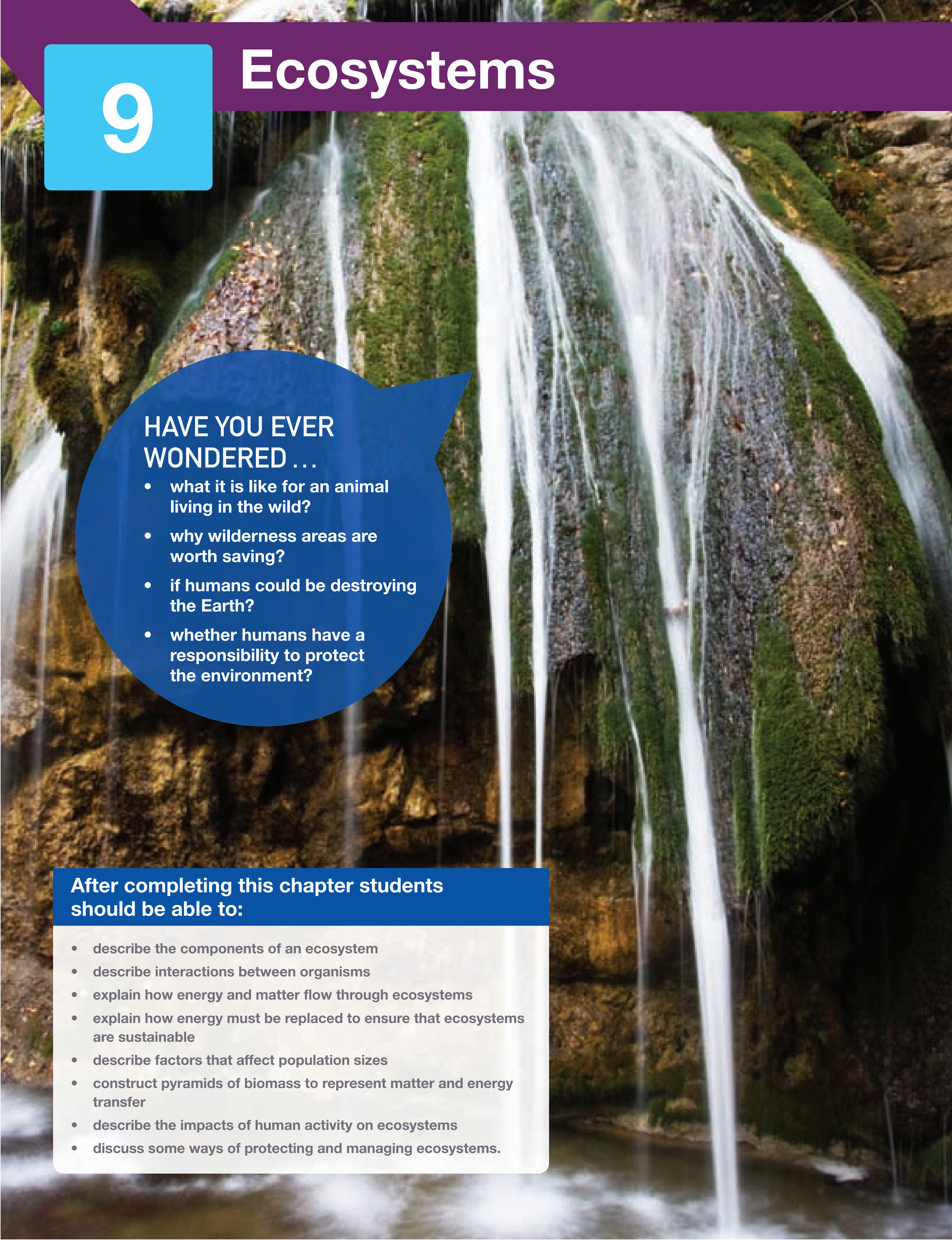
9 Ecosystems



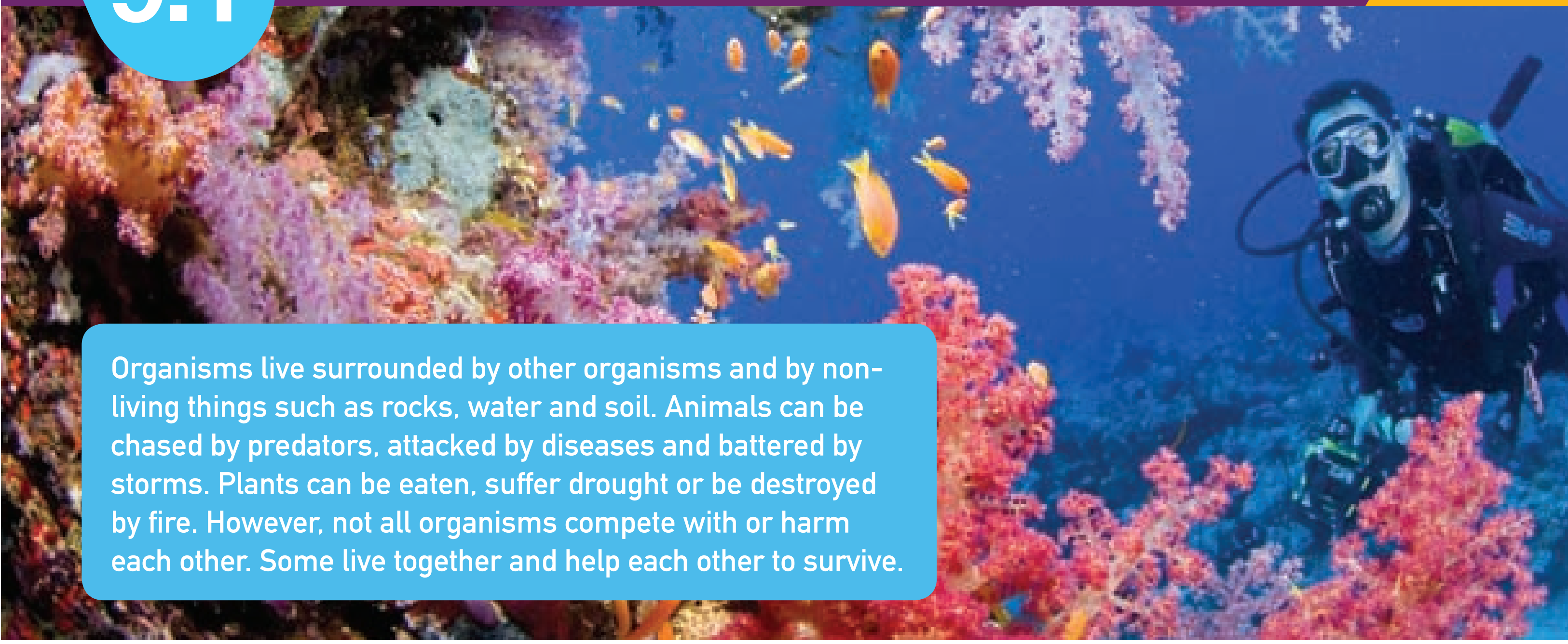
HAVE YOU EVER WONDERED . . .

- what it is like for an animal living in the wild?
- why wilderness areas are worth saving?
- if humans could be destroying the Earth?
- whether humans have a responsibility to protect the environment?

After completing this chapter students should be able to:

- describe the components of an ecosystem
- describe interactions between organisms
- explain how energy and matter flow through ecosystems
- explain how energy must be replaced to ensure that ecosystems are sustainable
- describe factors that affect population sizes
- construct pyramids of biomass to represent matter and energy transfer
- describe the impacts of human activity on ecosystems
- discuss some ways of protecting and managing ecosystems.

9.1 Natural ecosystems



Organisms live surrounded by other organisms and by non-living things such as rocks, water and soil. Animals can be chased by predators, attacked by diseases and battered by storms. Plants can be eaten, suffer drought or be destroyed by fire. However, not all organisms compete with or harm each other. Some live together and help each other to survive.

Interdependence

Living things depend on each other for survival. An example of this is the relationship between termites and microscopic organisms called flagellates (Figure 9.1.1). Termites feed on wood and other tough plant materials. However, they lack the digestive enzymes to digest these materials themselves.

The flagellates live inside the gut of the termites and digest the wood, and the termites absorb these digested nutrients. In return, the flagellates have a moist and stable place to live. The termites and flagellates are **interdependent**—they affect one another's survival.

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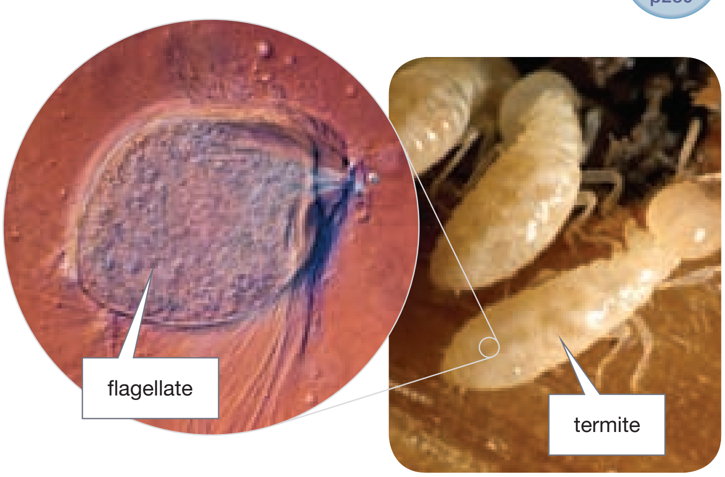

Figure 9.1.1 Flagellates live inside the gut of termites. They are interdependent.

Ecology

Studies such as those of the termite and the flagellate belong to a sub-branch of biology called ecology. **Ecology** is the study of how organisms interact with each other and with their environment. To interact means to affect each other, in ways that may assist or harm each other. The **environment** consists of all the factors in an organism's surroundings that affect it.

A **habitat** is not the same as an environment. The habitat is simply where an organism lives. The habitat is a place, whereas an environment is a set of factors that affect survival.

Ecosystems

To help understand how organisms live in a particular environment, ecologists use the concept of an **ecosystem**. An ecosystem is a system formed by a group of living things interacting with each other and their non-living surroundings.

Ecosystems have three main components:

- physical surroundings, such as rocks, soil and water
- living organisms
- living and non-living factors that make up the environment.

An ecosystem is a place where organisms and their physical surroundings form a balanced environment that is different from others nearby. Natural ecosystems can exist on their own. The lake ecoystem in Figure 9.1.2 on page 282 is an example.

Figure 9.1.2 A freshwater lake is an ecosystem.

Humans can create artificial ecosystems such as the aquarium shown in Figure 9.1.3. These ecosystems are usually not balanced. They need to be managed by adding food materials and removing wastes.

Figure 9.1.3 An aquarium is an artificial ecosystem because it cannot survive without human help.

Factors influencing organisms

Organisms in an ecosystem can be affected by two main sets of factors. One set of factors is due to the actions of living organisms, while the other set is due to the non-living surroundings.

The non-living factors are called **abiotic factors**, also known as **physical factors**. These include water, air quality, the amount of light, temperature, wind, soil type, humidity of the air, tides, waves, lightning and fires.

The living factors are called **biotic factors**. Living factors in the human environment include predators such as sharks, parasites, fungi, infectious organisms, competitors (such as other humans trying to obtain food) and collaborators (such as a breeding partner). Some of these are shown in Figure 9.1.4.

