4 Ecosystems

Ecology is the scientific study of the relationships between living things, and between living things and their environments. The environment is all around us . . . but we are only a small part of it.

OVERARCHING IDEAS

- Patterns, order and organisation
- Form and function
- Stability and change
- Matter and energy
- Systems

SCIENCE UNDERSTANDING

Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions.

Elaborations

Using food chains to show feeding relationships in a habitat

Constructing and interpreting food webs to show relationships between organisms in an environment

Classifying organisms of an environment according to their position in a food chain

Recognising the role of microorganisms within food chains and food webs

Investigating the effect of human activity on local habitats, such as deforestation, agriculture or the introduction of new species

Exploring how living things can cause changes to their environment and impact other living things, such as the effect of cane toads

Researching specific examples of human activity such as the use of fire by traditional Aboriginal people and the effects of palm oil harvesting in Sumatra and Borneo

THINK ABOUT ECOSYSTEMS

- Why is your ecological footprint a different size from other people's?
- What's the point of keeping a compost heap when it's just a load of rubbish?
- What's your home address got to do with tolerance?
- What have chains and webs got to do with food?
- What's all this fuss about cane toads?
- Who's on your NOT WANTED ecoposter?
- Why are greenhouse gases a 'hot' environmental issue?
- Is it all bad for an animal to be 'behind bars'?

YOUR QUEST

Gaia

The scientific theory of Gaia is named after the goddess Gaia, the mythical Greek goddess of Mother Earth. The Gaia theory was developed by biologist Professor James Lovelock. His theory states that Earth is a 'super-organism' made up of both the physical environment and living organisms. In this theory, the forests are like skin and they sweat to keep us cool. Rivers and oceans are like blood carrying supplies to where they are needed and washing away wastes. The air is like lungs and the rocks are like bones. In the Gaia theory, interactions in one part may have implications in another part. Hurting one part will hurt all; likewise, helping one part will help all.

INQUIRY: INVESTIGATION 4.1

Modelling interactions

Ecosystems are made up of biotic and abiotic factors. Biotic factors are living things (for example, bacteria, plants and animals) and abiotic factors are non-living things (for example, temperature, wind and water). We can use a model to demonstrate interactions of these factors within ecosystems.

KEY INQUIRY SKILLS:

- questioning and predicting
- communicating

Equipment:

one large label per student

ball of string

- Select a part of the environment for each student. Examples you could use are the sun, temperature, wind, soil, water, light, a bee, a worm, a bird, a plant or a human. Attach a large label to each person to show what they are representing.
- Organise yourselves into a circle.
- Decide who is to go first. This person holds onto one end of the string and passes the ball of string to another student in the circle, while explaining their relationship to what that student represents. For example, a 'plant' may pass the string to 'light' and say, 'I need light in order to photosynthesise'.
- Repeat the last step until you can't think of any more relationships.
- Have a scribe record your string pattern on paper, the board or an overhead transparency.
- What do you think might happen if one part of your 'circle environment' is removed? Try this and discuss what happens.
- While standing in the circle, discuss which parts of the environment you would not let go of. Include reasons for suggestions given.
- In your circle, get all of those parts that are non-living (abiotic) to sit down. Discuss your observations.

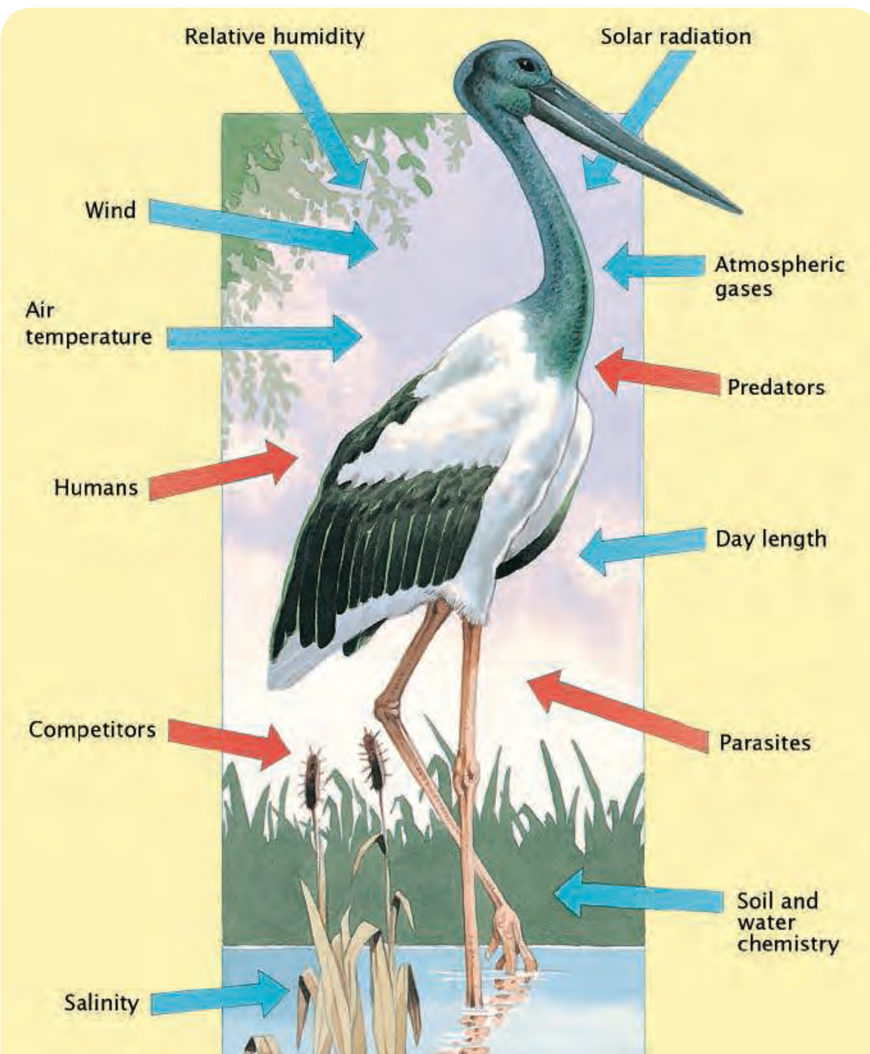
4.1 OVERARCHING IDEAS

Systems:Ecosystems

Ecosystems are not just about whether something is living or not; they involve both living and non-living factors and how they interact with each other.

Ecosystems — living AND not?

An **ecosystem** is made up of living things (**biotic factors**) and non-living things (**abiotic factors**) that interact with each other. Organisms such as bacteria, worms, birds, plants and snakes are examples of biotic factors. Examples of abiotic factors include water, temperature, pH, salinity and light intensity. Within an ecosystem there are interactions between the biotic factors, between the abiotic and biotic factors and also between abiotic factors.



Organisms can be affected by both abiotic and biotic factors. These factors also interact.

A complex level of organisation

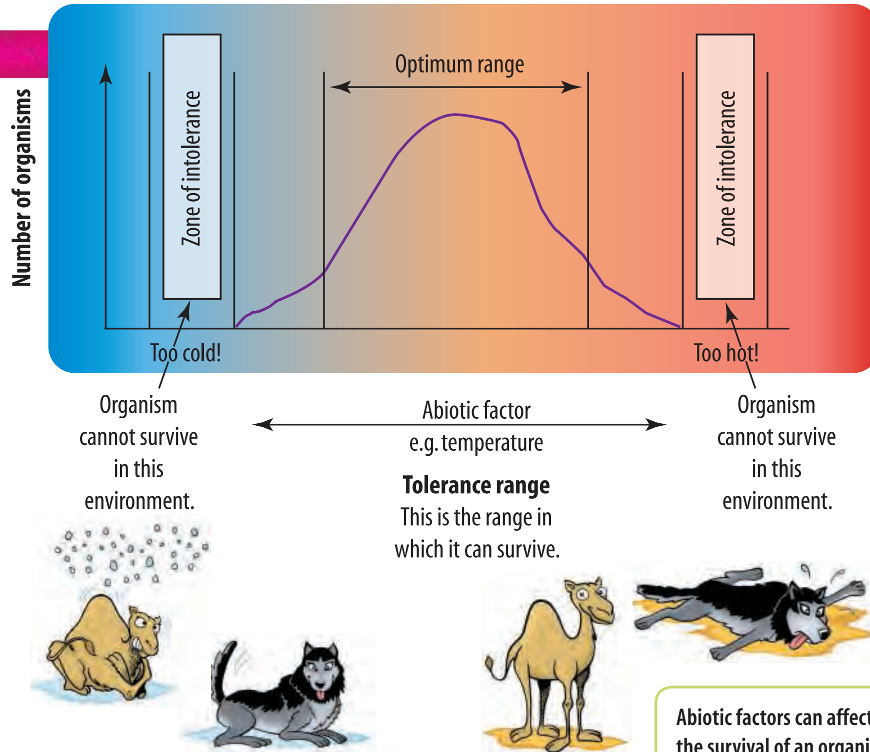
If you were to consider the biotic factors within an ecosystem, you could group them in a number of different ways. One way is in terms of complexity. While an **organism** can be made up of one or more cells, particular organisms can belong to the same **species**. A **population** consists of all of the individual organisms of one particular species living in the same area at the same time. The term **community** is used to describe all of the populations of various organisms living in the same area at the same time. Ecosystems consist not only of the communities within them, but also the physical surroundings and the interactions within and between them.

An ecosystem is a complex level of organisation.

Cell → Organism → Species → Population → Community → Ecosystem

Habitat is home!

An ecosystem may contain many habitats. A **habitat** is the name given to the place where a particular organism lives. The match between the environmental conditions and the needs of organisms is responsible for the **distribution** and **density** of organisms within it. Distribution refers to where the organisms are located in the habitat, whereas density refers to the numbers of organisms. Each species has a **tolerance range** for each abiotic factor. The **optimum range** is the range within the tolerance range in which it functions best.

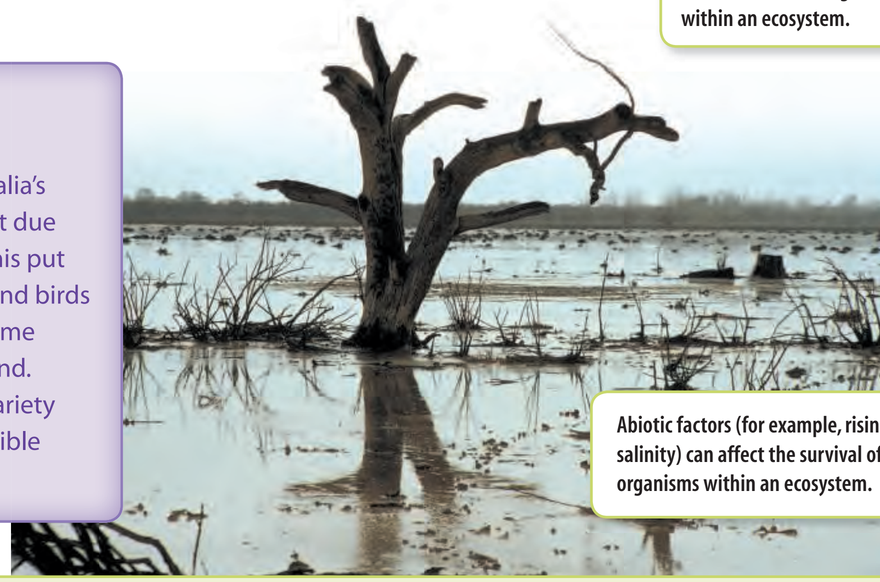


Abiotic factors can affect the survival of an organism within an ecosystem.

HOW ABOUT THAT!

The white plague

Did you know that a number of Australia's rivers and landscapes are under threat due to increased salinity? Not only does this put almost 450 species of plants, insects and birds under threat, but it is also affecting some of our most productive agricultural land. Australian scientists are exploring a variety of engineering- and plant-based possible solutions. What can we do to help?



Abiotic factors (for example, rising salinity) can affect the survival of organisms within an ecosystem.

INQUIRY: INVESTIGATION 4.2

A mini ecosystem

KEY INQUIRY SKILLS:

- questioning and predicting
- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

1 L clear plastic bottle
scissors or knife
masking tape
soil or potting mix
small plants or seedlings
grass clippings or ground mulch (including small organisms). If there are few organisms in the grass clippings or mulch, you may want to add ants or slaters.

- Cut the top off the bottle.
- Pour the soil or potting mix into the bottom of the bottle.
- Plant the seedlings into the potting mix.
- Place the ground mulch or grass clippings over the potting mix and around the seedlings.
- Add sufficient water to moisten the soil.
- Put the top back on the bottle and seal it with masking tape. The bottle should be completely sealed so that no air, nutrients, animals or plants can be added or removed from the mini ecosystem for the duration of the experiment.
- Observe your mini ecosystem each lesson for the duration of this topic.

INQUIRY: INVESTIGATION 4.2 (CONTINUED)

INVESTIGATE, DISCUSS AND EXPLAIN

1 Explain why it is not necessary to regularly water the plants in this ecosystem.

2 The living things in the ecosystem use up oxygen.
  (a) Suggest what the living things need oxygen for.
  (b) Suggest why the oxygen doesn't run out.

3 Where do the living things get their energy from? Suggest why there is no need to feed them.

4 If the ecosystem is balanced, the organisms inside the bottle continue to live for a very long time without needing extra water or food.
  (a) Explain what a balanced ecosystem is.
  (b) Suggest what could cause this mini ecosystem to become unbalanced.

5 List three strengths in the design of this investigation.

6 Suggest three ways in which this investigation could be improved.

7 (a) Suggest a hypothesis that you could use this equipment (with possible modifications) to investigate.
  (b) Outline the procedure you would use to investigate your hypothesis.

INQUIRY: INVESTIGATION 4.3

Measuring abiotic factors

KEY INQUIRY SKILLS:

- conducting
- evaluating
- processing and analysing data and information

Equipment:

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

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.

- Use the thermometer to measure the temperature of each water sample and each soil sample.
- Pour 5 mL of 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.
- Pour 5 mL of water sample A into another test tube. Add 3 drops of silver nitrate solution. Note whether the sample remains clear, becomes slightly cloudy or turns completely white/grey. Work out the salinity of the water sample using the table below. Repeat using water sample B.

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

- Put a small amount of soil sample A on 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.

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

INVESTIGATE, DISCUSS AND EXPLAIN

1 Copy and complete the results table on the previous page.

2 A pH less than 7 is considered acidic. The lower the pH the more acidic the sample is.
  (a) Which water sample was more acidic?
  (b) Which soil sample was more acidic?

3 One of the environments is near the ocean and so some sea water mixes with the water in the river. Was this environment A or B? Explain your answer.

4 Which of the tests in this investigation were qualitative and which were quantitative?

5 Which variables were controlled in the salinity test?

6 List two strengths in the design of this investigation.

7 Suggest two ways in which this investigation could be improved.

8 Find out and report on some of the effects that changes in pH or salinity may have on ecosystems.

9 Suggest a research question that you could investigate using what you have learned from this investigation.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Provide an example of each of the following.
  (a) An abiotic factor
  (b) A biotic factor
  (c) A species
  (d) An ecosystem

2 Outline the relationship between ecosystems, abiotic factors and biotic factors.

3 Organise the following in terms of complexity, from simplest to most complex: ecosystem, species, community, cell, population, organism.

4 Distinguish between:
  (a) abiotic and biotic factors
  (b) distribution and density
  (c) cells and organisms
  (d) population and community
  (e) habitat and ecosystem.

INVESTIGATE, THINK AND DISCUSS

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.
  (c) (i) Select one of these biotic or abiotic factors and research the possible consequences if it changed.
    (ii) Suggest how any negative consequences might be minimised.

6 Use the **CSIRO** weblink in your eBookPLUS to find out the difference between dryland salinity and irrigation salinity and see an example of a possible consequence of each.

eBook*plus*

7 Find out more about the effects of rising salinity on our ecosystems and then suggest why rising salinity has been described as a 'white plague'.

8 Human activity can result in changes in abiotic factors which may have an impact on the survival of organisms within ecosystems.
  (a) Find out why rising salinity is an issue in Australia.
  (b) Investigate examples of research that Australian scientists are undertaking in their search for possible solutions to the threat of rising salinity within many of our ecosystems.

9 Select an abiotic factor from the list below and find out more about how it affects the survival of a particular organism.
  - Acidity
  - Salinity
  - Temperature

10 Find a photograph or image of an animal and use two different-coloured arrows, one for abiotic and one for biotic factors (similar to the figure on the left of the first page of this section), to add examples of factors that can affect its survival.

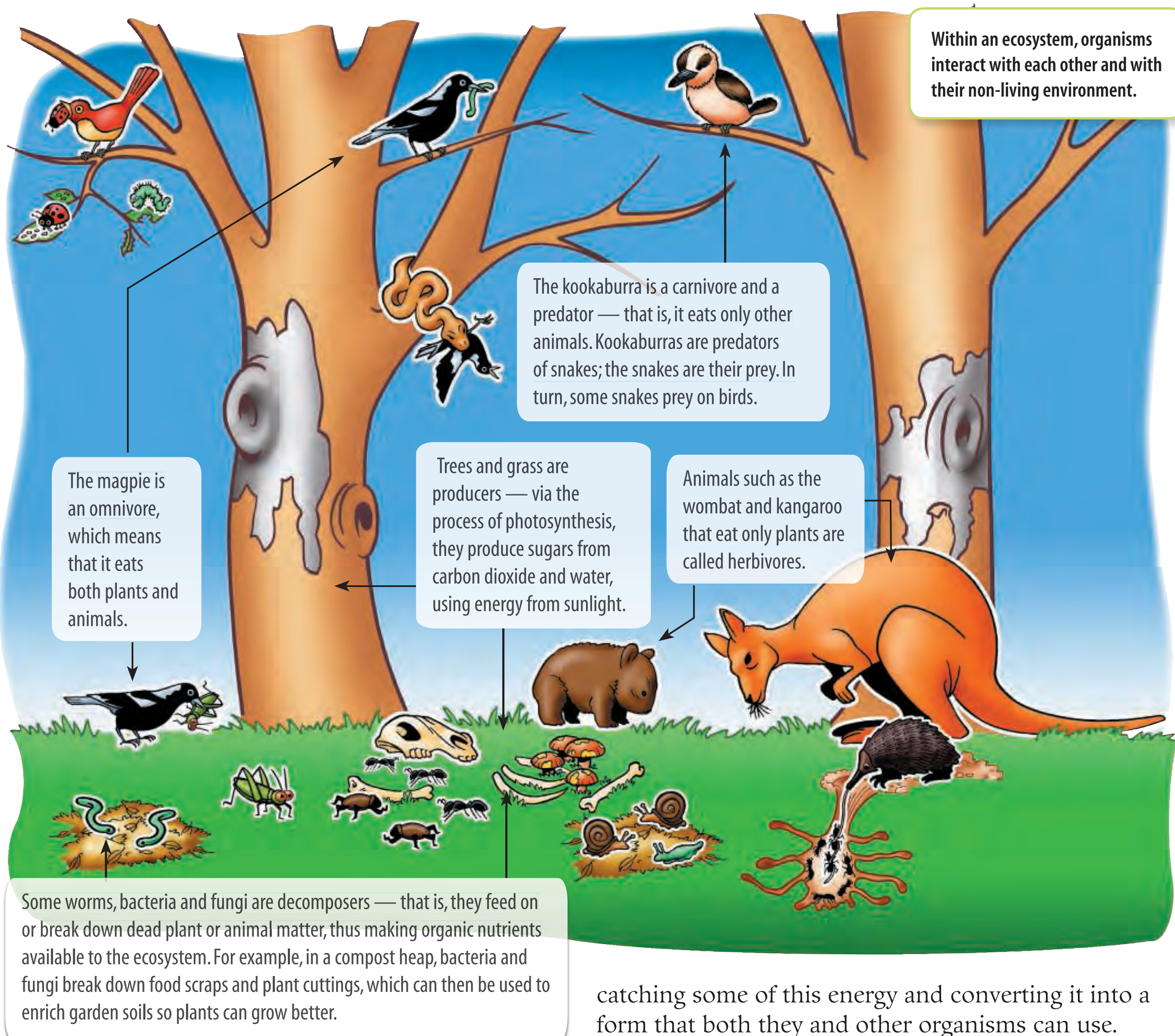
11 (a) Find out more about two types of research into water management in Australia.
  (b) Summarise your findings so that they can be communicated to others.
  (c) Put forward an argument that justifies the research from:
    (i) a scientific perspective
    (ii) an ethical perspective
    (iii) a financial perspective.

work sheet 4.1 Biotic and abiotic factors

4.2 SCIENCE UNDERSTANDING

Food chains and food webs

Ecosystems are busy places! Some of the interactions between organisms within an ecosystem provide the nutritional contribution that keeps them alive. Organisms can be named on the basis of these interactions.



Who are you in the food chain?

PRODUCERS

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.

Producers are organisms that produce their own food from their non-living environment. Grass and trees are examples of producers that make their own food by the process of **photosynthesis**.

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

(or other light-capturing pigment)

Being green is not essential to be able to photosynthesise. While some photosynthetic algae and phytoplankton are green, others may be red, yellow or brown. Although **chlorophyll** is the most common light-capturing pigment, there are also other coloured pigments that can absorb light energy.

Photosynthetic organisms, such as plants, algae and phytoplankton, are called producers or **autotrophs** because they can produce their own food.

CONSUMERS

Consumers are organisms that eat other organisms or their products. They cannot make their own food, so they need to eat other organisms for energy and chemical building blocks; they are therefore called **heterotrophs**. All animals, fungi and many bacteria fit into this category.

Within an ecosystem, consumers can be grouped on the basis of what food they eat. Animals that eat only plants are called **herbivores**, those that eat only other animals are called **carnivores** and those that eat both plants and animals are called **omnivores**.

Naming consumers

There are other ways to describe consumer feeding relationships. Some bacteria, worms and fungi can also act as **decomposers**. They break down plant and animal remains into simple compounds that make them available again for use by other organisms. This provides a way of recycling matter within an ecosystem. An animal described as being a **predator** hunts another animal for its food. The animal that it hunts is called its **prey**. Organisms that eat the same food are called **competitors**, because they compete with each other for the same food source.

Food chains

The feeding relationships between organisms can be shown in a **food chain**. Food chains show how energy is passed from one organism to another. An arrow indicates 'is eaten by' and describes the flow of energy.

ORDERS IN CHAINS

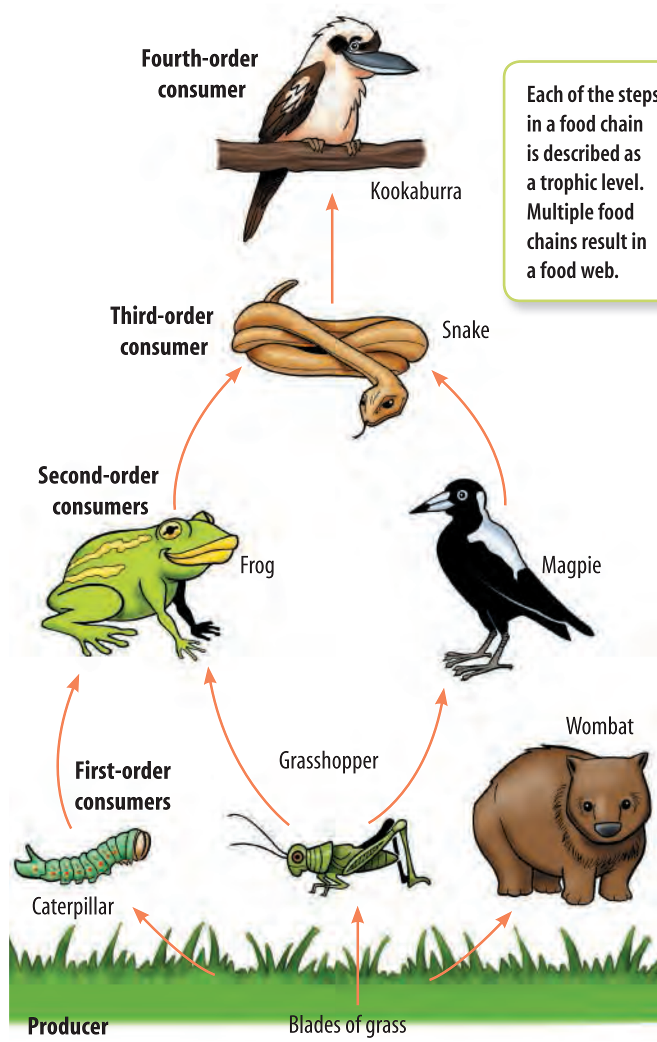
Imagine that you are eating fish and chips for dinner. The fish most commonly sold is flake, which is shark meat. The food chain that links you and a shark is illustrated above right.

The algae is the producer in this food chain. An animal that eats a producer is called a **first-order consumer** (for example, a small fish). A consumer that eats a first-order consumer is called a **second-order consumer** (for example, a large fish), the consumer that eats that is called a **third-order consumer** (for example, a shark) and that is eaten by a **fourth-order consumer** (for example, you).

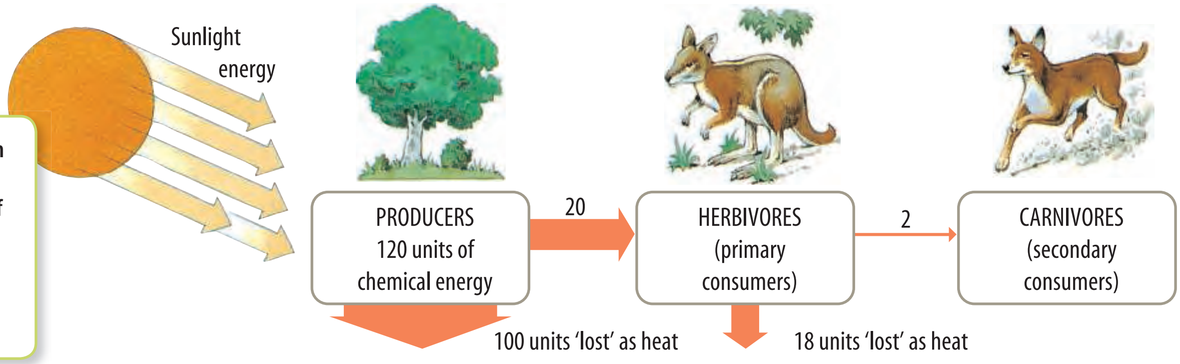
The food chain that links you and a shark: algae → small fish → large fish → shark → human

Food chains make up food webs

In the food chain shown below, the grasshopper can be described as a first-order consumer and magpie and frogs as second-order consumers. In the second food chain, the snake can be described as a third-order consumer and the kookaburra as a fourth-order consumer.



Each of the steps in a food chain is described as a trophic level. Multiple food chains result in a food web.



Energy flow in an ecosystem. The values of units of energy flowing through the food chain are averages.

