PEARSON

Science

STUDENT BOOK | VICTORIA

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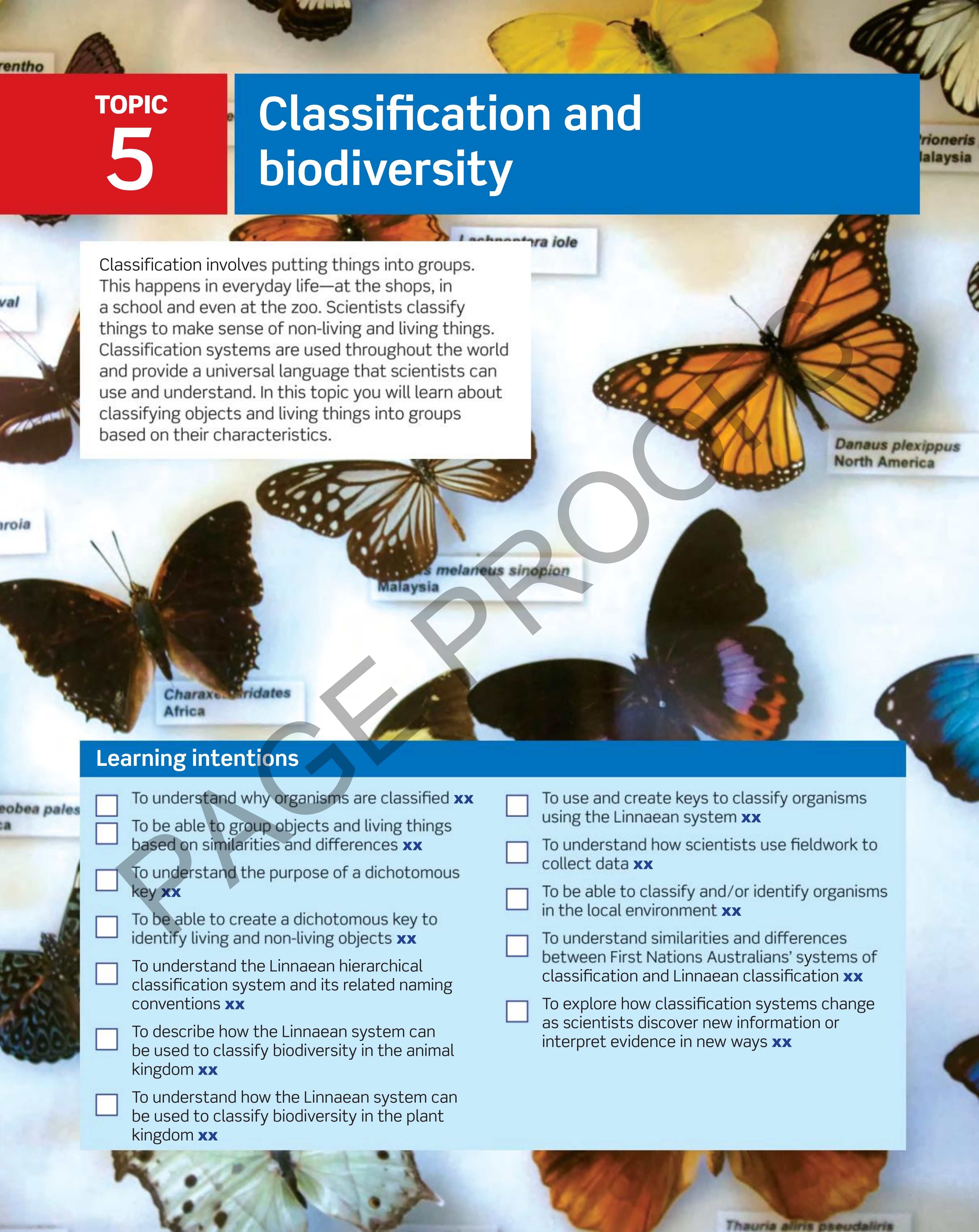


TOPIC 5 Classification and biodiversity

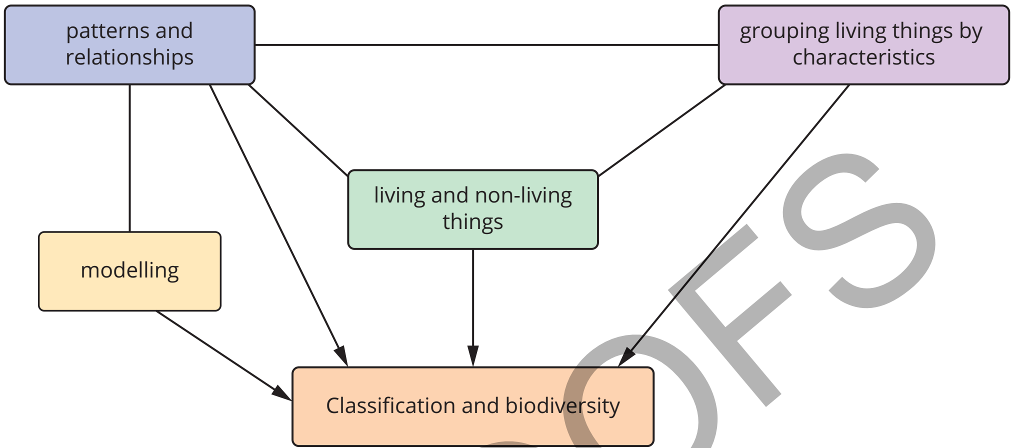
Classification involves putting things into groups. This happens in everyday life—at the shops, in a school and even at the zoo. Scientists classify things to make sense of non-living and living things. Classification systems are used throughout the world and provide a universal language that scientists can use and understand. In this topic you will learn about classifying objects and living things into groups based on their characteristics.

Learning intentions

- ☐ To understand why organisms are classified **xx**
- ☐ To be able to group objects and living things based on similarities and differences **xx**
- ☐ To understand the purpose of a dichotomous key **xx**
- ☐ To be able to create a dichotomous key to identify living and non-living objects **xx**
- ☐ To understand the Linnaean hierarchical classification system and its related naming conventions **xx**
- ☐ To describe how the Linnaean system can be used to classify biodiversity in the animal kingdom **xx**
- ☐ To understand how the Linnaean system can be used to classify biodiversity in the plant kingdom **xx**
- ☐ To use and create keys to classify organisms using the Linnaean system **xx**
- ☐ To understand how scientists use fieldwork to collect data **xx**
- ☐ To be able to classify and/or identify organisms in the local environment **xx**
- ☐ To understand similarities and differences between First Nations Australians' systems of classification and Linnaean classification **xx**
- ☐ To explore how classification systems change as scientists discover new information or interpret evidence in new ways **xx**

5 Classification and biodiversity

The key concepts that you will use in this topic:



The following prior knowledge questions will help to support your learning in the topic and can be attempted before the first lesson.

Living and non-living things

1 Identify one characteristic that would classify something as being ‘living’.

Grouping living things by characteristics

2 Explain how a butterfly, a caterpillar and a honeybee could be classified according to how they move.

3 Compare the terms invertebrate and vertebrate, using examples.

Identifying patterns and relationships

4 The African Elephant lives in Africa while the Asian Elephant lives in Asia. Based on their physical features, how might early scientists have predicted that these two organisms were related?

Using models to represent data and observations

5 Aboriginal and Torres Strait Islander people classify some plants based on whether they can be food or medicine. Describe an advantage of this classification model.

5.1 Introduction to classification

Lesson overview

Classification is an important concept in science. It is easier to understand when you think about how you organise and locate items in your daily life. Just as files on a computer are sorted or books in a library are categorised, scientists use systems to organise a vast range of objects and substances based on specific criteria.

Imagine strolling through a supermarket where goods are neatly arranged into aisles and shelves. This simplifies the task of finding the product you are looking for. Classification in science is like how the aisles and shelves are organised, as it helps scientists work out the complex relationships among species to simplify the study of the diverse planet.

In this lesson, you will gain a deeper understanding of classification systems in science and their critical role in identifying the many living things on Earth.

Learning intention

To understand why organisms are classified

Success criteria

SC 1: I can describe the role of classification of biodiversity on Earth.

SC 2: I can describe at least two reasons for classifying the diversity of life on Earth.

SC 3: I can suggest how classification systems are affected by cultural perspectives and world views.

SC 1 I can describe the role of classification of biodiversity on Earth

Classification is used by humans to group things in their everyday lives so that they can make sense of the relationships and connections between them. Scientists, for example, study the **diversity** of living things by grouping them according to similar **characteristics**.

The first person to suggest a classification system for life on Earth was Carl Linneaus, who lived in the 1700s. His approach described the relationships between living things and their environment with a focus on plants. Still used today, the Linnaean system organises living things into different levels or **hierarchies,** although there have been many adjustments made to it over time.

Look at some of the other classification systems used across the sciences and think about the ways that different patterns and features are used to group a wide range of things.

KEY TERMS

characteristic a feature of a living or non-living thing
classification the process of putting things into groups
diversity the variety of differences
hierarchy an arrangement that shows items at different levels compared to others
state one of the three forms that matter can exist in—solid, liquid or gas

Chemists

Chemists classify substances based on their structure, colour and the **state** that they occur in at room temperature. For example, oxygen and carbon dioxide are gases, mercury is a liquid, and metals such as magnesium and iron are solids (Figure 5.1.1).

FIGURE 5.1.1 Left: Magnesium is classified as a metal because of its properties including colour, shininess, strength and ability to conduct electricity; Right: Although mercury is a metal, at room temperature it is liquid rather than solid

Astronomer

There are differences between stars, planets and comets that enable astronomers to classify new 'heavenly bodies' when they encounter them (Figure 5.1.2). For instance, stars are massive, glowing spheres of hot gas that produce their own light, while planets are smaller objects that orbit stars, like Earth in the solar system.

Geologists

Geologists classify rocks according to characteristics such as colour, hardness and the way they are structured (Figure 5.1.3). Igneous rocks are formed from molten magma cooling and solidifying deep within the Earth, and these rocks often have a coarse texture. Sedimentary rocks are created when layers of sediment, like sand or mud, compact and harden over time, often producing a layered appearance.

FIGURE 5.1.2 Astronomers track celestial bodies, such as Halley's comet which will pass by Earth in 2061.

FIGURE 5.1.3 Geologists sorting rock and mineral samples according to colour

Biodiversity is the word used to describe the huge variety of life on Earth. As in the examples of other fields of Science above, patterns and features are also used to classify **organisms** within this huge variation. By classifying organisms into groups at multiple levels, scientists can better understand the survival and behaviour of living things.

KEY TERMS

biodiversity the number and range of species that exist in an ecosystem

organism a living thing

SC 1 CHECK YOUR UNDERSTANDING

Define the term 'classification' in the context of biodiversity.

SC 2	I can describe at least two reasons for classifying the diversity of life on Earth.

There are millions of different living things on Earth. To make the study of lifeforms more manageable, scientists divide them into smaller groups. These groups are organised or 'classified' based on the features, patterns and behaviours that organisms share; for example, if they have fur or scales, smooth leaves or spiky leaves, or lay eggs versus give birth to live young (Figure 5.1.4).

FIGURE 5.1.4 Classification systems can be applied to all living things on the planet

Classification is used by biologists to:

- name new species
- compare characteristics of new species to current or extinct species
- study how organisms are connected or related to each other
- create a universal language for scientists to use that is standard across the globe to share their findings
- explore new understandings of species.

The need for a system

Common names and **scientific names** are crucial for identifying and classifying species in biology. Common names, given by the public, vary across regions and reflect local perspectives. By contrast, scientific names offer a standardised global system, removing any confusion with common names across the globe.

Many living things are known by their common names in different countries, which can become confusing if these names suggest a link between species where none exists. The examples in Table 5.1.1 each use 'bobtail' in their common names, though they belong to very different species.

TABLE 5.1.1 These animals that have 'bobtail' in the common name are not the same species.

Bobtail lizard	Bobtail squid	Japanese bobtail cat
		
The Bobtail lizard is also known as a skink or stumpy tail. The tail of the Shingleback skink (*Tiliqua rugosus*) resembles its head, thus confusing predators.	The Atlantic bobtail squid (*Sepiola atlantica*) gets its name from the distinctive shape of its body, specifically its short and rounded back end, which resembles a bobbed tail.	Unlike many other cat breeds that have long, flowing tails, the Japanese bobtail cat (*Felis catus*) has a short, often kinked or curved tail.

SC 2 CHECK YOUR UNDERSTANDING

List two reasons why scientists classify the species in Biology.

SC 3 I can suggest how classification systems are affected by cultural perspectives and world views

World views

The way people view the world, often described as a **world view,** is affected by a range of factors. These include **cultural perspectives** which inform peoples' thoughts and actions.

Western science is a relatively new world view. There also exists vast amounts of Indigenous Knowledge, often collectively learned through observation and experiment and communicated by oral traditions and other recording methods.

KEY TERMS

common name the name of an organism based on everyday language, can vary with location, language and culture

scientific name a Latin name for an organism based on the binomial system

HINT

Scientific names are always written in italics.

KEY TERMS

world view a way of considering the world in terms of attitudes, values and beliefs

cultural perspective way that an individual is affected by its environment, as well as social and cultural factors including race and gender

Western science approaches and ways of scientific working that are derived from European countries

KEY TERMS

culture a combination of the values, beliefs, language systems, communication, and practices that people share

Western system approach and way of working derived from European countries

ecosystem a system formed by organisms interacting with each other and their nonliving surroundings

cultural significance the special meaning or importance of traditions, customs, symbols, beliefs, art forms, or historical sites to a cultural group

spiritual importance the value of something that connects people to a force greater than themselves

FIGURE 5.1.5 Wurundjeri people of the Eastern Kulin nation have a deep understanding of bush tucker in the region. The kangaroo apple is toxic when it is green, but becomes edible once fully ripened.

Cultural perspectives

Throughout the world, indigenous peoples and **cultures** have different approaches to classifying living and non-living things commonly found in their environment. Instead of using **Western systems**, many categorise elements of the natural world based on their roles within the **ecosystem**, physical attributes, **cultural significance** or **spiritual importance**.

First Nations classification systems

First Nations Australians, for example, have developed intricate classification systems that align with their dietary, environmental, practical and spiritual contexts. Importantly, plants and animals are first classified according to whether they are edible or inedible (Figure 5.1.5). Natural elements such as water, celestial (sky and space) bodies, animals and plants may also be classified according to their spiritual meanings, often linked to specific social groups or tribes.

Traditionally, these classification systems have been important in performing tasks such as food gathering and water sourcing, but this knowledge of the land's physical features and seasonal variations is still transmitted across the generations through storytelling, cultural ceremonies and direct observation.

Classifying seasons

First Nations classification is guided by unique markers and changes in the environment – such as celestial events and the stages of the water, plant and animal cycles and behaviour – that signify when a particular season has started/ended.

Depending on their location, First Nations groups may recognise as many as six distinct seasons, or as few as two, in contrast to the four seasons defined by Western societies. These environmental cues also trigger seasonal adjustments in practices and behaviours. As for the naming of living things, this often involves providing descriptive markers to enhance understanding of the organism's characteristics and features.

