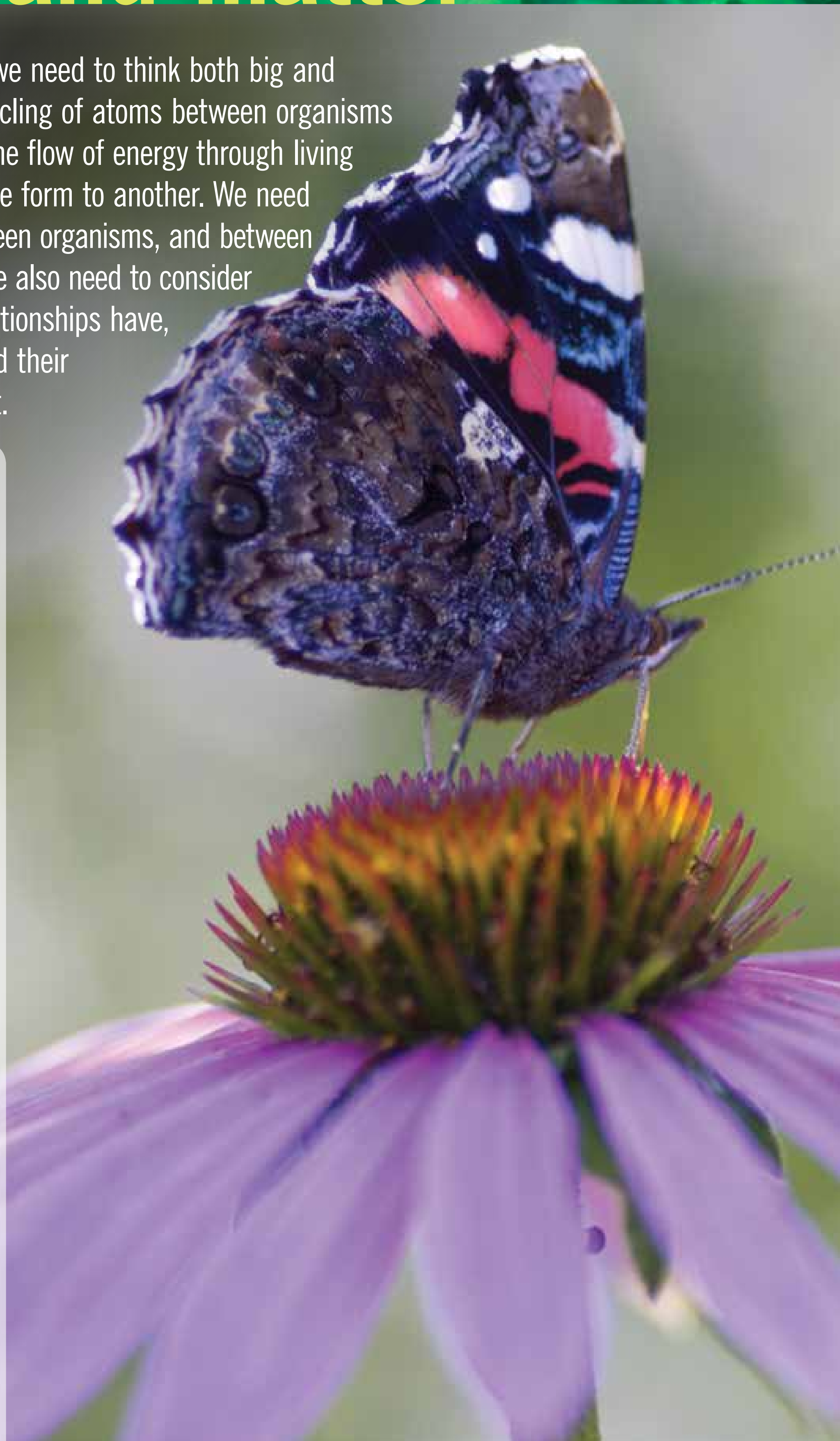
5 Ecosystems — flow of energy and matter

When we think about ecosystems, we need to think both big and small. We need to consider the recycling of atoms between organisms and within their environment and the flow of energy through living organisms and its changes from one form to another. We need to appreciate the relationships between organisms, and between organisms and their environment. We also need to consider the potential effects that these relationships have, not only on individual organisms and their environment, but also on our planet.



Think about ecosystems

- How can stomata help pull water up a plant?
- Is being green essential for photosynthesis?
- Why do some cells have more mitochondria than others?
- What's the difference between nitrifying and denitrifying bacteria?
- Why do energy pyramids always have the same basic shape?

In this chapter:

YOUR QUEST

Water

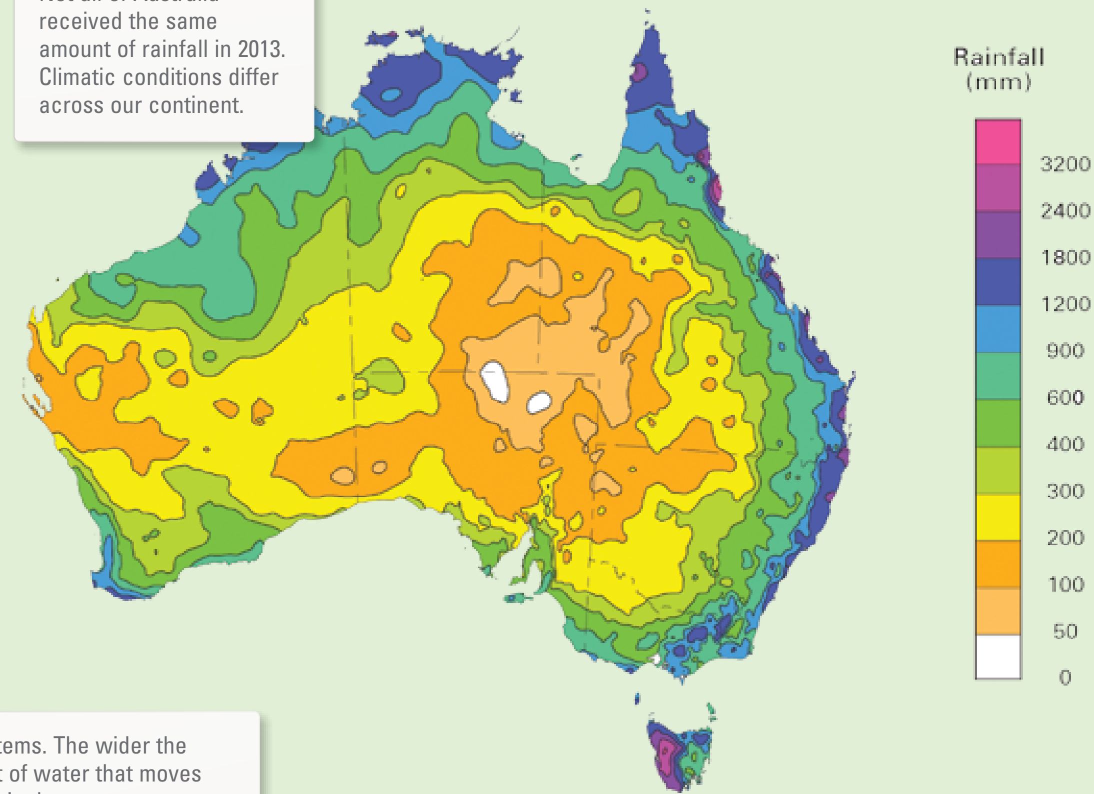
Organisms need water to survive. The good news is that water cycles through ecosystems. The bad news is that, at times, the amount of water available can be too great (as in the case of floods) or too little (as in the case of drought).

Some species have adapted to these conditions and possess adaptations that increase their chances of survival. Other organisms are not so fortunate and severe conditions of too much or too little water can result in their death. If too many of a particular type of organism die, then the decrease in their population size can have implications not only for other members of their food web, but also for other biotic and abiotic factors within their ecosystem.

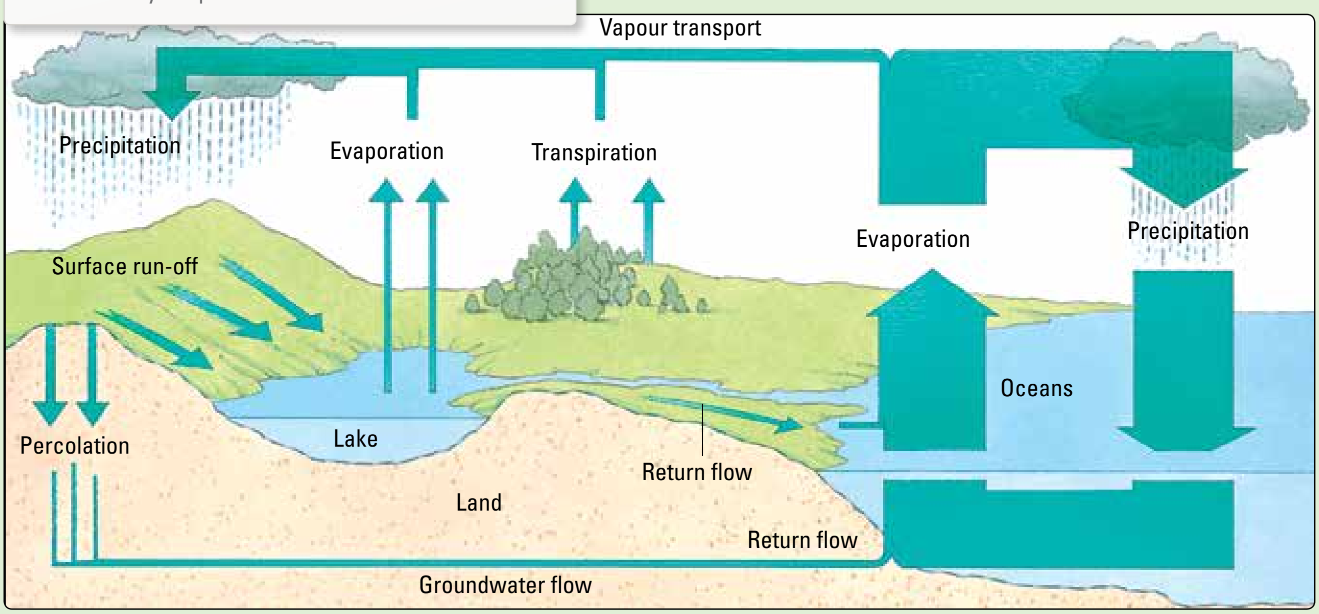
THINK, INVESTIGATE AND CREATE

Carefully examine the water cycle and the 2013 Australian rainfall figures. Australia is considered to be one of the driest continents on Earth, yet there is a variety of ecosystems within it. Use a range of resources to answer the following essential question: How can *where* an organism lives affect *how* it lives? Present your findings as a set of models or in a creative multimedia format.

Not all of Australia received the same amount of rainfall in 2013. Climatic conditions differ across our continent.



Water cycles through ecosystems. The wider the arrow, the greater the amount of water that moves through that part of the cycle. Is the movement of water by transpiration greater or less than the movement by evaporation from the ocean surface?



Systems: Ecosystems

Living together

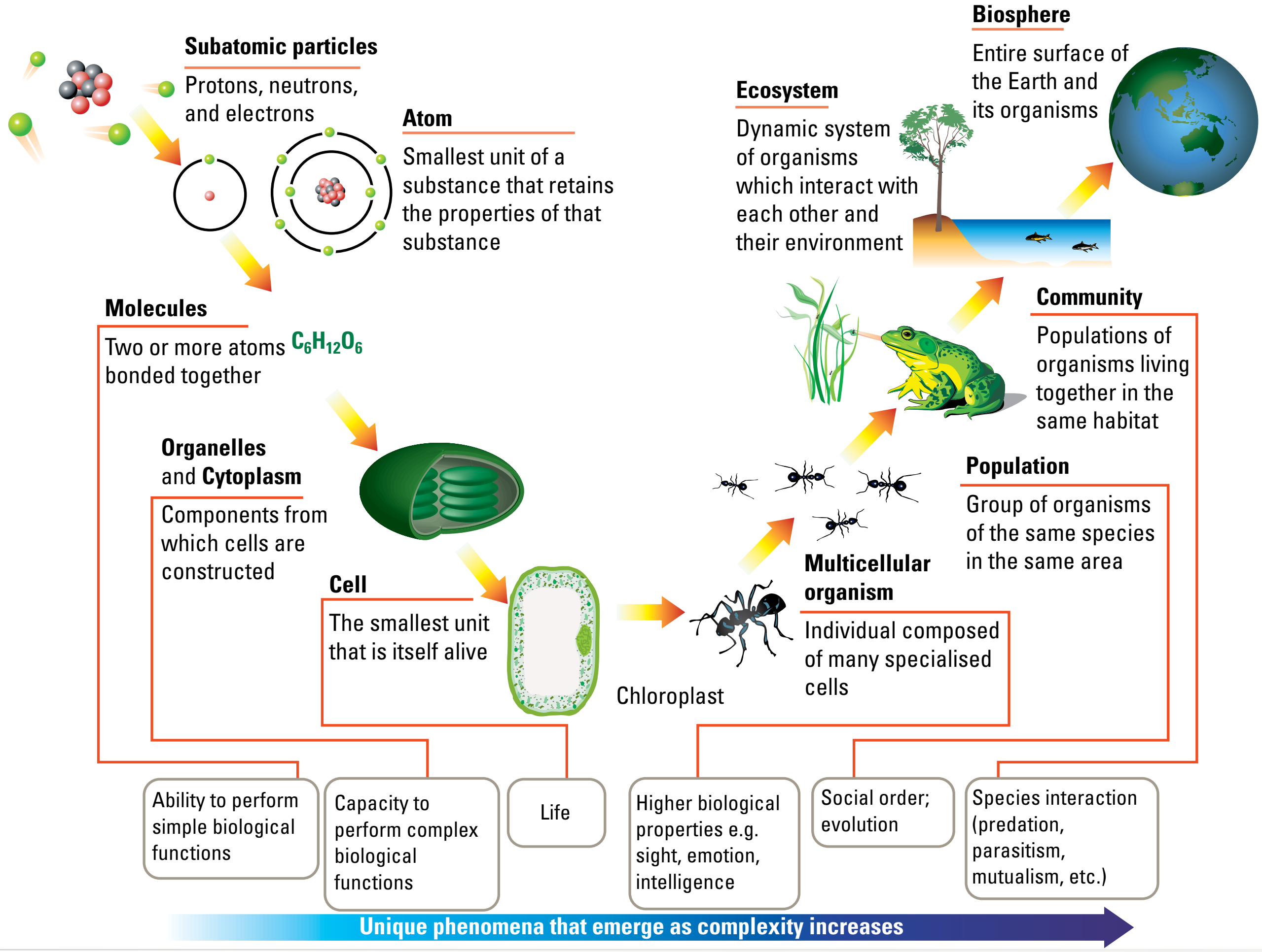
You are a multicellular **organism** of the **species** *Homo sapiens*. When you are with others of your species in the same area at a particular time, you belong to a **population**. When the population you are part of is living with populations of other species, then collectively you could be described as a **community**. Communities of organisms living together interact with each other and their environment to make up an ecosystem.

Ecology

An **ecosystem** is a complex level of organisation made up of living (biotic) parts, such as communities of organisms, and non-living (abiotic) parts, such as the physical surroundings. The study of ecosystems is known as **ecology**.

Ecosystem: temperate marine kelp forest
Producers: algae, including the string kelp, *Macrosystis angustifolia*

Ecosystem: Antarctic marine ecosystem
Producers: many species of phytoplankton



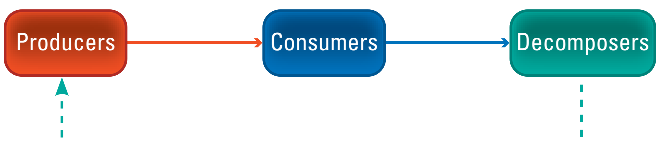
Levels of biological organisation. As each level increases, structural complexity increases and unique phenomena may emerge.

Ecosystem: temperate closed forest
Producers: various woody flowering plants, ferns and mosses

How do you get your food?

The members of every community within an ecosystem can be identified as being either a producer (autotroph), consumer (heterotroph) or decomposer. The feeding relationships between these groups can be shown in food chains or food webs (see section 5.6).

While **producers** are responsible for capturing light energy and using this energy to convert inorganic materials into organic matter, **decomposers** break down organic matter into inorganic materials (such as mineral ions) that can be recycled within ecosystems by plants.



Producers

Producers within ecosystems are essential as they are at the base of the food chain. Plants are examples of producers. They use the process of **photosynthesis** to capture light energy and use it to convert simple inorganic substances (carbon dioxide and water) into organic substances (glucose). Since plants are able to convert glucose into other essential organic substances and do not need to feed on other organisms, they are often referred to as **autotrophs** ('self-feeders').

Plants also release oxygen gas as a waste product of photosynthesis. This molecule is essential for a type of cellular respiration called aerobic respiration — a process essential to the survival of the majority of organisms on our planet.

Consumers

As animals are unable to make their own food, they are called **heterotrophs** ('other-feeders'), and because they obtain their nutrition from consuming or eating other organisms, they are called **consumers**. Consumers are divided into different types on the basis of their food source and how they obtain it.

Herbivores eat plants and are often described as being **primary consumers** because they are the first consumers in a food chain. **Carnivores** eat other animals and are described as secondary or tertiary consumers in food chains or webs. Humans are examples of **omnivores**, which means we eat both plants and animals.

Another group of consumers releases enzymes to break down the organic matter in rotting leaves, dung and decaying animal remains, and then absorbs the products that have been externally digested. This group of consumers is known as **detritivores**, and they include earthworms, dung beetles and crabs.

The koala is a herbivore.

The dung beetle is a detritivore.

The Tasmanian devil is a carnivore.

Fungi and bacteria such as those growing on this loaf of bread are decomposers. They recycle organic matter by converting it into inorganic material.

Decomposers

While producers convert inorganic materials into organic matter, decomposers convert organic matter into inorganic materials. This is an example of how matter can be recycled within ecosystems so that they remain sustainable.

Fungi and bacteria are common examples of decomposers within ecosystems. These heterotrophs obtain their energy and nutrients from dead organic matter. As they feed, they chemically break down the organic matter into simple inorganic forms or mineral nutrients. Their wastes are then returned to the environment to be recycled by producer organisms.

Interactions between species

Species exist in an ecosystem within a specific **ecological niche**. The niche of a species includes its habitat (where it lives within the ecosystem), its nutrition (how it obtains its food) and its relationships (interactions with other species within the ecosystem).

Interactions within an ecosystem may be between members of the same species or between members of different species. Examples of types of interactions include **competition**, predator–prey relationships and symbiotic relationships such as **parasitism**, **mutualism** and **commensalism**.

Competition

Organisms with a similar niche within an ecosystem will compete where their needs overlap. Competition between members of different species for the same resource (e.g. food or shelter) is referred to as **interspecific competition**. Competition for resources between members of the same species (e.g. mates) is referred to as **intraspecific competition**.

Predator–prey relationship

In a **predator–prey relationship**, one species kills and eats another species. The predator does the killing and eating and the prey is the food source. Examples of predator–prey relationships include those between eagles and rabbits, fish and coral polyps, spiders and flies, and snakes and mice. How many others can you think of?

Herbivore–plant relationship

Plants cannot run away from herbivores! How then can they protect themselves against being eaten? Some plants protect themselves by using physical structures such as thorns, spines and stinging hairs; others use chemicals that are distasteful, dangerous or poisonous.

Symbiotic relationships

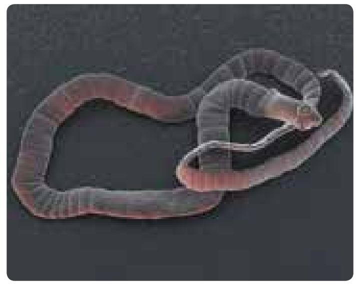
Symbiotic relationships are those in which the organisms living together depend on each other. Examples of symbiotic relationships include parasitism, mutualism and commensalism.

Interaction	Species 1	Species 2
Parasitism	✓ (Parasite)	× (Host)
Mutualism	✓	✓
Commensalism	✓	**0**

✓ = benefits by the association; × = harmed by the association; **0** = no harm or benefit

WHAT DOES IT MEAN?

The word *ecology* comes from the Greek terms *oikos*, meaning 'home', and *logos*, meaning 'study'.

Type of symbiotic relationship	Description	Example
Parasite–host	Parasites are organisms that live in or on a host, from which they obtain food, shelter and other requirements. Although the host may be harmed in this interaction, it is not usually killed. Some parasites are considered to be pathogens, as they can cause disease. This means that the functioning of their host is in some way impaired or damaged.	
	Parasites living *on* the host are called ectoparasites (e.g. fungi, fleas, ticks, leeches and some species of lamprey [see photo at right]). An example of an ectoparasite is the fungus that causes tinea or athlete's foot. The fungus secretes enzymes that externally digest the skin that it is attached to. It then absorbs the broken-down nutrients. This causes your skin to break and become red and itchy.	
	Parasites living *inside* their host are called endoparasites (e.g. flatworms such as *Echinococcus granulosus* or roundworms such as *Ascaris lumbricoides).* Tapeworms (see photo at right) are an example of an endoparasite. Their heads have suckers (and sometimes hooks) to firmly attach themselves to the walls of their host's intestine. They do not need a digestive system themselves as they live off the digested food within the intestine. Tapeworms vary in length from 1 cm to 10 cm. As each tapeworm contains both male and female sex organs, they don't need a mate to reproduce.	
Parasitoids	A new group of consumers has been suggested, called parasitoids ('-oid' means '-like'). These organisms are halfway between predators and parasites. While they act like parasites, they kill their hosts within a very short period. Examples of organisms that may be classified as parasitoids are mainly wasps (see photo at right) and flies. The female parasitoid lays her egg(s) in the body of the host; when the eggs hatch, they eat the host from the inside. The host is killed when vital organs have been eaten. This relationship has applications in horticulture as a potential biological control method for pests feeding on crops.	
Mutualism	An interaction between organisms of two different species in which they both benefit is called mutualism. In many cases, neither species can survive under natural conditions without the other. Tiny protozoans found in the intestines of termites help them to digest wood. These organisms are dependent on each other for their survival. Another example is that of lichen (see photo at right), which is often found growing on rocks or tree trunks. Lichen is made up of a fungus and an alga living together. The alga uses light from the sun to make glucose and the fungus uses this as food. The fungus shelters the alga so that it does not get too hot or dry out.	
Commensalism	An example of commensalism is found between remora fish and sharks. Remora fish are often found swimming beneath sharks and benefit by being able to feed on leftover scraps; the sharks are not harmed but receive no benefit. The organism that benefits is referred to as the commensal and the other is sometimes referred to as the host. Clownfish and sea anemones are another example. While the clownfish (*Amphiprion melanopus)* lives among the tentacles of the sea anemone, it is unaffected by their stinging cells and benefits from shelter and any available food scraps.	

UNDERSTANDING AND INQUIRING

REMEMBER

1 Use Venn diagrams to compare the following relationships.
  (a) Commensalism and mutualism
  (b) Parasitism and commensalism
  (c) Predator–prey and parasite–host

2 State the name of the species to which you belong.

3 Outline the relationship between species, organisms, populations, communities and an ecosystem.

4 Define the term *ecology*.

5 Construct a flowchart that shows the relationship between producers, consumers and decomposers.

6 Construct a continuum to arrange the following in terms of increasing complexity: biosphere, cell, population, molecules, organisms.

7 Explain why producers are essential to ecosystems.

8 Construct a Venn diagram to compare autotrophs and heterotrophs.

9 Distinguish between herbivores, carnivores, omnivores and detritivores.

10 Identify a type of organism that you may find in
  (a) a temperate marine kelp forest ecosystem
  (b) a temperate closed forest ecosystem
  (c) an Antarctic marine ecosystem.

11 Distinguish between producers and decomposers.

12 Identify two common examples of decomposers.

13 Define the term *ecological niche*.

14 Distinguish between *interspecific competition* and *intraspecific competition*.

15 Construct a table to summarise the similarities and differences between parasitism, mutualism and commensalism.

INVESTIGATE, THINK AND DISCUSS

16 (a) List three examples of predators and then match them to their prey.
  (b) Suggest structural, physiological and behavioural features that may assist:
    (i) predators in obtaining food (e.g. webs, teeth, senses, behaviour)
    (ii) prey in avoiding being eaten (e.g. camouflage, mimicry, behaviour, chemicals).

17 In the interaction between a clownfish and a sea anemone, which is benefited?

18 Use a flowchart to describe how a parasite obtains its food.

19 Suggest why a parasite does not normally kill its host.

20 Use a visual thinking tool to show the difference between a commensal and a parasite.

21 Is a mammalian embryo a parasite? Explain your answer.

22 Parasite–host relationships also exist within the plant kingdom. The two main types of these relationships are holo-parasitism (in which the parasite is totally dependent on the host for food) and hemi-parasitism (in which the parasite obtains some of its nutrients from the host but can make some itself). Some plant species belonging to the genus *Rafflesia* are examples of holo-parasites, and many Australian species of mistletoe are hemi-parasites. Research and report on:
  (a) *Rafflesia* parasites and their host *Tetrastigma*
  (b) pollinators for *Rafflesia* flowers
  (c) one of the following hemi-parasites:
    (i) sheoak mistletoe (*Amyema cambagei*) and its host *Casuarina cunninghamiana*
    (ii) paperbark mistletoe (*Amyema gaudichaudii*) and host *Melaleuca decora*.

23 Decide whether the following relationships are examples of parasitism, commensalism or mutualism.
  (a) A dog with a tapeworm in its intestine, absorbing the digested food
  (b) Egrets staying near cows and feeding on the insects they stir up
  (c) Harmless bacteria *Escherichia coli* living in human intestines
  (d) Root nodules of clover contain bacteria — the clover benefits, but can survive without the bacteria; the bacteria don't live anywhere else
  (e) A fungal disease on human skin, such as ringworm

24 The koala and the bacteria that live in its gut have a symbiotic relationship. Find out how each of the organisms benefits from this relationship.

25 Choose one of the following parasites: malaria parasites, tapeworms, ticks, insects that make galls in trees, blight-causing bacteria. Explain how it infests its host and how it affects its host.

26 Click on the **Parasites** weblink in your eBookPLUS to find out about the symptoms and treatment of some common parasites in humans.

eBook*plus*

27 Some clovers (Trifolium) produce cyanide. Find out how this may protect them against being eaten.

28 Find examples of ways that Australian plants try and protect themselves from being eaten by herbivores.

29 Use internet research to identify three problems that can be investigated about interactions between organisms.

30 Construct a model that simulates interactions between at least four different types of organisms.

work sheet 5.1 Food webs

Mapping ecosystems

Are you at home? What does that mean to your survival? A habitat is the name given to the place where an organism lives.

It needs to be convenient and provide conditions that are comfortable to the functioning of cells and life processes of its inhabitants. The match between the environmental conditions and the needs of organisms is responsible for the **distribution** and **density** of species within it.

An **ecosystem** may contain many habitats. It is made up of living or **biotic factors** (such as other organisms) and non-living or **abiotic factors** (such as water, temperature, light and pH) that interact with each other.

Tolerance — the key to survival

Each species has a **tolerance range** for each abiotic factor. The **optimum range** within the tolerance range is the one in which a species functions best. Measuring the abiotic factors in a habitat can provide information on the abiotic requirements for a particular organism in that habitat. Can you think of features that organisms possess to increase their chances of survival in some habitats more than in others?