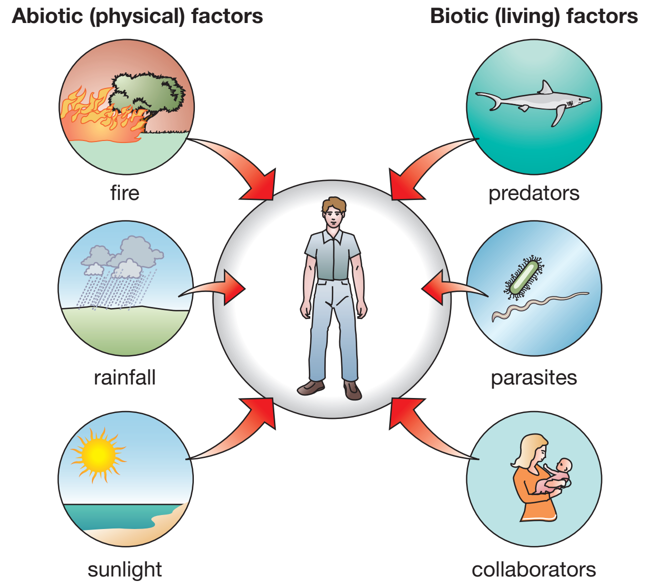

Figure 9.1.4 Abiotic and biotic factors affect all organisms.

Abiotic factors

Water

Water is essential for the chemical reactions in the cells of living things. All organisms require water, though not all need to drink it. Some obtain enough water in their food. For land animals, the availability of water is often the most vital factor in survival.

Temperature

Heat affects the speed of chemical reactions in the cells. The higher the temperature, the faster these reactions take place.

The body temperature of fish, reptiles (like the one in Figure 9.1.5) and amphibians depends on the temperature of the environment. These animals can influence their body temperature in some ways, such as by lying on warm rocks in the sunlight to heat up, or hiding in a burrow if they are too hot. Biologists use the term **ectothermic** to describe these animals, rather than 'cold blooded'. This is because many of these animals are not 'cold' but have body temperatures that vary with the environment. Ectothermic means the organisms must obtain body heat from the environment rather than by generating it internally by body chemistry.

Figure 9.1.5 A reptile's body temperature depends on the temperature of the environment. Its temperature will be very low overnight and on cold mornings, and high after it has been lying in the sunlight.

Birds and mammals like humans and kangaroos are 'warm blooded', or **endothermic**. Endothermic means that the organisms have the ability to generate heat internally and control heat loss to keep their body temperature constant.

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The price of being an endotherm

Up to 80% of food consumed by an endothermic animal goes to generating heat to maintain a constantly warm body temperature. This means an endothermic animal must find and consume many times more food than a comparable ectothermic animal.

Fire

Some fires start because of lightning hitting trees, or because of human activity. Australian Aborigines have used fire for many thousands of years to keep the bush open and to improve the growth of plants. They knew that many Australian plants re-grow quickly after fire.

A bushfire like the one in Figure 9.1.6 can kill some plants, but it may help others. Some plants flower better after a fire and some drop their seeds. Many Australian plants will germinate after a fire due to the chemicals released in the smoke.

9.1

Figure 9.1.6 Fire can kill some organisms but help others.

INQUIRY science 4 fun

Fish shapes

Why are fish shaped like they are?

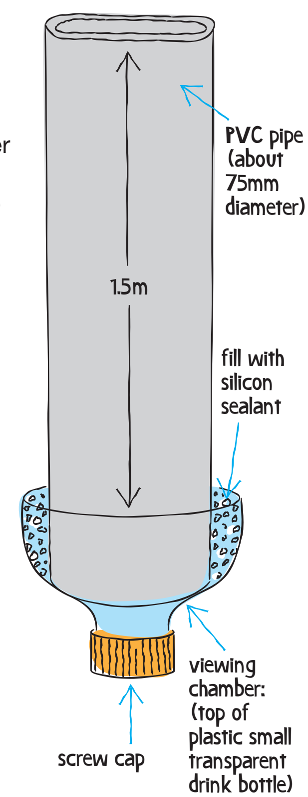
No

Collect this ...

- test container (see diagram)
- plasticine to make fish
- bucket
- timer
- water

Do this ...

1 Make the test container as shown in the diagram. It will need to be 1.5 m in height.
2 Cut five cylinders of plasticine about 2 cm wide by 2 cm long.
3 Use the plasticine to make a fish shape (with tail) and different shapes such as a sphere, cube, pyramid and rectangle. These should all be approximately the same size.
4 Fill the test container with water. Drop the shapes into the top of the container and time how long it takes each to reach the bottom.



Record this ...

Describe your results. Use a table.

Explain why fish are shaped as they are.

Light

Light is necessary for photosynthesis. **Photosynthesis** is the process by which plants manufacture their food materials using water, carbon dioxide and light. Changes in the amount of light over the seasons trigger plant growth and flowering in many species.

Soil type

Soils are not all the same. Some have more nutrients than others and some soils hold water better than others.

Gas levels

Most organisms require oxygen for respiration. There is usually enough oxygen in the air for organisms, but the amount in water can change greatly. Colder water contains more oxygen than warm water does.

Biotic factors

Organisms rarely live alone—they are surrounded by other living things including plants, animals and microorganisms. The living things in an ecosystem form a community. Different relationships exist between the organisms in a **community** and these relationships are classified by how the organisms interact.

There are many different interactions between living organisms. These interactions are biotic factors, and they play a major role in the survival of all species. Sometimes organisms assist each other, and sometimes they harm each other.

Competition

Organisms are said to be in competition when they both try to obtain the same resource, which may only exist in limited amounts. **Competition** occurs between members of the same species (like the chicks shown in Figure 9.1.7), and between different species.

Figure 9.1.7

Baby birds compete with each other for food by trying to attract their mother's attention.

There is only a limited supply of food and resources, and so some individuals will not survive. In natural communities, competition is often fierce. There is a constant struggle for existence, and many die, especially the young, the old and the weak.

Predation

When one organism kills and eats another, the attacker is called the predator and the one being eaten is called the prey. This feeding relationship is known as **predation**. An example is shown in Figure 9.1.8.

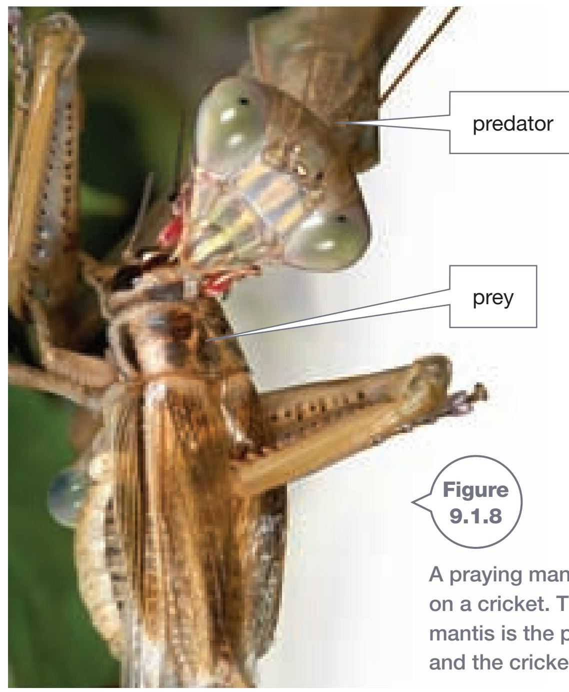


Figure 9.1.8

A praying mantis preying on a cricket. The praying mantis is the predator and the cricket is its prey.

Mutualism

Mutualism is a relationship where two organisms live closely together and both benefit. The flagellates in a termite's guts are a good example. Without the flagellates, the termite would not have any food. The flagellates receive food and the correct temperature and moisture levels for survival. Both organisms depend upon each other.

The cleaner shrimp shown in Figure 9.1.9 eats parasites on the skin of the fish. Both the cleaner shrimp and the fish it cleans of parasites benefit, so this is an example of mutualism.

Pollination is another example of mutualism. Many flowering plants depend on animals (like the honeyeater bird in Figure 9.1.10) to pollinate them. Pollination is the transport of pollen (the male sex cells) to the female parts of the flower. Pollination results in seeds. Many flowering plants are adapted to use particular animals for pollination, and without them the plants would be unable to reproduce and would eventually die out.

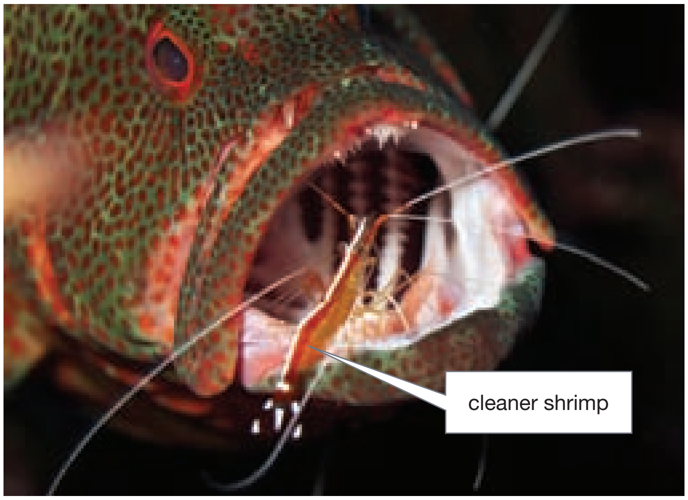


Figure 9.1.9 Cleaner shrimp and the fish they clean are an example of mutualism.

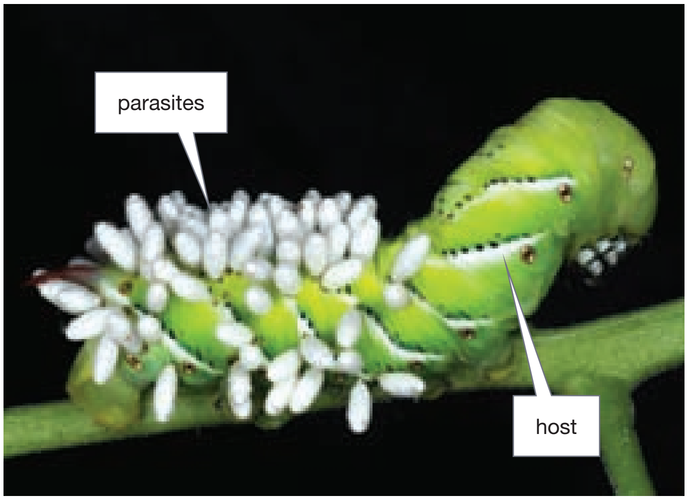


Figure 9.1.11 A parasitic wasp has layed its eggs on this caterpillar. They will hatch and eat the caterpillar.

Figure 9.1.10 Flowering plants rely on pollinators such as this honeyeater to transfer pollen, which enables the plants to make their seeds.

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River blindness

River blindness is caused by a parasitic worm that lives in human eyeballs. The worm is transmitted by a bite from a type of fly called a blackfly. The worm is estimated to have made about half a million people blind.

Parasitism

Parasitism is a relationship where one organism lives on or in another organism (the host) and feeds off it. The parasite cannot survive without the organism in which it lives. The parasite usually harms the host, but rarely kills it. An example is the caterpillar in Figure 9.1.11, which has been attacked by a wasp parasite.

Commensalism

Commensalism is a relationship where one organism benefits and the other is unaffected. An example is the strawberry poison arrow frog. This South American frog raises its tadpoles in pools of water trapped in bromeliad plants, as shown in Figure 9.1.12. The plant is neither harmed nor receives benefit.

Figure 9.1.12 The strawberry poison arrow frog raises its tadpoles in pools of water in the leaves of bromeliads.This is an example of commensalism.

Defining relationships

Scientists sometimes reclassify relationships as more research is carried out and they learn more about them. An example is the relationship between clownfish and anemones.

Figure 9.1.13 Clownfish in a sea anemone

Anemones are related to jellyfish, and have stinging tentacles. They kill small animals and eat them. The clownfish are immune to the stings and feed on the anemone's leftover food, and receive protection from predators.

1 Recent research has shown that some anemones grow better if clownfish live in them. So there must be a benefit to those anemones. Some species of clownfish scare away butterfly fish, which can eat anemones. Both the anemone and the clownfish benefit and so the relationship is mutualism.

2 In aquariums, one type of clownfish catches small fish and drags them over to the anemone. The anemone stings the small fish and kills them. Both the clownfish and the anemone then feed on the dead fish. Both benefit, so once again the relationship is mutualism.