The seasonal classification system used by the Wurundjeri people in the Eastern Kulin nation, that are the traditional land owners of the Yarra river region in Victoria is shown in Table 5.1.2. The land of this region is a cooler climate in comparison to other regions in Australia, so people of this land have a unique seasonal understanding.

Scifile

Emu in the sky

The Celestial Emu, or Emu in the Sky, is a constellation that can be used as a classification system by linking its position and visibility in the night sky to the breeding, hatching and nesting seasons of emus. This is then linked various seasonal and ecological events on Earth throughout the year.

TABLE 5.1.2 The seasonal classification system used by the Wurundjeri people of the Eastern Kulin nation, Victoria Australia

Biderap Dry Season	January and February. Hot and dry season, with average temperatures ranging from 13°C to 27°C and low rainfall.	Grasses are long and dry during this season which increases the risk of grassfires. Water sources start to reduce forcing Luk Eels to start migrating down the river.	 Common tussock grass, *Poa labillardieri*
luk Eel Season	March. Temperatures start to cool from Biderap season, but the rainfall is still low.	Luk (Eels) have matured in size and are ready to be caught for eating. Local gum trees are flowering. Cultural burning commences to reduce scrub to enhance the health and biodiversity of the land.	 Short-finned eels (*Anguilla australis*)
Waring Wombat Season	April – July. The temperatures are the coldest for the year, particularly in the mornings and late evening. Frost has even started in some areas. Rainfall has dramatically increased for some of the wettest days of the year.	At the start of this season, wombats leave their burrows, kangaroo's and wallabies become more active to find soft tree ferns that have grown to consume. With increased rainfall many fungi start to emerge.	 Yarra river, Warburton, Victoria
Guling Orchid Season	August. It is still very cold and wet, but slightly less than the Waring Wombat season.	Gulling (orchids) and local wattles start to flower signaling that Gurrborra (koalas) are soon to start their mating season moving between trees to find mates. Caterpillars are also active during this time.	 Koala in a gum tree
Poorneet Tadpole Season	September- October. The average temperatures are ranging from 7°C to 17°C and but the rainfall is still high at this time of year.	Spring is alive and the young of marsupial mammals start to emerge including joeys the leave the pouch of their mothers. The flowering of Yam daisy's indicate that a food source, the yam, is ready to be harvested.	 Kangaroo mother and joey

Buath Gurru Grass Flowering Season	November. It is really starting to warm up again, with average temperatures range from 10°C to 22°C and rainfall reducing.	The flowering of new plants encourages increased butterflies and insects in the region that Buliyong (bats) consume. Rivers and creeks are still full of water with abundant fish to eat.	 Kangaroo grass flowers
Kangaroo-apple Season	December. Hotter weather with more rainfall than Biderap, but less than Buath.	Ectothermic animals such as lizards and snakes start to emerge to bask in the warmer suns after a long season of cool weather. Wedgetail eagles commence their breeding season.	 Wedge-tailed Eagle

SC 3 CHECK YOUR UNDERSTANDING

Describe ways non-western cultures may categorise organisms.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1. Explain why classification is important for studying biodiversity.
2. Describe how you could classify a newly discovered organism using a classification system.
3. Describe how you would explain the importance of classification to someone unfamiliar with biology.
4. Identify one way First Nations Australians might classify plants.
5. First Nations people have been classifying organisms for thousands of years.
   a. Describe ways that first nations people have communicated their understanding of classification.
   b. Briefly explain one example of classification that has been communicated.
   c. Explain how scientists may benefit from knowledge that First Nations Australians have about classification.

5.2 Recognising similarities and differences in objects and living things

Introduction

Have you been to the zoo recently? You may have noticed that the animals seem to be grouped according to the type of animal or where they live in the wild. Botanical gardens group plants according to their environment and even size.

Organisms can be grouped according to their similarities and differences. This makes it easier to classify and identify them.

In this practical investigation you will investigate how to group organisms based on their similarities and differences using the example of fruits and vegetables.

Learning intention

To be able to group objects and living things based on similarities and differences

Success criteria

SC 1: I can identify differences and similarities in organisms from real objects, images or descriptions.

SC 2: I can place organisms with similar features into groups.

SC 3: I can evaluate methods used to sort organisms.

Background

Many people consider the items in salads to be vegetables, but some of them are actually fruit, such as tomato (Figure 5.2.1). Fruits and vegetables are classified according to the part of the plant that is eaten. Table 5.2.1 outlines the different classifications for fruits and vegetables.

TABLE 5.2.1 Classification: Fruit or vegetable?

Classification	Description	Fruit or vegetable?
aggregate fruit	many small fruits, or fruitlets, joined together to make a large fruit	fruit
berry	fleshy, edible fruit that has seeds embedded within its flesh	fruit
legume	also known as a pod; opens at the side to release seeds	fruit
simple fruit	fruit formed around a hard stone or pit which contains a seed	fruit
bulb	grows in clusters or layers just below the soil surface with a leafy shoot above	vegetable
leaf	an edible leaf	vegetable
root	usually, a long or round root	vegetable
stem	edible stem or stalk of the plant	vegetable
tuber	grows underground, attached to the root of the plant	vegetable

FIGURE 5.2.1 In biology, tomatoes are classified as a simple fruit because the seeds are contained within the edible part of the plant.

SAFETY NOTES

- Make sure you and your classmates are not allergic to any of the food samples used.
- Do not taste or eat the food items.
- Knives are sharp and can cause injury if not used appropriately.

Aim

To investigate the similarities and differences between fruits and vegetables

Materials

- various samples of fruits and vegetables, such as carrot, potato, apple, garlic, onion, snow pea, capsicum, spinach, celery, raspberry, olive and lettuce
- knife
- cutting board

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

HINTS

Refer to Table 5.2.1 that describes the features of different types of fruits and vegetables.

Make sure that you observe colour, texture, whether the food contains seeds to help you to create a method of grouping the items.

Method

1. Use a knife to cut through the food items to reveal the internal characteristics that assist with the correct grouping of the food items, as shown in Figure 5.2.2.
2. Choose two food items that have been supplied and observe them carefully. Write down their features.
3. Use the table to classify these foods.
4. Create your own table to record the features and classification of the food you chose.

FIGURE 5.2.2 Be sure to observe the outside and the inside features of the food

Results

Create a results table to record your observations and classify the food items as fruit or vegetable.

Include the name of the fruit or vegetable, the external features observed, the internal features observed and the classification you gave each item. Record your observations and the reasons for the classification decisions you made.

Conclusion

Write your conclusion to this investigation by completing the following tasks.

1. Describe the key features that enable food to be classified as fruit or vegetable.
2. Explain why it is incorrect to classify a tomato as a vegetable.

Evaluation

Suggest two ways this investigation was challenging and what could be done to improve it.

5.3 Introduction to keys for identification

Lesson overview

Scientists organise things according to their similarities and differences. Keys for classifying living things include a series of questions or statements about the features of organisms. Classification keys are used to identify the group that an object or living thing belongs to. By working through the steps in a key, the group that an organism belongs to can be identified.

There are several types of keys that can be used, but the simplest are called dichotomous keys (Figure 5.3.1). The prefix 'di' at the beginning of the word means two. In these keys, each stage of the key has two choices, based on the characteristics of the organism.

In this lesson, you will learn about classification keys and how they are developed and used to assist with the identification of living things.

Learning intention

To understand the purpose of a dichotomous key

Success criteria

SC 1: I can use a branching dichotomous key to identify objects or organisms.

SC 2: I can use a table dichotomous key to identify objects or organisms.

SC 3: I can evaluate the strength of dichotomous keys and suggest ways to make them more effective.

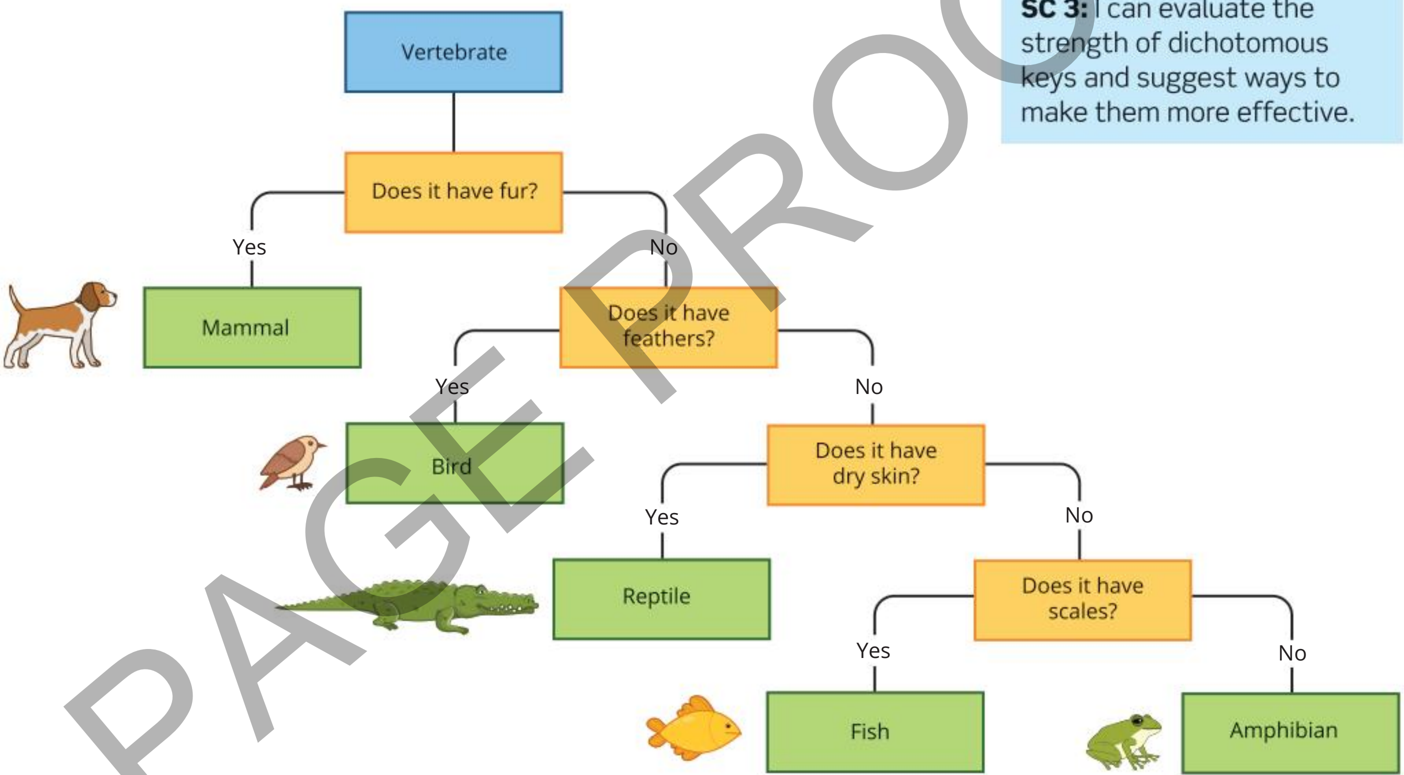


FIGURE 5.3.1 A dichotomous key used to classify animals with backbones (vertebrates)

SC 1 I can use a branching dichotomous key to identify objects or organisms

Classification is used to group things so that relationships and connections between them can be used for clear identification. Scientists use keys to assist with the organisation of objects and organisms and can be used to identify new additions to the group.

KEY TERM

dichotomous key a key with two choices at each stage

Although millions of different species of organisms have been identified by scientists, many more are likely to still be discovered. A **dichotomous key** is a tool used by scientists to help them identify new organisms and compare them to organisms that have already been classified and described. Some dichotomous keys are based on structural features that do not change, such as number of legs or shape.

There are two types of dichotomous keys: branching and tables. Both keys use a series of two criteria to tell the difference between features of objects and organisms. The following simple example shows how these two types of keys: table and branching, can be used to identify different shapes.

Scifile

Classifying butterflies

With a dichotomous key, you can identify butterfly species by looking at wing patterns and colours. This tool helps entomologists (scientists who study insects) understand butterfly diversity and track changes in populations.

A table dichotomous key

The four different shapes in Figure 5.3.2 can be classified by referring to the dichotomous table key. Start by reading from the top of the table and working through the questions, until you get to the final name.

1a	Has straight sides	Go to 2
b	No straight sides	Go to 3
2a	Has four sides	Square
b	Has three sides	Triangle
3a	All diameters are equal	Circle
b	Diameters are not all equal	Oval

FIGURE 5.3.2 A table dichotomous key used to classify shapes

A branching dichotomous key

A branching flow chart key as seen in Figure 5.3.3 is read by starting at the top and working through the descriptions until you can classify the shape.

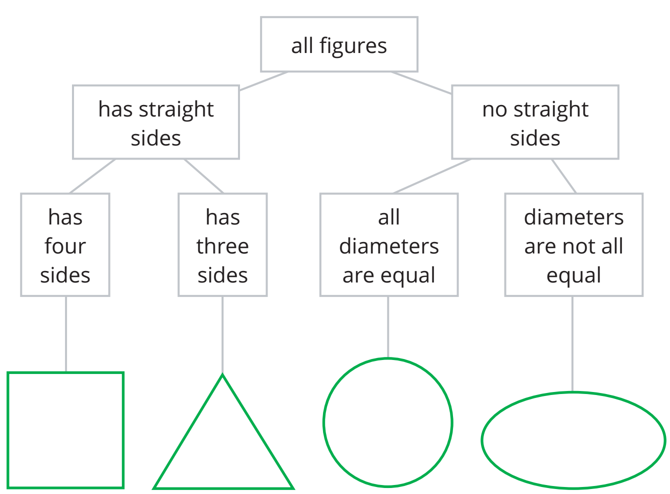


FIGURE 5.3.3 A branching dichotomous key used to classify shapes

Using a branching dichotomous key

Items and living organisms can be identified or classified using branching dichotomous keys. You always start at the top and move down through the key. By identifying a characteristic, you are then directed to the next options to match with your item.

Consider this branching key (Figure 5.3.4) designed to identify types of modes of transport. A particular mode of transport was known to have these features: does not need fuel; had four wheels in one line.

By following the options at each stage, the item can be identified. The description allows the item to be identified as a rollerblade.

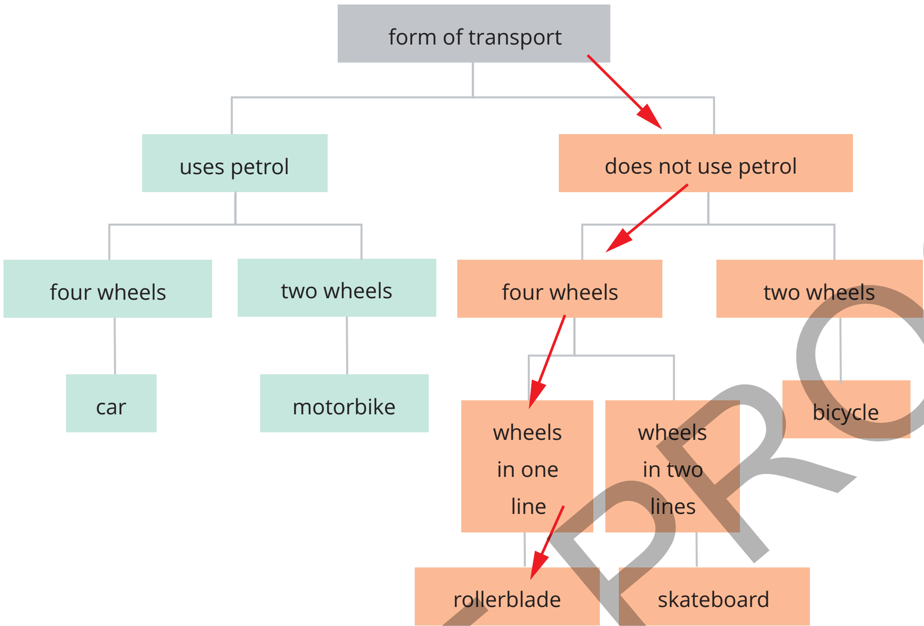


FIGURE 5.3.4 An example of how a branching dichotomous key can be used to classify rollerblades

SC 1 CHECK YOUR UNDERSTANDING

Explain how a branching dichotomous key functions.

