TOPIC 3 Classification

3.1 Overview

Our planet contains an amazing variety of living things. Scientists classify these living things into groups on the basis of their similarities and differences.

This seahorse is called a sea dragon. Is it like a horse or can it be classified as something else?

3.1.1 Think about Classification assesson

- How can you use a key to unlock the door to classification?
- Why bother classifying living things?
- Which animals have their skeletons on the outside?
- I have scales and lungs and live on land. What am I?
- In terms of biological classification, which class do you belong to?
- What did prehistoric pelycosaurs use their sail-like fins for?
- Which herb helps relieve constipation?

LEARNING SEQUENCE

Numerous **videos** and **interactivities** are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the concepts covered in this topic.

3.1.2 Your quest

Sorting out dragons

Harry Potter met a dragon, as did Shrek and Bilbo Baggins. In fact, dragons feature in almost every culture from around the world — but did they really exist? If they did, were they somehow related to snakes, lizards or birds?

Think

What sorts of features do the dragons on these pages have in common? How are they different? What criteria could you use to divide the dragons up into groups?

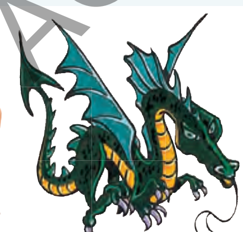
Dragon impostors?

The names of some plants and animals include the word ‘dragon’. Look at the sea dragon on the opposite page and the ‘dragon’ examples on this page and suggest why this is. The use of these common names can lead to misunderstandings about the similarities and differences of these organisms. One reason scientists use a classification or naming system is so that we have a shared understanding of what is meant and can communicate with each other more effectively.

Komodo dragon

Dragonfly

Snapdragon



INVESTIGATION 3.1

Dragon mapping

AIM: To find similarities between dragons

Form a group of four and allocate the roles of scribe, captain/organiser, timekeeper and encourager.

1. Brainstorm all that your group knows about dragons. Each person then uses that information to construct a bubble map of different dragons and their features (see section 5.9 for more information about bubble maps).
2. Compare your bubble map with those of others in your group. On a new piece of paper, the group scribe should collate all of the group’s ideas into a group bubble map, adding any extra points that arise during your group sharing.
3. On your group bubble map, use one colour to highlight the features that are common to all dragons.
4. Can any of the dragons shown above be grouped using the features left uncoloured in your bubble map? If so, highlight each group in a different colour.
5. Organise your group’s bubble map into a cluster map to show how your dragon information can be grouped or clustered (see section 2.8 for more information about cluster maps).
6. Use the internet to find out more about one area in your group’s cluster map.
7. Report back to your group and produce a group summary that you can present to the class.

3.2 Patterns, order and organisation

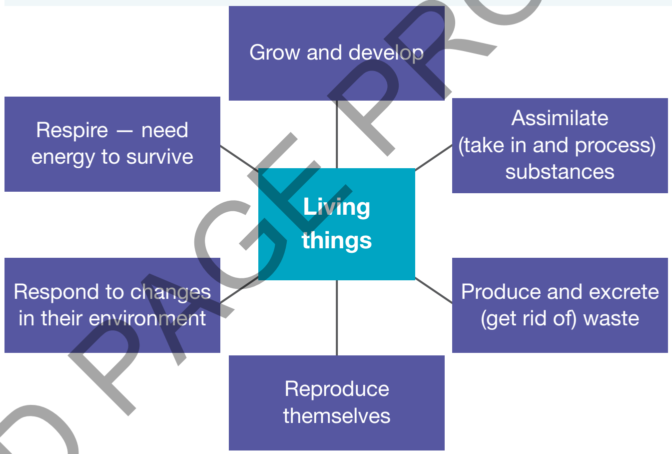
Is it alive? What is it? Is it friendly or dangerous? Can I eat it? Our brain is very good at recognising patterns and grouping similar patterns together. By organising information into patterns, it is easier to remember. Sometimes your survival can depend on recognising important patterns in the world around you.

3.2.1 Why classify?

We classify things into groups to make them easier to identify, remember and describe. Classifying is a way of organising and bringing order. Classification of living things (also known as organisms) enables scientists to put some order on the natural world. In this way, scientists can communicate with each other and know whether they are talking about the same or different kinds of organisms.

Classification is useful, for example, when dealing with diseases, disease-carrying organisms and disease control. There are thousands of different types of mosquitoes, but only a small number of these transmit the parasite that causes malaria. Instead of spraying all mosquito populations, scientists can identify those that may result in malaria and then take steps to control them.

Features common to all living things



3.2.2 Is it alive?

Prior to classifying living things, a shared understanding of the features of living things (organisms) is required. All living things **respond** to

HOW ABOUT THAT!

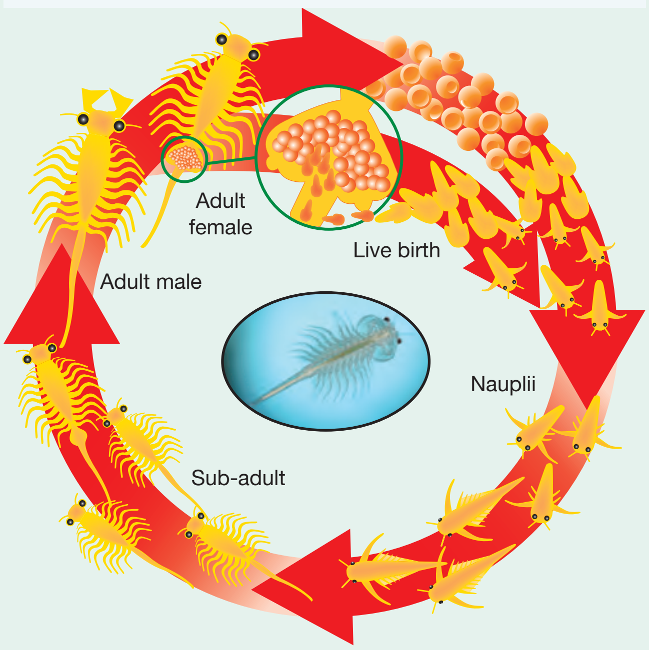
Instant life?

Just add water and, 'hey presto', you've brought sea monkeys to instant life! Are they really alive? Are they really monkeys? Can you create them just by mixing up sachets of powdered ingredients and adding water?

Sea monkeys are not really monkeys … but they are alive! They are made up of cells that require nutrients and produce wastes. They belong to the animal kingdom and are classified as members of the Arthropoda phylum and Crustacea class. They are actually a type of brine shrimp belonging to the species *Artemia salina.* As they can tolerate very salty water they are naturally found in salt lakes. Their gills help them to cope with high levels of salt by absorbing and excreting ions and producing very concentrated urine from their maxillary glands.

The 'magic' behind the sea monkeys appearing to become instantly alive is the process of **cryptobiosis**. This is a type of 'suspended animation' of the egg. One of the powders in the sachets sold in the sea monkey package contains *Artemia salina* eggs in their cryptobiotic stage. When these eggs come into contact with water, this phase ends and they begin their next stage of development and grow into 'sea monkeys', which swim around in their watery environment.

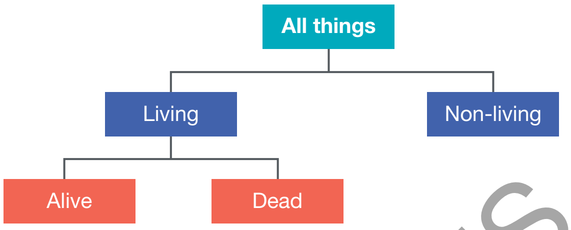
The life cycle of the sea monkey (*Artemia salina*)



changes in their environment, **need energy** to survive, **assimilate** (take in and process) substances, produce and **excrete** wastes, **grow** and **reproduce**.

If a living thing stops living, then it is **dead**. If something is **non-living**, then it has never had all of the characteristics of living things. For example, a squashed snail and roast chicken are dead, whereas a rock, a car and a computer are non-living.

Living, non-living or dead?



HOW ABOUT THAT!

Stromatolites — look like rocks but are alive

These excellent specimens of stromatolites live in Hamelin Pool Marine Nature Reserve in Shark Bay in Western Australia. At first scientists thought they were rocks, but they are in fact layered fossil records of living algae called cyanobacteria.

INVESTIGATION 3.2

Living, non-living or dead?

AIM: To classify things as living, non-living or dead

Method and results

1. Copy and complete the table below.

Characteristics	Robo-bilby (electronic toy) 	Bilby 	Bilby fossil 
Independent movement			
Requires oxygen			
Requires water			
Requires nutrients			
Produces and excretes wastes			
Grows as it gets older			
Responds to changes its environment			
Reproduces itself			

2. Construct another table the same as the one above but replace the bilbies with:
   (a) paper
   (b) fire
   (c) a tree.
3. Complete the table.

Discuss and explain

4. Identify which of the three bilbies is non-living. List the characteristics it has.
5. Identify which of the three bilbies is living. List the characteristics it has.
6. Of the paper, fire and tree, which is non-living?
7. Does the living thing have all of the characteristics listed?
8. Which characteristics does the living thing have that the non-living thing does not?

3.2.3 Made up of cells

Cells are the building blocks that make up all living things. Organisms may be made up of one cell (**unicellular**) or many cells (**multicellular**). These cells contain small structures called organelles that have particular jobs within the cell and function together to keep the organism alive.

Cells can be divided on the basis of the presence and absence of particular organelles and other structural differences. Organisms can be classified by the different types of cells they are made up of.

A painting of Carolus Linnaeus as a young man

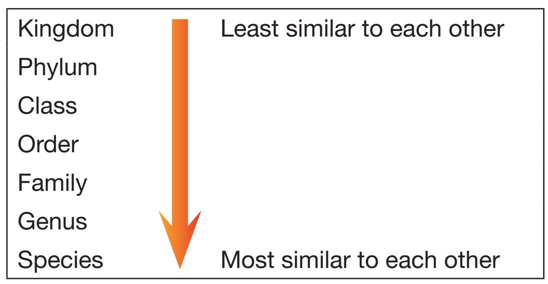
WHAT DOES IT MEAN?

The prefix *uni-* comes from the Latin term meaning 'one'. The prefix *multi-* comes from the Latin term meaning 'many'.

Cell or cell-less?

Protoctistan cells and **prokaryotic** cells are both very small and are living things. The types of cells that make them up are different. If you were to view the cellular details of protoctistans such as *Amoeba, Euglena* and *Paramecium* under a microscope, you would notice that they were more complex in their structure than prokaryotic cells.

There are other small things on Earth that show some features of living things but not others. These are not made of cells. **Viruses**, **viroids** and **prions** are three groups that are not made up of cells, but appear to show some features of living things when they have infected the cells of living organisms.



3.2.4 Classification — grouping to order and organise

Taxonomy is the formal classification of living things. A taxonomist is a biologist who specialises in classification. The Swedish naturalist Carolus Linnaeus (1707–1778) is considered to be the 'father of taxonomy' because his classification system formed the basis of our current system.

Linnaeus sorted organisms into groups based on their physical similarities. He called the largest grouping **kingdoms** and the smallest grouping **species**. Organisms classified into the same kingdom are more similar to each other than are organisms classified into different kingdoms. For organisms within a kingdom, however, as you move down the hierarchy of groupings (see figure above), the more alike its members are.

3.2.5 Classification systems can change

New technologies have provided us with more information about organisms. This new knowledge can change the classification of a particular organism and may even result in the proposal of new classification systems or categories.

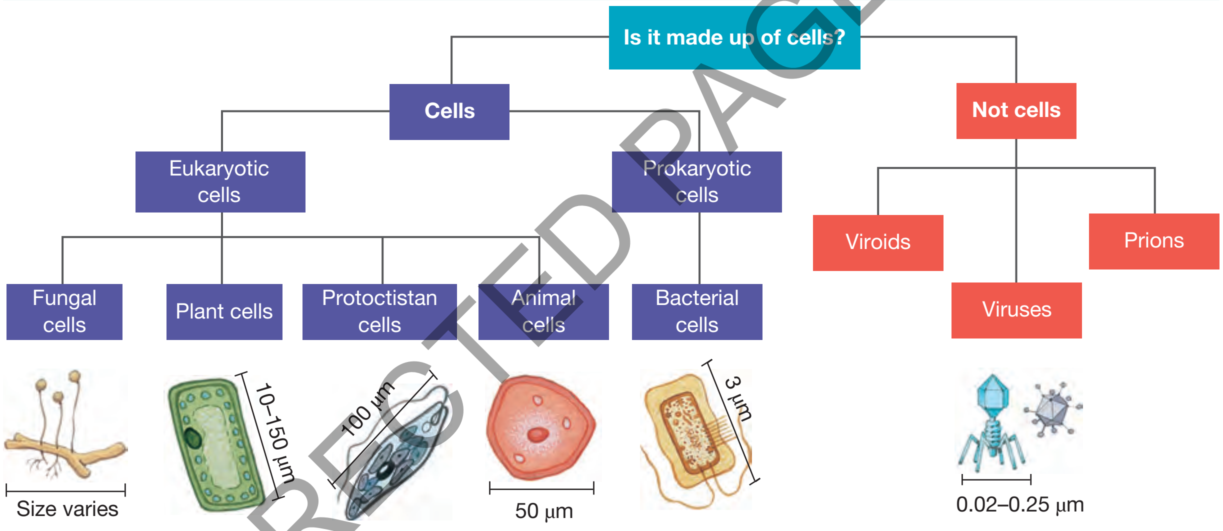
In the 1700s, Linnaeus proposed that living things could be grouped into three kingdoms. However, the invention of the microscope led to the discovery that all living things were made up of cells, but it also revealed that some organisms did not fit into the three proposed kingdoms.

3.2.6 Five kingdoms?

In the 1960s, a five-kingdom system of classification was proposed by ecologist, Robert Whittaker. This divided all living things up into the Animalia, Plantae, Fungi, Protista (or Protoctista) and Monera (or Prokaryotae) kingdoms. A key characteristic used to classify organisms into the five different kingdoms was the structure of their cells.

Scientists have discovered that viruses, viroids and prions show some features of living things but other features of non-living things. As they are not made up of cells, they are not considered in the five-kingdom classification system.

A key characteristic used to classify organisms into kingdoms is the structure of their cells.



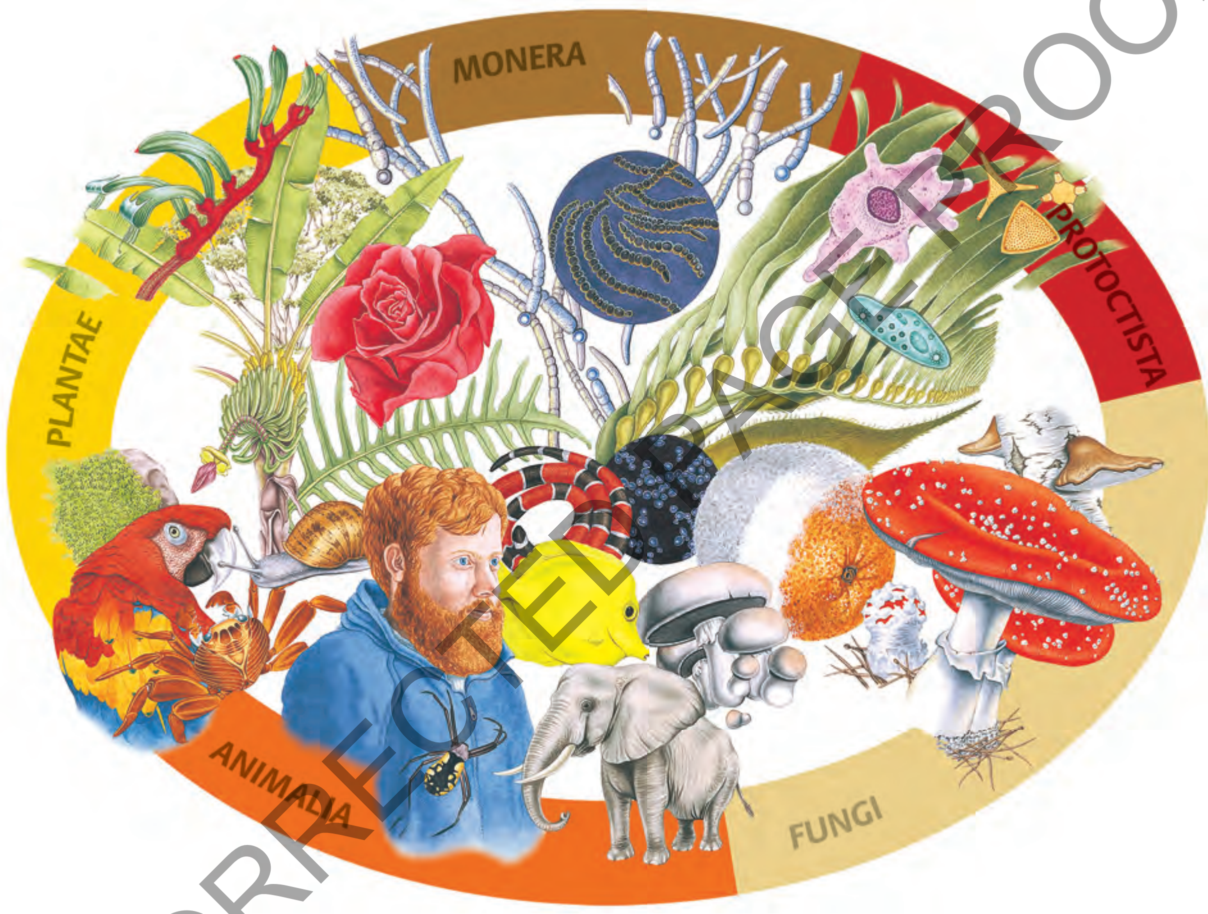
Other key features that can be used to divide organisms into the five kingdoms are shown in the table below.

Kingdom	Animalia	Plantae	Fungi	Protista	Monera
Unicellular or multicellular?	Multicellular	Multicellular	Most multicellular; some unicellular	Unicellular	Unicellular
Cell wall	No cell wall	Cellulose cell wall	Predominantly chitin	Many have no cell wall; some have a cell wall	Cell wall present; composition varies
True nucleus	Present	Present	Present	Present	Absent
Mode of nutrition	Eat or absorb other organisms	Photosynthesise to produce sugars	Produce chemicals that break down the material on which they grow and absorb the nutrients released	Some photosynthesise; some ingest food	Some absorb nutrients from surroundings; some photosynthesise; some use other chemical processes

(*continued*)

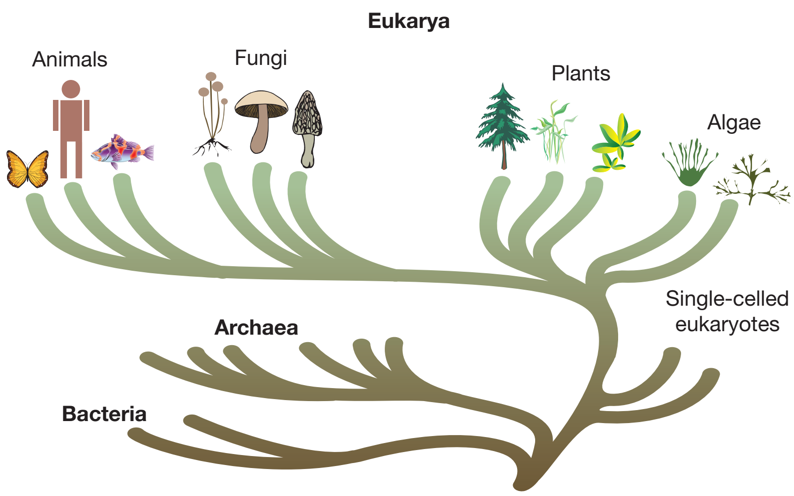
Kingdom	Animalia	Plantae	Fungi	Protista	Monera
Chloroplasts	Absent	Present	Absent	Present in those that photosynthesise	Absent (those that photosynthesise have chlorophyll but no chloroplasts)
Examples	Pigeon, earthworm, ant, camel, human, starfish	Eucalyptus tree, grass, wheat, rose bush	Baker's yeast, mushrooms, bread mould	Amoeba, Euglena, Paramecium	*Escherichia coli, Staphylococcus aureus*

The five kingdoms into which organisms are classified



3.2.7 Classification systems still changing?

This five-kingdom system is still often used. However, with new technologies and discoveries, other classification systems have been (and are being) proposed that are based on genetic rather than physical characteristics to group organisms. One of these is based on research findings by Carl Woese. Instead of five kingdoms, he suggested that there should be three domains: Archaea, Bacteria



(true bacteria) and Eukarya (living things made up of one or more cells with a nucleus). Eukarya is then divided up into kingdoms.

Although classification systems are not fixed and can change when new information is discovered, they are very useful in the organisation of organisms into groups. Classification systems help us to see patterns and order in the natural world.

3.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Match the 'heads' and 'tails' in the table below.

Head	Tail
Cells …	describes something that has never been alive (e.g. a clock).
Dead …	is the smallest grouping of living things used by Linnaeus.
Kingdom …	are the building blocks that make up all living things.
Non-living …	describes something that was once alive but is not now.
Plant …	describes an organism made up of only one cell.
Species …	is the largest grouping of living things used by Linnaeus.
Taxonomy …	is the use of a formal system for classifying living things.
Unicellular …	is a multicellular organism containing chloroplasts and a cellulose cell wall.

2. Provide two examples of each of the following.
   (a) Non-living thing
   (b) Plant
   (c) Fungus
   (d) Protist
3. Distinguish between each of the following.
   (a) A living thing and a non-living thing
   (b) A dead thing and a non-living thing
   (c) Kingdom and species
   (d) Plant cells and animal cells
4. Use a flowchart to order the following in terms of their complexity, from simplest to most complex.
   kingdom, species, family, phylum, class, genus, order
5. Outline the relationship between:
   (a) living things, non-living things and dead things
   (b) fungal cells, plant cells and animal cells
   (c) Linnaeus, Whittaker and Woese.
6. (a) State the scientific name for sea monkeys.
   (b) State the phylum that sea monkeys belong to.
7. Suggest how sea monkeys can tolerate living in very salty water.
8. Define the term 'cryptobiosis'.
9. Are sea monkeys living or non-living? Give reasons for your response.
10. Suggest why scientific definitions of classification systems sometimes change over time.
11. Identify whether the following statements are true or false. If a statement is identified as false, justify your response.
   (a) Living things are also referred to as organisms.
   (b) All types of mosquitoes can transmit the malarial parasite.
   (c) Sea monkeys are non-living monkeys.
   (d) All living things need energy to survive.
   (e) If a living thing stops living, it is referred to as non-living.
   (f) Stromatolites are living rocks.
   (g) Organisms made up of many cells are called unicellular.
   (h) Organelles are small structures inside cells that have particular jobs.

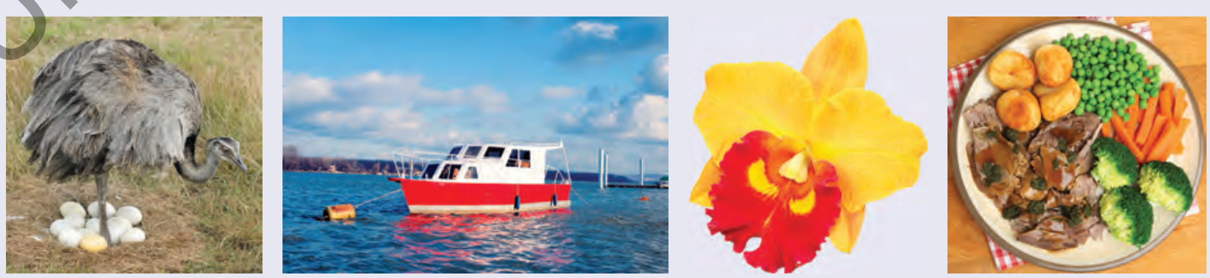
(i) Cells can be classified on the basis of the presence or absence of particular organelles or structures.
(j) Protoctistan cells are structurally more complex than prokaryotic cells.
(k) Viruses are made up of cells.
(l) Taxonomy is the formal classification of living things.
(m) Carl Linnaeus sorted organisms into groups based on physical similarities.
(n) Members of the same species have less in common than members of the same kingdom.
(o) The five-kingdom classification system includes viruses.
(p) Fungal cells, plant cells, animal cells and protoctistan cells are all examples of prokaryotic cells.
(q) Bacterial cells are larger than animal cells.
(r) Animal cells do not possess chloroplasts.
(s) Plant cells possess a cellulose cell wall.
(t) Mushrooms consist of fungal cells.
(u) *Amoeba*, *Euglena* and *Paramecium* are all protists (protoctistans).
(v) Bacterial cells possess a true nucleus.
(w) *Staphylococcus aureus* is an example of a bacterium.
(x) *Eucalyptus* trees are made up of eukaryotic cells.
(y) Earthworms are made up of prokaryotic cells.
(z) Classification systems are fixed and do not change.