3 It is not clear whether all clownfish and their anemones show mutualism. Some species of anemones may neither benefit nor be harmed by the clownfish. Only the clownfish is benefiting, and so the relationship is one of commensalism.

Adaptations

Organisms are able to cope with the biotic and abiotic factors in their environment because they have special features that assist them to survive. These features are called **adaptations**. An adaptation is any feature that assists an organism to survive and reproduce in its environment.

Organisms have adaptations for every activity they engage in. Adaptations are classified as structural, behavioural or functional features of the organism.

Structural adaptations

A structural adaptation is a body part that helps an organism to survive. For example, a bat has wings for flying. The bat's fingers are very long and form struts to support skin. You can see this in the ghost bat in Figure 9.1.14. This forms a wing, which helps the bat to survive by giving it access to a wide range of food sources. The bats can exploit foods such as flying insects, plant fruits or nectar high in trees.

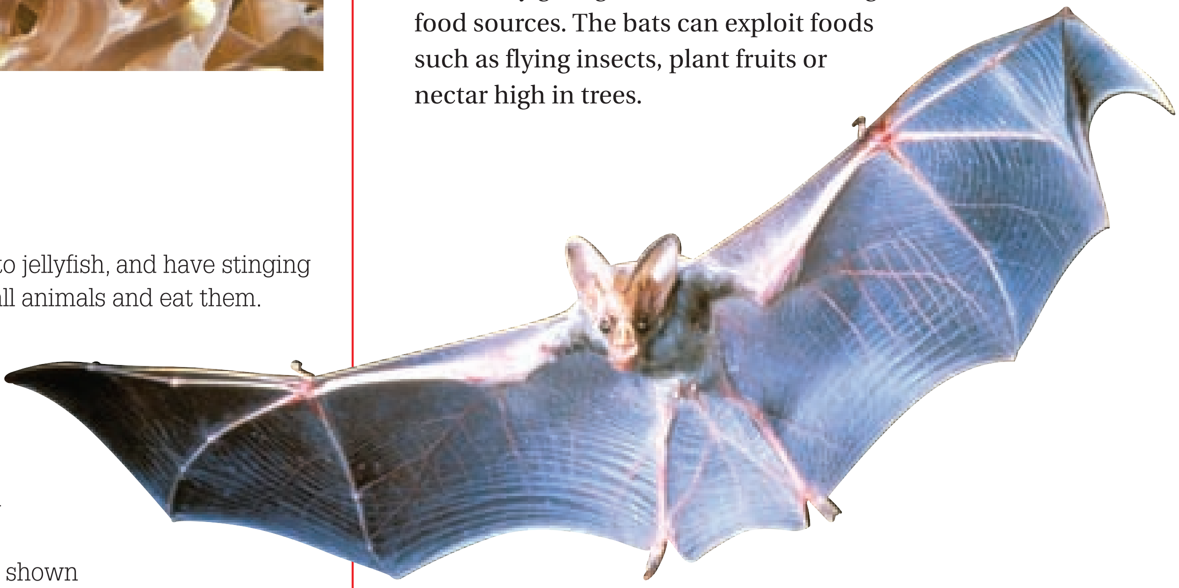

Figure 9.1.14 A ghost bat's wing is a structural adaptation that allows it to fly.

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Ghost bats

Ghost bats are not as efficient at using echolocation as many other bats. Ghost bats hunt mainly using their eyesight and hearing. They have large ears and eyes. These too are structural adaptations.

Behavioural adaptations

A behavioural adaptation is a feature of an organism's habits, actions or way of life that helps it. For example, the spinifex hopping mouse, shown in Figure 9.1.15, only comes out at night when the air has cooled, so that it does not lose water and dehydrate. The mouse avoids the heat of the day by remaining in its burrow. A burrow is cooler and the air there is humid, with a lot of moisture in the air. This helps to slow the evaporation of moisture from the mouse.

Figure 9.1.15 The spinifex hopping mouse hides in a burrow during the day, which helps the mouse avoid dehydration.

Dolphins use a behaviour called echolocation. When they want to know what is in the water around them, they emit clicking sounds, as shown in Figure 9.1.16. These sound waves travel through water, reflect off objects and return to the dolphin. The dolphin has the ability to receive these sound waves and form a mental image of the objects around it.

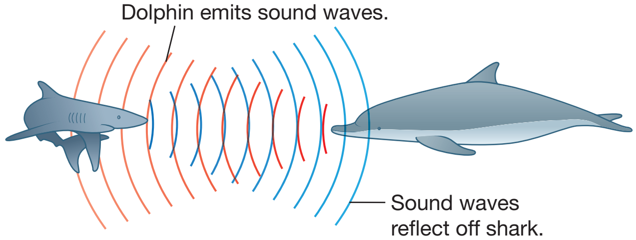

Figure 9.1.16 Dolphins use a behaviour called echolocation to detect prey and enemies.

Sound vision

Because sound waves can penetrate objects, scientists have concluded that dolphins can 'see' into each other. This would mean that a male dolphin may be able to tell if a female dolphin is pregnant.

SciFile

The large-eared horseshoe bat (Figure 9.1.17) also echolocates its prey. It sends out high-pitched sounds through its nose, which has a structure called a noseleaf that focuses the sound into a beam. The bat moves its ears and head around to locate the returning sounds that have bounced off its prey. The bat's brain creates a 'picture' in its head of where the prey is located.

Figure 9.1.17 The large-eared horseshoe bat hunts using echolocation.

Functional adaptations

9.2

A functional adaptation is a feature of the way an organism's body works. When you exercise, your body automatically makes your heart beat faster so that more blood is supplied to your muscles. This is a functional adaptation, not a behavioural adaptation, because it is controlled automatically—you cannot consciously change it. Functional adaptations are sometimes called physiological adaptations. The science of physiology is concerned with how organisms function. Sports scientists study human physiology.

Figure 9.1.18 Increasing heart rate is a functional adaptation to allow increased activity.

9.1 Unit review

Remembering

1 **Name** the term that means ‘a list of all the factors in an organism’s surroundings that affect it’.

2 **List** the three main components of any ecosystem.

3 **List** five different physical, or abiotic, factors that affect organisms.

4 **List** five different types of relationships between organisms.

Understanding

5 **Explain** why birds and mammals are not affected by cold weather as much as reptiles are.

6 **Explain** how fire can be useful in the Australian bushland.

7 **Define** the following terms.
   a structural adaptation
   b functional adaptation
   c behavioural adaptation

8 **Explain** why honeyeater birds are important to plants.

Applying

9 Choose an area in your garden at home, or a favourite area of bush. Think about the changes in the physical conditions throughout the year. **Identify** all the physical factors and the changes that occur in them in a year.

10 **Demonstrate** how a eucalypt depends on both its biotic and its abiotic environment.

Analysing

11 **Compare** a community with an ecosystem.

12 a **Discuss** five biotic factors and five abiotic factors in your environment.
   b **Compare** these factors with those for a gorilla.

13 Most of the land animals found in the Arctic and Antarctica are birds or mammals. Few are reptiles or frogs. **Compare** these animals in a way that explains this observation.

Evaluating

14 a **Classify** each of the relationships listed below.
   b **Justify** your answers.
      i falcon and budgerigar
      ii tick and bobtail lizard
      iii human and pet budgerigar
      iv tinea and human
      v lion and cheetah
      vi sheep and bacteria in its gut
      vii rabbits, foxes and wedge-tailed eagles
      viii soldier ant and worker ant in a colony

15 *In Australia, it is said that termites are very important decomposers.* **Use** your knowledge of termites to **critically evaluate** this statement. (*Hint*: Is it really the termites who are the decomposers?)

Creating

16 **Design** an alien animal. In a drawing, detail ten adaptations (of any type) that could help it survive on a planet where all of the following conditions occur.
   - Gravity is ten times greater than Earth’s gravity.
   - The atmosphere has only 10% oxygen.
   - The temperature and sunlight are three times as intense as on Earth.
   - The evaporation rate is double that of Earth’s hottest desert.

Inquiring

1 Research a rainforest and sand dunes at the beach. Choose five physical factors that could affect the plants in each place and describe the differences in the factors.

2 Research the adaptations of animals such as the desert hopping mouse to drought conditions in desert regions.

3 Animals can adapt in some amazing ways to avoid being eaten. Research and describe the adaptations of five different animals that help them avoid predation.

4 Design an experiment to test the response of an animal to light. Appropriate animals to test are slaters, mealworms and millipedes.

9.1 Practical activities

1 Termite guts

Purpose
To investigate what lives inside termite guts.

Materials
- termite
- small watchglass
- fine forceps
- 0.6% saline solution (non-iodised salt) in dropper bottle
- petri dish
- microscope slides
- coverslips
- monocular microscope with 40× objective lens
- razor blade
- dissecting needle

SAFETY

Be extremely careful with the razor blade, needle and forceps.

Wash your hands carefully after the dissection.

Procedure
1. This involves killing a termite. If you don't want to do this, ask your teacher to do it. Grasp a termite with fine forceps and drop it into the saline solution in the watchglass.
2. Using the razor blade, remove the termite's head. Hold the thorax with fine forceps and use a dissecting needle to pull out the abdomen and puncture the gut.
3. Place a drop of saline on a slide and dip the gut into it. Then put the gut back in the petri dish. Add a coverslip and observe with a light microscope. Observe first on low power, then on high power with a 40× objective.

Results
1. Describe the organisms you see and record how many different ones there are.
2. Sketch the different flagellates you find.

Discussion
Propose an explanation for the flagellates in the termite's gut.

2 Temperature and activity

Purpose
To design and conduct an experiment to test the hypothesis that temperature affects the activity of animals.

Materials
- animals such as slaters, ants, mealworms or other insects
- access to hot and cold water
- ice
- thermometer
- at least four containers such as beakers and petri dishes
- marking pens

Procedure
1. As part of the planning process, decide which animals you will use in the activity. Remember that you must not harm the animals. To design your experiment, you must consider:
   - a what activity you will measure
   - b how to change the temperature
   - c what equipment you will need.
2. Outline how you will carry out your experiment, how you will collect your data and a list of equipment you will need. Show this to your teacher before you start experimenting.
3. Carry out your experiment and collect your data.

Results
Present your data in a suitable way and answer the questions below.

Discussion
1. **Describe** any pattern or patterns you found in the data.
2. **Summarise** the relationship between temperature and animal activity.
3. **Explain** the relationship between temperature and activity.

9.2 Sustainability

Most natural ecosystems are sustainable, meaning they maintain living conditions for the community. As long as ecosystems have a supply of matter and energy, and have a fairly large range of species, they can sustain themselves. Each organism in the ecosystem influences others and can be viewed as performing a role for the benefit of the ecosystem.

INQUIRY science 4 fun

Making starch

Do plants make starch in the light?

No

Collect this …

- leaves from plants that have been growing in the dark and in the light
- iodine solution
- labels for dark and light
- 2 petri dishes
- tripod
- hotplate
- gauze mat
- bench mat
- tweezers
- 2 test-tubes
- methylated spirits
- 100 mL beaker
- starch solution

SAFETY

Iodine stains hands and clothes.

Do not breathe the methylated spirits fumes.

Methylated spirits is highly flammable. Keep away from naked flames.

Do this …

1. Boil about 50 mL of water in a 100 mL beaker. Drop the leaf from the dark into the water for 2 minutes.
2. Take it out and put it in a test-tube with 5 cm of methylated spirits. Plug the test-tube with some cotton wool. Label it 'Dark' at the top. Tip out the water from the beaker. (*Careful*: it is hot.)
3. Repeat steps 1 and 2 for the other leaf, but label it 'Light'.
4. Put the test-tubes into about 70 mL of water in the beaker and boil for 5 minutes.
5. Take out the test-tubes and place the leaves in separate petri dishes. Add 10 drops of iodine solution to each leaf.
6. Put some drops of iodine solution into some starch in a test-tube.

