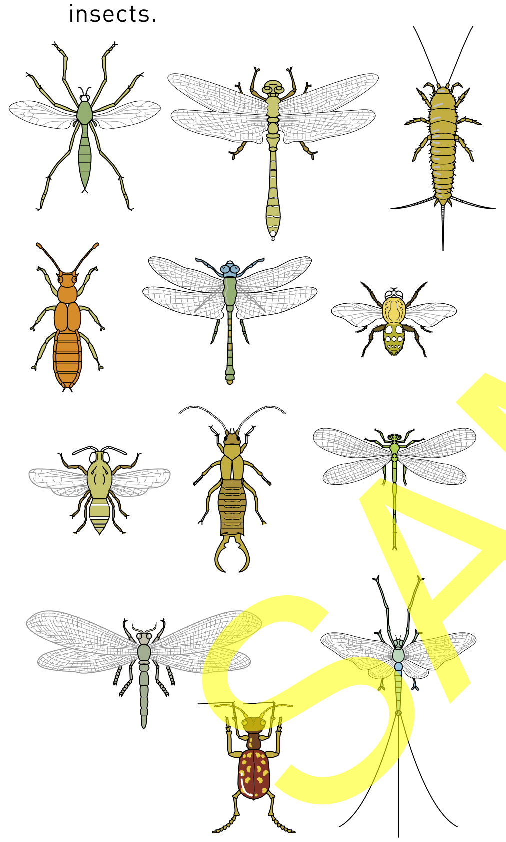

Figure 5.45

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

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

Research

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

> **A newspaper article**

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

> **A trip to the Kimberley**

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

1 Draw six different versions of these organisms.

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

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

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

*KEY WORDS

5

amoeba
type of single-celled organism belonging to the Protista kingdom

autotroph
organism that makes its own food (e.g. plants)

bacteria
unicellular organisms with a cell wall but no nucleus

binomial system
double-name system created by Linnaeus to name organisms; the first name is the genus, the second name is the species

botanist
scientist who studies plants

branched key
a method of identifying a species using questions that lead to further questions and eventually to the name of the species

cell wall
a structure that provides support around some cells

dead
something that was once living but no longer has the characteristics of a living thing

dichotomous key
diagram used in classification; each 'arm' of the key contains two choices

ectotherm
organism with a body temperature that changes with the environment

endoskeleton
internal skeleton

endotherm
organism with a constant body temperature

exoskeleton
external skeleton

genus
a group of closely related species

heterotroph
organism (e.g. fungi) that needs to absorb nutrients from other living things

invertebrate
organism with an exoskeleton (external skeleton) or no skeleton at all

key
(biology) visual tool used in the classification of organisms

Linnaean taxonomy
system of classification first developed by Carl Linnaeus (1707–1778) in which all organisms are grouped into one of five kingdoms

microbiologist
a scientist who studies microorganisms

multicellular
organism that has more than one cell

mycologist
a scientist who studies fungi

non-living
something that has never had the characteristics of a living thing

nucleus
a membrane-bound structure found in cells that contains most of the cell's genetic material

plankton
microscopic organisms that float in fresh or salt water

species
group of organisms that look similar to each other, can breed in natural conditions and produce fertile young

taxonomist
scientist who classifies living things into groups

unicellular
orgamism that consistes of only one cell (e.g. bacteria)

vascular tissue
in a plant, tube-like structures that transport water from the roots to the leaves

vertebrate
organism with an endoskeleton (internal skeleton)