Think and discuss

12. Carefully observe the items below.
    (a) Construct a table to show your classification of each of the items in the drawing as either living, non-living or dead.
    (b) Which of the things were difficult to classify? Why?
    (c) Which characteristics of living things did the non-living or dead classified items *not* display?

Living, non-living or dead?

13. Carefully observe the items below. These items can be divided into a number of different groups by using different classification criteria. Using criteria other than living, non-living and dead:
    (a) divide the items into four groups
    (b) give each group a name and list the features that you used as criteria
    (c) compare your classification groups with those of others in the class
    (d) comment on similarities, differences or patterns in how the items were classified.






Investigate, think and discuss

14. Find out more about the history, advertising strategies and commercial success of sea monkeys. Who 'discovered' them and developed a commercial business around them? How effective was the advertising? How accurate are their claims? Construct a PMI chart, and then present your information as a poster, PowerPoint presentation or newspaper article.
15. In 1972, a US patent was granted for 'hatching brine shrimp or similar crustaceans in tap water to give the appearance of instantaneous hatching'. What is a patent? What do you think about the idea of patenting living organisms? Research this patent and then share and discuss your opinions with others.
16. When conditions are not suitable, seeds from some plants may remain dormant rather than germinate. For example, lotus seeds can germinate after being dormant for more than a century.
    (a) In their dormant state, are the seeds living, non-living or dead?
    (b) Use Venn diagrams to show how the seeds are:
        (i) similar to viruses
        (ii) different from viruses.
17. Suggest why the ability to classify organisms is important in the following situations.
    (a) You have been bitten by a spider.
    (b) You are very hungry and find a bush with berries in the forest.
18. Search the internet to find more information (including pictures) about each of the five kingdoms. Use this information to construct, on a sheet of A3 paper, your own 'kingdom wheel' similar to that on page 50.

learnON RESOURCES — ONLINE ONLY

Try out this interactivity: Time out: 'Kingdoms'
Searchlight ID: int-0204

Complete this digital doc: Worksheet 3.1: Animal features
Searchlight ID: doc-19799

Complete this digital doc: Worksheet 3.2: The great debate
Searchlight ID: doc-19800

Complete this digital doc: Worksheet 3.3: Is it alive?
Searchlight ID: doc-19801

Complete this digital doc: Worksheet 3.4: Five-kingdom classification
Searchlight ID: doc-19802

Complete this digital doc: Worksheet 3.5: Creatures from a parallel universe
Searchlight ID: doc-19803

Complete this digital doc: Worksheet 3.6: Responding
Searchlight ID: doc-19804

3.3 Unlocking meaning—patterns in scientific language

Quidquid latine dictum sit, altum sonatur. Have a go at saying this Latin phrase as if it were a magic spell. While this looks and sounds a little scary and alien, its translation seems to match its meaning — 'whatever is said in Latin sounds profound'. *Res ipsa loquitur* — which literally means 'the matter speaks for itself'.

3.3.1 Science spells magic?

You may have heard modifications of scientific language spoken by wizards, elves, dragons and witches in books you have read or movies you have seen. Many spells and incantations are derived from Classical languages, particularly Latin and Greek.

Although the English language is a mixture of many different languages, it was during the sixteenth and seventeenth centuries that new discoveries created the need for new words to communicate them. Because Latin was the scholarly authoritative language of the time, many of the new words were derived from this language. Roots of Greek words, another classical language of the time, were also used.

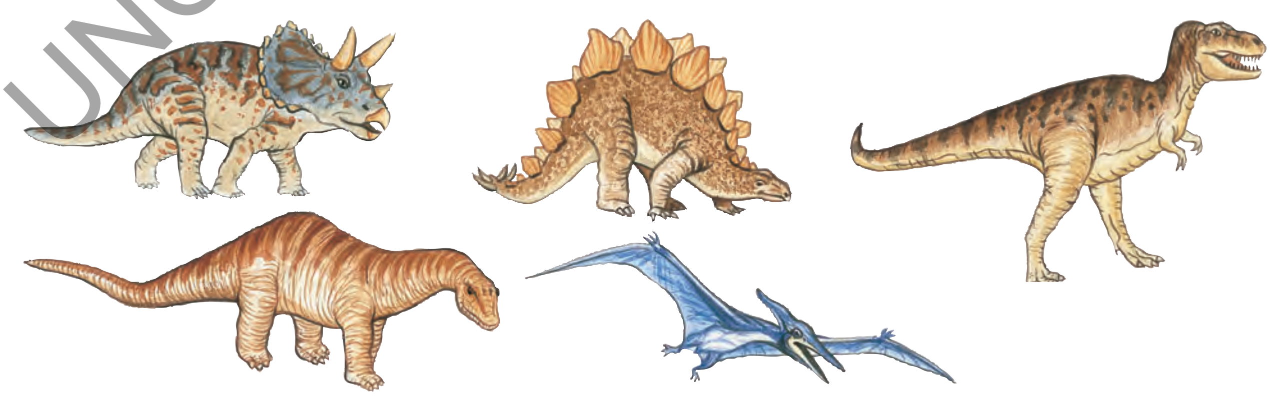
Harry Potter spell	Latin 'root'	Suggested meaning	Effect of spell in Harry Potter stories
Aparecium	*appareo*	To become visible or to appear	Invisible ink becomes visible
Confringo	*confringo*	To break into pieces, to bring to naught	Objects explode in flames
Geminio	*gemino*	To double	Duplicates an object
Lumos	*lumen*	Light	Produces light from wand tip

3.3.2 Historic keys?

Etymology is the term used to describe the study of words, their origin and grammar. Words are often made up of a prefix at the beginning of the word and a suffix at the end. Some examples of prefixes and suffixes that you might come across in science are shown in the table on page 56. Being aware of this pattern will help you to unlock the meaning of many new scientific words that you come across.

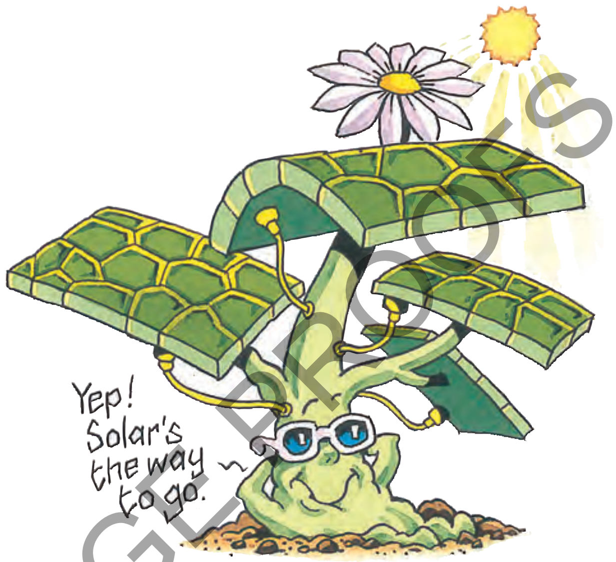
3.3.3 Name me a dino …

Tyrannosaurus, *Pterosaurus*, *Stegosaurus* … Did you ever wonder why the dinosaurs had such big names? Do you know what they mean? The term 'dinosaur' was actually decided on by the British anatomist and palaeontologist, Sir Richard Owen in 1842. *Dino* means 'terrifying' and *saur* means 'lizard'. Some dinosaurs were named for their unusual head or body features, others for their teeth or feet, or after a person or place.



3.3.4 Unlocking patterns

Many scientific terms, like others in our language, begin with a particular prefix and end with a specific suffix. These can give you hints about what the words mean. For example, the terms 'chlorophyll' and 'chloroplast' both begin with *chloro*, which comes from the Greek word *chloros*, meaning 'green'. Chlorophyll is the green pigment found in the chloroplasts of plant cells. This green pigment captures light energy so that plants can made their own food using the process of photosynthesis (*photo* = light and *synthesis* = to make). The presence of chlorophyll in the chloroplasts is the reason that they (and plants) appear to be green.



Leucoplasts (*leuco* = 'white') and chromoplasts (*chromo* = 'colour'), like chloroplasts, are plastids found in plant cells. Leucoplasts are not coloured as they do not contain coloured pigments. Chromoplasts are coloured and contain pigments other than chlorophyll. They are responsible for pigment synthesis and storage and are found in the coloured parts of plants, such as fruit and petals, giving them their characteristic colours. These pigments can be extracted and used as plant dyes.

Chemicals such as those in foods that you eat also have clues in their names that help you to work out what they are made of. You may have heard of glucose, sucrose and starch. Gluc*ose* and sucr*ose* are both sugars. Glucose is a *mono*saccharide (*mono* = 'one' and *saccharide* = 'sweet'). Sucrose is a *di*saccharide and made up of two monosaccharides. Starch is a *poly*saccharide and is made up of many monosaccharides.

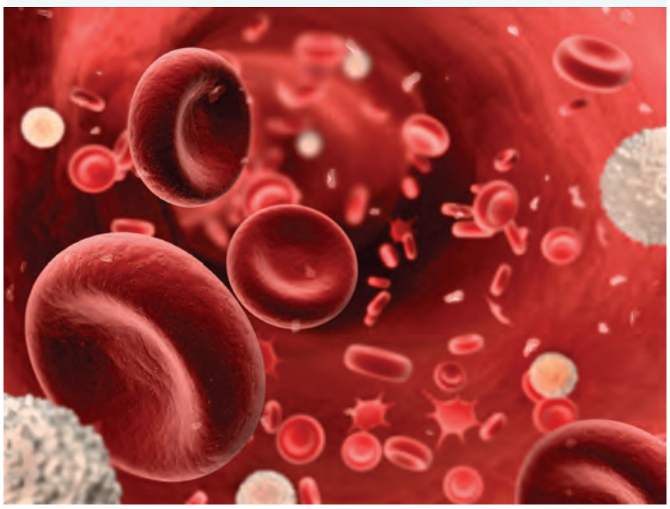
There are other prefixes that provide you with clues about size and number. Microscope (*micro* = 'small' + *'scope'* = view) and megafauna (*mega* = 'large' + *fauna* = 'animal') are examples of terms that indicate size in their names. Can you deduce which numbers are indicated in the following words: *uni*cellular, *bi*nary, *di*chotomous, *tri*pod, *quad*rant, *deci*mal, *centi*grade, *milli*pede?

'Cell speak'

Later, when you study different types of blood cells, you will come across terms containing the suffix or prefix *cyte*. This is a variation of *cyto*, which means 'cell'. Examples of terms that you may come across include:

monocyte	cytology
phagocyte	cytoskeleton
leucocyte	cytotoxic
lymphocyte	phagocytosis
erythrocyte	endocytosis
cytosol	exocytosis
cytoplasm	

Erythrocytes (red blood cells) and leucocytes (white blood cells)



Inside or within

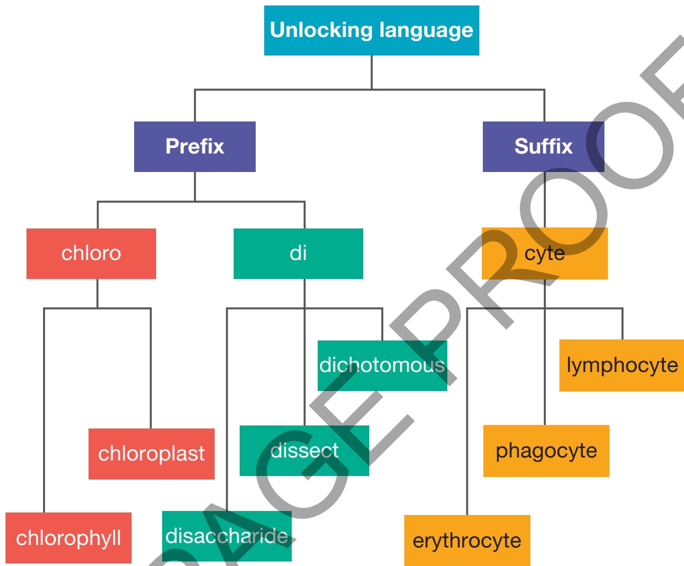
In science, you will learn about endoskeletons, endocytosis, endoplasmic reticulum, the endocrine system and endoparasites. The prefix *endo* in these words tells you that they all have something to do with 'inside' or 'within'. Even without knowing their full definitions, you can begin to see patterns and get an idea about what they may refer to.

Numbers or words?

In science you also need to know the difference between two different ways of describing your data. One of these is *qual*itative and the other is *quant*itative. Qualitative data describe your observations in words (describing the 'qualities' of the data), whereas quantitative data are numbers (or 'quantities').

Hookworms are endoparasites and live inside their hosts. You can see the hooks that it uses to attach itself to its host.

The prefixes and suffixes of scientific terms often give you hints about what they mean.



INVESTIGATION 3.3

Cryptonym game

AIM: To increase familiarity with scientific prefixes and suffixes

Method

- In teams, begin by writing each of the scientific terms in the table below on a card.
- One player should shuffle the cards and then observe which term is on the top card without letting others in the team see.
- Place the card face down and 'act out' its meaning.
- The first team member to identify the term gets to shuffle the cards and act out the next term.

Discussion

1. A *crypto*graph refers to secret writing and a *crypto*nym is a secret name. Suggest the meaning of *crypto*.
2. Identify the types of questions that were most helpful in predicting the correct name on the card.

Conclusion

3. Suggest how you could transfer what you have learned in this activity to predicting the meanings of scientific terms.

Latin/Greek prefix or suffix	Meaning	Scientific term
bio + ology	life + study	Biology
etymon + ology	true + study	Etymology
heteros + trophe	different, other + to feed or eat	Heterotroph
echinus + dermis	spiny + skin	Echinodermata (e.g. sea urchin)
anthros + zoion	flower + animal	Anthrozoa (e.g. sea anemone)
epi + dermis	outside + skin	Epidermis
arthron + pous	joint + foot	Arthropod (e.g. insect)
gastro + pous	stomach + foot	Gastropod (e.g. snail)
poly + dactylus	many + finger or toe	*Polydactylus*
kroko + deilos	pebble + worm	*Crocodylus*
photo + synthesis	light + make, build	Photosynthesis
exo + skeleton	outer, external + skeleton	Exoskeleton

3.3 Exercises: Understanding and Inquiring

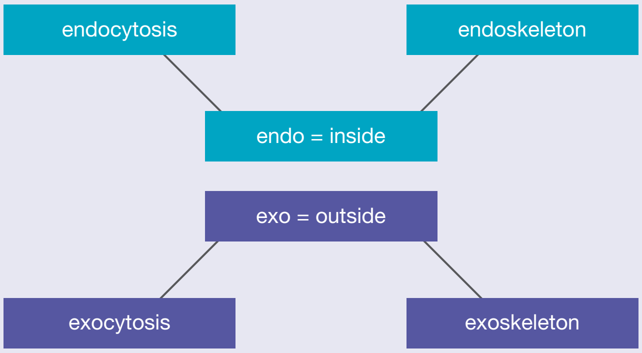
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Suggest what type of animal may have *saur* in its name.
2. Outline the difference between the terms 'prefix' and 'suffix'.
3. Identify the shared meaning between the terms:
   (a) chlorophyll and chloroplast
   (b) monocytes, leucocytes and erythrocytes.
4. (a) Where are you likely to find leucoplasts, chromoplasts and chloroplasts?
   (b) Describe how they differ.
5. Outline the difference between qualitative and quantitative data.
6. Suggest the suffix that sugars may share in their names.
7. Distinguish between monosaccharides, disaccharides and polysaccharides.
8. If you came across two words and one began with *micro* and the other with *mega*, predict what the difference between them would be.

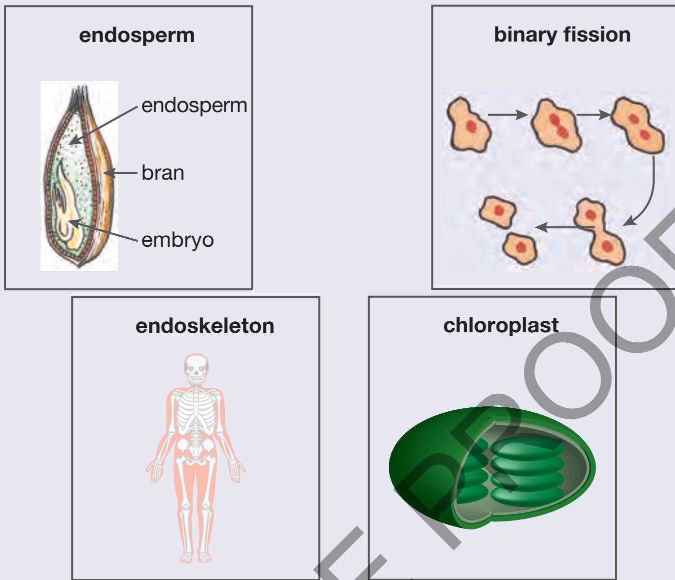
Think, investigate and discuss

9. (a) Carefully examine the dinosaur names below and discuss with your partner any clues that may help you predict their meanings.
   Triceratops, *Spinosaurus*, *Ceratosaurus*, *Heterodontosaurus*, *Pentaceratops*, *Microdontosaurus*, *Microceratops*
   (b) Find out the meanings behind the dinosaur names above.
   (c) Based on your findings, comment on any patterns and suggest groups you could divide them into.
10. Find out about the life and scientific contributions of Sir Richard Owen in 1842. Report your findings in a timeline.
11. Research examples of Australian megafauna. Report on clues within their names that help describe what they may have looked like.
12. Find out what palaeontologists do, investigate their distinct ways of working and representing their specialised knowledge, and give an example of a contribution an Australian palaeontologist has made to our understanding of ancient life in Australia.
13. Find out prefixes for one, two, three, four, ten and hundred that have originated from Latin or Greek words. State an example of a scientific term that uses each prefix.
14. Find out the meanings of and similarities and differences between the following:
   (a) microscope, telescope, periscope
   (b) millimetre, centimetre, nanometre, kilometre
   (c) binary fission, dichotomous key, binocular
   (d) *Tyrannosaurus, Pterosaurus, Stegosaurus*
   (e) anatomist, scientist, palaeontologist
   (f) cardiac, renal, pulmonary
   (g) dehydrated, deoxygenated, denatured
15. Throughout history, coloured pigments from plants and animals have been used by humans. Find out about two plant and two animal examples. Identify the scientific names of the pigments and what they mean.
16. Chlorine is an element. Suggest what colour it may be.
17. Find out the history behind the names of the elements in the chemistry periodic table. Present your findings as a picture book.
18. Find out the definition and two key points for each of the *endo* and *exo* words shown in the diagram at right.



19. (a) Find at least five examples of scientific terms that begin with the following prefixes: *endo*, *bio*, *anti*, *chloro*, *thermo*, *bi*, *hetero*.
(b) Create your own set of scientific terminology cards, using a particular colour for each prefix and adding a diagram or image for each that provides a hint about its meaning. The illustration below shows what your cards may look like.
(c) Design a game that uses the cards to teach students about scientific terminology. Include an instruction brochure or rule book with your game.
(d) Play your game and those of others.
(e) Construct a PMI chart for each game that you play.

An example of what your cards may look like



Think and create

20. Research the meanings of the words below and then construct a Venn diagram to show similarities and differences between them:
(a) chlorophyll and chloroplast
(b) leucocyte and erythrocyte
(c) prefix and suffix
(d) endoparasite and ectoparasite
(e) cilia and flagella
(f) plant cells and animal cells
(g) vertebrates and invertebrates.

21. (a) Carefully observe the information in the boxes on the right, and then construct Venn diagrams to compare the different types of dinosaurs.
(i) *Microceratops* and *Triceratops*
(ii) *Triceratops* and *Pentaceratops*
(iii) *Microdontosaurus* and *Heterodontosaurus*
(iv) *Microdontosaurus* and *Microceratops*
(b) Suggest the meanings of the prefixes *micro*, *tri*, *penta*, *micro* and *hetero*.
(c) What do you think the prefix *donto* might refer to? Justify your response.

Microceratops
- Name means 'small-horned face'
- Only 76 cm long
- Lived about 83–65 million years ago

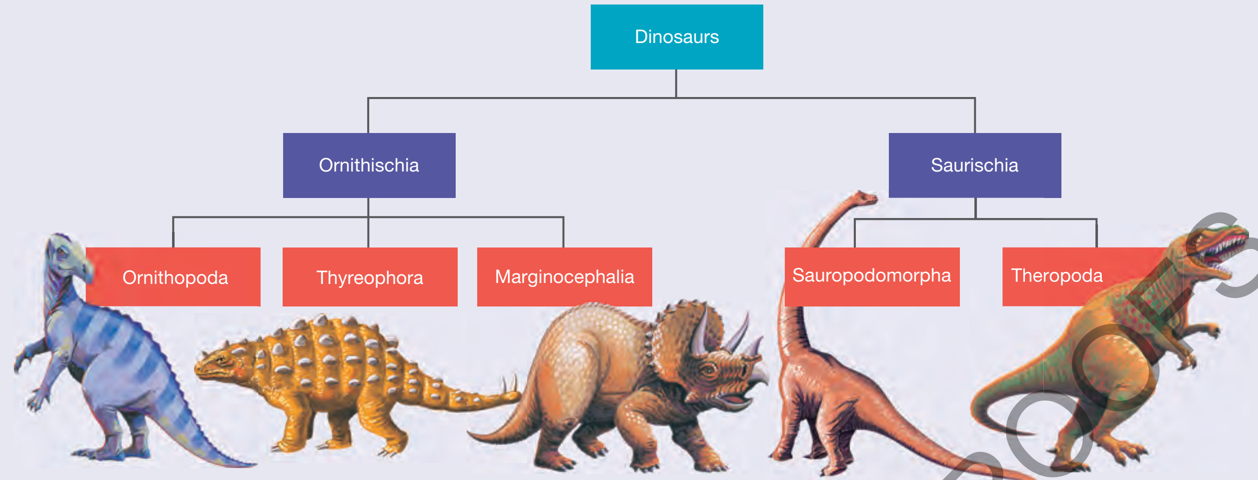
Heterodontosaurus
- Name means 'different-toothed lizard'
- Had three types of teeth
- 2.2 m long
- Lived about 208–200 million years ago

Pentaceratops
- Name means 'five-horned face'
- Had three horns on its head
- 8 m long
- Lived about 75–65 million years ago

Triceratops
- Name means 'three-horned face'
- 'Frilled' dinosaur
- Had three horns on its head
- 8 m long
- Lived about 75–65 million years ago

Microdontosaurus
- Name means 'tiny-toothed lizard'
- 8 m long
- Lived about 75–65 million years ago

22. Use the information in the diagram below to construct the following Venn diagrams.
(a) Dinosaurs under 10 metres long and dinosaurs over 10 metres long
(b) Dinosaurs with horns and spikes and dinosaurs without horns and spikes
(c) Dinosaurs that weighed less than 8000 kilograms and dinosaurs that weighed more than 8000 kilograms



Example: *Iguanodon*
Weight: 5000 kg
Length: over 9 m, up to 5 m tall

Example: *Ankylosaurus*
Weight: up to 4000 kg
Length: over 10 m

Example: *Triceratops*
Weight: up to 11 000 kg
Length: over 9 m

Example: *Brachiosaurus*
Length: up to 24 m, up to 12 m tall

Example: *Tyrannosaurus rex*
Weight: up to 8000 kg
Height: over 6 m

3.4 Unlocking patterns in scientific names

Now that you are more aware of the patterns in scientific language, you can apply what you know to the classification of living things.

3.4.1 Levels of classification

You may recall that living things can be grouped into five kingdoms and that these kingdoms contain a number of sub-groups. As you move from kingdoms to species, the members of the group have increasingly more in common. Organisms of the same **species** resemble each other and can interbreed to produce fertile offspring.

Monument to carl Linnaeus in Stockholm, Sweden

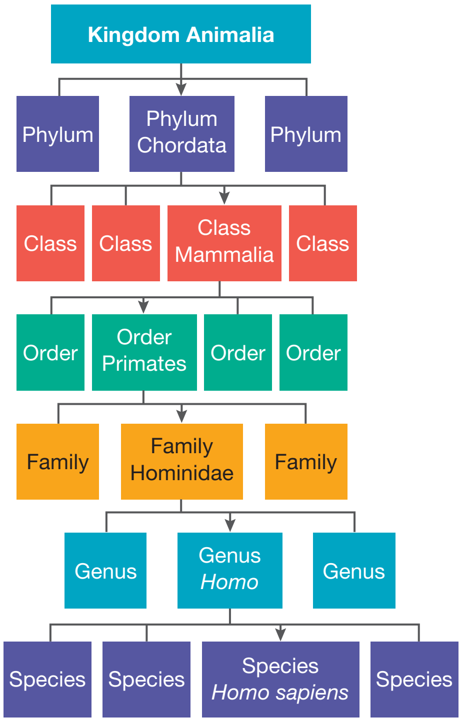
Kingdom → Phylum → Class → Order → Family → Genus → Species

WHAT DOES IT MEAN?