Record this …

Describe what happened.

Explain why you think this happened.

Food in ecosystems

In any ecosystem, food is vital. Food contains the matter and energy required by living organisms. To understand how ecosystems function, it is important to understand the feeding relationships between organisms. Ecologists consider that each organism performs a role in the ecosystem. The organisms do not know they have a role, or that it will support the ecosystem. They are simply trying to survive. However, their interactions result in a balanced system.

Producers

Every community must have a source of food, which is made by organisms called **producers**. Most producers are green plants such as flowering plants, conifers, moss and algae, though some are bacteria. Producers are essential for the community. Without them there would be no life, because other organisms such as animals and fungi cannot make their own food.

All the organisms that require a ready-made source of food are called **consumers**. Even humans cannot produce food without the help of plants. All the food people 'make' comes from plant or animal products. For example, bread comes from wheat seeds. Many animals that we eat (such as chickens and cows) are raised on plant foods. Even some animals that are carnivores (such as tuna fish) are part of a chain of other animals that started with plant eaters. All food was originally made by a producer.

Almost all producers, apart from some bacteria, make food by **photosynthesis**. This is a chemical process that takes place inside cells containing a green pigment called chlorophyll. Photosynthesis is a complicated process of many chemical reactions, but it can be summarised in a word equation as:

$$\text{carbon dioxide + water} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose + oxygen}$$

For land plants, the carbon dioxide gas is absorbed from the air, and water is absorbed through the roots. When sunlight falls on the cells containing chlorophyll, the cells start making a sugar called glucose.

Figure 9.2.1 Trees are producers. They make their food by photosynthesis.

The glucose made by photosynthesis is vital to the plant. It is used to make all the other materials that a plant needs, such as proteins, fats and vitamins. Often the sugar is turned into starch and stored in the leaves until it is needed. Many plants also store starch in seeds. This is why wheat is used to make bread and other foods. Some plants (including most grasses) do not store starch in their leaves.

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Food chains and webs

In communities, there are sequences, or 'chains', of organisms feeding on each other. For example, the koala in Figure 9.2.2 feeds on eucalyptus leaves. Likewise in Figure 9.2.3, grass is eaten by the grasshopper, which may then be eaten by the frog, which in turn may be eaten by the tiger snake. A **food chain** is a sequence of organisms feeding on each other.

Organisms are classified according to their position in food chains. A herbivore (plant-eating animal) is always referred to as a **first-order consumer**. An animal feeding on the herbivore is a **second-order consumer**. In Figure 9.2.3, this is the frog. An animal feeding on a second-order consumer is a **third-order consumer**, and so on. An animal that eats another animal is also referred to as a carnivore.

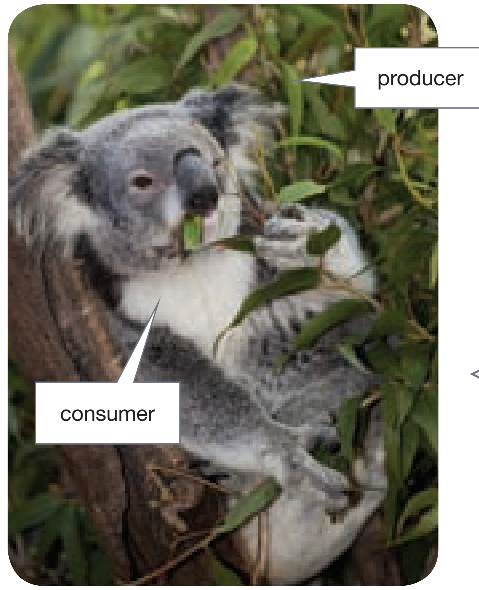

Figure 9.2.2 Eucalypts make food materials that koalas need.

Food chains help you see that all organisms in a food chain depend on the producer.

To understand what happens to food materials in a food chain, consider Figure 9.2.3. The food materials made by the grass, such as proteins, fats and vitamins, are passed to the grasshopper when it eats the grass. The grasshopper uses these food materials to build and maintain its own body. When the grasshopper is eaten by the frog, the food materials in the grasshopper's body are used by the frog to build and maintain its body. Similarly, when the frog is eaten by the snake, food materials pass to the snake. So the grasshopper, the frog and the snake all depend on the grass to make the food materials they need. Without grass, the snake has no food.

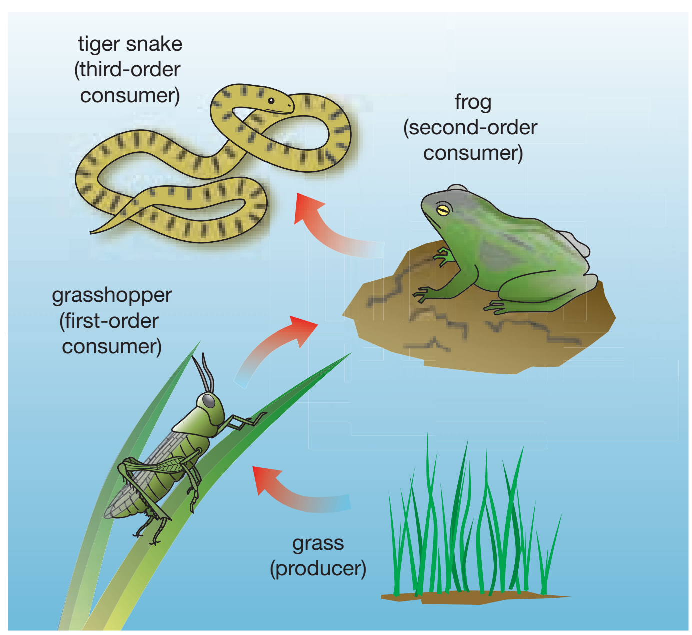

Figure 9.2.3 A food chain shows the sequence of organisms feeding on each other.

There are many food chains in communities and they are all interconnected. All the connected food chains are known as a **food web**. Food webs are usually complex, with each organism appearing in many food chains. Figure 9.2.4 shows a small part of a food web, which demonstrates that most organisms are in several food chains. The honeyeater is in four food chains, while the bee is in three.

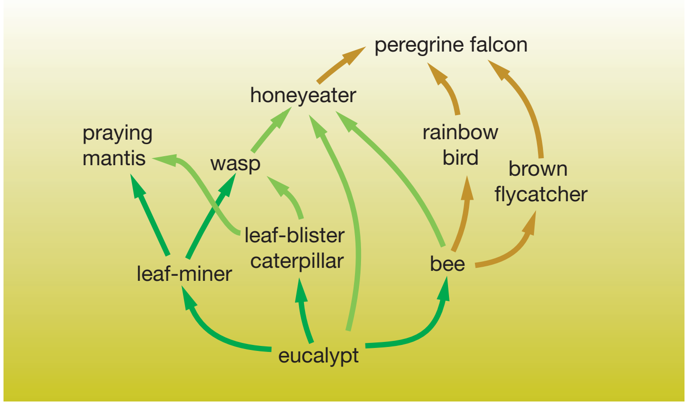

Figure 9.2.4 Part of a food web in a eucalypt woodland community

Chemosynthesis
Some producers do not use photosynthesis to make food. They use chemosynthesis, which does not require light. These producers are bacteria that can obtain energy from chemicals from volcanic activity. Some live at the bottom of the ocean near underground volcanoes where magma erupts into the sea. This feeds a community that lives in total darkness.

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Recycling of matter

A vitally important group of organisms in any ecosystems is the **decomposers**. These organisms are fungi (like the ones in Figure 9.2.5) and bacteria that break down dead bodies and wastes, and recycle matter for the producers to reuse. You can see this process in Figure 9.2.6. Decomposers are vital for the ecosystem to keep functioning. Without them, ecosystems would run out of resources. Decomposers allow matter to cycle in all ecosystems.

Figure 9.2.5 Fungi are important decomposers in an ecosystem.

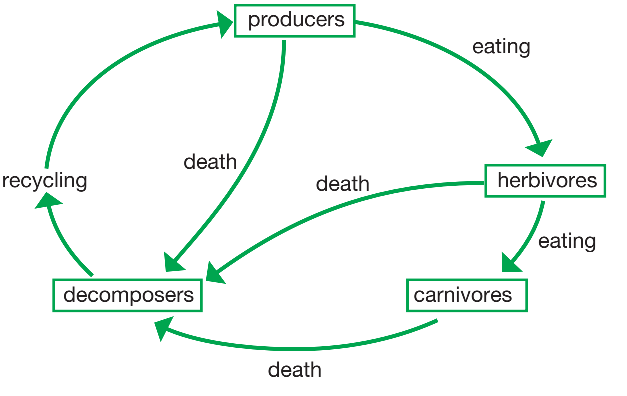

Figure 9.2.6 Decomposers recycle materials back to the physical surroundings for reuse.

Energy flow in ecosystems

Energy does not cycle through ecosystems like matter does. Energy is said to flow continuously through the ecosystem, being lost as fast as it is gained.

To understand how energy flows through ecosystems, think about what you eat. You eat food for two reasons:

- to build new cells needed for growth and repair
- to provide energy for movement and internal processes.

In ecosystems, energy flows from one organism to another as it is eaten. The food material available to each organism is only that which is in the body cells of the organism it eats. The food materials that an organism has used up for energy are not available to the organism that eats it.

Figure 9.2.7 shows that the energy in 1000 kg of grass in an area of ground can only sustain about 100 kg of grasshoppers feeding on that grass. This is because each grasshopper uses up about 90% of the food for energy, rather than for making chemicals that form part of its body cells.

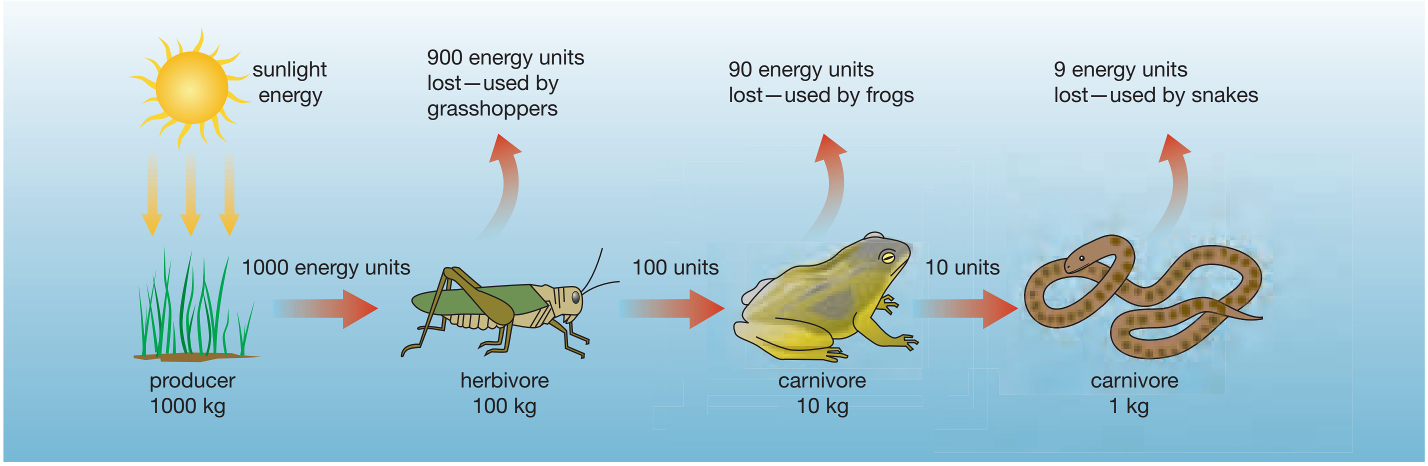

Figure 9.2.7 Energy flow through food chains results in energy losses.