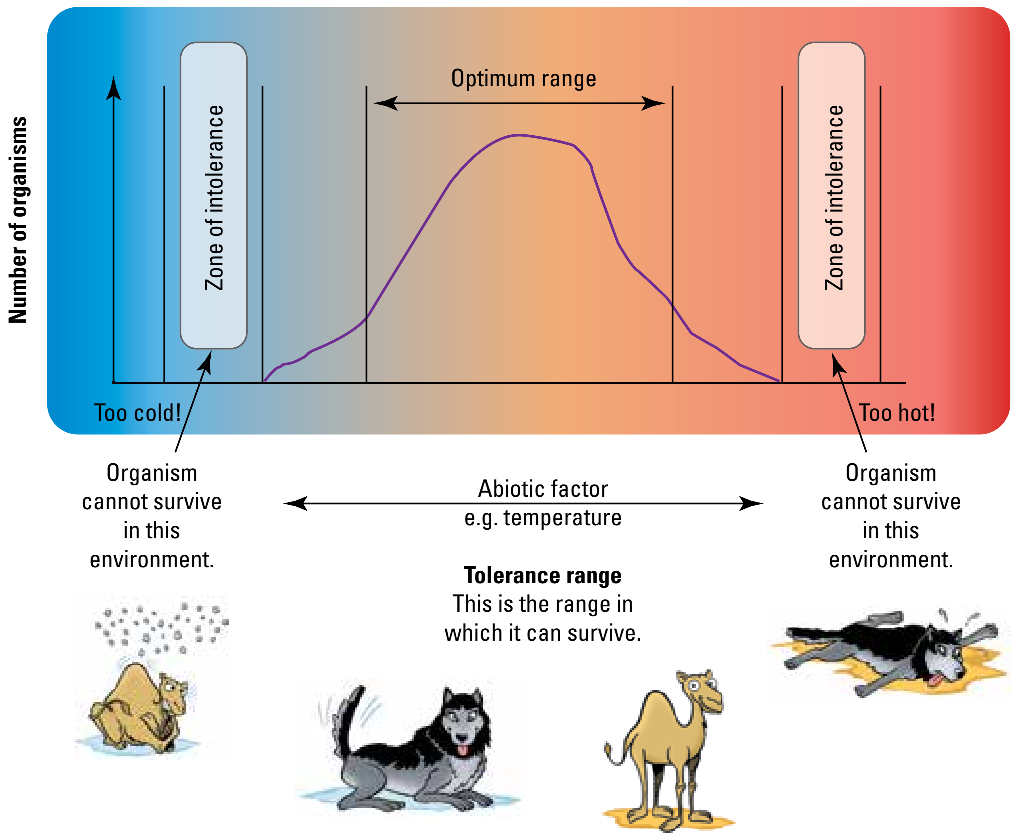
How many and where?

Investigation of an ecosystem involves studying how different species in it interact. To do this, you need to:

1. identify the organisms living in the ecosystem by using keys and field guides
2. determine the number or density of different species in the particular area. This indicates the biological diversity (**biodiversity**) within the ecosystem.
3. determine the distribution of the different species or where they are located.

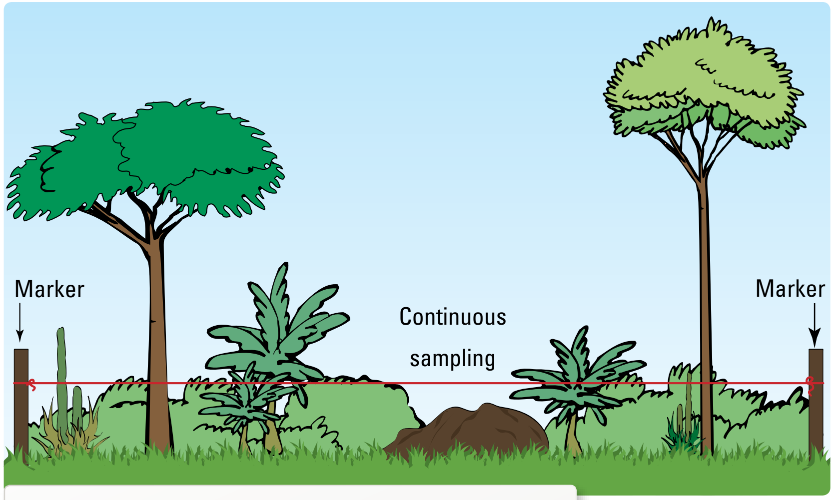
Sampling an ecosystem

Sampling methods are used to determine the density and distribution of various populations and communities within the ecosystem. **Transects** are very useful when the environmental conditions vary along the sample under investigation. **Quadrats** can be used to estimate the distribution and abundance of organisms that are stationary or do not move very much. The **mark, release and recapture** sampling method is used to determine the abundance of mobile species.



Life in a square

A quadrat is just a sampling area (often 1 square metre) in which the number of organisms is counted and recorded. When organisms are counted in a number of quadrats, this is usually considered to be representative of the total area under investigation. The average density of the total area can be estimated using the equation shown:



Line transects provide information on the distribution of a species in a community.

Estimated average density

$$= \frac{\text{total no. of individuals counted}}{\text{no. of quadrats} \times \text{area of each quadrat}}$$

For example, if the total number of individuals counted = 100,

number of quadrats = 4,

area of each quadrat = 1 m^2, then

estimated average density

$$= \frac{100 \text{ individuals}}{4 \times 1 \text{ m}^2} = 25 \text{ individuals/m}^2.$$

INVESTIGATION 5.1

Using quadrats

AIM To estimate the abundance of eucalypts in two different environments

BACKGROUND

- The maps of environments A and B show each eucalyptus tree as a cross.

Materials:

maps of environments A and B (provided by your teacher)
transparent sheet

METHOD, RESULTS AND DISCUSSION

1. Copy and complete the table below.

Quadrat number	Number of eucalypts	
	Environment A	Environment B
1		
2		
3		
4		
5		
Average		

2. Measure the length and width of each map and calculate the area of each using the following equation.

$$\text{Area} = \text{length} \times \text{width}$$

3. Make a quadrat by cutting a 3 cm × 3 cm square out of transparent sheet. Calculate the area of the quadrat.
4. Close your eyes and drop the quadrat anywhere on the map. Count how many eucalypts (crosses) are inside the quadrat. Repeat four more times. Do this for both maps.
5. Estimate the abundance of eucalypts in each environment using the equation shown in the previous box.
6. Ask your teacher for the actual abundance of eucalypts in each environment. Compare your estimate with the actual abundance.
7. Suggest what you could have done to make your estimate more reliable.

INVESTIGATION 5.2

Measuring abiotic factors

AIM **To investigate some abiotic factors in two different environments**

BACKGROUND

In this investigation you will measure some abiotic factors for environments A and B. The soil samples were collected from these environments. The water samples were collected from rivers that run through each environment.

Materials:

water samples A and B and soil samples A and B (provided by your teacher)
thermometer
dropper bottle of universal indicator solution
universal indicator colour chart
dropper bottle of silver nitrate solution (0.1 mol/L)
calcium sulfate powder
test tubes

Abiotic factor	Equipment used and/or method
Water temperature (°C)	Thermometer
Soil temperature (°C)	Thermometer
Water pH	Pour 5 mL of tap water sample A into a test tube. Add 3 drops of universal indicator. Compare the colour of the water with the colour chart and record the pH of the water sample. Repeat using water sample B.
Soil pH	Place a small sample of soil A onto a watchglass. The soil should be slightly moist. If the soil is very dry, add a few drops of distilled water. Sprinkle some calcium sulfate over the soil. Add some drops of universal indicator over the calcium sulfate powder. Compare the colour of the powder with the colour chart and record the pH of the soil. Repeat using soil sample B.
Water salinity	Pour 5 mL of water sample A into a test tube. Add 3 drops of silver nitrate solution. Note whether the sample remains clear, becomes slightly cloudy or turns completely white/grey. Use the salinity table below to work out the salinity of the water sample. Repeat using water sample B.

Description	Salinity
Clear	Nil
Slightly cloudy	Low
Completely white/grey	High

METHOD AND RESULTS

1. Review the table at right.
2. Copy the table below and add your abiotic factor results for each environment.

Abiotic factor	Environment A	Environment B
Water temperature (°C)		
Soil temperature (°C)		
Water pH		
Soil pH		
Water salinity		

3. Construct column graphs that show the abiotic factor results for each environment.

DISCUSS AND EXPLAIN

4. pH is a measure of the alkalinity or acidity of a substance. A pH of more than 7 is considered to be alkaline whereas a pH below 7 is considered to be acidic.
   (a) Which water sample was most acidic?
   (b) Which soil sample was most acidic?
5. Identify any trends or patterns in your results. Suggest reasons for these patterns.
6. Which of the tests in this investigation were qualitative and which were quantitative?
7. In which way were the variables controlled in this investigation?
8. Are your temperature results accurate for each environment? Explain.
9. Suggest two ways in which you could improve this investigation.
10. Design an investigation that could examine abiotic factors in your local school environment.

INVESTIGATION 5.3

The capture–recapture method

AIM To estimate population size using the capture–recapture method

Materials:
a large beaker
red and yellow beads (substitute other colours if needed)

METHOD, RESULTS AND DISCUSSION

1. In your notebook, draw a table similar to the one shown below with enough room for 10 trials and the average.

Trial	Number of untagged fish (red beads)	Number of tagged fish (yellow beads)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average		

- Place about 200 red beads in the large beaker (you do not need to count them exactly at this stage). These represent goldfish living in a pond.
- Catch 25 of the goldfish and tag them (replace 25 of the red beads with yellow beads).
- Mix the beads thoroughly.

2. With eyes closed, one student should randomly select 20 beads from the beaker. These are the recaptured goldfish. Count how many fish are tagged (yellow beads) and untagged (red beads), and enter the numbers in the table.
3. Return the beads to the beaker and mix thoroughly. Repeat the above step a further nine times.
4. Calculate the average number of tagged and untagged fish per capture.
5. Calculate the total number of fish using the equation:

$$\text{population size} = \frac{n_1 \times n_2}{n_3}$$

in which n_1 = number caught and initially marked,
n_2 = total number recaptured
n_3 = number of marked individuals recaptured.

6. Count how many beads were actually in the beaker and compare the actual number to the number you calculated using the capture–recapture method.
7. List any source of errors in this experiment.
8. Explain why this method can only be used for animals that move around. Why can't it be used to estimate the number of trees in a forest, for example?

INVESTIGATION 5.4

Biotic and abiotic factors

AIM To measure biotic and abiotic factors in different areas in an environment

CAUTION Be sun-safe!

Materials:
access to a natural area in your school grounds or bushland near your school
a data logger with temperature probe and light probe or a thermometer and hand-held light sensor
wet–dry thermometer (or humidity probe for data logger)
wind vane
soil humidity probe (optional)
calcium sulfate powder
water in a small wash bottle
Petri dish
universal indicator
tring
tape measure or trundle wheel
sunhat and sunscreen

METHOD AND RESULTS

- Break up into groups. Each group will need to study a different area of the environment. Try to choose areas that are different (e.g. sunny and shady areas, or near paths and away from paths).

Abiotic factor	Materials used/ method	Measurement
Temperature		
Air humidity	Wet–dry thermometer	
Light intensity		
Soil humidity	Soil humidity probe (if available)	
Water pH	Refer to Investigation 5.2	
Soil pH	Refer to Investigation 5.2	
Water salinity	Refer to Investigation 5.2	

Part A: Abiotic factors

1. Copy the table above into your notebook. Fill in the missing materials of equipment in the second column.
2. Use the equipment available at your school to measure the abiotic factors listed in the table. Complete the third column of the table.
3. When you are back in the classroom, construct a table or spreadsheet to enter the results collected from each group. Calculate the average reading for each abiotic factor measured.
4. Choose one of the abiotic factors you measured and construct a column graph showing the reading for each location studied.

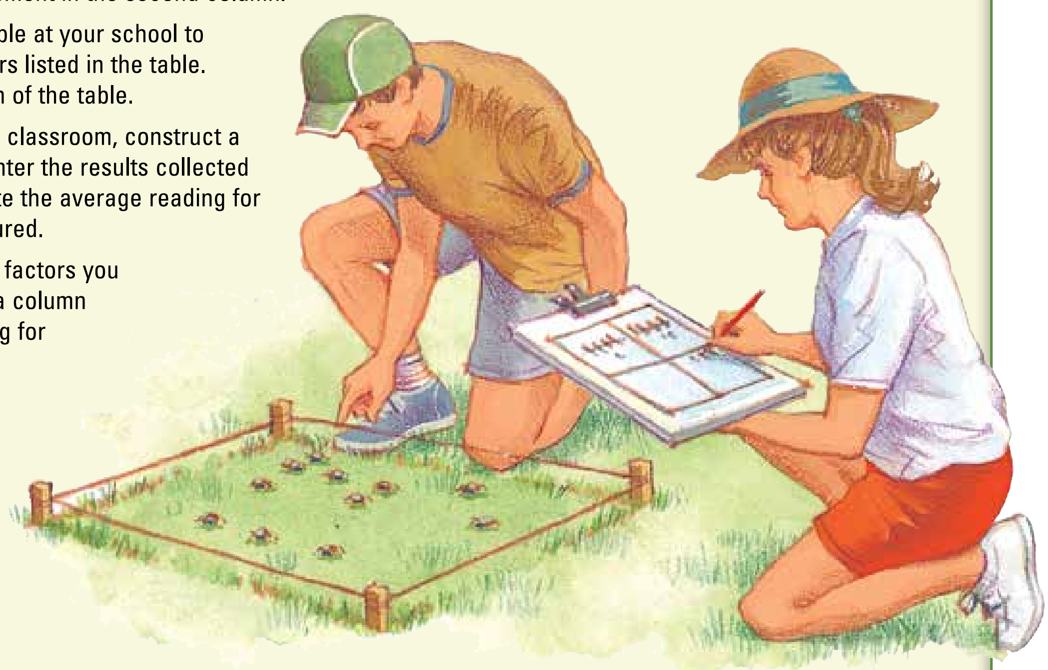
Part B: Biotic factors

- Use a trundle wheel to measure the length and width of the total area you are studying. If the area is too large to measure you may be able to estimate the surface area using a map.
- Use the tape measure and string to cordon off an area 1 m by 1 m. This is your quadrat.

5. List all the different species you can see inside your quadrat. If you do not know their names, describe or draw them.
6. Decide which plant(s) you will count; you may wish to count clovers, for example. Count how many of this type of plant(s) are in your 1 m × 1 m square.
7. Estimate the total number of each plant(s) counted using the equation below:

$$\text{Total number} = \frac{\text{average number per quadrat} \times \text{total area}}{\text{area of quadrat}}$$

8. Identify any trends in the results you obtained in your abiotic factor observation. For example, how did the results for sunny areas compare with those for shady areas?
9. Some organisms living in your quadrat cannot be seen. Give some examples. Why are these organisms very important?
10. Compare the class results for parts A and B. Identify any trends in the results. Is there a relationship between any of the abiotic factors and the type of organisms found?



UNDERSTANDING AND INQUIRING

REMEMBER

1 Outline the difference between density and distribution.

2 Define each of the terms below and provide an example.
- Habitat
- Ecosystem
- Abiotic factor

3 Recall the type of information that is provided by:
(a) quadrats
(b) transects.

THINK

4 Describe the difference between a habitat and an ecosystem.

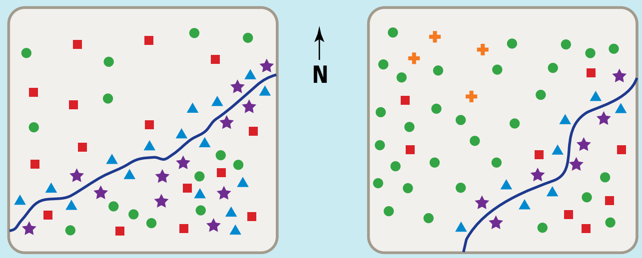
5 (a) List five biotic factors that are part of the ecosystem in which you live.
(b) List five abiotic factors that are a part of your ecosystem.

6 Suggest ways in which a freshwater habitat may vary from a marine habitat. Relate these differences to the differences in features of organisms located in each habitat.

7 Suggest the difference between the terms *environmental factors* and *environmental conditions*.

USING DATA

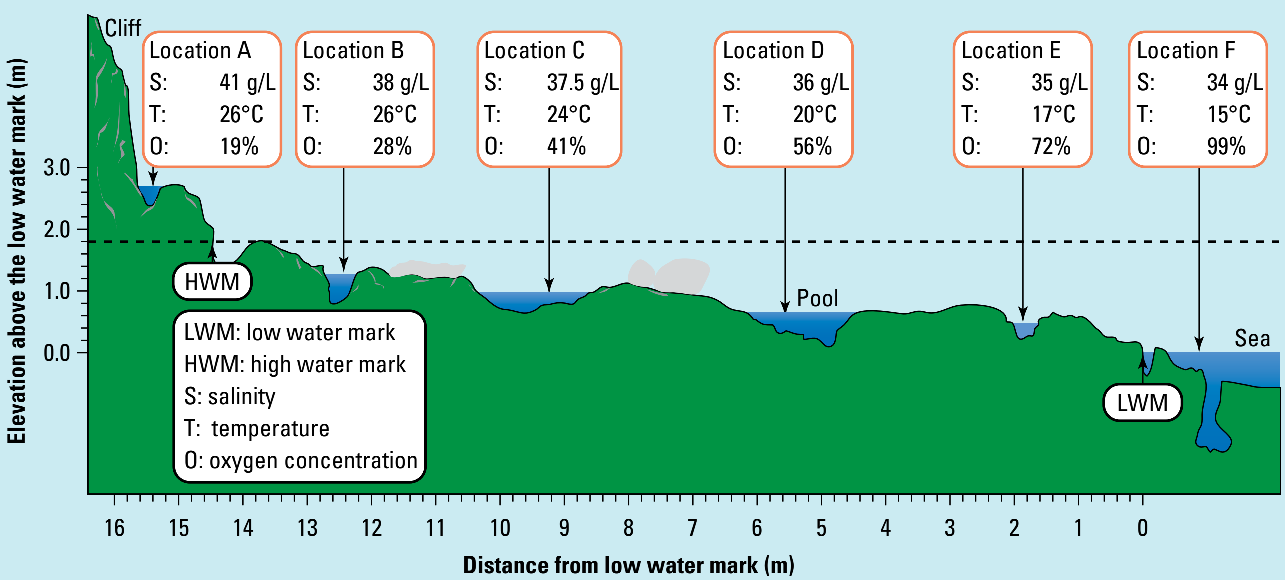
8 The location of five different types of trees in the two quadrats above right is indicated by the five different symbols.
(a) Count and record the number of trees in each quadrat.
(b) Count and record the number of the different species in each quadrat.
(c) Which quadrat provides the greatest variety of habitat types for wildlife? Give reasons for your response.
(d) Suggest why the rainforest species in both quadrats are located most densely near the creek.

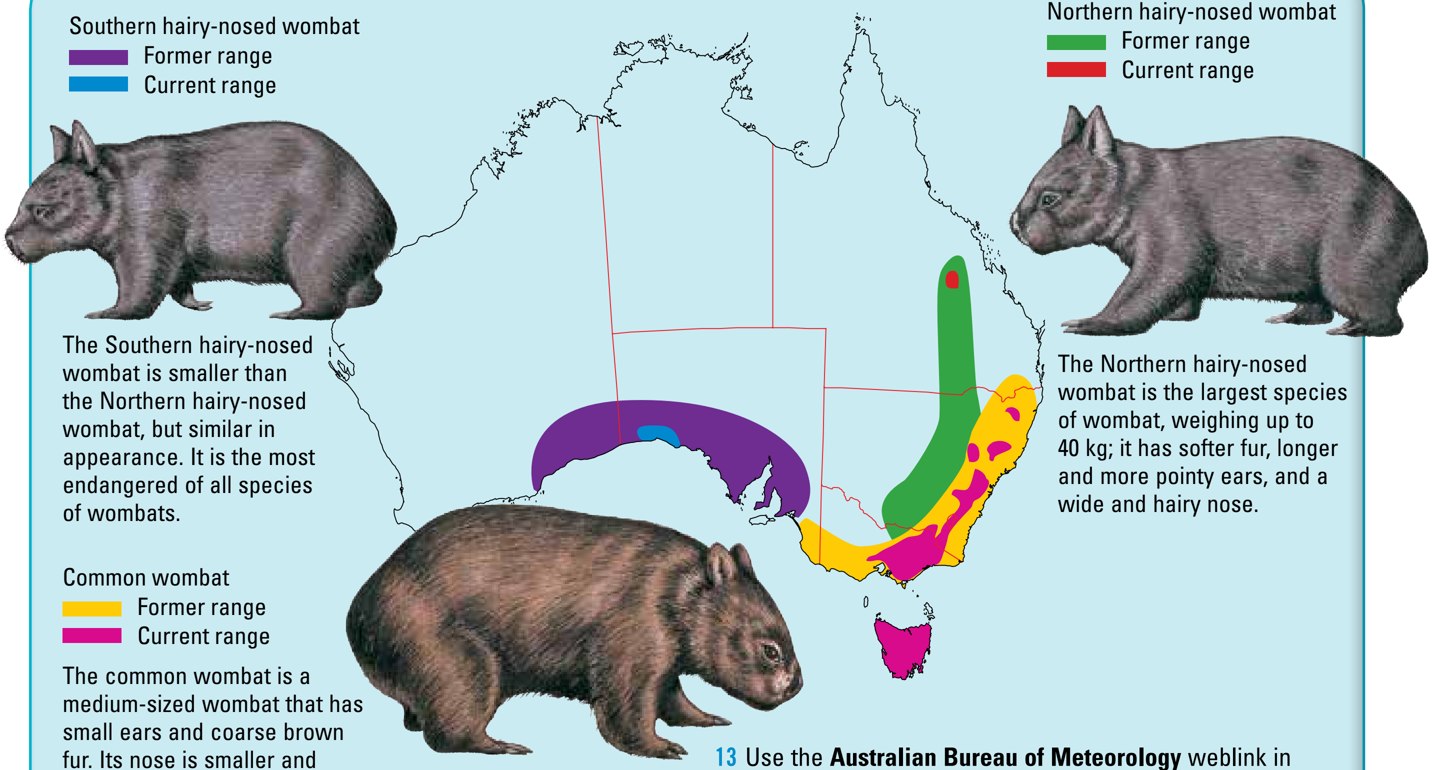


Key
- ★ Myrtlebeech, a rainforest tree
- ▲ Sassafras, a rainforest tree
- ■ Mountain ash, smooth-barked eucalypt
- ● Blackwattle tree
- ✚ Messmate, rough-barked eucalypt
- ∼ Creek

9 (a) Carefully observe the diagram below. Describe the patterns along the rock platform to the sea for each of the abiotic factors measured.
(b) Suggest the features that organisms living at these locations would need to possess.
(i) Location A
(ii) Location D
(iii) Location F

Physical factors — salinity, temperature and dissolved oxygen at low tide on a rock platform. *Source*: Biozone International (Year 11 Biology 1996 Student Resource and Activity Manual).





The Southern hairy-nosed wombat is smaller than the Northern hairy-nosed wombat, but similar in appearance. It is the most endangered of all species of wombats.

The Northern hairy-nosed wombat is the largest species of wombat, weighing up to 40 kg; it has softer fur, longer and more pointy ears, and a wide and hairy nose.

The common wombat is a medium-sized wombat that has small ears and coarse brown fur. Its nose is smaller and lacks whiskers.

10 Suggest why wombats living in different areas have different features. Suggest how these differences may increase their chances of survival. Suggest reasons for the difference between their previous and recent habitat ranges.

INVESTIGATE, THINK AND DISCUSS

11 Find out more about research that the CSIRO, the Bureau of Meteorology or other Australian research institutions are involved in that is related to the climate and ecosystems. Share your findings with others. Suggest a question that you would like to investigate if you were involved in that field of research.

12 Light intensity, water availability, temperature and dissolved oxygen levels are examples of abiotic factors that may be limiting factors in determining which organisms can survive within a particular habitat. Consider the details in the table below and suggest responses for each of the blank cells.

13 Use the **Australian Bureau of Meteorology** weblink in your eBookPLUS and record any differences in various abiotic factors over the last ten years. Identify and comment on any observed patterns and their possible consequences. Suggest a research question that could be further explored. eBook*plus*

14 Select a particular Australian organism and then research its habitat range over the last 100 years. Construct graphs and labelled diagrams to share your findings.

15 Find out how radio or satellite tracking techniques are used to track animals whose habitats range over large areas.

16 Use the **Quadrat method** interactivity for a virtual experience of this method of sampling. **int-0984** eBook*plus*

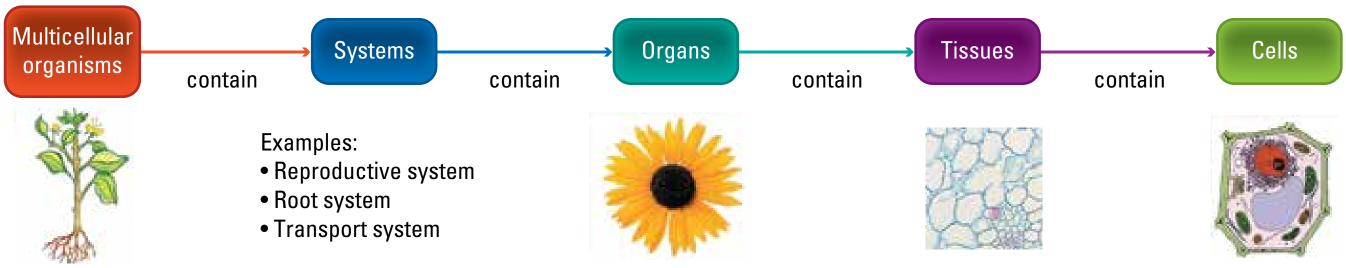
17 Use the **Capture/recapture method** interactivity for a virtual experience of this method of sampling. **int-0985**

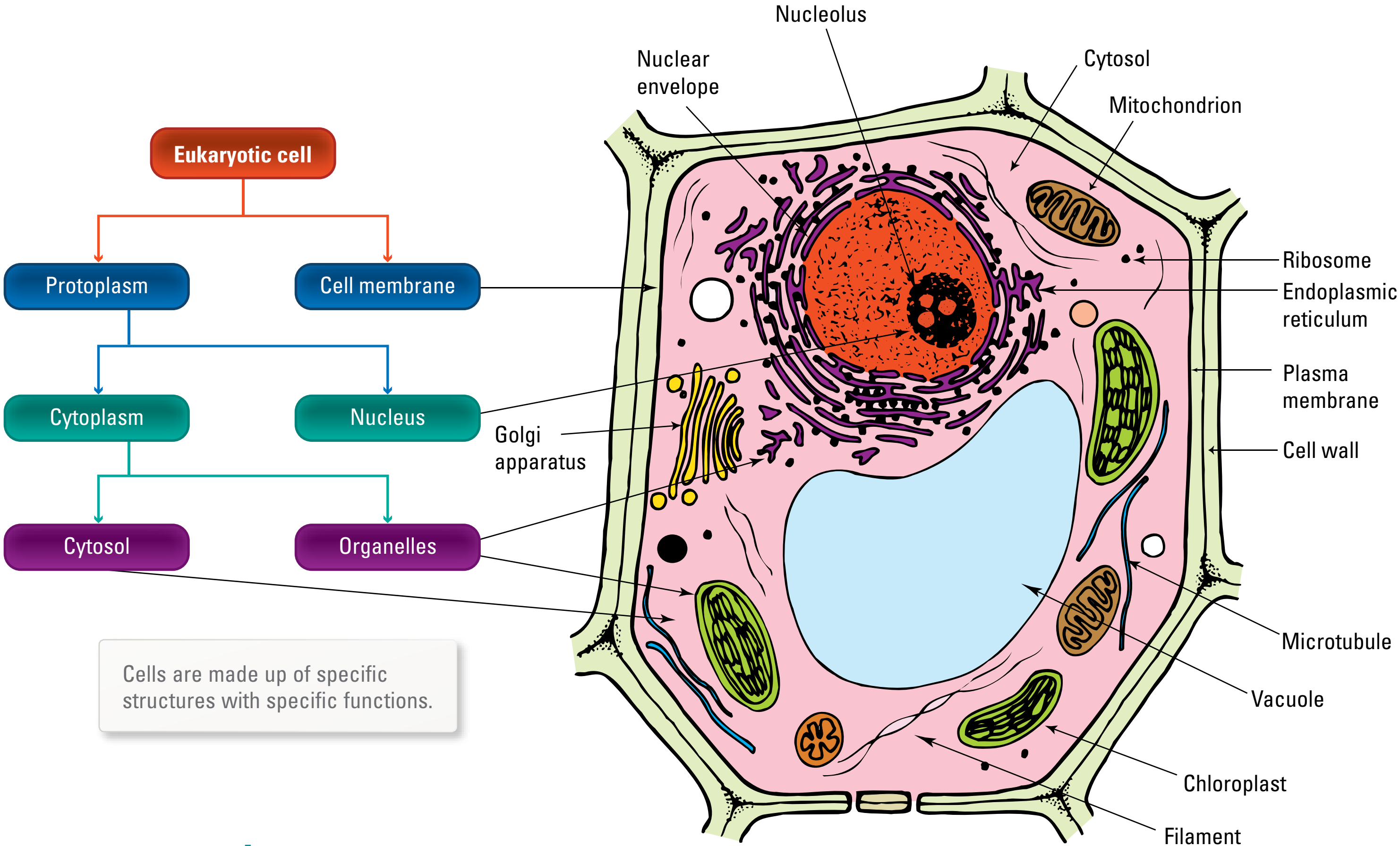
work sheets
5.2 Estimating the size of a population
5.3 Abiotic factors in an ecosystem

Abiotic factor	Abiotic factor description	Example of habitat	Features of organism that could survive
Light intensity	Low	Floor of tropical rainforest	
Water availability	Low	Desert	
Temperature	Very high		
Dissolved oxygen levels	Low		

Plant organisation

Like other multicellular organisms, plants contain organs that work together to keep them alive. The main organs in vascular plants are roots, stems, flowers and leaves.