The word *binomial* comes from the Latin terms *bi-*, meaning 'two', and *nomen*, meaning 'name'.

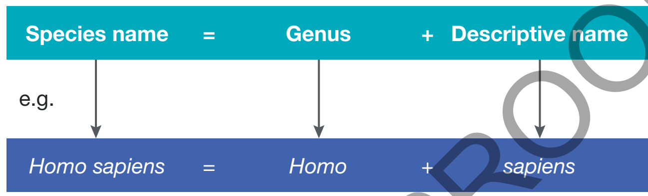
3.4.2 Binomial nomenclature

Carl Linnaeus (1707–1778), a Swedish botanist, zoologist and physician, developed a naming system called **binomial nomenclature** in which each species has a name made up of two words. The scientific names given to organisms were often Latinised. In this system, the species name is made up of the genus name as



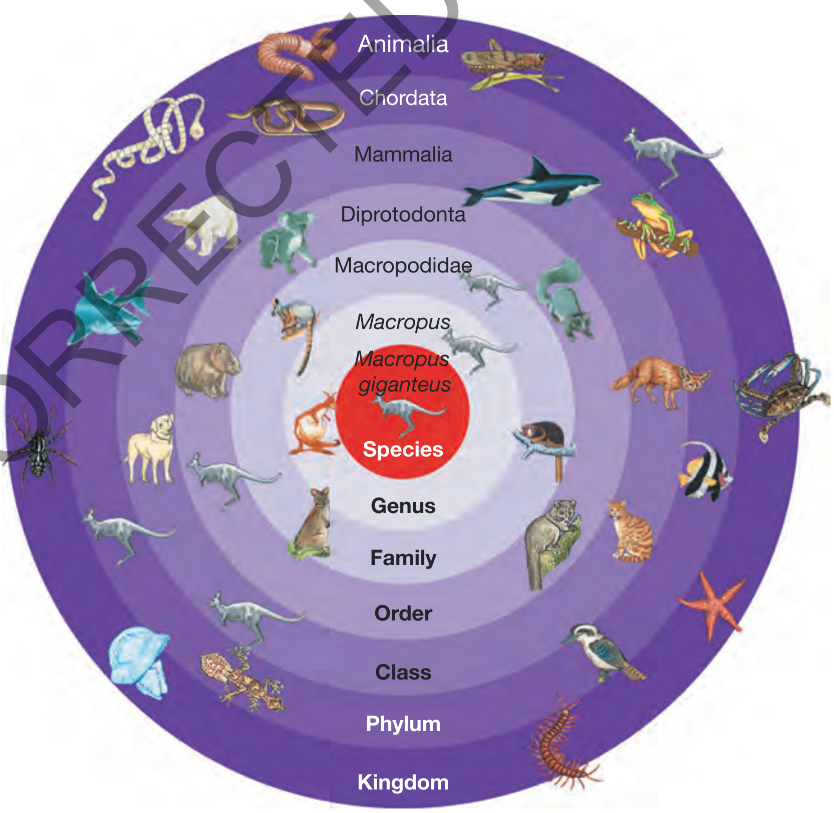
the first word and the descriptive or specific name as the second word. The genus name begins with a capital letter and lower case is used for the descriptive name. If handwritten, the species name should be underlined; if typed, it should be in *italics*.

The chart on left shows the various groups that you belong to. You are a member of the *Homo sapiens* species, in the *Homo* genus, in the Hominidae family, in the Primate order, in the Mammalia class, in the Chordata phylum, in the Animalia kingdom.



This target map shows the classification groupings of eastern grey kangaroos or *Macropus giganteus* species. Which levels of classifications do these kangaroos share with your species?

The scientific name for the Eastern grey kangaroo is *Macropus giganteus*. *Macropus* is the genus name and *giganteus* is the descriptive name.



Many of the words used in our classification system tell a story about history and language.

Common name: Major Mitchell's cockatoo
Species name: *Cacatua leadbeateri*

What's the story?

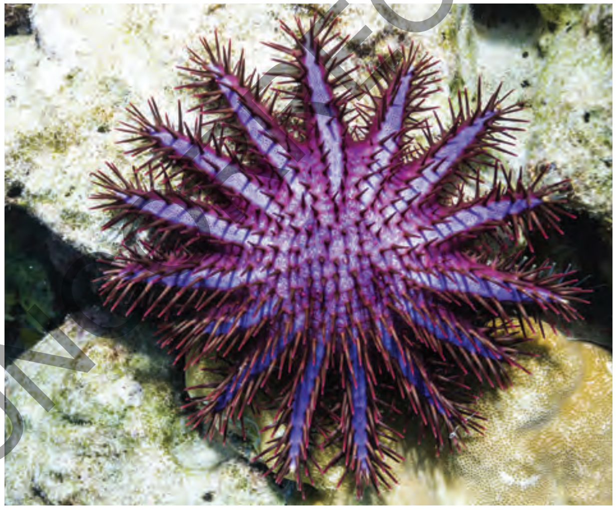
- *Cacatua* — derived from the Greek terms meaning 'dawn' and 'crest', referring to a crest like the rising dawn
- *leadbeateri* — named after British naturalist Benjamin Leadbeater
- cockatoo — this word originates from the Malay name for the bird, *kakaktua*, from *kakak* meaning 'sister' and *tua* meaning 'old'.

Common name: Freshwater crocodile
Species name: *Crocodylus johnstoni*

What's the story?

- *Crocodylus* — derived from the Greek terms *kroko*, meaning 'pebble', and *deilos*, meaning 'worm'
- *johnstoni* — named after Johnson, the first European to discover and report it. Note that his name was actually Johnson and has been misspelt!

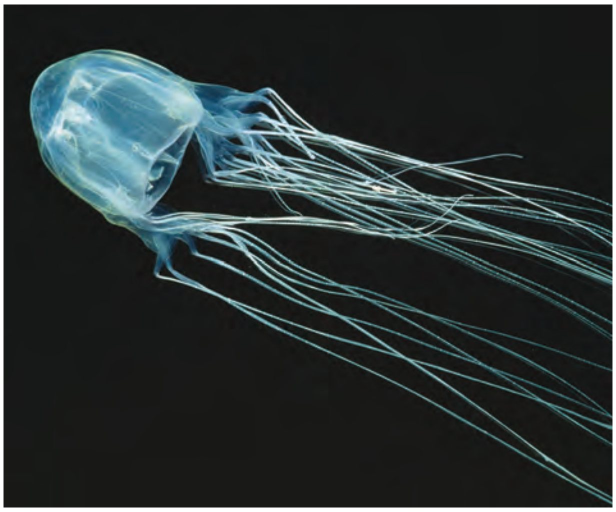
Common name: Crown-of-thorns starfish
Species name: *Acanthaster planci*



What's the story?

- *Acanthaster* — derived from the Greek terms *acantha*, meaning 'spiny' or 'thorny', and *aster*, meaning 'star'
- *planci* — possibly named after Max Planck, a German physicist

Common name: Box jellyfish
Species name: *Chironex fleckeri*



What's the story?

- *Chironex* — derived from the Greek and Latin terms *cheiro*, meaning 'hand', and *nex*, meaning 'murder' or 'violent death'
- *fleckeri* — named after Dr Hugo Fleck, a radiologist in Cairns, Qld, for his contribution to science

Examples of drought-tolerant Australian plants

Common name: Native wisteria, ‘Happy Wanderer’
Species name: *Hardenbergia violacea*

What’s the story?
- Genus was named after Countess von Hardenberg.
- Wisterias are named after the American anatomist Caspar Wistar by the English botanist Thomas Nuttall.

Common name: Snow gum
Species name: *Eucalyptus pauciflora*

What’s the story?
- Genus name comes from the Greek terms *eu*, meaning ‘good’ or ‘well’, and *calyptos* or *kalyptos*, meaning ‘veiled’ or ‘covered’.
- Species name comes from the Latin terms *pauci*, meaning ‘few’, and *florus*, meaning ‘flowered’.

Common name: Kangaroo paw
Species name: *Anigozanthos flavidus*

What’s the story?
- Species name comes from the Greek terms *anis*, meaning ‘unequal’, *anthos*, meaning ‘flower’, and *flavidus*, meaning ‘yellow’.
- Common name is due to its similar appearance to a kangaroo’s paw.

Common name: Golden wattle
Species name: *Acacia pycnantha*

What’s the story?
- Genus name comes from the Greek term *akakia*, meaning ‘thorny Egyptian tree’ (after the first thorny species discovered).
- Species name comes from the Greek terms *pyknos*, meaning ‘dense’, and *anthos*, meaning ‘flower’.
- In 1988 the golden wattle was proclaimed Australia’s national floral emblem.

3.4 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Name the person who is recognised as having developed the naming system for all living things.
2. Use a flowchart to show the names of the groupings in the hierarchical classification system, from largest to smallest.
3. In each of the following pairs, identify which group contains members that have more in common.
   (a) Kingdom and species
   (b) Genus and family
   (c) Order and phylum
   (d) Class and order
4. Describe the binomial system of nomenclature and give an example.
5. State the common name of each of the following.
   (a) *Crocodylus johnstoni*
   (b) *Cacatua leadbeateri*
   (c) *Chironex fleckeri*
   (d) *Acacia pycnantha*.
6. True or false? When writing a species name, the genus should begin with a capital letter and the descriptive name should begin with a lower-case letter.

Think and discuss

7. Use the information in the table to answer the following questions.

Species name	Common name
Cherax destructor	Crayfish
Rhyothemis phyllis	Dragonfly
Crocodylus johnstoni	Freshwater crocodile
Felis domestica	House cat
Felis leo	Lion
Crocodylus porosus	Saltwater crocodile
Antirrhinum australe	Snapdragon

   (a) Identify the species name of a lion.
   (b) State the common name of the organism that belongs to the species *Felis domestica*.
   (c) State the name of the genus to which a crayfish belongs.
   (d) Suggest why it might be useful to know whether a crocodile was of the species *Crocodylus porosus* or *Crocodylus johnstoni*.
8. Construct a Venn diagram to show the similarities and differences between the classifications of saltwater and freshwater crocodiles.

Investigate

9. Research and report on how the box jellyfish *Chironex fleckeri* got its scientific name. Research the various types of jellyfish that can be found in Australian waters.
   Suggest why it is important to know the name of the type of jellyfish. Which features are used to classify them?
10. Research and report on the one of the following.
   - British naturalist Benjamin Leadbeater and the various species named after him
   - The naming of *Crocodylus johnstoni* and other crocodiles
   - The scientist Max Planck, the Max Planck Institute and *Acanthaster planci*
   - The significance of the naming of *Cherax destructor*
   - Radiologists in Australia — what do they do?
   - Careers associated with identifying, classifying and naming organisms

11. (a) Research features, classification and the life cycle of a crown-of-thorns starfish. How is it different from other types of starfish found in Australian waters? Outline research on its impact on the Great Barrier Reef.
    (b) In a team of four, imagine that you are investigating the impact of this starfish on the Great Barrier Reef. In your team, formulate questions that you would need to consider in your research.
12. Research Carl Linnaeus and the binomial system of nomenclature. Document his contributions to the taxonomy of plants and animals.
13. (a) Which group contains more living things, the Animalia kingdom or the Primate order?
    (b) Dogs belong to the Animalia kingdom, Chordata phylum and Mammalia class. Use the table below to list some characteristics that dogs and humans have in common.
14. Outline features that crayfish, yabbies and lobsters have in common. How does the classification system deal with them?

Create

15. Create a cartoon to show how to write the scientific name of an organism.
16. In pairs or groups, create a song or poem to help you to remember the following and then present your finished product to the class.
    (a) The order of the groupings kingdom, phylum, class, order, family, genus and species
    (b) Rules for writing scientific names
    (c) Which groups you belong to
17. Construct a target map to show the classification groups that you belong to in a scientific context and then do the same for another animal that does not belong to the same kingdom as you.
18. The full classification for humans is shown below.
    (a) Which group contains more living things, the kingdom 'animal' or the order 'primate'?
    (b) Dogs belong to the animal kingdom; they are vertebrates and they are also mammals. Use the table blow to list some characteristics that dogs and humans have in common.
    (c) Chimpanzees and humans are closely related. Which of the groups listed in the table below do chimps belong to?

Category	Group	What all the living things in the group have in common
Kingdom	Animalia	Made up of more than one cell; eats food
Phylum	Chordata	Backbone
Class	Mammalia	Hair or fur; feeds its young milk
Order	Primate	Opposable thumb; nails instead of claws; binocular vision
Family	Hominidae	Arms shorter than legs; nails flattened; upright stance
Genus	*Homo*	Walks upright on feet only; cares for young for a long time
Species	*Homo sapiens*	Large brain; can talk and think abstractly; complex social structures

learnON RESOURCES — ONLINE ONLY

Try out this interactivity: Time Out: 'Kingdoms'
Searchlight ID: int-0204

3.5 Keys to unlock identity

Who do you think you are? *What* are you? *How* can I tell?

3.5.1 Giants in a lost world

In 2009, scientists discovered creatures trapped within a 'lost world' in an extinct volcano (Mount Bosavi) in Papua New Guinea. One of the creatures discovered was a gigantic silvery-grey rat with thick woolly fur.

It was about 82 centimetres long and weighed around 1.5 kilograms — the size of a domestic cat. Along with the discovery of this new species of rat (*Mallomys* spp.) were 16 species of frogs, 1 species of gecko, 3 species of fish and at least 20 species of insects and spiders.

3.5.2 Giant 'animal-eating' plants

In 2007, scientists on an expedition to catalogue the different species of pitcher plant found in an area in the Philippines discovered giant 'rat-eating' carnivorous pitcher plants. The pitchers of these plants were open and completely filled with fluid containing digestive enzymes that broke down the bodies of the large insects (and possibly rats by misadventure) that were trapped in them.

That's one big rat! The volcano's crater was 2.5 miles wide and rimmed with walls nearly half a mile high.

Giant 'rat-eating' plant *Nepenthes attenboroughii,* named after the science documentary broadcaster and naturalist Sir David Attenborough

3.5.3 Why classify?

Scientific curiosity has resulted in the discovery of an increasing number of living things. This has led to the increased need to classify living things into groups. Classifying things into groups makes them easier to remember, describe and identify.

When scientists such as those in the above expeditions find an unknown organism, they make observations about its features and behaviour. Various technologies can also be used to obtain information about its chemistry and genetic make-up. This information is used to sort the organisms into groups on the basis of similarities and differences. Classification of organisms into groups enables more effective communication and understanding.

3.5.4 Keys for ID

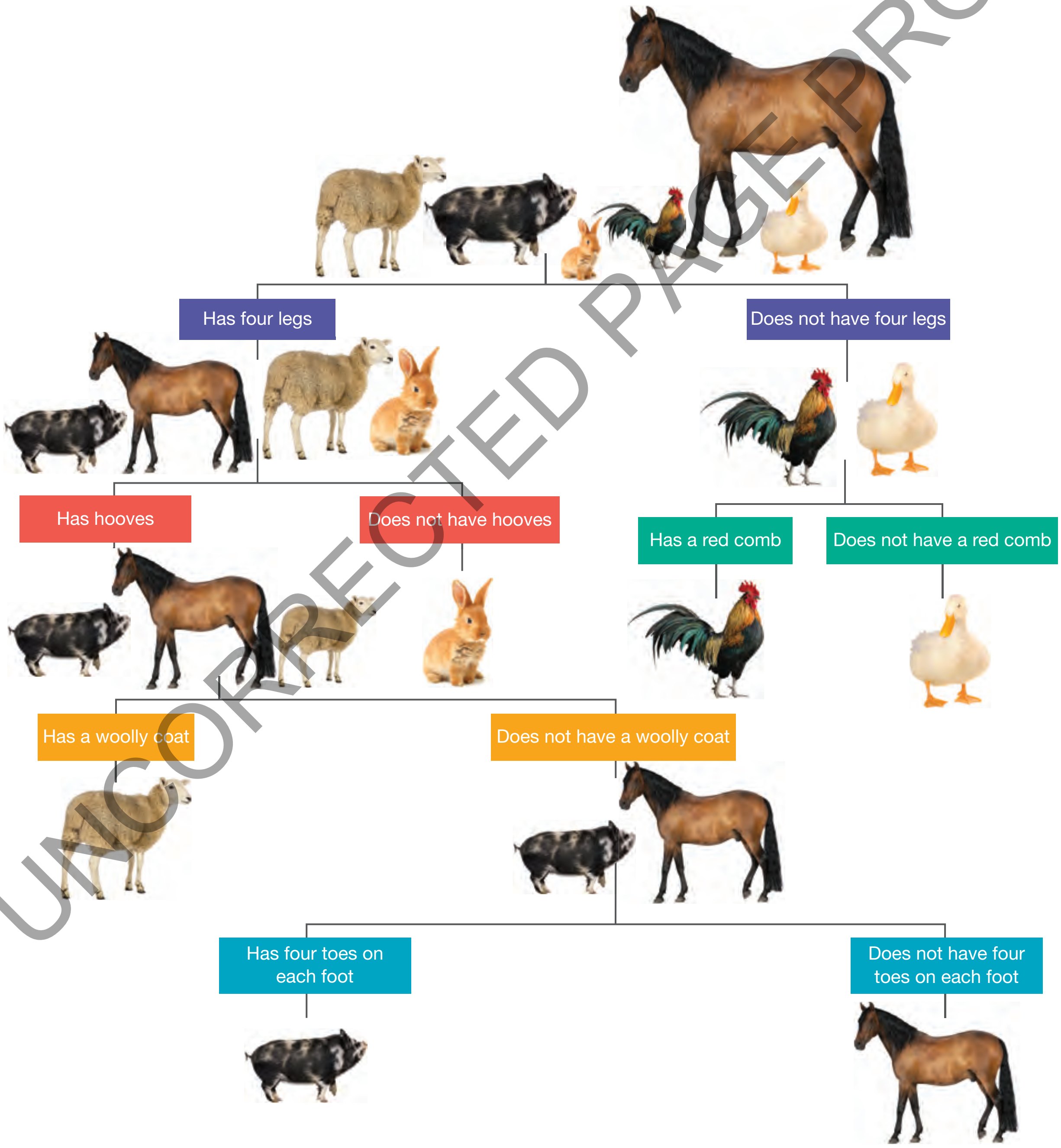
Keys and field guides can be used to identify organisms. A variety of criteria are used to classify the unknown organism into smaller groups on the basis of whether it has a particular feature.

Dichotomous keys

Dichotomous keys provide choices at each branch (*dichotomous* = 'cutting in two'). Features such as size, colour, behaviour and habitat are not good for classification because they can change throughout the life of the organism. It is better to use the presence or absence of structural features or differences in these features.

Dichotomous keys can be presented as branching keys or tabular keys. Examples of each of these keys can be seen below and on the next page. To convert information from a branching key to a tabular key, each fork of the branching key is given a number, which becomes the step number in the tabular key. Tabular keys are often used because more information can fit into a smaller space.

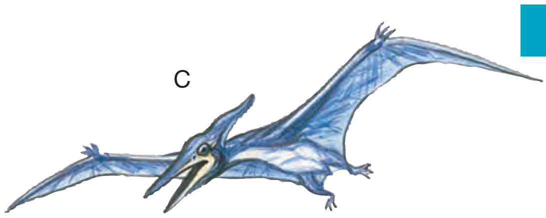
In a dichotomous key, you always select from two choices. In this key, you decide whether an organism has a particular feature.



A

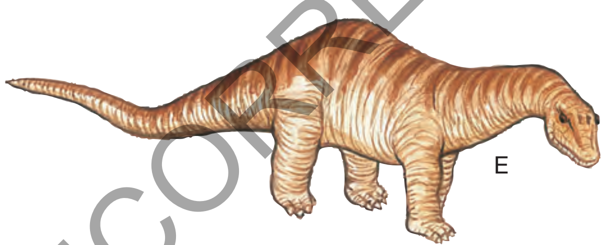
B

C



D

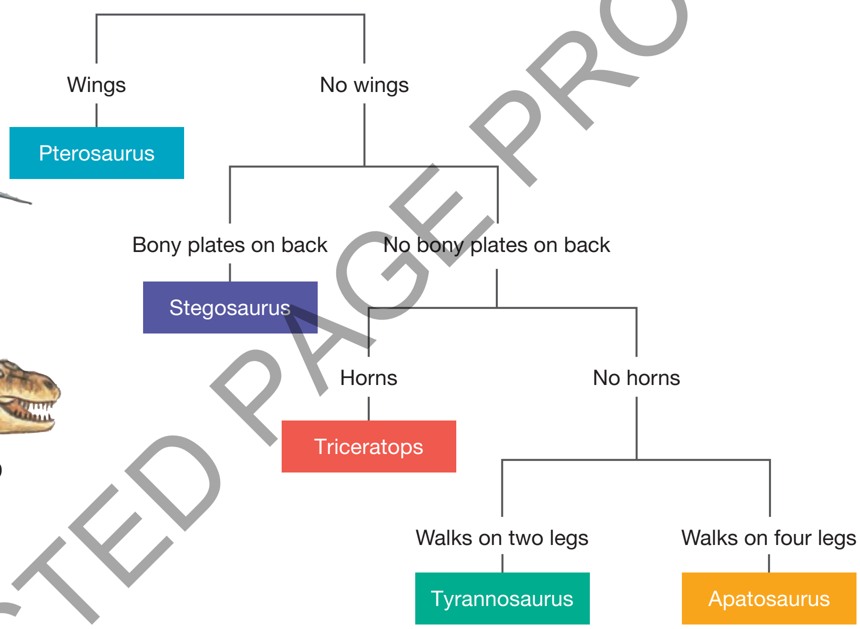
E



A tabular key

1. Wings................*Pterosaurus*
   No wings................Go to 2
2. Bony plates on back................*Stegosaurus*
   No bony plates on back................Go to 3
3. Horns................*Triceratops*
   No horns................Go to 4
4. Walks on two legs................*Tyrannosaurus*
   Walks on four legs................*Apatosaurus*

A branching key

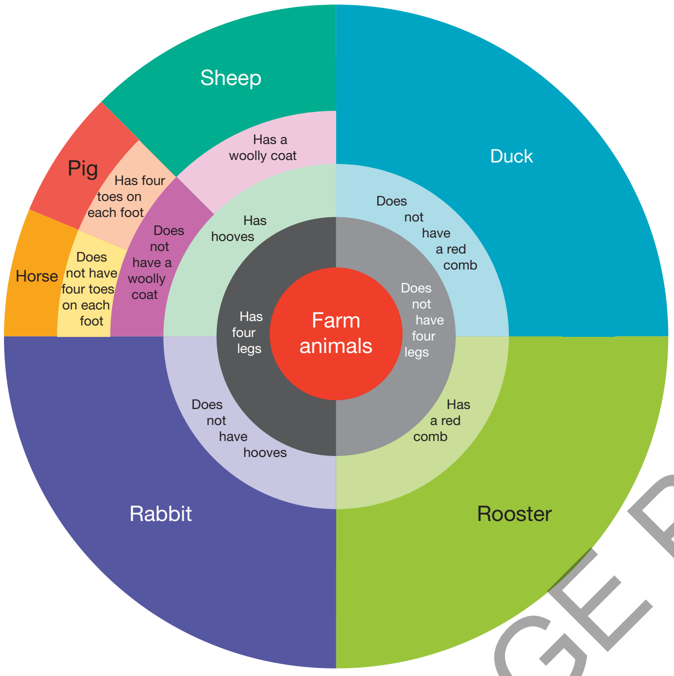


Circular keys

Circular keys can also be used to unlock identity. To read this type of key you start in the middle and work outwards, choosing one of the options in each layer. The final layer provides you with the organism's identity.

Carefully observe the dinosaurs A–E shown above and consider features that could be used to separate them into groups. Consider how you could use these features in the design of a circular key that would enable each individual to be identified.