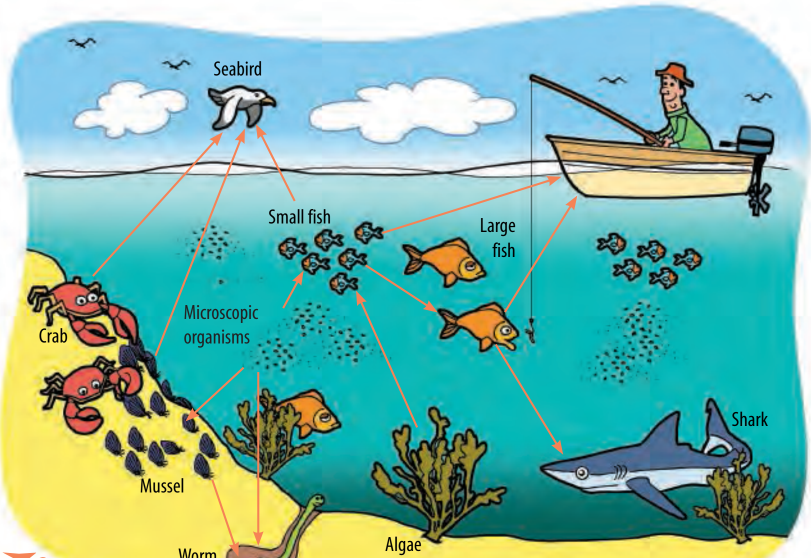
These two food chains have some organisms in common. There may also be other food chains that may also interlock with them. Joining a number of food chains together results in a **food web**.

Energy flows . . .

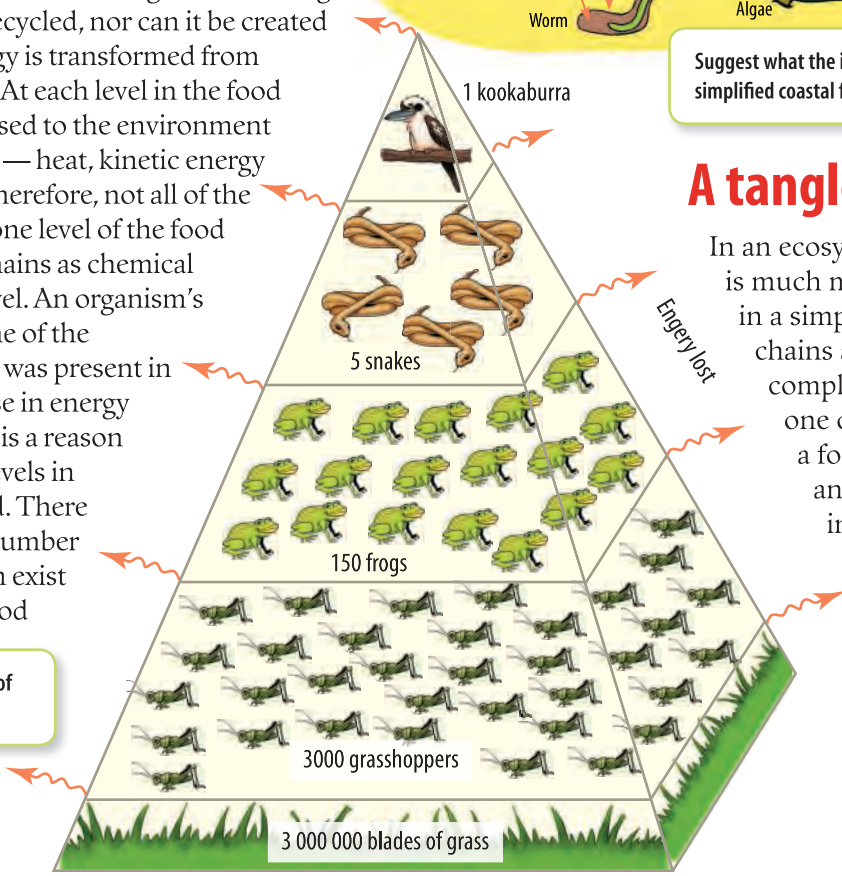
Our sun is the initial source of energy for our ecosystems. It is during the process of photosynthesis that producers capture light energy from the sun and use it to make glucose. When consumers eat the producers, energy is passed along the food chain.

Energy pyramids

Only some of the energy captured by producers is converted into chemical energy. Of that energy, only some of it is passed on through each feeding level. Energy is not recycled, nor can it be created or destroyed — energy is transformed from one form to another. At each level in the food chain, energy is released to the environment in the form of wastes — heat, kinetic energy and sound energy. Therefore, not all of the energy passed from one level of the food chain to the next remains as chemical energy in the next level. An organism's body stores only some of the chemical energy that was present in its food. This decrease in energy along the food chain is a reason that the number of levels in food chains is 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.



Suggest what the implications might be to this simplified coastal food web if the algae died out.



Pyramid showing numbers of organisms in a food web

A tangled web

In an ecosystem, the situation is much more complex than in a simple food chain. Food chains are only parts of complex food webs. If one of the organisms in a food web is removed and a new organism introduced, other organisms within the food web may be affected. The food web may become unbalanced.

INQUIRY: INVESTIGATION 4.4

The pigments in leaves

The process of separating colours used in this part of the experiment is called chromatography.

KEY INQUIRY SKILLS:

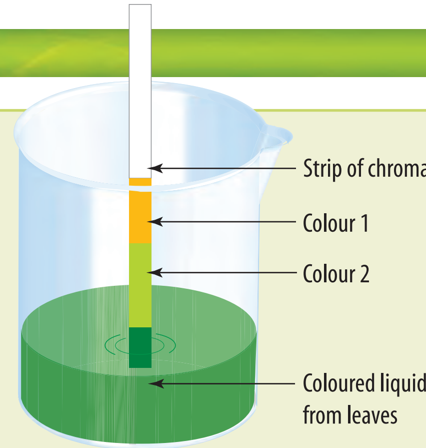
- questioning and predicting
- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

large beaker — *hotplate*
leaves from seedlings or plants: geranium, hydrangea, lettuce, spinach or silverbeet cuttings are excellent
metal tongs — *large test tube or small beaker*
methylated spirits — *test-tube holder*
stirring rod — *clear plastic wrap*
medium-sized beaker — *filter or chromatography paper*

CAUTION: Methylated spirits is toxic and extremely flammable.

- Half-fill the large beaker with water and bring to a gentle boil on the hotplate. This large beaker will serve as a water bath.
- Soften two or three leaves by dipping them with tongs into the hot water for 10 seconds.
- Place the leaves into a test tube or small beaker and cover them with 30–40 mL of methylated spirits. Use a test-tube holder to hold the test tube or small beaker upright in the water bath, so that its contents do not spill into the water.
- When the leaves turn pale and the methylated spirits deepens in colour, remove the test tube or small beaker from the water bath.



Chromatography separates colours in mixtures.

- Decant the coloured methylated spirits into the medium-sized beaker. Allow the liquid to cool for 10 minutes.
- Suspend a long narrow strip of chromatography paper or filter paper in the beaker so that just 2–5 mm sits in the liquid, as shown in the diagram below. Fold the paper over the side of the beaker to hold it in place.
- Remove the strip of paper from the methylated spirits before the colours reach the top of the paper.

INVESTIGATE, DISCUSS AND EXPLAIN

1. Use coloured pencils or textas to record the colours that you have found.
2. How many different colours could you identify?
3. What seems to be the most prominent colour?
4. List two strengths in the design of this investigation.
5. Suggest two ways in which this investigation could be improved.
6. (a) Suggest a hypothesis or research question that you could use this equipment (with possible modifications) to investigate.
   (b) Outline the procedure you would use to investigate your hypothesis.
7. Find out possible names for the pigments that you have separated, and at least one interesting piece of information about each of them.

INQUIRY: INVESTIGATION 4.5

Make a food web

KEY INQUIRY SKILLS:

- processsing and analysing data and information
- evaluating

- Construct a food web using students connected by pieces of string. You can use one of the food webs described here or make up one of your own by discussing it in a group and planning it out on a large piece of paper.
- Pull on one string and see how it affects other organisms. If you feel a tug on a string you are holding, then pull on all the other strings you are holding.

DISCUSS AND EXPLAIN

1. Which 'organisms' in the food web felt the tug on the string?
2. Which 'organisms' did not feel anything?
3. List two strengths in the design of this investigation.
4. Suggest a way in which this investigation could be improved to better model or simulate food web interactions.
5. Try out your suggestion to see how it works, making more modifications if required.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Construct a double bubble map to show some of the similarities and differences between carnivores and herbivores.

2 Give examples of a food chain and a food web.

3 Use a relations diagram or cycle map to show the role of decomposers in a food web.

4 Which organisms trap the energy from the sun?

5 Use a mind map, flowchart or another visual tool to describe how energy flows through an ecosystem. Add lots of colour and diagrams to your map. Compare your map with others in the class, and then make any changes or modifications you wish.

6 Construct a mind map to show the links between and key points about the following: producers, consumers, carnivores, herbivores, omnivores, decomposers, predators, prey.

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

8 Name the green pigment that can capture light energy.

9 Recall the word equation for photosynthesis.

10 Is being green essential to be able to photosynthesise? Explain.

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

12 Use a Venn diagram to compare producers and consumers.

THINK AND INVESTIGATE

13 In a team, think about and discuss the following 'what if' statements.
(a) The sun stopped shining
(b) All plants died
(c) There were no decomposers
(d) There were no carnivores
(e) There were no herbivores

14 Write down a food chain in which you are:
(a) a first-order consumer
(b) a second-order consumer
(c) a third-order consumer.

15 Give an example of each of the following.
(a) Competition between two carnivores
(b) Competition between two herbivores
(c) A predator and its prey

16 Try to draw a food chain that contains a fifth-order consumer.

17 Why do food chains rarely contain more than three levels of consumer?

18 Describe a situation in which an organism can be both a second-order consumer and a third-order consumer in a food web.

19 Draw a pyramid showing the numbers in a food chain in a parasite–host feeding relationship. How is it different from the predator–prey pyramid on page 124?

20 A number of years ago the insecticide DDT was used on farms to kill insect pests. Find out:
(a) why DDT causes a problem for consumers higher up the food web
(b) how DDT got into aquatic environments such as lakes and the ocean.

USING DATA

21 Genevieve and Callum made some observations over a period of a week about the feeding habits of a number of organisms in a small pond. Their results are listed below.

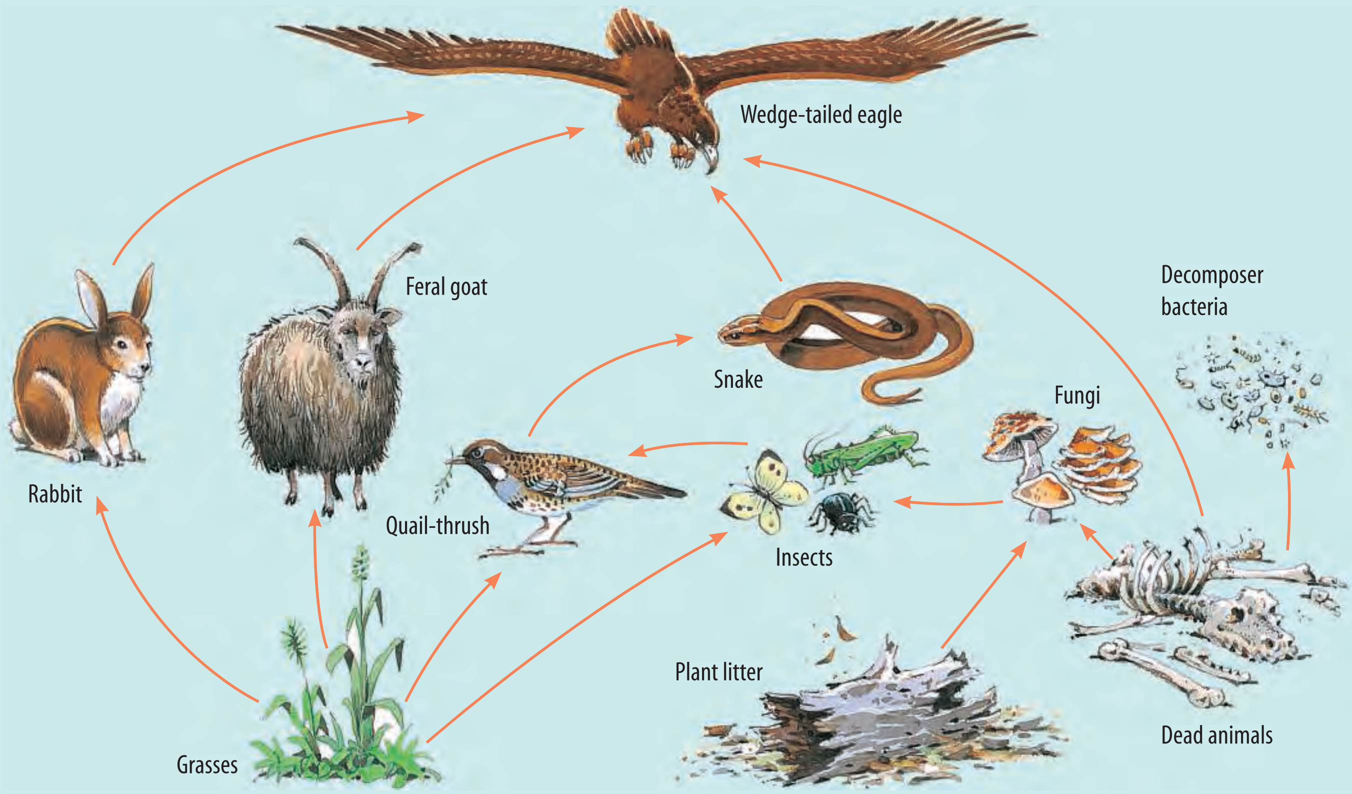
- Snails eat water plants and algae.
- Tadpoles eat algae.
- Small fish eat snails, algae and water plants.
- Larger fish eat snails, small fish and tadpoles.

Construct a food web using the information above. Start with the producers at the bottom and work upwards. Make sure your arrows face the right way.
(a) Which organisms are the producers?
(b) Which organisms are first-order consumers?
(c) Which organisms are both second- and third-order consumers?
(d) Which organism is an omnivore?
(e) Which organisms are predators of the snail?
(f) Which organisms are competitors of the tadpoles?
(g) What would happen to the water plants and the larger fish if the snails increased in number?
(h) What would happen to the snails and the larger fish if the small fish disappeared?

CREATE

22 (a) Draw a food web for a community of organisms in one of the following: your own garden, a forest, a desert, a river or a marina.
(b) Convert your food web into a mobile, model, rug or blanket.

23 Write a play about the flow of energy in ecosystems. Create puppets to represent various characters or features in your play and then act it out for the class.



24 For the food web above:
(a) construct three different food chains
(b) identify a producer
(c) identify a first-order consumer
(d) identify a second-order consumer
(e) identify a third-order consumer
(f) identify a decomposer.

25 (a) On your own or in a team, create a list of key terms and important information from this section.
(b) Use your list to construct a set of *Flowing on* flash cards. Add diagrams, symbols, colour or other details to your cards.
(c) Create a game that uses these cards to help other students learn about the flow of energy within ecosystems.
(d) Construct a rule book and other items essential for your game.

26 Write a play about a food web in an ecosystem and create puppets to act it out to the class.

eBook*plus*

27 Are carnivorous plants autotrophs or heterotrophs? You can find one answer to this by visiting the **Carnivorous plants** weblink in your eBookPLUS.

work sheets
4.2 Food webs
4.3 Ocean explorations
4.4 Nature pyramids
4.5 Food chains and food webs
4.6 Cycles in nature

Recycle me!

Tyrannosaurus rex stalked the Earth over 65 million years ago. We have found the bones, but what happened to the atoms that made up its flesh?

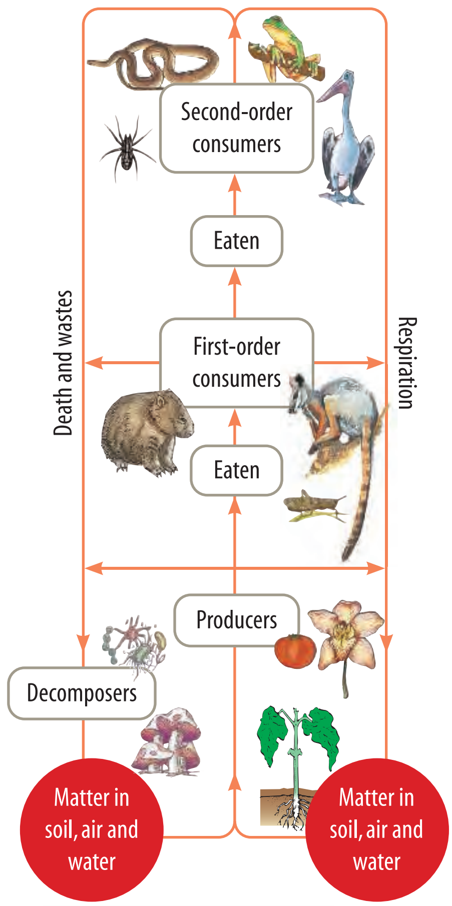
Saint Joan of Arc, a great military leader and religious visionary, was burned at the stake in 1431. What became of the atoms in her body? What will happen to the atoms in your body when you die? The answer to each of these questions is the same — they will be recycled.

You are what you eat

All living things are made up of atoms, as is the food that is consumed. Through the processes of digestion and absorption, some of the food atoms become atoms in your body. Not all of the food is digested and so some atoms simply pass through the body in the faeces. Atoms that are absorbed are used in the continuous processes of respiration, tissue repair and cell replacement.

Waste not!

These processes produce **wastes** that may be harmful to an organism. These wastes, also made up of atoms, are released to the environment. In animals, these include perspiration, urine and gases (including carbon dioxide and methane). Plants also release waste gases (carbon dioxide and oxygen) to the air and they often store other wastes in specialised cells and tissues inside the plant body. While an organism lives, it absorbs matter and rearranges that matter during the set of complex chemical reactions called **metabolism**. Some of the matter produced by metabolism is retained for a time and some of it is returned to the environment as waste matter. In this way, living organisms constantly recycle atoms.



Matter cycles through ecosystems

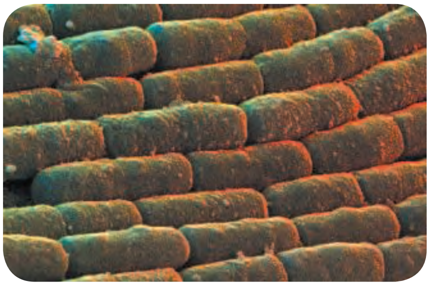
Cycles in nature

Three very important cycles explain how living organisms recycle atoms. They are the carbon cycle, the water cycle and the nitrogen cycle.

If an organism is burned after it dies, gases are released into the atmosphere, leaving behind ash. If a dead organism is simply left on the surface of its normal habitat, its remains will be consumed by other organisms. **Scavengers**, such as birds, fish, crustaceans or large insects, may break off parts of the organism for food. The organism may also be used as a food source by decomposers such as fungi, **protozoa** and bacteria. The flesh of the dinosaurs was recycled with the help of scavengers and decomposers.

Flies lay their eggs on dead and decaying animals. The eggs hatch into larvae that are called maggots. The maggots can quickly eat away large parts of a dead animal. The maggots grow up to become flies, which lay eggs somewhere else, or become food for other animals. This recycles the nutrients from the dead animal back into the ecosystem.

Worms are very effective recyclers. Worms eat just about anything and can do so quickly. They are especially good at recycling our food waste. Worms are found underneath dead organisms in the soil. They feed on animal and plant remains, recycling them into nutrients for plants.



Bacteria can grow on almost anything — dead or alive. They grow and reproduce very quickly. Bacteria reproduce by simply dividing in half. They feed on decaying material to help break it down and recycle nutrients for other animals. This photograph of bacteria was taken using an elecron microscope.

Mushrooms and toadstools are fungi that feed on dead material. Another variety of fungi is called mould and looks 'fuzzy'. Fungi grow microscopic threads into the food they are feeding on. These threads help to break down the dead organism. Fungi may become food for other animals, or they may decay. This allows the nutrients to be recycled back into the ecosystem.

INQUIRY: INVESTIGATION 4.6

Looking at decomposers

KEY INQUIRY SKILL:

- processing and analysing data and information

Equipment:

safety glasses
6 nutrient agar plates
fresh grass
grass that has recently died
decomposing grass
3 paper bags
forceps
Bunsen burner, heatproof mat and matches
stapler and marking pen
tape
stereo microscope or hand lens

- Sterilise the forceps by holding them in a Bunsen burner flame for one minute.
- Using the forceps, place a sample of the fresh grass in a paper bag. Fold the edge over several times and staple the fold securely closed. Label the bag 'fresh'.
- Resterilise the forceps and repeat the procedure above for the other two samples of grass. Label them 'dead' and 'decomposing' respectively.
- Place all three bags in a hot oven for 15 minutes.
- While the bagged samples are sterilising in the oven, use sterile forceps to gently wipe a sample of fresh grass over the surface of an agar plate, taking care to use the correct technique. (See the figure on the right.) Label this plate 'fresh U'. (U means unsterilised.)
- Resterilise the forceps and repeat the procedure for the other two samples of grass, labelling them 'dead U' and 'decomposing U' respectively.
- Using the correct technique (see instructions below left and figure below), gently wipe a sample of each of the three types of sterilised grass over an agar plate. Use a new plate for each sample. Label the three samples 'fresh S', 'dead S' and 'decomposing S'. (S means sterilised.)
- Incubate all six plates for 24 hours at about 37°C.
- Use a stereo microscope or hand lens to observe any growth of micro-organisms.

DISCUSS AND EXPLAIN

1 Which plate had the greatest amount of microbe growth?
2 Why were samples of each of the grasses sterilised?
3 Which type of microbe was more prevalent on the plates, bacteria or fungi? (Bacteria make smooth, shiny and usually round colonies, whereas fungi make fuzzy, irregularly shaped growths.)
4 What do your findings suggest?

Make sure that the lid of the agar plate is only slightly lifted as you rub the grass over the agar.

INQUIRY: INVESTIGATION 4.7

Sustainable cyberhunt

One of the simplest and best definitions of sustainability is 'to meet our needs in the present without compromising the ability of future generations to meet their needs'.

Choose a science cartoon from the internet that will illustrate an issue related to sustainability.

KEY INQUIRY SKILL:

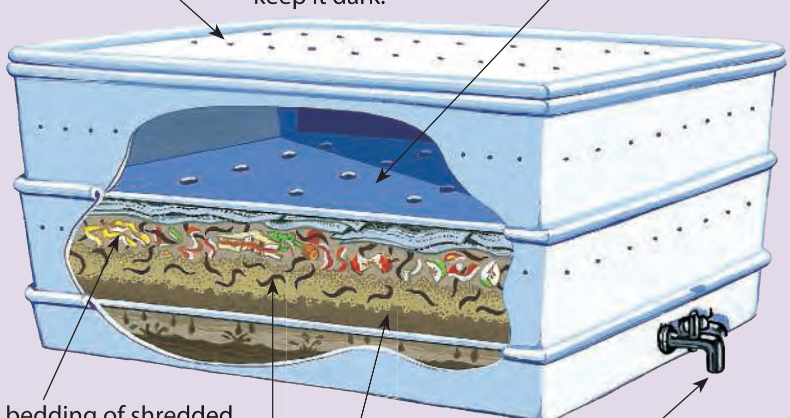
- communicating

- Choose a search engine such as Yahoo! or Google.
- In the search box, type 'science + cartoons' or 'science + environment' or 'science + sustainability' or 'cartoons + recycle'.
- Select 'images', then search.
- Choose a cartoon that you think makes an important point.
- Write a paragraph explaining what message the selected cartoon gets across and why it is funny.

HOW ABOUT THAT!

The amazing worm farm

About 60 per cent of our household rubbish can be used as worm food. Worms eat just about anything that was once living, including kitchen scraps, garden waste and manure. They love pizza and will even eat the box it comes in! Worms can eat about half their body weight in food each day. We can use a worm farm to feed our once-living rubbish to worms. This is how a worm farm works.



HOW ABOUT THAT!

Is it a boy? A girl?

Earthworms — like many flowering plants, snails and coral — are hermaphrodites. This means they have both male and female reproductive organs and so can produce both eggs and sperm. But earthworms still need mates to reproduce.

First, the earthworms swap each other's sperm, depositing it in special openings in the body. Then a swollen area near each worm's head, called a clitellum, produces a mucus that slides down over the head of the worm like a tiny tube. The worm lays a few eggs in it and adds a few of the sperm cells deposited by the other earthworm. Then the tube is tied off to form a little cocoon. If soil conditions and temperature are right, the embryos hatch in about three weeks.

eBook*plus* **eLesson**

Global warming in Australia

Learn why many scientists believe the Earth is getting hotter and how Australia is addressing this global problem.

eles-0057

HOW ABOUT THAT!

An entomologist is a scientist who studies insects. Sometimes entomologists are asked to provide information to help solve crimes. After a person or animal dies, insects are attracted to the corpse and feed on it. They lay their eggs in the corpse, and larvae eventually emerge from the eggs and develop into adult insects.

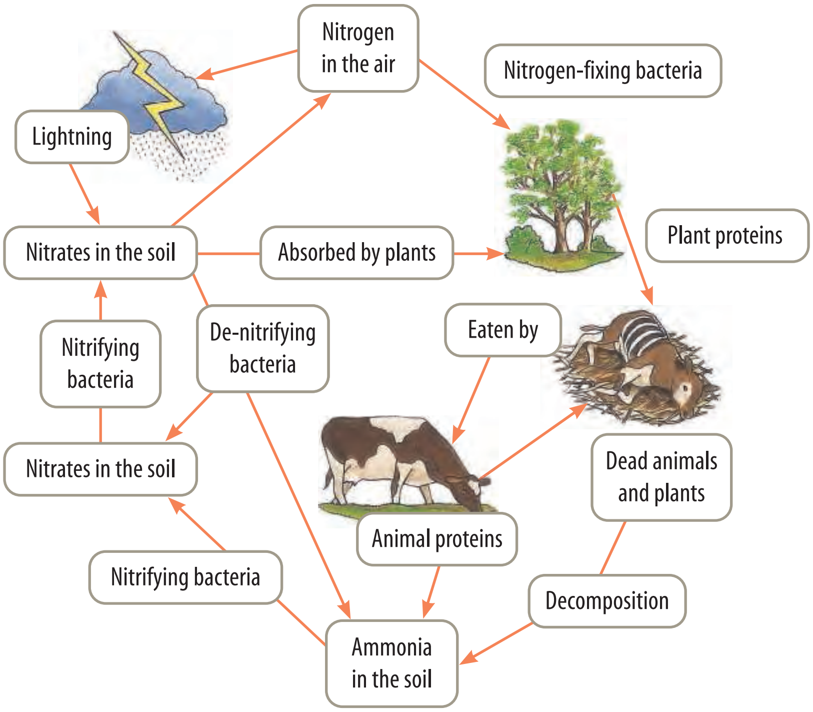
Over time, different types of insects colonise the body. By looking at the types of insects and what stage of their life cycle they are at, it is often possible to work out the time of death. It is sometimes also possible to find out other information about the crime from the types of insects that have colonised the body. If a body spent some time in a dry cool area before being buried in dry sandy soil, the insects living on it would be different from those that would be present if it had been buried in dry sandy soil straight after death.