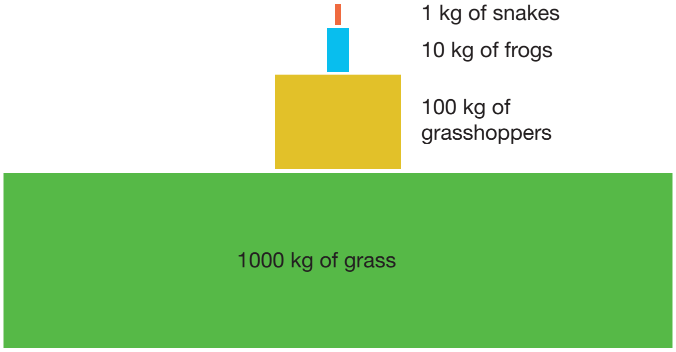

Figure 9.2.8 A pyramid of biomass shows the mass of organisms at each level in a food chain.

The 100 kg of grasshoppers can only feed about 10 kg of frogs. The frogs use 90% of the food materials to maintain themselves and, again, only about 10% of the energy ends up in the cells of the frogs. The same losses of energy occur when the frogs are eaten by the snakes.

So, the 1000 units of energy originally in the grass ends up as only 1 unit of energy in the snakes. This food chain demonstrates that there is a great loss of energy along food chains.

The progressive loss of energy along food chains explains why the chains are short. There is little energy available to the organisms by the time it reaches the end of the chain. It also explains why there are fewer large organisms like snakes than small animals like insects. The total mass of organisms increases at each successive stage of a food chain.

Pyramids of biomass

Ecologists construct diagrams called **pyramids of biomass**, which show the total mass of organism at each stage of a food chain. The area of each section represents the mass of organism at each stage. For the food chain in Figure 9.2.7, a pyramid of biomass would look like the one shown in Figure 9.2.8.

Pyramids of biomass are useful, because they allow ecologists to understand the total **productivity** of an area. Productivity means how well it supports life. Pyramids of biomass can be used to compare different ecosystems, and are useful in farming, fisheries, and wildlife conservation.

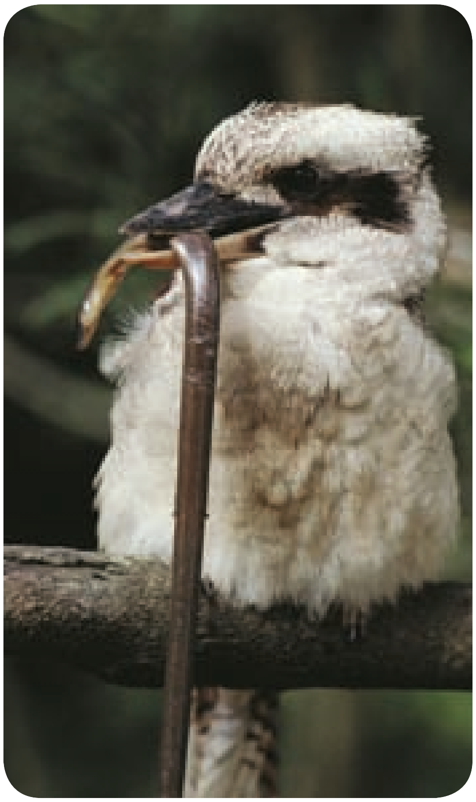

Figure 9.2.9 The kookaburras will have less total energy available in food than the snakes had. There are likely to be fewer kookaburras than snakes in the ecosystem.

9.3

Biodiversity

Biodiversity refers to the range of different species in a community. High biodiversity means a large number of different species in an ecosystem. An ecosystem with many different species is less likely to be disrupted by environmental changes.

There are many reasons why biodiversity enables an ecosystem to remain stable and continue to function. Consider the invasion of an ecosystem by species from other countries, such as weeds invading an area of Australian bush (see Figure 9.2.10). It is much harder for weeds to invade a community that has many species than to invade a community with only a few species. With only a few species, it is likely that weeds could out-compete the native plants for resources. But in a community with many different native species, it is less likely that the weeds will be superior to them all.

Figure 9.2.10 When a foreign species such as this Paterson's curse invades an ecosystem, the ecosystem is more likely to resist the invasion if there are many different species in the ecosystem.

Biodiversity also helps stabilise the ecosystem when physical conditions change. Look at the food web in Figure 9.2.4 on page 292. If there is a change in the weather leading to an unusually heavy flowering of eucalypts, then there may be an increase in the number of bees. This is because more food is available and so more bees can survive. If the number of bees increases, then there is more food for honeyeaters, rainbow birds (Figure 9.2.11) and brown flycatchers. Numbers of these birds increase, and the bee population is gradually reduced again. As the bee numbers start dropping again, it becomes harder for the birds to find food. So the bird numbers decrease as the birds die or migrate away.

Figure 9.2.11 Rainbow birds are predators that eat bees and so affect the population size of bees in an ecosystem.

So the numbers of a predator and its prey tend to change as they affect each other. You can see this in Figure 9.2.12. A rise in prey numbers is followed by a rise in predator numbers. As the predator numbers increase to high levels, the prey numbers decrease. The predator numbers then decrease to very low levels, which triggers another rise in the prey. So the predators seem to control the numbers of its prey.

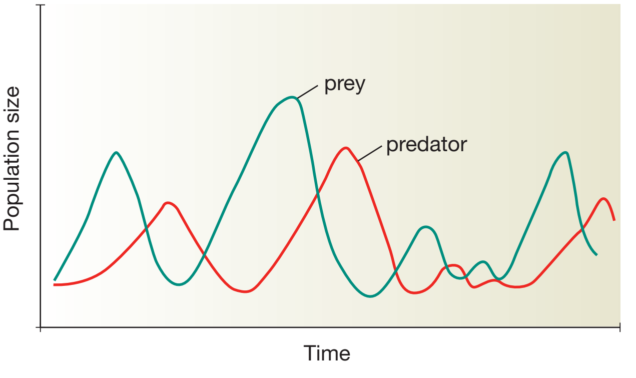

Figure 9.2.12 Predator and prey numbers affect each other.

Food webs with few species are very susceptible to changes in any one of the species. That one species may have been supporting a large part of the food web. In a food web with more species, if one source of food is lost, there will be others available.

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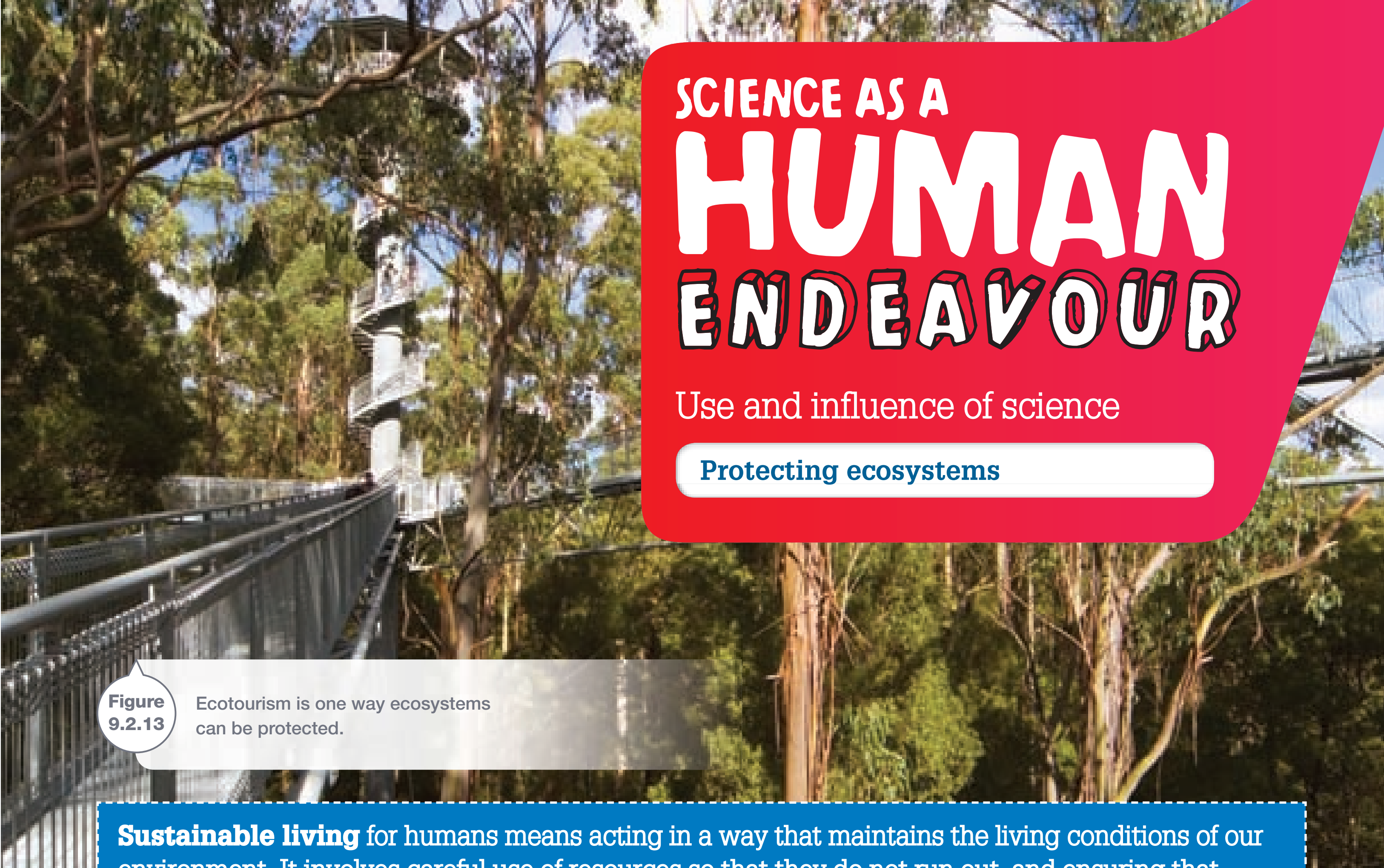


Figure 9.2.13 Ecotourism is one way ecosystems can be protected.

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Protecting ecosystems

Sustainable living for humans means acting in a way that maintains the living conditions of our environment. It involves careful use of resources so that they do not run out, and ensuring that natural ecosystems that keep us alive are not damaged by our actions.

The idea that we should protect our environment rather than just exploit it is fairly new in European and Western civilisations. In the past, few people cared or recognised that the environment was being damaged. Only recently have scientists realised that some civilisations such as Australian Aboriginals and African Bushmen had the balance right between protecting and using the environment.

One recent discovery of ecologists is that there are **keystone species** that are critical to the survival of the whole ecosystem. For example, earthworms enrich the soil and enable plants to grow, and so support all the other organisms. If earthworms were to disappear, the ecosystem would be in danger of collapsing. Research into keystone species is essential if we are to understand how to better manage ecosystems.

Another recent idea for measuring sustainable living is ecological footprint (or eco footprint) analysis. The **ecological footprint** of a population is the area of land and water required to supply the resources needed for survival and to cope with the wastes produced. As Figure 9.2.14 shows, the area of land needed to support each Australian is about 7.5 hectares. The world average is about 2.2 hectares. Ecologists have suggested that Australians need to change how we live, to reduce our ecological footprint to about 2 hectares.

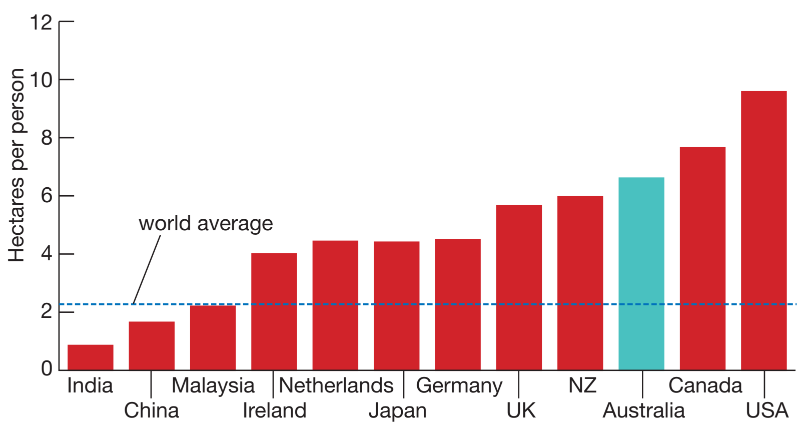


Figure 9.2.14 Australia's ecological footprint is among the highest in the world.