SC 2 I can use a table dichotomous key to identify objects or organisms

Table dichotomous keys

Table keys use paired questions that start with general characteristics and gradually become more specific. For example, in a key used to classify food, the first question could be whether the food is a fruit, and then the later question could be about the fruit's features such as colour and shape.

The word dichotomous means divided into two parts. Branching keys and table keys always present two choices based on the key characteristics of the object or organism in each step. By selecting the correct choice at each stage, the name or grouping of the object or organism can be identified at the end. Both qualitative observations of physical features such as how the object or organism looks, its shape and what colour it is, and quantitative factors such as the number of legs, number of leaf veins and number of eyes should be considered.

Scifile

Identifying plants in your garden

In Australia, many gardeners use dichotomous keys to identify native plants. By answering questions about the shape of leaves, the type of flowers, and other characteristics, you can figure out what plant you are looking at. This can help you take better care of your garden and even contribute to local biodiversity by planting native species.

These keys are used in biology so that unknown or newly discovered organisms can be compared to known species and thus identified within a specific group and then named.

Using table dichotomous keys

Table keys present the observable features in a table where the user starts at the top and works down, matching features and moving to the next set of options.

Consider the table key for identifying animals that live in and around soil (Table 5.3.1). A creature was found to have 16 pairs of legs and no antennae.

TABLE 5.3.1 Animals that live in and around soil

1	1a Legs	*Go to 4*
	1b No legs	*Go to 2*
2	2a Antennae	*Go to 3*
	2b No antennae	**worm**
3	3a Shell	**snail**
	3b No shell	**slug**
4	4a More than 10 pairs of legs	*Go to 5*
	4b Less than 10 pairs of legs	**beetle**
5	5a More than 20 pairs of legs	**millipede**
	5b Less than 20 pairs of legs	**centipede**

By following the options at each stage, the item can be identified.

So, the animal is a centipede.

SC 2 CHECK YOUR UNDERSTANDING

Describe what a table dichotomous key looks like and how it is used.

SC 3 I can evaluate the strength of dichotomous keys and suggest ways to make them more effective

Effective dichotomous keys

Developing dichotomous keys can be challenging and it is important that they can be used effectively to identify things.

Features of good dichotomous keys include:

- a clear and straightforward **dichotomous question**; for example, 'has a red beak' or 'has an orange beak'
- a focus on features of the organism that are unlikely to change over time; for example, fur colour may change throughout the seasons of the year, but the number of legs of an organism do not. Leg number would be a better choice for a key
- a criterion that is not subjective; for example, 'tall' or 'short' is a subjective criterion, but 'larger than 100 cm' and 'smaller than 100 cm' is an objective and measurable criterion.

KEY TERM

dichotomous question a question that limits responses to only two possible answers

HINT

Terminology support

Subjective data is based on personal views, feelings and experiences. Objective data is based on measurable facts and information that is free from personal bias.

SkillBuilder

Dichotomous questions

Dichotomous questions are questions that have only two possible answers. They are used in dichotomous keys which can be used to classify or identify organisms.

Method for writing good dichotomous questions

1. Decide on the characteristic, feature or behaviour that will reveal a difference (distinguish) between the organisms being classified or identified.
2. Choose a characteristic that is easy to observe or can be measured, such as number of legs, length of body compared to head, or shape of wing.
3. Avoid characteristics that are not easy to observe or measured, or that can change on an animal or plant depending on the age of the organism or the time of year, such as size and colour.
4. Draft a question about that characteristic that has either a 'yes or no' answer, or has only two possible answers.
5. Try to use a question that does not just separate one organism from all the others. (However, these types of questions can be used later in the key when you only have a few organisms to identify.)

   For example, Stella was developing a key used to distinguish between breeds of cat. She wanted to use the appearance of the cats. Three questions that she chose to use were:
   - Does the cat have more than one colour on its coat?
   - Does the cat have stripes of different colours?
   - Is the head of the cat a different colour to most of the rest of the body?

Worked example

Dichotomous questions

Problem

Which of the following are dichotomous questions that can be used in keys? Explain your reasoning.

a. How many legs does the animal have?

b. Does the organism have six legs?

c. Is the plant big?

d. Does the animal like eating fish?

e. Does the plant have leaves that have smooth edges?

Solution

Thinking	Working
a How many legs does the animal have?	
Are there only two possible answers?	No, the answer can be a range of different numbers, so this is not a valid question for a dichotomous key.
b Does the organism have six legs?	
Are there only two possible answers?	Yes, it either has six legs or does not have six legs.
Is the question clear?	Yes
Can you observe the answer to the question?	Yes, you can count the exact number of legs.
Is this a valid dichotomous question	Yes
c Is the plant big?	
Are there only two possible answers?	Yes, it is either big or not big.
Is the question clear?	No, the description 'big' is not clearly defined, so this is not a valid question for a dichotomous key.
d Does the animal like eating fish?	
Are there only two possible answers?	Yes, it is either likes eating fish or does not like eating fish.
Is the question clear?	Yes
Can you observe the answer to the question?	No, you do not know if the animal 'likes' eating fish (you cannot ask them!), so this is not a valid question for a dichotomous key.
e Does the plant have leaves that have smooth edges?	
Are there only two possible answers?	Yes, this is relatively easy to judge.
Is the question clear?	Yes
Can you observe the answer to the question?	Yes
Is this a valid dichotomous question	Yes

Try yourself

Consider the following questions and analyse whether they are suitable for use in a dichotomous key. To be a suitable dichotomous question, it must have only two possible answers and be clear.

a Does the tree have lots of leaves?

b Does the animal have four legs?

c Where does the animal live?

d Does the insect have more than one pair of wings?

SC 3 CHECK YOUR UNDERSTANDING

Explain what a dichotomous question is.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Explain the purpose of a dichotomous key in biology.

2 Identify two features of a branching dichotomous key.

3 Create a dichotomous key question that would separate a house fly and a dragon fly.

4 Explain why a dichotomous key is a useful tool for scientists.

5.4 Creating dichotomous keys

Introduction

Organisms are grouped according to the similarities and differences to make it easier to classify and identify them. The easiest way to classify things is to create keys to organise them using specific criteria. The tool that biologists use is the dichotomous key. These keys can be branching keys or table keys, although there are some other types of keys less commonly used.

In this practical investigation you will create dichotomous keys to group objects and organisms based on their similarities and differences.

Learning intention

To be able to create a dichotomous key to identify living and non-living objects

Success criteria

SC 1: I can write suitable questions for use in a dichotomous key.

SC 2: I can create and use a branching dichotomous key.

SC 3: I can create and use a table dichotomous key.

Background

Taxonomy is the field of science that classifies living things. **Taxonomists** are scientists who classify living things based on their similarities and differences, naming them so they can be identified and discussed. You may have seen books or apps called 'field guides' that describe different types of organisms (such as birds, reptiles, insects and plants). A dichotomous key is a tool used to classify organisms (Figure 5.4.1); it has two choices at each step (for example: serrated leaves or smooth leaves).

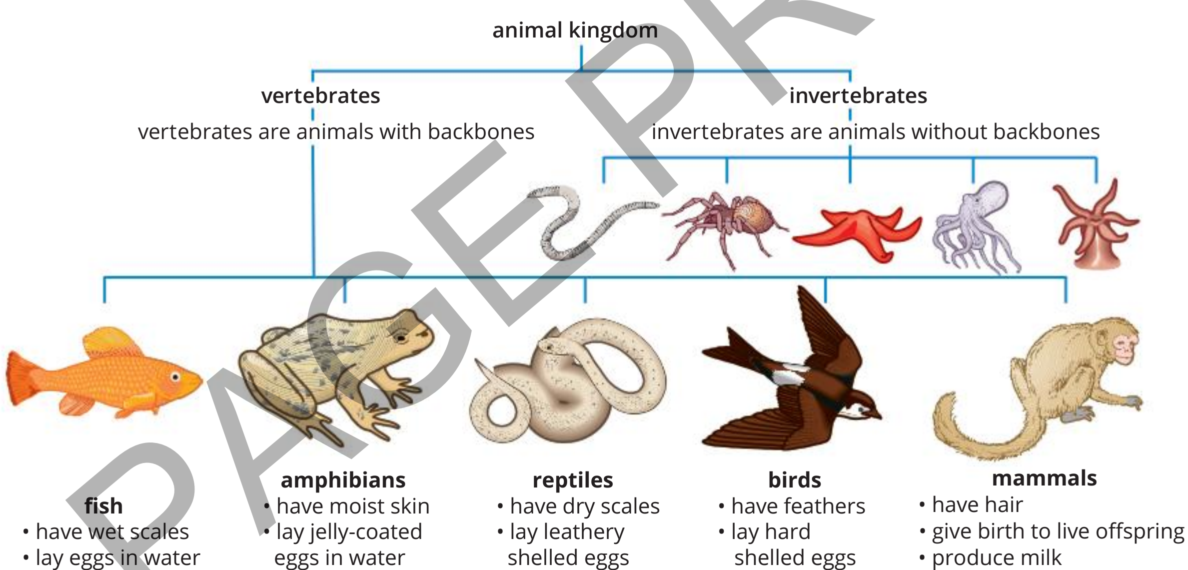


FIGURE 5.4.1 Branching dichotomous key used to classify animals

Aim

To create keys that can be used to identify types of pasta and types of leaves

KEY TERMS

taxonomy the science of classifying and naming things

taxonomist a scientist who specialises in classifying and naming things

SAFETY NOTE

- Do not taste or eat the food items.

HINT

Look for differences in shape and size. A table will help to organise the similarities and differences so that similar pasta types will be more obvious.

Materials

Part A

- various samples of pasta
- paper and pencils

Part B

- 10 different leaves
- large sheet of paper
- pencil
- marker pen
- camera (optional)
- field guidebooks or app for Australian garden and native plants (optional)

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

Method

Part A: Types of pasta

1. Describe each type of pasta, focusing on differences between the types of pasta. Think about how you can present your observations.
2. Create some dichotomous questions that can be used to distinguish between the types of pasta.
3. Use the differences to construct a table dichotomous key.

Part B: Identifying leaves

1. Collect 10 leaves from different healthy plants. Take a single leaf without damaging the main plant. If you have a camera, photograph each plant and your leaf sample.
2. In the classroom, trace an outline of each leaf onto paper.
3. Write labels A–J inside the 10 leaf outlines. Use the marker pen to write matching letter codes on each leaf. For plants that you know, also write the plant's name inside the shape.
4. On the paper, make a list of features that could be used to sort your leaves into different groups.
5. On your list, highlight the strongest features for classifying the leaves (such as shape, arrangement of veins, leaf edge characteristics).
6. Select one feature and use it to sort the leaves into two groups (such as round leaves/non-round leaves). Record these two options as the first step in your dichotomous key.

7 Working with one group of leaves at a time, select a different feature and use it to sort that group of leaves. Record these two options as the second step in your dichotomous key.

8 Continue selecting features and sorting leaves until you reach an individual leaf. Record each step in your dichotomous key.

9 When your key takes you to an individual leaf, record the leaf on the key with its letter code (A–J).

10 Repeat steps 6–9 until you have classified all the leaves that you collected.

Results

Review your dichotomous key and, if required, redraw a final version.

Evaluation

Ask other students to try classifying leaves or pasta using your keys and use other students' keys.

1 Describe any improvements that you could make to the keys to enable more effective classification.

2 Identify strengths and weaknesses of dichotomous keys.

HINT

Identification keys work best if they use strong features that stay the same over time and are easily observed.

Remember to use two opposing choices at each step (such as pointed leaf tip or rounded leaf tip).

Quantitative features (features you can measure) are stronger to use than qualitative descriptions. For example, 'mature leaf, 2 to 3 cm length', is better than 'older, long leaf.'

5.5 Linnaean classification system

Learning intention

To understand the Linnaean hierarchical classification system and its related naming conventions

Success criteria

SC 1: I can list the levels in the Linnaean hierarchical classification system in order.

SC 2: I can classify an organism's kingdom, phylum and class using the Linnaean hierarchical classification system.

SC 3: I can identify the genus name and species name in an organism's scientific name.

HINTS

Terminology tip

A naturalist is a person who studies the natural world.

A philosopher is a person who studies philosophy, which in the past included physics, mathematics, biology and chemistry.

KEY TERMS

kingdom the highest level that organisms can be classified into according to Linnaean taxonomy

species the last level of classification of living things

Lesson overview

Historically, humans have always tried to make sense of things around them, especially living things that they share their environment with. Human survival was dependent on being able to distinguish between predator and prey, and between poisonous and non-poisonous. People sorted the things around them using characteristics such as colour, size of teeth, and by observing other animals' feeding habits. This 'classification' was based on trial and error, and stories passed through the generations so that people learned from others' mistakes.

In this lesson, you will learn about how philosophers and scientists in the past created naming systems that were more specific and enabled the enormous diversity of life on Earth to be classified scientifically and more precisely.

SC 1 I can list the levels in the Linnaean hierarchical classification system in order

Development of classification systems

Many ancient philosophers developed their own ways of classifying the living things around them. One of those philosophers was Aristotle, a Greek who lived from 384 to 322 BCE. He attended Plato's Academy in Athens and studied medicine, philosophy, astronomy and was a naturalist.

Aristotle originally divided all living things into two groups: plants and animals. He then subdivided plants into trees, shrubs and herbs, and animals into groups based on their habitats (water, air and land). He also divided them according to whether they had red blood or not.

Carl Linnaeus and hierarchies

Later, a Swedish scientist called Carl Linnaeus, who lived from 1707 to 1778, developed a more specific classification system using a hierarchy (Figure 5.5.1). The highest level of the hierarchy originally divided living things into animals and plants.

FIGURE 5.5.1 Carl Linnaeus

Over time, especially since the invention of microscopes, the characteristics of living things have been observed more closely at the cellular level and there are now at least five distinct kingdoms recognised today by taxonomists. The smallest and most specific level of classification is the **species**.

The Linnaean hierarchy

In the Linnaean classification, organisms can be classified based on specific characteristics that they share. The levels of this hierarchy are kingdom, phylum, class, order, family, genus and species (Figure 5.5.2).

The class of organisms you are most familiar with is mammals. Humans, for example, are classified as mammals because they share key characteristics with other mammals, such as horses and dogs.