Professor Jerry Butler is an entomologist. He is shown here examining hairy maggot blowfly larvae retrieved from a murder victim.

The nitrogen cycle

Nitrogen is an element that is essential to build proteins. Approximately 80 per cent of the air is made up of clear, colourless and unreactive nitrogen gas. Although plants and animals need nitrogen atoms for the production of protein, they are not able to absorb the nitrogen from the air to enable this to happen.

Certain bacteria, called **nitrogen-fixing** bacteria, are the only organisms on Earth capable of absorbing nitrogen and turning it into nitrates. Plants absorb nitrates from the soil and use them to build proteins. Other bacteria, called **nitrifying bacteria**, are also involved in the nitrogen cycle. When an organism dies, its proteins break down and the nitrogen-containing molecule ammonia (NH_3) is formed. This also happens when an animal's wastes decompose. Nitrifying bacteria turn the ammonia firstly into **nitrites** and then into **nitrates**. Nitrates can be absorbed from the soil water by the roots of plants. Plants then use the nitrates to make proteins. When an animal consumes a plant, it uses the plant proteins to make new animal proteins. A third group of bacteria, the **de-nitrifying bacteria**, are able to turn nitrates back into nitrites and ammonia, and even into nitrogen gas. This is not good for plant growth as it is the nitrates that a plant needs to make protein, not the nitrites. Nitrites are poisonous to plant growth. Nitrates can also be formed by lightning during storms which causes nitrogen and oxygen to react together.

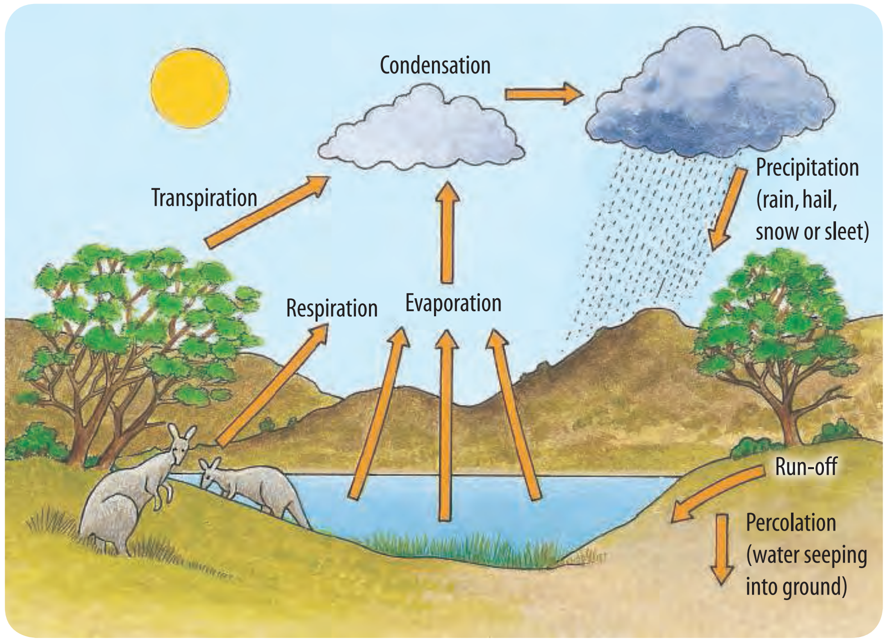


The water cycle

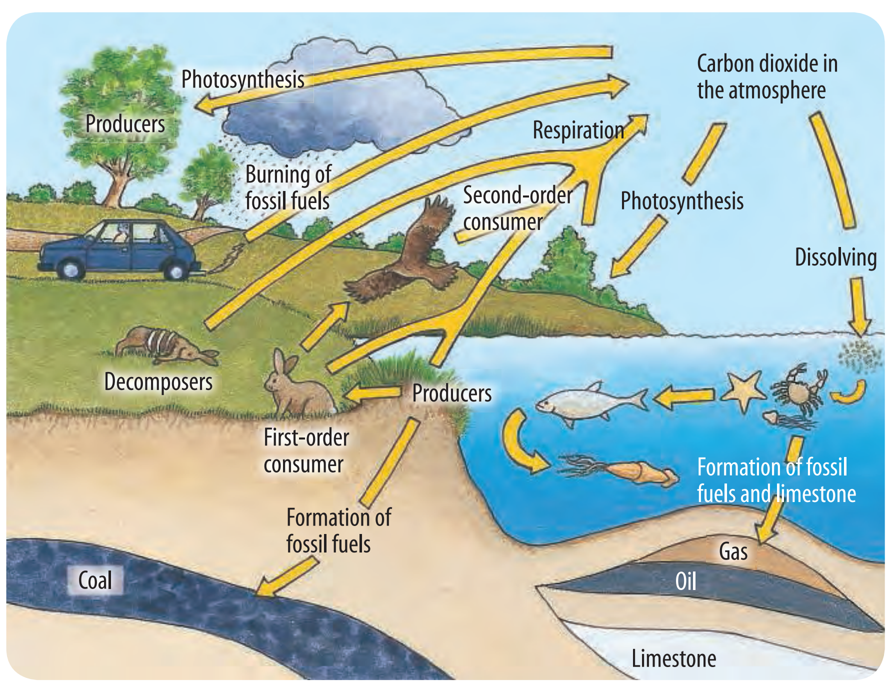
Water, warmed by energy from the sun, evaporates from lakes, rivers, oceans and the soil surface to form water vapour in the atmosphere. When the water vapour condenses into large droplets, rain falls on both land and water bodies. When rain soaks into the soil it becomes soil water. This water is found between the grains of soil and is taken up by plants. As it passes through plants, some of the water molecules are involved in the process of photosynthesis. The rest of the water molecules pass through the plant body and out through the stomata, to become water vapour in the atmosphere again. This process is called **transpiration**. Transpiration occurs because the sun causes water to evaporate from the leaves of plants. If it did not, water would not move up the inside of the plant.

The carbon cycle

Carbon atoms exist in the atmosphere in carbon dioxide gas. Carbon dioxide is absorbed by plants, where it is combined with water and turned into glucose molecules. After more chemical reactions, the carbon is stored in complex molecules in the plant body. When an organism consumes a plant it absorbs the plant's carbon atoms, which then become part of the organism's body. The carbon is found in the compounds that make up carbohydrates, fats and proteins. When organisms respire, the carbon atoms combine with oxygen atoms to form carbon dioxide, which is then released to the atmosphere. If plants or the **fossil fuels** that form from plants are burned, carbon atoms again combine with oxygen atoms to form carbon dioxide, which is released into the atmosphere. Carbon dioxide also dissolves in the sea. Here it is absorbed by sea plants and other sea organisms that photosynthesise. These producers are consumed by fish and other sea creatures, which are, in their turn, consumed by other organisms. Some of the carbon becomes part of coral reefs and shells, which, over millions of years, form limestone. Limestone is mined and, when heated in factories, releases carbon dioxide to the air, where it can again be absorbed by plants.



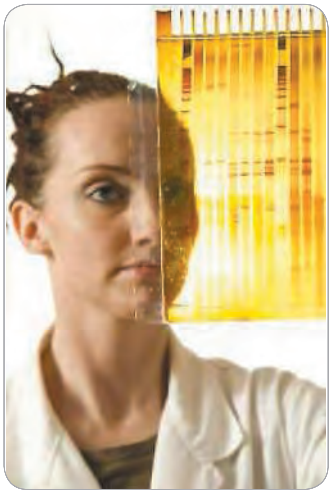
The water cycle



The carbon cycle

Stinky forensics

Dr Rachel Parkinson is investigating the bacterial species that decompose bodies and researching whether the types of different bacteria can provide information about when a person died. Instead of using human bodies in her research, she uses the decomposing bodies of pigs. She is getting used to the smell and the maggots, but still holds her breath a lot. Her research has shown that the same combination of bacteria breaks



down the bodies of both humans and pigs. She has also found that the types of bacteria involved in the decomposition change over time, providing some information as to possible times of death. Dr Parkinson suggested that this was because once one type of bacteria has used its specific food source, it dies off and is replaced by another.

eBook plus **eLesson**

Reducing your carbon footprint

Find out 10 practical tips to help you do your bit to stop global warming.

eles-0163

UNDERSTANDING AND INQUIRING

REMEMBER

1 List the wastes that can be produced by animals.

2 If a dead organism is burned, what are the two main chemicals that are released to the atmosphere?

3 What happens to an organism that is buried?

4 What does a decomposer organism do? Give an example of a decomposer organism.

5 Name the process that removes carbon dioxide from the air and converts it to food.

6 Why is transpiration necessary in plants?

7 Which organisms are responsible for absorbing nitrogen from the air?

8 Why do animals and plants need nitrogen?

THINK AND DISCUSS

9 Explain the difference between nitrogen-fixing bacteria, nitrifying bacteria and de-nitrifying bacteria.

10 Explain the role played by photosynthesis in the carbon cycle.

IMAGINE

11 Write a short story that describes what may have happened to the carbon atoms in Leonardo da Vinci's body when he died.

12 Imagine that suddenly all the nitrifying bacteria on the planet were killed by a mystery virus. Write a paragraph describing the effects of this global disaster.

CREATE

13 Create a poster of the water, carbon or nitrogen cycle. On your poster, follow the passage of one particular atom, explaining the changes that it experiences.

INVESTIGATE AND DESIGN

14 Find out why the bones of the dinosaurs were not decomposed by micro-organisms.

15 Things that can be broken down by decomposers, such as paper and food scraps, are described as biodegradable. Plastic bags and foam packaging are described as nonbiodegradable.
(a) Find out why nonbiodegradable items are not broken down by decomposers.
(b) Create an advertisement that may influence people to use fewer nonbiodegradable items.
(c) Suggest advantages and disadvantages of using paper bags instead of plastic bags.
(d) Design your own biodegradable carry bag.

16 (a) Some types of worms are better recyclers than others. Design an experiment to test how good different worms are at recycling food scraps.
(b) Investigate the structure and systems of worms and their requirements for life.
(c) Investigate worm farm designs.
(d) Design and construct a worm farm for your class. Use lunch scraps to feed your worms.
(e) Decide on questions that you could research with your worm farm.
(f) Construct a PMI chart about worm farms.

17 Research an issue related to Earth cycles, recycling or sustainability, and create a written report, multimedia presentation, web page, poster or drama script to present your findings.

18 Research examples of forensic succession and prepare your findings as a police report.

19 Find out more about the field of forensic entomology. Report your findings as a job advertisement.

Bush tucker

Before European settlement over 200 years ago, Aboriginal Australians were able to obtain a balanced diet from the bush.

Whether they lived by the sea, on the banks of a river, high in the mountains or in the desert, they successfully gathered and hunted food. Traditional Aboriginal communities still obtain a balanced diet from 'bush tucker'. The photograph on the top of the next page shows a selection of colourful and nutritious bush tucker.

Old know-how

Aboriginal people hunted for almost any available animal. They knew the habits of the animals and kept a close watch on changes in the weather and plant growth. Their knowledge and skill allowed them to hunt very successfully. Aboriginal Australians were also skilled gatherers of food. They obtained shellfish, nuts, berries, fruits, waterlily stems and roots, ants and much more. They knew which foods were poisonous and were able to prepare some of these so that they could be eaten safely.

Some of the early European settlers and explorers learnt some of the traditional Aboriginal bush tucker skills, but most didn't bother. The explorers Burke and Wills died of starvation in central Australia on their return journey to Melbourne in 1861, even though seeds, roots and grubs eaten by the local Aborigines were available.

A witjuti grub — regarded as a delicacy in drier areas

Essential water

Water, of course, is scarce in most areas of Australia. Aboriginal people knew how to obtain water in even the most arid areas. They knew where to dig in dry creek beds and were able to obtain water from tree roots, tree stems, frogs and other animals. Aboriginals cut tree roots into small sections and sealed the ends with clay to store water.

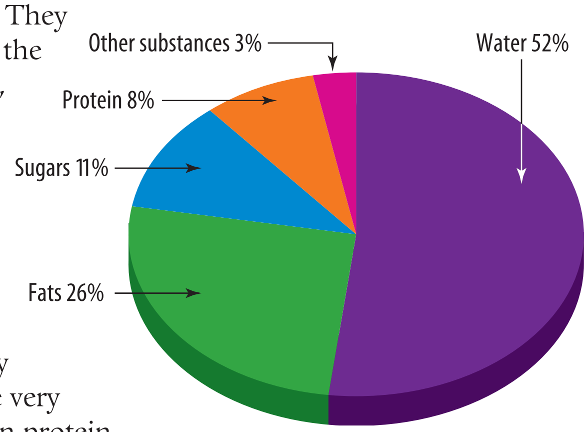
Witjuti tucker

Witjuti grubs were regarded as a delicacy in drier areas. They could be obtained from the roots and stems of trees, especially the witjuti bush, after which they are named. Witjuti grubs are the white larvae of beetles and can be up to 13 cm long. They live off the sap of the trees that they live in. Witjuti grubs are very nutritious and are rich in protein, fat and sugars. They are also good sources of iron, calcium and water.

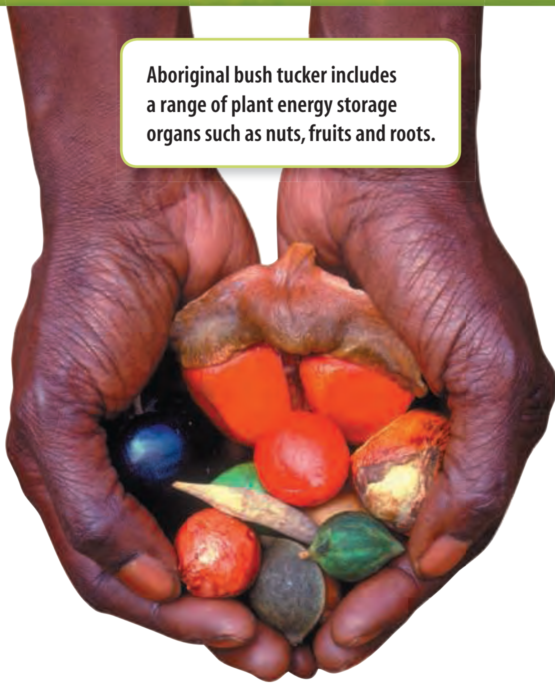
Plants — living warehouses

Plants also store material for future use, often in special storage areas which are formed when that part of the plant swells up. The stems, roots or leaves may be involved in storage. The main form of storage in plants is carbohydrate stored as **starch**. Other forms of carbohydrate, protein and fat can also be stored. **Sucrose** is stored in the stems of sugarcane and **glucose** in grapes.

A potato is actually an underground stem swollen with starch; a carrot is a specialised storage root; rhubarb and celery are storage-filled leaf stalks; and an onion is a swollen mass of leaves. Vegetarians make use of the **protein** stores in various seeds, grains and nuts to make up for the protein that would otherwise be provided by meat. Nuts are also known for their storage of fats and oils and are hence a source of concentrated energy.



Average body composition of a witjuti grub



Aboriginal bush tucker includes a range of plant energy storage organs such as nuts, fruits and roots.

A considerable number of plant storage organs are found in an Australian bush tucker menu. For example, cycad nuts, bush potatoes and several types of yams and seeds provide a variety of nutritional energy sources when properly prepared.

Dugong gone?

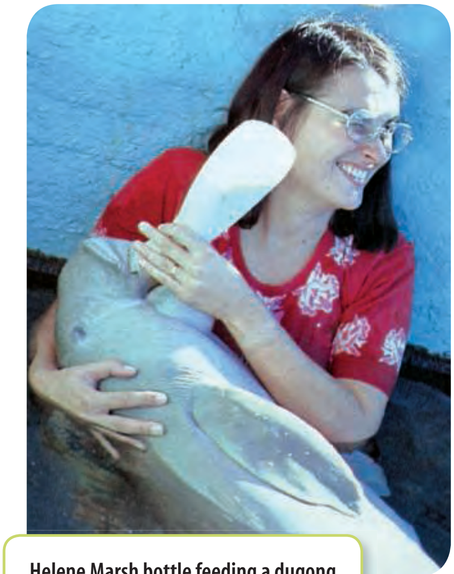
Dugongs are fully marine animals, with a flattened tail and cow-like appearance. They are thought to be the source of myths about mermaids, and they feature in the creation stories of many Indigenous peoples across northern Australia.

Dugongs are now considered endangered. Although they can live for up to 70 years, they have a slow reproductive rate, long gestation period and slow growth rate. Their coastal habitats are being destroyed, and they have been hunted for food and accidentally captured in fishing nets.

For some coastal Australian Aborigines and Torres Strait Islanders, dugongs have been a highly prized source of meat. In the past, white settlers were allowed to hunt them for food, hide and oil. However, it is now legal only for Indigenous peoples to hunt them, and only if they use traditional methods of hunting. Even with these restrictions, dugong populations in some regions are dwindling to dangerous levels.

HELENE MARSH

Professor Helene Marsh studies dugongs. A dugong is a type of mammal that lives in the ocean and feeds on seagrass. Her research initially involved studying the carcasses of dugongs that had died in shark nets. She worked out a way of estimating the age of dugongs by studying their tusks. Later, she focused on the reproductive cycle of dugongs. Helene has also been involved with estimating the abundance of dugongs in various areas using aerial photographs. By measuring the abundance of dugongs regularly, it has been possible to identify areas where dugong numbers are falling and suggest strategies to maintain dugong numbers.



Helene Marsh bottle feeding a dugong

Healthy tucker

In 2009, the CSIRO produced a research report on the presence of 'health-enhancing compounds' in a variety of native herbs, spices and fruit samples. They reported that the 'bush foods' sampled were exceptionally rich sources of antioxidants, folate, iron and vitamins C and E.

Grow your own?

Interest in 'bush tucker' or Australian native foods is increasing. Some Australians are even taking on the challenge

Some of the findings of a 2009 CSIRO report on Australian native foods

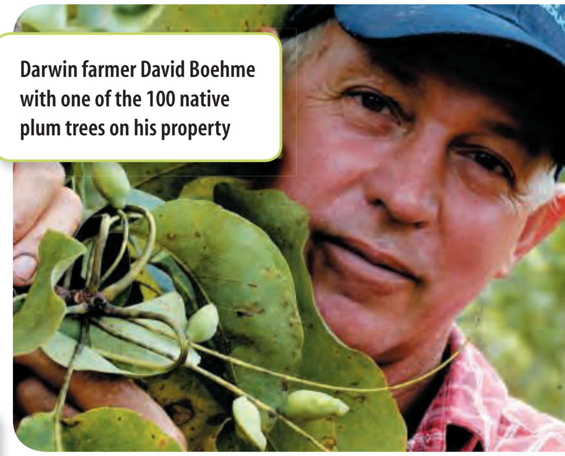
'Bush food'	High in antioxidants	High in vitamin C	High in folate	High in iron
Kakadu plum	✓	✓	✓	
Quandong	✓		✓	✓
Tasmanian pepper leaf	✓		✓	✓
Lemon myrtle	✓		✓	
Australian desert lime		✓	✓✓	

Matthew Koop — a quandong pioneer?

of trying to grow native foods themselves. Matthew Koop is one such pioneer. Matthew believes that he is the sole commercial quandong harvester in Victoria. These tangy-fleshed stone fruits are native to Australia's central deserts and southern arid regions.

Kakadu plum trees may be another native plant that we could see growing in orchards in the future. Dave Boehme, a Darwin farmer, believes that this plant has the ability to be grown successfully in remote communities and may be a very successful indigenous horticultural project. Increased interest in bush foods may see many more of our Australian natives cultivated to become viable economic enterprises.

Quandongs



Darwin farmer David Boehme with one of the 100 native plum trees on his property

UNDERSTANDING AND INQUIRING

REMEMBER

1 Outline examples of knowledge and skills that Aboriginal Australians traditionally used to help them achieve a balanced diet.

2 State where witjuti grubs may be found and what they look like and suggest why they are described as being very nutritious.

3 Describe how Aboriginal Australians living in arid areas find enough water to survive.

4 Construct a matrix table to show the similarities and differences between potatoes, carrots, rhubarb, celery and onion.

5 Bush tucker can provide a balanced diet. Give examples of bush foods that contain:
   (a) protein
   (b) carbohydrate
   (c) fats and oils.

6 Construct a Venn diagram to compare the following.
   (a) Kakadu plums and quandongs
   (b) Lemon myrtle and Tasmanian pepper leaf

7 (a) Describe the distinctive features of dugongs.
   (b) Suggest reasons why dugongs are endangered.
   (c) Which groups of people in Australia are allowed to hunt dugongs and why?
   (d) Which part of the dugong was used to determine its age?
   (e) Explain the purpose of using aerial photographs in dugong research.

INVESTIGATE, DESIGN AND CREATE

8 Find out and report on research into Australian native plants as a source of food or medicine. Display your findings in a brochure, story book or journal article.

eBook*plus*

9 Use the **Bush foods extravaganza** weblink in your eBookPLUS to research examples of bush tucker recipes and create your own recipe book. (**CAUTION: Take food allergies into careful consideration when planning your recipes.**)

INVESTIGATE AND SHARE

10 Investigate how Indigenous land management practices can help inform sustainable management of the environment.

11 What do you think about hunting dugongs? Who should be allowed to hunt them? How many should be taken, when and why? Research dugong hunting, then share your findings and opinions with your team. Organise a class debate on an aspect of dugong hunting.

12 Dugongs feature in the creation stories of many Indigenous peoples across northern Australia. Find out more about one of these stories and present it in a creative way to your team or class.

13 The tears of baby dugongs have been sought as an aphrodisiac. Share your research on dugong tears with your team and collate your team research into a report that uses the six thinking hats.

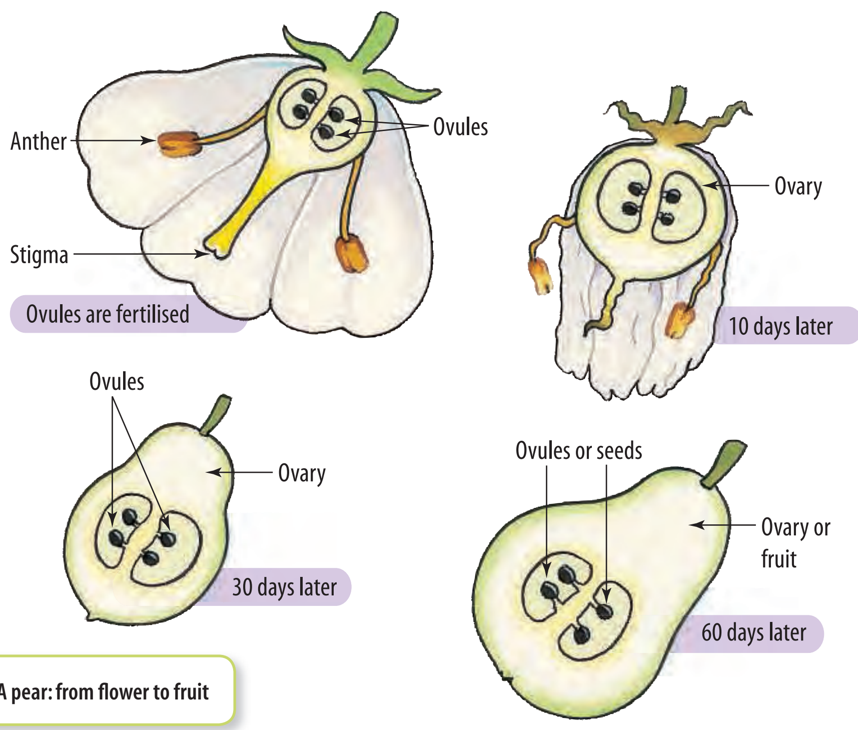
4.5 SCIENCE UNDERSTANDING

Plant tales

Are you aware that when you bite into an apple, cherry or orange you are actually eating the enlarged ovary of the plant? Did you know that these swollen ovaries contain the plant's 'babies' in their embryonic form? The plants are using you as a way of distributing their 'young' out into the world.

Eggs, embryos, seeds and fruit

Once the flower has done its job and the egg cell has been fertilised by the **pollen** nucleus, another sequence of events takes place. The fertilised egg, in the middle of the **ovule**, divides into a little ball of cells that becomes an **embryo**. Special tissue called **endosperm** surrounds the embryo and supplies it with food.



A pear: from flower to fruit

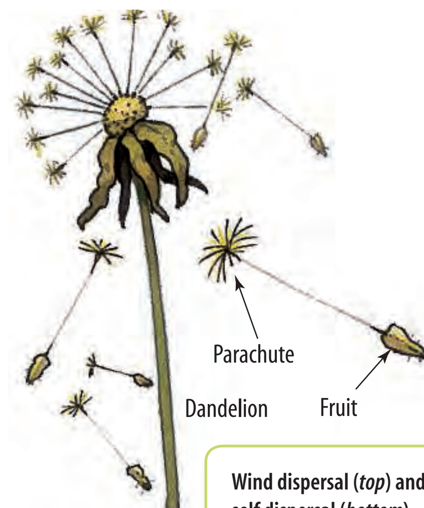
The ovule becomes the **seed** and tissue forms around it to provide a protective **seed coat**. During the formation of the seed, the ovary expands and turns into a **fruit**.

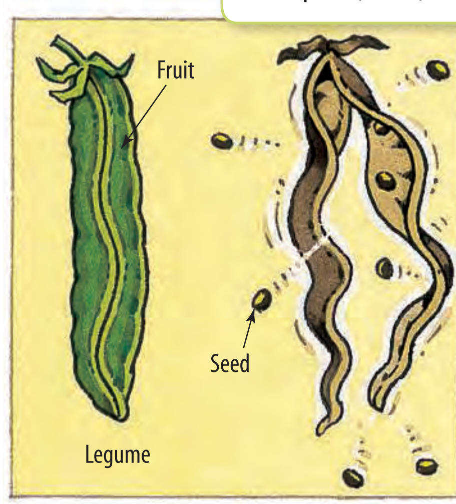
Seed dispersal

One of the main jobs that fruits do is to help disperse or spread the seeds. There is a variety of ways in which plants disperse their seeds: dispersal may involve animals, including birds (such as in tomatoes, grapes and apples); water (such as in coconuts); or wind (such as in grasses and dandelions). Some plants can disperse their seeds by themselves. For example, the fruits of some plants in the pea family (legumes) split open suddenly when they are ripe and dry, throwing the seeds out for long distances.

HOW ABOUT THAT!

Fruits that attract animals are usually brightly coloured. When a fruit is eaten by an animal, only the soft parts of the fruit are digested. The seeds are not broken down inside the animal and are passed out in its faeces.