Why protect ecosystems?

Compassion

Compassion is humans feeling sympathy for other organisms. The philosophy of compassion is that all organisms have a right to live, and that humans have no right to exterminate any species. It recognises that humans are the only organism on Earth capable of understanding the possible fate of all life. Humans therefore have a responsibility to make wise decisions.

Figure 9.2.15 This whale became stranded on a beach and was rescued by compassionate humans.

Cultural value

Some species have a value as part of our culture. They are part of our national view of ourselves. The Australian coat of arms in Figure 9.2.16 has a kangaroo and an emu on it. Imagine how most Australians would feel if these animals were hunted to extinction. Many animals and plants are a source of wonder, interest and enjoyment and would be deeply missed.

Figure 9.2.16 The Australian coat of arms shows some of the organisms we value as part of our culture.

Economics

Many previous generations exploited the environment to make money but gave little thought to protecting ecosystems. The concept of the ecosystem was only conceived of in the early twentieth century. Now there is an increased awareness that money can still be made and the environment protected at the same time.

One source of income from ecosystems is tourism. People like to holiday in Australia so they can see the spectacular wildflowers, forests and animals. Australian plants and animals are world famous. This creates many jobs in the tourism industry.

Another source of income is from farming or cropping native species. Conserving commercial species, such as eucalyptus trees, prawns or kangaroos, while still cropping them, ensures that they will always be there to use.

Many useful pharmaceutical drugs have been produced from plants that were previously not used by humans. Conserving species means that new discoveries could be made as new needs arise. Also, certain animals could be possible biological control agents in the future for controlling new pests. In the future, many animals and plants may be used for cross-breeding experiments to improve the health of existing farm animals and crops.

Survival

It is possible that humans could destroy all life if we continue to over-exploit other species. The survival of humans as a species depends on making smart decisions about the environment. For example, clearing much of the world's forests for timber could reduce the amount of oxygen in the air. If the ocean fisheries are disrupted or destroyed by over-fishing or chemical pollution, then human food resources would be seriously reduced. Clearing trees means that soils are destroyed. Some effects of clearing are soil erosion and salting of land. This alters the soil and reduces the productivity of the land, so less pasture and crops can be grown, and so less food can be produced, and people could starve.

9.4

9.2 Unit review

Remembering

1 **Recall** photosynthesis by writing a word equation.

2 **Name** the term that means:
- a organisms that eat food
- b animals that only eat plants
- c animals that only eat other animals
- d organisms that break down dead bodies and wastes, and recycle material for the producers to reuse
- e animals that feed only on dead organisms.

3 **Name** the term that means:
- a the range of different species in a community
- b managing and protecting ecosystems so they continue to exist
- c species that are critical to the survival of the whole ecosystem
- d the area of land and water required to supply the resources needed for survival and to cope with the wastes produced.

4 **Name** the group of organisms that makes the food for an ecosystem.

5 **List** four arguments in favour of protecting ecosystems.

Understanding

6 **Explain** why photosynthesis is so important to ecosystems.

7 **Explain** why decomposers are vital for a sustainable natural ecosystem.

8 **Explain** how energy enters an ecosystem, and what happens to it immediately after it enters plants.

9 **Explain** what is meant by *biodiversity* and why it is important to maintain this in an ecosystem.

10 Briefly **discuss** some ways in which protecting natural ecosystems can be worth money.

Applying

11 **Use** the eucalypt food web in Figure 9.2.4 on page 292 to answer the following questions.
- a **Name** a herbivore.
- b **Name** two first-order consumers.
- c **Name** a carnivore.
- d **Name** two third-order consumers.
- e **List** three different food chains containing the peregrine falcon.
- f **List** three food chains, one containing three organisms, one containing four organisms and one containing five organisms.

12 **Use** Figure 9.2.4 on page 292 to **name**:
- a three animals that compete for bees as a food source
- b two animals that compete for leaf-miners as a food source.

13 **Identify** what level of consumer you are in a food chain when you eat:
- a beef
- b an apple.

14 **Use** a pyramid of biomass to **describe** energy flow for a particular food chain of your choice from Figure 9.2.4 on page 292.

15 **Use** Figure 9.2.7 on page 293 to **calculate** how much energy would be available to eagles that ate snakes.

Analysing

16 If the amount of wattle in the food web in Figure 9.2.17 on page 298 increased, **discuss** what you think would happen to each of the following populations.
- a leaf hoppers
- b wasps
- c honeyeaters
- d beetles

17 **Contrast** the flow of matter and energy through a natural ecosystem.

Evaluating

18 **Propose** a reason why producers are not found in caves.

19 Critically **evaluate** the view that forests are mainly useful as a source of timber.

Creating

20 **Construct** a scientific argument that it is more efficient to feed the world's population on plants than on animals. Use your knowledge of energy flow in ecosystems as part of your argument.

Unit review

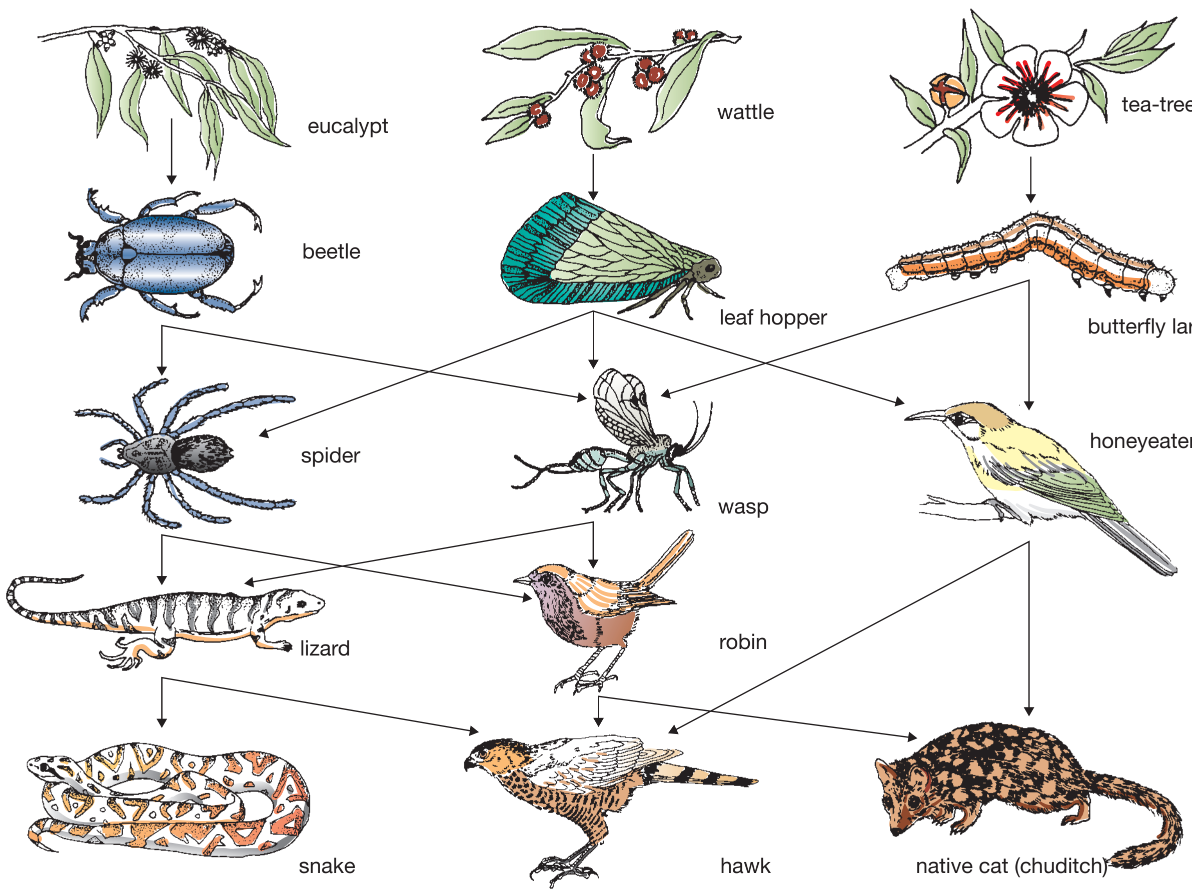


Figure 9.2.17

Inquiring

1 Research five species, including some threatened plants and animals. For each species:
   - **a** show on a map where it can be found, naming any national parks in the area
   - **b** include a picture of the species
   - **c** state the known population size
   - **d** if it is threatened, state the main reason for its threatened status.

2 Consider the following suggestions from a pamphlet designed to help farmers protect and encourage native animals.
   - Fence off from the stock any native vegetation remaining on the farm on land that cannot be used.
   - Plant many different trees and shrubs native to the area.
   - Leave old trees standing, especially those with hollows in them.
   - Form corridors of vegetation between bushland areas on the farm and neighbouring farms.

   Discuss how each of these suggestions may help protect and encourage native animals in farming areas.

3 Research the relationship that Indigenous Australians have with the land and how their traditional land practices affected the sustainability of ecosystems.

9.2 Practical activities

1 Photosynthesis

Purpose

To determine whether carbon dioxide and light are necessary for photosynthesis.

Materials

- 3 × 250 mL conical flasks and stoppers to fit
- 2 small plants or shoots (e.g. clover, soursob, geranium)
- aluminium foil to cover one conical flask
- 150 mL dilute bromothymol blue solution
- straw
- lamp

SAFETY

Bromothymol blue is toxic if swallowed.

Wear safety glasses and avoid contact with skin.

Procedure

1. Your teacher will blow through the bromothymol blue solution until it turns yellow. This is adding carbon dioxide to the water.
2. Label the flasks 1–3. Add 50 mL of the yellow bromothymol blue to each conical flask.
3. Add a plant to flasks 1 and 3. Stopper all flasks.
4. Wrap flask 3 in aluminium foil so that light cannot enter. Your set-up should look like Figure 9.2.18.
5. Place all three flasks in the light until the next day. If you can, put them in the sun during the day and leave them under a lamp overnight.

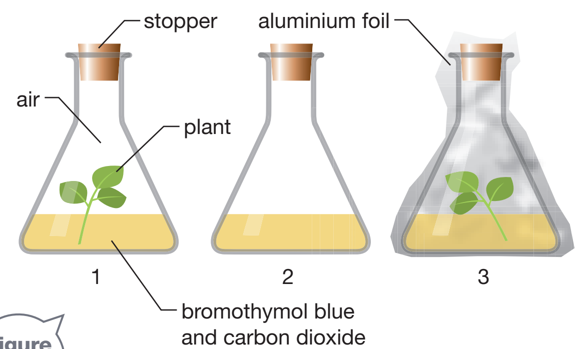


Figure 9.2.18

6. Observe the flasks the next day.

Results

Record your results in a table.

Discussion

1. **State** the colour of bromothymol blue when carbon dioxide is present and when it is absent.
2. **Identify** the flasks that had no carbon dioxide left at the end of the experiment.
3. **Compare** flasks 1 and 2. What do you conclude happened?
4. **Compare** flasks 1 and 3. What do these results tell you?
5. **Explain** what this experiment has shown you about photosynthesis.
6. **Explain** how this practical is relevant to understanding ecology.

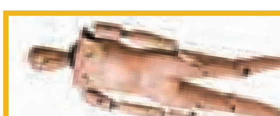
2 Studying a leaf litter environment

Purpose

To study the community and the physical conditions in a leaf litter environment.

Materials

- 3 plastic bags
- margarine container
- thermometer
- 2 strips of blue cobalt chloride paper in a plastic bag, or a moisture meter
- binocular microscope
- petri dish
- fine forceps
- mounted needle
- diagram sheet of soil organisms



SAFETY

Do not go near long grass or possible hiding places for snakes.