Like humans, horses and dogs have fur or hair on their skin and feed their young with milk produced by mammary glands. However, unlike humans, horses and dogs have tails and they have eyes positioned on the sides of their heads.

Primates, including gorillas and monkeys, share more features with humans, such as forward-facing eyes, and belong to the same order. However, monkeys have fewer traits in common with humans and gorillas, so they do not belong to the next hierarchical level, the family.

Although gorillas share more similarities with humans than most other animals, they also have unique features, placing them in their own genus.

Modern humans are classified as animals and specifically as *Homo sapiens*, with *sapiens* being the species name (Figure 5.5.3).

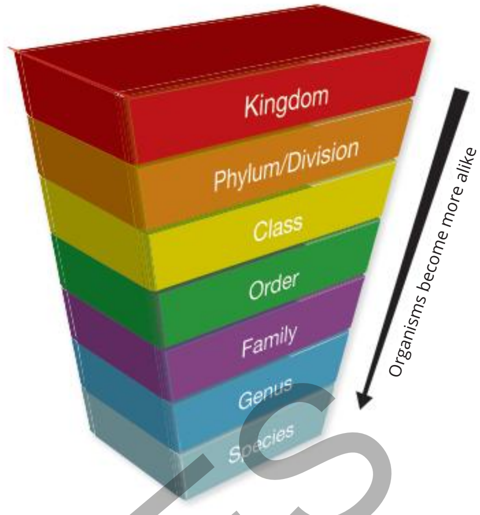


FIGURE 5.5.2 The Linnaean classification system is a hierarchical system with organisms most closely related belonging to the same species

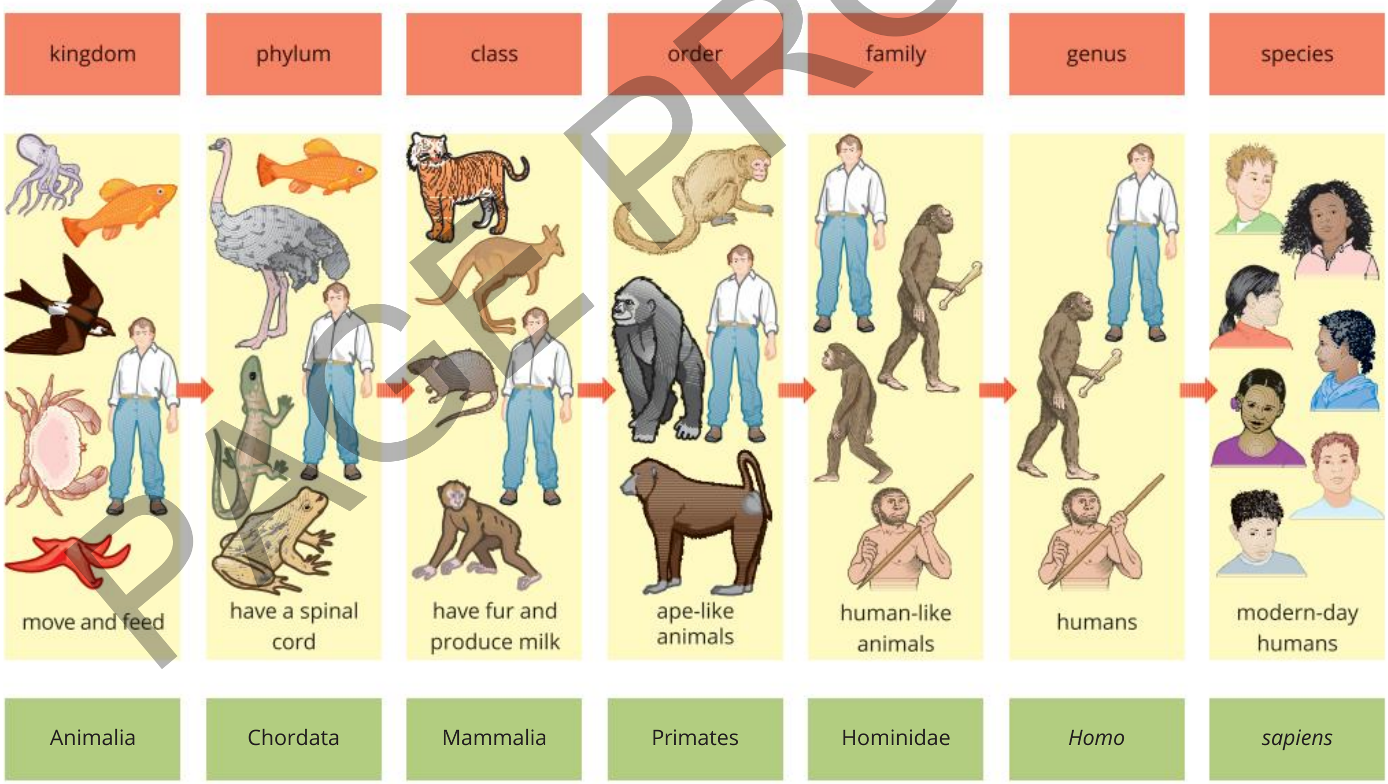


FIGURE 5.5.3 Levels of classification show how much more similar organisms become as they progress through the hierarchy

SC 1 CHECK YOUR UNDERSTANDING

List the levels of the Linnaean hierarchical classification system from highest to lowest.

SC 2 I can classify an organism's kingdom, phylum and class using the Linnaean hierarchical classification system

Kingdoms

Until quite recently, biologists classified all living things into two kingdoms, animals and plants. Then it was realised that fungi were not plants as they do not make their own food as plants do. In 1968, the five-kingdom classification was developed which included the Monera (mostly bacteria) and the protists (mostly amoeba and algae). In 1990, microbiologist Carl Woese proposed that Monera should be separated into Eubacteria and Archaebacteria, thus creating a six-kingdom classification model (Figure 5.5.4) which is now widely used.

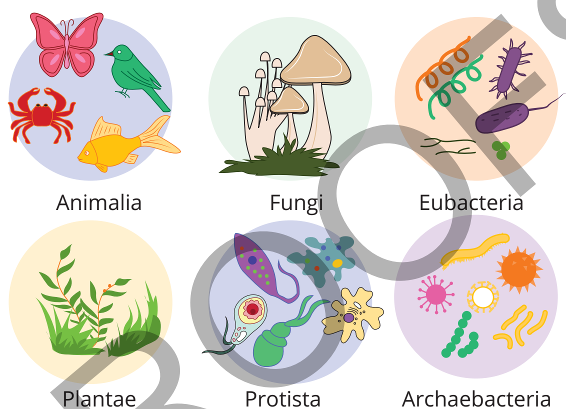


FIGURE 5.5.4 The six kingdoms Animalia, Fungi, Eubacteria, Plantae, Protista and Archaebacteria

Classification models have evolved as scientists gained access to more powerful microscopes, allowing for a deeper understanding of both the structure and behaviour of organisms. For example, it was not until the 1990s that microbiologists had the technology to distinguish key differences between bacteria, leading to the classification of archaebacteria and eubacteria into separate kingdoms.

Phyla

Each of the kingdoms is divided into **phyla** (singular form: phylum). For example, animals that have backbones such as humans, snakes, birds and fish are classified in the Chordata phyla. Other phyla include the annelids or round worms, the arthropods that include insects and spiders, and the molluscs such as crabs, snails and squid.

Classes

Organisms belonging to the same phyla have more features in common than those belonging to the same **class**. For example, the phylum **Chordata** within the animal kingdom, is comprised of animals that have backbones. This phylum is then subdivided into classes based on even more specific characteristics, including the type of skin they have. For example, the class of reptiles have dry scaly skin, whereas mammals have fur.

KEY TERMS

phyla the category of Linnaean classification below kingdom and above class
class the category of Linnaean classification below phyla and above order
Chordata the phylum that includes animals with backbones

SCIENCE IN SOCIETY

Wildlife conservation

The Linnaean system is essential for wildlife conservation efforts. Accurate identification of organisms is important for developing conservation strategies that protect endangered species and their habitats.

In Australia, the Linnaean system is used to classify and study native animals like the endangered Tasmanian devil, helping conservationists monitor their populations and take action to protect them.

FIGURE 5.5.5 Accurate classification of wildlife, like this Tasmanian Devil, is an important part of wildlife conservation.

SC 2 CHECK YOUR UNDERSTANDING

There are many different types of reptiles that are native to Australia.

a State the correct name for the kingdom that reptiles belong to.
b State the phylum that reptiles belong to, giving a reason for your answer.

SC 3 I can identify the genus name and species name in an organism's scientific name

Scientific names

Scientific names are very useful to biologists as they enable them to know exactly what the organism looks like and how it is related to other similar organisms. There are often many 'common names' for living things used by people from different countries and cultures. Providing a scientific name enables the names to be recognised world-wide (Figure 5.5.6).

Scientific names use a binomial system. Binomial means that two names are used, the genus and the species names. This system of naming and classification was developed in the 1700s in Europe, when Latin was the language used by the most well-educated people who developed the system. This system is used internationally even though, nowadays, most people do not speak Latin.

FIGURE 5.5.6 The common name for this mammal is the eastern grey kangaroo. The scientific name is *Macropus giganteus*.

KEY TERM

genus a category of the Linnaean classification system above species and below family

FIGURE 5.5.7 The grey iron bark has the scientific name *Eucalyptus* (genus) *paniculate* (species).

Genus

The **genus** that an organism belongs to will have highly specific characteristics and relatively few members compared with the higher levels of classification such as order or family. The genus name always begins with a capital letter.

Species

The species name of an organism is unique to it. No other species within the genus has the exact same characteristics. New species are found regularly and are given a name that is not given to any other organism. The species name always begins with a lower-case letter, and this distinguishes it from any other level of classification.

How to write a scientific name

When scientific names are typed, they are in italics, with the genus first then the species, like this: *Genus species*. For example, the scientific name for humans is *Homo sapiens*. If the name is written by hand, it should be underlined (<u>Homo sapiens</u>). Examples of binomial scientific names with commonly used names are shown in Table 5.5.1.

TABLE 5.5.1 Examples of commonly used names for organisms followed by their scientific names

Humboldt penguin – *Spheniscus humboldtii* 	Lacy tree fern – *Cyathea cooperi* 
Funnel web spider – Atrax robustus 	*E. coli bacteria – Escherichia coli* 

SkillBuilder

Scientific names

Classification systems have different levels. The further you go down through the levels, the fewer living things there are at each level.

The seven levels of classification for living things (organisms) are:

Level of classification	Example
Kingdom	Animal
Phylum	Chordate (animals with backbones)
Class	Mammal (animals with backbones that females produce milk)
Order	Diprotodontia (mammals with two large front teeth and two toes fused together)
Family	Macropod (*diprotodontia* with no canine teeth and very strong fourth toes)
Genus	*Osphranter* (macropod with long rear feet and strong back legs
Species	*robustus* (Latin for strong/sturdy)

The bottom two levels of classification, the genus and the species, are added together to give the scientific name of the organism.

Note that the genus name starts with a capital letter and the species name starts with a lower-case letter.

The genus and species are usually written in italics.

Naming a species

Identify the genus to which the organism belongs.

1. This is the first word of the name and is written with a capital letter.
2. Identify the species of the organism.
3. This is the second word of the name and is written with a lower-case letter.

For example, Hugo was asked to give the scientific name for humans.

The genus is *Homo* and the species is *sapiens* so the scientific name is *Homo sapiens*.

Worked example

Scientific names

Problem

Give the scientific name of the red kangaroo. The kangaroo is in the genus *Osphranter* and the Latin word for red-haired is *rufus*.

Solution

Thinking	Working
1 Identify the genus name.	*Osphranter*
2 Identify the description of the species.	*rufus*
3 Combine the name.	*Osphranter rufus*

Note that, as scientists' understanding of the genetics of living things continues to improve, some classifications may change. For example, in the past the red kangaroo had the scientific name *Macropus rufus*. *Macropus* was the genus and *Osphranter* was the subgenus. However, in 2019, *Osphranter* was moved to the genus level. Genetic analysis confirmed the red kangaroos' inclusion in the genus *Osphranter*.

Try yourself

In December 2021, scientists at Kings Park in Perth WA created the world's first blue kangaroo paw using plant hybridisation techniques. The scientist called the new species 'masquerade'. Kangaroo paws belong to the *Anigozanthos* genus.
Create the scientific name for this new species.

SC 3 CHECK YOUR UNDERSTANDING

Identify the genus and species name of the scientific name for cat, *Felis catus.*

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 List the levels in the Linnaean hierarchical classification system in order from smallest to largest.
2 Identify the two hierarchies used when writing a scientific name.
3 Name the kingdom and phylum of a magpie.
4 Identify the genus and species name in the scientific name '*Homo sapiens*'.
5 Explain the benefit of scientific names over common names.

5.6 Levels of classification in the animal kingdom

Lesson overview

It is estimated that more than eight million living things on Earth are part of the animal kingdom. All animals have typical animal cells, and this distinguishes them from other kingdoms. Animals are also multi-cellular, which means they are made up of many cells. It is thought that the earliest animals existed as far back as 560 million years.

As there are so many animals, it makes sense to divide them into small groups based on similar features. There are nine main phyla of animals.

In this lesson, you will investigate the characteristics that separate the animal kingdom into phyla, and explore the key features of the classes of one of the phyla, chordates.

Learning intention

To describe how the Linnaean system can be used to classify biodiversity in the animal kingdom

Success criteria

SC 1: I can describe the characteristics of nine major animal phyla and give examples of each.

SC 2: I can describe the characteristics of the classes of chordates and state an example of each.

SC 3: I can describe the classification levels of a range of Australian native animal species.

SC 1 I can describe the characteristics of nine major animal phyla and give examples of each

Most people think of well-known living things, such as humans, dogs, cows and elephants as animals (Figure 5.6.1). Within the Animal kingdom, nine major phyla are used to classify biodiversity, ranging from organisms with and without backbones, many limbs and no limbs, and even those with different coloured blood. The common characteristic they share is they are all made up of many animal cells. As cells cannot be seen without a microscope, most animals can be identified as animals because they require oxygen and food, they move and can sense the environment around them.

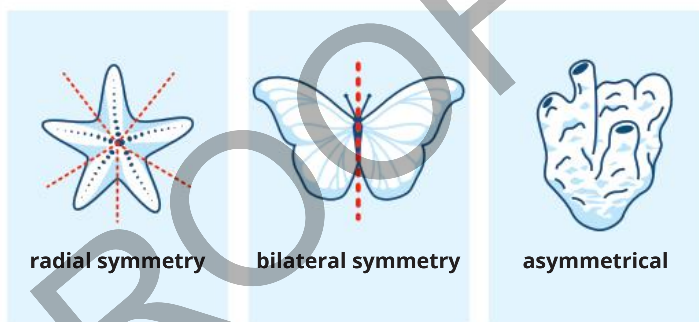
FIGURE 5.6.1 Humans and dogs belong to the phylum Chordata and the class Mammalia

HINT

Note that the names of the phyla end in -a, for example Annelida. Animals that belong to that phyla can be described as annelids. Animals that belong to the phyla Chordata are called chordates.

The different phyla in the animal kingdom are usually based on the characteristics shown in Table 5.6.1.