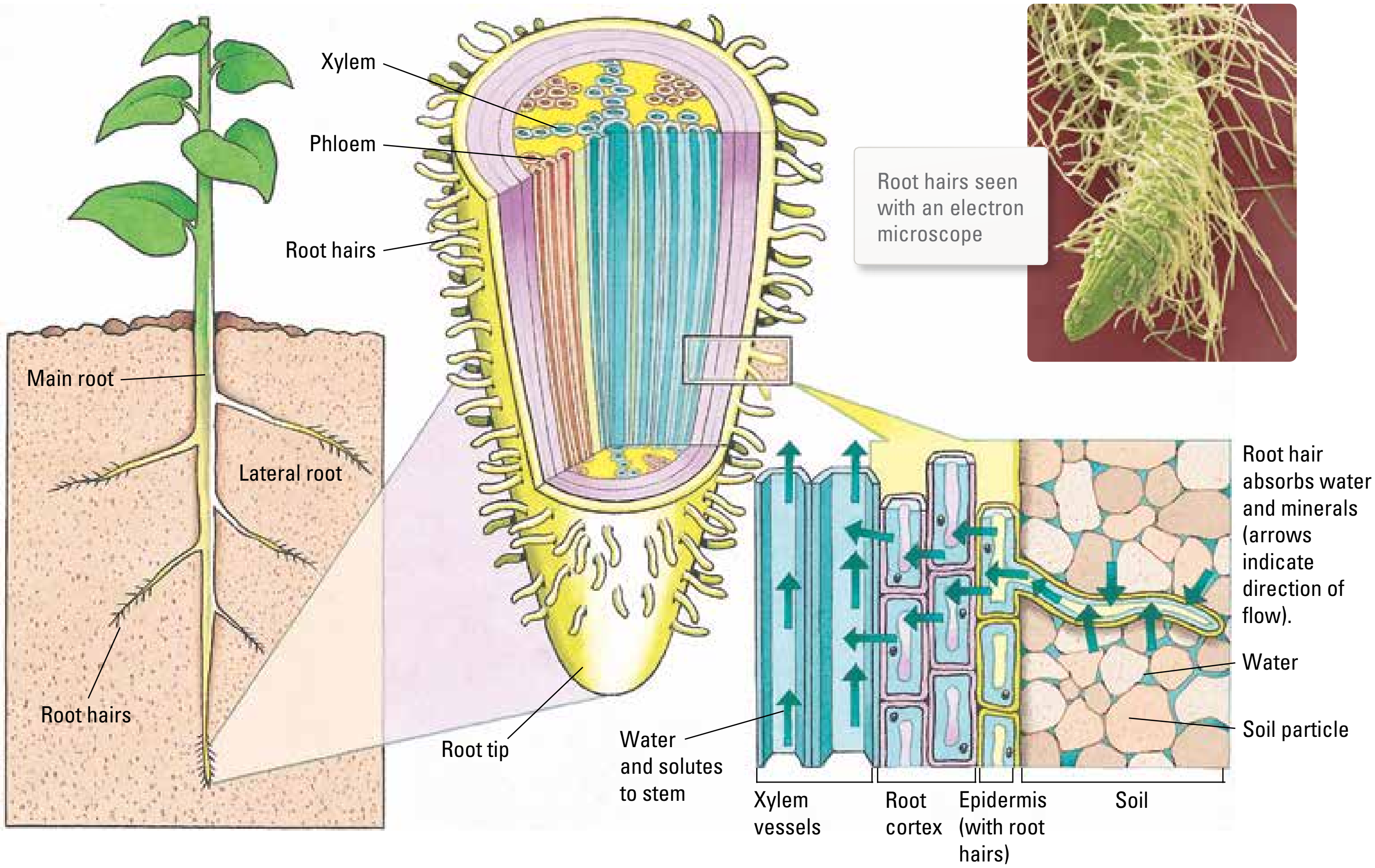
Cells are made up of specific structures with specific functions.

Roots: hairy roots

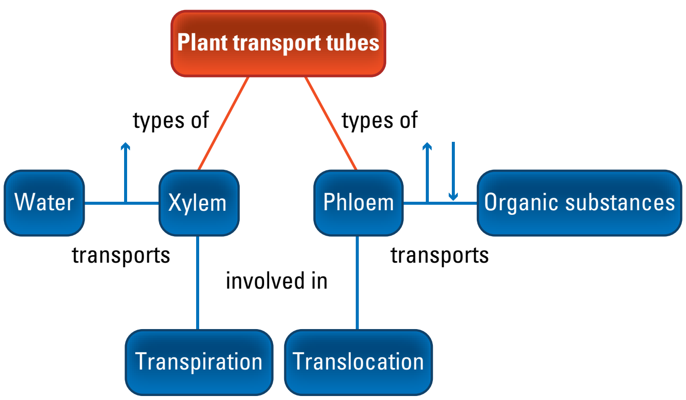
Roots both anchor plants and help them to obtain oxygen, water and mineral salts from the soil. **Root hairs** found on the outermost layer of the smallest roots can greatly assist this process by increasing the amount of surface area available for absorption. These long cells act like thousands of tiny fingers reaching into the soil for water and soluble salts.

Stems: transport tubes

Plants have a transport system made up of many thin tubes which carry liquids around the plant. The two main types of tubes in vascular plants are the **phloem** and **xylem vessels**. These tubes are located together in groups called **vascular bundles**.



Root hairs seen with an electron microscope



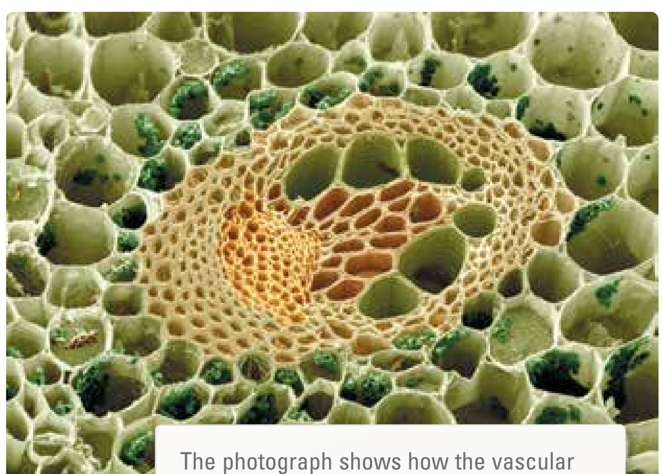
Translocation

Organic substances are transported up and down the plant in the phloem. This is called **translocation**. The two main types of organic molecules transported are nitrogenous compounds (for example, amino acids) and soluble carbohydrates (for example, sucrose).

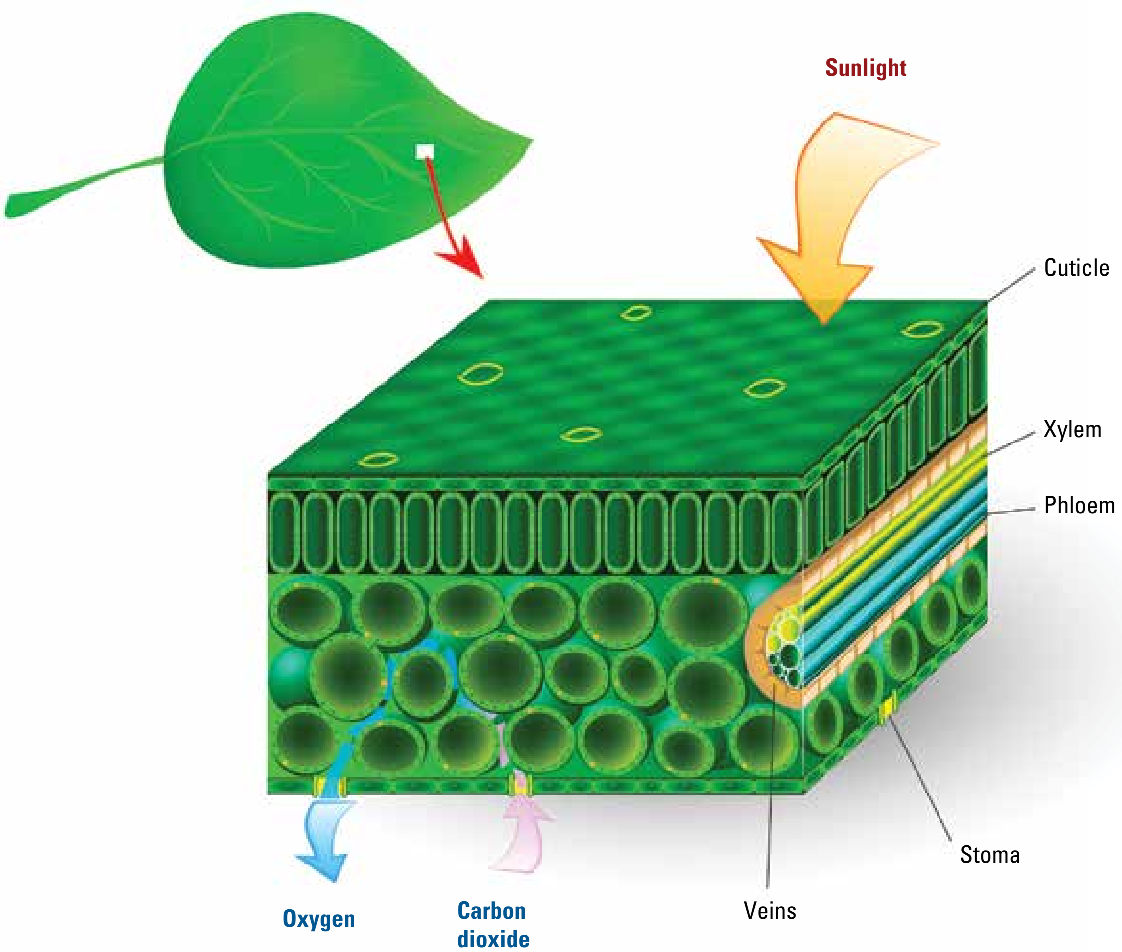
Transpiration

The transport of water up from the roots of the plant, through the xylem and out through the stomata as water vapour is called the **transpiration stream**. As this water vapour moves from the plant, suction is created that pulls water up through the xylem vessels from the roots. The loss of water vapour from the leaves (through their stomata) is called **transpiration**.

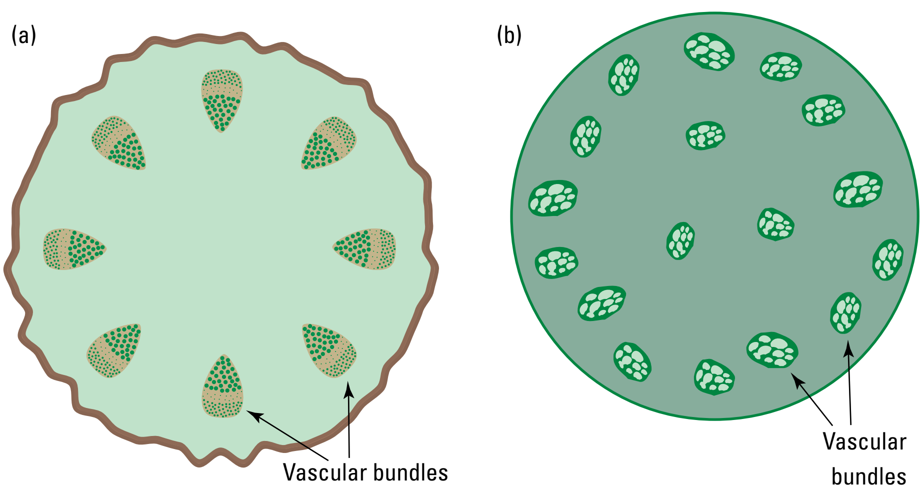
The strong, thick walls of the xylem vessels are also important in helping to hold up and support the plant. The trunks of trees are mostly made of xylem. Did you know that the stringiness of celery is due to its xylem tissues?


The photograph shows how the vascular tissue of a dicot (buttercup) appears when viewed under an electron microscope.

LEAF ANATOMY



Transverse section through a portion of a leaf showing xylem and phloem tissue.



Diagrams of typical cross-sections of the stem of (a) a young dicot and (b) a monocot

Leaves: chloroplasts

A plant leaf is an organ that consists of tissues such as epithelium, vascular tissue and parenchyma tissue. The structure of cells within the tissues and the organelles that they contain can vary depending on the function of the cell. Leaf cells, for example, contain **organelles** called **chloroplasts**. Chloroplasts contain **chlorophyll**, a green pigment that is involved in capturing or absorbing **light energy**. The synthesis of **glucose** also occurs in the chloroplast.

Flaccid or turgid

Plants need water to survive. If not enough water is available or too much water is lost, the plant may wilt. When this occurs, water has moved out of the cell vacuoles and the cells have become **flaccid**. The firmness in petals and leaves is due to their cells being **turgid**.

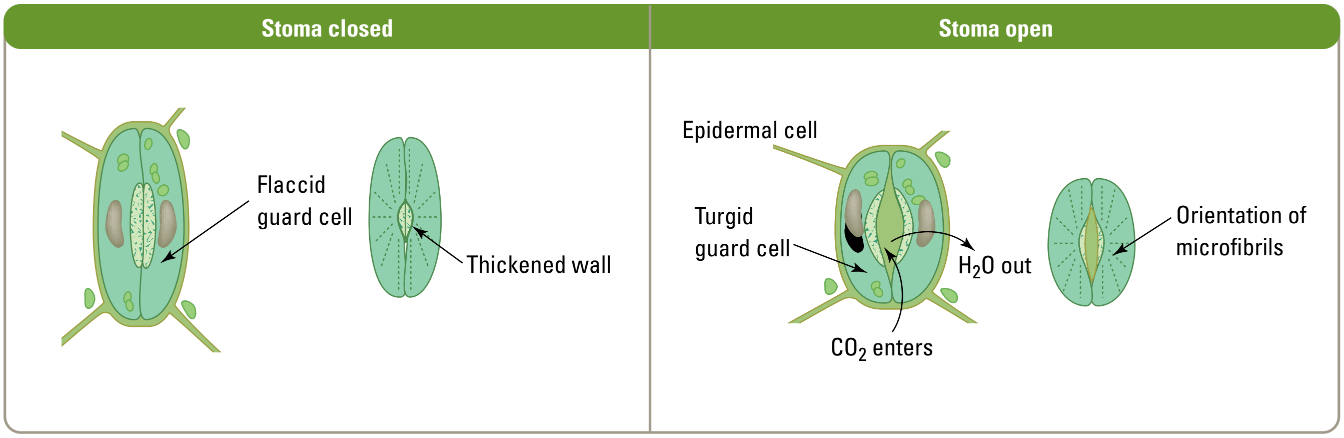
Leaves: stomata

The exchange of gases such as oxygen, carbon dioxide and water vapour between the atmosphere and plant cells occurs through tiny pores called **stomata**. These are most frequently located on the underside of leaves. Evaporation of water from the stomata in the leaves helps pull water up the plant.

Guarding the pathway

Guard cells that surround each **stoma** enable the hole to open and close, depending on the plant's needs. When the plant has plenty of water, water moves into the guard cells, making them turgid. This stretches them lengthways, opening the pore between them (the stoma). If water is in short supply, the guard cells lose water and become flaccid. This causes them to collapse towards each other, closing the pore. In this way, the guard cells help to control the amount of water lost by the plant.

Surface view of leaf showing distribution of stomata. Note epidermal cells, guard cells and their chloroplasts, and stomal pores.



Inner and outer walls of guard cells may be of different thicknesses. A thinner outer wall can stretch more than a thicker inner wall. Microfibrils in guard cells also influence the extent to which walls of guard cells can stretch. As the outer walls of guard cells stretch, the stoma (pore) opens.

Flowers

Flowers make up the reproductive structures of some plants. Within the flower there are structures that produce sex cells or **gametes**. **Anthers** produce **pollen grains** (sperm) and **ovaries** produce **ova**.

Pollination

Before the gametes can fuse together (**fertilisation**) to make a new plant they need to find each other. First contact, or **pollination**, is achieved by the pollen grains landing on the **stigma**. Some plants pollinate themselves (**self-pollination**) and others require **cross-pollination**; that is, pollination involving others. Cross-pollination may involve not only other plants of the same species, but sometimes assistance from other species.

Wind-pollinated

Pollen is transferred between some plants by the wind (**wind pollination**). The flowers of plants that use this type of pollination are usually not brightly coloured and have a feathery stigma to catch pollen grains which were previously held on stamens exposed to the wind.

Animals as vectors

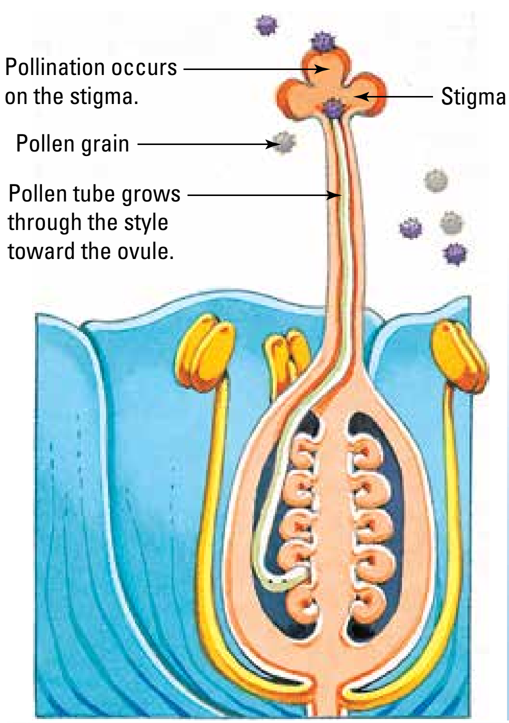
The flowers of plants that use animals as **vectors** to carry their pollen between plants are often brightly coloured and may reward the animal with food. In some cases, the reward may be sugar-rich nectar or protein-rich pollen. In other cases, the reward may have more of a sexual nature as some plants have evolved over time to mimic the sexual structures of their vector's potential mate.

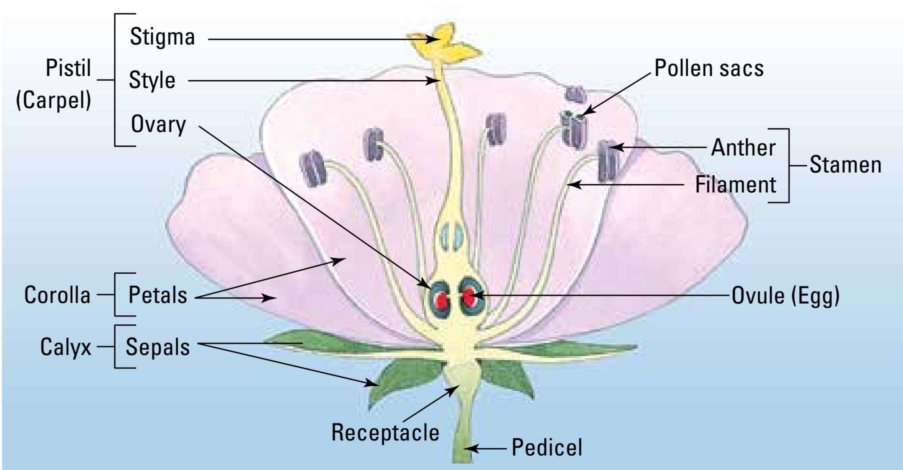
Insect-pollinated

Flowers that are pollinated by insects (**insect pollination**) are often blue, purple or yellow (colours that insects can see), possess a landing platform, have an enticing scent or odour and contain nectaries offering a food supply to these hungry **pollinators**. When the insects visit their next sweet treat of nectar on another flower, they transport pollen from their previous visit to the stigma of their new meal provider.

Bird-pollinated

Flowers that are pollinated by birds are often red, orange or yellow (colours recognised by hungry birds as food) and possess petals in a tubular shape, with nectaries usually inside the base of the flower. As in insect pollination, the birds carry pollen from one meal to their next.





Parts of a typical flower. Note the presence of pollen-producing and egg-producing organs in the same flower.

INVESTIGATION 5.5

Stem transport systems

AIM To observe how water moves up celery stems

Materials:

celery stick (stem and leaves)	*blue food colouring*
knife	*red food colouring*
two 250 mL beakers	*hand lens*
water	

METHOD, RESULTS AND DISCUSSION

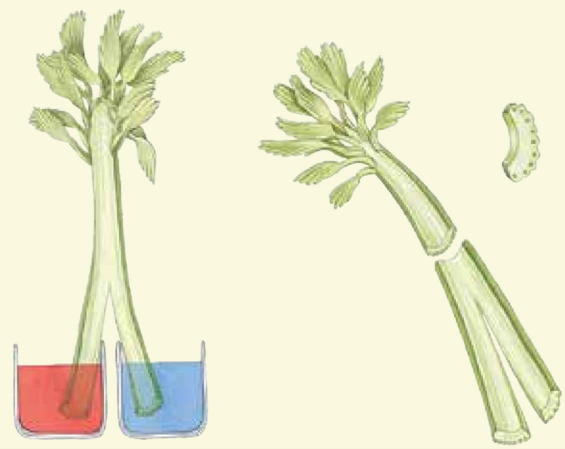
- Slice the celery along the middle to about halfway up the stem.
- Fill two beakers with 250 mL of water. Colour one blue and the other red with the food colouring.
- Place the celery so that each side of the celery is in a separate beaker.
- Leave for 24 hours and then observe the celery.
- Cut the celery stick across the stem.
- Use the hand lens to look at the inside of the stem.

1. Look at where the water has travelled in the celery. Draw a diagram to show your observations.

2. Draw a diagram to show what you can see when you cut across the stem.
3. Where is the differently coloured water found in the stem?
4. Where are the different colours found in the leaves?
5. Draw a diagram of the whole celery stick and trace the path of the water through each side to the leaves.
6. How could you turn a white carnation blue? Try it.

EVALUATION

7. Did you encounter any difficulties or problems in this investigation?
8. Suggest ways in which you could improve your investigation if you were to repeat it.
9. Suggest a hypothesis that you could test using similar equipment.



INVESTIGATION 5.6

Observing leaf epidermal cells

AIM To observe stomata and guard cells in leaf epidermal cells

Materials:

leaf	*clear sticky tape*
microscope	*microscope slide*

BACKGROUND

You can make a slide of leaf epidermal cells with sticky tape.

METHOD AND RESULTS

- Put some sticky tape over a section of the underside of a leaf.
- Press the sticky tape firmly onto the leaf.
- Tear the tape off. Some of the lining cells should come off with the sticky tape.
- Press the tape, sticky side down, onto a microscope slide.
- View the sticky tape under the microscope.
- Try to find a pair of guard cells and one of the stomata.

1. Is the stoma (the opening) open or closed?
2. Make a drawing of a group of cells, including the guard cells. Include as much detail in your drawing as possible.
3. Label the guard cells and stomata.
4. Date your drawing and give it a title. Write down the magnification used.

DISCUSS AND EXPLAIN

5. Summarise your observations.
6. Suggest a hypothesis that you could test using similar equipment.
7. Propose a research question that could be investigated.

UNDERSTANDING AND INQUIRING

REMEMBER

1 What is the name of the tubes that carry sugar solution around the plant?

2 Describe the difference between:
(a) sugar and water transport in plants
(b) the arrangement of vascular bundles in dicots and monocots.

3 Describe the patterns in which the vascular tissue is arranged in the stems of different plants. Obtain your information by:
(a) examining stained cross-sections
(b) finding and examining diagrams of the stems of different plants in cross-section.

4 How long do you think it would take for a plant to take up 50 mL of water? What conditions might speed it up? Put forward a hypothesis, and then design an experiment to test your hypothesis.

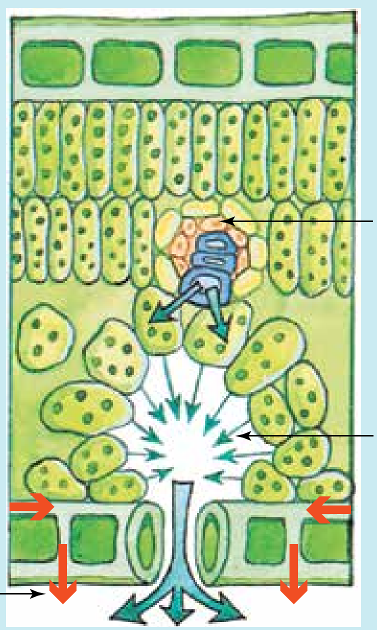
5 Design an experiment to test the time taken for different volumes of water to be taken up by the plant.

6 On which part of the plant are stomata usually found? Can you suggest why?

7 Describe how the guard cells assist the plant in controlling water loss.

8 Suggest why plant roots have small hairs.

9 Label the figure below using the following labels: cuticle, vascular bundle, water loss through stomatal pore, xylem, chloroplast, upper epidermis.



INVESTIGATE

10 Some plants have special features that help them reduce water loss. Some leaves have a thick, waxy layer (cuticle). Others have a hairy surface or sunken stomata. Plants that are able to tolerate extremely dry environments are called *xerophytes*. Find out some ways in which plants in dry environments, such as deserts, reduce their water loss. Present your information on a poster or as a model.

11 Design an experiment to measure the amount of water lost through the leaves of a plant.

12 Place a plastic bag over the leaves of plants growing in the school grounds. Seal the bag and record the amount of water collected over 24 hours. What conclusions can you draw from your results?

13 Find out more about the use of paid domestic honeybees in Australia to pollinate crops, and issues related to feral honey bees incidental pollination.

14 Some plants are described as being grown hydroponically. Investigate what this means and reasons for it.

15 (a) Suggest why flowers pollinated by birds are generally red, orange or yellow, not strongly scented and tubular in shape.
(b) Use the internet and other resources to see if your suggestions were correct. Report back on your findings.
(c) Investigate and report on Australian research into bird-pollination of plants.
(d) On the basis of your research, propose two relevant questions that could be investigated and collate these with questions from other students in the class.
(e) From the class question databank produced in part (d), select a question and research possible answers, sharing your findings with others.

16 Suggest why flowers pollinated by insects are blue, yellow or purple, can be scented and contain nectaries at the base. Report your findings.

17 There have been claims that bee populations are declining around the world and that their pollination of flowers may be becoming unsynchronised with the life cycle of the plants. Some suggest that the culprit is climate change. Investigate these claims and construct a PMI chart that shows support for the claim, support against the claim and interesting points relevant to the claim. What is your opinion? Do you agree or disagree with the claim? Justify your response.

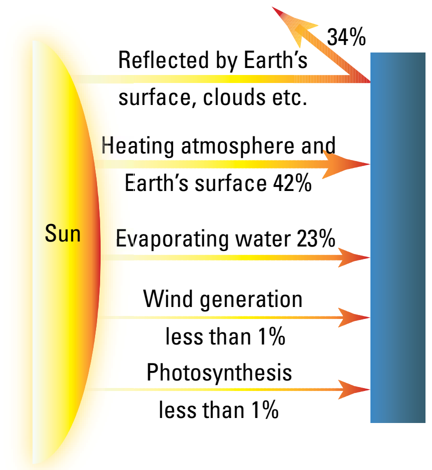
CREATE

18 In a group, write and then act out a play or simulation of the way water moves through a plant.

19 Write a story about a group of water molecules that travels from the soil, through a plant and then into the atmosphere as water vapour.

Photosynthesis

Being green helps plants make their own food.



Solar energy coming into Earth has various fates. What percentage of this energy is immediately reflected out? In what form is the incoming energy? In what form is the major outgoing energy?

Solar powered

Did you know that life on Earth is solar powered? The source of energy in all ecosystems on Earth is sunlight. Plants play a very important role in catching some of this energy and converting it into a form that both they and other organisms can use.

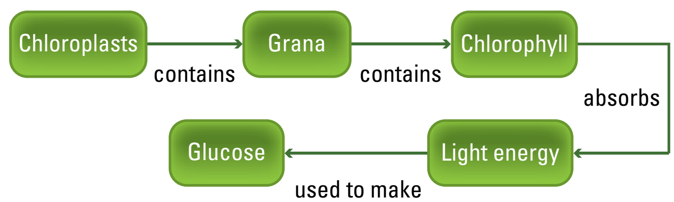
Why are plants called producers?

Photosynthetic organisms such as plants, algae and phytoplankton are called **producers** or **autotrophs** because they can produce and use their own food. They use light energy to make complex, energy-rich organic substances from simpler inorganic substances (such as carbon dioxide and water).