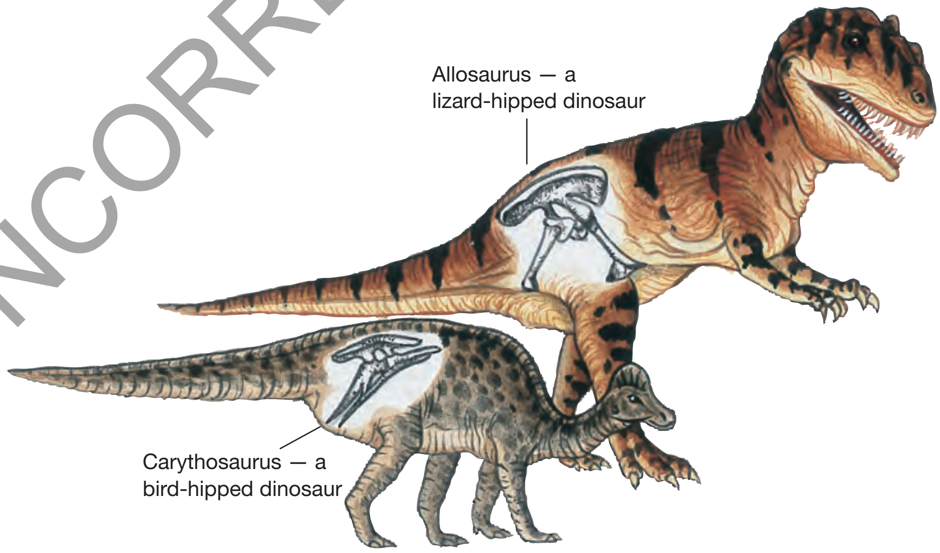
Keys to unlock farm animal identity



Field guides

Field guides are a commonly used type of reference book to help people identify organisms. These guides are specially designed to assist you in 'on-the-spot' identification. They often contain brief written descriptions and pictures, and are small enough to take outside when you are observing wildlife. There are also a number of electronic 'field guide' databases available.

Dinosaurs can be classified on the basis of the position of their hipbones. The 'lizard-hipped' dinosaurs belong to the meat-eating saurischian group and the 'bird-hipped' dinosaurs belong to the plant-eating ornithischian group.



The insets show the hips. These are not drawn to scale.

INVESTIGATION 3.4

Making a class key

AIM: To use appropriate classification criteria in the construction of a class key

Materials:

tape measures or string and rulers

Method and results

1. Measure, observe and record at least 10 different characteristics for each member of the class. You may like to include some of the following.
   - wrist size (cm)
   - distance from elbow to shoulder (cm)
   - foot length (cm)
   - height (cm)
   - eye colour
   - hair colour
   - wears watch
   - pierced ears

- Have each member of the class select a secret code name.

2. Use some of these recorded class characteristics to construct a key (tree map or dichotomous key) that will separate as many individuals (using their code names) as possible.
   (*Hint:* You may find it best to describe measurements as 'greater than' or 'less than' a particular measurement.)

- Have someone from outside the class use the key to find the identity of one of the class members.

Discuss and explain

3. How successful was your key?
4. If you were to do the activity again, what would you do differently to improve its success?
5. Were some characteristics of more use than others? Explain.

INVESTIGATION 3.5

Making a class field guide

AIM: To use appropriate classification criteria in the construction of a class field guide

Materials:

paper, pencils

photocopies of photographs of each student (e.g. the school class photograph copied), or students can sketch each class member themselves

Method and results

- Work in pairs. If there is an odd number of students in your class, your teacher might agree to participate.

1. Observe your partner and record data such as height, hair colour, eye colour etc.
2. Interview your partner to find out some other details such as favourite music, movie, sport, colour, food etc.
3. Allowing about half an A4 page for each class member, present the information and photograph/sketch.
4. Make the pages into a book or poster.

- Use the class field guide to see how easy it is to identify each student.
- Try making a field guide for the teachers in your school.

Discuss and explain

5. What are the benefits of a field guide?
6. Which features do you think would be most useful to include in a field guide to assist in identifying a class member? Why?
7. Which features would be most useful to include in a field guide for:
   (a) plants
   (b) birds
   (c) insects?
8. Describe any problems that you encountered when you were constructing the field guide.

3.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Suggest why scientists classify living things.
2. Some types of features are not very useful as classification criteria. Explain why this is the case, including examples.
3. Identify three features that would be useful as classification criteria.
4. State the name of the Swedish biologist that our current classification system is based on.
5. Suggest reasons why the current classification system may change.
6. What is a dichotomous key? Give an example of such a key.
7. Suggest why tabular keys are sometimes used instead of branching keys.
8. Outline the differences between field guides, branching keys, circular keys and tabular keys.
9. State the name of the genus to which the giant rat discovered in the extinct volcano in Papua New Guinea in 2009 belongs.
10. Identify who the giant 'rat-eating' carnivorous pitcher plant discovered in 2007 in the Philippines was named after.

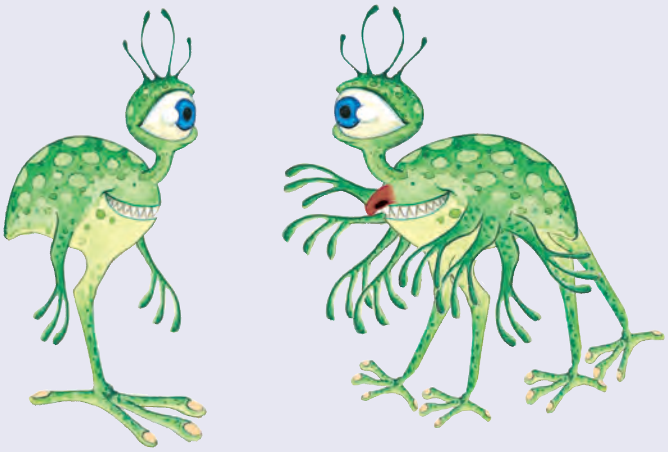
Think and discuss

11. Use the dinosaur keys on page 67 to identify the dinosaurs illustrated on that page.
12. Imagine that you have landed on another planet and seen the two creatures below. Use the circular key to identify them.

13. Explain how supermarkets provide an excellent example of the effectiveness of a classification system. Include the types of criteria that are used. Construct a dichotomous key that would enable ten different supermarket items to be identified.

Investigate

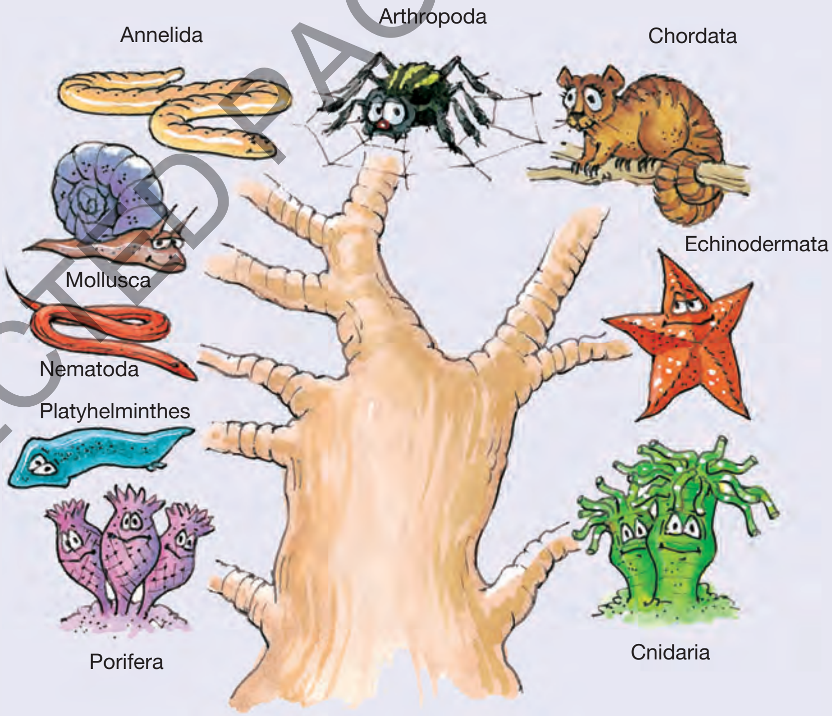
14. Cave people were often interested in only two groups of living things — those that were useful to them and those that were dangerous. Research and report on examples of bush and native foods and their parts that can be eaten and those that are poisonous. Display your findings in a format that includes dividing them into groups using relevant criteria.
15. Research and report on the various types of pitcher plants and how they are classified.
16. Research and report on one of the discoveries below and report your findings as a newspaper article, poster, PowerPoint presentation or journal entry. Include the types of information that were used to classify and identify it in your presentation.
    - *Homo floresiensis* (possible human ancestor)
    - *Fruitadens haagarorum* (tiny dinosaur)
    - *Mycena luxaeterna* (glowing fungus)
17. Observe the types of grass or insects in your local environment and construct a simple key to classify them.
18. Find and use two different online classification databases for either plants or animals. Comment on features that you find most useful in the database.
19. If you could meet and talk to a dinosaur, which one would it be and what questions would you ask? Find out the answers to your questions and use them to write an article for a class newspaper about dinosaurs.



Think and create

20. Carefully observe the features of animals in the animal kingdom evolutionary tree below.
    (a) Construct a mind map to record as many features for each animal as you can.
    (b) Compare your mind map with those of others in the class.
    (c) Discuss similarities and differences in your mind map observations.
    (d) If you wish, modify your mind map to include new ideas from your discussions.
    (e) Based on the features recorded in your mind map, construct a tree map or a dichotomous key that would enable the identification of each animal group.

The animal kingdom evolutionary tree, based on genetic and structural information

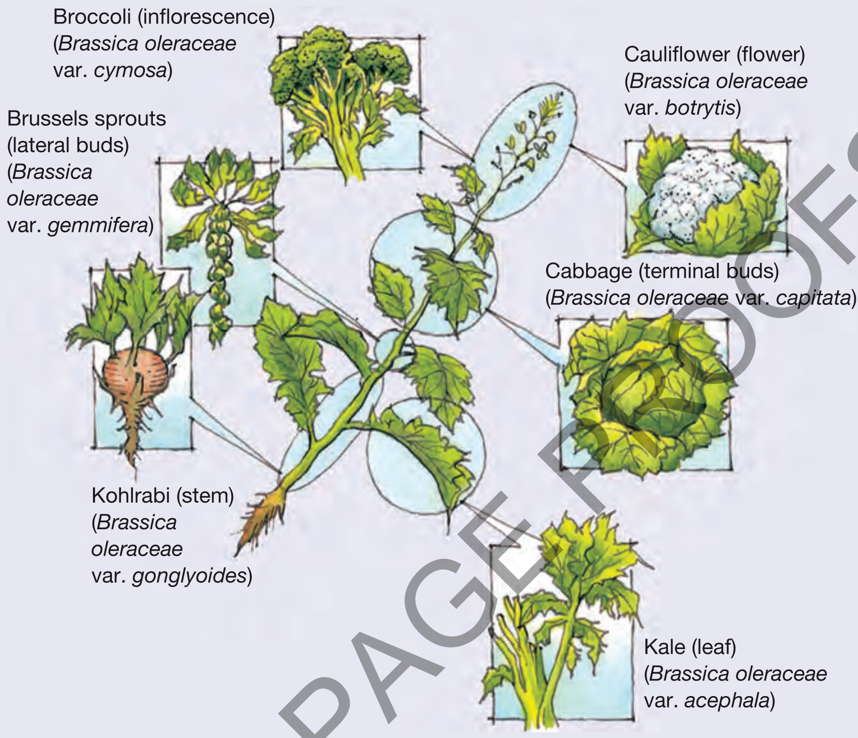


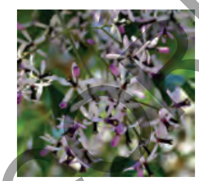
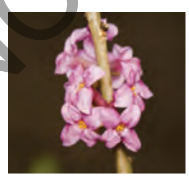
21. Carefully observe the features of vegetables in the figure on next page.
    (a) State the species names for the following vegetables.
        (i) Cauliflower
        (ii) Cabbage
        (iii) Broccoli
        (iv) Brussels sprout
    (b) State the genus to which all of these vegetables belong.
    (c) Discuss with your partner your observations on the features of these vegetables.
    (d) Construct a mind map to record as many features for each vegetable as you can.
    (e) Compare your mind map with those of others in the class.
    (f) Based on the features recorded in your mind map, construct a tree map or a dichotomous key that would enable the identification of each vegetable species.

(g) These vegetables were produced by artificial selection and share a common ancestor. Find out what artificial selection is and then research and report on the history of these vegetables.

22. The table below provides information about some poisonous plants.
(a) Construct a dichotomous key that allows identification of each plant.
(b) Considering two plants at a time, use the information in the table to construct four different Venn diagrams.

All of these vegetables were produced by artificial selection and share a common ancestor. Could this have happened by natural selection also?



Common name	Botanical name	Poisonous parts	Symptoms	Degree of toxicity	Type of plant
Bird of paradise 	*Caesalpinia gilliesii*	Pods, seeds	Gastroenteritis	Mild *	Shrub
White cedar 	*Melia azedarach*	Fruit (6–8 can kill small child)	Nausea, spasms	High ***	Tree
Daphne 	*Daphne odora*	All parts, especially berries	Burning sensation in mouth/stomach, vomiting, collapse	High ***	Shrub

Common name	Botanical name	Poisonous parts	Symptoms	Degree of toxicity	Type of plant
Oleander 	*Nerium oleander*	All parts, and smoke from burning wood	Vomiting, dizziness, irregular pulse, collapse	High ***	Shrub
Poinsettia 	*Euphorbia pulcherrima*	Leaves, sap, seeds	Delirium, gastroenteritis; sap injurious to eyes and mouth	Moderate **	Shrub
Wisteria 	*Wisteria sinensis*	Seeds, pods	Gastric pain, vomiting	Mild *	Climber

* Mild symptoms may occur if a large quantity of the poisonous parts are eaten.
** Causes discomfort and irritation but is not lethal.
*** Can cause serious illness or death.

Create

23. Collect a leaf from each of eight different plants in the school grounds.
    (a) On an A3 sheet of paper, create a branching dichotomous key to classify the leaves.
    (b) Construct the key in your exercise book as a tabular key.

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- **Complete this digital doc:** Worksheet 3.7: My own zoo
  Searchlight ID: doc-19805
- **Complete this digital doc:** Worksheet 3.8: A catalogue of cats
  Searchlight ID: doc-19806
- **Complete this digital doc:** Worksheet 3.9: Branching keys
  Searchlight ID: doc-19807
- **Complete this digital doc:** Worksheet 3.10: Tabular keys
  Searchlight ID: doc-19808

3.6 Which animal?

Do you have a backbone? It may seem a strange question to ask, but this is one of the key criteria used to classify animals into groups.

3.6.1 Classified by structural features

Animals can be classified into eight phyla (plural for phylum) on the basis of their structural features. Two commonly used features are their type of skeleton and their symmetry.

Have you got a backbone?

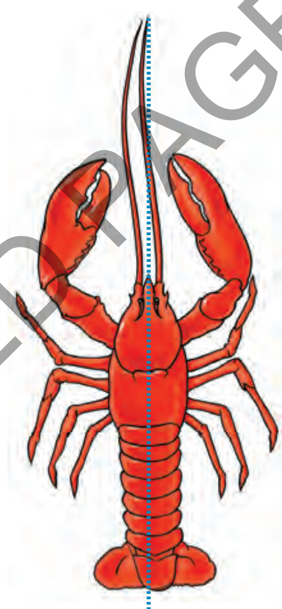
Animals that have internal skeletons or backbones are called **vertebrates**, whereas animals with external or no skeletons are referred to as invertebrates. Most of the animals on our planet are **invertebrates**.

3.6.2 Endoskeletons and exoskeletons

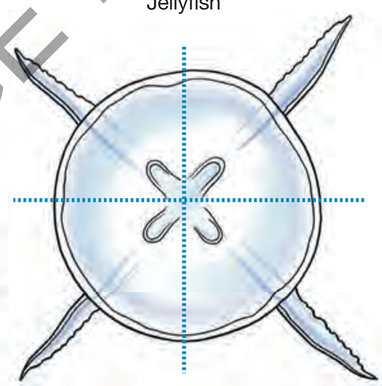
Did you know that 75 per cent of all animals in the world have a skeleton on the outside of the body? These external skeletons are called **exoskeletons**. They may be thick and hard like those of crabs and lobsters or as thin and tough as those of ants and centipedes. As these animals grow, they sometimes moult or discard their old exoskeleton before growing a bigger one.

Although exoskeletons are good for jumping and swimming, they do not allow flexibility for the twisting and turning actions that are possible for animals with an inside skeleton (**endoskeleton**). In an animal with an exoskeleton, the muscles are attached inside the skeleton, whereas the muscles in an animal with an endoskeleton are connected to the outside of the skeleton. The human endoskeleton is an internal skeleton which is made of bone and cartilage and clothed in muscle and skin.

Lobster



Jellyfish



3.6.3 No skeleton at all

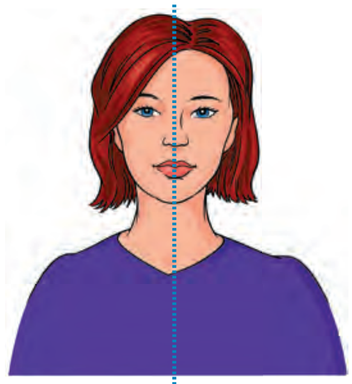
Some animals, such as worms and jellyfish, have no skeleton at all. The body is supported by the pressure of fluid within it. What do you think would happen if a lot of fluid was lost? How can animals without skeletons move?

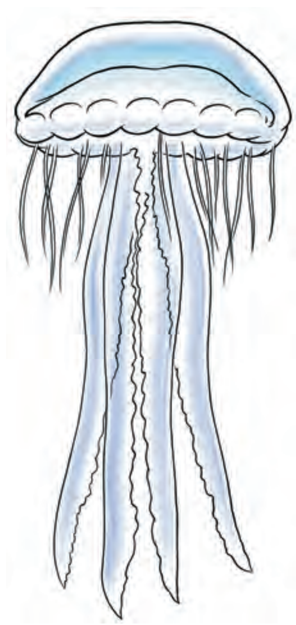
Earthworms expand and contract their bodies to burrow through the soil. They use two sets of muscles to do this. One set of muscles wraps around the body. When these contract, the body becomes long and thin, enabling the worm to poke into crevices in the soil. The second set of muscles runs along the length of the body. When these contract, the worm becomes short and fat. This helps to anchor the worm in place, pushing the soil apart to form a burrow. By shortening the rest of its body, the worm pulls itself up and moves through the soil.

What's your symmetry?

The type of symmetry that describes an animal's body design can also be used as a structural feature to help classify it. Some animals such as jellyfish and sea stars have **radial symmetry** whereas humans, lobsters and earthworms have **bilateral symmetry**.

Midline





Side view of jellyfish

INVESTIGATION 3.6

Classifying animals into phyla

AIM: To investigate characteristics used to classify animals

Materials:

preserved specimens or photos of animals from a range of phyla
hand lens

Method and results

- Observe each specimen carefully. Use a hand lens if necessary.

> **CAUTION**
>
> Some specimens are preserved in a liquid called formaldehyde, which is toxic and possibly carcinogenic. If you are provided with specimens in jars that contain liquid, do not open the jars. Look at the specimen through the sealed jar.

- Use the key on the previous page to decide which phylum each animal belongs to.

1. Draw up a results table with the following column headings:
   – Name of animal
   – Phylum
   – Characteristics used to classify.

Disscussion

2. Were there any characteristics in the key that were difficult to identify in the specimens?
3. Which phyla were most difficult to distinguish? Why?

3.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Construct Venn diagrams to show the similarities and differences between:
   (a) vertebrates and invertebrates
   (b) endoskeleton and exoskeletons.
2. Identify which group, vertebrates or invertebrates, is more abundant on Earth.
3. List two criteria that can be used to divide invertebrates into groups.
4. Describe the difference between the way in which muscles are attached in animals with endoskeletons and those with exoskeletons.
5. Worms have no skeleton and no legs. Describe how they are able to move.

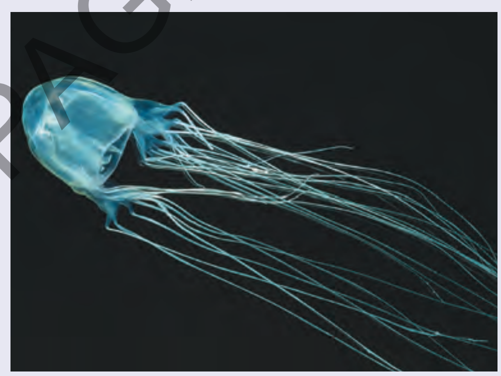
Think, discuss and design

6. The Great Barrier Reef is home to a diversity of living things. There are links between many of them, without which not only they but also other organisms may not survive. Find out more about the animals living on the Great Barrier Reef. Research and report on:
   (a) one invertebrate and one vertebrate
   (b) links between four different organisms
   (c) the issue of the crown-of-thorns starfish
   (d) the issue of tourism and the sustainability of the Great Barrier Reef
   (e) identify current research questions being investigated.
   Present your findings as a PowerPoint presentation, poster, picture book, podcast or newspaper article or in a multimedia format.
7. Carefully observe the pictures of the marine animals below.
   (a) Label features that you consider may be useful as criteria to classify and identify the organisms.
   (b) Design a dichotomous key that would enable each of these organisms to be identified.

(c) Compare your key with those of others in the class.
(d) Convert your dichotomous key into either a tabular or circular key.
(e) Use your key to try to classify two animals not shown below. Suggest any modifications that would enable them to be identified using your key.









3.7 Got a backbone!

What do you have in common with a jawless fish like a lamprey, you may ask? The answer is that you both have a backbone. Lampreys represent one of the earliest vertebrates.

3.7.1 Similar, but different?

Although there are many different groups of vertebrates, they all share some common features because they have shared common ancestors at some point in their evolution. Some scientists study these structural similarities to determine how recently they may have shared common ancestors. One example is the study of bones that are similar in shape.

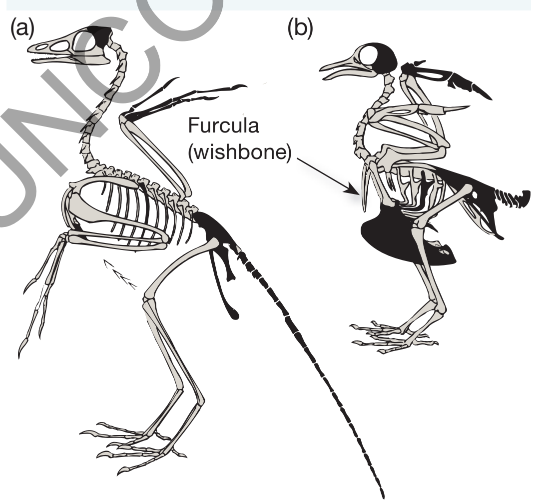
3.7.2 Linking features?

You can also see similarities between the skeleton and backbone of a modern day chicken and that of an extinct animal called *Archaeopteryx*, which some scientists suggest is the link between dinosaurs and birds.

3.7.3 Not just one bone, but many

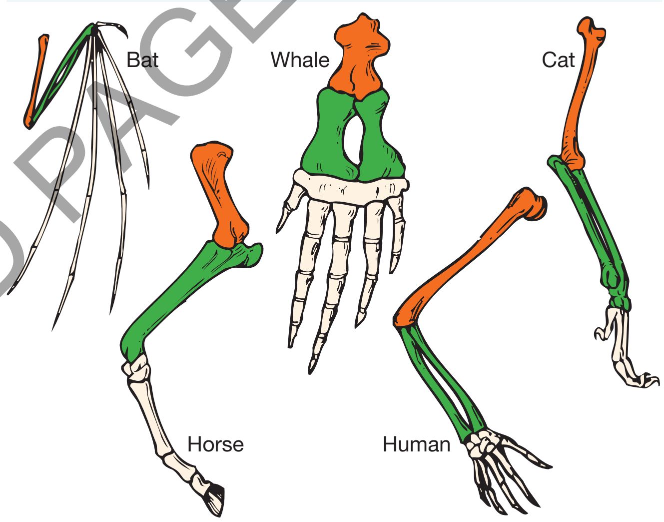
The word 'vertebrate' is derived from the Latin word *vertebra,* which means 'joint'. Your backbone is not a single bone. It is made up of many small bones called **vertebrae**, which are stacked on top of one another to form your **vertebral column**.

Skeleton of (a) *Archaeopteryx* and (b) a modern flying bird. The black regions on the skeletons show distinctive reptilian features (at left) and bird features (at right).

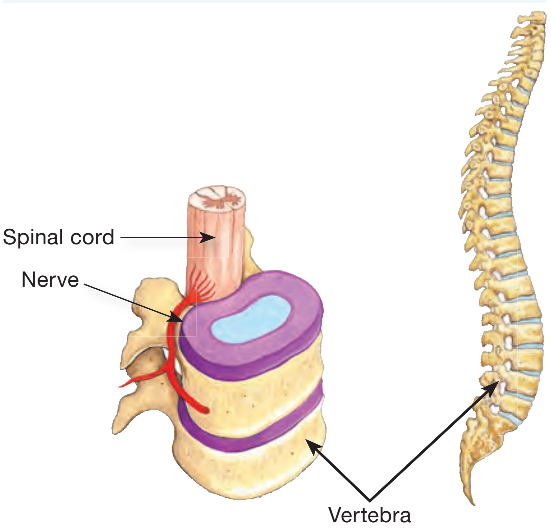


Did you know that the lamprey was one of the earliest vertebrates?