TABLE 5.6.1 Characteristics of different phyla

Characteristic	Explanation
Symmetry	Symmetry is the amount of similarity between different sides of the organism. There are two main types of symmetry: • Radial symmetry, where the organism appears the same the whole way around a middle point. • Bilaterial symmetry, where the organism is the same on the left and right sides or top and bottom, like a mirror image. Asymmetry/asymmetrical is where the organism has no symmetry and is an irregular shape. 
Skeleton type	Animals can have an **endoskeleton**, an **exoskeleton**, a **hydroskeleton** or no skeleton.
Additional body features	Animals can have a range of features that assist them to live in different environments. Some examples of these features are legs, gills, fins and suckers.

KEY TERMS

endoskeleton a skeleton inside the body

exoskeleton a skeleton on the outside of the body

hydroskeleton a fluid filled soft tissue found inside the body

Facts about the main animal phyla

Poriferons

Symmetry: asymmetrical

Skeleton type: no skeleton

Additional features: live in water and are spongy with pores and tubes that filter food and excrete waste; some sponges look like tubes and have an opening at the top that acts as a waste removal system

Cnidarians

Symmetry: radial (all the sides of the cnidaria usually look the same)

Skeleton type: usually have no skeleton

Additional features: have a single body opening to allow food and waste to pass through; live in water and can have stinging cells to poison and capture prey; the box jellyfish (*Chironex fleckeri)* has extremely poisonous venom secreted by the stinging cells on its tentacles

Echinoderms

Symmetry: radial (all the sides of the cnidaria usually look the same)

Skeleton type: usually have an endoskeleton with a spiney or leathery outer covering

Additional features: range in colours and have a thick 'armour' on their exterior to protect them from prey, which is left behind when they die; there are two types of echinoderm in this photograph – you can see the orange pigment of a sea star (on the left) and the black spines of a sea urchin (on the right)

Annelids

Symmetry: bilateral

Skeleton type: have a hydroskeleton that works similarly to an endoskeleton but made of a fluid-filled cavity

Additional features: have segments, a tubular gut that stretches along the length of the animal and tiny feet-like projections on either side of the body that assist with movement; *Annelida* is the phylum that includes segmented worms, such as the earthworm and leaches

Nematodes

Symmetry: bilateral

Skeleton type: many have a hydroskeleton

Additional features: have a long gut that runs the length of the animal, and is more complex in structure and function compared with annelids; require a watery or damp environment and are found in huge numbers in almost every environment on Earth; some nematodes are parasitic, such as *Ascaris lumbricoides,* which lives in the human intestine and can grow up to 35 cm long

Platyhelminthes

Symmetry: bilateral

Skeleton type: neither an endo- nor an exoskeleton

Additional features: require a watery or damp environment, have one opening for both food and wastes and are flat to allow oxygen to pass into their bodies from the water; *Platyhelmintha* is the phylum that includes flatworms; they range in size from 1 millimetre to 15 metres in length

Molluscs

Symmetry: bilateral

Skeleton type: either an endo or an exoskeleton

Additional features: have complex organ systems and highly developed nervous systems; some have a hard shell to cover their soft bodies and a muscular foot to assist movement; *mollusca* is a highly diverse phylum that includes snails, slugs, mussels and squid; the protective shell of the snail is clearly observable; the internal skeleton of the squid is a hard white substance often found washed up on beaches

Arthropods

Symmetry: bilateral

Skeleton type: exoskeleton

Additional features: the body is usually divided into three segments and has complex organ systems; legs and antennae are also segmented to enable movement; spiders are just one example of the huge number of arthropods found on Earth; there are many other types including insects, prawns and crabs

Chordates

Symmetry: bilateral

Skeleton type: most have an endoskeleton

Additional features: have a backbone with a nerve chord that runs the length of the vertebral column; birds and mammals are examples of chordates

SC 1 CHECK YOUR UNDERSTANDING

List three major animal phyla and provide one example for each.

Scifile

Subclasses of mammals

The class of mammals is sub-divided into three groups according to reproduction method. Placentals, such as humans and whales, develop offspring in the body and birth when developed young. Monotremes, such as echidnas, lay eggs. Marsupials, such as kangaroos, give birth to underdeveloped babies that grow in a pouch.

SC 2 I can describe the characteristics of the classes of chordates and state an example of each

Animals that have a backbone or vertebrae are classified in the phylum **Chordata**. Chordates all have a nerve cord running down their backs, which gives the phyla its name. Often this cord is protected by a form of backbone made up from small bones called vertebrae. There are some chordates, such as sea squirts, that do not have vertebrae or a backbone but are also classified under the phylum Chordata because they still have the nerve cord. There are eight classes of chordates:

- Agnatha
- Chondrichthyes
- Osteichthyes
- Amphibians
- Reptiles
- Aves
- Mammals
- Chordates without backbones

In the past, the fish were in a single class but now they are divided into three different classes, the Agnatha (jawless fish), Chondrichthyes (cartilaginous fish with jaws), and the Osteichthyes (bony fish). The other classes of chordates include the Amphibians, Reptiles, Aves or birds, and Mammals (Table 5.6.2).

TABLE 5.6.2 The eight classes of chordates

Class	Features	Example
Agnatha	• jawless fish • internal skeleton made of cartilage • gills for obtaining oxygen • soft skin and no scales • fin along their backs • mouth is a sucker lined with horny tooth plates • all are parasites	Lamprey 

Class	Features	Example
Chondrichthyes	• sharks and rays • skeleton made of cartilage • gills for obtaining oxygen • have jaws and teeth • fins on side of body and on their back (dorsal fin)	Stingray 
Osteichthyes	• bony fish • skeleton made of bone • gills for obtaining oxygen • fins on side and back of their bodies • jaws and teeth	Barramundi 
Amphibians	• include frogs, toads and salamanders • live in water and on land • breathing through gills, lungs or skin • ectothermic (cold-blooded – relies on external sources to regulate body temperature)	White-lipped tree frog 
Reptiles	• snakes, lizards, crocodiles, turtles and tortoises • dry scaly skin • breathe through lungs • ectothermic	Eastern brown snake 
Aves	• birds • feathers cover their skin • breathe through lungs • all have wings but some, such as penguins and emus, do not fly • endothermic (warm-blooded – regulate body temperature by generating their own body heat)	Flamingos 
Mammals	• includes animals such as the flying fox, hippopotamus and human • hair or fur covers their skin • breathe through lungs • endothermic • presence of mammary glands	Hippopotamus 
Chordates without backbones	• includes sea squirts and lancelets (small fish-like animals with transparent bodies) • have a nerve cord but not a backbone to protect it • known as invertebrate chordates	Sea squirts 

SCIENCE IN SOCIETY

Marine biology

Marine biologists use the Linnaean system to classify and study ocean life (Figure 5.6.2). For example, by classifying different types of coral, scientists can study their interactions with fish and other marine organisms, which is important for protecting coral reefs.

In the Great Barrier Reef, the Linnaean system is used to classify and study the reef's species. This helps researchers monitor the health of the reef and develop strategies to protect it from threats like climate change and pollution.

FIGURE 5.6.2 A marine biologist collecting data to classify organisms

KEY TERMS

monotreme subclass of mammal that lays eggs; examples include echidna and platypus
marsupial subclass of mammal that gives birth to immature young that are suckled in a pouch; examples are koala, kangaroo and wombat
arthropod animal with an exoskeleton and jointed limbs; examples include crabs and insects
cnidarian animal with radial symmetry, one body opening and stinging cells

SC 2 CHECK YOUR UNDERSTANDING

List the characteristics that distinguish the class Aves.

SC 3 I can describe the classification levels of a range of Australian native animal species

Biodiversity in Australia

Australian native animals are unique in many ways. Australia is a very large island isolated from all other land masses. This means that the native animals have had to adapt to the various and harsh environments where they live.

Of the class Mammals, the **monotremes** are only found in Australia and most species of **marsupials** are native to this country. Various other types of animals such as **arthropods**, **cnidarians** and chordates are also unique to Australia.

Many of the kangaroos and wallabies in Australia belong to the same family (macropods) as they have many characteristics in common (Figure 5.6.3). The differences are indicated by the genus and species to which they belong.

Some animals, such as the duck-billed platypus, have characteristics of several classes of chordates and were originally difficult to classify by early European naturalists. The platypus, for example, has features of mammals, as it is covered in fur, a bird as it has webbed feet like a duck, and a fish as it swims very well in water and lives in water most of the time (Figure 5.6.4). It also lays eggs, just like birds or even reptiles!

By accurately classifying Australia's unique biodiversity, it allows scientists to create more effective conservation strategies to help protect Australia's fauna from threats like habitat destruction and climate change.

FIGURE 5.6.3 Rock wallaby in the Northern Territory

FIGURE 5.6.4 The duck-billed platypus has the scientific name, *Ornithorhynchus anatinus*

The classification of Australian native species

	Short-beaked echidna	Red kangaroo	Sydney funnel-web spider	Red-bellied black snake
				
Kingdom	Animal	Animal	Animal	Animal
Phylum	Chordata	Chordata	Arthropoda	Chordata
Class	Mammalia	Mammalia	Arachnid	Reptile
Order	Monotreme	Diprotodon	Aranaea	Squamata
Family	Tachyglossidae	Macropod	Hexathelidae	Elapidae
Genus	*Tachyglossus*	*Magaleia*	*Atrax*	*Pseudechis*
Species	*aculeatus*	*rufa*	*robustus*	*porphyriacus*
Scientific Name	*Tachyglossus aculeatus*	*Magaleia rufa*	*Atrax robustus*	*Pseudechis porphyriacus*

SC 3 CHECK YOUR UNDERSTANDING

Identify the kingdom, phylum and class of the red kangaroo.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Define the term 'phylum'.

2 List two examples of organisms that are found in:

- **a** phylum Cnidarian
- **b** class Amphibia.

3 Explain the characteristics that define the phylum Chordata.

4 Explain the characteristics that define the class Mammalia.

5 Name three Australian native animal species and provide their classification up to the class level.

6 Explain the importance of classifying Australian native animal species.

5.7 Levels of classification in the plant kingdom

Learning intention

To understand how the Linnaean system can be used to classify biodiversity in the plant kingdom

Success criteria

SC 1: I can describe the characteristics of some plant divisions and give examples of each.

SC 2: I can describe the characteristics of flowering plants and state an example.

SC 3: I can describe the classification levels of a range of Australian native plant species.

FIGURE 5.7.1 The plant kingdom includes organisms such as trees, ferns and mosses

KEY TERMS

photosynthesis the chemical reaction in plants that converts carbon dioxide and water into oxygen and glucose using energy from sunlight

division the level below kingdom in the classification of plants

Lesson overview

The plant kingdom contains millions of different species. They are distinguished from the other kingdoms as they are made up of plant cells which have cell walls and the ability to produce their own food. Plants evolved from forms of green algae more than 400 million years ago.

The plant kingdom is divided into divisions, not phyla. Taxonomists chose to use the term phyla for animals and divisions for plants. Each division is subdivided into classes.

In this lesson, the characteristics that separate the plant kingdom into divisions will be explored, and the key features of the classes will be described.

SC 1 I can describe the characteristics of some plant divisions and give examples of each

The plant kingdom is extremely diverse and includes thousands of species of trees, ferns, and flowering plants to name a few (Figure 5.7.1). They all have one thing in common that makes them unique and different from other kingdoms – they can make their own food by harnessing the energy from the sun using the process of **photosynthesis**. Plants absorb carbon dioxide, water and sunlight to produce sugars and oxygen. This makes them essential to all other life on Earth.

Plant divisions

The plant kingdom is split into **divisions** according to their method of reproduction and the level of organisation of their transport systems. Plant transport systems are responsible for the transfer of water and nutrients throughout the plant.

Three of the plant divisions are considered here (Figure 5.7.2). They are:

- mosses and liverworts
- ferns
- seed-producing plants.

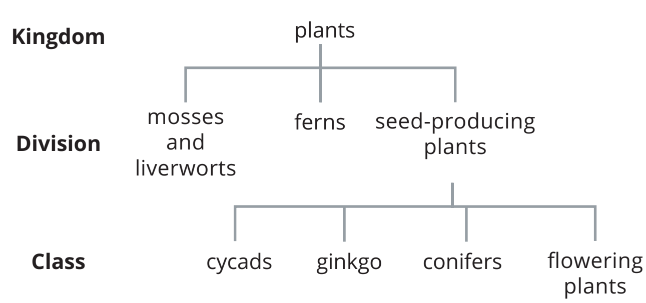


FIGURE 5.7.2 The three plant divisions

These three plant divisions are explored in more detail here.

Mosses and liverworts

Mosses and liverworts are small, simple plants with no roots or flowers. They survive by absorbing water from their environment. Marchantia Polymorpha, also known as the common liverwort, is found all around the world and prefers to live near shaded pools of water.

Ferns

Ferns have true root systems, stems and leaves that allow the plant to take in and distribute water and nutrients. Ferns form some of the oldest known plant fossils. Australia is lucky enough to have tree ferns that belong to a family with origins of over 300 million years ago.

Seed-producing plants

Seed-producing plants are some of the most complex plants in the world. They can use their reproductive systems to make seeds to grow new plants. Some seed-producing plants can produce flowers to assist in **pollination**. Examples of seed-producing plants include cycads, ginkgos, conifers and flowering plants.

SC 1 CHECK YOUR UNDERSTANDING

List three major plant divisions.

SC 2 I can describe the characteristics of flowering plants and state an example

KEY TERM

pollination the transfer of pollen from anther to stigma

Flowering plants

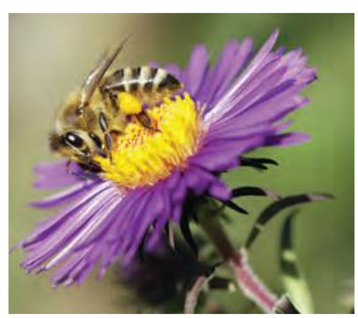
Flowering plants have complex leaves, stems and roots, as well as various types of flowers that contain the reproductive parts of the plant. There are many different shapes and colours of flowers. These attract certain insects for pollination. Smaller examples of flowering plants, such as grasses, rely on the wind to carry the pollen to other plants.

Flowering plants are seed producing plants that have flowers and fruit. Their method of reproduction is what distinguishes them from other plants, using fruit to spread their seeds. The male part of the flower is the stamen and produces the pollen that is gathered by insects or dispersed by the wind for pollination. The female part is the ovary (Figure 5.7.3). When the ovary is fertilised, it becomes a fruit and encloses the growing seed. Animals eat the fruit and then spread the seeds so that new plants grow.

Scifile

Buzzing pollinators

Bees are important pollinators of flowering plants. They cause the plant to vibrate, and the pollen is released. Bees carry pollen to other flowers and deposit it there.