This process of capturing light energy and its conversion into chemical energy is called **photosynthesis** because it involves using light energy to synthesise glucose. Once it is in this chemical form, it can be used as food, stored as starch or converted into other organic compounds.

Photosynthesis

The light energy captured by chlorophyll provides energy to split water (H_2O) molecules into oxygen and hydrogen. The oxygen is released as oxygen (O_2) gas into the atmosphere through the stomata. The hydrogen combines with carbon dioxide (CO_2) obtained through stomata from the atmosphere to make glucose ($C_6H_{12}O_6$).

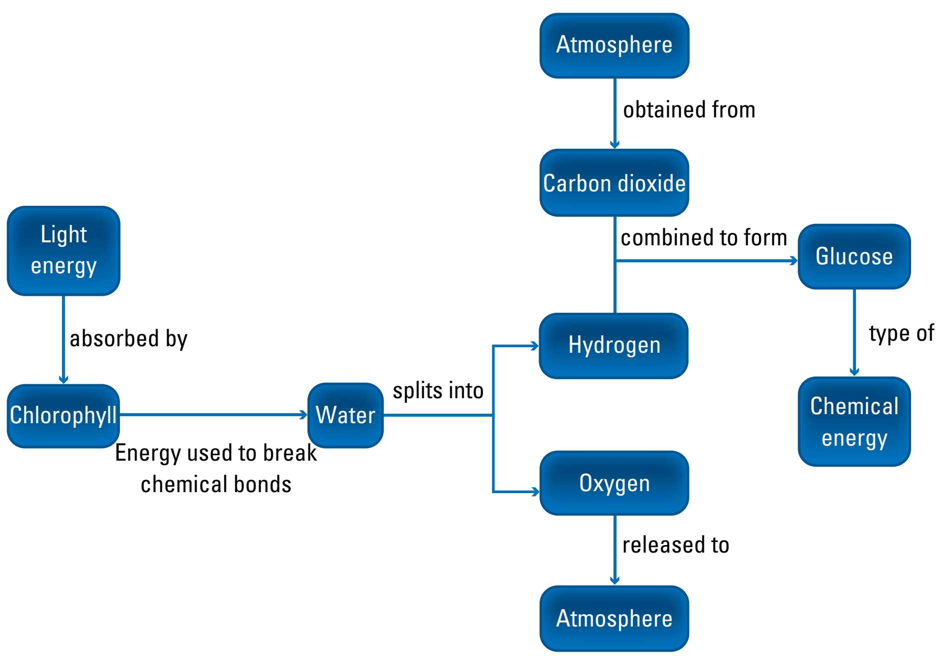


An overall chemical reaction for photosynthesis can be written as:

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{visible light energy}} \text{glucose} + \text{oxygen} + \text{water}$$

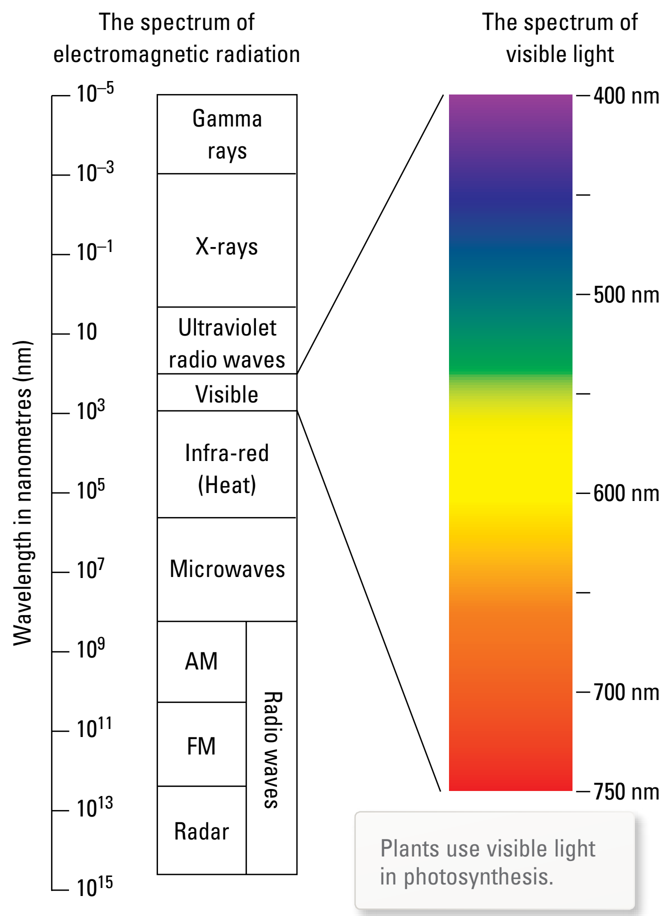
It can also be represented in chemical symbols as:

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{visible light energy}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

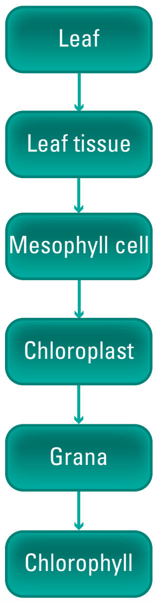


Why are plants green?

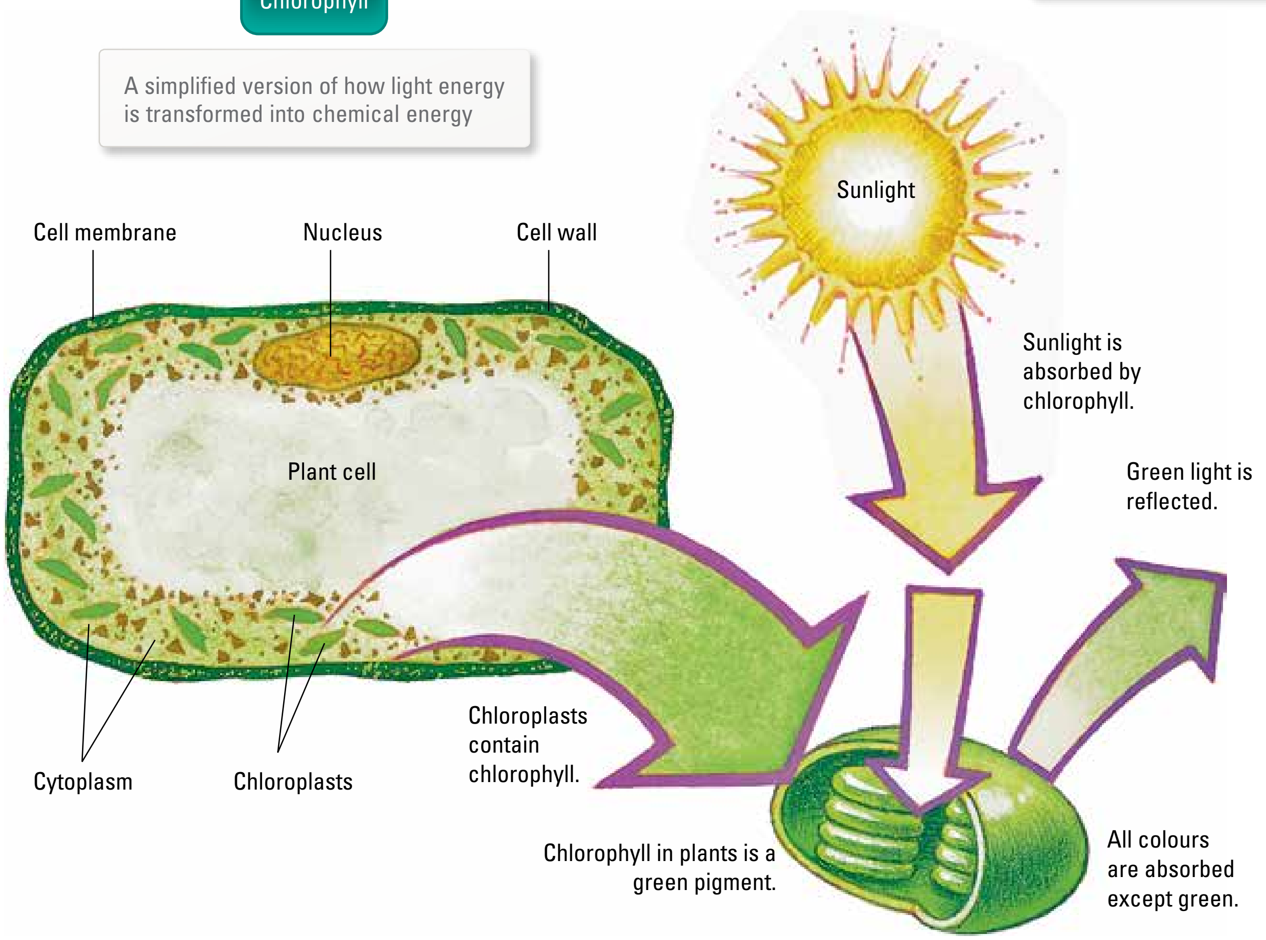
Visible light consists of all of the colours of the rainbow! Of the whole spectrum, chlorophyll reflects only green light and absorbs other wavelengths of light (colours). It is for this reason that plants look green. Being green, however, is not essential to be able to photosynthesise. Some plants — algae and phytoplankton, for example — may contain light-capturing pigments that are red, yellow or brown.



Plants use visible light in photosynthesis.



A simplified version of how light energy is transformed into chemical energy



HOW ABOUT THAT!

Discovery journal of photosynthesis

1450

Nicholas of Cusa
German cardinal
(1401–1464)
Proposed idea that weight gained by plants is from water, not earth.

Jan Baptista van Helmont
Dutch physician
(1577–1644)
Demonstrated that most material in a plant's body does not come from soil; he suggested it comes from water.

1700

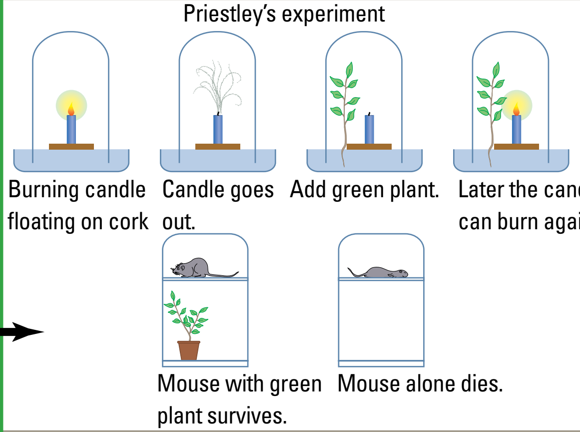
1720

Stephen Hales
British physiologist/clergyman
(1677–1761)
Suggested plants get some nourishment from air.

1740

Joseph Priestley
British chemist/clergyman
(1733–1804)
Showed that plants could 'restore' air injured (by respiration).

Priestley's experiment



1760

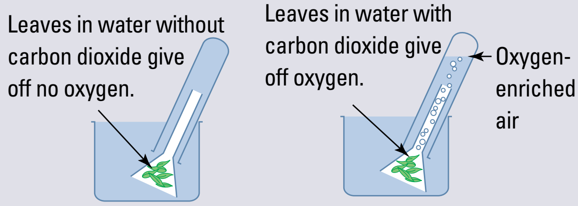
1780

Jan Ingenhousz
Dutch physician
(1730–1799)
Showed that plants need sunlight to restore 'injured air' and that only the green parts do this; all parts of plants 'injure' air (i.e. respire).

1800

Various European chemists (late 18th century)
Oxygen discovered and identified as 'restored' air, carbon dioxide discovered and identified as the 'injured' air.

Jean Senebier
Swiss minister (1742–1809)
Plants use carbon dioxide dissolved in water as food.

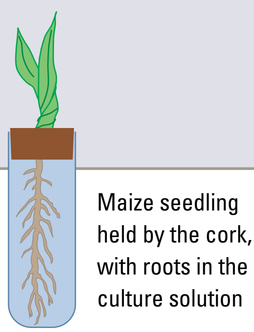


1820

1840

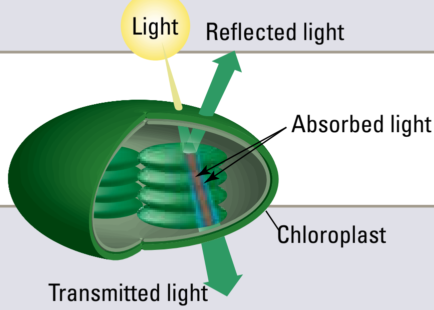
1860

Julius von Sachs
German botanist
(1832–1897)
Discovered plant respiration, and that chlorophyll is found in chloroplasts; showed that starch grains form during photosynthesis, and that plants take in and use minerals from the soil; showed that minerals were required for making chlorophyll.

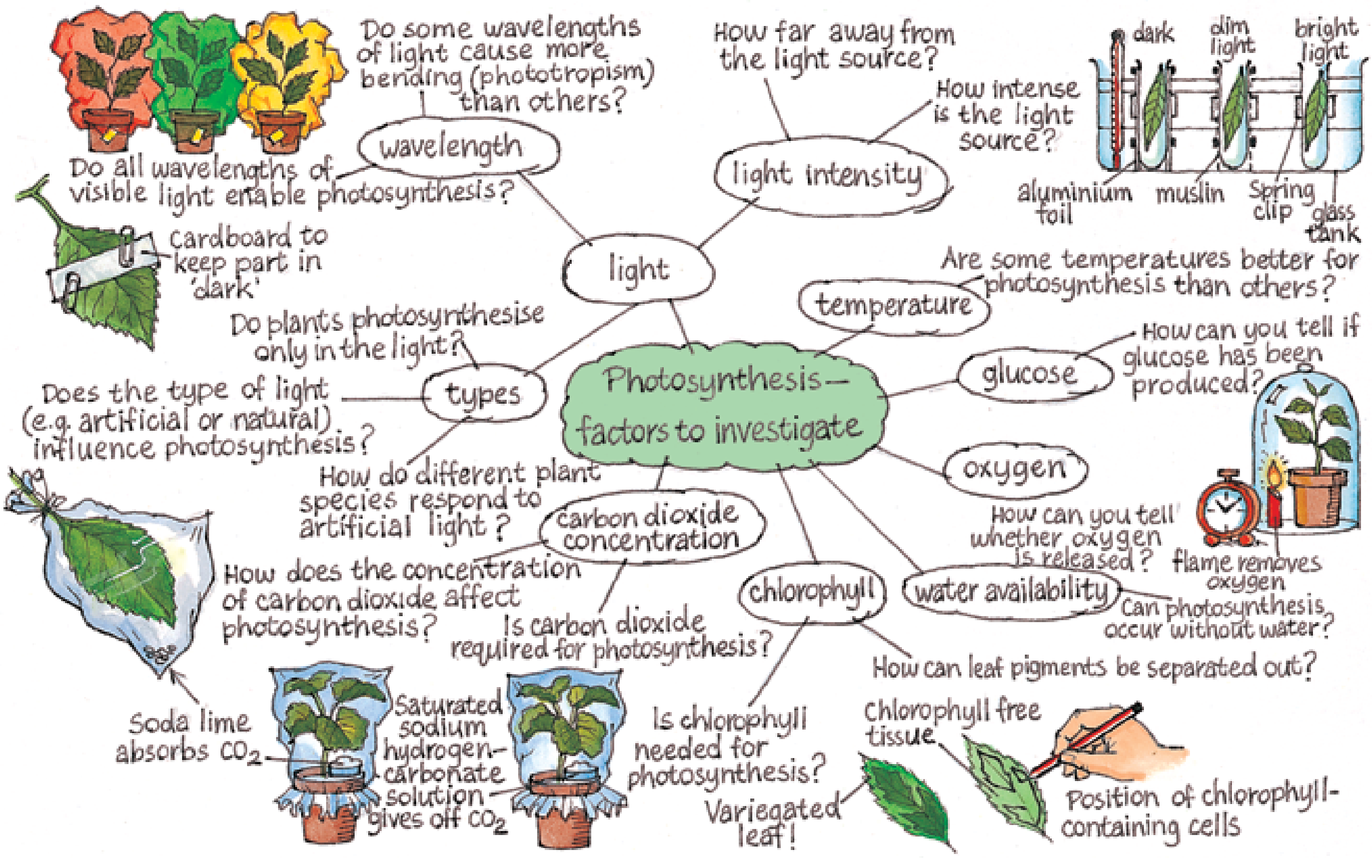


1880

Theodor Wilhelm Engelmann, German physiologist (1843–1909)
Showed that oxygen was produced by chloroplasts; and that red and blue light are the most important wavelengths for photosynthesis.



1900



INVESTIGATION 5.7

Looking at chloroplasts under a light microscope

AIM To observe chloroplasts under a light microscope

Materials:

tweezers
water
dilute iodine solution
moss or spirogyra
light microscope, slides, coverslips

METHOD AND RESULTS

- Using tweezers, carefully remove a leaf from a moss plant or take a small piece of spirogyra.
- Place the leaf in a drop of water on a microscope slide and cover it with a coverslip.
- Use a light microscope to observe the leaf.
- Put a drop of dilute iodine solution under the coverslip. (Iodine stains starch a blue–black colour.)
- Using the microscope, examine the leaf again.

DISCUSS AND EXPLAIN

1. Draw what you see.
2. Label any chloroplasts that are present.
3. Describe the colour of the chloroplasts.
4. What gives chloroplasts their colour?
5. (a) Did the iodine stain any part of the leaf a dark colour?
   (b) If so, what does this suggest?
6. What conclusions can you make about chloroplasts?
7. Identify the strengths of this investigation.
8. Suggest improvements to the design of this investigation.
9. Suggest a hypothesis that could be investigated using similar equipment. (You may use internet research to identify relevant problems to investigate.)
10. Design an experiment to test your hypothesis. Include an explanation for your choice and treatment of variables.
11. Share and discuss your suggested hypothesis and experimental design with others and make any refinements to improve it.

INVESTIGATION 5.8

Detecting starch and glucose in leaves

AIM To detect glucose and starch in plant leaves

BACKGROUND

Glucose can be detected with a chemically sensitive paper. The polysaccharide starch, which glucose is converted into for storage, is detected by iodine.

Materials:

iodine solution in a dropper bottle
1% starch solution
white tile or blotting paper
leaves from seedlings or plants of one type (geranium, hydrangea, lettuce, spinach or silverbeet cuttings are good)
glucose indicator strip with colour chart
1% glucose solution in a dropper bottle
mortar and pestle
sand
small beakers or petri dishes for testing different substances.

METHOD AND RESULTS

1. Construct a table like the one below for recording your observations.

Item tested	Iodine test		Glucose test	
	Colour	Starch present?	Colour	Concentration of glucose

TESTING LEAVES FOR STARCH

- To observe the effect of iodine solution on starch, place a few drops of starch solution on a piece of blotting paper or a white tile. Add a few drops of iodine.
- Soften two or three leaves by dipping them with tongs into hot water for 10 seconds.
- Repeat the test with the softened leaves. Keep one leaf aside that is not tested with iodine to compare it with the leaves that you test.

2. Record the colour observed and the presence of starch in your table.

TESTING LEAVES FOR GLUCOSE

- To observe the effect of glucose on the glucose indicator strip, place a drop of glucose solution on the end of the strip on a white tile.

Iodine is an indicator of starch in leaves.

- Use the chart of colours to determine the concentration of the glucose.
- Using the mortar and pestle, grind some fresh leaves with a little water and a sprinkle of sand.
- Allow a strip of glucose indicator paper to soak up the liquid.

3. Record the colour and glucose concentration in your table.

DISCUSS AND EXPLAIN

4. Describe the effect of the iodine on the starch solution.
5. Describe the effect of the glucose solution on the indicator strip.
6. What do your results suggest about the way energy is stored in leaves?
7. Why was sand added to the mixture in the mortar?
8. The sand does not affect the result on the indicator strip. How could you show this?
9. Identify the strengths of this investigation.
10. Suggest improvements to the design of this investigation.
11. Suggest a hypothesis that could be investigated using similar equipment. (You may use internet research to identify relevant problems to investigate.)
12. Design an experiment to test your hypothesis. Include an explanation for your choice and treatment of variables.
13. Share and discuss your suggested hypothesis and experimental design with others and make any relevant refinements to improve it.

INVESTIGATION 5.9

Out of the light

AIM **To investigate differences in a plant's production of starch when light is removed**

CAUTION Ethanol is flammable. Do not place it near a naked flame.

Materials:

pot plant that has been kept in the dark for a few days
several strips of aluminium foil
scissors and sticky tape
hotplate
500 mL beaker of boiling water
test tube of ethanol
forceps
iodine solution and dropping pipette
Petri dish
watchglass with a small sample of potato starch

METHOD AND RESULTS

- Fix aluminium strips to one leaf of a plant as shown in the figure below. Make sure that both sides of the leaf are covered by the strip and that you do not damage the leaf.

Make sure that the aluminium strips are secured, and that you do not damage the leaf.

- Leave the plant in the light for 3 days.
- Remove the leaf from the plant and take off the foil.
- Dip the leaf into boiling water for 10 seconds, then place it in a test tube of ethanol.
- Stand the test tube in the beaker of hot water and leave for 10 minutes. This treatment will remove the chlorophyll.

1. While the leaf is in the ethanol, test a small sample of potato starch on a watchglass with the iodine solution. Note any colour change.

- Remove the leaf from the ethanol with the forceps and dip it into the hot water in the beaker again to remove any excess ethanol.

2. Place the leaf into a Petri dish and cover with iodine solution. Note any colour change and where on the leaf any such change occurred.

DISCUSS AND EXPLAIN

3. Glucose is produced during photosynthesis and is then converted to starch and stored. Did your test show any differences in starch production between the sections of leaf exposed to the light and the sections kept in the dark?
4. Which variable has been investigated in this experiment?
5. Why was the plant kept in the dark for a few days prior to the experiment?
6. What inferences (suggested explanations) can you make from your observations?
7. What is the control in this experiment?

EVALUATE

8. Identify the strengths of this investigation.
9. Suggest improvements to the design of this investigation.
10. Suggest a hypothesis that could be investigated using similar equipment. (You may use internet research to identify relevant problems to investigate.)
11. Design an experiment to test your hypothesis. Include an explanation for your choice and treatment of variables.
12. Share and discuss your suggested hypothesis and experimental design with others and make any suitable refinements to improve it.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Identify the source of energy for all ecosystems on Earth.

2 (a) Name the green pigment that can capture light energy.
(b) Name the structure in which you would find this pigment in a plant.

3 Recall the word equation for photosynthesis.

4 Is being green essential for photosynthesis? Explain.

5 Identify an example of an autotroph and an example of a heterotroph.

6 Use a Venn diagram to compare producers and consumers.

7 Identify the scientist who:
(a) suggested that plants get some nourishment from air
(b) proposed that plants use carbon dioxide dissolved in water as food
(c) discovered that chlorophyll was found in chloroplasts
(d) showed that oxygen was produced in chloroplasts.

THINK AND DISCUSS

8 How can you test whether photosynthesis has occurred in all parts of a leaf?

9 If you were testing a leaf for carbon dioxide and enclosed it in a plastic bag with soda lime in it, why would you also put the control plant without soda lime in a plastic bag?

10 Starch found in a leaf is used as evidence of photosynthesis in the leaf. Where else might the starch have come from?

11 If you were measuring the effect of light intensity, why would you also need a thermometer?

12 Name the chemical produced in photosynthesis that contains chemical energy for the plant.

13 Explain how it can be said that photosynthesis is the reverse reaction of aerobic respiration.

14 During a 24-hour period of day and night, when will a plant be respiring and when will it be photosynthesising?

15 Give two examples of movements that plants make.

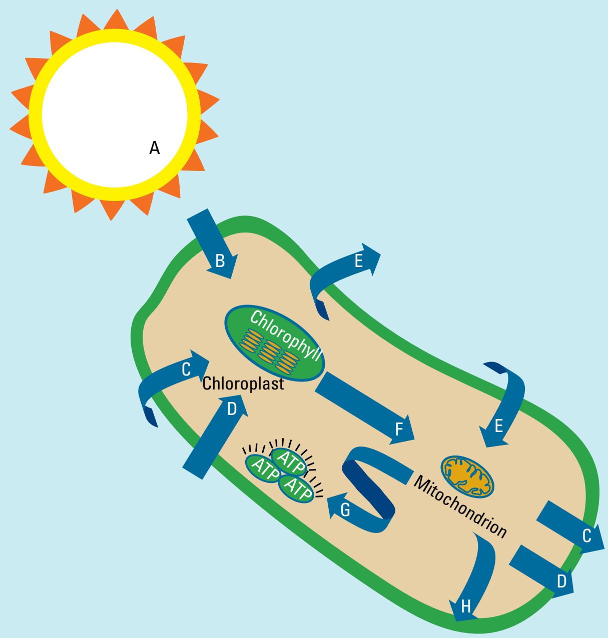
16 Apart from the production of food, how are plants important to life on Earth?

INVESTIGATE

17 Refer to the *Discovery journal of photosynthesis* in this section to answer the following questions. Which scientists made discoveries and when did they make them? Were their ideas accepted immediately? Which ideas did their new ideas replace?

18 Select one of the questions about photosynthesis experiments in the diagram above Investigation 5.8. Design (and if possible perform and report on) an experiment to try to find the answer or more information about it.

19 The diagram below shows a chloroplast and a mitochondrion in a plant cell.



(a) Which energy conversion takes place in the chloroplast?
(b) The arrows on the diagram above show the flow of energy and substances into and out of the cell. Choose words from the box below that are represented on the diagram by the letters A–H.

Water	Oxygen	Sun
Carbon dioxide	Heat energy	Chemical energy
Light energy	Glucose	

20 If someone said to you: ‘If all photosynthesis on Earth stopped, humans would eventually become extinct’, would you agree or disagree? Justify your answer.

21 Investigate and report on the hottest creatures on Earth that live in deep-sea hydrothermal vents. You will find some of these creatures by using the **Deep sea** weblink in your eBookPLUS. In your report, describe the creatures and how they survive.

eBook*plus*

Cellular respiration

Taking what we need

Unlike plants, animals cannot convert light energy into chemical energy. Our energy and nutritional demands are met by taking in or consuming other organisms. That is why we and other organisms with this need are called consumers or heterotrophs.

When a consumer eats another organism, not all of the chemical energy is used to form new tissues or stored for later use. Humans can store some of the unused energy as glycogen in their liver or as **fat** in fatty tissue beneath the skin. Some of the chemical energy is also converted into other forms; for example, some of it is released as heat.

Cells are busy places

The conversion of chemical energy and the growth and repair of cells result from thousands of chemical reactions that occur in your body. These reactions are known collectively as **metabolism** and occur in all living things.

Cells need energy

All living things respire. **Cellular respiration** is the name given to a series of chemical reactions in cells that transforms the chemical energy in food into **adenosine triphosphate (ATP)** — this is a form of energy that the cells can use. The energy in ATP can later be released and used to power many different chemical reactions in the cells.

Aerobic respiration

Aerobic respiration is the process that involves the breaking down of glucose so that energy is released in a form that your cells can then use. The overall equation for cellular respiration is shown below:

$$\text{Glucose} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{carbon dioxide} + \text{water} + \text{energy}$$

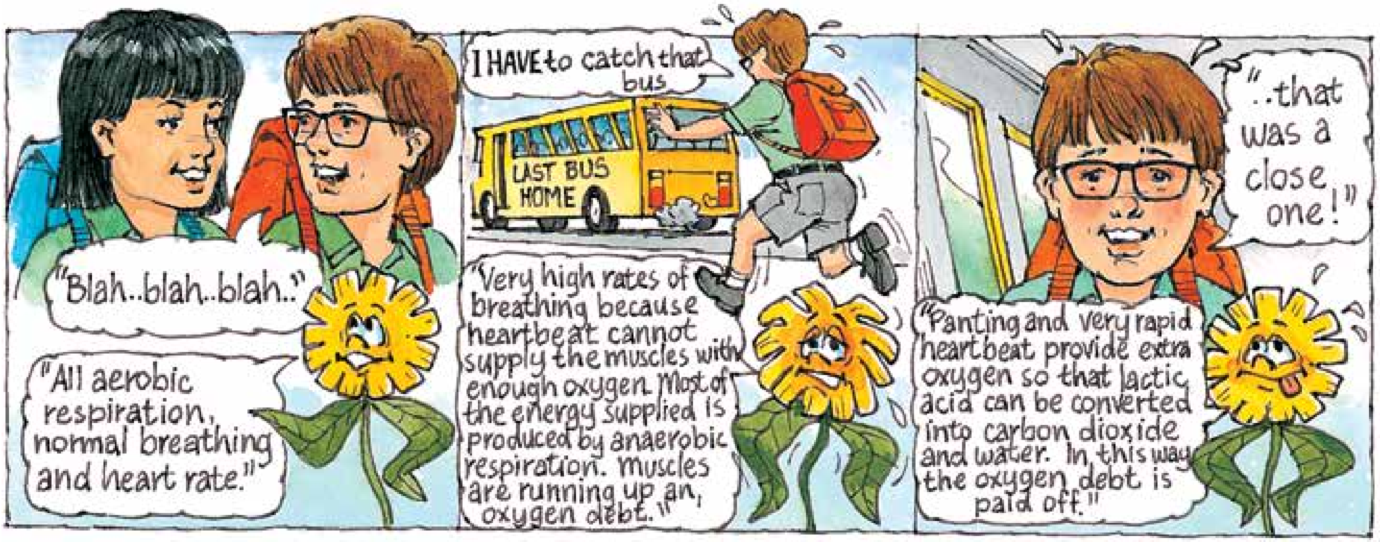
$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{enzymes}} 6CO_2 + 6H_2O + \text{energy}$$

Your digestive and circulatory systems provide your cells with the glucose that is required for this very important reaction. Your circulatory and respiratory systems also work together to supply your cells with oxygen and to remove the carbon dioxide that is produced as a waste product.