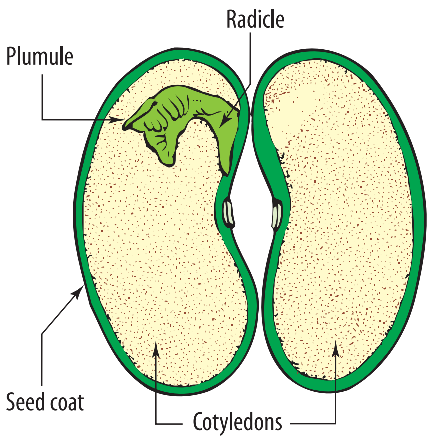




Wind dispersal (*top*) and self dispersal (*bottom*)

Seeds and germination

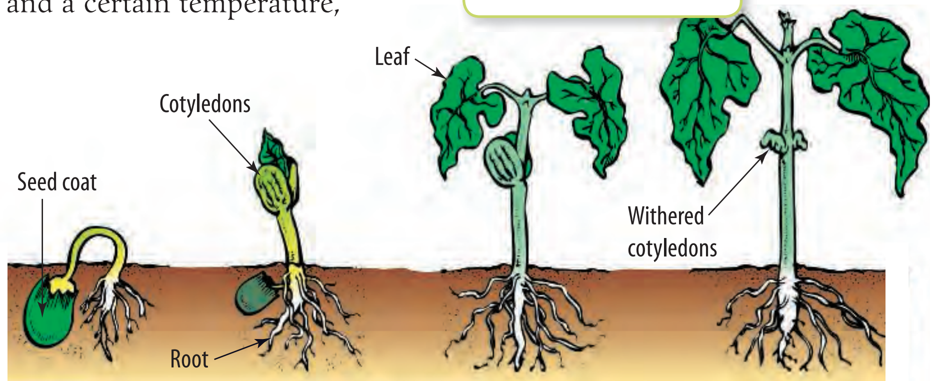
The embryo, inside the seed, is made up of three different parts: the baby shoot (**plumule**), the baby root (**radicle**) and one or two thick, wing-like **cotyledons**.



When the conditions are right, the seed bursts open and a new plant grows out. This process is called **germination**. When germination is complete, the embryo has become a young plant or **seedling**.

There are three environmental conditions that are needed by all seeds before they will germinate: water, oxygen and a certain temperature, usually warm. Water is necessary for the seed to swell and burst open and then to transport food to the growing embryo. Oxygen is required to help provide the energy needed for growth and development. The temperature varies with the particular type of plant.

Germination of a broad bean



INQUIRY: INVESTIGATION 4.8

Sunflowers and maize seeds — watch them grow

KEY INQUIRY SKILLS:

- conducting
- processing and analysing data and information

Equipment:

2 maize seeds and 2 sunflower seeds (all soaked for at least 24 hours)

transparent glass jar with a lid

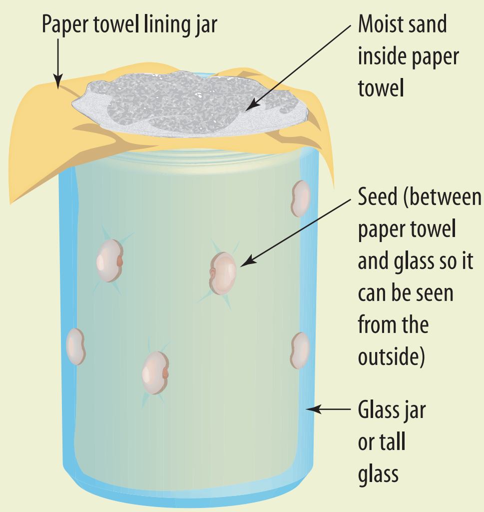
blotting or absorbent paper

hand lens or stereo microscope

- Closely examine the soaked seeds.
- Place some absorbent paper around the inside of the clean, dry glass jar.
- Carefully push the four seeds down between the paper and the jar (each about one-quarter of the way around).
- Pour water into the jar to a depth of about 3 cm.
- Make some holes in the lid, then screw it onto the jar.
- Carefully observe the seeds each day.

DISCUSS AND EXPLAIN

1 Sketch each seed, recording as many observations as you can.



2 Make detailed drawings of each seed and describe its development.

3 Record observable shoot and root measurements each day in a table.

4 Did the two different types of seed grow the same way? Describe the similarities and differences.

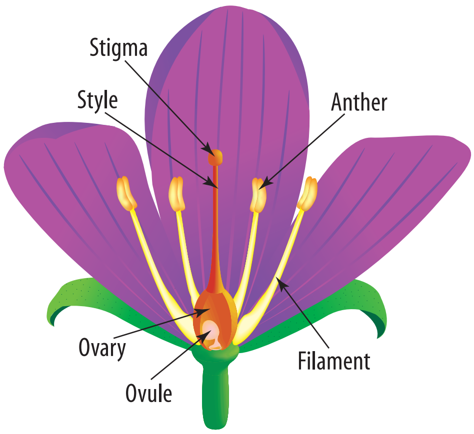
5 Summarise your measurements in a graph.

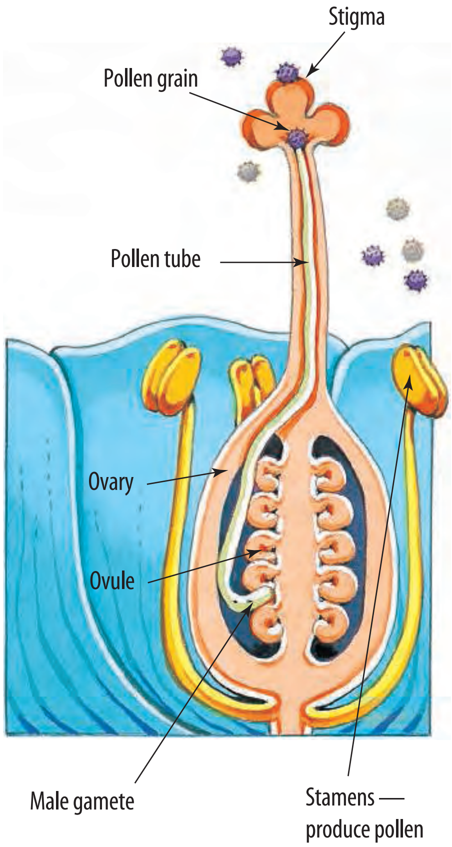
6 Did you obtain the results that you expected? Explain.

7 Write a conclusion on the basis of your findings.

Some Australian plants, such as *Banksia* and mountain ash (*Eucalyptus regnans*), require high temperatures to burst the fruit so that the seeds may be released. This adaptation gives these plants an excellent chance of survival in regions prone to bushfires.

Although light is not necessary for the germination of most seeds, it is needed once the young shoot breaks through the soil surface so that the plant can make its own food.

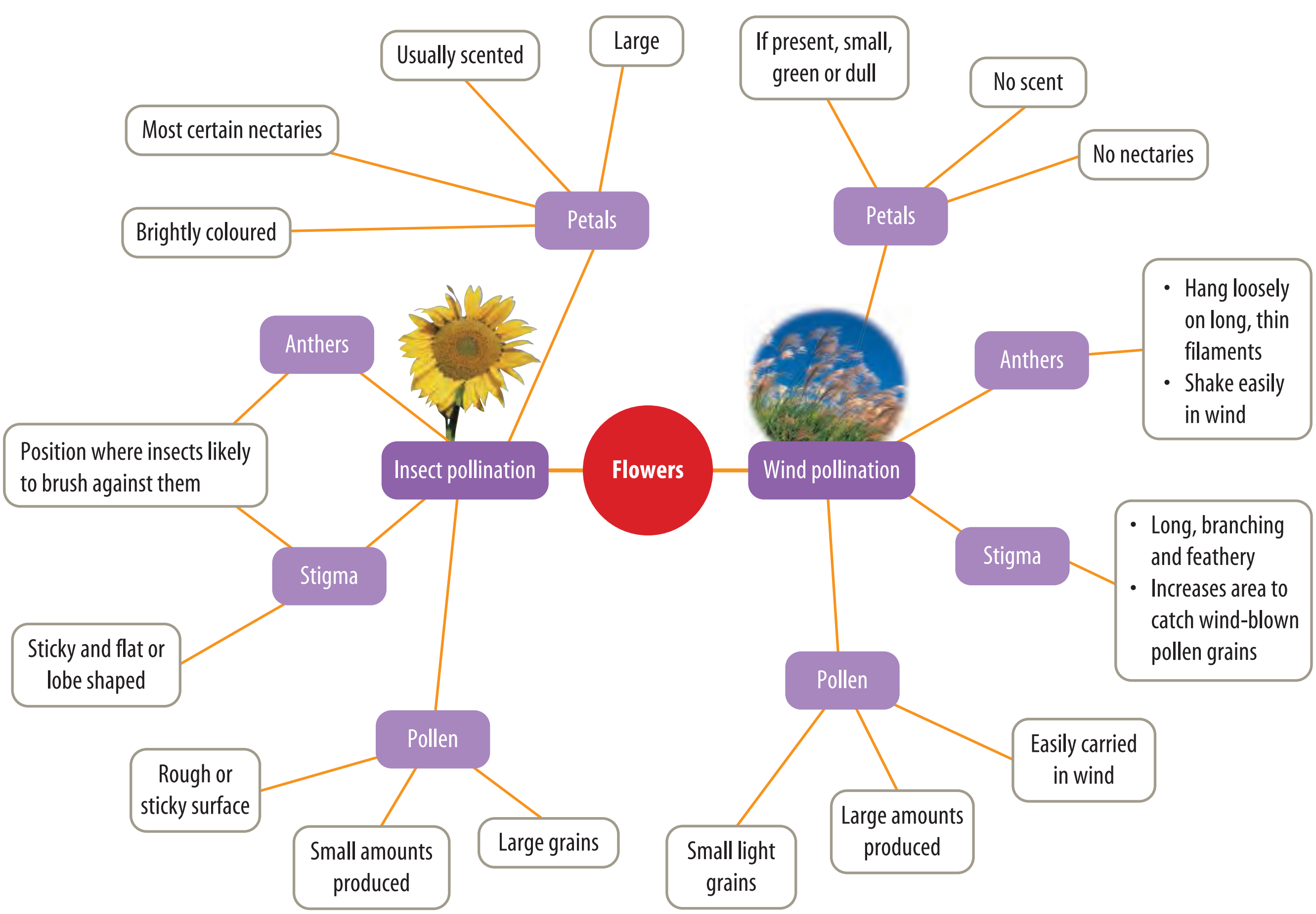




Pollination pathways

Like animals, many plants can reproduce sexually. Flowering plants have their reproductive structures located in their flowers.

Pollination occurs when pollen grains reach the **stigma**. Plants may pollinate themselves (self-pollination) or they may obtain pollen from a flower of another plant of the same species (cross-pollination). Cross-pollination increases the variation among the offspring and gives the species a better chance of survival.



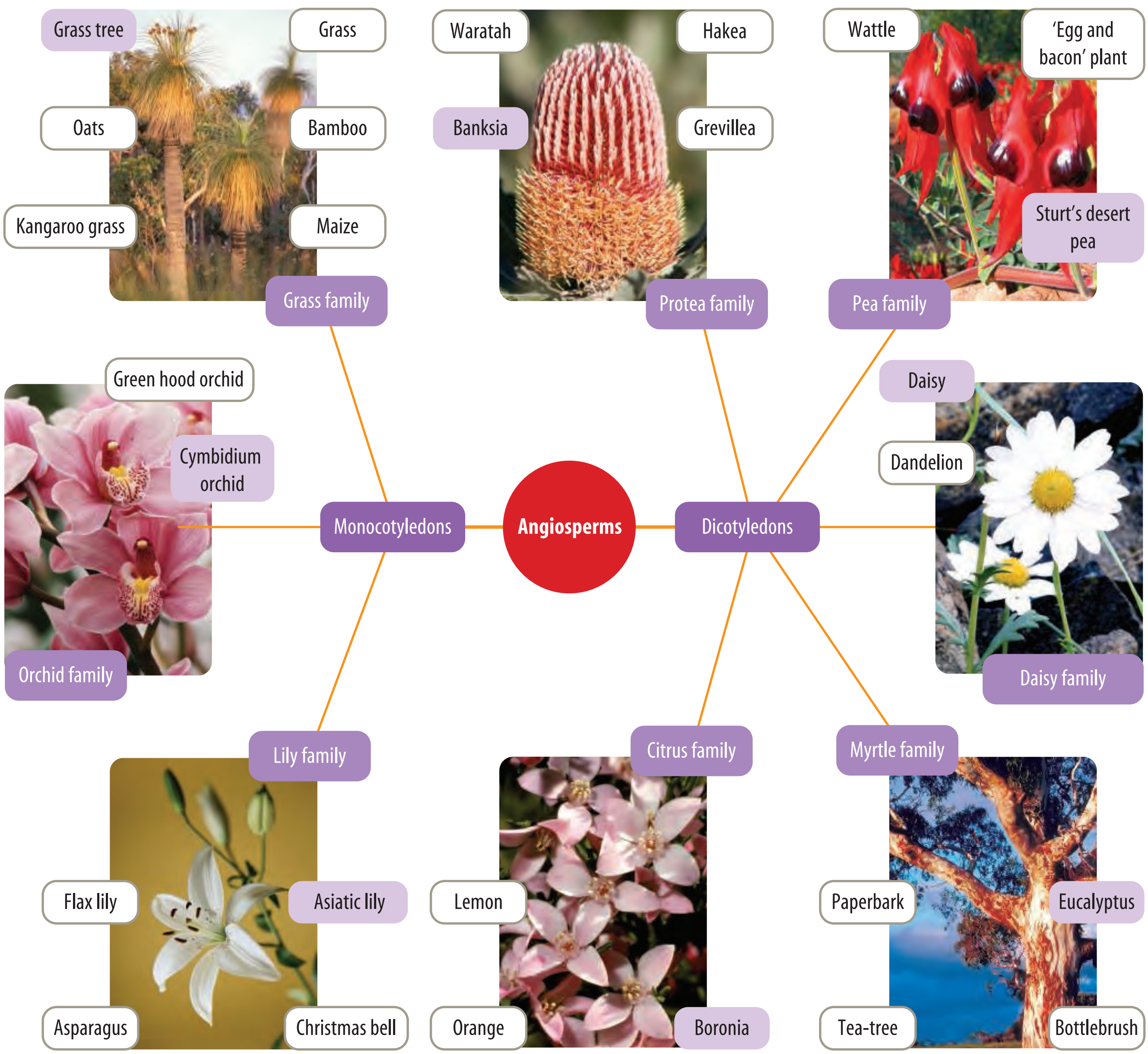
The plants that produce flowers are called **angiosperms**. Angiosperms reproduce sexually, and have flowers that produce seeds after fertilisation. Inside each seed is an embryo plant which has one or two seed leaves called cotyledons. Plants with one cotyledon are called **monocotyledons** (monocots) and those with two cotyledons are called **dicotyledons** (dicots).

HOW ABOUT THAT!

Using flowers to tell the time

You may have noticed that most flowers open in the morning and remain so throughout the day. Some plants, however, have flowers that open at particular times. Carl von Linné (1707–1778), a well known Swedish naturalist, was one of the first to study the opening and closing of flowers. He even arranged a flower clock which showed some typical opening times of flowers. Some opening times are shown in the table on the right.

Time of flower opening	Common name
4 am	Tall morning glory
5 am	Corn poppy
	Pumpkin
6 am	Fireweed
	Chicory
7 am	Coltsfoot
8 am	Marsh marigold
6 pm	Evening primrose
7 pm	Catchfly



INQUIRY: INVESTIGATION 4.9

Practising botanists

KEY INQUIRY SKILLS:

- processing and analysing data and information
- evaluating

Equipment:

5 pieces of blank A4 paper
pencil

SOME WORDS OF WARNING:

1 Be responsible in your fieldwork and handle the plant parts very gently and carefully.
2 Do not pick, break, tread, trample or climb the plants.
3 Remember that you are dealing with living things.

- Find five plants, each with different types of flower.
- Using a separate page for each plant:
  (a) at the top of the page
  — record your name and the date
  — record the plant's name, or, if unknown, record it as 'specimen A, B, C' etc.
  — give a general description of the location in which the plant is found.
  (b) divide the rest of your A4 sheet into three sections:
  (i) half-page sketch of a flower
  — Try to show the parts listed in the table on the opposite page and label them.
  — Count or estimate how many stamens, stigma, petals and sepals are present.
  (ii) quarter-page sketch of a leaf — include any veins that you see.
  (iii) quarter-page sketch of the plant's overall appearance.
- Record the colour, scent (also give a mark out of 10 for its strength), and the texture and shape of the flowers, leaves and stems next to your diagrams.

DISCUSS AND EXPLAIN

1 Suggest which of the plants were likely to be pollinated by insects or the wind, or by other means. List this information in a table. Give reasons for your suggestions.
2 For those plants that you suggested were insect-pollinated, suggest a type of insect that may pollinate them. Give reasons for your suggestions.
3 Suggest which plants are monocots and which are dicots and give reasons for your suggestions.
4 What difficulties did you encounter when doing this activity? Suggest how they might be overcome (or any improvements) if you were to do it again.
5 Design a field guide, cluster map, classification key or multimedia summary that could be used to separate and describe the plants you observed.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Which part of the plant is the fruit?
2 What conditions are needed for germination?
3 Why is light usually necessary only once the plant has germinated?
4 If birds eat the seeds of fruit, how can the seeds be dispersed?
5 State the names of the two main groups of angiosperm.

INVESTIGATE AND DESIGN

6 Design an experiment to see whether water affects the germination of a variety of different types of seeds.
7 Find out more about the seed dispersal of five different types of plants and report your findings in a visual map.
8 Find out more about each of the different families of plants listed in the diagram on the opposite page. Present your information in a poster.
9 Find out other differences between monocotyledons and dicotyledons and communicate your findings in a matrix table.
10 Not all plants are welcome in Australia. Some plants have been identified as Australian 'weeds of national significance'. Features shared by these plants relate to their invasiveness, their potential to spread and their effect on primary production and the environment.
(a) Find out the names of five plants on the Australian government's list of twenty 'weeds of national significance'.
(b) Select any plant on this list and complete the following in a brochure or electronic format.
(i) State the common and scientific names of the plant.
(ii) Describe the plant (include size, shape, structures and colour).
(iii) Describe the distribution of this plant in Australia.
(iv) Outline some interesting points about this plant.
(v) Suggest why this plant is considered to be a weed.
(vi) Suggest ways to control or eliminate this weed in Australia.
(vii) Use a relations diagram or algorithm to suggest possible consequences of removing this weed from Australian ecosystems.

Another beanstalk story

Bean plants grow quickly. Here is your chance to think like a scientist and design and carry out your own investigation about the growth of bean plants.

Planning your investigation

In planning your investigation, you need to ask yourself some key questions.

1 What is your research question? What do you want to find out? What 'one thing' do you want to change to see what effect it has on some 'other thing'?

Answering these questions will help you to answer the next questions concerning which variable you will deliberately change (**independent variable**), which you will measure (**dependent variable**) and which you will keep the same or constant (**controlled variables**).

2 What is the one thing you are going to change?

In designing your investigation you should change only ONE variable at a time. The variable that you deliberately change is called the independent variable.

3 What thing are you going to measure?

The variable that you measure is called the dependent variable.

4 What other variables are there to keep the same? How can you keep them the same?

It is important to keep the variables that you are NOT investigating the same. These are called controlled variables. This increases the chance that it is the variable you are changing that is causing the effect you are measuring, rather than some other variable.

5 How can you make sure that the investigation is fair and not a 'fluke' or mistake?

A control enables you to see whether the independent variable has an effect on the dependent variable and provides a baseline for comparison. A large sample size and repeating the investigation decreases the chance that your findings were a fluke or due to a mistake. It also helps to reduce the effects of individual variations that may occur in your data.

6 What is your prediction as to what the answer to your research question might be?

A **hypothesis** is an educated guess or prediction of what the results of an investigation may be. An example is 'that bean growth is faster when watered with tap water rather than salt water' or 'that bean germination decreases with increasing salt concentration'.

You need at least two groups of plants.

7 What materials and equipment do you need for your investigation?

Once you have decided on the variables in your investigation, you can write a list of what you will need to perform it. Include quantities and specific descriptions so that you remember to keep your controlled variables constant.

8 What are you going to do in your investigation? What steps are you going to follow?

By having your steps clearly outlined you could repeat the investigation in exactly the same way if you were to do it again. This is your **procedure** or **method**. Others could repeat it as well. If you make any changes to your plan when you are conducting your investigation, make sure you make a record of them. If you are using bean seeds, remember to soak your bean seeds (10 seeds or more) in a dish of water overnight. There are some examples of set ups for you to consider in the figures below.

Step 1

Press a hole about 2 cm deep into the potting mixture with a pencil.

Step 2

If you are planting more than one plant in each container, mark the position of each seed by sticking a toothpick beside it.

Step 3

Label your container with your name and the date and any other vital information, e.g. 'salty water', 'red light'.

Step 4

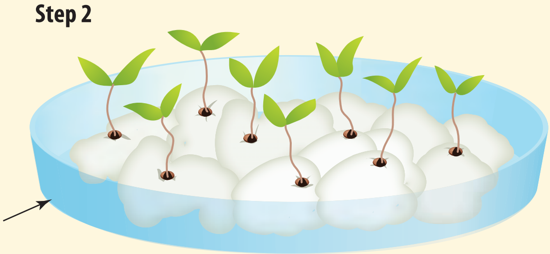
Water your seeds, but take care not to overwater! Leave your seeds in a warm and sunny position.

Planting your seeds

Step 1

Put some cotton wool in a Petri dish or plate. Add enough water to moisten the cotton wool. Place the pre-soaked seeds on top of the cotton wool.

Step 2



Water the seeds as required to keep the cotton wool moist, but do not overwater as mould will grow on the seeds.

Another way to set up your experiment

9 What are you going to record and how are you going to record it?

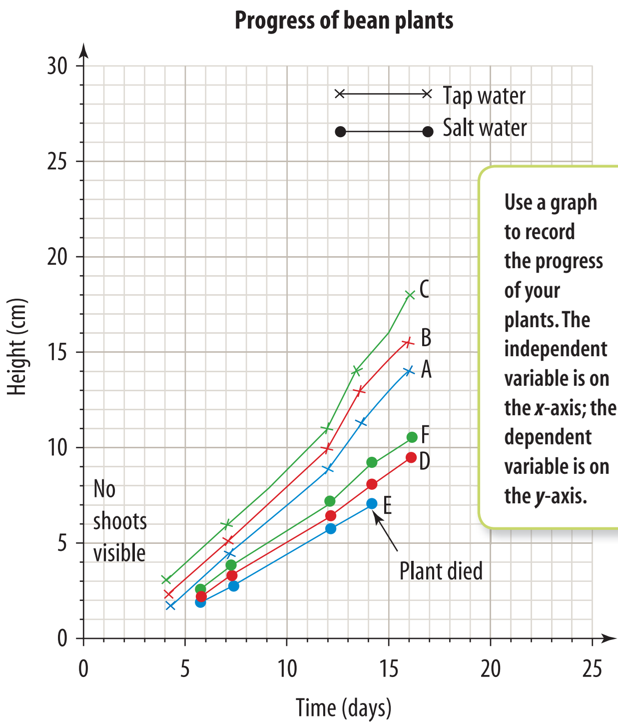
In your procedure you should have outlined *what you intended to measure* and *how you intended to measure and record it*. The details that you record are your **results** or **data**. You may decide to record your results in a table similar to the one shown below or you may use a journal or diary to record observations as diagrams with descriptive labels and measurements.

Date	Day	What I did	Height of seedling (mm)												Observations and diagrams
			Tap water						Salt water						
			A	B	C	D	E	Ave.	A	B	C	D	E	Ave.	
5/3	10	Watered all plants at 3 pm; gave each plant 50 mL water	7.1	8.0	8.9	7.5	8.2		5.0	4.4	5.8	4.8	5.2		

Sample table. This table could be used to record the results for an experiment to find out whether watering plants with salt water affects their growth.

Reformatting your data

While your bean plants are growing, you can record their progress on a line graph such as the one below. This graph shows how the height of two groups of plants changes. If any of your plants die, your investigation is not a failure. You should, however, make a reasonable attempt to suggest why they died.



Use a graph to record the progress of your plants. The independent variable is on the *x*-axis; the dependent variable is on the *y*-axis.

By changing the format of your data into graphs, it can help you see patterns. It will make it easier for you to make conclusions about your data.

Writing your report

In reporting your investigation to others, you should use the headings listed below. You will find a description of what should be included under each heading on page 20 of this book.

- Purpose or aim (you may include your research question or hypothesis)
- Procedure (materials and method)
- Results (all of the data that you have collected including graphs, diagrams and tables)
- Discussion (comments on patterns, relating your data to theory and what your results suggest)
- Evaluation (of your procedure and results)
- Conclusion (relate your key findings to the purpose of your investigation)

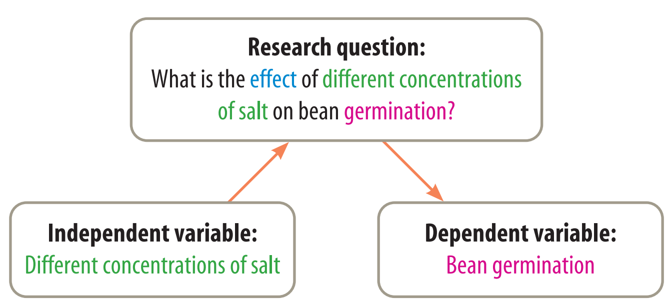
Example of investigation planning

RESEARCH QUESTION: WHAT IS THE EFFECT OF DIFFERENT CONCENTRATIONS OF SALT ON BEAN GERMINATION?

- **Independent variable:** different concentrations of salt
- **Dependent variable:** bean germination
- **Controlled variables:** for example, types, ages and size of beans, type of salt, temperature, intensity and colour of light, volume of solution added
- **Control:** set-up that had everything the same, but used water with no salt. This could be used as a baseline for control to see whether the addition of salt had an effect on bean germination.
- **Sample size:** using 10 bean seeds instead of one seed in each set-up and using class results to increase the number of times that the investigation was performed.

Examples of variables that you may choose to investigate in an experiment on bean growth

Dependent variable	Independent variables (vary only one at a time)
Number of seeds germinated in a week	• Salt concentration • Volume of water added each day • Amount of light (e.g. using different types of cloth to cover)
Time taken for seeds to germinate	• Colour of light (e.g. red, green, blue or yellow cellophane covers) • Different substances added to water (e.g. caffeine, sugar, salt or garlic)
Height of shoots each day	• Type of growth medium (e.g. water, soil, sand, soil, gravel or cotton wool)



Scientific design for investigations

A tale of cane, bugs and toads...

Sugar cane is one of Australia's most important export crops and the production of sugar is considered one of our key rural industries. Our Australian cane industry produces 32–35 million tonnes of cane each year. When processed, this can result in the production of about 4.5–5 million tonnes of sugar.

Humans, however, are not the only animals with a 'sweet tooth'. *Dermolepida albohirtum* is an example of a beetle whose larvae have taken a liking to the roots of sugar cane, causing damage or even death to the plant.

Cane toads *(Bufo marinus)* were introduced into Australia in 1935 to eat these 'cane beetles'. Unfortunately, this was extremely unsuccessful — cane toads did not control the numbers of cane beetles. They were, however, poisonous to other native Australian animals and had no natural predators to keep their numbers in check, and each female cane toad could produce between 8000 and 35 000 eggs twice a year! Cane toads are now a major pest in Australia, and they are spreading at an extremely fast rate across our country.

So what went wrong? How could knowing more about life cycles, reproduction, growth and behaviour stop this from happening again? What can be done to fix our current cane toad problem?