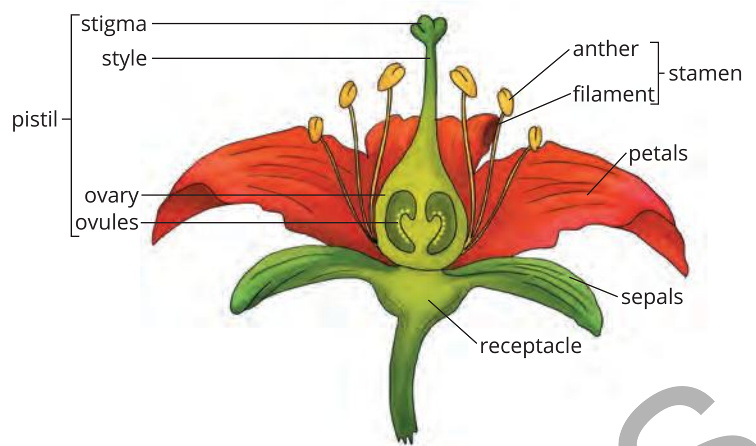


FIGURE 5.7.3 The main parts of a flower: the ovary and ovules are part of the female section of the flower (the pistil); pollen is produced in the male section (the stamen)

Examples of flowering plants

Humans rely on flowering plants for food, or to feed the animals that they eat. Table 5.7.1 shows some types of flowering plants. They also provide medicines, timber, dyes, flavour and fragrances.

TABLE 5.7.1 Examples of flowering plants

A rarely seen flower	A flowering plant with edible fruit	Flowers that people travel to see
		
The corpse flower, or Titan arum, smells like dead flesh and only blooms for 48 hours after taking years to bloom.	Orange trees provide fruit rich in vitamin C. There are more than 400 varieties of oranges grown worldwide.	Japanese cherry blossom is a tourist attraction in Japan as it blooms in March and April.

SC 2 CHECK YOUR UNDERSTANDING

Identify a key characteristic of flowering plants.

SC 3 I can describe the classification levels of a range of Australian native plant species

Australian native plants, like the country's unique wildlife, have adapted to survive in harsh environments, often with very little water.

For thousands of years, First Nations peoples have relied on native plants for food, medicine (Figure 5.7.4), tool-making materials, and even as a means of locating water. These plants also play a crucial role in providing habitats and food for native animals.

FIGURE 5.7.4 The bark of the blackwood (*Acacia melanoxylon*) is used in traditional medicine as a mild sedative or to soothe indigestion or rheumatism.

While all native plants have common names, they are also classified using scientific names. The classification system for plants differs slightly from that of other living organisms, following this hierarchy: kingdom, division, class, order, family, genus, and species. Many eucalypts, for example, share the same kingdom, division, class, order, family, and even genus, as they exhibit numerous common traits. Their differences are primarily distinguished at the species level.

Well-known examples of Australian native plants include conifers and eucalypts.

Australian conifers

Conifer is a plant that bears seeds on cones and has male and female cones on the same tree. There are many types of Australian conifers, including the Huon pine (*Lagarastrobos franklinii*) and the Wollemi pine (*Wollemia nobilis*).

The Wollemi pine produces female cones and male cones on the same tree (Figure 5.7.5). The seeds are protected inside the cone until they are ready to be released and dispersed. The seeds have small thin wings, and they rely on the wind for dispersal.

FIGURE 5.7.5 Male cones (top) grow lower in the tree than female cones (bottom).

Wollemi pine

Kingdom: Plantae
Division: Pinophyta (conifer)
Class: Pinopsida
Order: Araucariales
Family: Araucariaceae
Genus: *Wollemia*
Species: *nobilis*
Scientific name: *Wollemia nobilis*

Australian eucalypts

The *Eucalyptus* are flowering plants. There are more than 700 species, and they make more than two thirds of Australian forests. They add a layer of bark to their trunk as they grow, and they are characterised by the shedding of the outer layer. They are adapted to fire and some need the heat for their seeds to open. The fruit is woody and is often referred to as a 'gumnut' (Figure 5.7.6).

FIGURE 5.7.6 Eucalypts produce fruit known as gumnuts.

Australian grey ironbark

Kingdom: Plantae
Division: Angiosperms (flowering plants)
Class: Dicotyledons
Order: Myrtales
Family: Myrtaceae
Genus: *Eucalyptus*
Species: *paniculata*
Scientific name: *Eucalyptus paniculata*

SC 3 CHECK YOUR UNDERSTANDING

Identify the kingdom, division and class of the Australian grey ironbark.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Define photosynthesis.

2 Explain the significance of flowers in the reproduction of flowering plants.

3 Name two Australian native plant species and provide their classification up to the class level.

4 Describe how you would classify a newly discovered plant into one of the major plant divisions.

5 The Huon pine (*Lagarastrobos franklinii)* and the Wollemi pine *(Wollemia nobilis)* are both examples of Australian conifers. Outline characteristics that would help identify these two plants as separate conifer varieties.

5.8 Creating and using keys for Linnaean classification

Introduction

You have learned that organisms are grouped according to their similarities and differences so that it easier to classify and identify them. The tool that biologists use is the dichotomous key that is created using specific criteria. Once the keys are developed, they can be used to classify unfamiliar or new species of organisms.

In this practical investigation, you will create branching or table dichotomous keys to group animals into the classes of chordates.

Learning intention

To use and create keys to classify organisms using the Linnaean system

Success criteria

SC 1: I can identify features of animals that will enable them to be classified into a class of chordate.

SC 2: I can create a dichotomous key that will enable the classification of familiar and unfamiliar animals into classes of chordates.

SC 3: I can evaluate the strength of a dichotomous key used for classification and suggest improvements.

Background

All chordates have a nerve cord and most of them have a backbone to protect it.

There are eight classes of chordates. In the past, fish were in a single class but are now divided into three different classes: the Agnatha (jawless fish), Chondrichthyes (cartilaginous fish with jaws), and the Osteichthyes (bony fish). The other classes of chordates include the Amphibians, Reptiles, Aves (birds), and Mammals.

Observation of the structural features of organisms enables them to be organised into groups according to similarities and differences. This is the basis of classification and the creation of dichotomous keys.

Aim

To use the structural features of chordates to create dichotomous keys and classify them into classes

SkillBuilder

Developing branching flowchart dichotomous keys

Dichotomous keys can be used to classify or identify organisms that work by the process of elimination. They can be in the form of a branching flow chart, where the user starts at the top of the flowchart and tracks down through the questions until the organism is identified or classified.

Identifying and classifying

Identify means that you can actually name the organisms (specimens) that you are considering. For example, the naming of birds, or the identification of species of *Eucalyptus* trees in the forest.

Classify means that you can identify the group the specimens belong to. For example, identifying whether animals are reptiles, amphibians, mammals, birds or fish, or identifying the particular family that a tree belongs to.

Method

1. Observe and analyse your specimens and list the characteristics or features of your specimens so you can distinguish between them.
2. Choose characteristics that are easy to observe or can be measured.
3. Decide on what you think are the most general characteristics. Start your key with these.
4. Divide your specimens into two groups based on one of these general characteristics. Write a dichotomous question that will divide the group of specimens into these two groups.
5. Subdivide each of these first two groups into two more groups based on other characteristics, again drafting a dichotomous question which will divide the specimens. You should now have four groups.
6. Continue subdividing your groups in this way. You will soon have groups that only contain two or three specimens.
7. At this point identify one last characteristic that is different between the two specimens in that group, and you have completed that branch of your key.
8. Repeat the previous steps until all branches have been completed.
9. Test your key (or get someone else to test it) and make changes to the questions if required.

Examples

Laila was asked to create a key to identify breeds of dogs. Kai was asked to create a key to name pieces of fruit. Note that there are different ways to draw the flowchart key. Laila used Method 1 and Kai chose Method 2.

Method 1: The questions are written at the split in the branch and the new branches are labelled yes or no as shown in Figure 5.8.1, which is used to classify plants. Note that it is easier to always have the 'yes' branches on one side and the 'no' branches of the other side.

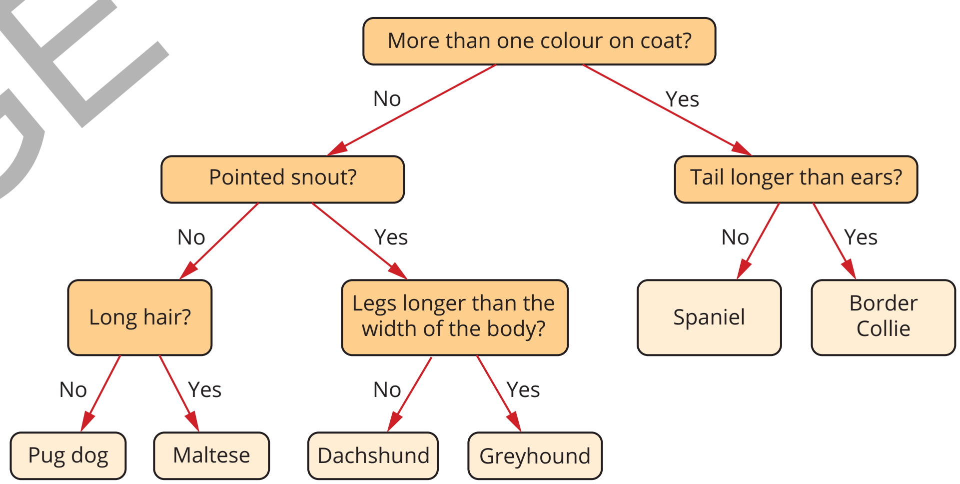


FIGURE 5.8.1 Laila's key

Method 2: Only the answers to each dichotomous question are written on the branch, as shown in Figure 5.8.2, which is used to classify animals.

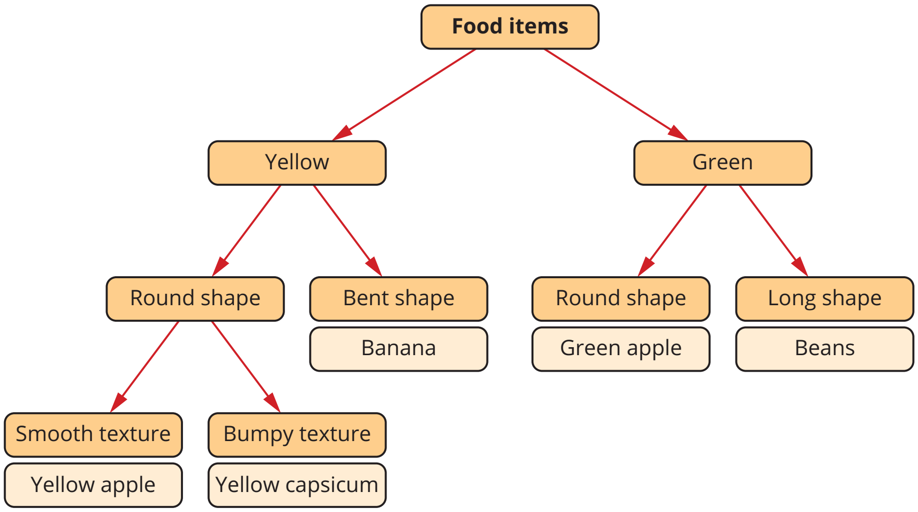


FIGURE 5.8.2 Kai's key

SkillBuilder

Developing table dichotomous keys

Dichotomous keys can be used to classify or identify organisms that work by the process of elimination. They can be in the form of a table where the user starts at the top of the table and follows the directions after each question until the organism is identified or classified. In effect you are following a trail, based on the answers to the questions.

Method

1 Observe and analyse your specimens and list the characteristics or features of your specimens so you can distinguish between them.
2 Choose a characteristic that is easy to observe or can be measured.
3 Decide on what you think are the most general characteristics. Start you key with these.
4 Divide your specimens into two groups based on one of these general characteristics. Write a dichotomous question that will divide the group of specimens into these two groups.
5 Set up with a bank table with three columns as shown below.

Step	Descriptions	Action
1		

6 Each step in the table is a dichotomous question with two possible answers.

7 For Step 1, write out the two answers to the first question and label these 1a and 1b.

Step	Descriptions	Action
1	1a Has fur	
	1b No fur	

8 Draft two more questions that will subdivide the groups and add to your table. For example:

Step	Descriptions	Action
1	1a Has fur	go to Step 2
	1b No fur	go to Step 4
2	2a Lays eggs	This is a monotreme
	2b gives birth to live young	Go to Step 4
3	3a has feathers	This is a bird
	2b no feathers	Go to Step 5

HINTS

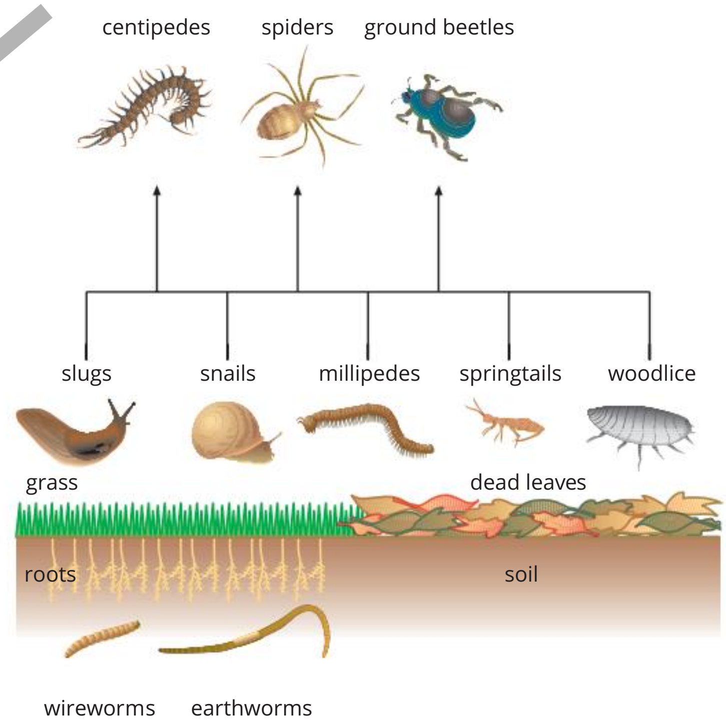
Note that table dichotomous keys are much easier to build digitally as you can edit the table as you build it.

9 Continue adding questions until all specimens have been identified or classified.

10 Test your key (or get someone else to test it) and make changes to the questions if required.

Example

Ethan was asked to create a table key to identify the minibeasts found in the soil.



His key is shown here.

Step	Descriptions	Action
1	1a Legs	Go to 5
	1b No legs	Go to 2
2	2a Antennae	Go to 4
	2b No antennae	Go to 3
3	3a 'Snake-like' shape	earthworm
	3b Not 'snake-like' shape	wireworm
4	4a Shell	snail
	4b No shell	slug
5	5a More than 10 pairs of legs	Go to 6
	5b Less than 10 pairs of legs	Go to 7
6	6a More than 20 pairs of legs	millipede
	6b Less than 20 pairs of legs	centipede
7	7a More than 3 pairs of legs	Go to 9
	7b 3 pairs of legs	Go to 8
8	8a Tail	ground beetles
	8b No tail	springtails
9	9a Two body segments	spider
	9b More than two body segments	woodlice

Materials

- multiple photos of animals belonging to the eight classes of chordates
- specimens (preserved), skeletons or fossils of the eight classes of chordates
- magnifying glasses
- butcher paper and coloured pens
- sticky notes or small pieces of paper

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

SAFETY NOTES

- The liquids used to preserve the specimens are hazardous and toxic.
- Do not open any jars or touch preserved specimens.

Method

Your teacher will provide several photos and specimens of animals that belong to the phylum Chordata.

1 Observe each of the specimens and note the following on a piece of paper or sticky note:

- The name of the specimen (common or scientific name).
- The distinctive characteristics and structural features of the specimen.