Three stages

Aerobic respiration requires oxygen and occurs in three stages. The first stage is called **glycolysis**, occurs in the **cytosol** of the cell and does not require oxygen. The next two stages, the **Krebs cycle** and **electron transport chain reactions**, occur in the **mitochondria**. It is in the mitochondria that most of the energy, in the form of ATP, is produced. Cells with high energy demands contain more mitochondria than other less active cells.

Mitochondria (shown in red) are the powerhouses of your cell.



Anaerobic respiration

Most of the time, aerobic respiration is adequate to supply enough energy to keep the cells in your body working effectively. Sometimes, however, not all of the oxygen demands of your cells can be met.

Your muscle cells have the ability to respire for a short time without oxygen using **anaerobic respiration**. Using this reaction, glucose that has been stored in your muscle cells is converted into **lactic acid**.

What's your end?

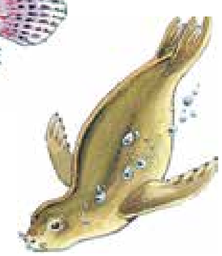
While the end products of aerobic respiration are always the same, the end products of anaerobic respiration can be different, depending on the organism. Humans and other animals produce lactic acid (or **lactate**), whereas plants and yeasts produce **ethanol** and carbon dioxide.

Although less energy is produced in anaerobic respiration (2 ATP) than in aerobic respiration (36–38 ATP), it is produced at a faster rate. This is very helpful when a quick burst of energy is needed for a short time.



$$\text{Glucose} \xrightarrow{\text{enzymes}} \text{lactic acid} + \text{energy}$$

$$C_6H_{12}O_6 \xrightarrow{\text{enzymes}} 2C_3H_6O_3 + \text{energy}$$






$$\text{Glucose} \xrightarrow{\text{enzymes}} \text{ethanol} + \text{carbon dioxide} + \text{energy}$$

$$C_6H_{12}O_6 \xrightarrow{\text{enzymes}} 2C_2H_5OH + 2CO_2 + \text{energy}$$

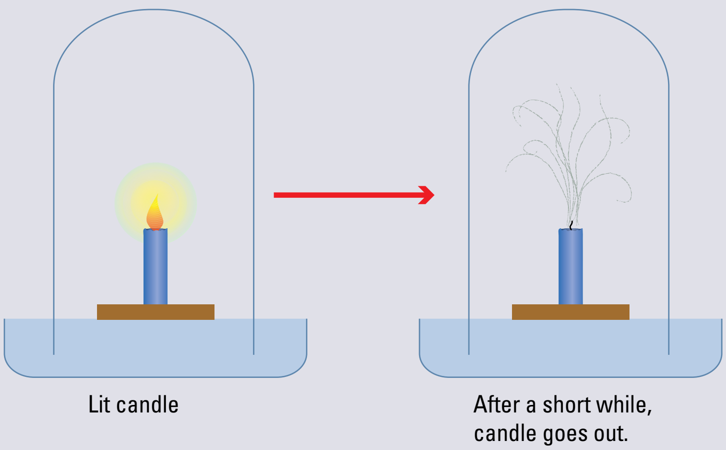
Features of aerobic and anaerobic respiration

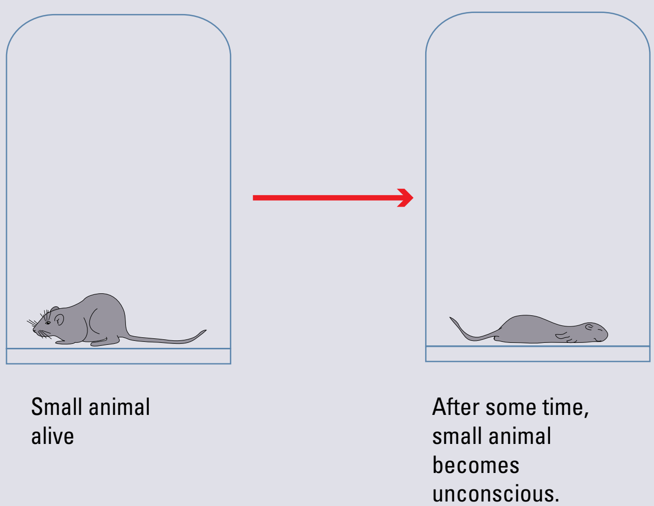
Question	Aerobic respiration	Anaerobic respiration
Is oxygen required?	Yes	No
What is glucose broken down into?	Carbon dioxide + water + energy	Lactic acid or ethanol + carbon dioxide + energy
For how long can the reaction occur?	Indefinitely	A short time only
Is the energy transfer efficient?	Yes	No
How fast is ATP production?	Slow	Fast
How many molecules of ATP are produced in each reaction?	36	2
What are the end products?	All organisms: carbon dioxide and water	Animals: lactic acid Plants and yeasts: ethanol and carbon dioxide
About how much energy is released per gram of glucose?	16 kJ	1 kJ

HOW ABOUT THAT!

Some micro-organisms respire only anaerobically, and can die in the presence of oxygen. These are referred to as **obligate anaerobes**. The bacterium *Clostridium tetani* is an example of an organism that can thrive only in the total absence of oxygen. At the site of a wound, tissue necrosis (death) provides a locally anaerobic environment in which these bacteria can grow. This bacterium releases toxins which cause tetanus (or lockjaw), a painful condition in which muscles remain contracted.

How did we find out about the link between respiration and oxygen? Robert Boyle (1627–1691) performed experiments that showed that something in air was needed to keep a candle burning and an animal alive. Joseph Priestley (1733–1804) took Boyle's experiment a step further and showed that plants produced a substance that achieved this.





INVESTIGATION 5.10

Fermenting fun

AIM To observe the process of fermentation

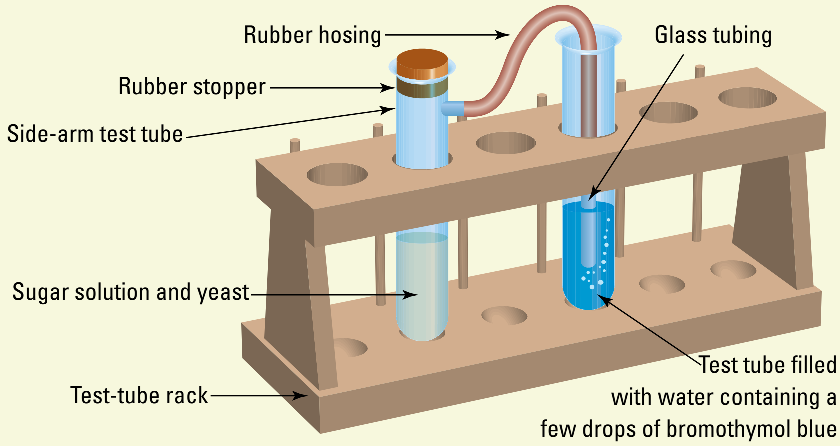
Materials:

safety glasses and laboratory coat
large side-arm test tube
rubber stopper to fit side-arm test tube
length of rubber hosing (25 cm) fitted with a short end of glass tubing
test-tube rack
½ spatula full of yeast
½ spatula full of sugar
20 mL of warm water
test tube half filled with water, with a few drops of bromothymol blue added
dropping bottle of bromothymol blue indicator

METHOD AND RESULTS

- Set up the apparatus as shown in the diagram on the right.
- Place the yeast, sugar and 20 mL of water in the side-arm test tube.
- Seal the top of the side-arm test tube with the rubber stopper and connect the rubber hosing between the two test tubes.
- Leave the apparatus set up in a warm place overnight.

1 Next day observe the colour of the bromothymol blue indicator and note the odour in the yeast test tube.



Experimental set-up for the fermentation of yeast

DISCUSS AND EXPLAIN

2 List the changes that occurred in the yeast test tube.

3 Bromothymol blue changes from blue to green to yellow in the presence of carbon dioxide. What does the colour change you observed suggest?

4 Describe the odour in the yeast test tube.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Suggest why humans are referred to as *consumers* or *heterotrophs*.

2 Describe what happens to chemical energy that is stored in your body.

3 Define the term *metabolism*.

4 Which organisms respire?

5 What does ATP stand for?

6 Outline the importance of ATP.

7 Write a word equation for aerobic respiration.

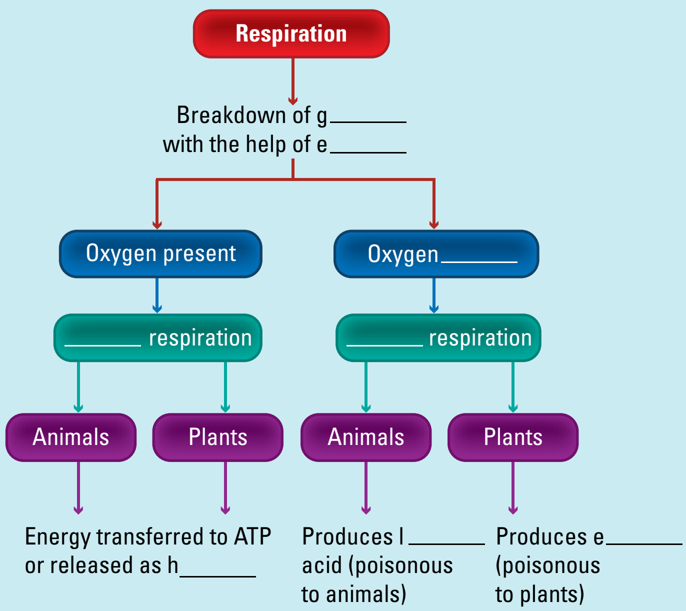
8 Write the chemical equation for aerobic respiration.

9 Outline the purpose of aerobic respiration.

10 Name the three stages of aerobic respiration.

11 State the location within the cell where each stage of aerobic respiration occurs.

12 Copy and complete the flowchart at right to illustrate the differences between aerobic and anaerobic respiration.



13 Suggest a link(s) between cellular respiration and the:
(a) digestive system
(b) circulatory system
(c) respiratory system.

14 Write the word equation for anaerobic respiration in:
   (a) animals
   (b) plants, yeasts and bacteria.

15 Use a Venn diagram to compare aerobic and anaerobic respiration.

INVESTIGATE, THINK AND DISCUSS

16 (a) What are the advantages of anaerobic respiration to a person who is a short-distance swimmer?
   (b) What are the disadvantages of anaerobic respiration to the body?
   (c) Which type of respiration, aerobic or anaerobic, is more likely to occur in each of the following activities?
      (i) Ten sit-ups
      (ii) A leisurely walk
      (iii) Lifting a very heavy steel bar above your head
      (iv) Watching TV from the sofa
      (v) A 30-metre sprint to catch the dog

17 The muscles of a sprinter respire anaerobically throughout a race.
   (a) Suggest how the sprinter could compete in a 100 m race without breathing.
   (b) Why does the sprinter need to pant to get extra oxygen at the end of the race?
   (c) Where does the extra oxygen enter the body while panting is used for breathing?

18 Intestinal tapeworms excrete lactic acid directly into their host's gut. Suggest the advantage to the tapeworm of this behaviour.

19 *Clostridium botulinum* is an anaerobe that cannot survive in the presence of oxygen. This microbe causes a potentially lethal form of food poisoning called botulism. Suggest why this bacterium may be a problem in canned foods.

20 Suggest why one type of cellular respiration releases more energy than the other.

21 Find out the methods used to make white wine, red wine, beer and Swiss cheese. Report your findings in the form of a recipe book.

22 How can anaerobic respiration be involved in the pickling of foods such as cabbage, pickles and olives?

23 What is an energy transformation?

24 Does metabolism occur in plants?

25 What can living energy converters do that non-living energy converters cannot?

26 How is the human body similar to a moving motor vehicle?

27 Why is it correct to say that your body burns food?

28 Suggest possible answers to the question below.

What am I?

You have to fill me with fuel regularly. The fuel is burned inside me in a chemical reaction in which chemical energy is transformed into mechanical energy. I get very hot when fuel is burned. The faster I go, the more fuel I need. I release waste products that smell and can pollute the environment.

29 Many Australians try to lose mass by dieting. Investigate one of the different types of diets used to reduce energy intake. Find out what foods are eaten while on the diet and explain how it can result in mass loss. You may like to investigate low-fat diets, joule-counting diets or high-fibre diets.

30 Who was James Prescott Joule? Write a short biography about him.

31 Find out how the energy content of food is measured accurately.

32 Energy is measured in joules or kilojoules. Find out the origin of the name given to this unit.

33 Childhood obesity is a health issue that has become prominent recently in Australian news. Search the internet, journals and newspapers to create a collage of headings and key points about this topic. Organise your collage as a PowerPoint, webpage, piece of art or poster.

34 Water is released from your body when you breathe out. Describe two other ways in which water is released from your body.

35 Why would human beings die within a few minutes if they could not breathe, even though they can live for several weeks if they do not eat any food?

36 Suggest the effect of activity and exercise on the rate of aerobic respiration. Use a visual thinking tool to show your thinking.

37 You need oxygen to live; find out how astronauts' needs are met.

38 The amount of oxygen in the air decreases as altitude increases when you go high up in the mountains. How do people who live up in these types of environments get enough oxygen?

39 Oxygen levels in the sea decrease with depth. Find out how deep-sea divers get their oxygen.

40 Prepare a PowerPoint presentation that summarises the information in this section. Present your summary to the class.

41 Find out more about mitochondria and then make a model of a mitochondrion.

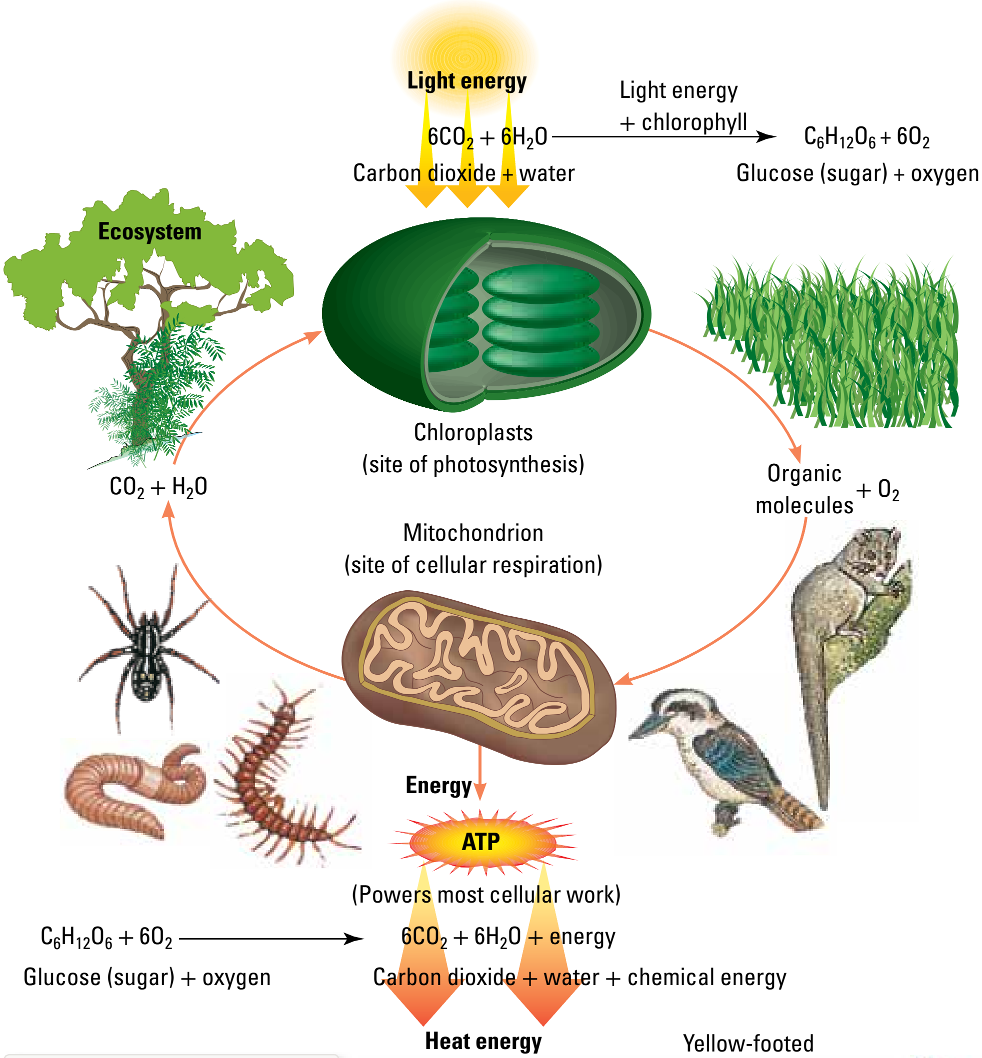
Sustainable ecosystems

Communities within ecosystems are made up of populations. Interactions between these populations and their environment enable matter to be recycled and energy to flow through the ecosystem.

Energy flows through ecosystems

Light energy is captured by producers and converted into chemical energy using the process of photosynthesis. Some of this energy is used by the producers themselves, some is released into the atmosphere and some is passed on through food chains to consumers. Energy flows through ecosystems.

Cellular respiration is a process that all living organisms use to convert energy into a form that their cells can use. Glucose and oxygen (the products of photosynthesis) are used in cellular respiration.



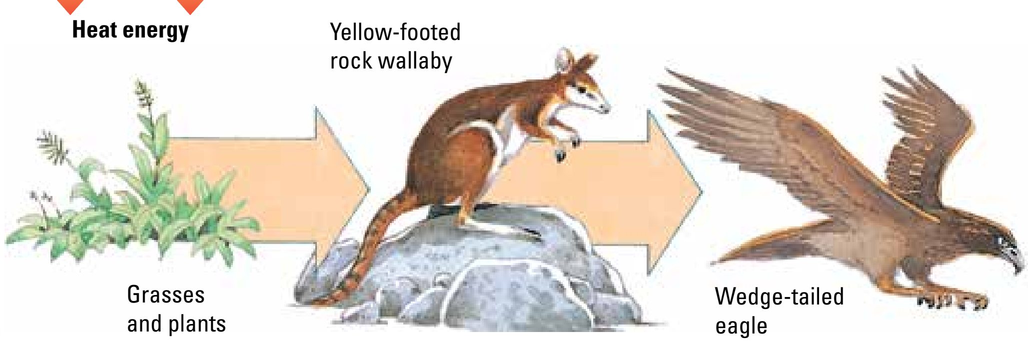
Living in the dark

How can ecosystems exist on the ocean floor, where there is no light for photosynthesis? Rather than being photosynthetic, some organisms are **chemosynthetic**. They use energy released from chemical reactions (rather than light) to produce organic molecules. Examples of these non-photosynthetic producers are autotrophic bacteria such as *Thiobacillus* spp.

Food chains and food webs

Feeding relationships in ecosystems can be described as **food chains** and **food webs**. Food chains show the direction of the flow of energy. Interconnecting or linked food chains make up a food web.

Photosynthesis is the process involved in capturing light energy and converting it into chemical energy. Respiration is the process that uses chemical energy produced from photosynthesis for energy to live.

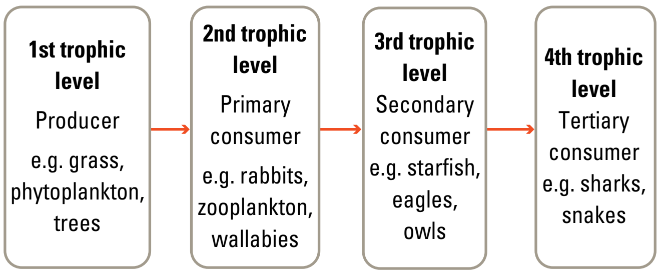


Trophic levels and orders

Within a food chain, each feeding level is called a **trophic level**.

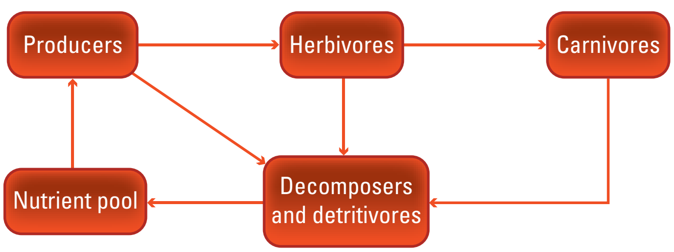
Producers make up the first trophic level and herbivores the next. As herbivores are the first consumers in the food chain, they are at the second trophic level and are referred to as **first-order** or **primary consumers**. Consumers that eat the herbivores are at the third trophic level and are called **second-order** or **secondary consumers**. As only about 10 per cent of the chemical energy is passed from one trophic level to the next, most food chains do not usually contain more than four trophic levels.

Some examples of organisms that could be present at each level are shown below. Organisms can appear within more than one trophic level.



Matter cycles through ecosystems

Food chains and food webs also describe how matter can be recycled through an ecosystem. Carefully observe each of the following figures to see how these relationships assist in maintaining a sustainable ecosystem.



A simplified view of how matter is cycled within an ecosystem

eBook plus **eLesson**

Reducing your carbon footprint
Find out ten easy and practical things you can do to help stop global warming.

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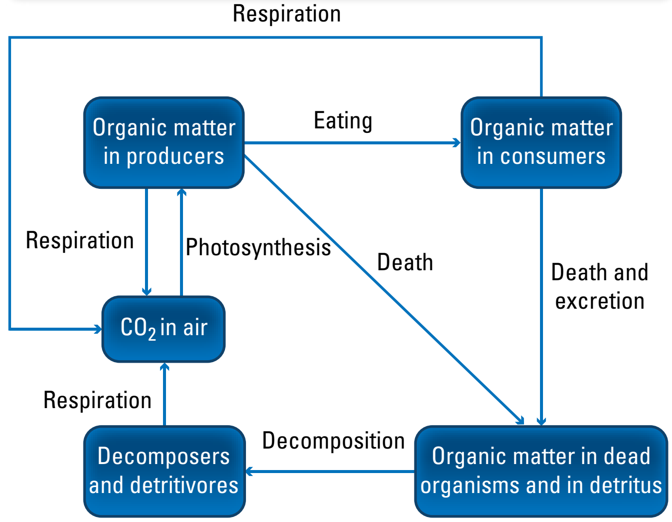
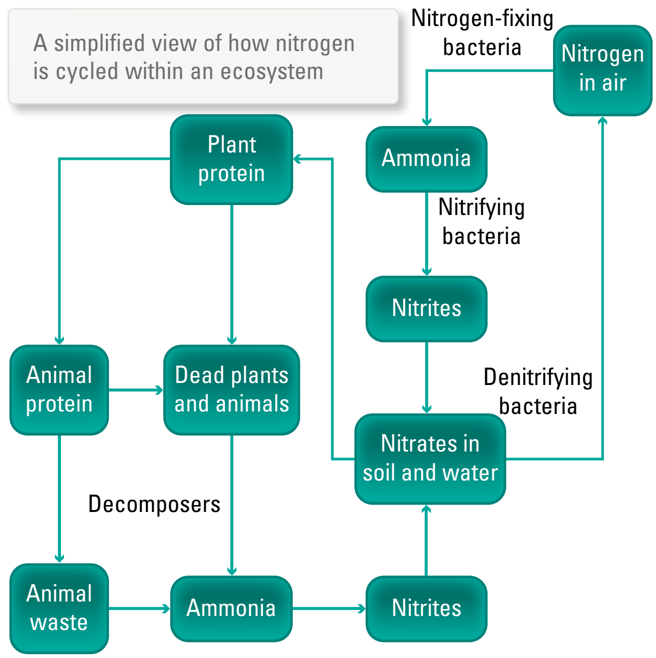
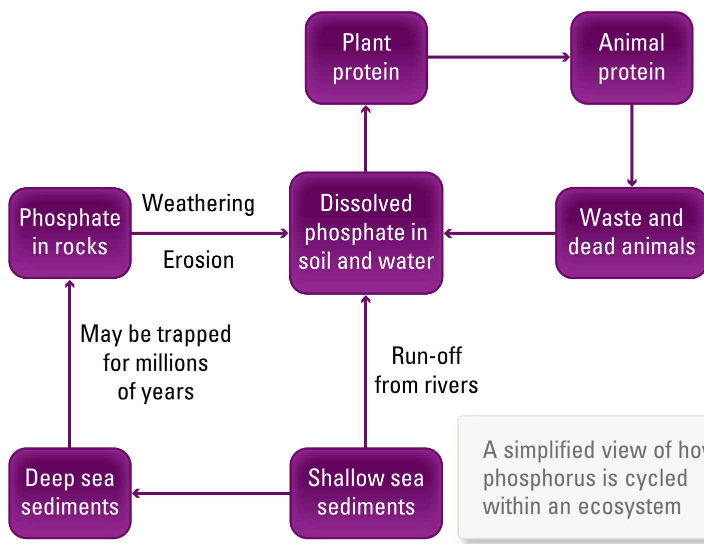
A simplified view of how carbon is cycled within an ecosystem



A simplified view of how nitrogen is cycled within an ecosystem





A simplified view of how phosphorus is cycled within an ecosystem

Ecological pyramids

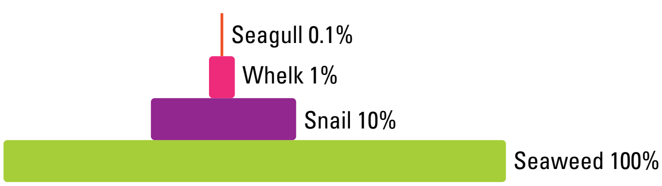
Ecological pyramids can provide a model that can be used to describe various aspects of an ecosystem. They can show the flow of energy, the recycling of matter through an ecosystem or the numbers of organisms and the relationships between them.

These pyramids are constructed by stacking boxes that represent feeding (or trophic) levels within a particular ecosystem. The size of the box indicates the number or amount of the feature being considered.

Energy pyramids

An **energy pyramid** for a food chain as described above would show a larger box at the bottom and smaller boxes as you move up the food chain. Energy pyramids always have this basic shape, because only some of the energy captured by producers is converted into chemical energy. Of the energy captured, only about 10 per cent is passed on through each feeding level, with about 90 per cent of the energy being transferred to the environment as heat or waste.

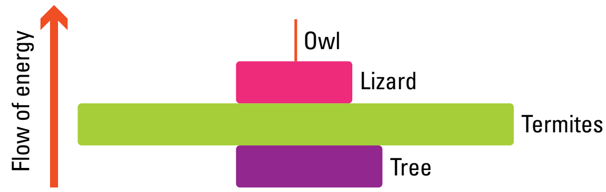
This decrease in energy along the food chain is one reason that the numbers of levels in food chains are limited. There is also a limit to the number of organisms that can exist at each level of the food chain. Energy pyramids show that, as you move up the food chain or web, there is less food energy to go around and therefore fewer of each type of organism.



An energy pyramid — only about 10 per cent of the food energy received at each level is passed through to the next; the other 90 per cent is transferred to the environment.

Pyramids of numbers and biomass

A **pyramid of numbers**, as the name suggests, indicates the population or numbers of organisms at each trophic level in the food chain. A **pyramid of biomass** shows the dry mass of the organisms at each trophic level. These pyramids can appear as different shapes due to reproduction rates or mass differences between the organisms.



A pyramid of biomass shows the dry mass of the organisms at each trophic level.