The structures shown have the same basic arrangement since they are all derived from a vertebrate forelimb. Do they have identical functions?



Your backbone is made up of many bones called vertebrae.

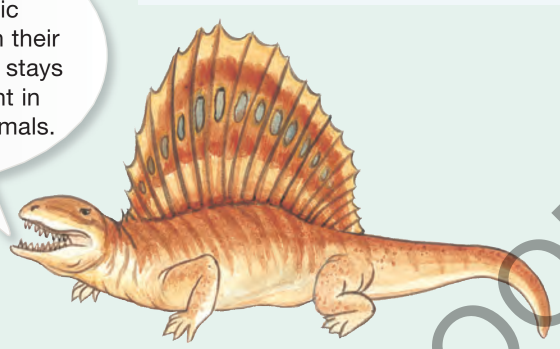


HOW ABOUT THAT!

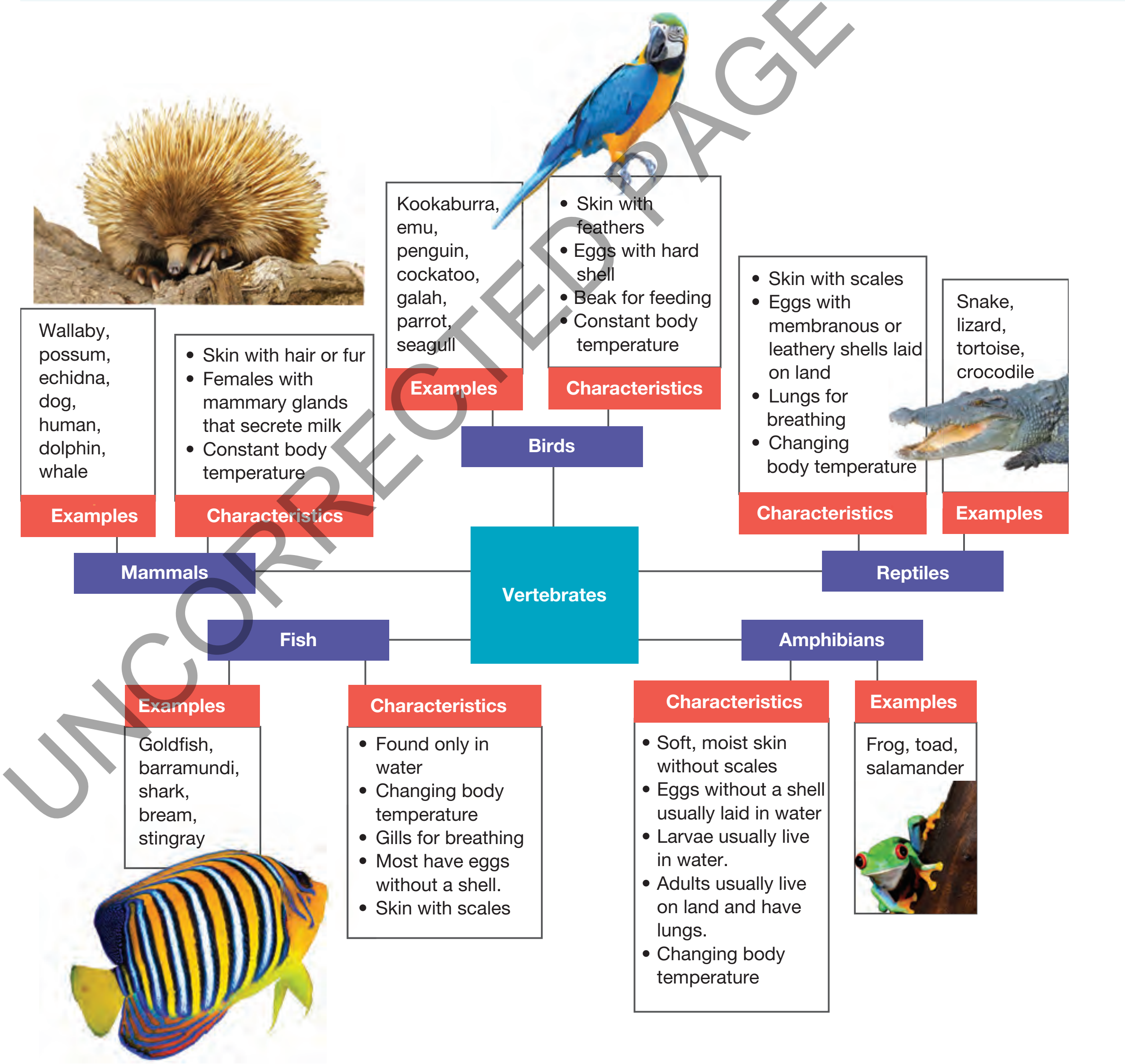
Dimetrodon was a meat-eating pelycosaur. The pelycosaurs were the most successful reptiles of the Permian period. They looked like big lizards with huge sail-like fins on their backs. The pelycosaurs used this 'sail' to regulate their body temperature. They could stand in the early morning sun with the sail arranged towards the sun to warm them up. They could turn it into the wind to cool off. It is thought that this fin arrangement was an early stage in the development of temperature regulation of mammals.

The body temperature of poikilothermic animals varies with their environment, but it stays relatively constant in homeothermic animals.

Dimetrodon — a mammal-like reptile



Vertebrates are animals that have a backbone made of bones called vertebrae. The five main groups of vertebrates are fish, amphibians, reptiles, birds and mammals.



INVESTIGATION 3.7

Flash 'n' mind

AIM: To learn the characteristics of the vertebrate groups

- You can make a set of *Flash 'n' mind* cards for yourself or for your team. Each card is about one-eighth of an A4 page in size, and made of coloured cardboard. You will need about 50 flash cards.

1. Type or write creatively the following terms on five separate cards: vertebrates, mammals, birds, reptiles, amphibians, fish.
2. On 21 separate cards, write each dot point from the characteristics sections on page 78.
3. Using the internet, clipart, magazines or other sources, find as many photographs or pictures as you can of the animals listed on page 78. Paste these images onto separate flash cards.
4. Shuffle your cards and, without looking at the figure on page 78, try to arrange them into a similar mind map. As you are laying each card down, say aloud why you are putting it in that place. If you are doing this as a team, discuss any differences of opinion. Once completed, check page 78 to see how you did.
5. As a team, use your *Flash 'n' mind* cards to design and play as many games as you can to help you learn the characteristics and examples of each vertebrate group.

3.7 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Identify the feature that jawless fish such as lampreys have in common with humans.
2. Suggest why vertebrates all share some common features.
3. What does the Latin word *vertebra* mean?
4. Describe the relationship between vertebrae and your backbone.
5. Construct Venn diagrams to show the similarities and differences between:
   (a) mammals and birds
   (b) reptiles and amphibians
   (c) fish and mammals.
6. Identify the group to which each of the following vertebrates belongs.
   (a) Snake
   (b) Cane toad
   (c) Goldfish
   (d) Whale
   (e) Emu
   (f) Shark
   (g) Lamprey
7. Suggest the function of the huge sail-like fins on the backs of pelycosaurs.
8. (a) Copy and complete the table below.
   (b) Are the answers to the questions in the table the same throughout the life cycle of the organism? Discuss your response with others in your class.

Feature	Mammals	Birds	Reptiles	Amphibians	Fish
Is body temperature constant or does it change?					
What type of body covering does it have?					
Does it lay eggs? If so, what type of shell do they have?					
Does it have lungs or gills?					
Does it feed its young milk?					
Give two examples.					

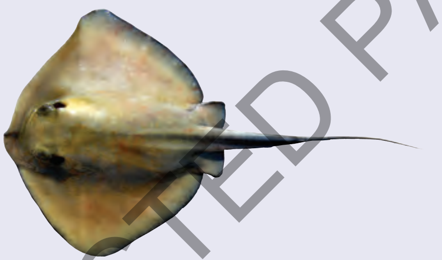
Think

9. Identify the group to which each of the following animals belongs.
   (a) I have lungs but no legs. My offspring are found in membranous-shelled eggs and use lungs to breathe.
   (b) I have moist skin but no scales, and two pairs of legs. Although I have lungs and live on land, my young usually live in water and use gills to breathe.
   (c) I have a constant body temperature, have feathers, and lay eggs with a hard shell.
   (d) I have a changing body temperature, gills and fins.
10. Suggest why it is thought that the pelycosaurs were a link between reptiles and mammals.
11. Using the table from question 8 and the translations in the table below, in which scientific classification groups would you place the vertebrates shown in the pictures below?

Latin or Greek word	English translation	Scientific classification
Amphis + bios	Double, both sides + life	Amphibia
Chondros + icthyes	Cartilage + fish	Chondrichytes
Marsypos	Pouch	Marsupialia
Osteon + icthyes	Bone + fish	Osteichtyes
Repere	To creep	Reptilia
Rodere	To gnaw	Rodentia
Siren	A kind of mermaid	Sirenia

Hamster

Stingray



Quokka

Eel

Dugong

Newt

Investigate

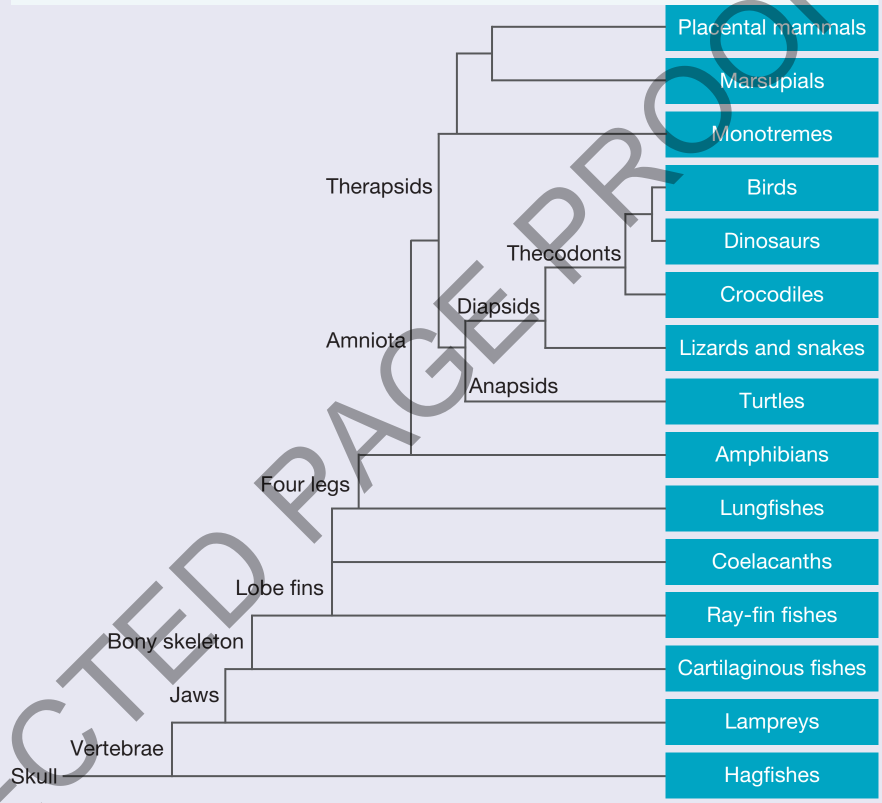
12. Goldfish and sharks are fish. Apart from their size, how are they different from each other? Construct a Venn diagram to summarise your findings of the structural and behavioural similarities and differences.
13. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions), but create new cards using scientific terms or animal groups that appear in this section.
14. Research and report on the issues and implications of tourism and overhunting on populations of the Australian freshwater crocodile, *Crocodylus johnstoni*, and share your findings with others.

Use data, investigate and create

Use the evolution figure on right to answer questions 16, 17 and 18.

15. Find out about the evolutionary history of lampreys and present your findings to the class as an annotated timeline.
16. Which of the following pairs would you suggest shared the most recent common ancestor?
    (a) Birds and dinosaurs or turtles and lampreys?
    (b) Marsupials and monotremes or placentals and marsupials?
17. Select two of the vertebrates in the figure on right and create a PowerPoint presentation or web page to show how they are similar and how they are different.
18. Find out about the features and 'lives' of two types of vertebrates in the figure above, construct puppets of each and present a story or play about their lives.

The branches of this evolution tree diagram show how recently various groups shared common ancestors.



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Complete this digital doc: Worksheet 3.11: Classifying vertebrates
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3.8 Mammals

Do you possess skin with hair or fur and have a constant body temperature? If you do, you could be one of the three types of mammals! The key criterion used to divide mammals is the way in which they give birth to their young.

3.8.1 Placenta, pouch or egg?

You are classified as a **placental mammal** because you grew inside your mother, receiving your needs via a placenta, and were born at a well-developed stage. **Marsupials**, however, are born at a very early stage of development and then grow inside their mother's pouch. **Monotremes** are laid in leathery-shelled eggs.

3.8.2 Unique for its mammals

Australia is unique in terms of the diversity of mammals that live here. Two-thirds of the world's marsupials live in Australia and monotremes are found naturally only in Australia and the nearby islands. Particularly in the spotlight is our platypus. Because of its uniqueness, research is currently being performed in a variety of different scientific fields.

Australia's native mammals are particularly well adapted to their harsh environments.

Mammals:
- have skin with hair and fur and have a constant body temperature
- have females with mammary glands that can secrete milk
- can be divided into three groups based on the way they give birth to their young.

Placental mammals

- Young grow inside the body of their mother and are attached by a cord to the placenta, which supplies their food.
- Young are well developed when they are born.
- Most mammals are placental mammals. Examples include horses, mice, humans, cats, cows and pigs.

Marsupials

- Although blind and naked, newborn marsupials crawl from their mother's birth canal to her pouch and attach themselves to the nipple to feed.
- Young are born at a very early stage of development.
- Two-thirds of the world's marsupials live in Australia. Examples include kangaroos, wombats, possums and koalas.

Monotremes

- Young are laid in leathery-shelled eggs.
- Monotremes are found only in Australia and some nearby islands. There are only two types of monotremes: the platypus and the echidna.

3.8.3 What kind of creature is this?

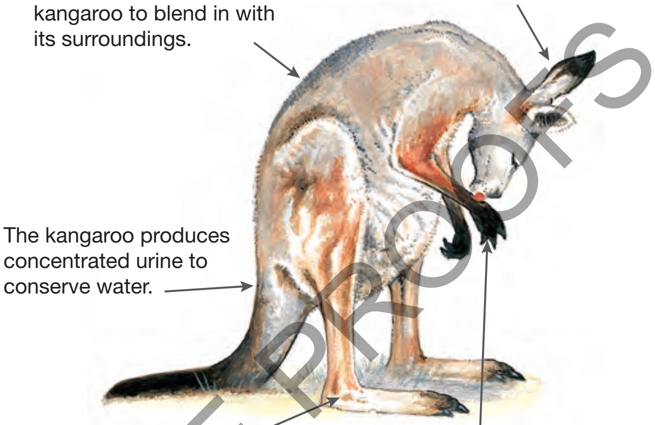
When European explorers returned from Australia with stories of 'strange' animals such as kangaroos, wallabies, koalas and wombats, people were surprised. Australian animals seemed so different from those common in Europe and other countries.

Imagine their disbelief when the platypus was first described to them. This strange animal had webbed feet and a bill like a duck, but it had no feathers. It laid leathery eggs like lizards and crocodiles, but it did not have scales on its skin. It also had fur and a large tail like that of an otter but, like a reptile, it had only one opening for ejecting faeces and urine.

In London in 1799, an Australian sailor presented a platypus specimen to Dr George Shaw, a prominent biologist of the time. It was so different that Shaw considered it a hoax and tried to cut off the duck-bill with scissors. The scissor-marks are still visible on the preserved platypus skin in the British Museum (Natural History) in London.

It is thought that the reason for the existence of Australia's unique animals like the platypus is Australia's isolation from the other continents after they separated millions of years ago. The animals evolved over time to be well suited to the unique Australian environment.

An **adaptation** is a feature that helps an organism to survive and reproduce in its environment. This figure identifies adaptations that help a kangaroo survive in the hot, dry Australian environment.



It's got webbed feet, a bill, fur and lays leathery eggs — is it real?

Genome

The platypus was the first Australian animal to be included in the Human Genome Project. The platypus (*Ornithorhynchus anatinus*) genome (genetic information) was published in 2008 and has brought new insights into mammalian evolution.

XXXXX-rated sex

Platypus sex is X-rated … in a big way! Sex is determined in most mammals by the X and the Y chromosomes — XX (two X chromosomes) will result in a female and XY (one X and one Y chromosome) will result in a male. In platypuses, however, it gets really interesting! Instead of having a single pair of sex chromosomes, platypuses have a set of ten chromosomes to determine sex. So a female has XXXXXXXXXX and a male has XYXYXYXYXY!

Monotreme milk

Teams of Australian scientists at the University of Melbourne, Deakin University and the Australian National University have been studying the milk produced by various mammals. Their research suggests that the milk from monotremes is very different from the milk of other mammals. This supports the theory that placental and marsupial mammals are more closely related to each other than they are to monotremes.

Venom

Platypus venom contains a cocktail of more than 50 different substances. Studies have suggested that some of these substances may be useful in the future as new painkillers. It will be exciting to see what new medicines may result from these findings.

3.8.4 A long, long time ago …

If you could travel back in time, you would be amazed by the types of megafauna (giant animals) that roamed our Australian continent. Imagine 'wombats' the size of cars (*Diprotodon optatum*), giant flightless birds (*Genyornis*) and lizards 7 metres long (*Megalania*). You might face fearsome lion-like marsupials (*Thylacoleo*) and wolf-like *Thylacinus*, not to mention having giant kangaroos (*Ptovspyofons*) bounding past.

Marsupial mammals have existed in Australia for about 35 million years and due to our 'isolation' many different types have evolved. The story of the history of our mammals is told in our fossil records.

WHAT DOES IT MEAN?

The word *megafauna* comes from the Greek word *megas*, meaning 'great' or 'large', and the Latin word *fauna*, meaning 'animals'. The Latin term *flora* means 'plants'.

Questions of the past in the future

Archaeologists and other scientists in a variety of fields are working together to answer questions such as 'Why did the megafauna become extinct?' and 'Why do platypuses have so many sex chromosomes?'.

Theories that have been suggested as to why the megafauna became extinct include the following.

- Aboriginal people may have hunted them as a food source.
- Aboriginal people may have brought diseases with them that infected and killed the animals.
- Fires lit by Aborigines may have led to a change in the types of vegetation.
- The climate became drier and vegetation changed so that food sources became scarce.

A timeline of some marsupial fossil finds and major mammal events

Some marsupial fossil finds and events	Era	Epoch (millions of years ago)	Period	Major mammal events
Present	Cenozoic era	HOLOCENE 0.01–present	Quaternary period	Humans investigate Earth's history.
Most of the large Pleistocene marsupials became extinct about 15 000–30 000 years ago.		PLEISTOCENE 1.64–0.01 mya		Aborigines arrived in Australia about 55 000 years ago.
Many giant browsing marsupials became extinct; there were grazing kangaroos and lots of diprotodons.		PLIOCENE 5.2–1.64 mya	Tertiary period	*Homo habilis,* the earliest known human, appeared in East Africa.
Primitive marsupial 'mice' and 'tapirs' were found at Lake Eyre, South Australia, and diprotodons at Bullock Creek, Northern Territory.		MIOCENE 23.5–5.2 mya		Lots of marsupial mammals were living in Australia and South America.
First Australian marsupials occurred about 23 million years ago. Diprotodons and a relative of pygmy possum fossils were found in Tasmania.		OLIGOCENE 35.5–23.5 mya		First marsupials appeared in Australia. First primates appeared.
Lots of marsupial fossils of this age were found in South and North America.		EOCENE 56.5–35.5 mya		Swimming and flying mammals appeared.
Dinosaurs became extinct about 65 million years ago.		PALAEOCENE 65–56.5 mya		More mammals appeared after dinosaurs became extinct.

In May 2013, an international team of experts published research findings stating that, of 90 megafauna, only 8–14 still existed when humans arrived. It concluded that climate change was the real culprit. Debate continues!

Giant kangaroo

The extinct giant kangaroo, *Procoptodon*, was heavily built and stood about 2.5 metres high. Procoptodons may have weighed about four times as much as the largest kangaroos of today. They had a short face and deep skull with huge molar teeth. Their molars may have helped them to eat tough plant foods. Procoptodons may have used their very long forelimbs to pull down the branches of trees and shrubs.

Diprotodons

The members of this group are all extinct. They were the largest of all the marsupials. *Diprotodon optatum*, often referred to as the diprotodon, was the largest known marsupial to have ever lived. The skeleton of the diprotodon suggests that the animal was about the size of a rhinoceros, being about three metres long and possibly weighing about two tonnes.

This illustration shows some of the animals that inhabited Australia in the Tertiary period. Others included marsupial lions, koalas, possums, wallabies, kangaroos, goannas and long-beaked echidnas (*Zaglossus*).

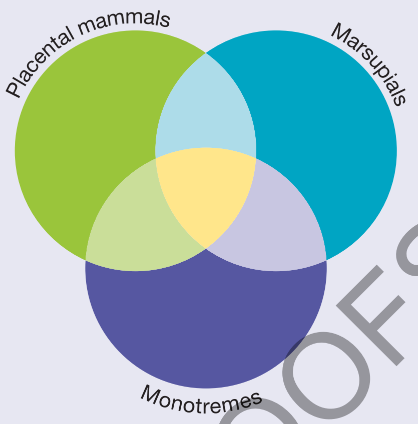
3.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember and think

1. Construct a three-column table and use it to summarise the main characteristics of each of the three groups of mammals.
2. Outline how marsupials are different from all other animals.
3. Suggest how placental mammals got their name.
4. Identify which group of mammals the following animals belong to.
   (a) Echidna (b) Possum (c) Cat
5. How many chromosomes decide the sex of a platypus? Suggest how this is different from the situation in other mammals.
6. Suggest how we know that marsupials have existed in Australia for millions of years.
7. List features of each of the following and suggest which living animal it is most similar to today.
   (a) *Procoptodon*
   (b) *Diprotodon optatum*
8. Outline the importance of the findings related to the genome of the platypus.
9. Suggest why Australian mammals are so different from those found in other countries.
10. List theories as to why Australia's megafauna became extinct. Which of these theories is currently supported by research?

Think and discuss



11. Construct a triple Venn diagram to show the similarities, differences and examples of the three mammal groups.
    Look at the illustration of prehistoric animals on the previous page.
12. Which animals alive today are they most similar to? Give reasons for your answers.
13. How are present-day wombats different from their ancient ancestors?

Analyse and evaluate

14. Use the timeline on page 84 to answer the following questions.
    (a) List the seven epochs in the table on page 84 in order of most recent to least recent.
    (b) In which epoch did marsupials appear in Australia? How do we know this?
    (c) Earth's greatest ice age was in the Pliocene epoch. When was this? What other events occurred then?
    (d) Look up other sources to find out what other important events occurred, and add these to your timeline.

Investigate

15. Find out more about one placental mammal, marsupial or monotreme and present your information in a poster or PowerPoint presentation.
16. Did you know that adult hedgehogs have 5000 spines? So that the birth canal is not damaged when the mother is giving birth, the initial spines of a newborn are covered with a layer of skin. The spines pop through hours after birth. Although hedgehogs are mammals and they look a little like echidnas because of their spines, they are not classified as monotremes.
    (a) Find out whether hedgehogs are placental mammals or marsupials.
    (b) How do hedgehogs differ from echidnas?
    (c) A porcupine also has spines. What type of mammal is a porcupine?
    (d) How are porcupines different from hedgehogs and echidnas?
17. Find out more about Australia's prehistoric marsupials, and present your information as a poster, poem, story or PowerPoint presentation.
18. Find out about the different climates, environments and organisms for one of the epochs in the Cenozoic era, and then write a story about an imaginary journey back in time.
19. Besides the Cenozoic, what are the other four eras used to describe the history of the Earth? Draw a timeline showing all five eras, including their periods, times in millions of years and any other information you can locate.
20. What do taxonomists in museums do? Why is their work important?
21. Research and report on one of the following topics of research in Australia.
    - Platypus genome
    - Platypus milk and lactation
    - Platypus venom
    - Platypus sex chromosomes and mating
    - Koala diet
    - Koala diseases
    - Koala reproduction
    - Tamar wallabies
    - Bilbies

    Present your findings as a poster, PowerPoint presentation, web page, picture book or journal article.
22. Find out the names and features of some Australian mammals and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.
23. Imagine you are an Australian palaeontologist with a time machine. Document a week in your journal. Share your journal with two others and find out about their adventures. Present the three journal entries to the class.