Do not write about its habitat or how it moves.

2 Use the butcher paper and coloured pens to organise the specimens into groups. You can use colour coding to help here. This will help you to create the dichotomous keys.

3 Discuss the features that your group will use to create a dichotomous key and use these features to develop dichotomous questions.

Results

Use your observations to create a dichotomous key, either a table key or branching key.

Evaluation

1 Ask other students to try using your key.

2 Classify an unfamiliar animal using your key.

3 Discuss any improvements that you could make to the key to enable more effective classification.

5.9 Fieldwork as a part of science inquiry

Lesson overview

Scientists ask questions and gather data to find answers. Biologists gather much of their data during fieldwork. Fieldwork involves making observations in the environment that the scientist is interested in. There are many techniques used in fieldwork, alongside safety considerations and ethical behaviour that limits the disruption caused to the ecosystem that is being observed and measured.

In this lesson, the observation techniques used in fieldwork will be discussed. Ethical and cultural considerations, including impact reduction on ecosystems during fieldwork will also be presented.

SC 1 I can describe methods that scientists use to observe and identify organisms in the field

Scientists who study the environment and living organisms must often work outside the laboratory; that is, in the field. **Fieldwork** involves making observations and collecting data that can be analysed later to help answer scientific questions. Observations must be accurate and precise so that important details are not missed; in classification, for example, such details could be vital for the correct identification of species.

Observations are made in many ways. Scientists make notes about what they observe and any measurements they take (Figure 5.9.1). For example, if they are studying the types of organisms that live in a specific environment, they may record the air temperature, humidity, light intensity and soil type. When recording details about the structure and features of organisms, scientists make sketches and take photographs in addition to their notes and measurements. This enables them to compare observations from previous studies and use keys to identify the organisms observed.

FIGURE 5.9.1 Scientist taking a photographic survey of a coral reef

Learning intention

To understand how scientists use fieldwork to collect data

Success criteria

SC 1: I can describe methods that scientists use to observe and identify organisms in the field.

SC 2: I can explain how scientists reduce their impact on organisms and the environment during fieldwork.

SC 3: I can analyse ethical and cultural considerations in conducting fieldwork.

KEY TERM

fieldwork a practical investigation performed mainly outside in nature

Scifile

Wildlife tracking

Scientists use fieldwork to track wildlife populations by observing animal tracks, droppings, and other signs. This data helps them understand animal behaviours and habitats, contributing to conservation efforts and protecting endangered species.

FIGURE 5.9.2 Taking measurements is an important part of analysing environments

FIGURE 5.9.3 Scientists must reduce their impact on the environment when working in the field

Recording data

Methods for recording data in the field can include:

- making notes
- sketching organisms to scale
- taking photos
- taking measurements and recording data; sampling an area
- taking measurements and recording data; individual measurements (Figure 5.9.2)
- using existing data, such as observations and scientific journals, to identify organisms
- using dichotomous keys to identify organisms.

SC 1 CHECK YOUR UNDERSTANDING

List two methods that can be used to record data in the field.

SC 2 I can explain how scientists reduce their impact on organisms and the environment during fieldwork

When scientists work out in the field, they need to minimise their impact on the environment (Figure 5.9.3). The harmful impacts of fieldwork include any activities that pollute or damage the environment or disturb local wildlife. For example, car tyres and shoes can damage the soil and vegetation and transmit diseases.

To minimise the **ecological** impact during fieldwork, consider these straightforward practices described in Table 5.9.1.

KEY TERM

ecological a description of something that relates to ecosystems or interactions between living things and their environment

TABLE 5.9.1 Ecological impacts and minimisation strategies

Potential impact	Minimisation strategy
Introducing new organisms from a foreign area	Before entering the field, especially if you have been on a farm or in a contaminated area, thoroughly wash all shoes and boots
Damaging plants and soil structure	Stick to designated pathways
Disrupting ecological balance	Avoid removing any organisms from the area. Leave the environment in the same condition as you found it (Figure 5.9.4)
Introducing contaminants (including chemicals and microorganisms) that can disrupt flora and fauna	Ensure you leave no litter behind, including liquid in containers (which can alter the area's scents), when you depart Refrain from introducing any substances into the water, including beverages
Disrupting natural animal behaviour	Avoid altering the natural lighting conditions in the area, such as shining a torch at night on possums or owls

FIGURE 5.9.4 Students making observations around rockpools using a quadrat, minimising disruption to the surrounding environment by only sampling a small area

SC 2 CHECK YOUR UNDERSTANDING

Identify one technique used to minimise impact during fieldwork.

SC 3 I can analyse ethical and cultural considerations associated with conducting fieldwork

All fieldwork should be planned and conducted in a way that is ethical, responsible and safe. **Ethics** are the moral values that regulate a person's behaviour and the way they conduct activities. In biological fieldwork, for example, ethical behaviour involves maintaining respect for the environment and making sure that no harm is done, which means leaving everything as it was found so as not to disrupt living organisms (Figure 5.9.5).

It is also important to consult with the First Nations people whose traditional **Country** will be affected by the work. This can be done through a Native Title group, a Local Aboriginal Land Council or similar body, which helps to ensure that the scientists are not disturbing culturally sensitive locations, such as burial sites. Finally, it is vital to understand that any ecological knowledge shared by First Nations people remains the rightful ownership of the community, which includes safeguarding their knowledge.

Another important thing to remember is that including knowledge from First Nations peoples in fieldwork research is important to make sure all parts of ecosystems are understood. First Nations peoples often have important knowledge about changes to vegetation and seasonal weather variations, for example, which gives scientists unique information about ecological processes over long periods of time. First Nations communities can also identify locations of cultural importance within a research site, making sure scientists conducting fieldwork are being respectful of these sites (Figure 5.9.6).

SC 3 CHECK YOUR UNDERSTANDING

Explain why it is important to consider cultural perspectives in fieldwork.

KEY TERMS

ethics a set of principles by which your actions can be judged morally acceptable or unacceptable

Country the land that First Nations peoples have a cultural connection to through their ancestry

FIGURE 5.9.5 A scientist taking photographs of the environment to study later; by only taking a photograph, the scientist is taking care to leave the environment as they found it

FIGURE 5.9.6 Protected areas in Budj Bim, Victoria have developed specialised zones for visitors viewing.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Define the term 'ecological'.

2 Name three things that a scientist might record about an environment when conducting fieldwork.

3 You are planning a fieldwork to observe a population of frogs in a wetland.

  a Identify one technique you could use to minimise your impact on the environment.

  b Explain why minimising impact is important for your study.

4 Explain why scientists might make sketches and take photographs along with their notes and measurements.

5 Describe one way you could address ethical considerations when planning fieldwork in a protected area.

5.10 Using the Linnaean classification system and a dichotomous key in fieldwork

Learning intention

To be able to classify and/ or identify organisms in the local environment

Success criteria

SC 1: I can select and plan for methods to observe organisms in the environment.

SC 2: I can use a dichotomous key based on organisms observed in the field.

SC 3: I can use data from observations in the field to determine kingdom, division and class using the Linnaean classification system.

FIGURE 5.10.1 You can use a dichotomous key to identify plants in your local environment

SAFETY NOTES

- Wear a hat and sunscreen when outside.
- Do not touch any plants.
- Some plants may be poisonous or may cause allergic reactions.
- Do not go into inaccessible areas.

Introduction

You have learned how to carry out fieldwork effectively and without causing any damage to the environment to be studied. You have also learned that organisms are grouped according to their similarities and differences to make it easier to classify and identify them. The tool that biologists use is the dichotomous key that is created using specific criteria.

In this practical investigation, you will bring your knowledge together to study a local habitat and classify living things by observation and classifying them using a dichotomous key (Figure 5.10.1).

Background

There are many varieties of plants even in small, local environments. Plants are classified into four divisions: mosses and liverworts, ferns, conifers and seed-producing plants.

Observation of the structural features of plants in the field can be achieved using many different methods. The data collected can be used to organise of them into groups according to similarities and differences. This is the basis of classification, and the use of dichotomous keys can identify the plants.

Aim

To use a provided key to identify and classify some plants observed in a local habitat

Materials

- notebooks and pencils
- magnifying glasses or hand lens
- camera
- access to reference books or the internet to research plant classification
- access to the dichotomous key for this activity

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

Method

Your teacher will take you to a local habitat.

1 Observe at least five specimens of plants.
   - Note the distinctive characteristics and structural features. Do this in your notebook for each specimen using dot points.

- Sketch the plant, especially the leaf structure, any flowers if present, cones, fruits, and estimate the size of the plant and the leaves. Try to sketch the leaves or flowers to scale.
- You may need to use a magnifying glass to see any detail.
- Take some photos of the specimens.

GO TO
Toolkit section 5.2, Scientific diagrams

2 Use the dichotomous key (Figure 5.10.2) to classify the plant into the divisions of plants. If the plant is seed-producing you could try to classify it into its class.

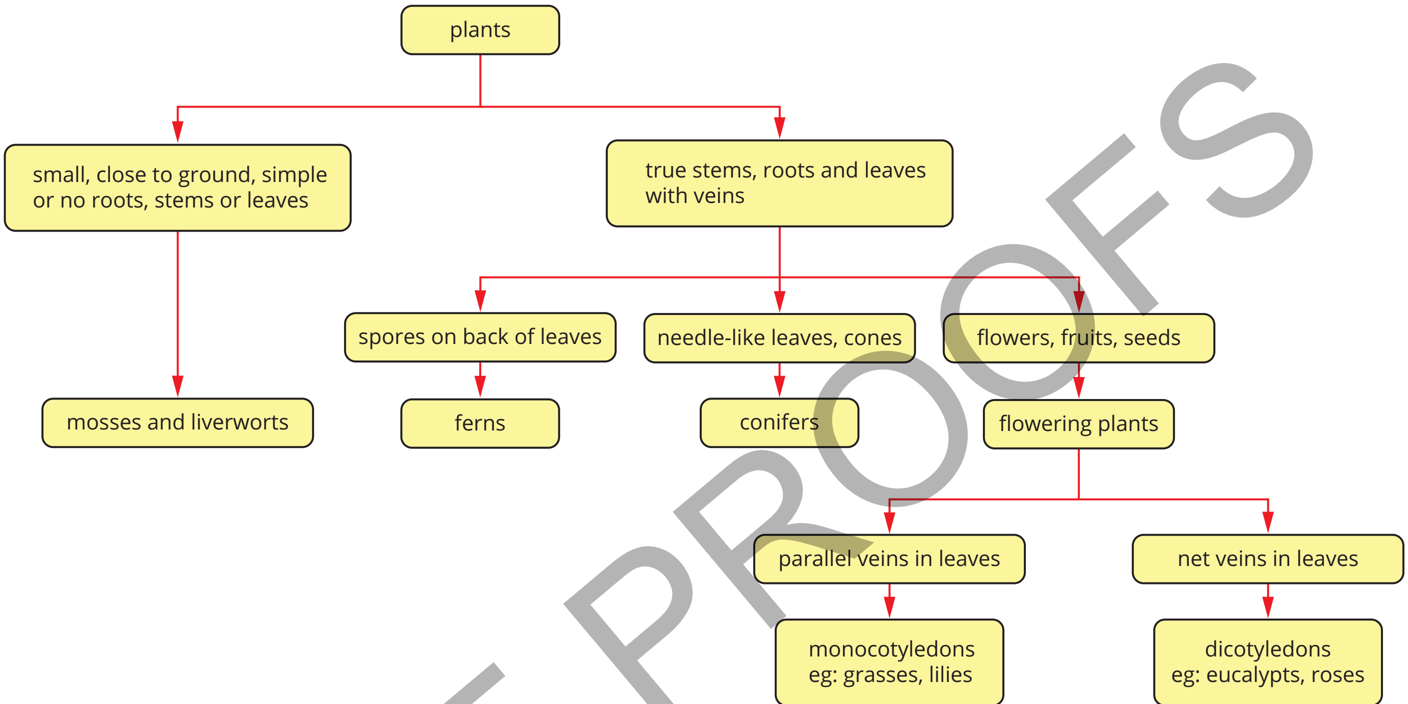


FIGURE 5.10.2 Use this key to help you classify plants in your local habitat

3 If you have reference material that is more detailed, you could use that to find out the scientific name of the plant.

Results

Present your observations, classification and identification of the plants studied in an organised way. Use the dichotomous key and any other resources available to identify your plant specimens.

Evaluation

1 Swap results with other students to try to classify plants using their observations.

2 Discuss any improvements that you could make to your observations to enable more effective classification.

3 Describe how you reduced the impact on the habitat during your fieldwork.

5.11 First Nations Australians' classification systems

Learning intention

To understand similarities and differences between First Nations Australians' systems of classification and Linnaean classification

Success criteria

SC 1: I can describe how a group of First Nations Australians classify plants or animals in their environment.

SC 2: I can compare First Nations Australians' systems of classification and the Linnaean classification system.

SC 3: I can describe how First Nations Australians' knowledge have contributed to development of knowledge of biodiversity.

Lesson overview

Various methods for organising and naming organisms are used within Australia and throughout the world. The Linnaean classification system, still widely used in Western science today, is a hierarchical method of grouping organisms into increasingly specific categories, starting with the broadest group (kingdom) and ending with the most specific group (species). In contrast, First Nations Australians have a unique classification system that draws on ecological knowledge alongside a deep spiritual and cultural understanding of their environment (Figure 5.11.1).

FIGURE 5.11.1 These grass trees are *Xanthorrhoea australis*, based on the Linnaean system, but are called balga, bukkup, baggup or kawee by First Nations peoples (depending on the language groups)

In this lesson, you will learn about the similarities and differences between First Nations Australians' systems of classification and Linnaean classification.

SC 1 I can describe how a group of First Nations Australians classify plants or animals in their environment

First Nations Australians have a deep understanding of the plants and animals in their environment, as they have lived in Australia for more than 60 000 years. This traditional knowledge is often based on the connections between living things, as well as their connections to the land and the spiritual world. Accordingly, it is important to understand how First Nations peoples name and classify the organisms in their environment.

For example, First Nations Australians have given names to plants and animals that communicate their specific characteristics, uses and cultural significance. First Nations Australians also have a special way of grouping and understanding living things. Their classification systems can include how the organism is used, how old it is, what stage in its life cycle it is in, its gender, social status, and whether it is associated with a **totem**. First Nations Australians express their knowledge in many ways including through oral

KEY TERM

totem a specific animal, plant or natural feature that a person is spiritually linked to; determines relationships with others and rights tradition and artwork (Figure 5.11.2). First Nations Australians' detailed knowledge of native plants and animals was initially ignored by European naturalists but in recent times has helped scientists to learn more about these organisms. This emphasises how important it is to respect and value different ways of understanding the natural world, and to work together to learn more about it.

FIGURE 5.11.2 First Nations artwork of a dugong

Eucalyptus trees

Many First Nations groups have a deep understanding of the different species of *Eucalyptus* and how to use them for medicinal, nutritional and other practical purposes. For example, the bark of some *Eucalyptus* species is rich in tannin, which is traditionally used for tanning animal hides (Figure 5.11.3). The leaves of some other species, by contrast, are rich in oils that can be used for making ointments and other medicinal remedies.