UNDERSTANDING AND INQUIRING

THINK

1 In the table on page 143, five bean plants are watered with each type of water. Explain why this is better than testing just one plant with each type of water.

2 Genevieve is investigating the effect of shadecloth on the growth of bean plants at home. She places three plants under the pergola at the back of her house, which is covered with shadecloth. She places the other three against the wall at the front of the house. All plants are in the same size pots and are given the same amount of water. Describe how Genevieve could improve her experimental design.

3 Cameron is trying to find out whether sand or garden soil is better for growing radishes. He also wants to find out if sugar added to the water that is given to plants makes a difference. Cameron plants three seeds in sand and three seeds in garden soil. The plants growing in sand are watered with tap water. The plants growing in garden soil are given the same amount of a mixture of sugar and water.
   (a) What two questions is Cameron trying to answer with his experiment?
   (b) Identify the major problem with Cameron's experimental design.
   (c) Is it possible for Cameron to design a better experiment to answer both of his questions with only six seeds? Explain how.

4 Summarise what you know about scientific method and reports into a mind map or another visual map.

INVESTIGATE

5 Propose how a plant would grow in a container that is upside down. Design and perform an experiment to find out.

6 Propose how a plant would grow in a fully enclosed container with a hole in one side. Design and perform an experiment to find out.

7 Can a plant grow without soil? Design and perform an experiment to find out.

8 Find out what hydroponics is and how it might be useful for the future.

9 (a) Research the life cycles of sugar cane (*Saccharum officinarum*), cane beetles (*Dermolepida albohirtum*) and cane toads *(Bufo marinus)*.
   (b) Find out why the cane toads did not control the number of cane beetles.
   (c) Suggest other methods that could be used to control the number of cane beetles and reduce damage to sugar cane plants.
   (d) Design an investigation to test one of the methods suggested in part (c).
   (e) Find out more about research into ways to control (or eradicate) cane toads in Australia.
   (f) Suggest how knowledge of the life cycles of organisms can be used to control their numbers in Australia.

4.7 SCIENCE UNDERSTANDING

Unbalanced ecosystems

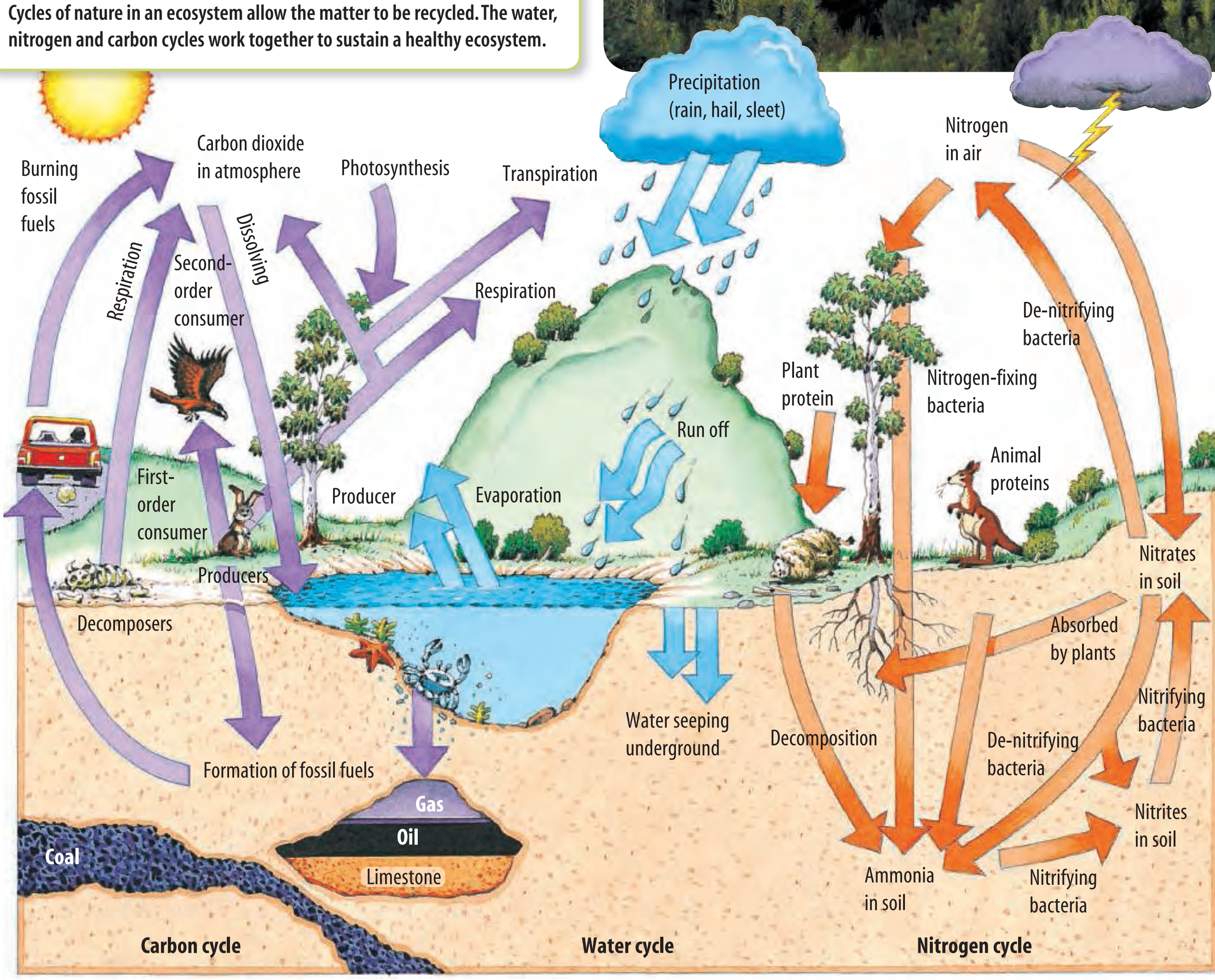
We have come a long way since we lived as hunter–gatherers — but have we gone in the right direction?

What have we done?

Have we been greedy?

While we have prospered as a species, our environment and numerous ecosystems have not! Our populations have dramatically increased in size, with many populations exceeding the available resources within their ecosystems. Yet we continue to strip ecosystems and give very little back in return. What will the consequences be? Are we going to experience them?

Cycles of nature in an ecosystem allow the matter to be recycled. The water, nitrogen and carbon cycles work together to sustain a healthy ecosystem.



When people lived as hunter–gatherers, they collected food without severely disturbing the environment. They consumed the fruits and roots of plants, leaving the rest of the plant to die and be broken down by decomposers.

In this way, the nutrients in the dead plants were returned to the soil. The soil was not dug over or exposed to the air. In these natural ecosystems, other animals, birds and insects would also feed off the plants and each other in a complex set of feeding relationships.

Cycles in ecosystems

Some wonderful recycling systems have evolved on our planet. The recycling of carbon, water and nitrogen are examples of how effectively atoms can be cycled through our ecosystems. But what happens when human activities disrupt this cycling?

Artificial ecosystems

About 5000 years ago when **agriculture** (farming) began, humans learned how to control the growth of other organisms in order to maximise their own food supply. These humans began to create artificial ecosystems.

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. To do this, it is necessary to interfere with the food web of which the selected organism is part. This often also requires the clearing of forests or removal of other organisms that may compete for resources and hence lower the yields. Such activities have led to the destruction of many natural ecosystems. The development of agriculture has led to drastic environmental changes in many ecosystems on our planet.

MONOCULTURES

Farms usually grow very large areas of only one type of plant. For example, in some regions there are thousands of hectares planted only with wheat, while in other regions thousands of hectares are covered with grapes, sugar cane or some other single crop. Such crops are called **monocultures** and can lead to reduced biodiversity.

At the end of each growing season, the crops are harvested, processed and delivered to shops and supermarket shelves for the consumer. There is little natural decomposition of dead material and the soil may be exposed to the effects of wind and rain for a certain period of the year. These factors combine to remove valuable nutrients from the soil. **Fertilisers** are added to the soil to replace the nutrients that are removed by harvesting and not replaced by decomposition. Some of these fertilisers may end up in waterways, where they add large quantities of nitrogen and phosphorus to the water and may result in a condition known as **eutrophication**.

CONTROLLING TROUBLE?

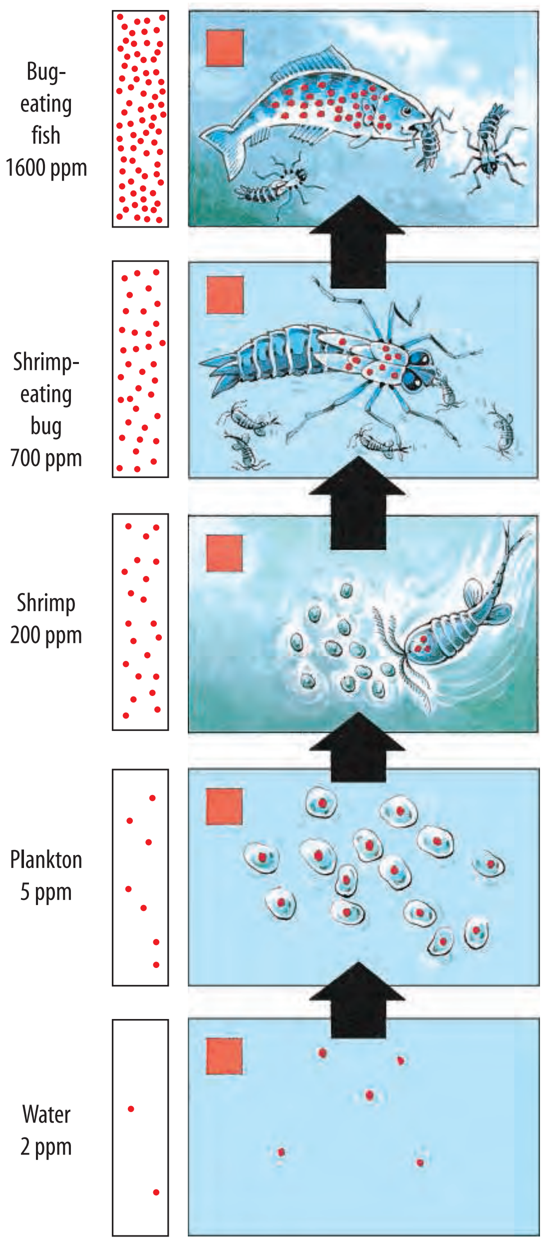
Organisms that compete for resources or potentially lower the yield of the plant crop being grown are considered to be pests that need to be controlled. Pest control may be carried out through the use of **chemical control** or **biological control**.

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.

Modern agriculture provides large amounts of food, but at a cost to the environment.

Although pesticides are still being used in agriculture, their effectiveness on target pest species often decreases. Other species within the ecosystem and food webs of which they are members may also be affected. 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 **biomagnification**.

Management of pests through biological control exploits natural existing ecological relationships. The use of natural predators to control a particular 'pest' is one such example. 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.

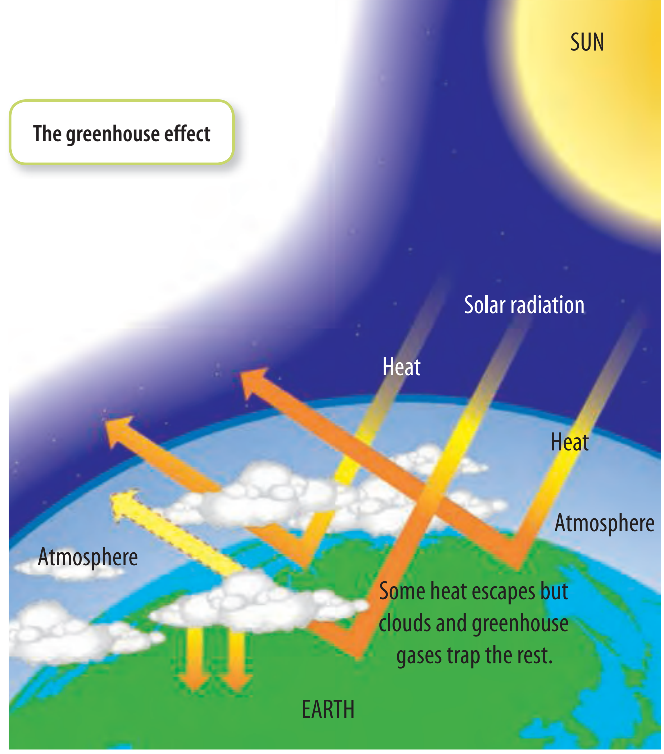


Some chemical pollutants such as pesticides can become more concentrated along the food chain.

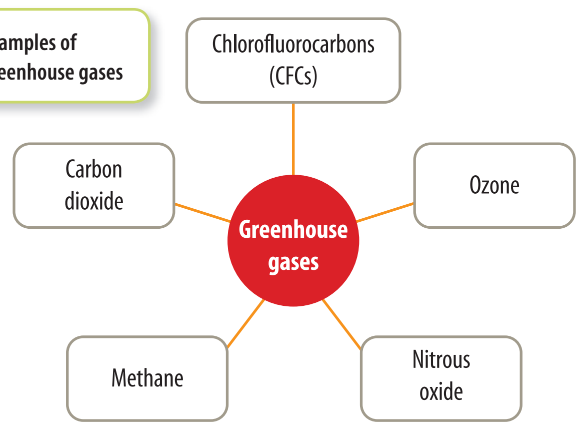
Global warming and the greenhouse effect

There is a bigger picture to consider. The Earth is surrounded by a layer of gases that trap the sun's heat, maintaining an appropriate temperature for life on our planet. The maintenance of Earth's temperature in this way is referred to as the **greenhouse effect**. Human activity has resulted in an increase of **greenhouse gases** (for example, carbon dioxide) that trap heat in our atmosphere. This increase is referred to as the **enhanced greenhouse effect** and contributes to the rising temperature of Earth known as **global warming**.

The greenhouse effect



Examples of greenhouse gases



AGRICULTURAL COLLABORATION

Throughout all of this 'doom and gloom' there have been some exciting developments. There is increasing collaboration between governments, communities, scientists and farmers to work together to:

- meet the demand for food for the world's increasing populations
- reduce damage to and preserve natural ecosystems
- reduce the risks of disease to crop plants
- develop strategies to deal with the possible effects of climate change and natural disasters such as droughts, floods and fires.

WHAT'S CARBON GOT TO DO WITH GLOBAL WARMING?

Producers capture light energy and use this energy plus carbon dioxide and water to make glucose (a type of sugar) and oxygen during the process of photosynthesis. The overall chemical word equation for photosynthesis is:

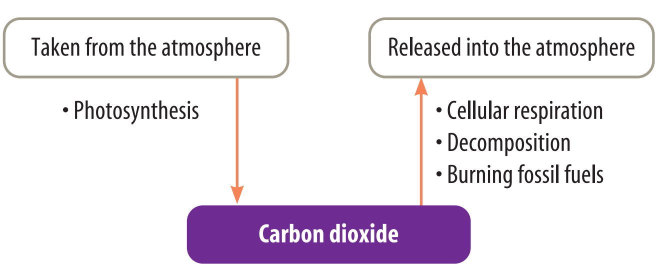
$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{visible light energy}} \text{glucose} + \text{oxygen} + \text{water}$$

Producers and consumers use **cellular respiration** to break down glucose into a form that their cells can use for the many activities required to keep them alive. The overall chemical word equation for cellular respiration is:

$$\text{glucose} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} + \text{energy.}$$

So, in terms of the carbon cycle, carbon dioxide is taken from the atmosphere during photosynthesis and released back into the atmosphere during cellular respiration. This suggests that if producers are reduced in number or removed from ecosystems there will be less carbon dioxide removed from the atmosphere, resulting in an overall increase in this gas. This explains why cutting down trees and replacing them with buildings or crops with lower photosynthetic rates can contribute to the enhanced greenhouse effect.

Not only living organisms release carbon dioxide into the atmosphere. Carbon dioxide is also released when dead organisms decompose and when fossil fuels (such as coal, petrol and gas) are burned. It has been argued that human activities have led to a rise in the release of carbon dioxide into our atmosphere and thus contributed to global warming. Australian scientists are asking questions about the cause and possible consequences of global warming and what we can do to protect our ecosystems and species, and to reduce its negative effects in the future.



Deforestation and removing trees can result in more carbon dioxide in the atmosphere as less is absorbed for use in photosynthesis.

Global warming — a hot environmental issue

In 2010, our federal government reported that the consequences of climate change (for example, global warming) will affect Australia's economy, society and environment and that 'adapting to climate change will involve all levels of government, business and the community'. This is where the challenge for us really begins. How will you be involved? What will you contribute?

INQUIRY: INVESTIGATION 4.10

The greenhouse effect on a small scale

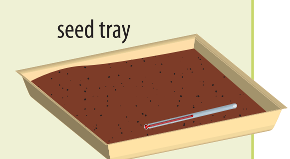
KEY INQUIRY SKILLS:

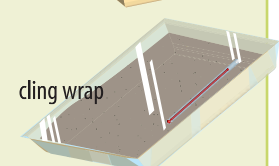
- conducting
- processing and analysing data and information

Equipment:

several kinds of flower seed	*2 seed trays*
moist soil	*plastic cling wrap*
2 thermometers	*2 sticks*

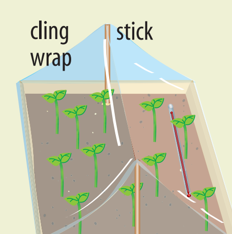
- Place the soil in two seed trays.
- Plant the flower seeds.
- Place a thermometer in each tray.
- Cover one of the trays with plastic cling wrap.
- Place the trays in an area exposed to the sun but protected from the rain.
- When the plants begin to grow, insert sticks in the covered tray to raise the cling wrap.
- Record the temperature in each tray every second day.
- Plot your temperature results on a graph using two different pencil colours, one for each tray.





DISCUSS AND EXPLAIN

1 Compare the temperature changes between the two different trays.
2 Suggest why one tray had a plastic covering and the other didn't.
3 Which tray represents the greenhouse effect? Why?



UNDERSTANDING AND INQUIRING

REMEMBER

1 List key terms associated with each of the following.
(a) Carbon cycle
(b) Nitrogen cycle
(c) Water cycle

2 Construct simple cycle diagrams to show how carbon and nitrogen cycle within ecosystems.

3 State the link between agriculture and artificial ecosystems.

4 Use Venn diagrams to compare the following.
(a) Herbicide and pesticide
(b) Chemical control and biological control
(c) The greenhouse effect and global warming
(d) Photosynthesis and cellular respiration

5 Suggest projects that governments, communities, scientists and farmers can work collaboratively on.

6 List five examples of greenhouse gases.

7 Suggest a possible link between deforestation (removal of trees) and global warming.

THINK AND DISCUSS

8 Do you think humans have been greedy in terms of their environment? Give reasons for your opinion.

9 Suggest how our lifestyles are different from those of our hunter–gatherer ancestors. Discuss possible consequences of the differences.

10 Construct a SWOT analysis of monocultures.

11 Use your coloured thinking hats to organise your thinking on woodchipping, logging or deforestation. Share your thinking with others in your team.

12 Look at the image of deforestation on page 146. Should forests be protected? If so, how many of them? If not, why not? Give reasons for your answers.

CREATE

13 Create a poster comparing the food web of a forest with the food web of a large apple orchard farmed using pesticides and fertilisers.

14 Create a poster, PowerPoint presentation or web page that warns of the consequences of changing the balance within one of nature's cycles. Choose an ecosystem close to your school.

15 Imagine that you are involved in each of the following situations. Prepare a brochure for both to promote your profession (or viewpoints), activities and any effects on the environment.
(a) Woodchipping, deforestation or land clearing
(b An environmental protection group, such as Greenpeace

INVESTIGATE, DISCUSS AND REPORT

16 Research the carbon cycle, nitrogen cycle or water cycle and find out how human activities have had an effect on it. Suggest possible consequences of this effect.

17 Investigate and report on the effect of agriculture or deforestation on an Australian ecosystem.

18 Investigate how land management practices of Aboriginal and Torres Strait Islander peoples can contribute to future sustainable management of the environment.

19 Research information about woodchipping, deforestation and land clearing. Organise a debate in which some members argue for and others against one of these human activities.

20 Research and report on different scientific responses to rabbit plagues in Australian agricultural areas.

21 Research and report on the use of fire by traditional Aboriginal peoples.

22 Research and report on the effects of palm oil harvesting in Sumatra and Borneo.

23 Construct a PMI chart to show how human activity in the community has had both positive and negative effects on the sustainability of ecosystems.

24 Identify and report on food chains (or food webs) that are relevant to either natural or artificial Australian ecosystems.

25 Use the **National Climate Change Adaptation Research Facility** weblink in your eBookPLUS to learn how the NCCARF is involved in leading the research community in a national interdisciplinary effort to explore areas that may help us to manage risks of climate change effects. Listen to or watch scientists talking about climate change and potential (or current) effects on our environment. Find out and report on types of research they are currently involved in.

eBook*plus*

26 Use the **Australian Terrestrial Ecosystem Research Network** weblink in your eBookPLUS to learn how TERN aims to provide researchers with the tools to better understand Australia's terrestrial ecosystems and biodiversity and the ways in which they will adapt to challenges such as climate change.
(a) Find out and report on TERN and their research.
(b) Find out and report on areas of research in which TERN's collaborating partners are involved.

27 Use the **Department of Environment and Conservation** weblink in your eBookPLUS to learn about the research projects led by the DEC and CSIRO Sustainable Ecosystems. Find out how the DEC suggests fire management can be improved and how it could be beneficial to native vegetation and biodiversity in Western Australia's wheat belt. Communicate your findings as a journal article or in an electronic format.

28 Click on the **CSIRO** weblink in your eBookPLUS and find their media centre. Find out about and report on research that you find of interest that involves CSIRO scientists.

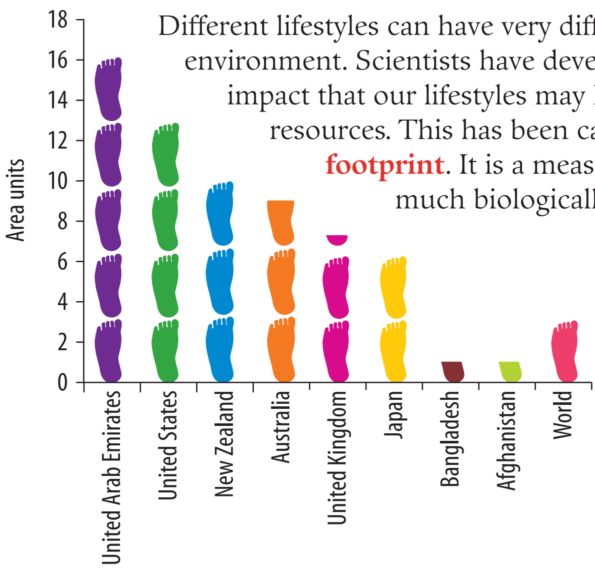
29 Use the **Greenhouse Gas Online** weblink in your eBookPLUS to find out about a topic you find interesting.

4.8 SCIENCE UNDERSTANDING

Ecological footprints

How much of our planet's resources do you take each year? Do you take more than your fair share? Who is doing without so that you can get all that you want, when you want it and how you want it?

What is an ecological footprint?



Comparison of ecological footprints of people in different countries

Different lifestyles can have very different impacts on our environment. Scientists have developed a scale of the impact that our lifestyles may have on our planet's resources. This has been called an **ecological footprint**. It is a measurement of how much biologically productive land our activities require. It helps us see the impact that we have on our planet.

How big is your ecological footprint?

Dear Bree

Thank you for your letter. We miss you, but are glad that you have finally settled into your new country. Your current science project is very interesting. I have never heard about ecological footprints before.

Your comment that an average North American has the same impact on the planet as 50 Sri Lankans or 290 Ethiopians was an eye-opener. I had no idea that, on average, a citizen of the so-called developed countries uses as much of the world's resources in two days as an Ethiopian uses in one year.

Having reflected on your research, I guess we in Australia leave larger ecological footprints than many other citizens around this globe. I found out that, on average, every person in Australia needs about 7 hectares of space — that's the size of 112 Olympic-sized pools! Some studies suggest that we are a greedy nation and are among the top eight users of Earth's resources.

Your letter inspired me to do some research of my own. It seems that the use of energy and other resources is distributed unevenly around the world. Sadly, some countries (and the people in them) are making huge efforts to get an even larger share of the resources. This greed is not only unfair, but also unsustainable.

Can you make any suggestions about how I could help out — any suggestions for reducing the size of my ecological footprint would be much appreciated!

Hope to hear from you again soon.

Yours sincerely
Cameron

Using more than the Earth can give

In order to live, we need to consume resources available on our planet. But what happens when we use more than is available to us? For example, what if humanity's ecological footprint is 20 per cent larger than what our planet has to offer (or can regenerate)? This would mean that it would take one year and two and a half months for the Earth to supply what we use in a single year. How could we pay back the debt each year?

Sustainability is based on the recognition that, if resources are consumed faster than they are produced or renewed, they can be depleted or used up. This may result in resources becoming costly or unavailable, resource conflicts and increasingly barren habitats. Many of our resources are finite and, once used, cannot be replaced.

By understanding the ideas behind ecological footprints, we can empower people to take their own personal and collective actions to support a sustainable lifestyle on our planet.

Do you take more than your share?

UNDERSTANDING AND INQUIRING

REMEMBER

1 Describe what is meant by the term 'ecological footprint'.

2 List the following countries in order of the size of their ecological footprints, from biggest to smallest: United Arab Emirates, Bangladesh, United Kingdom, Australia, United States.

3 Suggest how understanding ecological footprints can be useful.

THINK

4 If everyone on Earth had the ecological footprint described in the table below, we would need 2.7 planets to meet our needs.

Category	Global hectares
Food	1.5
Mobility	0.3
Shelter	1.1
Goods/services	1.9
Total footprint	4.8

(a) Suggest questions that might be asked about each category.
(b) Suggest answers that may be the most sustainable for the environment.

5 Under each of the following categories is a lifestyle activity statement — a suggested way of minimising our impact on the environment. In your team, brainstorm at least two other lifestyle activity statements for each category.

(a) Food consumption and packaging
- I take my own bags when I go shopping.

(b) Household energy and supplies
- I turn off the lights when rooms are not being used.

(c) Transport
- I often walk or ride to school.

(d) Recycling and reusing
- I use a reusable lunch box rather than plastic bags.

(e) Water
- I turn the tap off while brushing my teeth.