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Complete this digital doc: Worksheet 3.12: Looks can be deceiving
Searchlight ID: doc-19810

3.9 No backbone!

Feel a little itchy? Did you feed something in your sleep — or were you awake? Was it a flea, an insect, a worm or a louse? Did it burrow its way inside you to feed or did it get its food while crawling on your skin? Chances are it might have been an invertebrate — a creature with no backbone.

1 Arthropods
- Body divided into segments
- Exoskeleton
- Paired, jointed legs
- Most have antennae
- Include centipedes, spiders, crabs, ants, grasshoppers, moths

3 Echinoderms (pronounced ee-KAI-no-derms)
- Most have a soft body over an internal skeleton
- Rough, often spine-covered 'skin'
- Body has a five-part pattern
- Move through water by taking water in and pushing it out of tubes in their bodies
- Include sea stars, sea urchins, sea cucumbers

6 Annelids (also known as segmented worms)
- Internal segments with some repeated organs
- Soft bodies with an obvious head
- No exoskeleton
- Mouth and anus
- Include earthworms, leeches

Invertebrates
- Paired, jointed legs → Arthropods
- No legs
  - Body covered with a shell or rough, spiny skin
    - Soft body, usually covered with a shell → Molluscs
    - Body covered with a rough, spiny skin → Echinoderms
  - Soft outer body
    - Spongy body with holes → Porifera
    - Body without holes
      - Has tentacles → Cnidarians
      - Has no tentacles
        - Body segmented internally → Annelids
        - Body not segmented internally
          - Worm-shaped body → Nematodes
          - Flat body → Platyhelminthes








7 Nematodes (also known as roundworms)
- Soft, unsegmented bodies
- No exoskeleton
- Worm shaped
- Mouth and anus
- Include threadworms, roundworms

2 Molluscs
- Most have a shell
- Soft body, not divided into segments
- No legs, but may have tentacles
- Have a strong 'foot' muscle to help them move
- Include oysters, octopuses, scallops, slugs, snails

4 Porifera
- Spongy body with no body organs or tissue
- Exoskeleton made of fibres or pointed 'needles'
- Water and food enter through tiny pores (holes) in body
- Wastes pass out through one big opening
- Include barrel sponges, glass sponges, tube sponges

5 Cnidarians (pronounced ny-DAIR-ee-ins — the 'C' is silent)
- Hollow, soft body
- No body organs
- Take in food and pass out waste through one opening
- Have tentacles containing stinging cells, which fire shots of toxin
- Include box jellyfish, sea anemone, Portuguese man-of-war, coral

8 Platyhelminthes (pronounced plat-ee-hel-MIN-theez; also known as flatworms)
- Soft, flat, usually unsegmented bodies
- No exoskeleton
- Mouth but no anus
- Include tapeworm, fluke

3.9.1 Inside or outside?

Some organisms obtain their nutrients by feeding on other living organisms. These are called **parasites**. **Endoparasites**, such as tapeworms, live inside their hosts, whereas **ectoparasites**, such as head lice, live on the outside. Some of these organisms also act as carriers or **vectors**, transporting disease-causing organisms from one animal to another.

3.9.2 No backbone

No backbone? Animals without backbones are called invertebrates. Many invertebrates have an exoskeleton (skeleton on the outside) and some have no skeleton at all. About 95 per cent of animals are invertebrates. Have a look at the invertebrate dichotomous key on the previous page to see how many of the features, groups and examples you recognise.

3.9.3 Invertebrates beware!

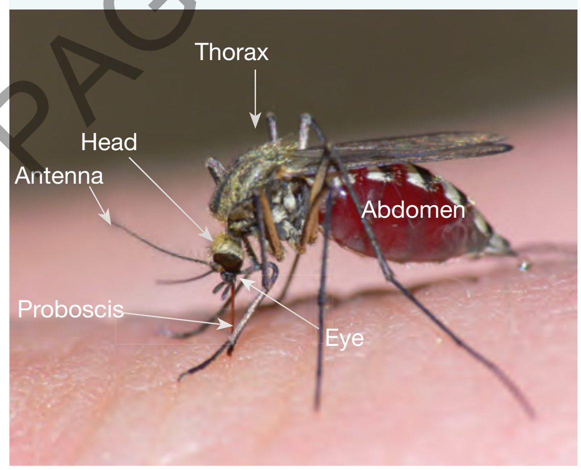
A number of the invertebrate groups contain organisms that may find you quite tasty. There are some well-known human parasites in the following groups of invertebrates:

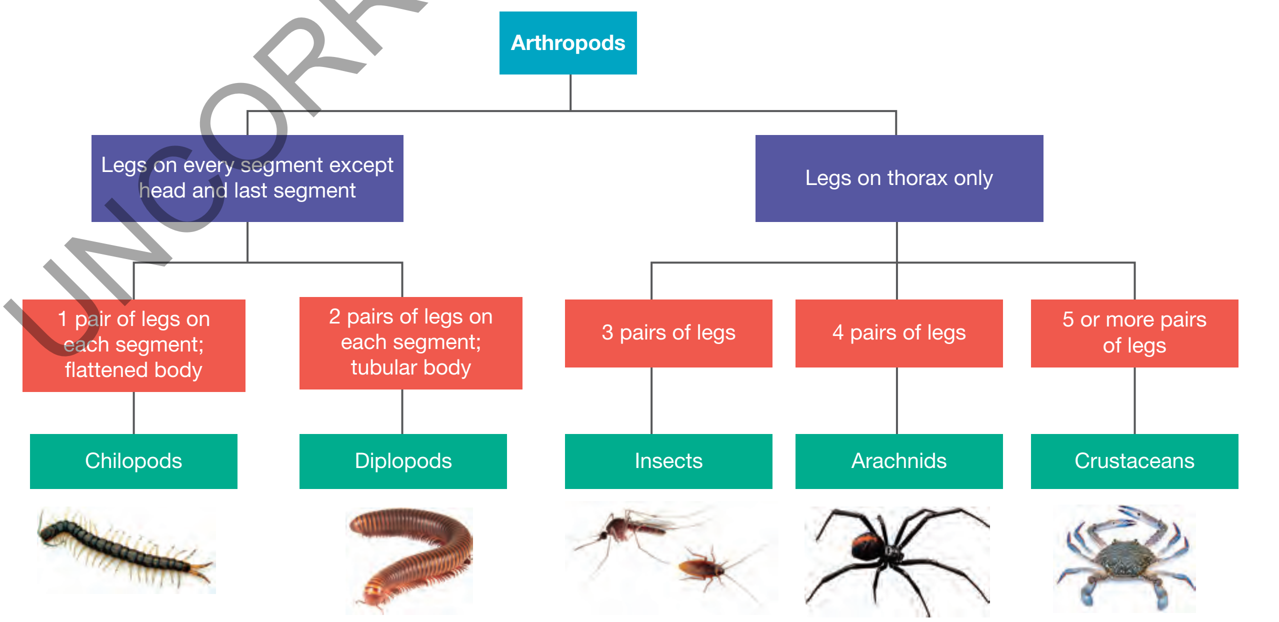
- arthropods (for example, head lice, mosquitoes, fleas, ticks and mites)
- nematodes (for example, threadworms, hookworms and pinworms)
- platyhelminthes (for example, liver flukes and tapeworms)
- annelids (for example, leeches).

3.9.4 Arthropods

About 80 per cent of invertebrates are **arthropods**. Arthropods can be classified on the basis of the organisation and number of their legs. The figure on right shows the head, thorax and abdomen of a mosquito. As there are three pairs of legs attached to the thorax, it is classified as an insect.

Insects' bodies are divided into three parts — the head, thorax (chest) and abdomen (stomach) — and have three pairs of legs attached. Most have either one or two pairs of wings, a characteristic that separates them from any other invertebrate animal. The proboscis of a female mosquito has sharp needles that poke out when a blood vessel in its victim is pierced.

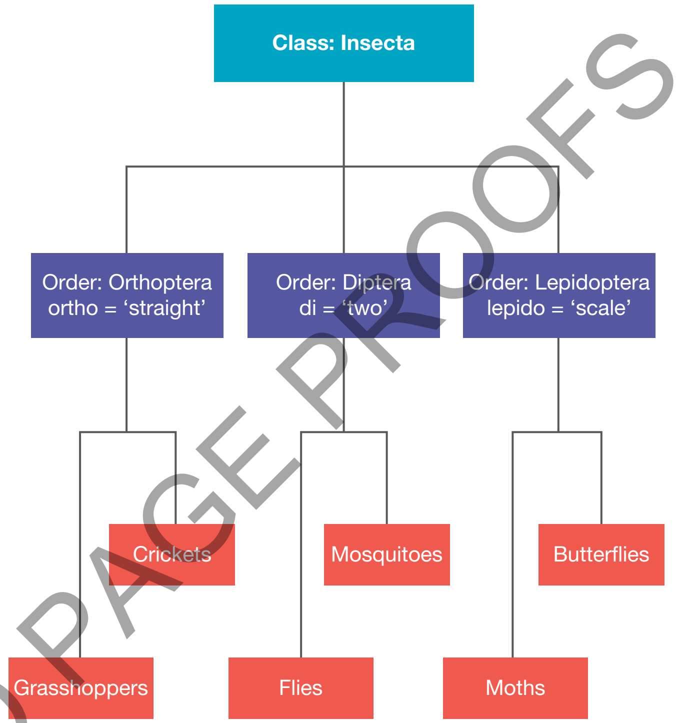




3.9.5 Insects

All insects have the same basic mouthparts, but over millions of years, depending on their particular diet, they have developed in different ways. Most insects either bite off pieces of food and chew them or suck up liquids such as nectar or blood.

Using the knowledge that *pteron* is Greek for 'wing' and the prefix translations above, can you suggest a feature that these insects all share, and one that can be used to separate them?



Sap and sweet suckers

Some insects may obtain their food by sucking sap from plants. The shape of an insect's head can often suggest the sort of food it eats. A sap-sucking insect usually has a tiny head with a long, pointed tube extending from its mouth, which it uses to suck up sap.

Moths and butterflies have a long tubular **proboscis** that unrolls to reach the nectar within a flower. Dragonflies also have extendable mouthparts for hunting.

WHAT DOES IT MEAN?

The term *platys* comes from the Greek term meaning 'flat'; *helminth* comes from the Greek word for 'worm'; *nema* comes from the Greek term for 'thread'; and *mollusc* comes from the Latin term *mollis*, meaning 'soft'.

Although adult mosquitoes feed on the sugar in plants, the females in some species must have one or more blood meals to produce eggs. In most species of mosquito, the female has a sharp, tubular proboscis well suited to piercing and sucking. Male mosquitoes never suck blood. Female mosquitoes may pass on malaria, yellow fever, elephantiasis and filariasis while obtaining blood, because they inject infected saliva into their hosts.

A hawk moth has an unusually long proboscis — it is often longer than its body. Moths and butterflies don't blow up their proboscis; they use muscles that act like an elastic rod, coiling it up again so that it may be kept coiled under the head.

Bee fly proboscis

Dragonfly mouth

Hawk moth proboscis

Butterfly proboscis

Bite and chew

Some insects have feeding structures that are designed for biting and chewing. They usually eat plants and have a large head to support the strong muscles and jaws that are needed to get through the tough plant tissue.

HOW ABOUT THAT!

Bedbugs (*Cimex lectularius*) come out at night and feed on the blood of mammals and birds. Their mouthparts are well suited to piercing their host's skin. They have barbed structures for piercing and sawing. The bugs have a pair of tubes, one of which inject saliva containing a substance that stops the blood from clotting, while the other sucks up the blood and saliva mixture. They usually feed just before dawn if the temperature is above 13 °C and may take five minutes or more to extract their meal before scurrying off to digest it and rest.

3.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

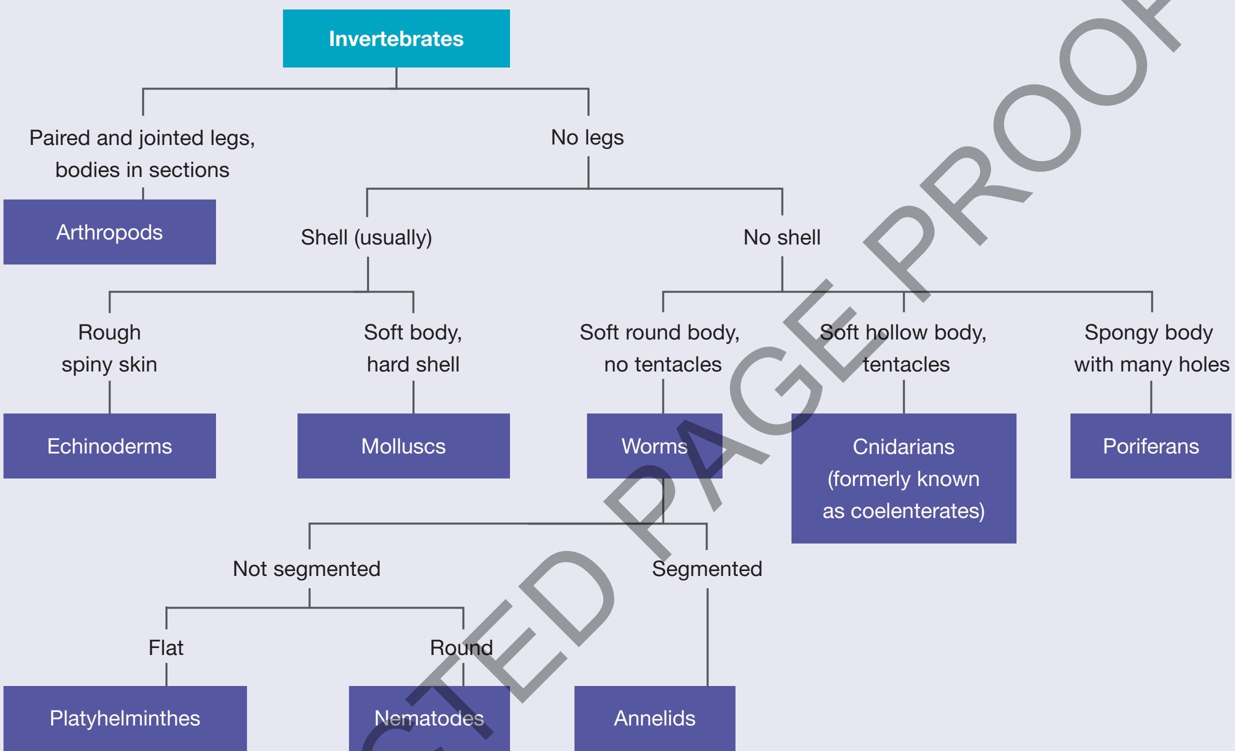
1. Define the term 'parasite'.
2. Outline the difference between endoparasites and ectoparasites.
3. What do all invertebrates have in common?
4. Identify the name of the invertebrate group to which each of the following organisms belongs.
   (a) Threadworm (b) Earthworm
   (c) Jellyfish (d) Tapeworm
   (e) Tube sponge (f) Sea urchin
   (g) Slug (h) Grasshopper

   Use the invertebrate dichotomous key on page 87 to answer questions 5 and 6.
5. State which of the following pairs have (a) most in common and (b) least in common.
   (A) Nematodes and platyhelminthes
   (B) Molluscs and annelids
   (C) Arthropods and cnidarians
   (D) Arthropods and annelids
6. For the pairs that you have identified in question 5, list the features that each pair has in common.
7. Construct a table to show examples of arthropods, nematodes, platyhelminthes and annelids that can be human parasites.
8. Suggest features that can be used to divide arthropods into groups.
9. Describe what a proboscis is used for.
10. Describe the features of the mouthparts of a bedbug that enable it to feed on humans.
11. Outline how the types of heads and mouthparts of insects can tell you about the way that they live and feed.

Using data, think and discuss

12. Who am I? Use the dichotomous key below to find the identities of the following invertebrates.
    (a) I do not have legs but I have a soft outer body and tentacles.
    (b) I have a rough spiny body covering, a five-part body pattern and no legs.
13. Use the dichotomous key below to classify an octopus.
    (a) To which group does it appear to belong?
    (b) Check the lists of characteristics to see if the answer you gave in part (a) was correct. If you find that you were incorrect, suggest why.
    (c) Classification is not always straightforward. Use the lists of characteristics to design a dichotomous key of your own that will make it easier to classify an octopus.
    (d) Test your key by using it to classify a snail, a starfish and an earthworm. Does your key seem to work?

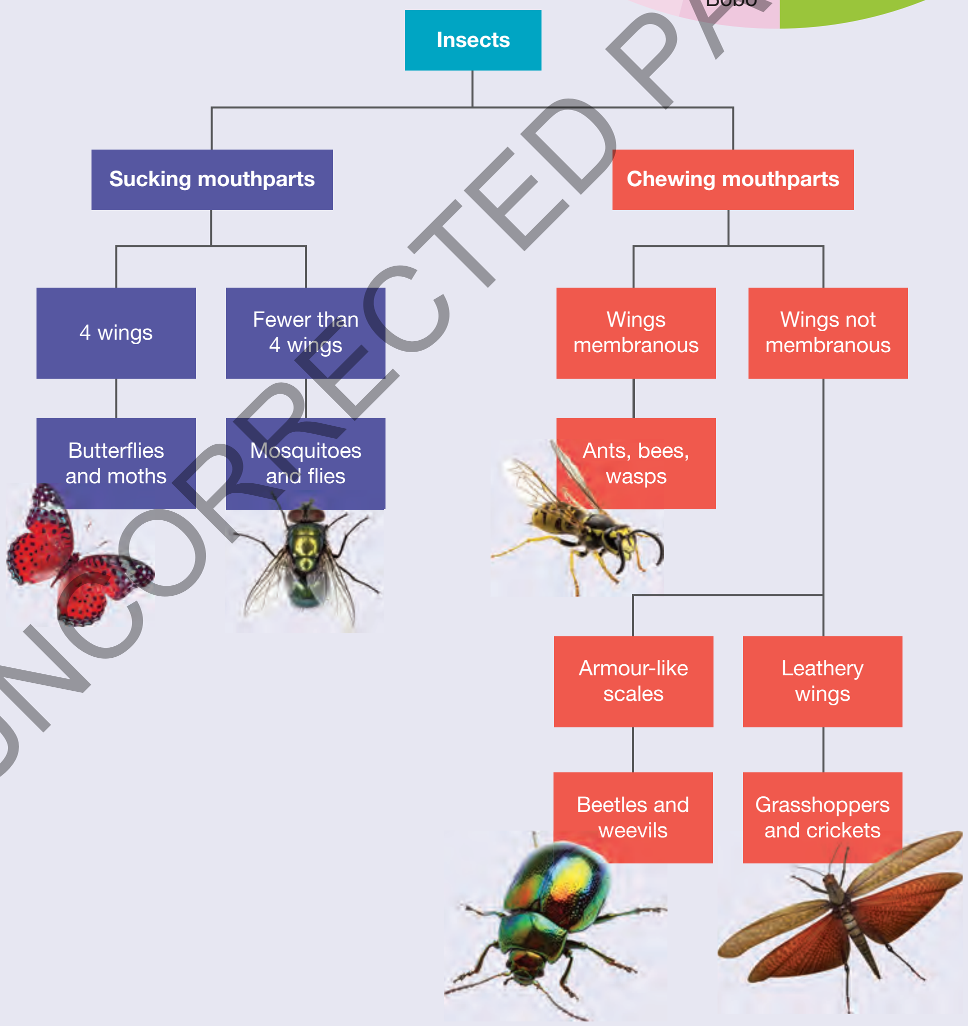
14. Use the lists of features of the invertebrate groups to state which group (or groups):
    (a) has jointed and paired legs
    (b) usually has a hard shell
    (c) can have tentacles
    (d) has a body with many holes.
15. Use the dichotomous key below to classify each of the following invertebrates. As you work down from the top of the key, list the characteristics of the animal that enabled you to classify it (for example: snail — no legs; shell (usually); soft body, hard shell).
    (a) Earthworm
    (b) Crab
    (c) Oyster
    (d) Spider



16. (a) In a table, list the features of slugs, earthworms and snails.
    (b) Highlight or circle features that they all have in common.
    (c) Which two appear to have most in common?
    (d) Use the invertebrate key to see if your data are supported by their classification group.
    (e) Discuss your findings.
17. Find out why cnidarians are no longer classified as coelenterates.
18. (a) Use the circular key on the right to identify the 'insect' creatures from another planet.
    (b) Describe the characteristics of a trisee, a peeler and a bitpart.
    (c) Make a sketch of a gazer and a bozo.
    (d) Which of the following are most similar: a bisharp, a noner and a peeler?
19. (a) Use the insect key below right to classify a variety of insects into their groups.
    (b) Did you have any difficulties using the key? Suggest any changes that you could make to improve it.
20. (a) Using the information on page 87 and images from the internet, clipart and magazines, create a set of Flash 'n' mind cards for invertebrates (see Investigation 3.6).
    (b) Design as many different games as you can that use the cards to help you learn the characteristics and examples of each invertebrate group.
    (c) Play some of your card games with your team and also with other teams.
    (d) Combine your invertebrate cards with your vertebrate cards from Investigation 3.6 to create a floor mind map to share with others what you have learned.
21. Design and make masks to model the feeding parts of several different insects.
22. Use a magnifying glass or stereo microscope to observe and sketch the heads of a range of insects. Pay special attention to the parts that may be involved in feeding. Suggest what types of food each of the insects might eat and how they might obtain these.

23. (a) Find out the similarities and differences between locusts and grasshoppers and present your results in a Venn diagram.
(b) Research the functions of the Australian Plague Locust Committee (APLC).
(c) Identify, research and report on a question or problem related to locust plagues.

24. Find out the names and features of invertebrates that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.



3.10 Zooming in … human endeavours into classification

Science as a human endeavour

Science is full of wonder, just waiting to be explored. More than in any other career, the scientist can be both an adventurer and an explorer. The opportunities to discover new things are almost endless, with the journey of discovery full of many twists and turns along the way.

The life of scientist Denis Crawford is one such adventure. He asks questions, makes observations and experiences new challenges as he tries to make sense of the world around him.

3.10.1 Chemical colours

Educated in West Essendon, Victoria, Denis studied a mix of humanities and sciences. After completing Year 12, he spent 18 months at Dookie Agricultural College. From there he moved to the Organic Chemical Research Section of ICI, experimenting with 'colourful chemistry'. His job was to discover new colours of pigments, paints and inks, and then think up names to describe them.

3.10.2 Caring for 'crawlies'

In 1977, the 'call of the wild' beckoned Denis. For the next 10 years he was involved in **entomological** research with the Department of Agriculture. He immersed himself in the world of insects. During the day he collected caterpillars and maintained breeding colonies in his laboratory. Here he could study not only the insect's reproductive cycle but also the best way to control insect populations. Over two billion dollars worth of pesticide is used annually in Australia to rid crops of agricultural pests; Denis's caterpillars were responsible for half of this use. During this time he was often referred to as 'the caterpillar chef'. He found that the best food for the caterpillars was a blend of baked beans and agar, which he set into blocks and cut up into insect 'bite size' pieces.

One of Denis's creeping, crawling specimens, an emperor gum moth larva (*Opodiphthera eucalypti*)

3.10.3 Snappy travels

Denis became more and more interested in the challenges involved in 'capturing' the wonders of the world around him. At the end of his time at the Department of Agriculture, he travelled overseas, taking photographs of the natural world around him. On his return to Australia, over 500 of his photographs were placed in a photographic library. This library acted like an agent and sold Denis's photographs to magazines, journals and other parties.

Denis Crawford photographing the Sorsdal Glacier

3.10.4 Getting a closer look

Denis's dual interests in natural science and photography led him to enrol in the RMIT's Applied Science (Photography) degree course in 1991. His third-year project was on close-up insect photomicrography, that is, taking photographs using a scanning electron microscope. His aim was to produce a series of photographs in which dead insects were made to look alive. Denis successfully met the challenge he set himself, and at the end of 1993 his work on the project earned him the Chris Hales Imaging Award.

3.10.5 Strange looking …

Denis was increasingly seen to be 'staring at bushes, waiting for insects to move into the right spot'. He remembers the reactions of other people when they saw him lying 'fully stretched out on the footpath photographing harlequin bugs going about their daily business'. As Denis recalls, 'People stared at me, gave me strange looks and then crossed the street to avoid me. To "shoot" a bug properly you have to get down to their level … I had no choice!'

3.10.6 Living in a freezer

The wilds of Antarctica had always held a fascination for Denis. Since he was young, he had loved to hear about Antarctic adventurers like Sir Ernest Shackleton, Captain Scott and Sir Douglas Mawson.

In 1994, he approached the Antarctic Division to offer his services as a photographer. Two years later, in January, he was on a ship travelling through rough seas and pack ice. His mission was to photograph small fossils in the Vestfold hills, in eastern Antarctica. Fifteen of the 70 expeditioners disembarked with Denis at Davis Station. They included a palaeontologist, a meteorologist, an astrophysical engineer, a space plasma physicist and a zoologist.