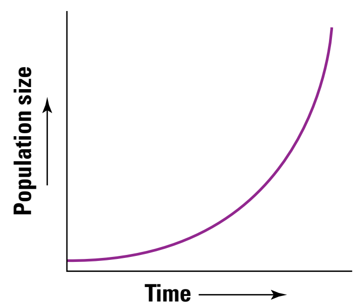
Population growth

The rate at which a population can grow is determined by its **birth rate** minus its **death rate**. The size of the population is also influenced by **immigration** (the number of individuals moving into an area) and **emigration** (the number of individuals leaving an area). It is also influenced by available resources, predators and disease. The overall growth rate can be calculated by the formula:

population growth = (births + immigration) − (deaths + emigration)

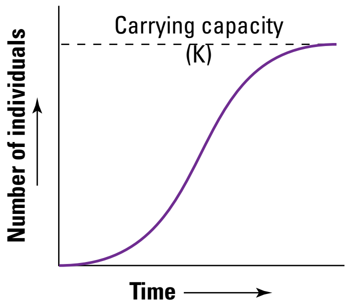
Growth without limits

If you were to provide a population with plenty of food, lack of predators and disease, it would grow rapidly. A bacterium, for example, divides every 20 minutes. Under favourable conditions, that single bacterium would produce a population of 1 048 578 individuals within 7 hours! Graphing this population growth would result in a J-shaped growth pattern known as **exponential growth**.



Carrying capacity

Populations, however, have only a limited amount of resources and if you were to graph their growth it would look more like an S-shaped, or **sigmoid**, graph. Eventually the population growth would be zero (overall). When this occurs the population is described as having reached a **steady state**, **plateau phase** or **equilibrium**. When the birth and death rates balance each other out, a point of **zero population growth** is reached. A population in its plateau phase contains the maximum number of individuals that its particular environment can carry — it has reached its **carrying capacity**.



Organisms need particular resources in order to survive. Some of these resources will be in limited supply, and organisms will need to compete with other organisms to get what they need. An ecosystem has limited resources and can carry only a particular number of organisms. This is called its carrying capacity, and is what causes a population to plateau when it reaches a particular size.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Rank these terms in order of complexity:
- ecosystem
- population
- community.

2 Name the process that plants use to convert light energy into chemical energy.

3 Identify the products of photosynthesis that are used as inputs for cellular respiration.

4 Construct a Venn diagram to compare photosynthesis and chemosynthesis.

5 Construct a food chain that contains four organisms.

6 Identify an organism that you may find at each of the following trophic levels:
(a) 1st trophic level
(b) 2nd trophic level
(c) 3rd trophic level
(d) 4th trophic level.

7 Suggest why food chains rarely contain more than four trophic levels.

8 Construct linked flowcharts to show a simplified view of how:
(a) matter is cycled within an ecosystem
(b) carbon is cycled within an ecosystem
(c) nitrogen is cycled within an ecosystem
(d) phosphorus is cycled within an ecosystem.

9 Describe how ecological pyramids are used to describe various aspects of an ecosystem.

10 State a formula that could be used to calculate an increase in a population.

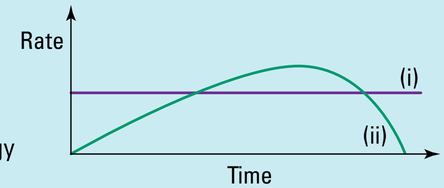
11 List three factors that may result in:
(a) an increased population size
(b) a decreased population size.

12 Describe the difference between sigmoid and exponential growth patterns.

13 Outline the relevance of carrying capacity to population growth.

THINK, DISCUSS AND INVESTIGATE

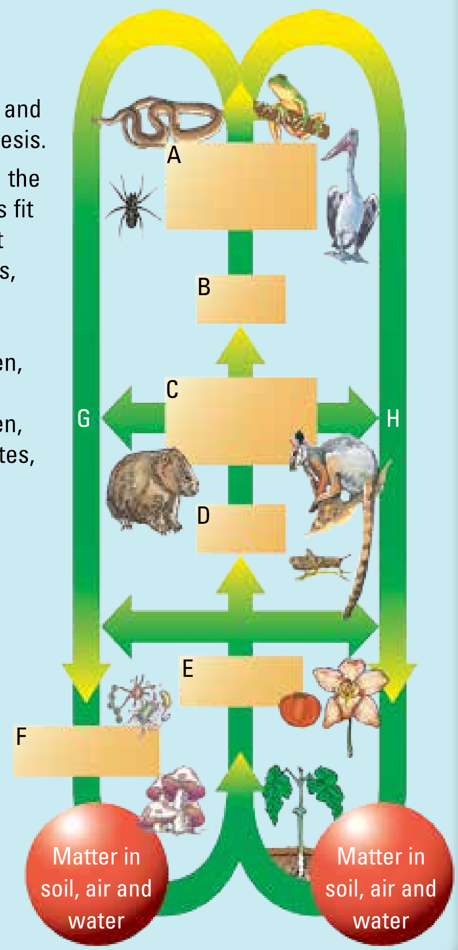
14 Look at the graph below showing the relationship between photosynthesis and respiration.



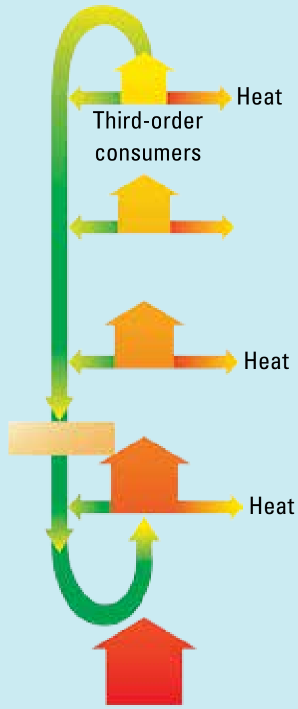
This graph shows the rates of photosynthesis and respiration for a plant over a 24-hour period.

(a) Which line of the graph represents the rate of photosynthesis?
(b) When would the rate of respiration be greater than the rate of photosynthesis?
(c) State three similarities between respiration and photosynthesis.

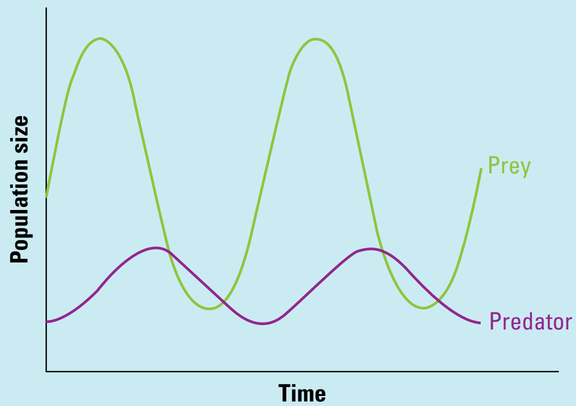
15 Suggest where the following labels fit on the figure at right: producers, decomposers, second-order consumer, eaten, first-order consumer, eaten, death and wastes, respiration.

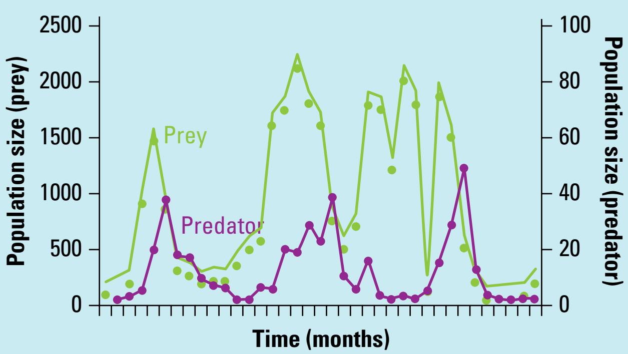


16 Suggest where the following labels fit on the figure below: producers, decomposers, second-order consumer, heat, first-order consumer, death and wastes, nutrients in soil, energy from sunlight.



17 Carefully observe the predator–prey graphs below.
(a) Comment on any patterns observed.
(b) Suggest reasons for the observed pattern.





18 Complete the following table.

Trophic level	Organism	Food source
First	Producer	Convert inorganic substances into organic matter using sunlight energy and the process of photosynthesis
	Primary consumer (herbivore)	Plants or other producers
Third		
	Tertiary consumer (carnivore)	

19 Investigate how scientists use models to predict changes in populations.

20 Select an organism and investigate the effect of seasonal changes on its population size.

21 Suggest why it is (a) necessary for energy to flow through ecosystems and (b) essential for matter to cycle through ecosystems.

22 Introduced species can have an effect on the feeding relationships within food webs.
(a) Find examples of three introduced species that have had such an effect in Australia.
(b) Find out when, why and how the species were introduced.
(c) Investigate the effect of the introduced species on Australian ecosystems.
(d) Research methods that have been used to reduce the effect of an introduced species or control its population size, and comment on the effectiveness of the methods.
(e) Construct a PMI chart on introduced species in Australia and discuss your comments with other students in your class.

23 Find out more about how autotrophic bacteria (such as *Thiobacillus* spp.) use chemosynthesis and where they may be found.

24 Some factors that have an impact on populations are related to the population size and are referred to as being density dependent. Other factors are density independent. Find out more about these two types of factors and share your findings with other students in your class.

25 Click on the **Food web** weblink in your eBookPLUS to build a food web.

eBook*plus*

work sheet 5.4 Cycling of materials

Changes in populations

The effect of a change in size of a particular population on an ecosystem can be predicted by observing feeding relationships in food webs. If, for example, the number of the producers is reduced, it will not just be herbivores that are affected, but also the animals that eat them, which in turn affects the organisms that either eat them or are eaten by them.

If a new species is introduced it may compete for the resources of another species, leading to a reduction in that population. This may have implications for organisms that either eat or are eaten by the affected population.

Artificial ecosystems

Humans have created artificial ecosystems to maximise the production of their own food supplies and resources. The purpose of agriculture is to turn as much of the sun's light energy as possible into chemical energy in particular crops or pasture plants for animals. In order to achieve this, humans have attempted to control populations of other organisms. This has led to interference in food webs and hence the ecosystems that contain them.

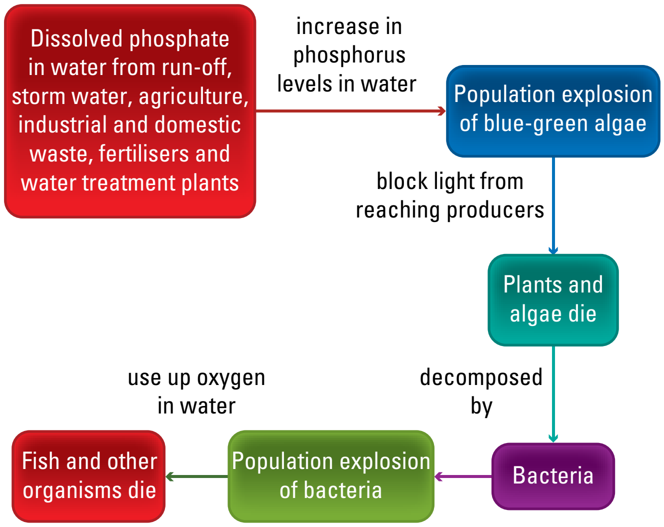
Taking away

To make room for crop plants, land has often been cleared of forests. The local habitats of many organisms have been destroyed. Organisms that may compete for resources or in some way potentially lower crop yields are considered to be pests and are also removed, or their populations killed or controlled.

Crops are often monocultures, consisting of only one species of plant. At the end of each growing season the crops are harvested, processed and removed from the ecosystem. There is little natural decomposition of dead material and exposed soil may be blown away by the wind. Valuable nutrients are lost. Such activities have led to the destruction of many natural ecosystems.

Giving back

Fertilisers are added in an attempt to replace some of the lost nutrients. Some of these may end up in waterways, adding large quantities of nitrogen and phosphorus to the water. This can lead to algal blooms or **eutrophication**, which may result in the death of organisms within the ecosystem.



Eutrophication is like suffocation of a waterway and can result in the death of organisms within the ecosystem.

Controlling pests

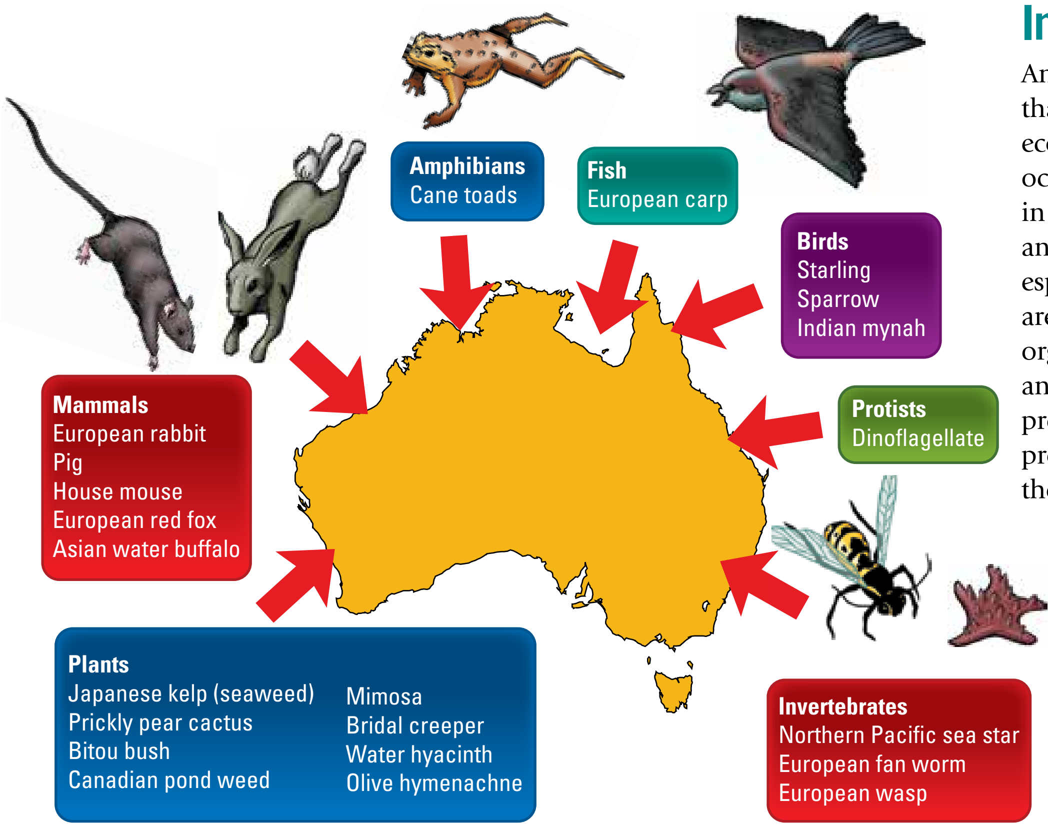
Organisms that compete for resources or potentially lower the yield of the plant crop being grown are considered to be pests that need to be controlled. Pest control may be carried out using chemical or biological control.

Biological control

Biological control of unwanted organisms can exploit naturally existing ecological relationships. Predators or competitors may be used to kill or reduce numbers of the pests or somehow disrupt the pests' reproductive cycle. A disease, for example, might be used to kill the unwanted organism without harming other species. While some cases of biological control have proven to be successful, others (such as the introduction of cane toads and prickly pear plants) have caused a variety of new problems.

Chemical control

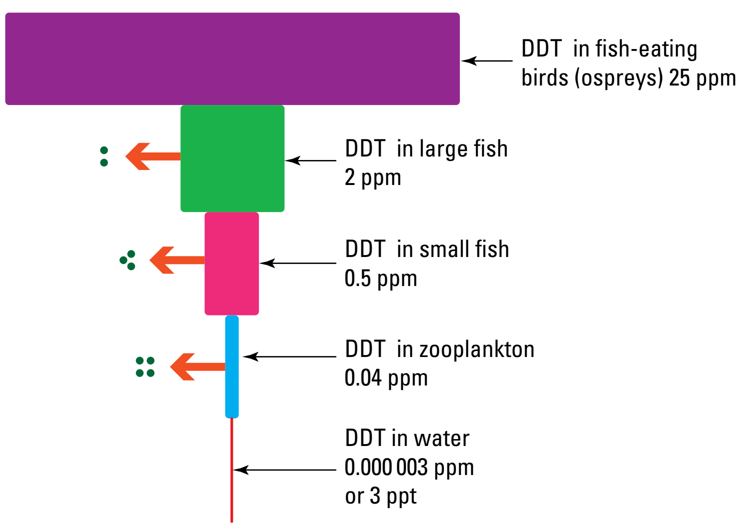
Chemical methods of control include the use of pesticides such as **insecticides**, **fungicides**, **herbicides** or **fumigants**. Herbicides kill plants other than the planted crop so that they do not compete for nutrients and water in the soil, and light from the sun. Insecticides are used to kill organisms that compete with humans for the food crops.



Introduced species

An **introduced species** is one that has been released into an ecosystem in which it does not occur naturally. The food webs in ecosystems are very delicate and can easily be unbalanced, especially when new organisms are introduced. These introduced organisms compete with other animals for food, provide predators with a new source of prey, or may act as predators themselves.

Although pesticides are still used in agriculture, their effectiveness on target pest species often decreases. Other species may also be affected within the ecosystem and the food webs in which the target species belongs. In some cases, concentrations of non-biodegradable pesticides (such as DDT) can be magnified along the food chain by a process described as **bioaccumulation** or **biological magnification**.



CANE TOADS

Ecological impact:

- Occupying water habitats so that native tadpoles cannot live there
- Killing fish that eat the tadpoles and other animals that eat the adult toads
- Eating our natural wildlife including frogs, small lizards, birds, fish and insects.
- Poisonous; fatal to animals that eat them

NORTHERN PACIFIC SEA STAR

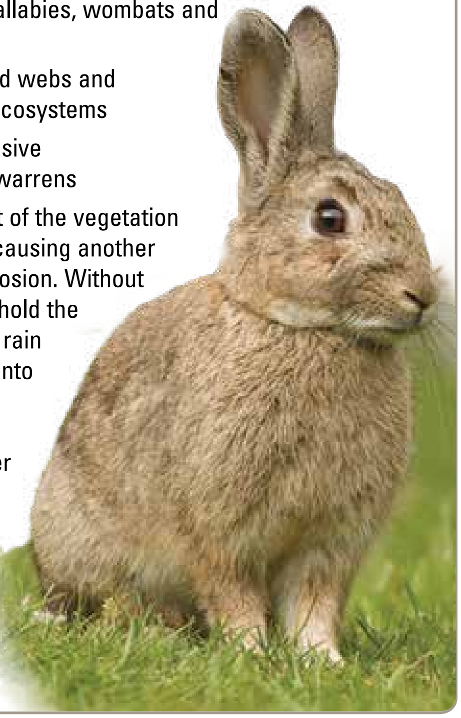
Ecological impact:

- Potential great harm to our marine ecosystem and to marine industries
- Threatening biodiversity and shellfish aquaculture in south-eastern Tasmania and Port Phillip Bay
- It is a voracious predator. Some of our native marine species, such as scallops and abalone, don't recognise it as a predator, so do not try to escape it.
- No natural predators or competitors to keep the population under control

RABBITS

Ecological impact:

- Competing for food with the native animals such as kangaroos, wallabies, wombats and bandicoots
- Disrupting food webs and unbalancing ecosystems
- Building extensive underground warrens
- Stripping most of the vegetation in their area, causing another problem — erosion. Without plant roots to hold the soil, wind and rain carry the soil into creeks, rivers and lakes, causing further problems for the organisms that lived there.



eBook*plus* **eLesson**

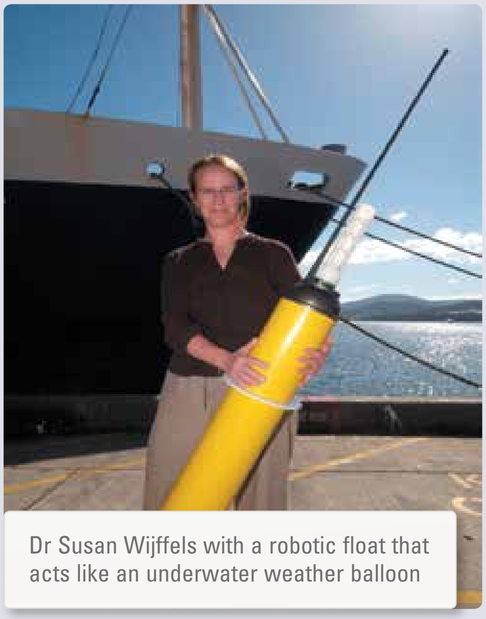
Native rats fighting for their habitat

Watch a video about rats that have been bred to be introduced into their native environment; how will the resident black rats react?

eles-1083

HOW ABOUT THAT!

Dr Susan Wijffels, CSIRO oceanographer and leader of the IMOS bluewater and climate node, is involved in research that investigates the impact of ocean ecosystems and the oceans' role in the carbon cycle. She is currently investigating the use of floating sensors, underwater gliders and satellite tags on marine animals. The tagging of these marine animals will provide information about when and where they feed and the types of salinity, pressure and temperatures that they feed in.



Dr Susan Wijffels with a robotic float that acts like an underwater weather balloon

Cameras mounted on seals provide information from the depths of the sea.

HOW ABOUT THAT!

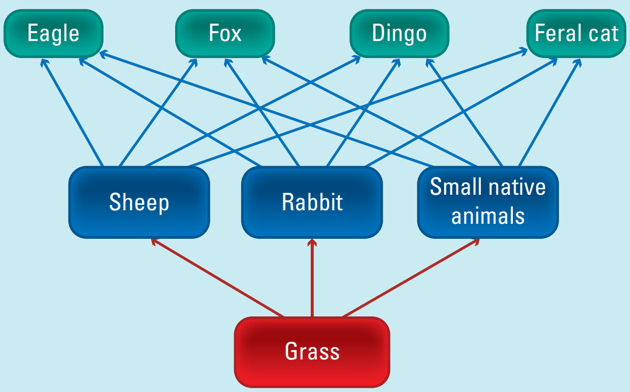
Researchers are working on an immunocontraception method that aims to block conception in rabbits to control their numbers. This method will use a virus that has been modified to contain genetic material that codes for the production of a protein essential for reproduction. When infected with this modified virus, (it is hoped that) the female rabbit produces the protein and her immune system responds by producing antibodies against it. These antibodies should then attack her eggs, blocking conception.

UNDERSTANDING AND INQUIRING

ANALYSE, THINK AND INVESTIGATE

1 Carefully examine the eutrophication flowchart at the beginning of this section.
   (a) Suggest how dissolved phosphate in waterways can be linked to algal blooms.
   (b) Do you think that suffocation is an appropriate description of the effect of eutrophication?
   (c) Find examples of algal blooms in Australia. Investigate:
      (i) the cause of the algal bloom
      (ii) consequences or effects of the algal bloom on the local ecosystem
      (iii) how algal blooms can be treated or prevented.

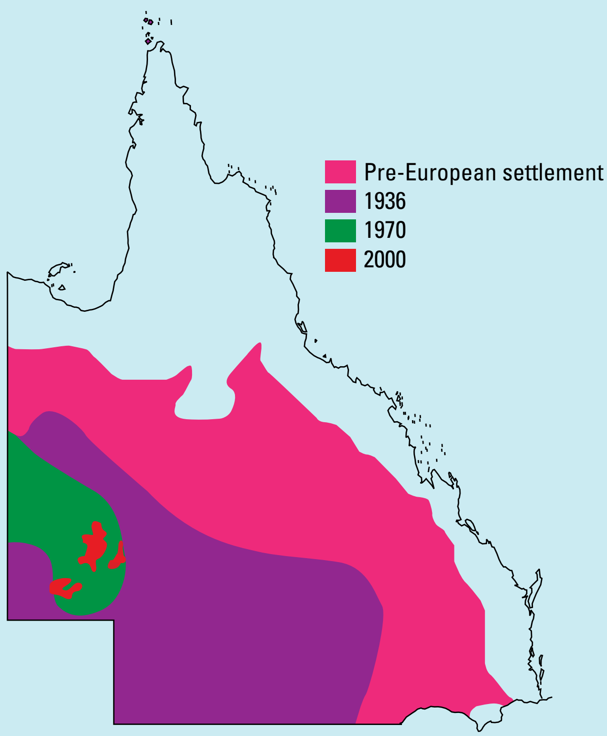
2 Observe the figure of the food web below and then answer the following.



   (a) Suggest possible consequences of a decrease in the population size of:
      (i) rabbits (ii) feral cats (iii) grass.
   (b) Suggest possible consequences of an increase in the population size of:
      (i) grass (ii) sheep (iii) eagles.

3 Habitat loss and introduced species have led to a decline in reptile populations. Find out more about the effects of habitat loss and introduction of cats, foxes and cane toads on Australian reptile populations and the ecosystems in which they live.

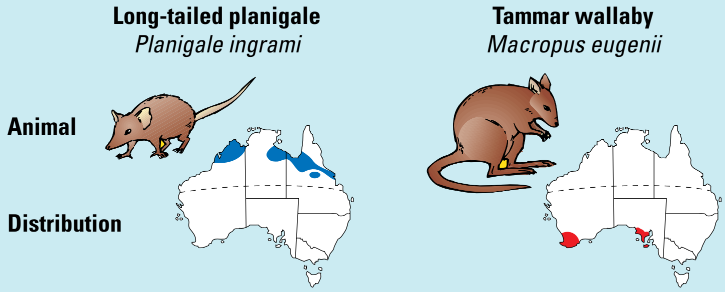
4 Although populations of greater bilbies once ranged over most of mainland Australia, predation by introduced species such as cats and foxes has eliminated them from most of their former habitats.
   (a) Carefully observe the figure below and describe the change in bilby distribution pattern over the recorded times in Queensland.
   (b) From the figure, estimate the percentage population values in Queensland for each year and construct a graph to show your data.
   (c) Find out more about bilbies, their predators and ways in which bilbies try to avoid their predators.
   (d) Find out more about the introduction of either cats or foxes to Australia, their effect on Australian ecosystems, and Australian research projects that are investigating ways in which to reduce their impact.
   (e) Find out more about Australian research into protection of bilby populations.
   (f) Suggest what you think should be done to protect the greater bilby from becoming extinct. Outline how this could possibly be achieved.



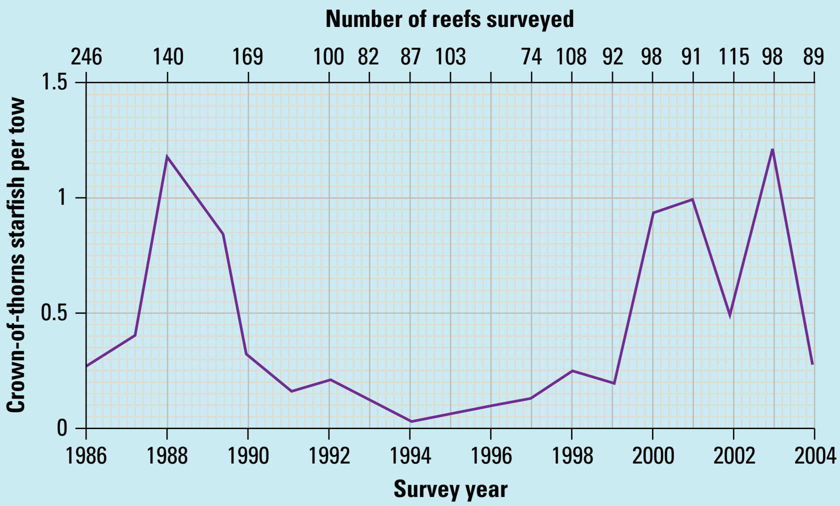
Location of bilby populations in Queensland

5 The lesser bilby, *Macrotis leucura*, is now extinct. Find out more about this species and possible reasons for its extinction. Knowing what we know now, suggest how this could have been avoided.

6 Carefully examine features of the planigale and wallaby, and the location of their distribution in Australia in the figure below. Find out more about each of these organisms and their habitats and relate their features to their suitability in these environments. Research the food webs in which they are linked and discuss possible (or real) implications of human activity to their survival.



7 Carefully examine the graph below showing crown-of-thorns starfish populations recorded in Great Barrier Reef surveys between 1986 and 2004. Suggest why scientists measure and record the size of populations of organisms. Find out more about the food webs that this starfish is linked to. What type of food does it eat? Which organisms eat it? Suggest possible implications of the changes in crown-of-thorns starfish populations for other members of its food web. Research issues relating to the crown-of-thorns starfish and the effect it has had on Australian marine ecosystems.



INVESTIGATE AND DISCUSS

8 Investigate ways in which human activities have affected either the nitrogen cycle or the carbon cycle, leading to an imbalance within an ecosystem.

9 Investigate the introduction of rabbits into Australia and research their effect on our ecosystems. Identify and research examples of methods that have been used to control the population growth of rabbits. Comment on the effectiveness of these methods.

10 Suggest a definition for the term sustainable agriculture. Find out whether your suggestion was correct and find out more about ways in which this form of agriculture differs from unsustainable agriculture.