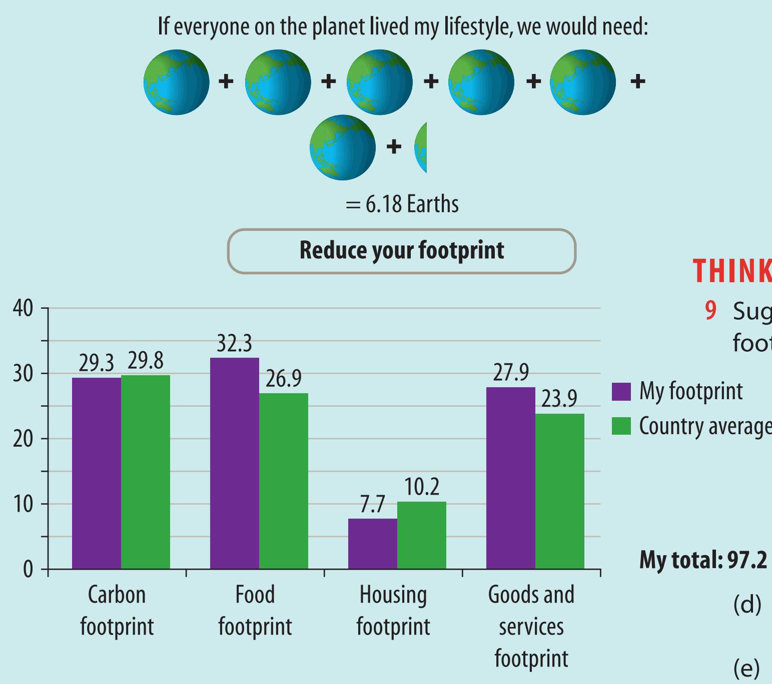
(f) The environment
- I treat my environment with respect.

INVESTIGATE

eBook*plus*

6 Use the **My footprint** weblink in your eBookPLUS and take a quiz to find out what your ecological footprint is. Use the links provided at the end of the quiz to find out some ways in which you could change your lifestyle to reduce your ecological footprint.

7 Charlotte completed an ecological footprint quiz. Her results are shown below:



(a) Explain the statement 'if everyone on the planet lived my lifestyle, we would need 6.18 Earths'.
(b) Overall, is Charlotte's footprint bigger or smaller than that of the average Australian?
(c) Suggest some ways in which Charlotte could reduce her food and goods and services footprint.
(d) People living in wealthy countries such as Australia and the US have, on average, a much bigger ecological footprint than people living in poorer countries. Explain why.

8 Professor Tim Flannery was named Australian of the Year in 2007. Professor Flannery began his scientific career studying the evolution of Australasian mammals and has helped Australians become more aware of environmental issues. Find out about and report on:
(a) Tim Flannery the research scientist
(b) scientific research that Professor Flannery has been involved in
(c) the evolution of Australasian mammals
(d) Professor Flannery's book *The future eaters*, which describes the damage humans have caused the Australian environment
(e) Professor Flannery's book *The weather makers*, which focuses on global warming and controversial ways of addressing the issue.

Tim Flannery

THINK AND DISCUSS

9 Suggest ways in which you could measure your water footprint.

10 (a) Suggest a link between energy, sustainable lifestyles and ecological footprints.
(b) In your team, discuss what may be meant by the term 'sustainable lifestyle'.
(c) Brainstorm some examples of sustainable lifestyles.
(d) Share your definition of 'sustainable lifestyle' and your examples with other teams.
(e) Select three of these examples to focus on yourself over the next week.
(f) Report your experiences to your team after a week.
(g) Suggest ways in which you could encourage others to have a more sustainable lifestyle.
(h) Create a web page, PowerPoint presentation, song, advertisement or poster that encourages a sustainable lifestyle.

eBook*plus*

11 The solar cube is another type of solar panel that Australians are working on. Use the **Solar cube** weblink in your eBookPLUS to find out why it is more efficient than traditional solar panels.

12 Play **The survival game** in your eBookPLUS and test your knowledge on how you can help to save the environment. **int-0217**

13 Complete the **Threats to Earth** interactivity in your eBookPLUS and spot the differences in an environment before and after human contact. **int-0218**

4.9 SCIENCE UNDERSTANDING

What a load of rubbish

Every Australian creates one tonne of rubbish each year, making the nation the second largest waste creator after the United States.

Most of the household rubbish we produce is packaging — the cartons, plastic wrapping and cans in which food and other products are sold. The packaging of clothing and some other goods is often excessive. Before choosing a brand of food or clothing, perhaps you should think about whether or not all of the packaging is needed.

At the tip

Your local city council collects rubbish and dumps it into big holes in the ground. Over many years, the rubbish settles and the hole is filled. A layer of soil is bulldozed over it and trees are planted. These areas are often used as parkland or reserves.

Biodegradable organic substances are broken down into simpler chemicals by bacteria and fungi, producing methane gas. Methane and other gases contribute to the smell around these landfills. The rubbish under the ground continues to decompose, although some materials such as plastic and glass will last for hundreds or thousands of years. That is why it is better to recycle them.

Landfill sites cause many problems. Pests such as rats, which can spread disease, breed in the rotting garbage. If industrial waste is dumped in this manner, toxic substances could leak into other areas and contaminate groundwater.

INTO THE SEA

Imagine how much space will be required if people keep dumping rubbish at this rate. Have you ever wondered what happens to the litter you see in the schoolyard? Quite a lot of it is blown and swept into street gutters. After heavy rain, litter flows into creeks, rivers, lakes and, eventually, into the sea.

The litter that ends up in the sea contains a large amount of plastics, metal and glass, which are **non-biodegradable**; that is, they are not broken down into simpler chemicals by bacteria and fungi. The litter may float on the surface or sink to the bottom, where it stays for many years. Litter can also cause injuries to many organisms in the ocean.

COMPOSTING

Food scraps can of course be recycled by setting up a **compost** heap. Compost is decaying plant matter. Composting encourages the breakdown of food scraps, leaves and other vegetable matter by bacteria, fungi, earthworms and insects. It produces a number of nutrients that help plants grow better. When compost is mixed with garden soil, it returns these nutrients to the soil and reduces the need for fertilisers.

Some people add manure or lime to compost heaps to speed up the composting process. Adding animal manure provides a balance of nutrients and helps provide the right conditions for decomposers to live. The addition of worms speeds up the process and produces a very rich compost from the products of digestion of vegetable matter by the worms. Decomposers need moisture and oxygen, so compost heaps, especially the bin type, must be turned to aerate them and occasionally even watered during hot, dry spells.

Are you a polluter?

A **pollutant** is anything added to the environment that harms living things. Examples of pollutants include car exhaust fumes, household waste, pesticides and industrial waste such as smoke, poisonous fumes and liquids. What if some things that you use were produced by processes that are destructive to your environment? Are you a polluter?

HOW ABOUT THAT!

Did you know that in 2004, Australians used about 5.6 billion single-use plastic bags? That is equivalent to one bag a day for every person in Australia throughout the year! After their first use, many became litter within our environment. Because most plastic bags are made up of non-renewable natural resources and can take up to 1000 years to break down naturally, these are likely to be still littering our environment today. While biodegradable plastic bags are being developed and are sometimes used, these also have a variety of problems associated with them. As well as their claimed ability to break down naturally being questioned, it is currently not known whether harmful products are left over once biodegradation has taken place.

INQUIRY: INVESTIGATION 4.11

Anti-litter video

Your task is to make a two-minute video that discourages littering. Your video should include:

- the concept of ecological footprints
- the extent of the litter problem
- future consequences
- possible solutions.

Write and record an audio commentary and use appropriate titles and transitions. Try to incorporate a suitable music track into your video.

INQUIRY: INVESTIGATION 4.12

Investigating rubbish

KEY INQUIRY SKILL:

- processing and analysing data and information

Equipment:

rubber gloves
several garbage bags
marking pen
bathroom scales
electronic balance
calculator

This experiment can be done around the school by collecting litter left on the ground over a period of several days.

CAUTION: Do not handle any sharp objects or put them in garbage bags. Inform your teacher if sharp objects are found.

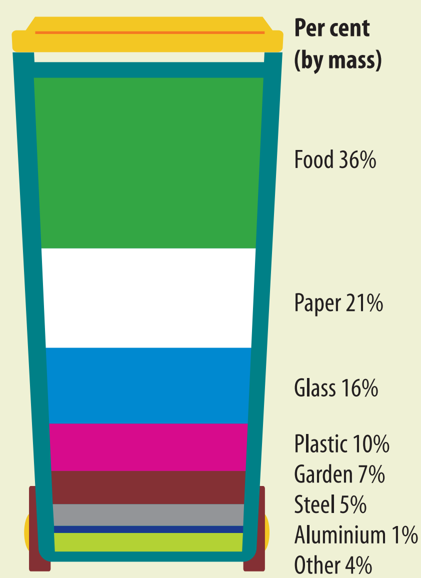
- Collect litter in a large garbage bag.
- Wearing rubber gloves, sort the rubbish into seven different garbage bags:
  - food scraps
  - paper and cardboard
  - plastic
  - glass
  - aluminium cans
  - other metal
  - other rubbish.
- Use bathroom scales or an electronic balance to estimate the mass, in kilograms, of the contents of each garbage bag. Think carefully about the best way to do this for each bag. Don't forget to divide by 1000 to convert to kilograms, if you measure the mass in grams.
- Construct a table like the one below in which to record your results. The example shown in the table records part of the rubbish taken on a single day from a single bin outside a school canteen. The total mass collected from the bin that day was 8 kilograms.
- Calculate the percentage of the total mass for each type of rubbish, using the following formula. (See the example in the table.)

$$\text{Percentage of total mass} = \frac{\text{mass of type}}{\text{total mass}} \times 100\%$$

- For each type of rubbish, estimate the mass that would be disposed of over a period of a year. Think carefully about how this should be done. The food scraps referred to in the table were found in a rubbish bin outside a school canteen. They represented one full day's rubbish in that bin. The mass was multiplied by 200 because there are about 200 days in a school year.

DISCUSS AND EXPLAIN

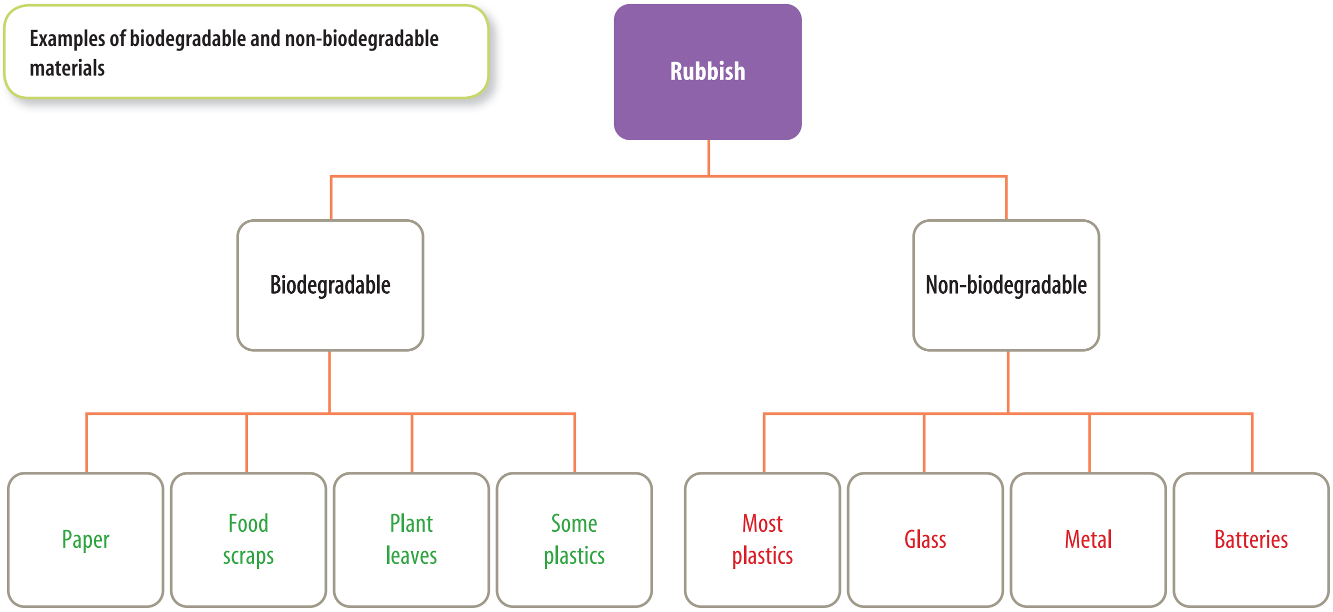
1 Which type of rubbish is the most common (by mass)?
2 Why is the total mass per year only an estimate?
3 Which types of rubbish collected could be recycled?
4 Discuss this question with the rest of your group: 'How could the amount of wasted recyclable rubbish be reduced?' Following the discussion, write down your own answers to the question.



A survey of household rubbish shows that a lot of materials that could be recycled are being wasted and unnecessarily damaging the environment.

Type of rubbish	Mass collected (kilograms)	Percentage of total mass	Estimated mass per year (kg)
Food scraps	2.5	$\frac{2.5}{8} \times 100\% = 31\%$	$2.5 \times 200 = 500$

Examples of biodegradable and non-biodegradable materials



UNDERSTANDING AND INQUIRING

REMEMBER

1 What is a pollutant? Give three examples of pollutants.

2 Give examples of what makes up most of household rubbish.

3 List three ways in which you can reduce your household rubbish.

4 Name a gas that contributes to the smell around rubbish tips.

5 List three problems associated with rubbish tips and landfills.

6 Describe the difference between biodegradable and non-biodegradable.

7 Suggest three advantages to composting.

8 State two conditions necessary for decomposition to take place in a compost bin.

THINK

9 Do you think loud noise is a pollutant? Explain your answer.

10 Christmas wrapping paper produces a lot of waste. List some creative ways of reducing the problem.

11 Ingestion of discarded plastic by our marine life is an increasing problem. Find out more about the effects of plastic on marine ecosystems. In a team, brainstorm ways to prevent this problem. Report your findings to the class.

12 Brainstorm ideas on the benefits of composting.

13 Use two thinking keys of your choice to unlock your thinking on litter.

CREATE

14 Set up a compost bin or heap in an appropriate area of the school. Find out in detail what you need to start one, how you are going to get food scraps and what you will do with the finished product — the compost.

15 Produce some posters that discourage littering. Display them around your school. Use a slogan or a simple diagram to get your message across.

16 (a) Create a mind map of relevant ideas, issues and information on the topic of rubbish.
(b) Write a *What a load of rubbish* picture story book that tells the tale from the perspective of (i) the rubbish, (ii) an organism being affected and (iii) the environment.

INVESTIGATE

17 Visit at least three local service stations and find out what happens to the used oil after they change oil in cars during a service. Present your findings to the class.

18 Visit a supermarket, clothing store or hardware store and make a list of at least 10 packaged products. For each product, state:
(a) why the packaging is used
(b) any disadvantages of the packaging
(c) your opinion about whether the package is necessary or excessive.
Before you start, design a table in which you can record the products and your comments.

19 Find out more about composting toilets and how they work. Search your neighbourhood, picnic areas and campgrounds to find out where composting toilets have been installed and why.

4.10 SCIENCE UNDERSTANDING

Water aware?

Feeling thirsty? What if there were no water to drink? What if you only received a cup of water a day — not just to drink, but to wash in as well? Australia is the driest inhabitable continent in the world! Fresh water is probably our most valuable **renewable resource**. Its quality is vital to human health, wildlife and agriculture.

Waterwatch

Waterwatch is a program that brings together schools, community groups, landcare groups, land owners, councils and water authorities in an effort to maintain and improve water quality. Together, these groups monitor the quality of streams and other freshwater sources throughout most parts of Australia. The water monitoring groups:

- survey streams and water sources to assess their present condition
- identify areas where water quality is poor
- identify the causes of poor water quality
- provide data that water authorities can use to analyse trends in water quality.

WATERWATCH SURVEYS

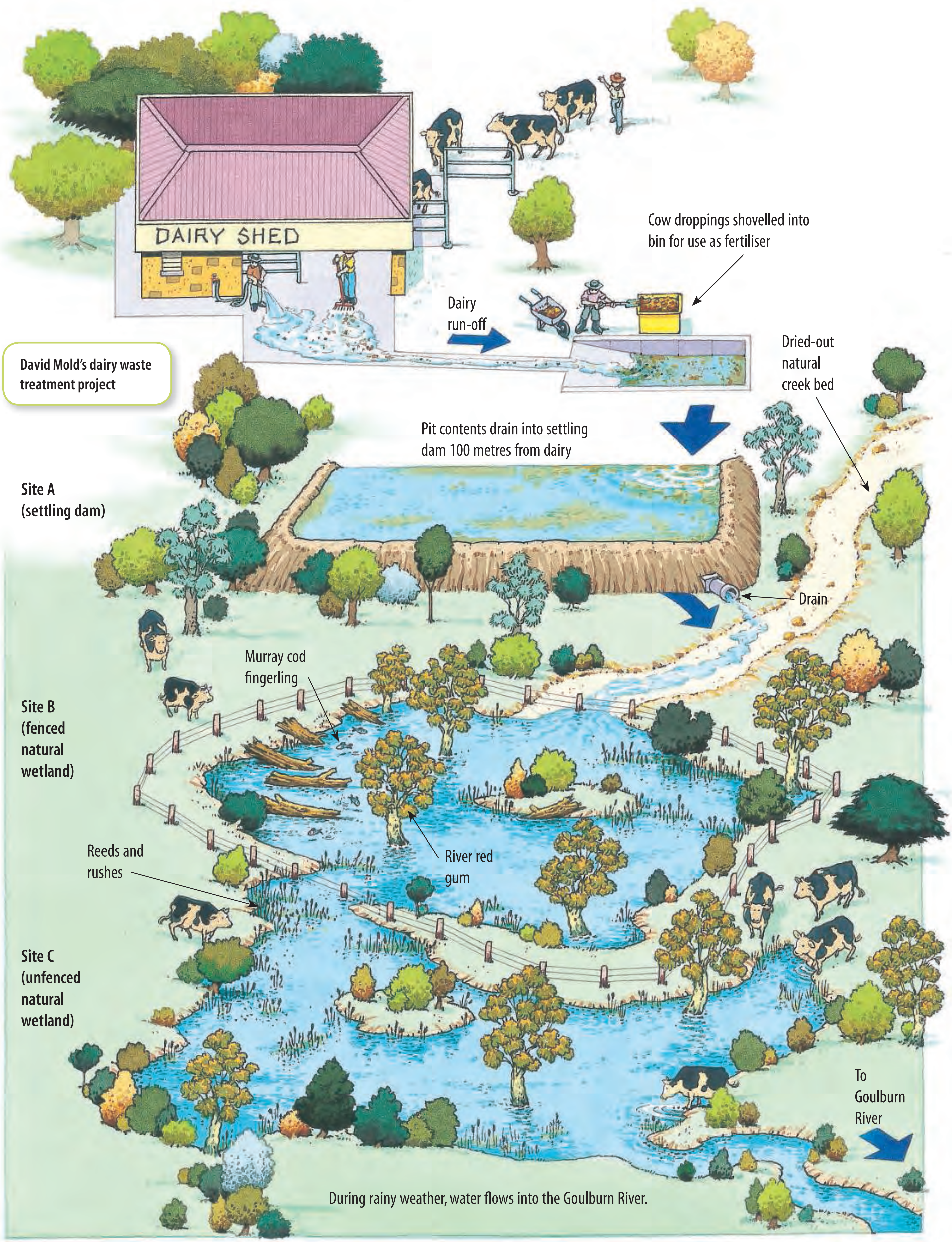
Most of the groups conduct **biological surveys** and monitor the physical and chemical properties of the water. Biological surveys involve observing, describing and counting organisms that live in fresh water. They are photographed and, in some cases, samples are taken.

The physical properties that are monitored include temperature, turbidity and rate of flow. **Turbidity** is a measure of how 'murky' or 'cloudy' the water is. Chemical monitoring involves testing for dissolved oxygen, pH, pesticides and nutrients such as phosphorus and nitrogen.

Farm'n'water

As part of the Waterwatch program, a group of students from Yea High School, Victoria, worked with their local dairy farmer David Mold to improve the quality of the water leaving his farm and entering the Goulburn River. After investigating several methods of treating dairy waste, David undertook his own waste treatment project. The students monitored the water at each of three sites. The types of chemical and physical factors that they monitored are shown in the table on page 160. The students visited regularly to build up a seasonal picture of life in each of the habitats.

Yea High School student Kathleen Oliver working with farmer David Mold to collect macro-invertebrates. Macro-invertebrates are those animals without backbones that can be seen without the aid of a microscope. They include worms, snails, yabbies and insects.


DAIRY SHED
Cow droppings shovelled into bin for use as fertiliser
Dairy run-off
David Mold's dairy waste treatment project
Dried-out natural creek bed
Pit contents drain into settling dam 100 metres from dairy
Site A (settling dam)
Drain
Murray cod fingerling
Site B (fenced natural wetland)
Reeds and rushes
River red gum
Site C (unfenced natural wetland)
To Goulburn River
During rainy weather, water flows into the Goulburn River.

INQUIRY: INVESTIGATION 4.13

Measuring water quality

KEY INQUIRY SKILLS:

- conducting
- processing and analysing data and information
- communicating

Equipment:

samples of water from various locations

turbidity tube

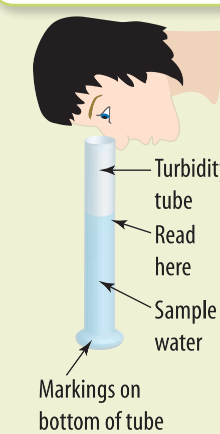
*data logger with the following probes: pH, temperature, dissolved oxygen, conductivity. (*Note: *if your school does not have data loggers or you do not have some of the probes listed you could use a thermometer, pH meter and conductivity meter instead)*

- Copy the table below into your book.

Measurement	Site X	Site Y	Site Z
pH			
Temperature (°C)			
Dissolved oxygen (ppm)			
Conductivity (S/m)			
Turbidity (mL)			

- Use the data logger and probes to measure pH, temperature, dissolved oxygen and conductivity.
- Place the turbidity tube on the floor and look down the tube. You should be able to see a mark on the bottom of the tube.
- Fill the tube using one of the samples until the mark can no longer be seen through the water. Read the turbidity reading off the side of the tube (see diagram below right).
- Repeat the above steps using the other water samples collected.

How to use a turbidity tube



DISCUSS AND EXPLAIN

1 Turbid water is not clear. You cannot see through it very well. Explain how the turbidity test works.

2 What could cause a high turbidity reading?

3 Why is it important to monitor the amount of oxygen dissolved in water?

4 Explain how sewage pollution might affect the dissolved oxygen level of a body of water. (*Hint:* Sewage contains organic matter which can be broken down by bacteria. Bacteria carry out respiration.)

5 Gases, including oxygen, are less soluble in hot water than in cold water. How might an increase in water temperature affect fish living in the water?

6 What effect would acid rain have on the pH of a stream?

7 When salts are dissolved in water its conductivity increases. Would you expect sea water or fresh water to have a greater conductivity?

8 Did any of the samples you tested appear polluted? Justify your answer.

Chemical and physical monitoring, 19 February 1997, 2 to 3 pm

Test	Site A (settling dam)	Site B (fenced wetland)	Site C (unfenced wetland)
Water temperature (°C)	32.2	24.5	24.5
Air temperature in sunlight (°C)	38.0	38.5	38.5
Dissolved oxygen (%)	Too murky to test	55	70
Nitrate level (mg/L)	1.144	0.189	0.484
Soluble phosphate level (mg/L)	0.429	0.106	0.191
pH	9.7	7.8	8.1
Conductivity (EC)	1540	860	1610
Turbidity (NTU)	180	55	41

David's waste treatment project

I first removed the solid waste dropped by the farm's 70 cows during milking (it is used as fertiliser on other parts of the farm). The run-off from the dairy includes mud, urine, milk and other liquid waste.

Site A – Settling dam

The run-off drains into a concrete pit and then drains into a settling dam (site A). This settling dam is about 100 metres from the dairy. Water running down from roadside and hillside drains adds to the dam, and it sometimes overflows in wet months.

Site B – Fenced natural wetland

From the settling dam, the water drains along a natural creek to a strip of natural wetland (site B). This wetland has been fenced to keep the cattle out. It is partially shaded by river red gums and has a cover of reeds, rushes and other wetland plants.

I have released 250 Murray cod fingerlings (about the length of a finger) into site B. They will help to recycle nutrients and compete with the European carp (an introduced species) that inhabit the creek. I'm hoping that the European carp will eventually be eradicated from the natural wetland.

I have also moved some old logs to this site, and plan to plant more native trees to provide a natural habitat for native plants and animals.

Site C – Unfenced natural wetland

Site C is located alongside the fenced wetland. It is similar to site B. However, as it is not fenced, the cattle have access to it. When it rains, water flows from site C along a two-kilometre route into the Goulburn River.

I am confident that the habitats I have created will be self-sustaining, and will provide a natural way of recycling the nutrients in the farm's dairy waste.

Thirsty for water?

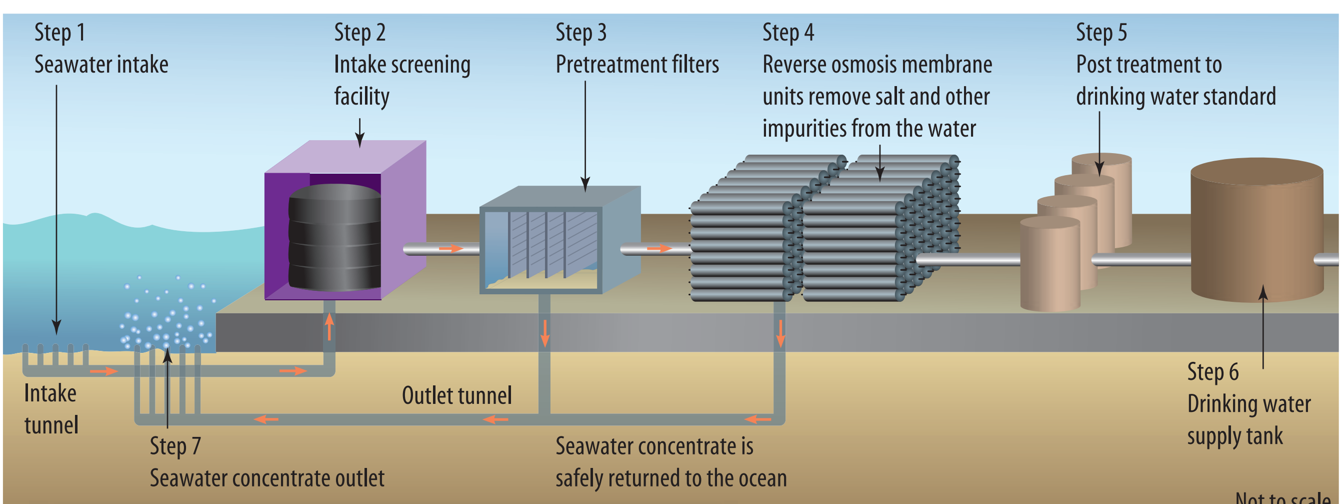
Conditions of drought can reduce the amount of fresh water available for our use. Although Australia is surrounded by sea water, fresh water is in short supply. What are our alternatives? Can we take the salt out of the sea water? Are there other ways in which we can 'make' water that we are able to drink?

DESALINATION — A SALTY ISSUE

A desalination plant has been built in Kurnell in Sydney, New South Wales. This plant uses a process called reverse osmosis which results in a more salty solution on one side of a membrane and 'pure' water on the other side. There are, however, some environmental concerns associated with this process. One is the huge amount of electricity (produced by the burning of coal or fossil fuels) needed to power the plant and another is the problem of what to do with the salt that is produced.