Do not pick up animals with your bare hands, as some may bite or sting. Use containers to pick them up.

Studying a leaf litter environment continues

Studying a leaf litter environment continued

Procedure

1 Take the bags, margarine container, thermometer, cobalt chloride paper and forceps to an area around the school that has a natural leaf litter cover.

2 Check the air temperature about 1 m above the soil and record it in your notes.

3 Carefully push the end of the thermometer into the leaf litter but not into the soil. Be very careful not to break the thermometer. Record the temperature in your notes. Replace the thermometer in its case.

4 Remove a piece of cobalt chloride paper with forceps and hold it in the air for 1 minute. Record the colour in your notes.

5 Place the other piece of cobalt chloride paper deep in the litter layer for 1 minute and then record its colour in your notes.

6 Quietly observe the surface of the leaf litter for a minute or so. Look for any small invertebrate animals moving near the surface. If you can catch them, put them into one of the bags. Do not try to collect vertebrates like lizards or frogs. Try not to kill any of them.

7 Scrape off some of the fresh litter from the surface and place it in the bag with the animals already collected. Try not to dig down into the lower layers of decaying leaves. Now scrape up the darker decaying litter layer into another bag. Finally, scrape up about half a cup of soil and place it into the third bag.

8 Return to the classroom and use the microscope and books to identify any animals in the three layers. Some leaf litter animals are shown in Figure 9.2.19.

Discussion

1 **Describe** the main physical conditions of temperature, light and water in the leaf litter layer.

2 Fresh leaves fall each year, but the litter layer tends to stay the same thickness. **Explain** this observation.

3 The breakdown of the leaf litter begins with fungi, bacteria and certain animals. You probably found some animals from each of the following two groups. Choose one animal in each group and **explain** why it lives in the litter.

- Group A: springtails, millipedes, symphylids, bristle tails, earwigs, slaters, white worms, amphipods, mites
- Group B: spiders, centipedes, flatworms, pseudoscorpions, fly larvae, beetle larvae

4 **Explain** why it is necessary to have biodiversity in a leaf litter community.

5 **Explain** how this activity is relevant to our lives.

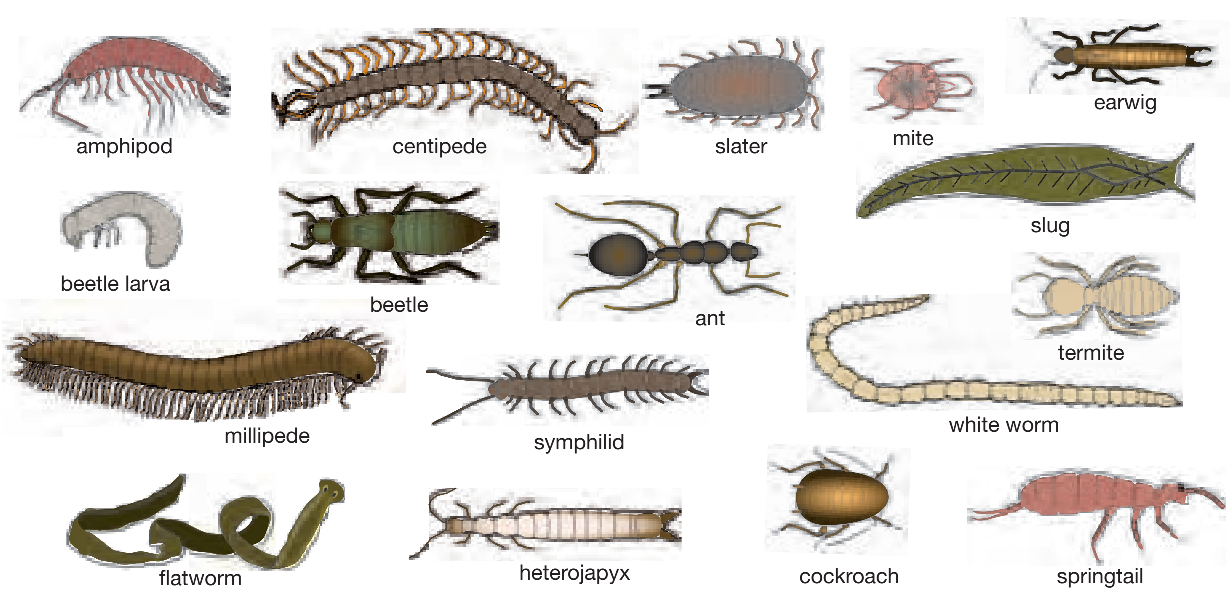


Figure 9.2.19

9.3 Natural and human impacts

Natural events such as fire, flood and drought can damage ecosystems, but they can also benefit ecosystems. Humans also affect ecosystems in positive and negative ways. However, it could be argued that humans are a major threat to the ecosystems of Earth. Ecologists have suggested that much of life on Earth could be destroyed unless most of us change how we live.

Change due to natural events

Many natural events affect ecosystems. As explained in Units 9.1 and 9.2, seasonal changes affect populations through the influence of physical (abiotic) factors. Other natural events such as bushfires, drought and flooding also have a huge impact on ecosystems.

Bushfires

Some effects of fire have already been discussed in Unit 9.1. **Bushfires** are fires that burn natural vegetation in forests, woodlands and grasslands. They can be lit by humans, but many fires are due to lightning strikes. Evidence suggests that natural fires have been affecting ecosystems in Australia for over 40 million years, while humans have probably only lived here for around 40 000 years.

Fire has a major impact on ecosystems in Australia because it promotes the germination of many plant species. After a fire, the bush regenerates through germination. Many plants are adapted to survive fires and even benefit from fire. Plants such as banksias and hakeas need fire to allow their seed cases to open and release the seeds (Figure 9.3.1). Grass trees and some orchids flower after a fire.

Figure 9.3.1 A bushfire will cause the seed cases of banksias and many other plant species to open up and drop their seeds.

Eucalypts have oils in their leaves that catch fire easily (Figure 9.3.2). Some also have 'stringy' bark that hangs down to the ground, as in Figure 9.3.3. There is a lot of plant litter that falls to the ground, such as dead leaves and bark. These may seem like strange features for a plant to have in an area where bushfires occur. However, helping a fire to spread probably provides an advantage to eucalypts. After a fire, eucalypts can quickly regenerate, whereas other plants may not. This gives eucalypts a competitive advantage in fire-prone areas.

Figure 9.3.2 Eucalyptus leaves catch fire easily because they have glands that make oils. All the light-coloured dots on the leaf are oil glands.

Figure 9.3.3 The bark on this Blue Mountains Ash is stringy and allows fire to rise up into the tree.

Eucalypts are adapted to survive fires in several ways. Having fairly thick bark keeps the growing part of the trunk and branches alive. The thick bark insulates the living cells beneath it against the heat of the fire. After a fire, new growth sprouts from the trunk and branches. All the leaves may have died, so new ones must grow to allow the plant to begin photosynthesising again. This growth is known as **epicormic growth** (see Figure 9.3.4). The new growth of shoots allows the plants to quickly produce food and gain an advantage over other plant species that may have been damaged or killed by the fire. Those species that were killed can only come back into the area by seeds from another area, and this can be a very slow process.

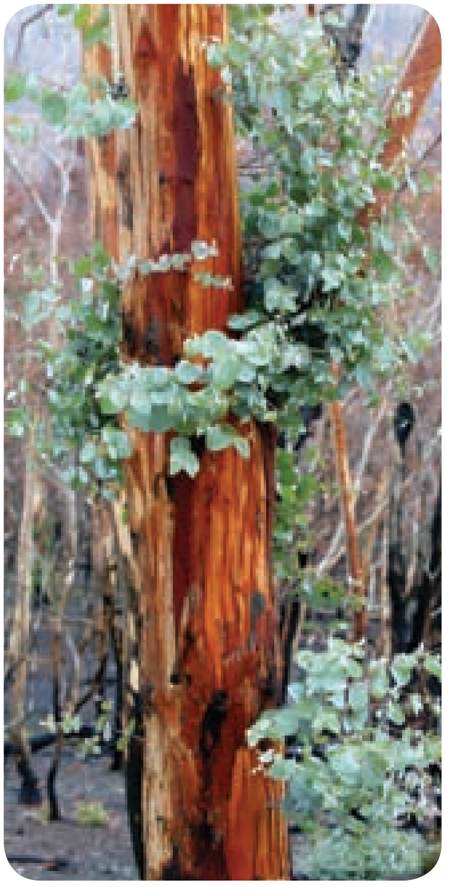


Figure 9.3.4 Epicormic growth is the sprouting of new leaves from the trunks of trees that have been burned and lost all their leaves.

Some eucalypt species have **lignotubers**. Ligontubers are swollen stems under the ground. The branches above the ground may have died in the fire, but those below ground are insulated from the heat and quickly sprout after a fire. Eucalypts that have this feature are called **mallees**. A mallee is shown in Figure 9.3.5.

The effects of fire on animals can vary. Slow-moving animals that cannot escape fires by burrowing or migrating may be killed. The dead are replaced by surrounding populations expanding back into the burnt-out area after the fire. Fire promotes the growth of fresh shoots that are highly nutritious for herbivores, which in turn benefit from the fire.

Figure 9.3.5 The top of the lignotuber, a swollen underground stem, can be seen at the base of this mallee eucalypt.

INQUIRY science 4 fun

Plants and fire

Would some plants survive a fire better than others?

No

Collect this …

- hand lens or magnifying glass
- digital camera or mobile phone with a camera
- large plastic bag

Do this …

1. Find an area where there are many different plants, ranging from trees to low shrubs. (It could be at home or in the school gardens.)
2. Observe the features of at least five different plants that you think could be affected differently by a fire. Look at features such as leaf position and structure, bark thickness and structure, branch height, seed cases, dead leaves and branches, and any other features that look relevant.
3. Take a photo of each plant and try to find out its common or scientific name. If you can't name it, at least record the type of plant. If possible, collect some parts (such as the bark) of the plant that you think could affect its fire resistance.

Record this …

Describe the features of each plant, in a table.

Explain why you think the features would be helpful or not helpful to the plant in surviving fire.

Drought

Drought is an extended period of no rainfall in an area. Drought can change ecosystems by increasing the death rate and causing some species to become extinct in an area. Death of plants due to lack of water will remove a resource for animals that use the plants for food, shelter and nesting sites. The animals then either die, as has happened to the kangaroo in Figure 9.3.6, or migrate out of the area.

Figure 9.3.6 Drought is a time when many animals such as this kangaroo die from lack of food and water.

Loss of plant cover in an area can lead to erosion of soil by wind. When the rains do return, water erosion can further damage the land by washing away the soil.

Australia suffers regular droughts. The organisms that live in drought-prone areas are adapted to the conditions. However, years of drought can still cause very high death rates and threaten the long-term survival of species in these areas. There are often extended periods of drought lasting five years or more over wide areas of the country. In these times, only the strongest individuals survive and reproduce.

Some species require regular water, such as river red gums. In times of drought, the rivers do not flow and no longer flood the areas where the gums grow. Many trees die after years of drought and it is possible to lose entire ecosystems.

Flooding

Floods are events where water temporarily covers land not normally covered by water. Heavy rains can result in rivers overflowing their banks and widespread flooding in some places. In north-eastern Australia in 2011, there were very heavy rains that led to severe flooding, especially in Queensland. Brisbane and several other cities were flooded.

The flooding also greatly affected natural ecosystems and there were high death rates among native plants and animals. Plants drown from lack of oxygen at the roots. Animals can drown or die from exposure.