Denis's first impressions of Davis Station were interesting: '… a Legoland on Mars … a colourful blockscape of buildings … all colour coded'. The Antarctic environment is, in fact, so unusual that NASA has used one of the ice-free regions as a training ground for astronauts in extraterrestrial living.

3.10.7 Finding frozen fossils

Denis was very excited about what he found, 'Fossils were sitting on the surface of what used to be a seabed four million years ago.

Denis's *Backyard Insects* book cover photograph of a honey bee

One of Denis's insect images of a robber fly

After the last major glaciation, about 12 000 years ago, a glacier receded and exposed this seabed. Although most of the fossils were of shells, there were also fossils of ancient dolphins and whales. They were extraordinary!

'As you walk across the Marine Plain, you disturb very fine dust. This dust is the remains of four-million-year-old diatoms (phytoplankton), and from time to time you have to stop to wipe the diatoms out of your eyes.

'Sitting on the surface of this flat plain are many unique rocks which have been moved from other areas and deposited here by the glacier. There is a two-metre high "turtle skull" rock which has strange holes in it caused by the eroding winds.'

3.10.8 Life at the bottom of the world

Wind is an ever-present and important feature of Antarctica. The winds come off the great Antarctic plateau from the South Pole and fall downwards towards the sea. They are known as katabatic winds. When the wind hits the coast, it can be travelling at a speed of 200 kilometres per hour.

Denis's challenge was to photograph fossils in the field. 'It was so windy it was difficult to set up the tripod, and the camera kept shaking. As it was so cold, I had to wear thick gloves. This made it hard to operate the camera. I ended up photographing the fossils in the station lab.'

Sleeping arrangements on field excursions were also curious. 'Once I was outside in the field for five days. During this time, the research team stayed in round fibreglass huts. These huts were named on the basis of their shape and size. I slept in a "melon" but there were also "apples" and "Smarties". The "melons" slept two people, whereas the "apple" slept only one. Although we had torches, we didn't really need them, as in summer there were 20 hours of full sunlight. The rest of the time was like a "weird dusk". We had no television but we didn't miss it because there was so much to learn and so many adventures to live …'

An Antarctic fossil

3.10.9 Fire and ice

The Sorsdal Glacier lies at the end of Marine Plain. Denis was among a group of scientists who climbed it, starting at twilight and reaching the top at midnight. 'When we reached the top, we celebrated by eating a packet of TimTams and drinking Tang. It was the most stupendous sight. I'll never forget the colours … the sky was on fire and the ice was purple.

'Wow! … to capture the colour and feeling of the moment. Hand me my camera quickly!'

And now? Denis's latest passion involves his company Graphic Science. What adventures await him once he's finished that journey?

3.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Draw a flowchart of Denis Crawford's life. Include years where possible.
2. What is photomicrography?
3. What was Denis's job while he was in Antarctica?
4. How old were the fossils that Denis photographed in Antarctica?
5. What are diatoms and why did they get in Denis's eyes?
6. Why didn't Denis need to pack a torch for his Antarctic travels?

Investigate, think and discuss

7. Find out more about types of collaborative transnational Antarctic science research by researching projects associated with the Scientific Committee on Antarctic Research (SCAR), European Project for Ice Coring (EPIC) or Interpolar Transnational Art Science Constellation (I-TASC).
8. What do palaeontologists, meteorologists, astrophysical engineers, space plasma physicists and zoologists do? What might they be doing in Antarctica?
9. Find out more about the lives and expeditions of Sir Ernest Shackleton, Captain Scott and Sir Douglas Mawson.
10. What is an entomologist?
11. Investigate some of the caterpillars that destroy Australian crops. How can farmers control them?
12. Investigate glaciers. How are they able to move rocks from one place to another? Where are the nearest glaciers to Australia?
13. Find out about the lives and features of organisms that inhabit Antarctica. How are they suited to their environment?

Imagine

14. Imagine you are going on an expedition to Antarctica. Suggest a scientific reason for your expedition. Carefully plan your trip including what types of scientists you would take. What two personal items would you take? Write an imaginary journal detailing your expedition.
15. Photograph some insects and use the photos to construct a class field guide to local insects. You will need to use reference books to find out about each insect.
16. Write a story about your future adventures. Include dates and key events. Your final story may take the form of a journal, biography, tape recording or video.

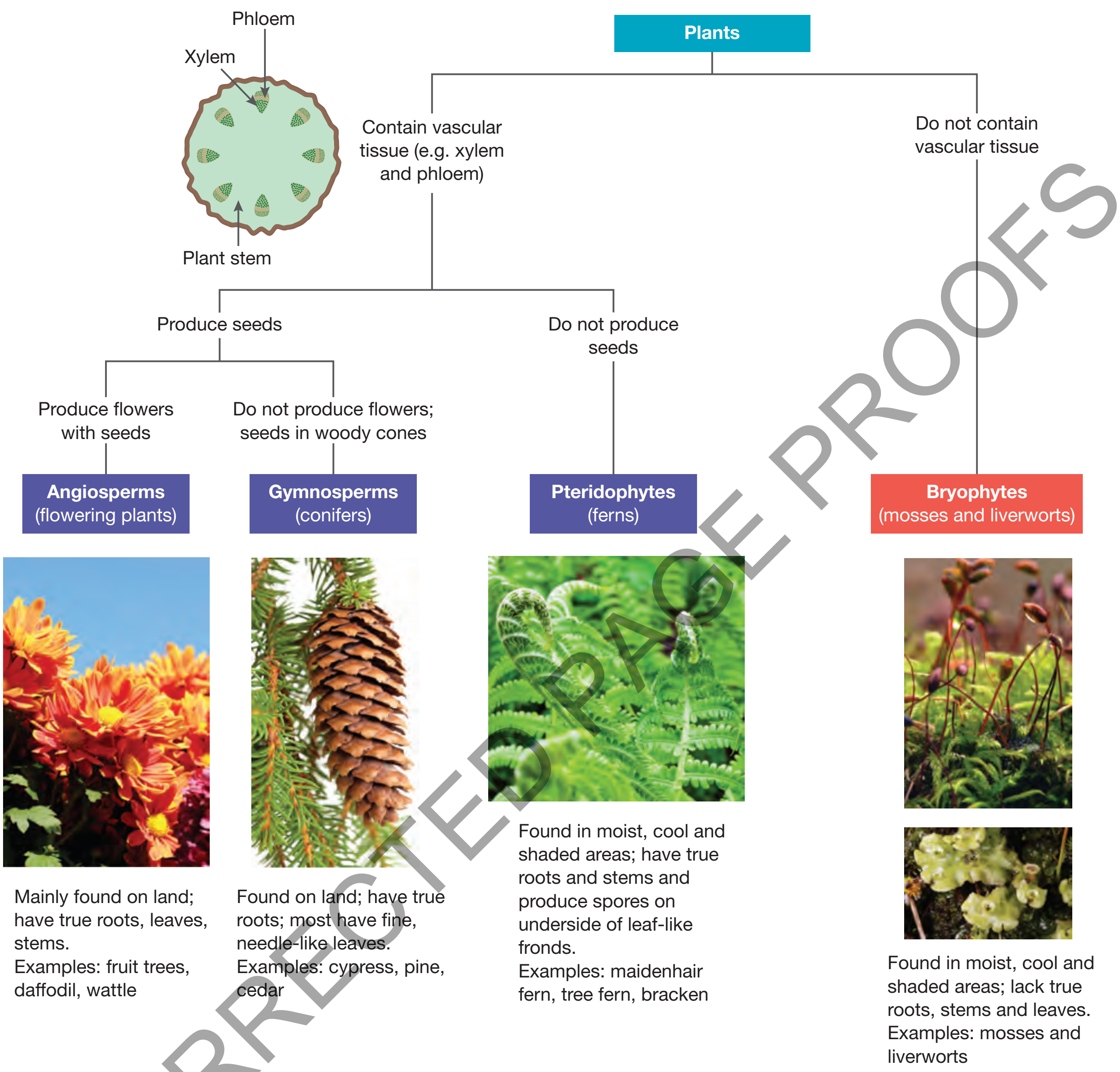
3.11 Which plant?

More than 23 centuries ago, a Greek philosopher named Aristotle developed one of the first widely used classification schemes. He divided plants into groups on the basis of their type of stem. Although this is still a useful system, like most classification systems it has limitations.

3.11.1 Patterns can be used to classify plants

Biologists often use the presence, absence or patterns in structural features or reproductive structures to group, classify and identify different types of plants. Plants that contain vascular tissue belong to a group called **tracheophyta** (= 'windpipe' + 'plant'). Ferns, conifers and flowering plants all contain **vascular tissue**. Mosses and liverworts do not. Vascular tissue consists of cells that make up tube-like structures that conduct (or transport) materials along the stem of a plant. **Xylem** and **phloem** are two types of conducting tissues. Xylem transports water and minerals from the roots up to the leaves, whereas phloem carries mainly sugars throughout the plant. The dichotomous key below shows one way these and other features may be used to group different types of plants.

Classification of plants



INVESTIGATION 3.8

Getting to know plants

AIM: To investigate features of some plant groups

Materials:

two pine cones
fern frond (with sporangia)
some moss
flowering weed pulled out of the ground (with roots attached)
camera (such as digital camera, webcam or mobile phone camera)

Method and results

1. Create a table with the following column headings: ‘Group’, ‘Photo’.
2. Take a photo of each plant or plant part. Insert the photos in the table you created and write down the group name for each photo.

3. Add labels to the photos. Label the following.
   – Scales on the pine cone
   – Sorus on the underside of the fern frond (The sori are the brown dots. Each sorus is a cluster of sporangia. The sporangia contain spores.)
   – One single moss plant
   – Roots, stem, flower and a leaf of the weed
- Leave one pine cone in a warm dry area overnight and place the other pine cone in water for one hour (or overnight).
4. Look closely at the pine cone that was left in the dry environment. Can you see any seeds between the scales? Can you get any of the seeds to fall out?
5. Observe the pine cone that was left in water. In what way is it different from the dry cone? What causes pine cones to open and close?
- Place the fern frond on a white piece of paper (with the sori on the bottom). Leave for an hour (or overnight).
6. Observe the white paper on which the fern was left. What has fallen on it?

Discuss and explain

7. On the basis of your observations, compare the pine cones and seeds with the fern sori and spores in terms of their structures and how they could be dispersed (spread out) from the plant.
8. Mosses are tiny plants that grow in moist environments. Suggest why they (a) grow in these locations and (b) are such tiny plants.
9. On the basis of your observations, suggest the benefits of weeds producing flowers and being made up of stems, leaves and roots.
10. For each plant observed, identify a structure with a function that helps the plant survive in the environment in which it lives.

3.11.2 The language of plants

Plants can be described using different words, depending on a person's purpose. For example, in describing a bottlebrush tree:

- a scientist would refer to its correct botanical name as *Callistemon citrinus* and say it belonged to the angiosperm or flowering plant group
- a gardener might say 'I planted a new tree called a bottlebrush'
- a horticulturalist would tend to use both scientific and common names.

Words used to describe groups of plants

Scientific term	Common name
Bryophytes	Mosses and liverworts
Pteridophytes	Ferns
Angiosperms	Flowering plants
Gymnosperms	Conifers
Tracheophytes	Plants with stems

Gardeners use words like 'tree', 'shrub', 'herb' and 'grass' to describe groups of plants. To a scientist, a tree could belong to the angiosperm or gymnosperm group. A scientist would carefully examine the characteristics of the plant to find out whether it had flowers,

A bottlebrush flower

seeds and fruit, or cones containing seeds. The scientific names for individual plants and groups of plants are more specific than the common names.

WHAT DOES IT MEAN?

The prefix *gymno* comes from the Greek word *gymnos*, meaning 'naked'; *angio* comes from the word *angios*, meaning 'vessel'; *phyton* comes from the word *phyton*, meaning 'plant'; and *pterido* comes from the word *pteron*, meaning 'feather'.

3.11.3 Evergreen quest

Have you ever grown a herb garden — your own 'evergreen quest'? Many believe that the use of herbal remedies to treat simple ailments is as old as the human race itself. From early hunting and gathering times, humans have had a close relationship with plants as sources of both food and medicine. Ancient civilisations of Egyptians, Chinese, Persian, Greeks and Romans all practised herbalism.

The herbs (and spices) in your kitchen could have medicinal properties — do you know what effects they might have on you?

Grow your own

Try growing these common herbs in your own garden or planter box.

- Thyme is used to make tea for treating stomach cramps, indigestion, colic and gas retention.

- Lemon thyme smells and tastes like lemon. A few sprigs of lemon thyme in boiling water can make refreshing herbal tea. It is also useful for treating asthma and coughing, and is considered great for boosting your immune system.

- Sweet basil (such as Greek basil) has tiny leaves with a spicy fragrance. Basil is best eaten fresh, rather than dried, and goes well with tomato-based dishes. It also helps digestion and relieves constipation.

- Dill is valued for its leaves in spring and its seed in autumn. Its flowers are pale yellow and stems grey-green. Dill is added to soups and fish dishes to enhance their flavour. It has also been used as a hair restorer, and as a tea for digestive ailments and to help relieve flatulence.

- Lemon balm is fabulous in salads and refreshing in iced tea. Its healing properties include promoting the relief of tension and restlessness. It also soothes toothache and headaches and relieves stomach-aches, indigestion and heartburn. Freshly crushed leaves have been used to soothe and cleanse wounds.

- Rosemary can be added to roast potatoes and garlic for a tasty feast. Oil extracted from the leaves and flowers is also used for stomach complaints, gas retention and cramping muscles and limbs — and for aromatic baths.

- Parsley (such as Italian parsley) is rich in vitamins A and C. A brew made from the roots is recommended in all ailments of the digestive and urinary tracts. Freshly crushed leaves are also used as a compress for insect bites. Although parsley is often used as a garnish, tabouli is an example of a food made mainly from parsley.

3.11.4 Plants beware

History is full of myths and stories about the 'magical' — and sometimes supernatural — properties and uses of plants, and about plants that carry out unusual 'unplant-like' activities. Some of these stories contain elements of truth.

HOW ABOUT THAT!

Don't get edible parsley mixed up with fool's parsley, which may look similar but can be poisonous. It can be distinguished from parsley by crushing its leaves, which give an offensive, nauseating odour resembling the stench of mouse droppings!

Witchcraft, superstition and customs

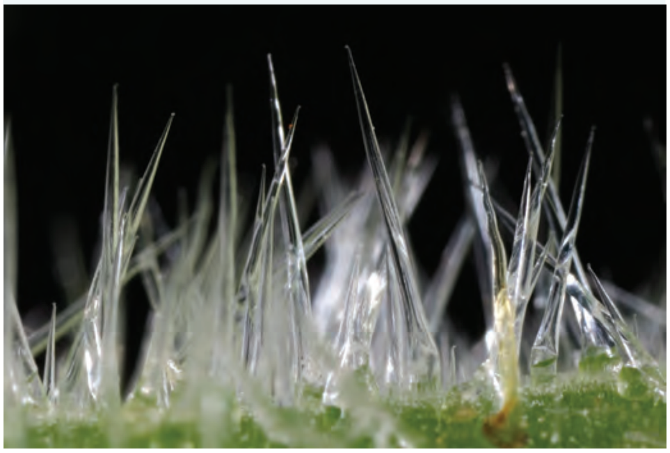
For hundreds of years, some plants have been associated with witchcraft and superstition. For example, the four-leaved form of clover (*Trifolium repens*) that is occasionally found has been considered to be a token bringing good luck. Another type of clover, *Trifolium pratense*, was thought to guard against witchcraft. In some cultures, people once used garlic (*Allium sativum*) to protect them against witchcraft and sorcery; some even added it to animal foods to protect them against evil.

Plants that get on our nerves

Inhabitants of tropical forests used some plants to make arrow poison. In Asia and South America, some species of the genus *Strychnos* were used to obtain arrow poison from their roots and bark. The poison used on the arrows was curare. Although a person hit with a poisoned arrow could still think and sense things for quite some time, organs involved in movement would gradually fail to function. In the end, the person's ability to speak would disappear, followed by the lack of movement in other areas (such as the face) and, finally, death.

Another type of plant with a sting is the giant stinging tree (*Dendrocnide excelsa*), which has large heart-shaped leaves covered with fine stinging hairs. It is commonly found in the rainforests of Queensland and New South Wales. Merely brushing against its leaves can result in a severe burning sensation that may persist for several months. Some people suggest that the juice of cunjevoi lilies (*Alocasia macrorrhizos*), squeezed over the stings, will relieve the stinging.

Stinging hairs covering the leaves of a giant stinging tree



Plants of prey

Some plants found in nitrogen-deficient soil 'eat' insects to supplement their nitrogen. Attracted by the smell of food and a safe landing place, insects can be lured into plants that are not what they seem. The Venus flytrap (*Dionaea muscipula*), for example, has a special trap with a hinged lid. As soon as an insect touches the trigger bristles on the trap's upper surface, the trap springs shut. The insect is then trapped in a cage-like prison. Acids and special substances called enzymes are secreted from the plant. These slowly break down the soft parts of the insect's body. It may take the Venus flytrap two weeks to fully digest a damselfly. When the trap reopens, the insect's hard exoskeleton, including its wings, is blown away by the wind.

Sundews (*Drosera* spp.) are another group of insect-eating plants, of which there are more than 50 different species in Australia. The upper part of the leaf is covered with thin red tentacles that are covered in a sticky substance. If an insect touches the tentacles, they bend inwards and trap it. The body of the trapped insect is then digested.

A Venus flytrap

A sundew is covered in a sticky substance.

3.11 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Make a table to summarise the characteristics of bryophytes, pteridophytes, angiosperms and gymnosperms. Include the headings shown below.

Name of group	Where found	Type of stem	Flowers or no flowers	Seeds or spores	Other information	Examples
Bryophytes						

2. Use a table to summarise the information provided in this section. Use the headings 'Plant' and 'Interesting feature, characteristic or myth'.
3. Describe the advantages to plants of being able to catch and digest animals as well as to photosynthesise.
4. Match the scientific names to the common names:

(a) *Dendrocnide excelsa*	Garlic
(b) *Allium sativum*	Clover
(c) *Dionaea muscipula*	Four-leaved clover
(d) *Trifolium repens*	Venus flytrap
(e) *Trifolium pratense*	Stinging tree

Think

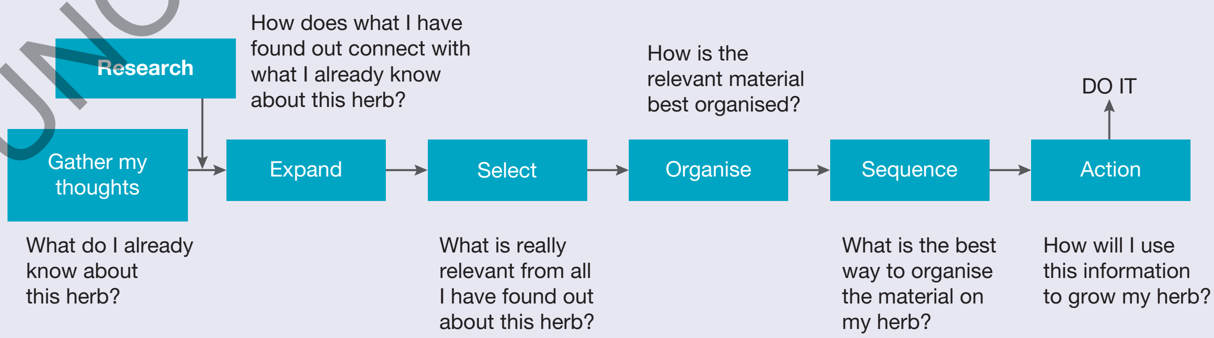
5. Design a key that uses the following features, in the order given below, to separate ferns, mosses and liverworts, conifers and flowering plants.
    - Seeds or no seeds
    - Seeds in cones or seeds in flowers
    - Stem or no stem
6. Make a list of 10 plants you already know. To which plant group does each belong?
7. Suggest what advantage it gives to plants to sting.
8. Construct a crossword using the information in this section.
9. Suggest why the inner surface of the leaves of a Venus flytrap has both nectar-producing glands and digestive glands.

Investigate

10. Design a key to help a gardener tell the difference between trees, shrubs, herbs and grasses. Ask at least five people to test your key.
11. (a) Find three examples each of a tree, shrub, herb and grass. Observe and record five characteristics for each of these plants.
    (b) Using your observations, decide which scientific plant group each example belongs to.
    (c) Use field guides or keys to identify the plants you observed.
12. What does a taxonomist in a herbarium do? Why is this job important?
13. (a) In pairs, walk around your school grounds and select ten plants.
    (b) Draw a sketch of each and add as many details as you can next to your diagram.
    (c) Construct a key to organise these plants into groups.
    (d) Use field guides and the internet to find out the identity of these plants.
    (e) Combine your data with that of other groups in your class and use it to construct a plant field guide and key for your school grounds.
14. Brainstorm with your team all the different plant names that you know. Select one of these and find out five interesting features to share with your team.
15. Find out the names and features of members of each of the plant groups that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.
16. Australia has about a thousand species of plants that are considered to be toxic to humans and our livestock. Of these, 60 per cent are natives. Investigate and report on an example of a toxic plant within each of these Australian plant families:
    (a) legumes (Fabaceae, Mimosaceae)
    (b) nightshades and tobaccos (Solanaceae)
    (c) buttercups (Ranunuclaceae)
    (d) cycads (Cycadaceae, Zamiaceae).
17. Find out the meaning of 'toxicology' and then find examples of Australian plant toxicology research.

Investigate, create and share

18. (a) Use the below figure to organise and record your research on a herb of your choice.
    (b) In the 'action' phase, use your information to set up an experiment to grow your herb.
    (c) Take photographs throughout your experiment and keep a journal to record all of your observations.



(d) Throughout your experiment, share and discuss your results with others growing the same herb and also with others growing different herbs.
(e) As a class or in groups, organise your observations into a summary that can be shared with another class.
(f) Find examples of four recipes (for food or herbal value) that use your herb.
(g) Select a recipe to use some of the herb that you have grown to demonstrate the importance and value of your herb.

Investigate, design and share

19. (a) In your workbook, or using a computer, construct a table with the following headings.
    - Herb
    - Genus or species
    - Description of useful plant part
    - Beneficial effects
    - Other details

    (b) Complete the table with details on the following herbs, using the information in this section and your own research. In the 'Description' column, you could insert a photo or drawing of the herb.
    (i) Peppermint (*Mentha piperita*)
    (ii) Sweet basil (*Ocimum basilicum*)
    (iii) Borage (*Borago officinalis*)
    (iv) Thyme (*Thymus serpyllum*)
    (v) Rosemary (*Rosmarinus officinalis*)
    (vi) Parsley (*Petroselinum sativum*)

    (c) Reformat your table into a visual map and share it with others in your group.
    (d) Add relevant information from others in your group to your map.
    (e) Select one of your herbs and find a recipe that uses it. When at home, make the food with the herb, take photographs and record your experience. Share your photographs and comments with other students.

Think and create

20. Summarise the information on the herbs described in this section into a mind map.
21. All blackberry plants should be destroyed. Is there a scientific basis for this claim? To help you evaluate this claim, construct a PMI chart on research relating to blackberry plants.

learnon RESOURCES — ONLINE ONLY

Watch this eLesson: Growing plants in Australia
This video lesson is presented by a top Australian horticulturist and will provide you with tips for growing plants successfully.
Searchlight ID: eles-0055

3.12 Gumnut babies

Science as a human endeavour

When you were young, did you read about the adventures of the Gumnut Babies, Snugglepot and Cuddlepie? They lived in the Australian bush and were constantly bothered by the Big Bad Banksia Man. Did you know they are based on real Australian plants?

May Gibbs was the creator of Snugglepot and Cuddlepie. She was inspired by our Australian bush.

The Gumnut Babies Snugglepot and Cuddlepie

3.12.1 Eucalyptus

The genus *Eucalyptus* includes gums, stringybarks, peppermints, boxes, mallees, ironbarks and ashes. Of the 800 species, all but 13 are endemic to Australia. Snugglepot and Cuddlepie, the Gumnut Babies, were inspired by the flowers of this group of plants.

The Banksia Man is based on the *Banksia* follicle, which is a woody, cone-like structure that develops after a *Banksia* flowers.

The flowers of a eucalypt

A *Banksia* flower

An example of the flower structure of a *Grevillea*. There are more than 360 species of *Grevillea*.

A *Hakea*

3.12.2 Proteaceae

Not all flowers have soft bright ribbon-like petals. You may not even recognise the flowers of many of our native Australian plants.

The early landmass Gondwana was the centre of the origin of the family Proteaceae and it is in Australia that this family has the greatest diversity. This group includes banksias, grevilleas, hakeas, macadamias and waratahs. Many of these have roots that are very efficient at absorbing water and nutrients and they are often able to grow in soil that may be deficient in nitrogen and phosphorus.