RECYCLED WATER — TASTY?

Fancy drinking recycled sewage? In 2006, the three dams in Toowoomba in Queensland had collectively fallen to below 20 per cent capacity. In July 2006, the residents of Toowoomba voted on a proposal that 25 per cent recycled water from the sewage treatment plant be added to the city's rapidly diminishing water supply. The issue divided the city. Despite an extensive educational campaign, the proposal was defeated (61.8 : 38.2 per cent). How would you have voted? Why?



The process of separating drinking water from sea water at a desalination plant

UNDERSTANDING AND INQUIRING

USING DATA

Use the data in the table on page 160 to complete the following.

1 Construct bar graphs to compare each of the following chemical or physical properties.
   (a) Dissolved oxygen
   (b) Nitrate level
   (c) Soluble phosphate level
   (d) pH
   (e) Conductivity
   (f) Turbidity

2 Nitrates and soluble phosphates are nutrients that occur naturally in water.
   (a) Suggest why the levels are so high in the settling dam.
   (b) Suggest why the levels are higher in site C than in site B.
   (c) What effects could these high levels of nutrients have on the dam?

3 Which of the three sites appears to be most suitable as a habitat for fish like the Murray cod? Explain why.

THINK AND DISCUSS

4 Why is fresh water described as a renewable resource?

5 Why do you think that David decided to kill the European carp that inhabited the creek?

6 Explain how David's project will help provide habitats for native wildlife.

7 David has invested a lot of time and money on his project. Is the investment worthwhile? Explain your answer.

INVESTIGATE

8 Find out what equipment you need to monitor some of the physical or chemical properties of a local stream or lake and design a monitoring program.

9 Find out the differences between the following alternative water supplies: groundwater, rainwater, grey water, stormwater, recycled water.

10 Suggest possible water-saving ideas for your school and/or home. Design a poster to display them.

11 List the types of chemicals that you pour down your kitchen sink over a week. Select two different chemicals and research what happens to them once they enter your drains. Select one of the chemicals you have researched and write a story about its experience.

12 Use the **Water saver** weblink in your eBookPLUS to play the water-saving game.

eBook*plus*

13 To take part in the waterworks adventure, use the **Waterworks** weblink in your eBookPLUS.

14 Use the **Sydney Catchment Authority** weblink in your eBookPLUS to find out how full the dams are that supply Sydney's water.

15 (a) What are water footprints? Find out more about them using the **Water footprint** weblink in your eBookPLUS.
   (b) Select one of the items shown in the table below and find out how its water footprint was calculated.

Everyday item		Water footprint
A glass of milk (200 mL)		200 L
A cup of tea (250 mL)		35 L
A slice of bread (30 g)		40 L
A potato (100 g)		25 L
A cotton T-shirt (250 g)		2000 L
An egg (40 g)		135 L
A sheet of A4 paper		10 L
A pair of cow leather shoes		8000 L

Source: The Helix, Issue 27 (Aug–Sept 2009), p. 9.

16 Use the **Water Investigator game** weblink in your eBookPLUS to build your own virtual home and calculate your family's water usage.

17 Using the **New Inventors** weblink in your eBookPLUS, browse the inventions by category and select the category 'environment'. List at least five Australian inventions that are aimed at conserving water, recycling water or obtaining fresh water from sea water.

4.11 SCIENCE UNDERSTANDING

Unwanted guests

Introducing trouble

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 be easily 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.

NORTHERN PACIFIC SEA STAR

History:

The Northern Pacific sea star (*Asterias amurensis*) is a marine pest, accidentally brought to Ausralia on the hulls of boats and ships and in ballast water. This foreign sea star was first discovered in the Derwent estuary near Hobart in 1986. Since then it has spread to Port Phillip Bay, with its population now estimated at around 100 million. The population is likely to continue to increase because it has no natural predators or competitors in our ecosystem, and the female sea star can produce up to 10 million eggs a year.

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.

Introducing control

Biological control of unwanted plants and animals uses other organisms, rather than chemicals (such as insecticides and herbicides), as a method of control. Biological control may use a predator or competitor to kill or reduce numbers of the pest, or somehow disrupt the pest's reproductive cycle. A disease might also be used to kill the unwanted plant or animal without harming other species. Sometimes, however, the method does not work as planned and the supposed cure becomes a problem.

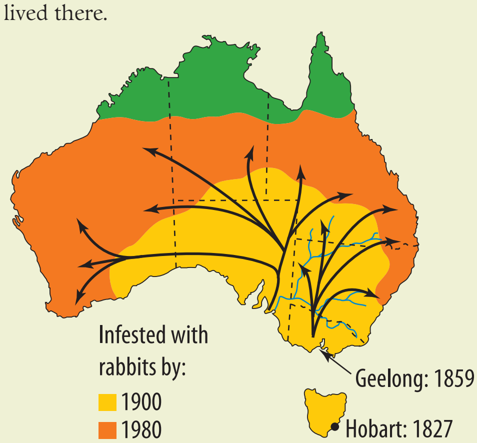
RABBITS

History:

In 1859, 24 rabbits were introduced from Europe and released in Geelong, Victoria. With few predators, they multiplied rapidly and thrived. By 1890, there were 600 million rabbits in NSW alone, all of which had descended from the first 24 rabbits introduced into Victoria.

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.



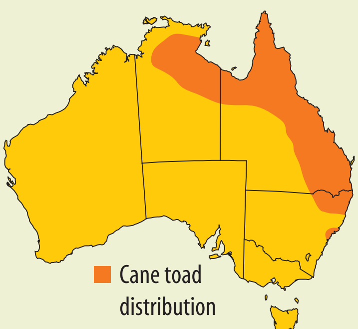
CANE TOADS

History:

The cane toad (*Bufo marinus*) was introduced into Australia in 1935 to control the sugarcane beetle which was destroying sugarcane in Queensland. Unfortunately, the cane toad preferred other insects and the cane beetle was not greatly affected. Cane toads are poisonous and kill animals that eat them. They need little water for breeding. In one season, the female toad can lay up to 40 000 eggs, which take only three days to hatch.

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.



LOCUSTS SET TO INVADE

by Adrian Tame

Swarms of locusts are set to swarm across the Murray River into Victoria.

The destructive swarms, some covering up to 200 sq km, have been massing in southern NSW over the past month.

Northerly winds early this week are expected to drive them into Victoria.

The Goulburn Valley, known as Victoria's fruit bowl, is among areas vulnerable to the voracious pests, capable of causing millions of dollars of damage to crops within hours.

Malcolm Campbell, a principal scientist with the State Department of Primary Industry, said the situation was grave.

One swarm, measuring up to 100 ha across, has already crossed the border and is being monitored in the Picola area, north of Shepparton, centre of the state's prime fruit-growing area.

The locusts cannot be sprayed in this area.

Potentially more serious are swarms north of a stretch of the NSW border extending from Swan Hill to Albury.

Areas facing the most significant threat include regions around Gunbower, Mitiamo, Rochester and Elmore and thousands of hectares south of Echuca.

Mr Campbell said even if the predicted northerlies fail to arrive, and Victoria has the same lucky escape it experienced in December, a further high-risk period is anticipated in late March, early April.

'This could be particularly damaging for cereal crops planted in late Autumn, when they are at their most vulnerable.

'We are expecting another generation of adult locusts in NSW around that time,' he said.

Locusts will eat almost any form of green leaf.

Source: Herald Sun, 27 February 2005

UNDERSTANDING AND INQUIRING

REMEMBER

1. Describe what is meant by the terms 'introduced species' and 'biological control'.
2. Give examples of:
   (a) three species that have been introduced into Australia
   (b) three ways in which biological control may be used
   (c) three reasons why rabbits, Northern Pacific sea stars and cane toads are not wanted in Australia.
3. Why is it important to spend a lot of time and effort testing biological controls before they are used?

THINK

4. Is biological control of pests better than using chemicals? Give some reasons for your answer.
5. Select two different thinking keys and use them to unlock your thinking on introduced species.

USING DATA

Use the following information to answer questions 6–12. Population statistics of several animals were collected in two areas over 5 years. One area contained only native animals, while the other area contained native animals with an introduced species — the rabbit.

The feeding habits of the animals were also studied:

- Bandicoots eat roots, seeds, leaves and insects.
- Dingos eat bandicoots, wallabies and rabbits.
- Wallabies eat grasses and leaves.
- Rabbits eat grasses and leaves.
- Insects eat roots, seeds, leaves and grasses.

Area 1: populations of native animals over 5 years

Year	1	2	3	4	5
Bandicoot	310	488	505	505	505
Dingo	5	11	11	12	10
Wallaby	90	197	281	293	290

Area 2: populations of native animals over 5 years

Year	1	2	3	4	5
Bandicoot	310	475	495	500	505
Dingo	5	11	11	12	10
Wallaby	90	199	72	72	73
Rabbit	6	412	5122	5114	5120

6 Draw two separate food webs: one of the native animals only, and the other one including the introduced species.

7 Plot two population graphs from the two tables, using different colours for each animal. Join the points with straight lines.

8 (a) Which native animal was most affected by the introduction of the rabbit into the second area?
(b) Which animals were least affected?

9 (a) What happened to the number of rabbits in the first two years?
(b) What happened to the number of rabbits after the first two years?
(c) Can you explain why this happened?

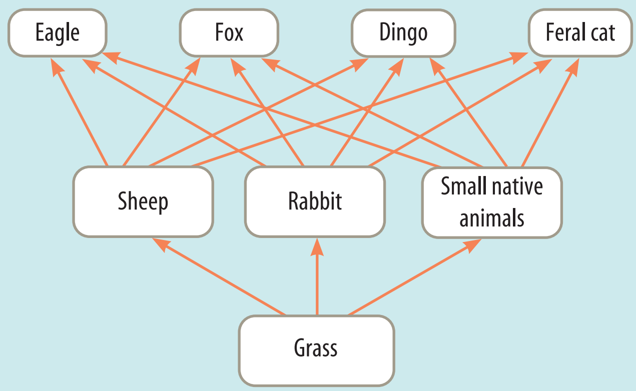
10 (a) What effect did the introduction of the rabbits have on the wallaby population?
(b) Why do you think the rabbits had this effect?

11 Did the rabbits have any effect on the dingo and bandicoot populations? Explain.

12 In your own words, describe any differences in the food webs of the two areas and how the populations of each of the native animals changed.

IMAGINE

The food web above right shows a northern Australian sheep station ecosystem. Imagine that a successful method of biological control was found to totally wipe out the rabbit population in Australia. Use the food web above right to help you answer the following questions about what might happen.



13 Which animals would benefit immediately from the disappearance of the rabbit? Explain why.

14 How would the diet of the eagles, foxes, dingos and feral cats change?

15 What do you think might happen to the populations of the small native animals over a longer period of time?

CREATE

16 Assign the roles of rabbit, kangaroo, sheep, farmer, rabbit hunter, eagle and fox to different members of your group. Interview each character about their thoughts on the introduction of rabbits to Australia, and what they hope will happen in the future.

INVESTIGATE

17 Find out more about the impact of one of the following introduced plants and animals: horse, camel, cat, fox, goat, hare, sparrow, mallard duck, pig, rat, garden snail, starling, water buffalo, deer, ferret, housefly, European wasp, thistle, blackberry, serrated tussock, Paterson's curse, ragwort, pasture grasses.

18 Find out more about the successes and failures of using myxomatosis and calicivirus to kill rabbits. Report your findings in a priority grid.

19 Find out why cane toads were unsuccessful as a biological control for the sugarcane beetle. Report your findings as a newspaper article, storyboard, puppet play, web page or PowerPoint presentation.

20 Read the article 'Locusts set to invade' on the previous page. Find out why locusts are unwelcome visitors. Display your findings in your own NOT WANTED poster.

21 One of the most successful examples of biological control in Australia is the control of prickly pear cactus. The moth *Cactoblastis cactorum* was imported from South America to eat the flesh and flowers of the cactus. Find out more about this and other successful examples of biological control.

work sheets
4.7 Population overload
4.8 Spot the pest

4.12 SCIENCE UNDERSTANDING

Going, going, gone!

Best not get too comfortable, because chances are you may not be staying — not even on the planet!

The intimate interactions that link us all together can also sometimes break us apart. During the 200 years since the European settlement of Australia, over 125 different species of Australian native plants and animals have become extinct. Many more species are in danger of extinction.

Some of the solutions put into practice to reduce the threat to endangered species include:

- declaring areas as national parks where plants and animals are protected
- setting up fauna and flora reserves, wetlands and other specialised habitats
- placing quotas (limits) on hunting and exports
- culling (reducing numbers) of overpopulated species, such as western grey kangaroos in some national parks, to allow native plants to survive.

Why worry?

Why should we be so concerned about endangered species? After all, there are many plants and animals on Earth and it may become overcrowded in the future.

Some of the reasons to be concerned about endangered species are that:

- their disappearance affects all other species in the food web
- all species have a right to live and share the Earth
- they may be useful in the future for food, medicines etc.
- future generations should have the same chance to see a diverse world.

Some reasons why animals and plants become endangered or extinct

- Numbers small to begin with
- Undesirable to humans, such as snakes and crocodiles
- Habitat destroyed by disaster or pollution
- Valued by humans for fur, skin, feathers, tusks, antlers, medicines or sport
- Not able to reproduce successfully
- Unable to move easily from one area to another
- Unable to compete with introduced species for food or shelter
- Live in special and scarce habitats, such as rainforests or swamps

Extinct and threatened species

Extinct

Extinct means the last of the species has died. Ecologists generally classify a species as extinct if it has not been seen in the wild for 50 years. More than 30 000 species of plants and animals are in danger of becoming extinct.

Threatened

Endangered

Endangered means the population is very small. If the species continues to decline in numbers it will not survive. Examples: the blue whale, humpback whale, Leadbeater's possum, swift parrot, helmeted honeyeater, beaked gecko.

Vulnerable

Vulnerable means decreasing in population. The species may become endangered if numbers continue to decline. Examples: mountain pygmy possum, squirrel glider, mallee fowl, diamond python, Murray cod, Gippsland giant earthworm.

Rare

Rare means the population is small but stable, and confined to a small area, or scattered thinly over a large area. Examples: eastern wallaroo, freckled duck, brolga, powerful owl, desert skink, alpine tree frog.

Hands off — leave me in peace!

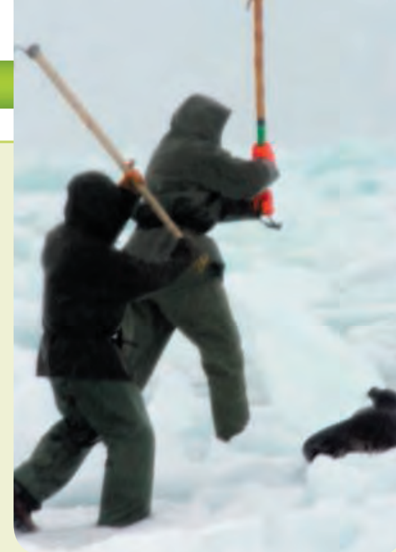
Australia is not the only place where organisms are in danger! All around the world, humans are threatening the survival of other inhabitants of our planet.

GREENPEACE SLAMS SEAL HUNT QUOTAS

by Deborah Mackenzie

Next week, weather permitting, hundreds of men armed with clubs will scramble onto the ice floes covering the sea off eastern Canada and kill more than 300 000 baby harp seals. It will be the largest seal kill since 1970.

Source: New Scientist, 26 March 2005



BONOBOS DYING AS THEY FLEE HUNTERS

by Duncan Graham-Rowe

Hunting may be altering the social ecology of our closest living relative, the pygmy chimpanzee, or bonobo, making this endangered ape even more difficult to study and protect.

Source: New Scientist, 5 February 2005

PRESSURE IS ON TO LIFT WHALING BAN

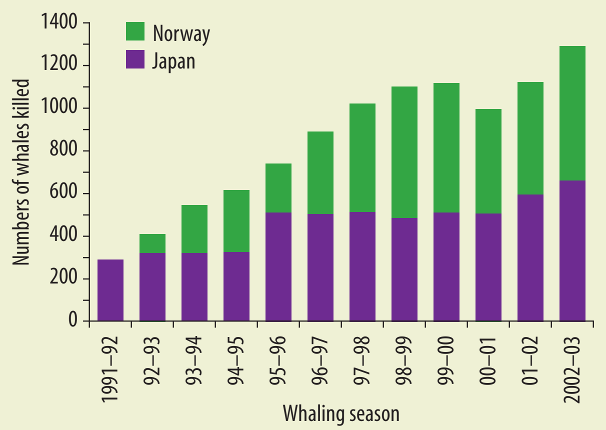
by Bob Holmes and Duncan Graham-Rowe

Pro-hunt nations say it is time to begin killing whales for profit once again. Could they be right?

Source: New Scientist, 18 June 2005

WHALE HARVEST ON THE INCREASE

Numbers of whales killed since the IWC Whaling Moratorium came into effect



In recent years, there has been a steady decline in the market for whale meat, despite increased whaling quotas and more whales killed.

OIL PLANS THREATEN WHALE'S EXISTENCE

by Duncan Graham-Rowe

The fate of the last remaining western grey whales is bringing conservationists and big business into open conflict. At the centre are plans to run an oil pipeline through the whales' main feeding grounds.

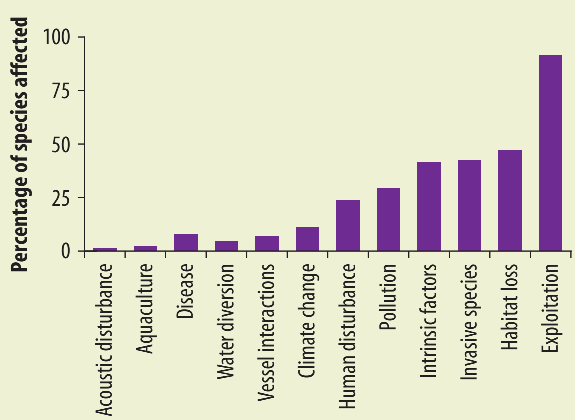
Source: New Scientist, 16 February 2005

LET THE BIG FISH GO TO SAVE THE SPECIES

by Stephen Leah

The trophy fish that anglers dream of landing are crucial for saving fish populations. It means fishery managers should rethink the common policy of chasing the big fish and letting the tiddlers go.

Source: New Scientist, 25 June 2005



INQUIRY: INVESTIGATION 4.14

Whales in a fishbowl?

KEY INQUIRY SKILL:

- communicating

Imagine this scenario. A committee has been set up to discuss whether the current whaling ban should be lifted.

Get together with other class members to make a team of five; number off from 1 to 5. Each number represents one of the following roles in the scenario.

1. A Japanese diplomat who claims eating whale is a tradition dating back 4000 years and is part of Japanese culture
2. An environmentalist who has strong anti-whaling views and is the president of a local environmental group
3. A marine biologist who has been studying whales for 10 years
4. A Norwegian whaler who has been whaling for over 30 years and has come from a family who have been whalers for generations
5. The chairperson of the committee who has worked as a politician in many environmental committees and is hoping to be elected as minister for trade and industry

- All class members with the same role number are to meet, decide on their character's name and 'history', and collect relevant information and ideas to assist them in 'becoming' that role. For example, all of the '1's are to become experts at being Japanese diplomats, and all of the '2's become experts at being anti-whaling advocates.
- The expert groups have a set time to prepare arguments to defend their positions.
- Students then return to their original teams and role-play a committee meeting on the issue of whaling. These meetings could be taped for other groups to view.
- Alternatively, expert groups could send a representative to the discussion and have a single committee meeting while others watch as an audience. This is called a fishbowl activity.

Behind bars

For thousands of years, humans have kept animals in captivity; animals have been kept as pets and they have been put on display in zoos, circuses and 'water worlds'. Many people believe that animals should not be held in captivity. What do you think?

INQUIRY: INVESTIGATION 4.15

Animals should not be kept in captivity

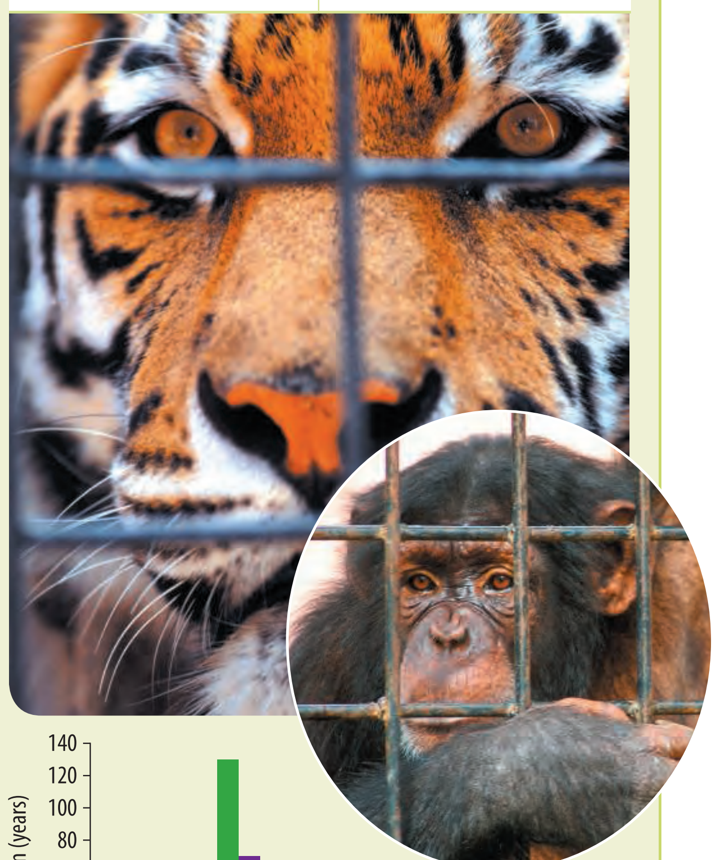
KEY INQUIRY SKILL:

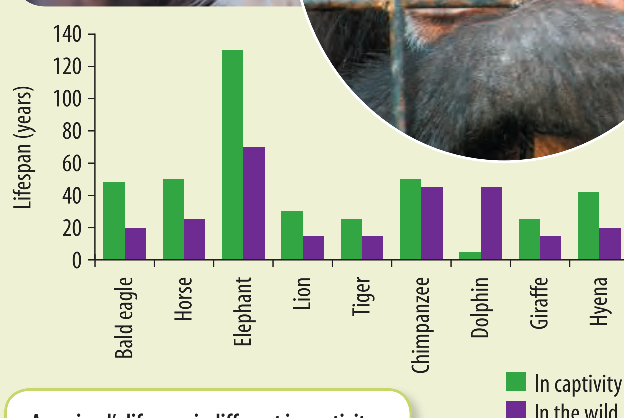
- communicating

Use the information and images in this section and in other resources to construct a written response to the statement: 'Animals should not be kept in captivity'.

Average distance travelled per day when living in the wild

Animal	Distance travelled (km)
Feral horse	65–80
Asian elephant	25
Red fox	10–250





An animal's lifespan is different in captivity.

ARGUMENTS AGAINST KEEPING ANIMALS IN CAPTIVITY

- The animals in zoos and circuses are kept in cages with little room to move and are out of their natural habitat. They don't feed naturally; for example, lions do not hunt for their food, and seals do not catch their own fish. Polar bears usually have to put up with temperatures at the zoo that are much higher than they are used to in their Arctic environment.
- Most animals in captivity are isolated from others of their own kind and cannot live in their natural social groupings.
- The living conditions and isolation of animals in captivity causes stress. This has an effect on feeding and reproduction; most animals do not reproduce well in captivity.
- Family pets are sometimes unwanted after a short period of time and are abandoned to roam the streets or escape into the bush. Some pets, such as cats, dogs and even horses, escape into the bush and become feral or wild, causing damage to the environment and killing or competing with native species.

  Thousands of birds and small native animals are killed by cats every year, especially in national parks and reserves such as Sherbrooke Forest in the Dandenong Ranges, Victoria. Many of the cats are feral but many are also pets that are allowed to roam outside at night.

ARGUMENTS IN FAVOUR OF KEEPING ANIMALS IN CAPTIVITY

- Zoos provide us with a very valuable educational resource, not only by allowing school children to study animals, but also by making the general public more aware of animals and their value in our world.
- There are many hundreds of species of endangered animals in the world today because of the destruction of their habitats by humans, pollution, overhunting and many other reasons. Zoos provide a breeding program for these animals so that the species can reproduce and have a better chance of survival in the future. For example, research has been carried out into freezing sperm and eggs from some animals, such as the clouded leopard, that are very aggressive towards each other and are unlikely ever to mate in captivity.

- Animal enclosures have improved greatly from the concrete-floored, barred, small 'box'. Today, most zoos have quite large, specially designed enclosures that imitate the natural habitats of the animals as closely as possible. At Melbourne Zoo, a gorilla rainforest has been created where people can observe the gorillas in a very natural environment. This type of enclosure is very different from the small cages of the past.
- Research is carried out at zoos into the needs and behaviour of animals, and this gives us a better understanding of the animals in their natural environments.
- Zoos are very good tourist attractions, and this benefits not only the zoo but also the city, the state and the country. They are great places to visit, especially if you live and work in the city and don't have much contact with nature.
- The benefits of household pets are too many to list here. They are great companions, especially for the elderly and sick. It has been shown that people recover more quickly from illness when they have a pet with them. Pets are also very good for children to play with and learn responsibility by looking after them.

UNDERSTANDING AND INQUIRING

REMEMBER

1 State the meaning of 'extinct'.

2 What is the difference between an endangered species and a vulnerable species?

3 How is a rare species different from endangered and vulnerable species?

4 List five of the factors that have contributed to the extinction of some species of animals.

5 Give two good reasons why endangered species should be saved.

6 What is being done to save endangered species?

7 Animals in zoos do not feed naturally. Give an example to explain this statement.

8 Give one reason why family pets can be a problem.

9 (a) What does the word 'feral' mean?
(b) Why are feral animals a problem?

10 How have animal enclosures in zoos changed over the years?

11 Why don't animals reproduce well in captivity?

12 How does the technique of freezing sperm and eggs help breeding programs in zoos?

THINK

13 How does logging of forests affect native plants and animals? Give some examples.

14 The extinction of one species affects several other species. Explain this statement and give some examples.

THINK AND DISCUSS

15 Observe the graph on page 167 showing numbers of whales killed.
(a) Describe the similarities and differences between the patterns of whale killing by Japan and Norway. Suggest reasons for these.
(b) Suggest reasons for the overall pattern of numbers of whales killed between 1991 and 2003.
(c) State your opinion on the killing of whales. Why? Compare your opinions with those of others.

16 (a) What if there were no fish left on our planet? Construct a mind map with your team's ideas and then write a story.
(b) What if all animals on our planet could talk to each other? What do you think they would say? Present your thoughts as a cartoon or storyboard.

17 Select three of the following thinking-key questions to unlock your thinking:
(a) 'combination' key — list the attributes of a whale and a flower, then combine them
(b) 'alphabet' key — list examples of parts of animals that are used by humans
(c) 'inventions' key — design a protective device for baby seals.