11 Find out more about critically endangered and endangered species and ecological communities that are affected by rabbits using the **Invasive animals** weblink in your eBookPLUS.

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12 Use the **Feral Focus** weblink in your eBookPLUS to take part in the online interactivities in unit 2, 3 or 4.

13 Get involved in helping to map feral animal sightings in your area using the **FeralScan** weblink in your eBookPLUS. In particular, look at the information about the RabbitScan project.

14 Research one of the following introduced marine species to find out why it is considered an environmental pest.

- Green shore crab (*Carcinus maenas*)
- Pacific oyster (*Crassostrea gigas*)
- European fan worm (*Sabella spallanzanii*)
- Japanese goby (*Tridentiger trigonocephalus*)

15 Find examples of non-indigenous fish or marine vegetation that have been introduced in each of the following ways.

- Ship fouling, ballast waters or dry ballast
- Stock enhancement, mariculture, or biological control
- Wave action or ocean currents

16 Find out more about Susan Wijffels and her research on ocean ecosystems.

17 Find out more about oceanographers and then write a short story about one of their adventures.

18 (a) Use internet research to identify a problem or issue about pests, population control or introduced species that could be investigated.
(b) Design an experiment that could be used to investigate the problem.

work sheet 5.5 Introduced pests

Dealing with drought

Approximately 80 per cent of Australia is described as having arid or semi-arid conditions. How can Australian plants and animals survive under such dry conditions?

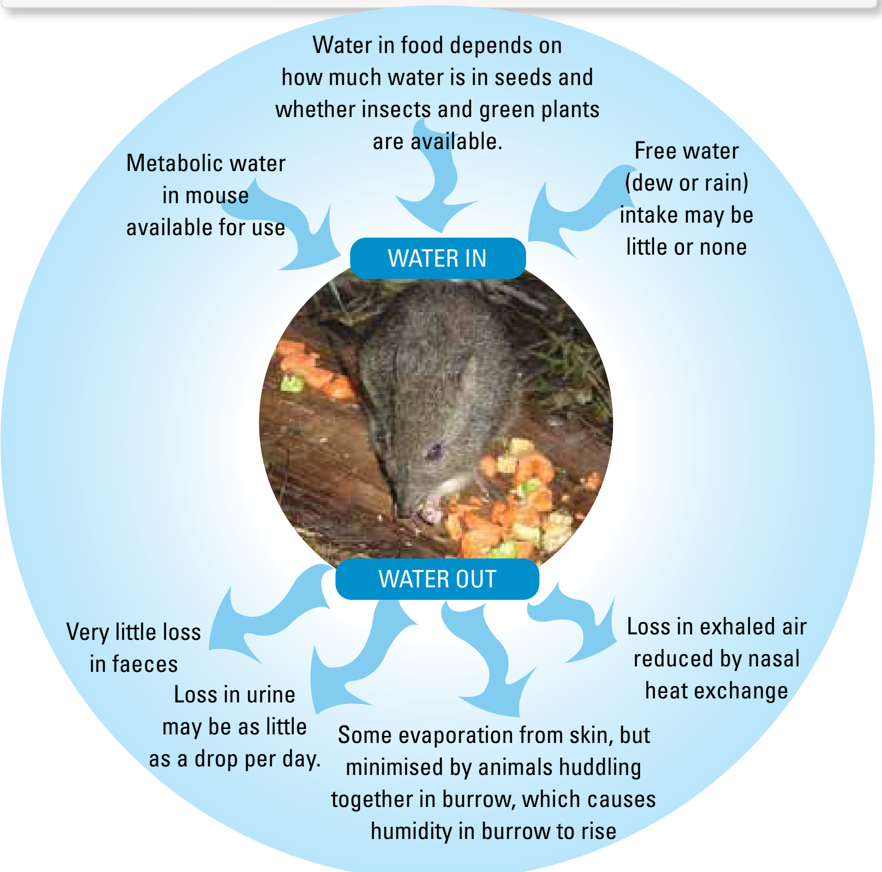
Australian animals have some clever ways to cope with limited water supplies in their environments. Some of these involve putting reproduction on hold, while others produce extremely concentrated urine, and yet others possess water collection structures.

The thorny devil (*Moloch horridus)* collects dew overnight on the large spines covering its body. Moisture eventually collects in a system of tiny grooves or channels running between their scales. These channels help direct the collected water towards the lizard's mouth where a gulping action takes in the water and quenches the animal's thirst.

Common name: Thorny devil. Scientific name: *Moloch horridus*

The spinifex hopping mouse (*Notomys alexis*) also has a few useful tricks. These small, nocturnal animals can survive without drinking water, and produce extremely concentrated urine. The figure below left shows some ways in which they are well adapted to surviving arid conditions.

An outline of how *Notomys alexis*, or the spinifex hopping mouse, achieves a water balance. For survival, water inputs must balance water outputs.



Finding food in the dark

Not only is water scarce, but temperatures in our Australian outback can be very high during the day. Many Australian animals are **nocturnal** — that is, they are active only at night. Nocturnal animals have adaptations that help them find their food in the dark.

Snakes such as pythons, for example, possess heat-sensitive pits in their lower jaw that contain **thermoreceptors**, allowing the location of their warm-blooded prey to be detected.

Bilbies are also well adapted to sense their food in the dark by using their sharp hearing and long, sensitive nose and whiskers to detect their food.

Common name: Central carpet python. Scientific name: *Morelia bredli*

Common name: Greater bilby. Scientific name: *Macrotis lagotis*

The plant *Arabidopsis* in which the drought-resistant mutation was discovered is a relative of mustard, cabbage and canola plants.

Hot and thirsty

Even though our native plants are unique and some have strategies to cope with our continent's harsh conditions, global warming and scarcity of water are a threat to their survival. Scientists around the world are seeking solutions to our current and future problems. One of these problems involves ways in which we can help plants survive conditions associated with droughts.

Hot plants of the future

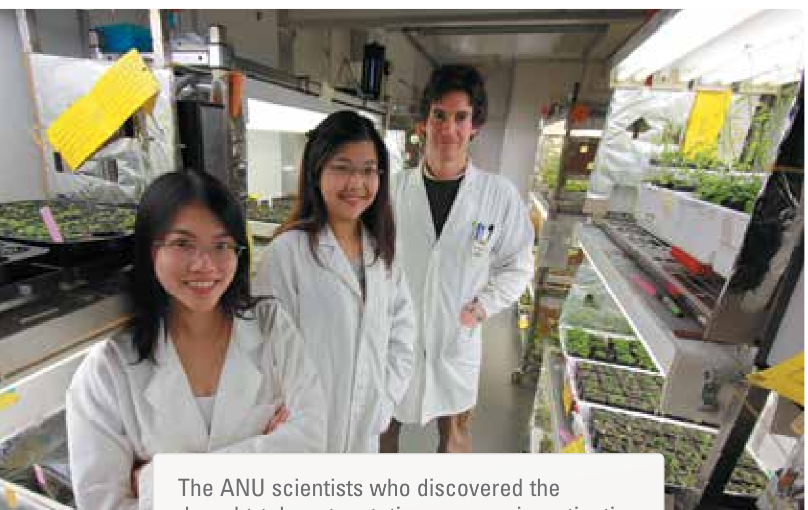
In 2009, a team of scientists at the Australian National University (ANU) discovered a subtle mutation in *Arabidopsis* (a relative of mustard, cabbage and canola plants) that may have important and far-reaching implications for establishing drought-resistant plants in the future. These scientists are currently investigating whether the mutation has applications in food crops such as wheat and rice.

Xerophytes

Xerophytes are plants that are adapted to survive in deserts and other dry habitats. Some xerophytes are **ephemeral** and have a very short life cycle that is completed in the brief period when water is available after rainfall. They survive periods without water by entering a state of dormancy until the next rains. This may be years later. Other xerophytes are **perennial** (living for three or more years) and rely on storage of water in specialised leaves, stems or roots.

Spines and swollen stems

Most cacti are xerophytes and have many adaptations to store rather than lose water. Their small spiny leaves reduce the amount of water lost by providing a small surface area. Their stem becomes swollen after rainfall, with pleats allowing it to expand and contract in volume quickly. The epidermis around the stem has a



The ANU scientists who discovered the drought-tolerant mutation are now investigating applications in Australian food crops.

Drought-resistant plants have developed strategies to avoid dehydration. Some plants, such as cacti, have developed thick, fleshy, water-storing leaves, hairy or reflective foliage and small leaves to reduce the area from which water can be lost.

thick waxy cuticle and contains stomata, which usually open during the night (to collect carbon dioxide required for photosynthesis) rather than during the day when water can be lost through them.

Can our Aussie plants survive?

But what if we can't wait for research and investigations to produce these drought-resistant plants … which plants can we plant and grow now? What can we do to help them survive? How do they survive, when others would die? Observe the figures of Australian plants below and try to see the structures that may assist them in drought tolerance.

Resistant or tolerant?

Our native plants are unique and have developed some strategies to cope with the harsh conditions that global warming and scarcity of water threaten them with. Although drought resistant and drought tolerant are often used as the same term, they are not. **Drought tolerant** means that the plant can tolerate a period of time without water. Plants that are **drought resistant** can store their water and live for long periods of time without water. Many of our Australian plants that live in water-limited environments would be classified as being drought tolerant.

Drought-tolerant features

Just because a plant is an Australian native doesn't mean that it is drought tolerant. It may have evolved to be better suited to high rainfall zones or cool mountain forests. Many drought-resistant plants already grow in areas where water is scarce. Examples of drought-tolerant adaptations to look for include:

- small narrow leaves
- grey or silver foliage
- furry texture
- water-retaining succulent (juicy) leaves or stems
- modified or absent leaves.

Adaptations that help eucalypt trees survive in a dry environment

Grevillea 'Robyn Gordon' is a drought-tolerant plant named after the eldest daughter of David Gordon (a keen botanist and founder of Myall Park Botanic Garden).

The leaves of many eucalypts hang vertically to reduce their exposure to the sun, and pendant branches move with the wind to create 'holes' in the soil under the tree which may later collect water.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Describe two ways in which Australian organisms can increase their chances of survival in arid or semi-arid environments.

2 Identify the common names of the following organisms: *Moloch horridus*, *Notomys alexis*, *Macrotis lagotis*, *Morelia bredli*.

3 Suggest why the recent discovery of the mutation in *Arabidopsis* is important.

4 Define the term xerophyte.

5 Describe ways in which xerophytes can increase their chances of survival.

6 Describe how cacti can survive in areas with limited water.

7 Describe features of eucalypts that help them to survive hot, dry conditions.

8 Outline the difference between drought resistant and drought tolerant.

9 List adaptations to look for that suggest a plant may be drought tolerant.

10 Who was *Grevillea* 'Robyn Gordon' named after?

INVESTIGATE, THINK AND DISCUSS

11 Kangaroos and wallabies can have joeys at different stages of development by producing different types of milk. Find out more about reproductive strategies that can increase the chances of surviving in arid environments for these animals.

12 Find answers to the following questions and then suggest your own question for research.
(a) Why do kangaroos lick their forearms?
(b) How did magnetic termite mounds get their name?
(c) Why do spinifex hopping mice huddle together during the day?

13 The Queensland bottle tree (*Brachychiton rupestris*) has an ability to store a significant amount of water. Find out more about how it reacts to drought and how it is used by indigenous populations.

14 Identify two examples of endangered species that live in the Australian outback. Investigate and report on the effect of introduced species on these endangered species. Outline research or projects that are currently underway to help control populations of any of the species involved.

15 *Even during drought conditions, kangaroos need to be killed so that our kangaroo industry meets its requirements for meat and skins.*
(a) Research information relevant to this quote and summarise your findings into a SWOT analysis.
(b) Discuss your findings with others, adding any more details to your SWOT figure.
(c) Consider and discuss the various perspectives relevant to this quote.
(d) Organise a class debate that considers at least four different perspectives.
(e) Outline your opinion on the quote. Include reasons for your opinion.

INVESTIGATE AND CREATE

16 Identify an example of a plant and an animal that lives in an arid or semi-arid Australian environment. Investigate the effect of seasonal changes on each of these species. Construct a seasonal calendar that includes graphs and diagrams to display your findings.

17 Investigate ways in which human activity is having an impact on ecosystems in regions affected by drought. Discuss your findings with others. Construct a PMI chart to summarise your findings.

18 Investigate how models can be used to predict changes in populations due to drought. Construct a graphical model that could be used to show changes in kangaroo or rabbit populations within a particular ecosystem over time.

19 Research feeding relationships between organisms living in arid or semi-arid Australian environments. Summarise your findings into a food web.

20 Design and create your own virtual drought-tolerant garden. Include captions or labels to identify the plants and describe how they can survive on limited water supplies.

21 Visit a nursery and make notes on the information about drought tolerance on the plant labels. Design and create your own labels.

22 (a) Find out more about various types of research into drought-tolerant and drought-resistant plants in Australia
(b) Formulate your own questions to help you identify your own hypothesis to test.
(c) Design and conduct your own investigation.
(d) Report your findings as a class presentation and a scientific journal article.

23 Organisms within an ecosystem can also be affected by too much water. Research the effects of floods on Australian ecosystems.

24 Find out more about one of the following Australian plants and construct a model that shows features that increase its chances of survival: *Hardenbergia violacea*, *Dianella revoluta*, *Anigozanthos flavidus*, *Callistemon viminalis*.

25 Create your own multimedia presentation about Australia's climate, geography, and plants and animals that can survive in arid conditions.

26 Create your own advertisement promoting Australia's unique climate, plants and animals.

Fire proof?

Natural disasters are not uncommon. They happen all over the world. Extremes of droughts, fire, flood, lightning, landslides, earthquakes, tornadoes, hurricanes and tsunamis are examples of natural disasters.

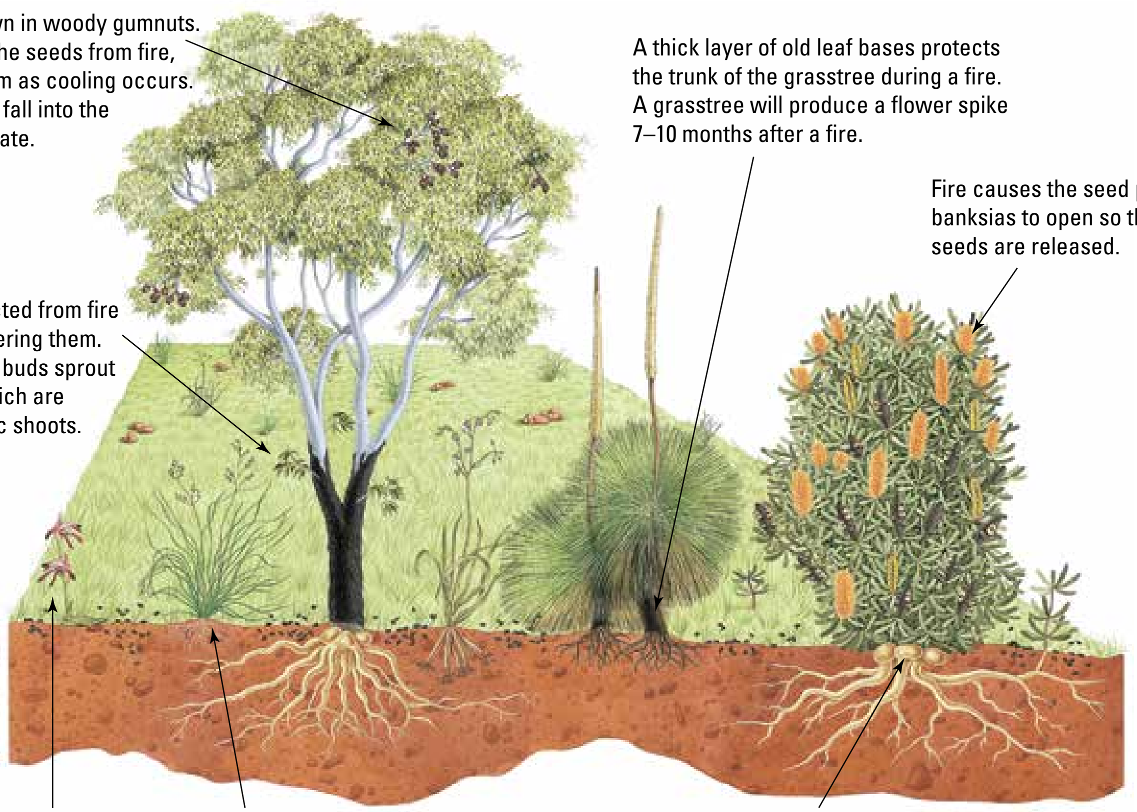
While their effects can be devastating to people, natural disasters can also have a great impact on ecosystems. In some situations, the species living within these ecosystems have developed strategies to survive such natural disasters.

Bushfires

Since the last ice age, bushfires have been a natural part of Australia's unique ecosystem. Over time, this has led to natural selection of various adaptations in its inhabitants. The PMI chart below shows pluses, minuses and interesting points about fire and our Australian ecosystem.

Many Australian plants have adaptations to help them survive bushfires.

Plus	Minus	Interesting
Clears the undergrowth	Slows down growth of mature trees	Aboriginal communities have traditionally used fire to manage land.
Helps regeneration of plants which produce seeds in hard or waxy husks	Damages timber, reducing value of trees	Eucalypt species have many features that help them to survive bushfires.
Releases stored nutrients, providing good conditions for new growth	Causes property damage if out of control	Without fire, open eucalypt forests would disappear, replaced by more dense forests containing trees that do not require fire to flower and produce seed.
Makes soil structure finer and easier for seeds to grow in	Makes soil finer and more easily washed or blown away by water or wind	Some animals burrow underground to escape a fire.
Destroys growth inhibitors in adult trees and allows young plants to thrive	Kills or drives off many animals, fungi and insects, and threatens other organisms in the food web with starvation	Some animals survive bushfire but die because of the reduced food supply in the period after the fire.
Allows sunlight to reach the soil, helping young plants to grow	Kills decomposers, which are then lost to the life cycle	Lightning and arson cause many of the large bushfires that result in death and property damage.



Aborigines Hunting Kangaroos by Joseph Lycett, c. 1817. Early Indigenous Australians used fire to increase grassland areas, providing grazing land for kangaroos which could then be hunted. This image of Indigenous land management and hunting was painted by Joseph Lycett when he was a convict in Newcastle, New South Wales.

Sunburnt country

I love a sunburnt country,
A land of sweeping plains,
Of ragged mountain ranges,
Of droughts and flooding rains,
I love her far horizons,
I love her jewel sea,
Her beauty and her terror —
The wide brown land for me!

So wrote Australian poet Dorothea Mackellar in her poem *My Country*. Some arid regions of Australia have highly erratic rainfall with long drought and flooding rains. These climatic conditions have a considerable effect on the plants and animals within these ecosystems. They also have implications for our farmers, who may not share this poet's love of our sometimes challenging climatic conditions!

Big or small?

Small controlled fire	Large bushfire
Some leaf litter destroyed; many insects and decomposers survive on the ground.	All leaf litter destroyed; no insects and decomposers survive on the ground.
Soil releases stored nutrients. Ash provides many minerals and fine texture. This helps seeds to germinate and new plants to grow.	
Heat and smoke cause some plants to release seed and some seeds to germinate.	Heat and smoke cause most plants to release seed and many seeds to germinate.
Many unburnt patches where grasses and shrubs survive; animals can find food and shelter here.	Few unburnt patches; no food or shelter is left for animals.
Many animals survive and can stay in the area. Food is still available.	Many animals are killed, or must move to another habitat. No food is available.
Fallen branches and logs survive to provide shelter for animals.	No fallen branches or logs survive so there is less shelter.

INVESTIGATION 5.11

Germinating seeds with fire

AIM **To investigate the effect of heat on germination of *acacia* and *hakea or banksia* seeds**

BACKGROUND

Many seeds need fire to germinate. It could be the smoke, heat or the chemicals in ash that cause the seeds to germinate.

CAUTION

- Make sure you are supervised by an adult.
- Burn seed pods only in a safe area.
- Do not do this activity on a hot windy day or a day of total fire ban.
- Have a bucket of water or a fire extinguisher ready.
- Pods stay hot for some time after burning. Give them time to cool before touching them.

Materials:

hakea or banksia seed pods — unopened
newspaper *matches*
bucket of water *seedling trays*
seedling mix *oven*
acacia seeds (silver or black wattle work well)

METHOD AND RESULTS

Part A

- Collect unopened banksia or hakea seed pods from trees in your local area.
- Wrap the seed pods in newspaper and burn them in a safe area. (Alternatively, heat the pods in an oven.)

1 Observe the seed pods after burning.

- Collect the seeds and plant them in the seedling trays. Care for them until they are large enough to plant in the garden.

DISCUSS AND EXPLAIN

Part B

- Divide the acacia seeds into two equal piles. Record the number of seeds in each pile.
- Plant one pile of seeds in a seedling tray.
- Heat the second pile in the oven.
- Plant these seeds in a separate seedling tray. Sprinkle some ash over the seedling tray.
- Keep the trays moist. Wait for the seeds to germinate. This could take many days.

2 Count the number of seedlings that have germinated in each tray. Compare class results.

- Look after your seedlings and, when large enough, plant them in a garden.

DISCUSS AND EXPLAIN

3 Describe the effect that heat or fire had on the pods.

4 Identify which group of seeds germinated most effectively.

5 Suggest what caused one group to germinate more than the other.

6 Explain how this is similar to the effect that fire would have on the seeds.

7 Suggest how opening the seed pods in response to heat may help the plants to grow at the right time.

8 Outline the strengths and limitations of this investigation, and suggest how this investigation could be improved.

9 (a) Suggest your own investigation question about germination and fire.
(b) Design an experiment to investigate your research question.

A fiery start

It is believed that Indigenous Australians first arrived in Australia over 40 000 years ago and successfully managed the land. They used very different hunting and gathering practices from those of Europeans. While Aboriginal people did have significant impact on the Australian environment, their lifestyle was sustainable and allowed resources to renew.

Some of the ways in which Indigenous people cared for their land included:

- moving from place to place rather than staying in the same location. This ensured that the plants and animals they fed on had a chance to replenish.
- eating a wide variety of food so that no single food source was depleted
- leaving enough seeds to ensure that plants could regenerate
- leaving some eggs in a nest when collecting
- not hunting young animals or the mothers of young animals
- not allowing particular members of a group to eat certain foods. This ensured that a wide variety of food was eaten and that 'taboo foods' were not depleted.
- leaving the land to recover for a period of time after harvesting a crop, such as bananas. This allowed time for the crop to regenerate and nutrients to return to the soil.

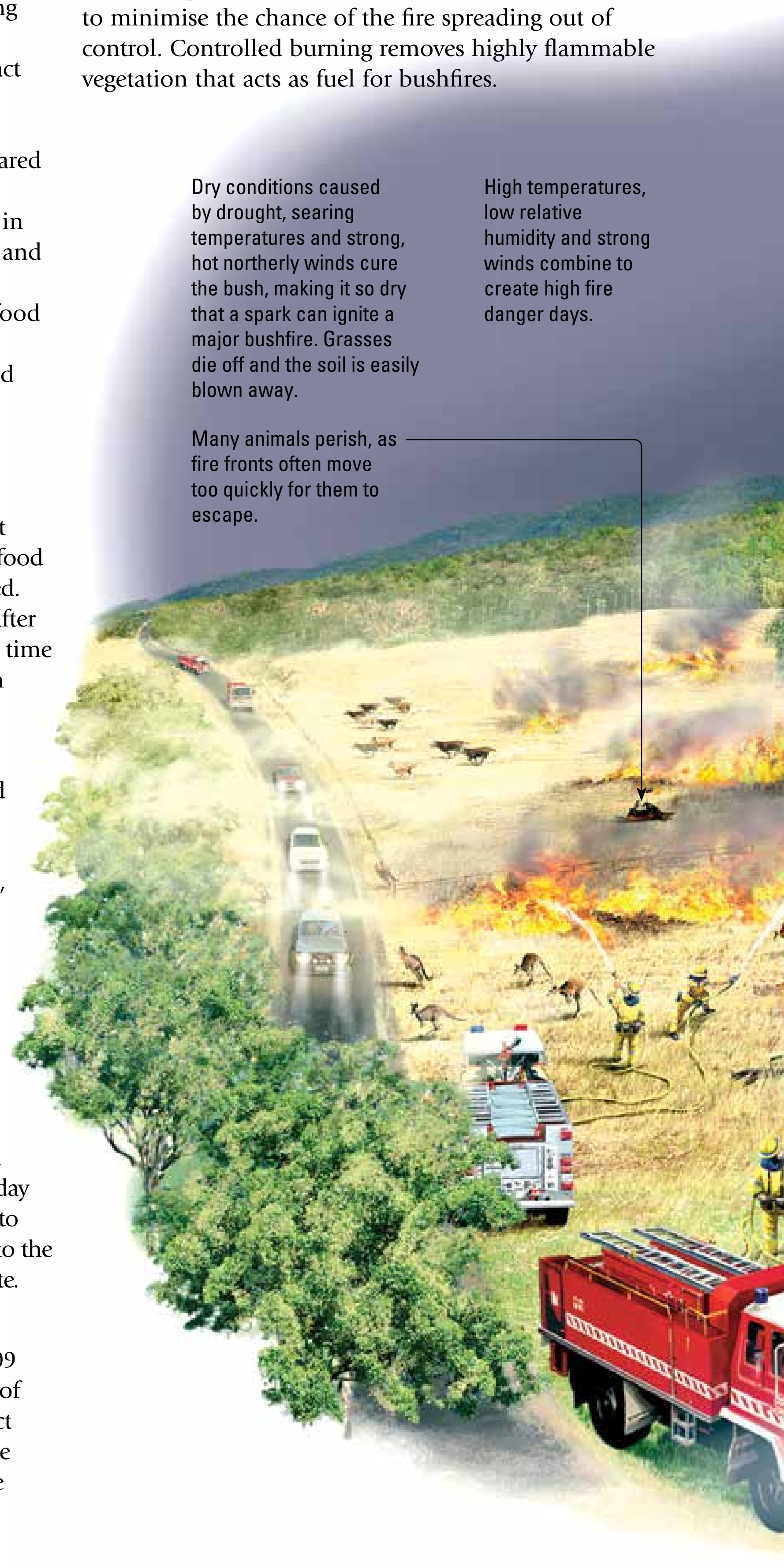
Using fire

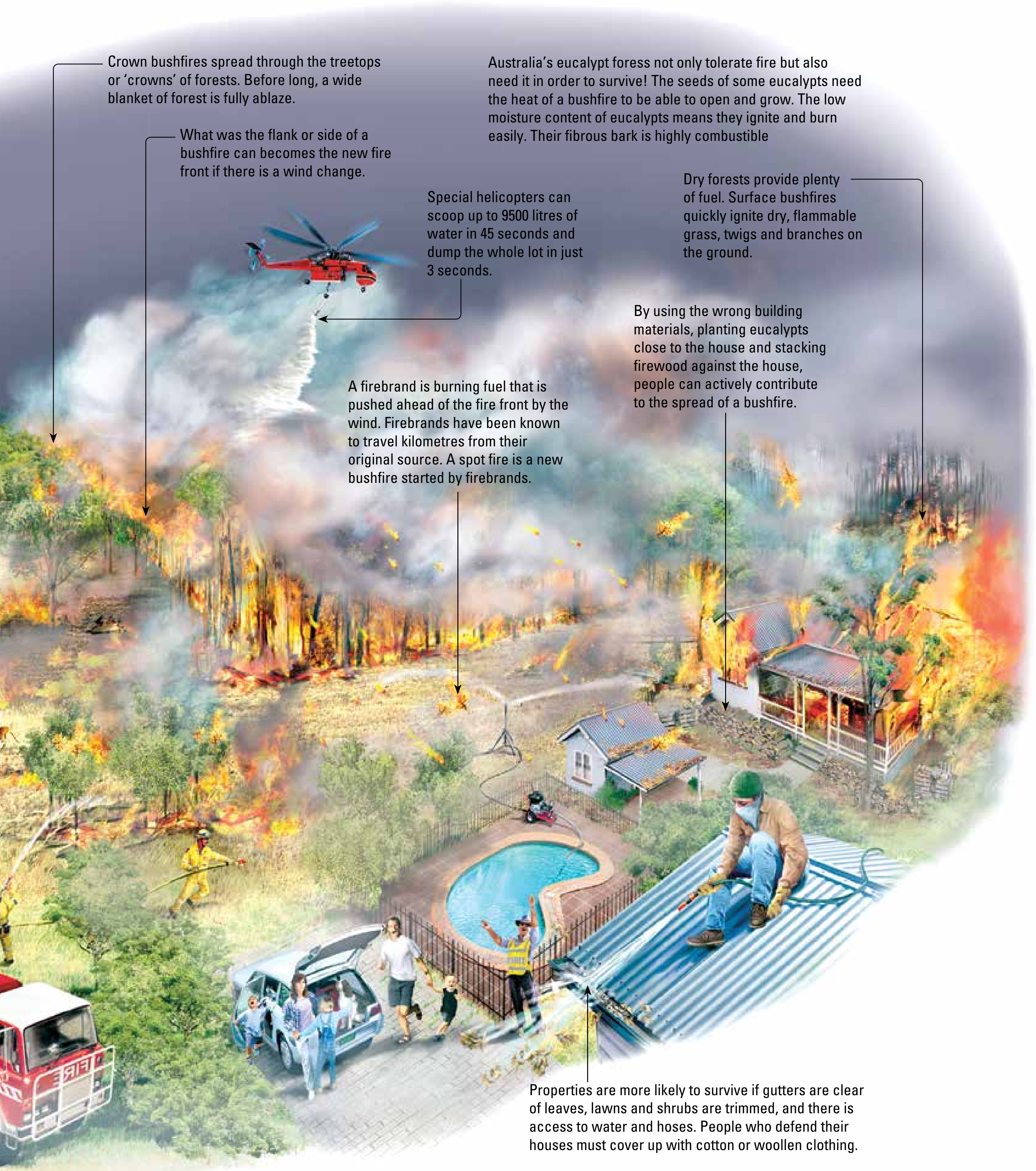
One way that early Indigenous Australians affected the environment significantly was through their use of fire. Fire was used for hunting. Setting fire to grassland revealed the hiding places of goannas, and possums could be smoked out of hollows in trees. Fire was also used to clear land. The grass that grew back after the fire attracted grazing animals, which could be hunted more easily.