3.12.3 Inspiration for *Banksia*

The genus *Banksia* was named in honour of Sir Joseph Banks (1743–1820), the first European to collect *Banksia* specimens. Of the 76 species of *Banksia*, all but one is native to Australia. All members of this genus have distinctive flower clusters or spikes. Each of these spikes is made up of hundreds (sometimes thousands) of tiny individual flowers with long, stiff projecting styles. Once fertilised, the outer parts of the flower die off and the fruit body develops into a hard, woody cone-like structure called a follicle. The seeds within these fruits are protected from foraging animals and fire. In many species, the seeds are not released until they are completely dried out or burnt.

Macadamia flowers and nuts

There are only five species of *Telopea*, commonly known as waratah.

3.12 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. List four Australian members of the Proteaceae family.
2. Recall who the *Banksia* genus is named after.
3. Describe the fruit and flowers of the *Banksia*.
4. List four Australian examples of the *Eucalyptus* genus.
5. State which type of plant Snugglepot and Cuddlepie, from May Gibbs's stories, were inspired by.

Investigate

6. Each Australian state and territory has its own floral emblem. Research:
   (a) the key features of each plant
   (b) why these plants were selected
   (c) any scientific research or interesting information.
   Present your findings in a visual, colourful and entertaining format to advertise each state or territory.

Floral emblems of Australia

State Australian Capital Territory
Common name Royal bluebell
Scientific name *Wahlenbergia gloriosa*

State New South Wales
Common name Waratah
Scientific name *Telopea speciosissima*

State Victoria
Common name Common heath
Scientific name *Epacris impressa*

State Queensland
Common name Cooktown orchid
Scientific name *Dendrobium phalaenopsis*

State Northern Territory
Common name Sturt's desert rose
Scientific name *Gossypium sturtianum*

State Tasmania
Common name Tasmanian blue gum
Scientific name *Eucalyptus globulus*

State South Australia
Common name Sturt's desert pea
Scientific name *Swainsona formosa*

State Western Australia
Common name Red and green kangaroo paw
Scientific name *Anigozanthos manglesii*

7. Find out who each of these Australian plants were named after and why they received these names.
   (a) Waratah
   (b) Proteus
   (c) Grevillea
   (d) Hakea
   (e) Banksia
8. On your own or in a team, write your own story, poem or play about our native flora.
9. Select two examples of Australian plants. Research and report on the history and importance of these plants.
10. Who was May Gibbs? Why did she include Australian plants in her stories?
11. Research a variety of Australian plants and create your own picture-book story. Have a book launch and invite friends, family and students from other year levels.
12. Investigate and report on Australian research into Australian plants.

3.13 Plants no more!

Algae, fungi and lichen were once considered the most primitive plants on Earth. These organisms do not produce flowers or seeds, nor do they have roots, stems or leaves. On the basis of current information, many biologists no longer consider them plants.

While most of these organisms are harmless to humans and other animals, some are not. For example, some fungi can cause disease and blue-green algae can poison water supplies.

Giant kelp (seaweed) is an alga.

3.13.1 Algae

Characteristics:

- All live in water
- Often unicellular
- No true roots, stems, leaves or flowers
- No special tissue for transporting food or water
- Divided into groups depending on their colour
- Make their own food using photosynthesis

Examples: diatom, *Euglena*, Neptune's necklace, sea lettuce

Not all mushrooms are safe to eat! Some mushrooms and toadstools can be poisonous.

3.13.2 Fungi

Characteristics:

- No true roots, stems, leaves or flowers
- Usually multicellular; some unicellular
- No chlorophyll and unable to make their own food
- Usually obtain their food from other living or dead organisms
- Produce enzymes that break down food outside their cells
- Broken-down food is absorbed through their cell walls

Examples: yeast, mould, mushroom, toadstool

Several types of lichen may grow together.

3.13.3 Lichens

Characteristics:

- Found on bare rocks, bark of trees, in cold polar regions and on mountain tops
- No true roots, stems, leaves or flowers

- Made up of two different organisms: an alga and a fungus
- Algal cells live among tiny fungal threads
- Algal cells photosynthesise and supply the fungus with food
- Fungus provides protection and anchorage for the algal cells
- Grow very slowly and are extremely long-lived
- Often responsible for breaking down rocks, allowing other organisms to grow

The key below can be used to separate algae, fungi and lichens from plants.

1a	No roots, stems, leaves or flowers	Algae, fungi and lichens
1b	Distinct leaves: with or without roots or flowers	Go to 2
2a	No true roots or flowers	Bryophytes
2b	True roots: with or without flowers	Go to 3
3a	No flowers or seeds, reproduce by spores	Pteridophytes
3b	Seed-bearing plants	Go to 4
4a	Seeds in cones	Gymnosperms
4b	Seeds produced in an ovary/flower	Angiosperms

Penicillin, from the fungus *Penicillium chrysogenum*, was first used successfully in 1941 to treat an infection caused by a bacterium. This antibiotic is used to treat many formerly fatal diseases.

Better dry between your toes or you may get the fungal infection athlete's foot (*Tinea pedis*).

Mushrooms are fungi we eat; and yeasts are very important in making bread and wine.

3.13 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Construct a table that summarises the characteristics of lichens, algae and fungi.

Think

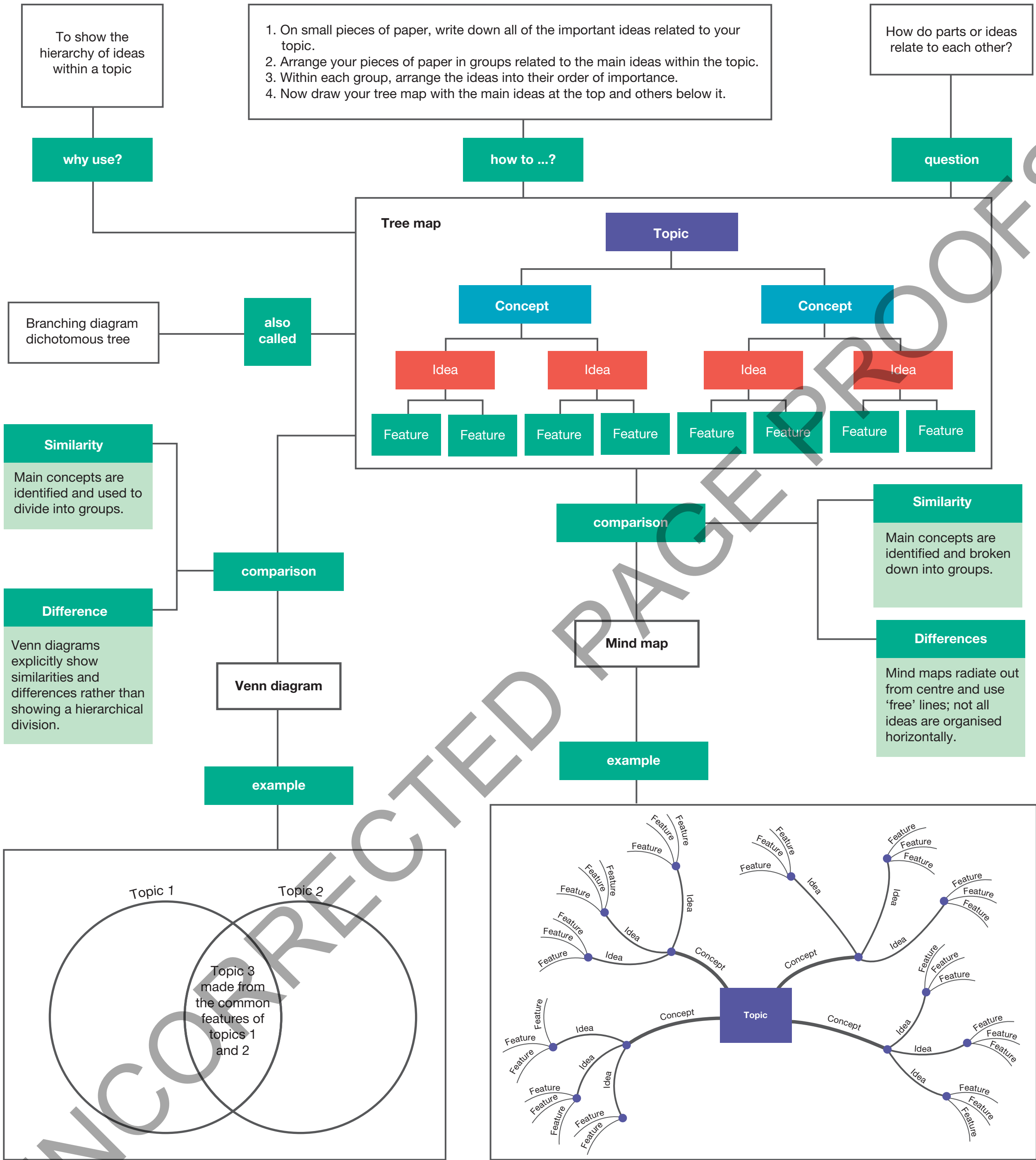
2. Construct a key to divide lichens, algae and fungi into separate groups.
3. Use your coloured thinking hats (see page 42) to describe your thinking on whether lichens, algae and fungi should be classified as plants.
4. Suggest reasons why lichens, algae and fungi were once classified as plants.
5. Which, if any, of these organisms do you think are most like plants? How?
6. If you were a biologist, would you classify any of these as plants? Why?
7. Within a group, prepare and then present a debate to the class on whether lichens, algae and fungi should be included in the plant kingdom.

Investigate

8. Look up lichens, algae and fungi in at least three different biology books and record whether they are classified as belonging to the plant kingdom or to a different group. Try to find at least one biology book published before 1980. Why have ideas about the classification of lichens, algae and fungi changed? Use your data to complete the table below.
9. Find out which features are used to classify fungi.
10. What are slime moulds? Describe their characteristics. Into which kingdom would you classify them?
11. Design an investigation, using slices of bread, to find out which conditions are best suited to growing moulds.
12. Find out more about the discovery of penicillin and the influence it has had on medicine and disease. Present your findings as a newspaper report, PowerPoint presentation, cartoon, poem or song.
13. What are the symptoms of tinea? How do you get it and how can it be prevented and treated? Present your findings in a concept map.
14. Find out the names and features of members of each of the groups algae, fungi and lichen that can be found in Australia and create new *Cryptonym* cards. Play the *Cryptonym* game (refer to Investigation 3.3 for instructions) with your new set of cards.

Reference title	Date published	Lichen grouping	Fungi grouping	Algae grouping
e.g. Text A	1983	Plant kingdom	Plant kingdom	Plant kingdom
e.g. Text B	1990	Fungi kingdom	Fungi kingdom	Protoctista kingdom

3.14 Tree maps, mind maps and Venn diagrams



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3.15 Project: Snakes alive!

3.15.1 Scenario

Every year in Australia, an average of around 4000 people are bitten by snakes. Some of these snakes are non-venomous and their bite results in little more than a nasty wound, but many are venomous with a bite that is deadly unless medical intervention can be reached in time — in fact, Australia has more venomous snake species than any other country in the world! You can encounter a snake just about anywhere — on bushwalking trails, in your back garden, in a shed, even swimming in the ocean — so it is really important that you know what kind of snake you are looking at.

3.15.2 Your task

Your group has been approached by State Parks and Wildlife to create a Snake Safety brochure, copies of which will be sent out to all bushwalking clubs and National Park centres in your state for distribution to bushwalkers, campers and nature lovers. The main part of the brochure will be an easy-to-follow identification key that allows the reader to quickly and easily determine the species of snake they have encountered and so learn whether it is venomous or non-venomous. The brochure will also contain a diagram indicating on a state map where different venomous species are usually found, as well as advice on what to do if you encounter a snake and what first aid you should render if someone is bitten by a venomous or non-venomous snake. You may also like to include some interesting snake statistics, or a Snake Fact or Fiction section.

3.15.3 Process

Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group. You can complete this project individually or invite other members of your class to form a group. Save your settings and the project will be launched.

3.16 Review

3.16.1 Diversity of living things: classification

- state the difference between 'unicellular' and 'multicellular'
- explain why biologists classify living things
- describe the hierarchy of biological classification
- distinguish between the five kingdoms
- use hierarchical systems to classify organisms into groups
- define the term 'taxonomy'
- describe the binomial system of nomenclature
- use scientific conventions for naming species
- explain how structural features can be used to classify organisms into groups
- use simple taxonomic dichotomous keys to identify, sort and name organisms
- interpret and design dichotomous keys to classify organisms
- classify vertebrates based on their characteristics
- classify invertebrates into groups using a dichotomous key
- distinguish between the following groups of organisms: vertebrates and invertebrates; placental, monotreme and marsupial mammals; different classes of arthropods; different types of insects; different plant phyla; prokaryotes and protoctistans; fungi, algae and lichens; prions, viroids and viruses
- provide examples of Australia's unique flora and fauna
- suggest why biological classifications have changed over time

3.16.2 Current issues, research and development

- describe the patterns and history of naming organisms
- describe research and discoveries by Australian scientists in the field of taxonomy
- describe examples of collaborative transnational Antarctic scientific research
- outline issues relevant to the patenting of living organisms

Individual pathways

ACTIVITY 3.1	ACTIVITY 3.2	ACTIVITY 3.3
Classification	Further classification	Developing biological classification
doc-6051	doc-6052	doc-6053

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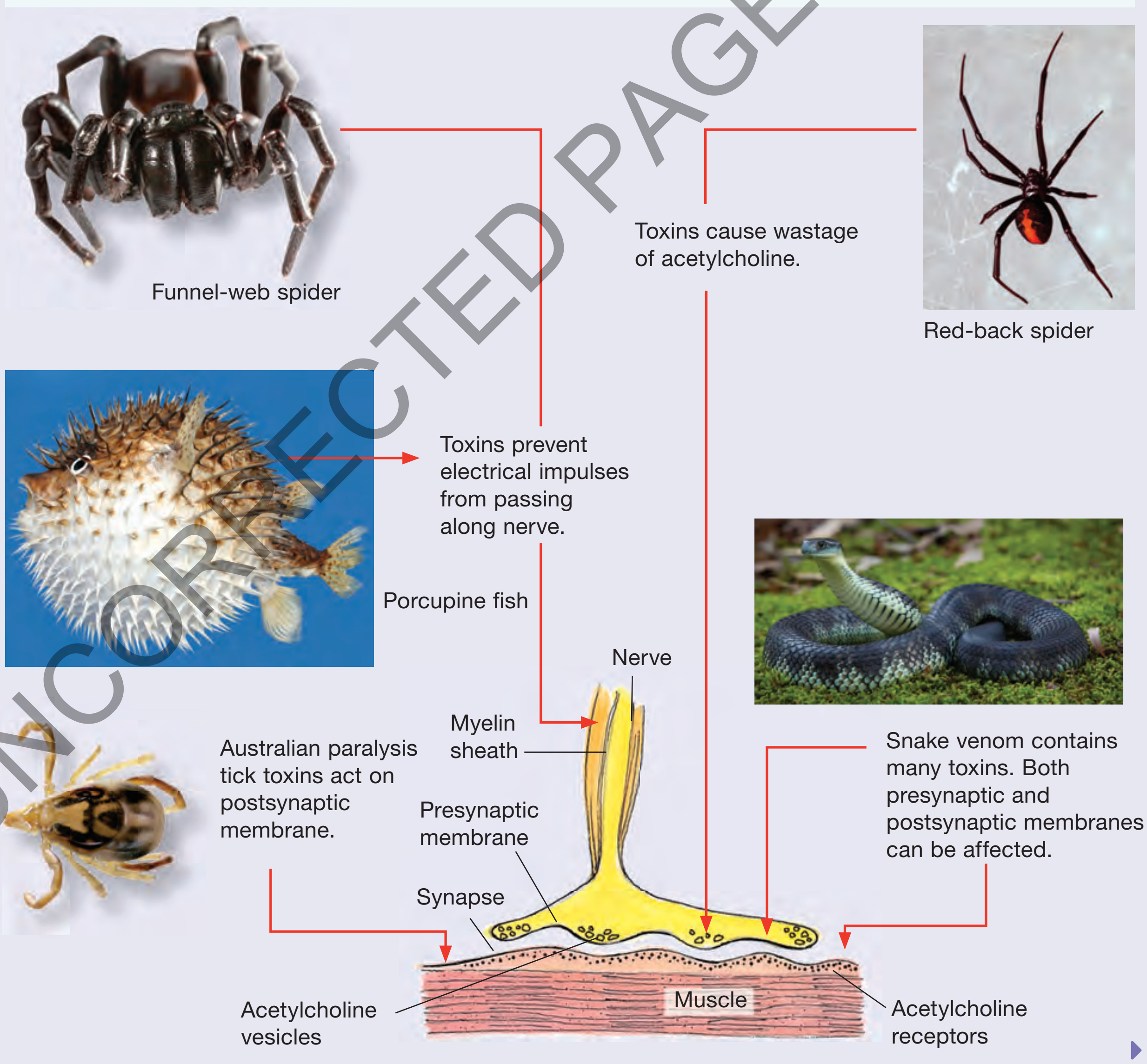
3.16 Review 1: Looking back

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

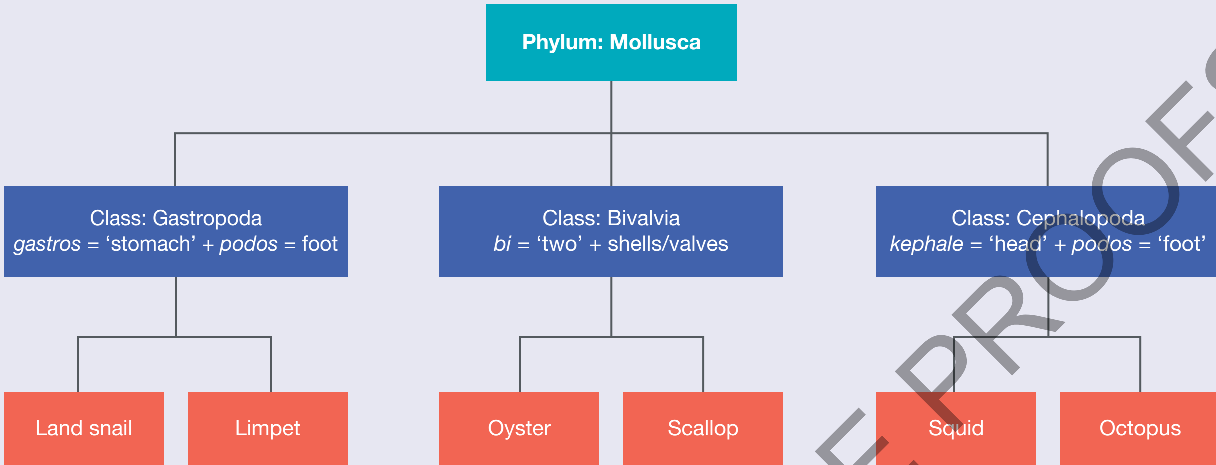
1. The figure on next page shows examples of some Australian animals.
   (a) Carefully observe and record the features of each organism. Discuss your observations with your partner and add any missing from your list. Record your observations in mind maps, tables or annotated diagrams.
   (b) Identify each of the organisms in the figure as a vertebrate or an invertebrate. Justify your responses.
   (c) Did you find any of the specimens difficult to identify? If so, suggest questions or details that would assist you in making a decision.

(d) On your own or with a partner, construct a dichotomous key that would enable you to identify each specimen.
(e) Use the details that you have recorded to suggest the following levels of classifications (and more if you can) for each animal.
    (i) Kingdom
    (ii) Phylum
    (iii) Class
(f) List the types of questions that were most useful in your research for part (e).
(g) Select one of the animals and research:
    (i) other features that could be used to identify it
    (ii) the name of a particular species that belongs to this group
    (iii) the effects of the toxin that it produces.
    Prepare a poster, brochure, PowerPoint presentation or animation that enables you to present your findings to the class.
(h) Investigate and report on an example of research in which the Australian Venom Research Unit (AVRU) is involved.
(i) Imagine that you are a scientist on an expedition to discover new organisms. Create a diary (including annotated diagrams of your findings). Prepare newspaper and journal articles to communicate your discoveries to the world.

Some Australian animals produce toxins that can interfere with our nervous systems.



2. Using your own knowledge and the information provided in the diagram below, construct Venn diagrams about:
   (a) a land snail and an octopus
   (b) an oyster and a squid
   (c) a limpet and an oyster.



3. (a) Suggest which two of the organisms shown below are most closely related.
   (b) Give a reason for your suggestion.
   (c) The common names for these plants are: borage, pincushion flower, fennel, spearmint, primrose, coltsfoot and peppermint. With your partner, try to match the common names of these plants with their scientific names.
   (d) Find out more about these plants and how they are classified into their groups.

Borago officinalis

Mentha piperita

Primula officinalis

Mentha spicata

Tussilago farfara

Scabiosa columbaria

Foeniculum officinale

WARNING ON JELLY INVASION

Holly Lloyd-McDonald
Herald Sun

JELLYFISH have invaded bayside beaches, with 22 children stung yesterday.

And with a hot Labour Day long weekend ahead, emergency services and the Melbourne Aquarium have warned swimmers to be on the lookout.

Seventy-six students from Chelsea Heights Primary School were at Chelsea Beach for the end of a week-long beach awareness program when students started to complain of itching and stinging.

As the Grade 6 students were ferried back to the Wells Rd campus, 22 of them fell ill with nausea and lethargy.

Principal Danny Mulqueen said paramedics were called and the school's first aid plan was implemented, with critical and non-critical patients separated.

'Young kids were stung and sore, and others get distressed too when they see them,' Mr Mulqueen said.

Metropolitan Ambulance Service group manager Andrew Watson said three ambulances were sent but there were no serious injuries.

Melbourne aquarium aquarist David Donnelly said the culprits were blue blubber jellyfish. The jellyfish has a pale blue tinge, short stumpy tendrils and a big head, or bell.

Mr Donnelly said a 'smack' — the collective noun for jellyfish — of the species, which he numbered in their thousands, had been pushed into the bay in recent weeks by currents and huge krill production in northern Bass Strait.

A concerned bayside resident who walks his dog on Melbourne's southeastern beaches also contacted Melbourne Aquarium yesterday to report foreshores studded with dead blubbers.

'If people leave them alone they won't get stung — but it's a mild tingle and uncomfortable, and it subsides quickly,' Mr Donnelly said.

'The best thing to do is to wear stockings, although I'm not sure how men would feel about that!'

Up to six different species of stinging jellies can reside in the bay at any time, with blue blubbers likely to stay from three days to three weeks.

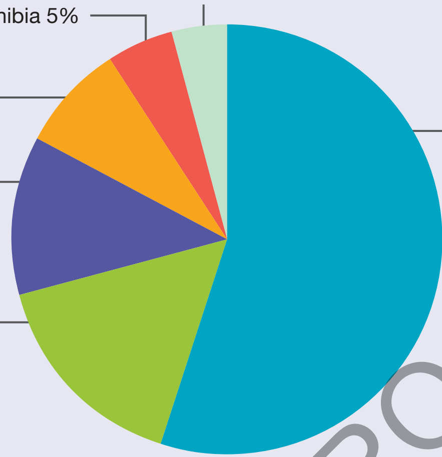
Mr Donnelly warned beachgoers not to touch any dead stingers because their tentacles could still pack a punch.

'My opinion is the blubber sting is low-risk with no serious adverse reactions.'

The marine expert recommended Stingose to ease the impact of the tingles, and paramedic Mr Watson recommended washing affected areas with clean water.

'Just keep an eye out and consult a doctor if the symptoms persist,' he added.

4. Read the article ‘Warning on jelly invasion’ above and answer the following questions.
   (a) List some of the symptoms that the students swimming in bayside beaches complained of.
   (b) Name the type of jellyfish that stung the students.
   (c) What does the jellyfish look like?
   (d) What is the collective noun for a group of jellyfish?
   (e) How many jellyfish had been pushed into the bay?
   (f) What does the article suggest as the reason for increased numbers of jellyfish?
   (g) How many different species of jellyfish may be found in the bay at any one time?
   (h) Describe ways to prevent getting stung and how stings could be treated.



5. The pie chart on the right shows some of the different kinds of vertebrates.
   (a) State which are in greatest abundance.
   (b) Recall the name of:
      (i) a primitive vertebrate
      (ii) a fish
      (iii) an amphibian
      (iv) a reptile
      (v) a bird
      (vi) a mammal.
   (c) Construct a mind, concept or tree map to show how these vertebrates are different.

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Complete this digital doc: Worksheet 3.13: Summing up
Searchlight ID: doc-19811

Complete this digital doc: Worksheet 3.14: Crossword
Searchlight ID: doc-19812