18 Keep an issue learning journal to track your personal learning. An issue learning journal is like a scrapbook diary that includes all of the issues that you find interesting, relevant or thought provoking. You could cut and paste articles, photographs, diagrams, notes, thoughts, clippings and summaries of your reading. You may decide to add comments on issues including:
- what the issue is about
- what you already know about the issue
- a PMI chart on the issue
- your opinion of the issue
- opinions of others in your class or family about the issue
- any biases in information about the issue
- how an author or presenter was effective in communicating the issue to others
- solutions or advice that might help resolve the issue
- other things you would like to find out the issue.

19 In a team, brainstorm other arguments for and against keeping animals in captivity. Organise a class or team debate.

USING DATA

20 (a) Copy and complete the table below, calculating the totals and entering them in the table.

Year	1930	1940	1950	1960	1965	1970
Blue whales killed	25 000	15 000	7 000	3 000	2 000	0
Fin whales killed	14 000	14 000	23 000	32 000	20 000	5 000
Sei whales killed	1 000	1 000	3 000	8 000	25 000	15 000
Sperm whales killed	1 000	5 000	12 000	20 000	30 000	23 000
Totals						

The data above have been adapted from P. R. & A. H. Ehrlich, *Population, Resources, Environment* (W. H. Freeman, San Francisco, 1972).

(b) Plot the data for all four whales, and the totals, on a graph, using the same set of axes for all of them. Put the years on the horizontal axis (scale of 1 cm = 5 years, starting at 1930) and the numbers of whales killed on the vertical axis (scale of 1 cm = 5000). Use different colours for the different whales and the total numbers, and make a legend to show which colour represents which whale.

(c) Which whale was killed less and less over the whole period?

(d) When was the total number of whales killed the greatest?

(e) What can you say about the rate of killing of the whales after 1965? Why do you think this happened?

(f) Why do you think there were fewer whales killed in total in 1940 than in 1930?

INVESTIGATE

21 Use the library or internet to find out more about one of Australia's most threatened vertebrate species. Write a short report, or design a poster, and include the following information:

(a) a description of the animal and its habitat

(b) a list of the animal's requirements (e.g. food, shelter)

(c) reasons why the animal is threatened with extinction

(d) what, if anything, is being done to save the species.

Choose your vertebrate from the species listed below.

- Mountain pygmy possum
- Leadbeater's possum
- Spotted-tailed quoll
- Dugong
- Southern right whale
- Humpback whale
- Western black-striped snake
- Western swamp turtle
- Platypus frog
- Trout cod
- Bar bar frog
- Mallee fowl
- Helmeted honeyeater
- Golden-shouldered parrot
- Yellow-bellied parrot

22 In a team of at least four, find out more about one of the issues in this section. Present your findings to the class as a debate, written report, multimedia presentation, web page, poster or dramatic script. In your presentation, include your own opinions with reasons.

23 Investigate some other ways in which humans have had an impact on the survival of other organisms. Present your findings in a storyboard, concept map, mind map or puppet play.

24 Find out why the baby fur seals, rather than the adults, are 'harvested'. Present a case for and against this harvesting.

25 Contact your local zoo or wildlife reserve and obtain information about which endangered animals are in their breeding programs.

IMAGINE

26 Imagine that you are an explorer in the ever-shrinking Amazon jungle. After many years of searching, you come across a small animal that has not been seen for many decades, and is spoken about only in stories told by the local people.

(a) Describe your discovery of the animal, what it looks like and how it lives.

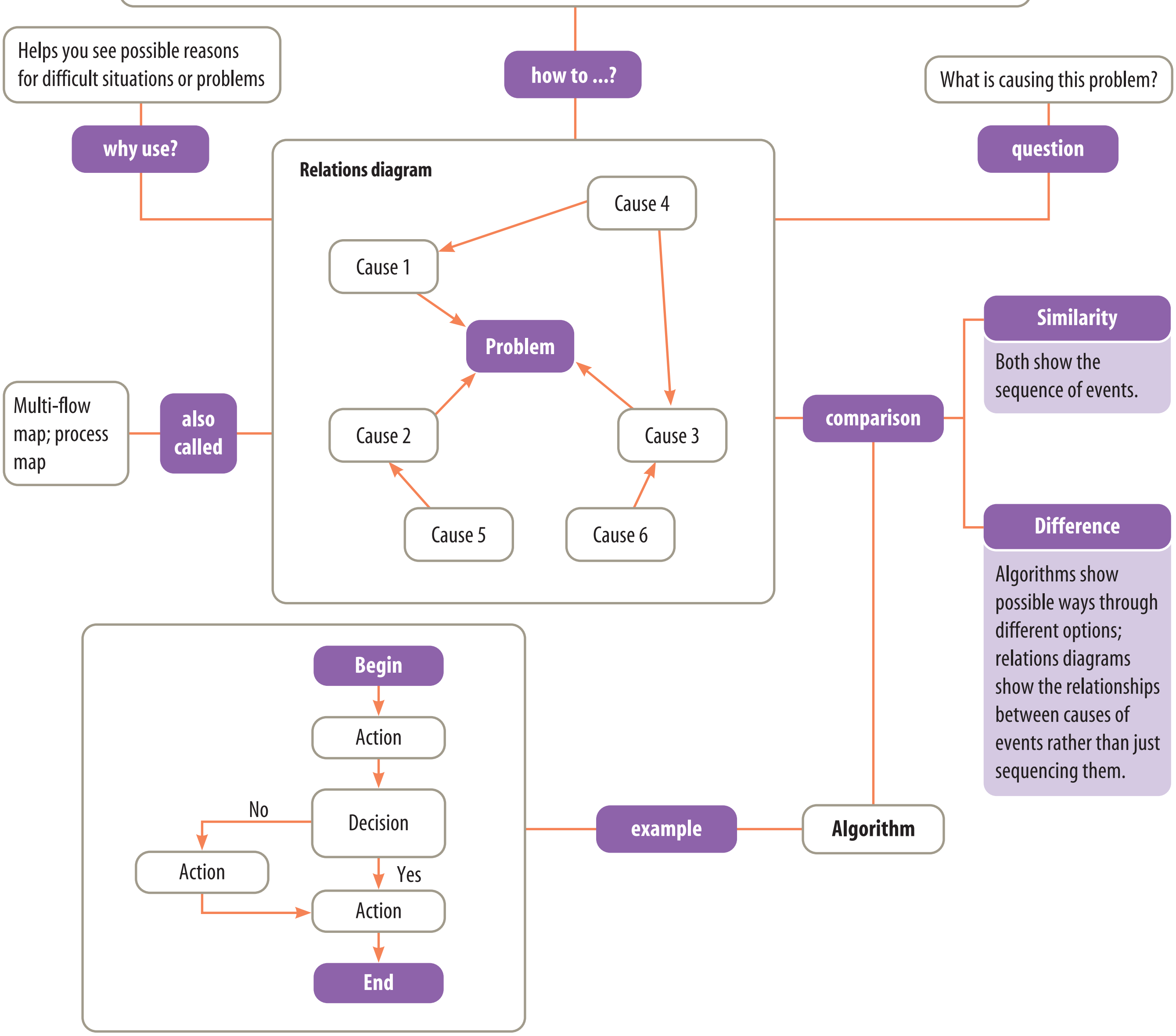
(b) Think about the choices of what to do about your discovery.

- Do you tell others?
- Do you capture it and take it back with you?
- Do you leave it alone despite the fact that it is probably endangered and will soon become extinct?

Put your thoughts down in your explorer's journal.

Relations diagrams and algorithms

1. Write the problem or situation that you are going to analyse in the centre of a sheet of paper.
2. Ask yourself possible reasons for the problem occurring.
3. Write your answers (causes) around the problem. These are your primary causes.
4. Ask yourself why each cause occurred; for example, 'What might the cause of the cause be?'.
5. Write these secondary causes around each primary cause and join them with arrows to show how they are linked.
6. Look for other links in your diagram and add arrows to show these.
7. Colour or highlight which you think are the main causes of the problem.



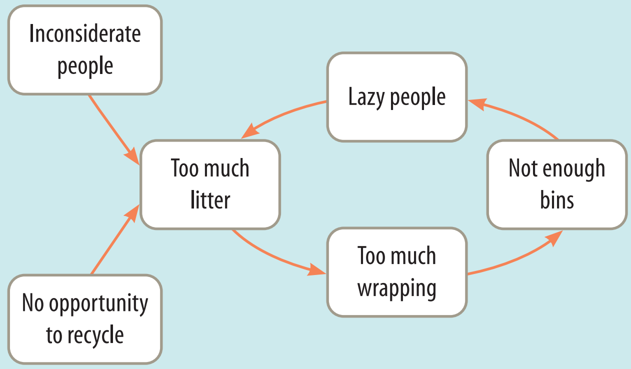
UNDERSTANDING AND INQUIRING

THINK AND CREATE

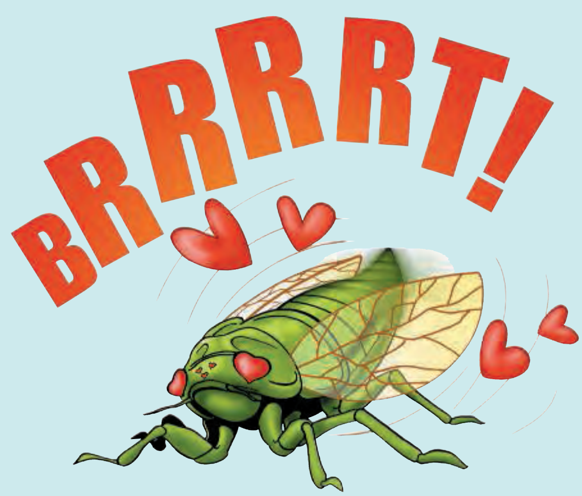
1 The hunting and fate of whales is of great concern to many Australians. Find out more about the issues associated with the hunting of whales.
   (a) Construct a relations diagram to show the reasons for the hunting of whales.
   (b) Construct an algorithm to show possible relationships between the reasons.

2 Use a relations diagram to capture your team's brainstorm of possible causes of, or reasons for:
   (a) Australians having large 'ecological footprints'
   (b) rubbish/litter on our beaches
   (c) the ecological impact of introduced species
   (d) species becoming endangered.

3 (a) In teams, brainstorm possible causes of litter in your school. Summarise your discussion into a relations diagram.
   (b) Compare your relations diagram with that shown below. Comment on any similarities or differences.
   (c) Construct an algorithm that could be used to discourage littering in your school.
   (d) Share and discuss your algorithm with those of your team-mates.



4 It's another lovely warm night with a slight breeze and a whiff of blossom in the air . . . but what's that dreadful noise? It's the cicadas' mating call! They may look scary with their strange-shaped heads, but they won't sting or bite you, and they are not poisonous.
   (a) Find out more about the life cycle of cicadas, where they live, what they eat and who eats them.
   (b) Use a relations diagram to show possible causes of a decrease or increase in their population.



5 Use an algorithm to suggest possible actions to address the following ecological problems:
   (a) Australians have large 'ecological footprints'
   (b) too much rubbish/litter on our beaches
   (c) the ecological impact of cane toads
   (d) species becoming endangered (e.g. blue whale, swift parrot, beaked gecko, helmeted honeyeater).

STUDY CHECKLIST

INTERACTIONS IN ECOSYSTEMS

- identify biotic and abiotic factors in ecosystems
- investigate the effect of an abiotic factor on a biotic factor
- distinguish between producers and consumers
- distinguish between predator and prey
- construct food chains and food webs
- use food chains to show feeding relationships within a habitat
- interpret food chains and food webs
- classify organisms according to their position in a food chain
- describe the role of decomposers in ecosystems
- describe the role of photosynthesis and cellular respiration in ecosystems
- outline how carbon, water and nitrogen is recycled in ecosystems
- describe how energy flows through ecosystems

HUMAN IMPACT ON ECOSYSTEMS

- describe how living things can cause changes to their environment and impact other living things
- define the terms 'greenhouse effect' and 'enhanced greenhouse effect'
- suggest strategies to address global warming
- distinguish between biodegradable and non-degradable substances
- suggest ways to reduce your weekly household rubbish
- define the term 'introduced species' and provide an example
- provide examples of the impact of introduced species to Australia
- define the term 'endangered species' and provide an example
- investigate the effects of the following types of human activity on Australian habitats: deforestation, agriculture, introduction of new species
- investigate ways to control the spread of introduced species (e.g. cane toads)
- research specific examples of human activity that have had an impact on Australian ecosystems

SCIENCE AS A HUMAN ENDEAVOUR

- identify contributions of Australian scientists to the study of human impact on environments and to local environmental management projects
- investigate research and issues on water use and management in Australia
- investigate how indigenous land management practices can help inform sustainable management of the environment
- consider effects of human activity in the community on the sustainability of ecosystems

INDIVIDUAL PATHWAYS

eBook*plus*

Activity 4.1	Activity 4.2	Activity 4.3
Investigating ecosystems	Analysing ecosystems	Investigating ecosystems further
doc-6054	**doc-6055**	**doc-6056**

ICT

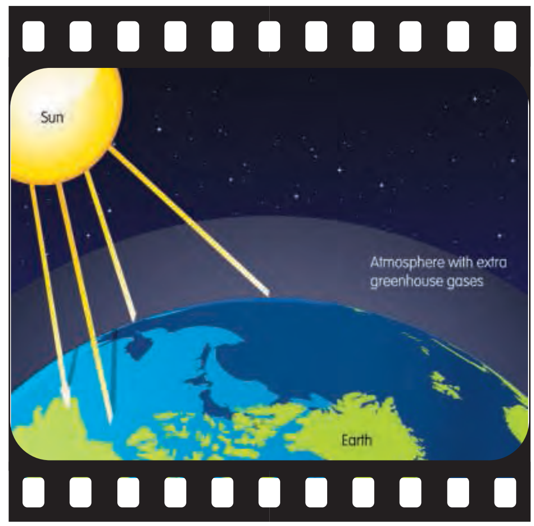
eBook*plus* Summary

eLESSONS

Global warming in Australia

This video lesson looks at the phenomenon of global warming. Learn about greenhouse gases and why many scientists believe the Earth is getting hotter. Discover some of the potentially catastrophic effects this could have on the Earth, and learn how governments and individuals can address this global problem. A worksheet is included to further your understanding.

Searchlight ID: eles-0057



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

INTERACTIVITIES

The survival game

This interactivity looks at the survival of the environment through a fun 'snakes and ladders' style game. Play the game and test your knowledge about how you can help save the environment.

Searchlight ID: int-0217

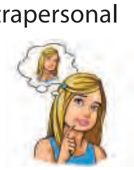
Threats to Earth

This interactivity looks at what is threatening life on Earth. See if you can spot the 10 differences in an environment before and after human contact. Instant feedback is provided.

Searchlight ID: int-0218

LOOKING BACK

1 Eco-MI toolbox — Select and complete four activities from the table below. Make sure that you have at least four rows represented in your selection.

Type of multiple intelligence (MI)	Activity 1	Activity 2
Verbal/linguistic 	Write a fable or legend to explain food webs or the nitrogen cycle.	Write a letter to a school newsletter or local newspaper to express your concerns about an issue related to your local ecosystem. Include suggestions.
Musical/rhythmic 	Write a story about a prey animal trying to convince its predator not to eat it. Put your story to music and turn it into a video or puppet play.	Think of at least ten keywords in this chapter. Write a song that includes examples and definitions.
Logical/mathematical 	Use a graph to summarise data on different temperatures across a range of habitats in a local ecosystem.	Construct a PMI chart on the issue of global warming.
Visual/spatial 	Create a set of illustrated flashcards on key terms used throughout this chapter. Create a mind map of these to show your understanding of the concepts.	Create a PowerPoint presentation to show a primary-school child the arguments for and against a particular ecosystem issue.
Bodily/kinaesthetic 	Using costumes and dialogue in a team of at least four, model a food web with at least three food chains.	Construct a mobile or wall hanging of a food chain in two of the following ecosystems: (a) inner city (b) Murray River (c) outback Australia (d) Great Barrier Reef.
Naturalist 	Having just crash-landed on another planet, describe what you need to find out about your new environment in order to survive.	Deforestation can have a big impact on ecosystems. State possible effects and problems that may be caused by this type of human activity and suggest how you could help to reduce the environmental damage or contribute to a solution.
Intrapersonal 	Think about what your ideal environment would look like, smell like and feel like. Create a Y chart about it.	Construct a single bubble map or cluster map to show ten things that you could do to protect your local ecosystem.
Interpersonal 	Research a local ecosystem issue, dilemma or problem. In a team of four, brainstorm how you could help address two of these issues. Construct a letter or proposal to relevant authorities with your suggestions and/or ways you could help out.	In a team of at least two, design a questionnaire to find information about a school or local ecological issue. Distribute your questionnaire to at least 20 people and summarise your findings in a school newsletter or local newspaper article.

2 Redraw the table below to correctly match the heads and tails.

Heads	Tails
Herbivores are …	organisms that produce their own food.
Producers are …	animals that eat plants.
Consumers are …	organisms that live in or on other organisms and obtain their food from them.
Parasites are …	organisms that break down dead plants and animals.
Decomposers are …	animals that eat other organisms.

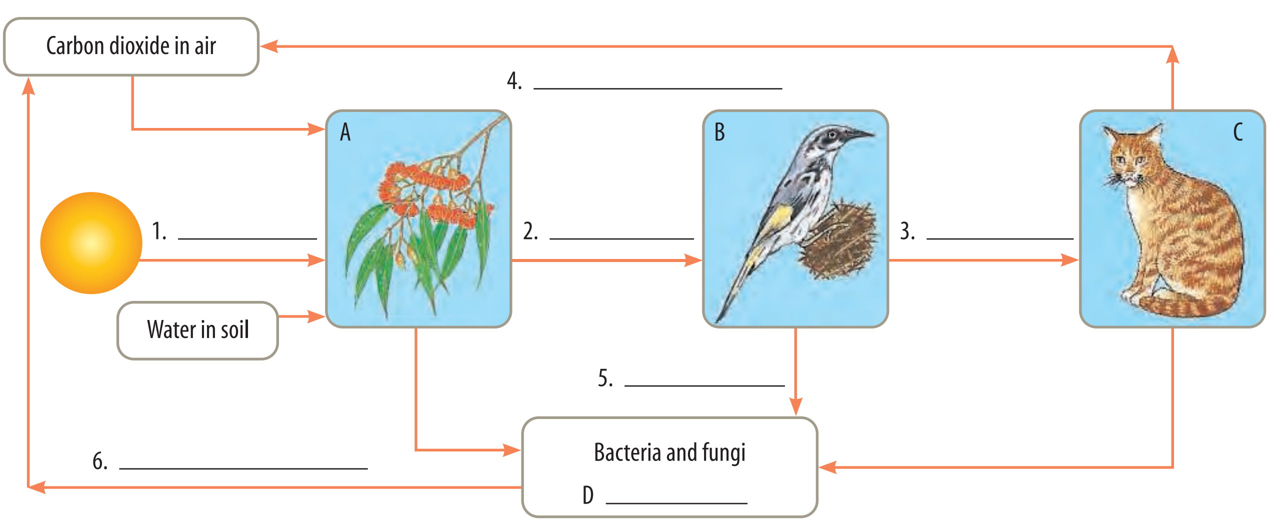
3 Unjumble the words below to reveal some of the important terms in this chapter. Write down what each term means and give an example.
(a) bttaiha (b) typstoossehinh (c) cibaoti (d) dofo incah (e) ytsseemco

4 Copy the puzzle below into your workbook, then use the clues to complete it.

(a) _ _ _ _ E _ _ _ _ _ _
(b) _ _ _ _ N _ _ _ _ _
(c) _ _ _ _ _ V _ _ _ _
(d) _ _ _ I _ _ _
(e) _ _ R _ _ _ _ _ _
(f) _ _ O _ _ _ _ _ _
(g) _ _ _ _ N _ _
(h) _ _ _ _ M _ _ _ _ _ _
(i) _ _ _ _ _ E _
(j) _ _ N _ _ _ _
(k) _ _ T _ _ _ _ _ _

Clues
(a) Animals that eat the same sort of food, and live in the same area
(b) Animals that are close to extinction
(c) Meat-eating animals
(d) A place where an organism lives
(e) Plant-eating animal
(f) A stable system made up of living and non-living things
(g) Describes plants or animals that no longer exist
(h) Organisms such as bacteria and fungi that break down plant and animal remains
(i) A diagram that shows the feeding relationships of organisms in an ecosystem
(j) Information about closeness of organisms determined by sampling
(k) The interaction between members of two species that benefits both species

5 Copy and complete the diagram below by filling in:
(a) the types of organisms labelled with the letters A, B, C and D
(b) the processes labelled with the numbers 1–6. You may use words more than once.



6 Think carefully about the following questions and write a paragraph to answer each one.
  (a) What is the difference between energy flow and matter recycling in an ecosystem?
  (b) There is a connection between the food you put into your stomach and the air you breathe into your lungs. Explain the connection.

7 Not all of the chemical energy in the plant material eaten by a caterpillar is used to form new caterpillar tissues. Use a cluster map to show other fates of this ingested energy.

8 The process of photosynthesis occurs by a number of steps. The speed of the overall process depends on the slowest step. This step is called the limiting factor because it holds up the whole process.
  Suggest two possible limiting factors for photosynthesis and describe how each could limit the rate of photosynthesis.

The amount of water that is put on the fire depends on how fast the slowest member of the chain can work. This person is the limiting factor.

9 (a) Identify the key source of energy in ecosystems.
  (b) Describe how energy moves through ecosystems.

10 Construct a pyramid that represents the transfer or transformation of materials and energy in food chains and webs.

11 Construct a food web that includes organisms in a local ecosystem.

work sheets
4.9 Ecosystems: Puzzles
4.10 Ecosystems: Summary

INQUIRY: INVESTIGATION 4.16

Mind 'n' flash

KEY INQUIRY SKILLS:

- observing and measuring
- developing explanations

1 Make up flash cards in the colours indicated, using the following terms.

  Green cards (use green card or green writing): photosynthesis, autotroph, producer, light energy, chlorophyll, chemical energy

  Orange cards (use orange card or orange writing): consumer, heterotroph, first-order consumer, second-order consumer, trophic levels, food chain, food web, decomposer, predator, prey, competitor

  Red cards (use red card or red writing): cellular respiration, pollination, germination, decomposition, chemical energy, heat energy

  Yellow cards (use yellow card or yellow writing): oxygen, carbon dioxide, water, chemical energy, glucose, sucrose, starch, protein, amino acid, nitrogen, carbon, hydrogen, nitrates, nitrites, ammonia, fossil fuels

  Blue cards (use blue card or blue writing): plants, animals, bacteria, fungi, nitrogen-fixing bacteria, nitrifying bacteria, de-nitrifying bacteria

  White cards (use white card): greenhouse effect, enhanced greenhouse effect, global warming, introduced species, endangered species, deforestation, pollution, biodegradable, non-biodegradable, renewable resource, biological control, ecological footprint, nitrogen cycle, water cycle, carbon cycle

2 Browse through this chapter and:
  (a) add any symbols or pictures on the fronts of the cards that will help you to remember their meanings or importance
  (b) add on the backs of the cards any summaries, key points or definitions.

3 Clear a playing area with space to arrange your cards in various mind maps, equations, cycles or flowcharts.

4 (a) Taking turns, each person in your team is to place a card in the playing area.
  (b) When it is your turn, try to use a card that links in some way to one of the cards already in place. As you place it near its connecting card, tell your team-mates what the connection is.
  (c) Continue this until no-one in your team can think of any other connections.
  (d) Elect two team members to stay with your mind map to explain it to 'visiting scavengers' and send the others out to scavenge ideas from other groups.
  (e) Make any adjustments suggested by your team-mates when they return.

5 (a) On A3 paper, write out your own version of your team 'flash card mind map'.
  (b) Convert your mind map into a concept map by adding your own notes to describe connecting lines between the terms.
  (c) Compare your map with those of others, adding any of their notes that help you make sense of why the terms are linked by these lines.

6 Reflect on what you have learned together.

projects*plus*

Small acts, big changes

SEARCHLIGHT ID: PRO-0036

Scenario

As a member of generation Y, climate change is an issue that is very important to you. Nearly every day you hear frightening statistics about what the world will be like by 2050 unless we all make dramatic changes to our lifestyles. You are also getting frustrated by how slowly change is being initiated. Therefore, you have decided to take action yourself and create a persuasive video that will inform households and local communities of actions they can take personally to help stop the consequences of climate change.

Your project brief includes a sample viral video on climate change.

Your task

Your task is to create a three-minute internet video to be distributed online. Your aim is for this video to become 'viral' — for it to be good enough that people want to pass it on to their friends. Your video should provide the viewer with practical advice on reducing their carbon footprint, but it should also be entertaining enough to appeal to a wide range of people who use the internet. Remember, the consequences of climate change have already begun, so your video should not only create a sense of urgency about the seriousness of the problem but also be persuasive enough to encourage its viewers to take immediate action. Therefore, you need to provide convincing and accurate facts while appealing to the emotional and intellectual capacities of your audiences.

Process

- Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group. You can complete this project individually or invite other members of your class to form a group. Save your settings and the project will be launched.
- Navigate to your Research Forum. A number of issues surrounding climate change have been loaded as topics to provide a framework for your research. Choose the issues you would like to include in your video and delete the other topics. You will need to research facts about what climate change is and the environmental problem it causes.
- Start your research. You should find at least two sources (other than the textbook, and including at least one offline source such as a book or encyclopedia) to help you discover extra information about the issues your video will present. The weblinks in your Media Centre will help you get started. Enter your findings as articles in the Research Forum. You can also view and comment on other group members' articles and rate the information they have entered.
- When your research is complete, navigate to your Media Centre, download the 'Shooting Script' template, and use it to create a script

Your ProjectsPLUS application is available in this chapter's Student Resources tab inside your eBookPLUS. Visit www.jacplus.com.au to locate your digital resources.

and shot list for your video. When planning your video, consider how different organisations are promoting action on climate change to a wide audience and which techniques are most effective.

- A selection of media has been provided in your Media Centre for you to download and use in your video. You can also create animations, or you might like to incorporate other media. Don't forget to record the source of any information or image that you use in your movie as you always need to acknowledge other people's work.
- When your shooting script is signed off, record your voiceover and then use video-editing software to create your final production.
- Print out your Research Report from ProjectsPLUS and hand it in to your teacher with your shooting script and your final video. You might even like to post your video on YouTube or hold a school screening.

SUGGESTED SOFTWARE

- ProjectsPLUS
- Microsoft Word
- Audacity, GarageBand or other voice-recording software
- Windows Movie Maker, iMovie or other editing software

MEDIA CENTRE

Your Media Centre contains:

- a bank of media to use in your video
- a 'Shooting Script' template
- weblinks to sites on climate change and free recording and editing software
- an assessment rubric.

eLesson

GLOBAL WARMING IN AUSTRALIA

This video lesson looks at the phenomenon of global warming. Learn about greenhouse gases and why many scientists believe the Earth is getting hotter. Discover some of the potentially catastrophic effects this could have on the Earth and learn how governments and individuals can address this global problem. A worksheet is included to further your understanding.

SEARCHLIGHT ID: eles-0057