Over time, some species of plants that were sensitive to fire became extinct whereas the plants with adaptations that allowed them to survive a fire or regenerate rapidly after a fire became more common. Adaptations are features that help an organism survive in its environment. Some modern-day species such as the banksia are not just well adapted to frequent bushfires; they actually need to be exposed to the high temperatures of a fire for their seeds to germinate.

Reducing the impact of bushfires

Large wild fires such as occurred in Victoria in 2009 can have devastating consequences including loss of lives and damage to property. They can also impact on ecosystems. As the bush burns, animals become victims of the flames or must flee, and habitats are destroyed. One way of reducing the frequency and severity of wild fires is through regular back-burning. This involves deliberately setting fire to vegetation when temperatures are low and the winds are calm to minimise the chance of the fire spreading out of control. Controlled burning removes highly flammable vegetation that acts as fuel for bushfires.




Crown bushfires spread through the treetops or 'crowns' of forests. Before long, a wide blanket of forest is fully ablaze.
What was the flank or side of a bushfire can becomes the new fire front if there is a wind change.
Australia's eucalypt foress not only tolerate fire but also need it in order to survive! The seeds of some eucalypts need the heat of a bushfire to be able to open and grow. The low moisture content of eucalypts means they ignite and burn easily. Their fibrous bark is highly combustible
Dry forests provide plenty of fuel. Surface bushfires quickly ignite dry, flammable grass, twigs and branches on the ground.
Special helicopters can scoop up to 9500 litres of water in 45 seconds and dump the whole lot in just 3 seconds.
By using the wrong building materials, planting eucalypts close to the house and stacking firewood against the house, people can actively contribute to the spread of a bushfire.
A firebrand is burning fuel that is pushed ahead of the fire front by the wind. Firebrands have been known to travel kilometres from their original source. A spot fire is a new bushfire started by firebrands.
Properties are more likely to survive if gutters are clear of leaves, lawns and shrubs are trimmed, and there is access to water and hoses. People who defend their houses must cover up with cotton or woollen clothing.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Use a single bubble map to show examples of natural disasters.

2 Use a cluster map to show how some Australian plants have adapted to surviving a fire.

THINK

3 Select a visual thinking tool (see section 2.10) and use it to help organise your thinking on fires, drought, tsunamis, floods, earthquakes or tornadoes.

4 Convert the information in the PMI chart at the beginning of this section into a different type of visual thinking tool.

INVESTIGATE

5 Investigate drought, tsunamis, floods, earthquakes or tornadoes, and present your findings in a PMI chart.

6 Find out more about how one of the following plants is affected by fire: mountain ash (*Eucalyptus regnans*), wattle (*Acacia*), grasstree, banksia, orchid.

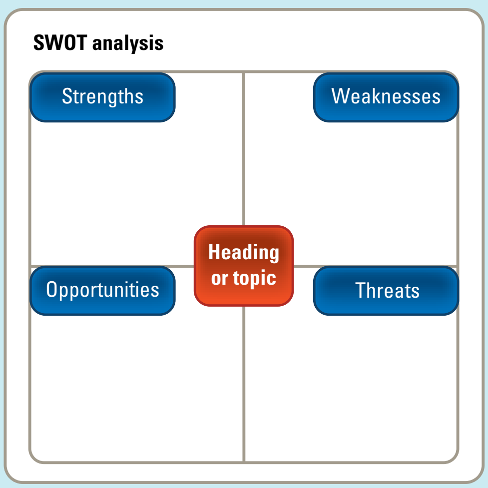
7 Find out how bushfires, drought or floods affect farmers in Australia. Construct a poem, song, play or video to share your findings.

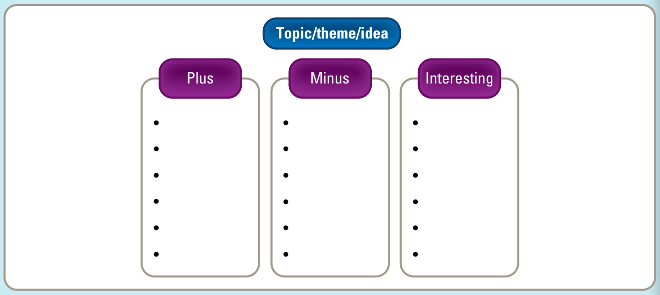
8 Many of Australia's plant and animal species have adapted to survive conditions in their environments. Investigate the adaptations of a particular species. Construct a model, poster or PowerPoint presentation to illustrate how these adaptations increase its chance of survival.

9 Organise a class or team debate on whether controlled burning should be legal.

10 (a) Find out what the regulations or local guidelines are for bushfire safety in terms of the bush ecosystem.

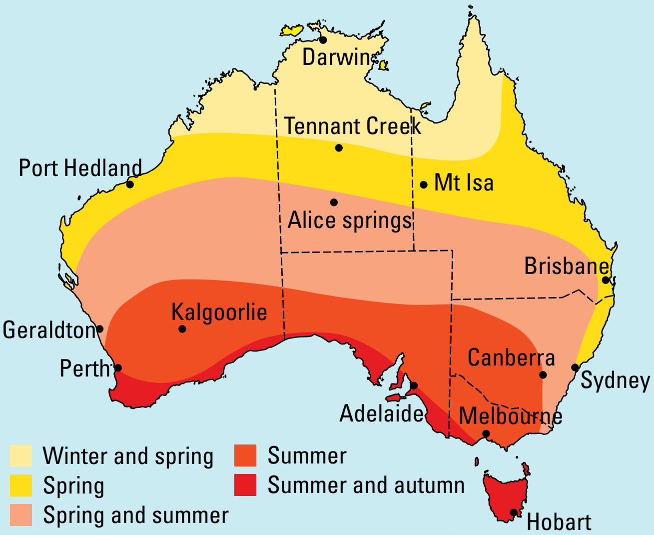
(b) In a team, construct a SWOT (Strengths, Weaknesses, Threats and Opportunities) analysis or PMI chart to evaluate these regulations or guidelines.





(c) As a team, create your own improved version of these regulations or guidelines.

11 Research the uses of fire by early Indigenous Australians.



Bushfire seasons throughout Australia

12 Find out why the bushfire seasons are different across our continent.

13 In the extremely intense 2009 Victorian bushfires, many bush animals died. Suggest ways in which five different types of animals could survive a less intense fire.

14 Use the **Bushfire** weblink in your eBookPLUS to find out what to do if you are caught in a bushfire. Create an emergency survival information card that people could use if they were caught in a bushfire.

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work sheet 5.6 Amazing fire trees

SWOT analyses and fishbone diagrams

1. Draw up a square and divide it into four quarters. In the centre of the diagram write down the topic or issue that you are going to analyse.
2. Think about or brainstorm the positive features and behaviours and record them in the Strengths section.
3. Think about or brainstorm the negative features and behaviours and record them in the Weaknesses section.
4. Think about or brainstorm possible opportunities and record them in the Opportunities section.
5. Think about or brainstorm possible threats and record them in the Threats section.

how to ...?

question

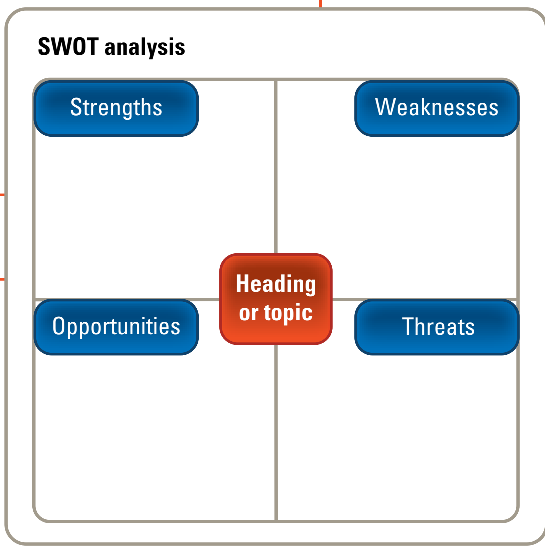
What are the strengths and weaknesses of your project?

why use?

Allows you to prepare a plan of action and to consider possible blockers to your project.

also called

No other names



comparison

Fishbone diagram

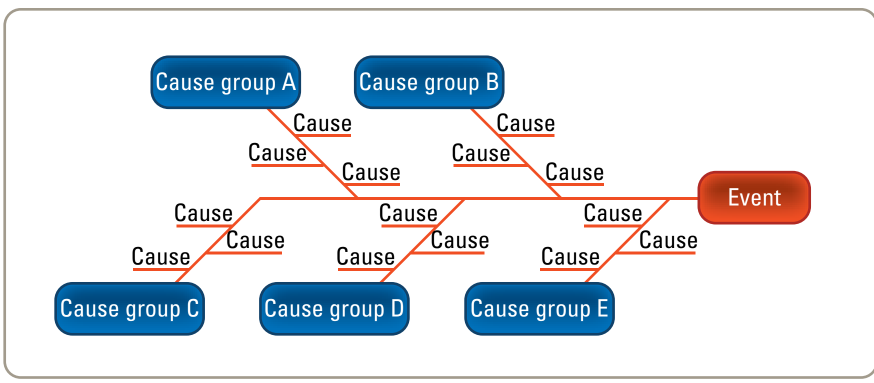
Similarity

Both can be used to group ideas and are useful in planning projects.

Difference

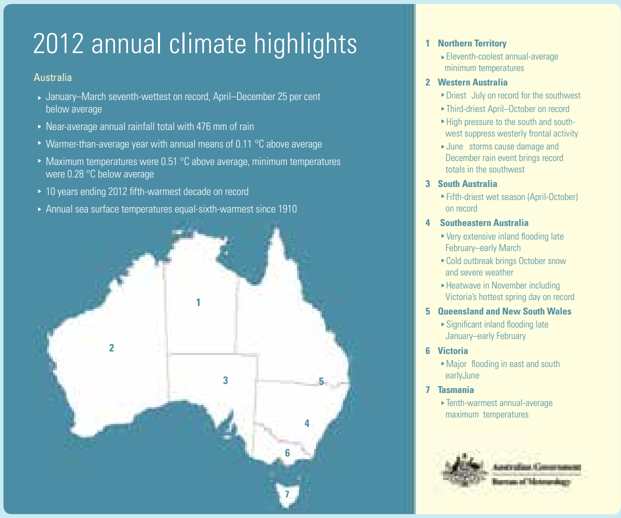
SWOT analysis groups ideas based on strengths, weaknesses, opportunities and threats. Fishbone diagrams categorise causes.

example



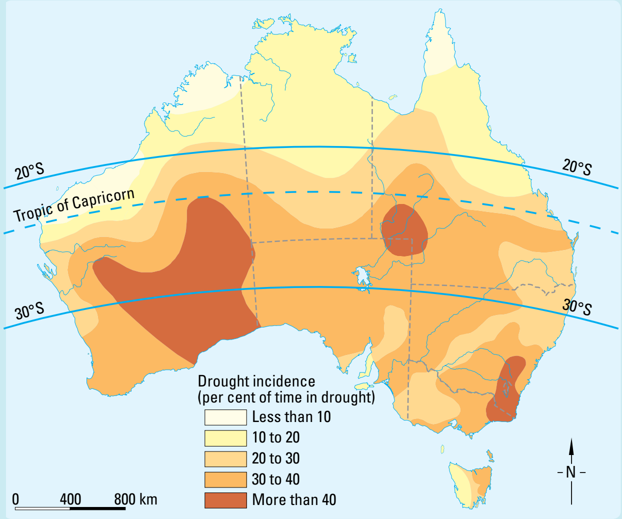
UNDERSTANDING AND INQUIRING

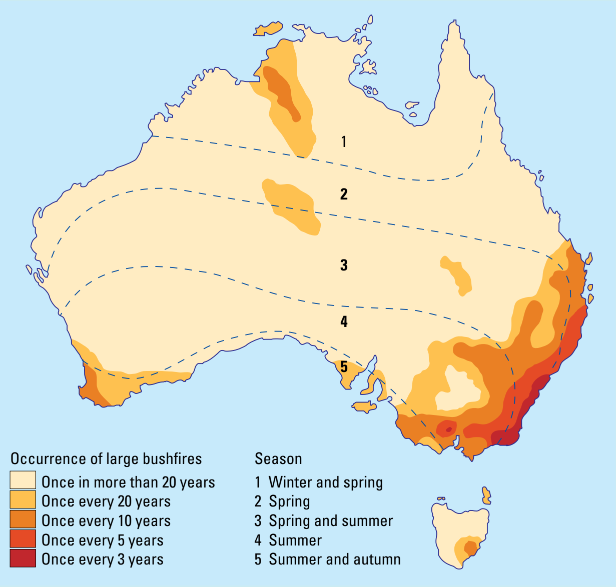
1 Examine the map below showing the 2012 Australian climate highlights for each Australian state or territory.
   (a) Research possible consequences of these highlights to populations living within ecosystems in each Australian state or territory.
   (b) Construct an overall SWOT analysis on the consequences of the 2012 Australian climate highlights.
   (c) Select a consequence and construct a fishbone diagram to categorise possible causes.
   (d) Research and report on current research on floods and their effect on Australian ecosystems.



2 Earthquakes and tsunamis in Japan in 2011 caused considerable destruction of habitats and damage to ecosystems. They also damaged a number of nuclear power plants, causing radiation to leak into the surrounding areas. In the media frenzy, varied reports, claims and statements were made. Not only did these cause panic, but they also suggested that there was a need to educate the population about different types of radiation and its possible effect on humans.
   (a) Locate examples of media reports about this disaster from the early stages to the more recent. On a timeline, collate examples of the headlines about this environmental disaster.
   (b) Research the damage to populations, habitats and ecosystems. Summarise your findings on your timeline from part (a).
   (c) Comment on any observed patterns or confusion.
   (d) Research relevant scientific knowledge about the cause and possible consequences of earthquakes, tsunamis and nuclear radiation.
   (e) Research possible connections between food webs and nuclear radiation.

3 Examine the maps at right showing the occurrence of bushfires and incidence of drought in Australia.
   (a) Describe patterns in the occurrence of bushfires.
   (b) Suggest reasons for the observed bushfire pattern.
   (c) Research possible causes and consequences of bushfires in Australian ecosystems.
   (d) Construct an overall SWOT analysis on the consequences of bushfires to populations within Australian ecosystems.
   (e) Construct a fishbone diagram to categorise possible causes of bushfires.
   (f) Describe patterns in the incidence of drought.
   (g) Suggest reasons for the observed drought incidence pattern.
   (h) Research possible causes and consequences of drought in Australian ecosystems.
   (i) Construct an overall SWOT analysis on the consequences of drought to populations within Australian ecosystems.
   (j) Construct a fishbone diagram to categorise possible causes of drought.





STUDY CHECKLIST

FEATURES OF ECOSYSTEMS

- ☐ identify examples of biotic and abiotic factors in ecosystems
- ☐ measure a range of abiotic and biotic factors in an ecosystem
- ☐ use the quadrat method and the capture–recapture method to estimate the abundance of a particular species in an ecosystem

RELATIONSHIPS WITHIN ECOSYSTEMS

- ☐ describe the following interactions between species: parasitism, mutualism and commensalism
- ☐ construct food chains and food webs
- ☐ describe the role of decomposers and detritivores in ecosystems

ENERGY AND MATERIALS IN ECOSYSTEMS

- ☐ describe the flow of energy through an ecosystem
- ☐ identify three types of ecological pyramids
- ☐ interpret ecological pyramids
- ☐ extract information from food webs
- ☐ use cycle diagrams to describe the carbon and nitrogen cycle
- ☐ outline the role of chlorophyll in photosynthesis
- ☐ recall word and symbol equations for photosynthesis and cellular respiration
- ☐ describe the role of photosynthesis and respiration in ecosystems

HUMAN IMPACT ON ECOSYSTEMS

- ☐ describe ways in which humans have affected on ecosystem
- ☐ identify an introduced species and describe its impact on other populations within an ecosystem

NATURAL EVENTS

- ☐ describe the effects of bushfires, floods and droughts on Australian ecosystems
- ☐ describe examples of adaptations of animals and plants to Australian ecosystems

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ANSWERS for this chapter can be found online in your eBookPLUS.

Online section

This section of the chapter can be found online in your eBookPLUS.

5.10 Thinking tools: SWOT analyses and fishbone diagrams (eBook*plus* ONLINE ONLY)

Individual pathways

Activity 5.1	**Activity 5.2**	**Activity 5.3**
Revising ecosystems	Investigating ecosystems	Investigating ecosystems further
doc-8443	doc-8444	doc-8445

FOCUS activity

Access more details about focus activities for this chapter in your eBookPLUS. doc-10678

eLessons

Reducing your carbon footprint

Do your bit for the environment and find out 10 easy and practical things that you can do around the home to help stop global warming.

Searchlight ID: eles-0163

Native rats fighting for their habitat

Watch a video about rats that have been bred to be introduced into their native environment; how will the resident black rats react?

Searchlight ID: eles-1083

Interactivities

The quadrat method

Experience this method of sampling used to estimate the number of a particular type of organism in an area.

Searchlight ID: int-0984

The capture/recapture method

Experience this method of sampling used to estimate the number of a particular type of organism in an area.

Searchlight ID: int-0985

Blast off into the future

What will life be like in your future? What sorts of challenges will you face? How can you best prepare yourself for a future that you have not yet seen? What skills will you need to survive?

You might be better able to not only survive, but also thrive, in an unknown future if you can:

- effectively observe, analyse and evaluate your environment
- generate relevant questions to explore perspectives and clarify problems
- selectively apply a range of creative thinking strategies to tackle challenges
- get along with others and respect their differences, viewpoints and ideas
- effectively communicate with others
- take responsible risks and be innovative and willing to tackle challenges
- manage your own learning and reflect on what and how you learn.

One way to develop these skills is to work as a team to solve a challenge or problem. Use the Blast off! situation shown below to find out more about living in a sustainable future and to present some possible solutions to the problem. It is important to realise that sustainability is not just about your environment and individual physical requirements; you also need to consider the social, political and emotional aspects.

Blast off!

Earth is about to explode! You have been selected as one of the humans to be sent into space. Your spacecraft is on a journey that will take 300 years to reach its destination — a planet that your descendants will colonise if they manage to reach it.

Blasting off

This activity works best in teams of four. It can be a brief experience or a more intensive journey, depending on how deeply you delve into each of the questions. You can use the material in the rest of this chapter to help you.

You may also decide to share and rotate various team roles throughout your journey (such as various combinations of project manager, recorder/scribe, devil's advocate, time keeper, researcher, resource manager, celebrator, presenter).

Before you begin, brainstorm ideas for the name of your spaceship. As a team, agree on one of them.

1. Pre-blast thinking

Life needs

(a) Use a table like the one below to list the things you need to survive and suggest how these needs or requirements are met on Earth.

What I need and how I get it

Life requirement	How the life requirement is met on Earth

(b) Compare your list and your suggestions with those of others in the class.

2. Who's going?

In your team, brainstorm and discuss the following points. (Visual thinking tools may be useful to record summaries of your discussions.)

(a) How many people will be going on the journey? Investigate models and theories of population growth to justify your response.

(b) What are their ages and jobs? Construct a table with the headings as shown below to list details of the members of your spacecraft community.

Give reasons why you would include these people and not others.

- How many males and females will you include?
- Why did you select individuals of these ages?
- Why did you select the various occupations of journey members?

Who will be on your spaceship and why?

Name (use your imagination)	Gender	Age	Occupation	Reason why individual selected

3. Fuelling up

(a) Write out a plan of the types of activities that a crew member may be involved in, and for how long, throughout a 24-hour period on your spaceship.

(b) Use your activity plan to help you estimate the amount of energy that would be needed by this crew member in a 24-hour period.

(c) Calculate the average daily amount of energy used by all of the travellers in your spaceship.

4. What's to eat?

(a) As well as energy, your crew will need nutrients such as proteins, carbohydrates, lipids, vitamins and minerals. Individually design a daily menu that would meet the requirements for a particular member of your crew, giving reasons for your selections. Share and discuss your menus with others in your team.

(b) Discuss some ways that these nutrients could be available throughout your 300-year journey.

Daily menu

Name: ....

Occupation: ....

Particular nutritional requirements: ....

Breakfast	Lunch	Dinner	Snacks

5. Home alone

(a) Which types of organisms (and how many) will you take on your journey?
(b) Suggest some examples of food chains and food webs that could exist within your spaceship.

6. Gassed up

(a) Estimate the amount of oxygen that you inhale in an average day. Multiply this by the number of people on your spaceship to get an estimate of the total amount that would be inhaled each day.
(b) Suggest why this oxygen is required.
(c) Estimate the amount of carbon dioxide that you exhale in a average day. Multiply this by the number of people on your spaceship to get an estimate of the total amount that would be exhaled each day.
(d) Discuss with your team some ways in which carbon dioxide may be converted into oxygen aboard your spacecraft. Summarise your discussion in the form of an annotated diagram.

7. Recycle me

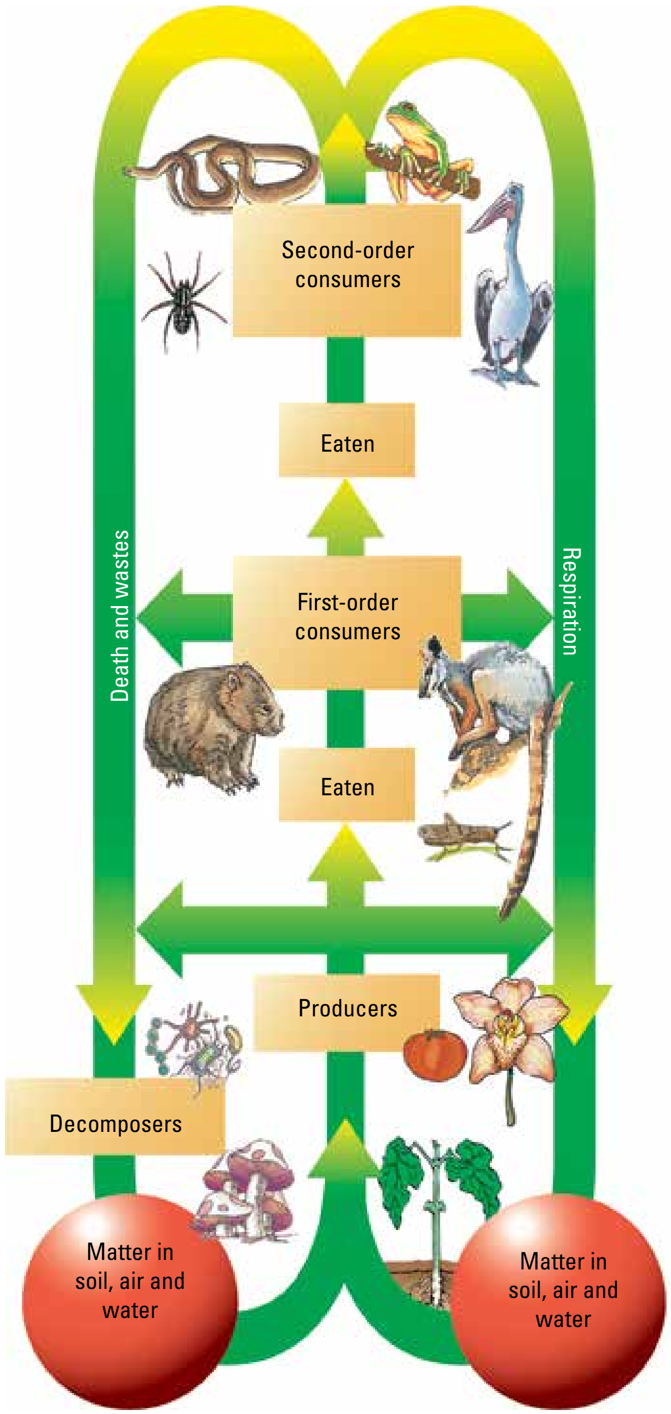
(a) On board your spacecraft, different types of waste will be produced. Suggest examples of these wastes and discuss how they could be managed.
(b) Water is also essential for life. Suggest some ways that water could be recycled on your spaceship.

8. Sustainability

(a) Discuss how the idea of an ecological footprint may relate to your spaceship design.
(b) Will the number of people on your spaceship remain the same throughout your journey? Discuss the implications of your response with your team.
(c) Compare your spaceship ecosystem with an artificial ecosystem such as the Biosphere 2 project.

9. Blast off!

(a) As a team, construct a model of your spacecraft. Include labels or a brochure to outline key features and details.
(b) Individually, write a week's diary entry describing life 300 years after leaving Earth. Share your diary entries with each other and with other teams.



(c) Present a summary of your findings for the entire activity using hyperlinked electronic text, PowerPoint, web pages or another creative format.

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work sheets
5.7 Ecosystems: Puzzles
5.8 Ecosystems: Summary

projectsplus

Blast off!

SEARCHLIGHT ID: PRO-0106

Scenario

By 2050, there will be 10 billion people on our small world and the human population will have expanded far beyond a number that the Earth's resources are capable of supporting. If we are to survive into the next century, we will need to find other worlds for settlement and resources. Exoplanets are planets that are found orbiting stars far from our own. So far, 560 exoplanets have been discovered, some of which could be similar enough to Earth for us to colonise. Of course, these star systems are very far away and the people who travel out into space to set up the new colonies will be on board their spaceships for very long periods of time.

The Australian Space Exploration Agency has been formed with the specific aim of sending a crew of 80 colonists to the exoplanet XY2305 — a world that is very similar to Earth — to form the basis of a much larger future settlement. The spacecraft engines that are presently available to the Agency are capable of getting the colonists there with a total journey time of twenty years. As part of the spacecraft design team at the ASEA, you will need to design a spacecraft that will meet all of the survival needs of the crew during their long journey.

The design brief for the spacecraft has the following specifications:

- As the spacecraft will be built in Earth's orbit and will not need to land on the planet at the other end, it does not have to have an aerodynamic shape. It can also be as large as you need; however, keep in mind that the best use should be made of the interior space so that it is easily negotiated by the colonists.
- Apart from an initial intake of supplies, all food, water and oxygen for the journey will need to be grown, recycled or produced on board the ship itself.
- If the ship is to have artificial gravity, the design must include a method of generating this gravitational field.
- Facilities need to be provided for research, sleeping, recreation and exercise.
- There will be equal numbers of male and female colonists who will be aged between 20 and 30 years of age.

Your task

Your group has been given a project brief to design a spacecraft that will be able to provide life support for 80 colonists for their twenty-year journey to the exoplanet XY2305. You will present your final design to the Administration of the ASEA in the form of (i) a PowerPoint demonstration and (ii) a labelled model of your spacecraft.

In your presentation, you will need to consider, among other things:

- the types of activities that an average crew member would be involved in and for how long, in each normal 24-hour period of time onboard the spaceship
- the amount of food, water and oxygen that each person will need every day to perform these activities
- how carbon dioxide would be converted into oxygen
- how water will be produced/recycled
- the different types of waste that will be produced and how these wastes will be managed /recycled.

Process

Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group.