FIGURE 5.11.3 The bark of the River Red Gum (*Eucalyptus camaldulensis*) is rich in tannin

Kangaroos

First Nations Australians classify animals according to their characteristics, behaviours and relationships with other species. Therefore, they may classify different types of kangaroos according to their size, colour and habitat, as well as noting their seasonal movements and the types of plants they eat (Figure 5.11.4). This knowledge is passed down through generations through storytelling, song, dance and other cultural practices.

FIGURE 5.11.4 First Nations Australians may classify kangaroos according to their seasonal movements and the plants they eat

SC 1 CHECK YOUR UNDERSTANDING

Identify two characteristics that First Nations Australians may use to classify kangaroos.

SC 2 I can compare First Nations Australians' systems of classification and the Linnaean classification system

The Linnaean classification system

The Linnaean classification system, developed by Carl Linnaeus in the 18th century, is based on a hierarchical system of grouping organisms based on physical characteristics and similarities. It organises organisms into increasingly specific categories, starting with the broadest, kingdom, and ending with the narrowest, species.

First Nations classification systems

The classification systems used by First Nations Australians are based on a different understanding of the natural world in comparison to the Linnaean classification system. These systems reflect a profound knowledge of the relationships between different organisms and their environment and often include both physical and **spiritual** aspects. For example, many plants and animals are totems or spiritual guides for specific communities that also appear in **Creation stories**, ritual and ceremony, art and storytelling and healing.

KEY TERMS

spiritual relates to the soul or spirit or religious beliefs

Creation stories stories that explain the origins of the universe, the rules for living and the relationship of people to each other and the environment; also known by many as Dreaming stories

KEY TERM

billabong a pond of still water in an isolated branch of a river that fills during a flood

FIGURE 5.11.5 Green Turtles are common in Australia's northern waters and around the Torres Strait Islands

FIGURE 5.11.6 Dugongs have many similarities with turtles but are classified as mammals in the Linnaean system because they give birth to live young

Habitat

First Nations classification systems are often more fluid than the Linnean system and can change over time. For example, in the Yanyuwa peoples' system of classification that separates coastal and inland regions, a turtle found in the sea may be classified as a marine organism, but if it is found in a freshwater **billabong**, it may be reclassified as an inland animal (Figure 5.11.5).

Time of life

The Yanyuwa language has one word for all dugongs and sea turtles as they both have flippers and live in water, but this category is broken down into at least 16 different names to distinguish between them. These names include variations based on the animal's age, size and even its status within its herd. Similarly, in the Meriam language of the Torres Strait, there is one word for a green turtle, but different words are used at different stages of the green turtle's development. In the Linnaean system, however, turtles and dugongs are classified in different groups or 'classes': turtles as reptiles and dugongs as mammals (Figure 5.11.6).

Comparison of classification systems

The Linnaean classification system is a hierarchical system that organises organisms into increasingly specific categories based on their physical characteristics. First Nations Australian classification systems also include physical characteristics but are based on a different understanding of the natural world, which includes spiritual, cultural and practical aspects that can be more fluid and adaptive.

SC 2 CHECK YOUR UNDERSTANDING

Explain one key difference between First Nations Australians' classification systems and the Linnaean system.

SC 3 I can describe how First Nations Australians' knowledge has contributed to the development of knowledge of biodiversity

First Nations Australians have a full and detailed knowledge of the biodiversity of their traditional lands, which has been passed down through generations. This knowledge has contributed to an understanding of the importance of biodiversity, the role different species play in their interactions, and the significance of preserving this delicate balance.

In First Nations culture, all organisms are given equal importance, fostering the preservation of biodiversity. Furthermore, First Nations knowledge has provided valuable insights into sustainable land management practices, such as fire management and the use of traditional burning techniques, as well as in the identification and conservation of threatened species and ecosystems.

Below are some examples of how the knowledge of First Nations Australians has contributed to the understanding of biodiversity and development of effective conservation strategies.

Fire management

First Nations Australians have used fire as a tool for thousands of years to manage the landscape and maintain biodiversity. In northern Australia, researchers have observed kites and falcons, known as 'firehawks', intentionally carrying burning sticks to spread fires. This remarkable behaviour challenges Western understanding of how birds interact with fire and highlights the complex relationship, understood by First Nations Australians, between fire management and biodiversity. Recognising the changes in plant biology caused by constant burning and the development of seed pods that only open with fire, First Nations practices encourage more fertile land and the cultivation of new plants, showcasing their extensive ecological knowledge (Figure 5.11.7).

FIGURE 5.11.7 First Nations land management practices such as cultural burning encourage more fertile land and plant germination

Threatened species conservation

First Nations knowledge has played a key role in the identification and conservation of threatened species, such as the giant barred frog and the northern quoll (Figure 5.11.8). First Nations rangers use their knowledge to monitor and protect these species, and to assist in reintroduction programs.

FIGURE 5.11.8 The endangered Northern Quoll (*Dasyurus hallucatus*)

Marine conservation

First Nations knowledge plays a vital role in managing and conserving Australia's marine biodiversity. Communities like the Torres Strait Islanders, for example, use their deep understanding of marine animal migrations to develop sustainable fishing practices. In this way, they have maintained a cultural and spiritual connection with the sea for generations.

Traditional stone **weirs**, built over centuries, showcase the technological expertise of First Nations communities along the coast. Similarly, traditional fish and eel traps are cleverly designed to consider genetic diversity by catching only larger animals and preserving the younger generation.

KEY TERM

weir a low barrier built across a river which can be used to raise the level of water upstream and/or control the flow of the river

Respectful rules like taking only what is needed, avoiding undersized or pregnant animals, and preventing overfishing to allow fish to breed and grow, maintain both sustainable populations and the wellbeing of communities (Figure 5.11.9).

FIGURE 5.11.9 The Gunditjmara people developed a large aquaculture system at Budj Bim in Western Victoria that demonstrates deep understanding of the sustainable fishing of short-finned eel.

Knowledge and use of plants

First Nations people possess a deep understanding of native plants' medicinal properties, shedding new light on the way people look at treating diseases such as cancer, respiratory problems and digestive ailments. For example, the Blushwood berry native to northern Queensland has been used for centuries by First Nations people to treat various health issues (Figure 5.11.10).

FIGURE 5.11.10 The Blushwood berry has been used for centuries by First Nations people to treat various health issues.

SC 3 CHECK YOUR UNDERSTANDING

Explain how traditional ecological knowledge from First Nations Australians has enhanced scientific understanding of biodiversity.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1. Name one way that First Nations Australians classify plants.
2. List the ways that First Nations Australians manage fish populations to maintain biodiversity.
3. Describe how an organism's habitat may alter its classification using a First Nations Australians classification system.
4. Explain how First Nations fire management can be used to improve ecosystems.

5.12 Changing classification systems

Introduction

Classification systems can change as scientists discover new information or interpret evidence in new ways. As scientists interpret evidence in new ways, their understanding of the relationships between different organisms may change, leading to changes in the classification system.

In this inquiry, you will explore how classification systems change as scientists discover new information or interpret evidence in new ways and you will research an example of this.

Background

Classification systems have changed over time as scientists have discovered new information and developed new methods for analysing data or information. In the past, classification systems were mainly based on morphological evidence, which is the physical characteristics of the organism. This led to classification systems that were based on observable features.

Scientists have used new tools to look at the **DNA** (Figure 5.12.1) of living things and see how they are related to each other. Scientists have learnt more about how different species changed over time. This has led to changes in classification systems, as genetic data has shown previously unknown relationships between organisms and provided information about how they have changed over time.

Aim

To explore examples of changing classification systems as scientists discover new information or interpret evidence in new ways

Plan

1 Using knowledge from this topic and further research, explore the types and/or sources of evidence that affect classification systems and summarise these.

2 Research and describe two examples of organisms that have been reclassified due to new scientific evidence.

Design

1 Choose one species, or groups of species, due to advancements in scientific evidence, is now classified differently from the traditional Linnaean system. Describe the species and explain why this reclassification was of interest to you.

Learning intention

To explore how classification systems change as scientists discover new information or interpret evidence in new ways

Success criteria

SC 1: I can describe types and/or sources of evidence that affect systems of classification.

SC 2: I can explain how classification systems have changed as a result of new scientific evidence.

SC 3: I can predict how classification systems may change in the future as a result of new technologies and/or scientific evidence.

FIGURE 5.12.1 Scientists can now use methods such as genetic analysis to classify living things

KEY TERM

DNA the genetic material found in organisms that is passed from generation to generation

GO TO
Toolkit section 4.3, Selecting and using secondary data
Toolkit section 5.1, Scientific writing

2 Consider how you might present information about this change to an audience. What information will you include and how will you present this information?

Conduct

You will now have an opportunity to create your presentation about a particular classification system that has been changed because of new scientific evidence. You may like to consider the questions below to help guide your content.

- What living thing did you investigate?
- How was the living thing classified in the past? What classification system was used to classify it that way?
- How is the living thing classified now? What classification system is used to classify it this way?
- What new scientific evidence was used that influenced this change?

Share your predictions about how this classification systems might change in the future because of new technologies and/or scientific evidence.

Improve

Suggest how you can improve your investigation by considering what worked well, what needed improvement and how you could modify your presentation to make it more effective at communicating the information.

Evaluate

1 In this activity, you planned and conducted an inquiry into classification systems that have changed due to new evidence. What skills did you use during this activity and how did your knowledge of classification systems improve?

2 Use your knowledge of classification and scientific evidence to predict how classification systems might change in the future because of new technologies and/or scientific evidence.

5 Classification and biodiversity

Topic summary

The key concepts included in this topic are:

- Organisms can be classified according to their similarities and differences.
- Scientists classify organisms so they can be easily identified.
- Scientific classification models are used for accurate identification of organisms.
- Dichotomous keys are tools used to identify and classify organisms.
- Changes to classification models occur over time.
- First Nations Australians have a unique way of classifying plants and animals based on their rich cultural understanding of the land.

Review questions

The following questions will assess your success in achieving the learning intentions for this topic.

Remember

1 Identify the main role of classifying biodiversity on Earth.

2 Describe the purpose of dichotomous keys.

3 Identify the first step in creating a dichotomous key.

4 Name one characteristic of the phylum Arthropoda.

Understand

5 Explain how classification helps in the study of biodiversity.

6 Explain how a classification key, such as a dichotomous key, can determine which group an organism will belong to.

7 Classify a lion (*Panthera leo*) using the Linnaean hierarchical classification system up to its class.

8 List the steps that would be used to classify a fern using the Linnaean system of kingdom and division.

9 Describe one way that First Nations Australians' knowledge has contributed to development of knowledge of biodiversity.

Apply

10 Gyaan is undertaking fieldwork to identify plants.
- a Suggest what type of data could be collected through observation.
- b Describe the process of how Gyaan would use the data to classify a shell that was found.

11 A dichotomous key was created to identify plants in a section of forest. How could you incorporate First Nations Australians' knowledge of plants into this key?

Analyse

12 There are many different species of kangaroo.
- a Identify the phylum to which kangaroos belong and explain the reasoning behind their classification into this group.
- b The western grey kangaroo (*Macropus fuliginosus*) and the red kangaroo (*Magaleia rufa*) share many common features. Describe the similarities and differences in the classification of these two types of kangaroos.

13 Compare the characteristics of flowering plants and non-flowering plants.

14 Ethics are an important part of scientific research practices.
- a Explain the concept of ethics in fieldwork.
- b Outline one ethical consideration that you would be mindful of when conducting fieldwork on endangered species.

Extension: Classifying

15 Australian native animals are an important part of biodiversity in Australia.

- **a** Create a set of instructions of how you could create a dichotomous key for classifying Australian native animals into their respective classes.
- **b** Use your instructions to create a branching dichotomous key using six different Australian animals.
- **c** Test how effective your key is by swapping with another student to see if they can correctly identify the animals you selected.

Topic reflection

The learning intentions for this topic are given in each lesson and at the beginning of the topic. Consider how well you have achieved them. Note down any particular areas that you are confident in, and others where you are not so sure.

5 Glossary

arthropod animal with an exoskeleton and jointed limbs; examples include crabs and insects

biodiversity the number and range of species that exist in an ecosystem, biome or biosphere

billabong pond of still water in an isolated branch of a river that fills during a flood

celestial relating to the sky or to space

characteristic a feature of a living or non-living thing

Chordata the phylum that includes animals with backbones

chordate animal with a nerve cord running down its back, and an endoskeleton

class the third level in the classification of living things

classification the process of putting things into groups

classification key a tool that helps scientists classify organisms based on their observations and descriptions

Creation stories stories that explain the origins of the universe, the rules for living and the relationship of people to each other and the environment; also known by many as Dreaming stories

cnidarian animal with radial symmetry, one body opening and stinging cells

common name a non-scientific name given to an organism

conifer a plant that bears seeds on cones and has male and female cones on the same tree

Country the land that First Nations peoples have a cultural connection to through their ancestry

culture a combination of the values, beliefs, language systems, communication, and practices that people share

cultural perspective way that an individual is affected by its environment, as well as social and cultural factors including race and gender

cultural significance the special meaning or importance of traditions, customs, symbols, beliefs, art forms, or historical sites to a cultural group

dichotomous key a key with two choices at each stage

dichotomous question a question that limits responses to only two possible answers

diverse having variety

diversity the variety of differences

division the level below kingdom in the classification of plants

DNA the genetic material found in organisms that is passed from generation to generation

ecological a description of something that relates to ecosystems or interactions between living things and their environment

ecosystem a system formed by organisms interacting with each other and their nonliving surroundings

endoskeleton a skeleton inside the body

ethics a set of principles by which your actions can be judged morally acceptable or unacceptable

exoskeleton a skeleton on the outside of the body

family the level in the classification system below order and above genus

fieldwork a practical investigation performed mainly outside in nature

genus the level in the classification system below family and above species

hierarchy an arrangement that shows items at different levels compared to others

hydroskeleton a fluid filled soft tissue found inside the body

Linnaean classification a hierarchical system of classifying organisms, aimed at reflecting their evolutionary relationships

kingdom the first level of classification of living things

marsupial subclass of mammal that gives birth to immature young that are suckled in a pouch; examples are koala, kangaroo and wombat

monotreme subclass of mammal that lays eggs; examples include echidna and platypus

nervous system body system that sends and receives signals from different parts of the body to control and coordinate movement and sensory information

order the level in the classification system below class and above family

organism a living thing

organ system two or more different organs that work together

phylum the second level of classification of living things, below kingdom and above class

photosynthesis the chemical reaction in plants that converts carbon dioxide and water into oxygen and glucose using energy from sunlight

pollination the transfer of pollen from anther to stigma

scientific name a Latin name for an organism based on the binomial system

species the last level of classification of living things

spiritual relates to the soul or spirit or religious beliefs

spiritual importance the value of something that connects people to a force greater than themselves

state one of the three forms that matter can exist in—solid, liquid or gas

totem a specific animal, plant or natural feature that a person is spiritually linked to; determines relationships with others and rights

taxonomist a scientist who specialises in classifying and naming things

taxonomy the science of classifying and naming things

weir a low barrier built across a river which can be used to raise the level of water upstream and/or control the flow of the river

Western system approach and way of working derived from European countries

world view a way of considering the world in terms of attitudes, values and beliefs

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