In drier places, the increased rainfall leads to an 'explosion' of life. Animals and plants in such places are adapted to rapidly reproduce to take advantage of the extra food and favourable living conditions. Aquatic animals hatch from eggs that were buried in the soil and some eggs arrive carried by the wind and migrating animals, such as pelicans that fly in to nest in the area. The pelicans arrive because they can feed their young on the abundant animal life that flourishes during the flooding. One amazing place where this occurs is Lake Eyre in South Australia. Heavy rain in Queensland feeds rivers that flow into Lake Eyre, such as the Warburton River, shown in Figure 9.3.7. This flooding may happen only every ten to twenty years or more. As shown in Figure 9.3.8, the ecosystem can be extremely productive, being able to support large populations such as the pelicans.

Figure 9.3.7 The Warburton River flows into Lake Eyre but rarely carries enough water into the lake to flood it.

Figure 9.3.8 Exceptional rains in Eastern Australia in 2011 resulted in flooding of Lake Eyre and an explosion of life in the lake.

Human impacts

Human impacts on ecosystems include habitat destruction, introduced species, chemical pesticides, chemical pollution and overcropping.

Habitat destruction

Habitat destruction is the damage done to the factors in the environment that an organism depends on for survival. Some examples are land clearing, mining, and logging like that seen in Figure 9.3.9. These activities don't necessarily destroy habitats permanently. Ecosystems can be repaired if there is enough knowledge of the environment and resources available.

Figure 9.3.9 Land clearing for farms has destroyed much habitat.

Animals such as the bilby, the woylie (brush-tailed bettong, shown in Figure 9.3.10), the rat kangaroo, the potoroo and the Regent honeyeater have declined in numbers as a result of agricultural development. However, some animal populations have increased because of the increased food supply. These animals include kangaroos, locusts and emus.

Figure 9.3.10 Woylie (brush-tailed bettong) populations have declined, partly due to habitat destruction.

Introduced species

Animals and plants brought to Australia from other countries are known as **introduced species**. Some of these animals are predators that kill native animals. Some just compete with the native species for food, and others destroy habitat.

Introduced animals that have become established in the wild are referred to as **feral animals**. In particular, domestic cats and foxes (Figure 9.3.11) have had a devastating effect on wildlife.

Figure 9.3.11 Feral cats and foxes are a great threat to native wildlife.

Animals such as rabbits, camels, donkeys, horses, goats, mice, rats and pigs have also been introduced. These can all be found running wild. They compete with native animals for food and shelter, and so fewer native animals survive.

The situation is just as bad with introduced plants. Many of these become weeds and successfully compete with native plants for the limited resources available. Examples are watsonia, blackberry, veldt grass and lantana (Figure 9.3.12). These cover large areas of native bush.

Figure 9.3.12 Lantana has become a problem weed in much of northern Australia.

Chemical pesticides

Scientists have found that some of the first insecticides (chemicals that kills insects) developed are dangerous to more than just insects. DDT is one example of this. Research in the 1970s found that DDT was present in all the organisms in a food chain, like the one shown in Figure 9.3.13. The amount of DDT increases along the food chain. The reason more DDT was found in the clam than in the plankton was that the clam consumed a great deal of plankton. The DDT in the plankton was nearly all stored in the clam's body, and little was lost during consumption. The gull ate many clams and stored most of the DDT in its body. So the gull contained a high concentration of DDT. Poisons that build up in organisms in this way are called cumulative poisons, because they accumulate.

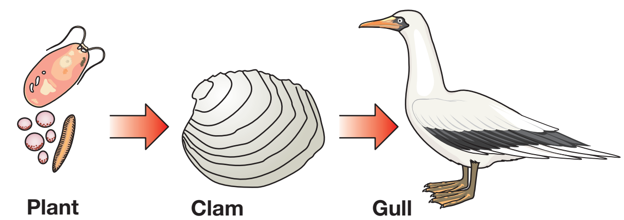


Figure 9.3.13 Food chain showing pesticide accumulation

The accumulated DDT had serious effects on some types of birds, especially those at the end of the food chain (such as peregrine falcons and eagles). DDT caused these birds to lay eggs with thin shells, which broke when the adult sat down to incubate them. So fewer young were produced, and the population decreased as adults died and were not replaced by young.

What really frightened many people was the discovery that DDT accumulated in humans, especially in breast milk. No one knew what effects it might have on human health. Research has since shown that it is linked to many diseases such as cancer, diabetes, hormonal disruption and reproductive problems. DDT use was banned in Australia in 1987. However, many poorer countries continue to use it, particularly those that have a malaria problem. In these countries, DDT levels in breast milk are extremely high.

Not all pesticides accumulate in organisms as DDT does. However, they can still cause problems if they are not used carefully. If the spray drifts away from crops, whether it is sprayed from the ground or from an aircraft (like the one in Figure 9.3.14) or if the farmer sprays at the wrong time, useful insects can also be killed.

Insects such as bees, which pollinate flowers (Figure 9.3.15), or predatory wasps that kill insect pests, can be killed.

Figure 9.3.14 Spraying insecticides on crops should be done carefully, to avoid killing useful insects.

Figure 9.3.15 Pollination of flowers can be affected when insecticides kill bees.

As the chemicals become less effective, larger and larger concentrations are needed to kill the pests. Studies have shown that the insects can now withstand much stronger sprays than when spraying began years ago. The insects have become resistant to the chemicals.

Insects become resistant to these chemicals by a process called natural selection. Natural selection will be covered in your Year 10 course.

9.6

SciFile

Go organic

Organic farming is based on the idea that many chemicals can cause problems. Organic farmers try to let pests be controlled naturally by the pests' enemies, rather than by using pesticides. The farmers also use recycled animal wastes instead of artificial fertilisers to enrich the soil. Another aim is to reduce contamination of the food by chemicals. Organically grown foods fetch high prices.

Chemical pollution

Many scientists argue that carbon dioxide is polluting the Earth's atmosphere and causing it to get hotter. There is much debate about whether the temperature of the Earth's atmosphere is rising or not. The terms used are **global warming** and the enhanced greenhouse effect. The general opinion is that the atmosphere is warming.

Increased production of carbon dioxide gas by human activities is thought to be contributing to global warming, but natural facors are also involved.

Figure 9.3.16 Burning reactions release carbon dioxide, a gas that is considered by many scientists to be responsible for global warming through the enhanced greenhouse effect.

Carbon dioxide absorbs some of the heat radiated from the Earth, warming the atmosphere. One group of scientists argue that this effect is tiny, and not important compared with the effect of other gases such as methane and water vapour. Another group argues that it is significant.

The problem with raising the Earth's temperature is that the polar ice caps may melt, causing sea levels to rise.

If the atmosphere is warming, it could also change wind and rainfall patterns. These changes could have large-scale effects on agricultural production and could even result in the extinction of many plant and animal species. Many governments have responded to this problem by trying to limit emissions of greenhouse gases, especially carbon dioxide.

Many other chemicals pollute our environment. Oil spills from ships can cause devastation to sea ecosystems (Figure 9.3.17).

Monitoring our environment to safeguard us against dangerous chemicals is an important job for health authorities and the environmental protection agencies of government.

1 p311 2 p311

Figure 9.3.17 A volunteer helps to save a bird affected by oil from an oil spill.

Overcropping

Overcropping of animal populations means killing more animals than can be replaced by the normal breeding cycle. This results in a decrease in the population. Many of the world's whale populations have declined dramatically as a result of overcropping. The population of the blue whale (shown in Figure 9.3.18) in the 1980s was only about 5 per cent of the population earlier in the century. Blue whales are now totally protected, but populations have recovered very slowly.

One of the important roles for ecologists is to find out how many animals can be removed from a population without endangering the survival of the species. Regulations control how many animals may be taken. These regulations vary for different species.

SciFile

Minamata disease

In the 1950s, over 100 people living near Minamata Bay in Japan died or suffered nerve damage. A chemical company had released mercury wastes into the bay, and these wastes were accumulating in the food chains in the sea. People eating the local fish absorbed large doses of these mercury compounds.

Figure 9.3.18 Overcropping of whales caused a population decline. This is a blue whale, which was almost hunted to extinction in the 20th century. Numbers of blue whale are still very low.

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Aboriginal people, fire and ecosystems

Figure 9.3.19 Fire is used to manage the landscape today, much like it was 50,000 years ago.

Australia's Aboriginal people have been here for over 50 000 years. There is debate about how their use of fire to improve hunting affected the vegetation and fauna of the country. Research is continuing into the impact this may have had. Burning of the bush was viewed differently by the early Europeans and the Aboriginal people. The early Europeans seem to have been frightened of fires, whereas in some areas the Aboriginal people burned bushland regularly to improve hunting.

Today, widespread burning is conducted by government departments to protect houses in fire-prone areas. Burning is also conducted to keep the amount of plant litter low, in order to prevent larger fires that could damage the bush as well as properties. Research indicates that keeping plant litter levels low helps in the management of hot fires.

Figure 9.3.20 A painting by Joseph Lycett showing Aboriginal people using fire to hunt in New South Wales in 1817

Figure 9.3.21 An Aboriginal park ranger at Uluru burning the land to prevent wildfires, much like his earlier ancestors did

Research into the effect of fire on native plants such as banksias has revealed that even the earliest plant fossils dating back to 40 million years ago were adapted to fire. Researchers concluded that Aboriginal people could not have affected the characteristics of these plants. However, Aboriginal land management practices may have affected where the plants grew. Most researchers agree that Aboriginal people in many areas of the country used a hunting method called '**firestick farming**'. Fires were deliberately lit at certains times of the year, to create conditions suited to plant regrowth.

The fresh growth attracted herbivorous animals to the area to feed, and made hunting easier. The fire also recycled nutrients back into the soil, which helped rejuvenate the land and made it more productive as a food source for humans. In some areas, small fires were lit to produce smoke, which frightened animals out of the undergowth and made them easier to catch.

Some recent research using satellite imaging of land being managed by the Martu people in the Western Desert has demonstrated that using a regular pattern of small fires changes the plant species that grow in grassland areas. The research showed that the vegetation in areas that had regular small burns is different from areas where lightning strikes started the fires. The main effect was that areas subjected to firestick farming had greater diversity of species. These research results support views proposed by ecologists many decades ago. Early last century, ecologists discovered that fire affects the germination of some species but not others, and that species favoured by fire become more common in areas that are burned.

Some recent evidence contradicts the idea that the use of fire by Aboriginal people had a major impact on the vegetation in forest areas. A research study headed by Dr Scott Mooney from the University of New South Wales looked at 223 sites around Australia and surrounding countries. The study compared charcoal deposits from the past 70000 years with climate records. The study concluded that the major factor affecting fires was variations in climate between hot and cold periods. Fire activity was high between 70000 and 28000 years ago, then decreased between 28000 and 18000 years ago. It increased again after 18000 years ago, and even more after European settlers colonised the country. This evidence seemed to indicate that climate rather than human activity was the main factor in fire history over a long period of time.

Research is continuing, and the debate about burning to control species diversity and to reduce the intensity of fires will probably continue for some time.

9.7

Figure 9.3.22 An Aboriginal man and his son using firesticks to burn off grassland in Arnhem Land, Northern Territory

9.3 Unit review

Remembering

1 **List** two characteristics of eucalypts that result in fires spreading.

2 **List** some ways in which drought and floods affect ecosystems.

3 **State** three examples of habitat destruction.

4 **Name** five introduced species that have caused problems for the native animals and plants in Australia.

5 **State** an example of damage to ecosystems caused by:
   a chemical pesticides
   b chemical pollution.

6 **State** a problem caused by continual use of the same insecticides on a pest species.

Understanding

7 **Explain** three adaptations of eucalypts that enable them to survive a fire.

8 **Explain** why eucalypts living in places where there are frequent fires could be at an advantage by having features that encourage the fire to spread.

9 **Explain** how drought could lead to damage to the soil.

10 **Explain** how overcropping can lead to the extinction of a species.

11 **Explain** how the clearing of land for farming has affected natural communities.

12 **Explain** how introduced animals (such as rabbits, foxes, cats and wild pigs) affect native animals.

13 **Explain** how the greenhouse effect may cause problems in the future.

Applying

14 **Use** your knowledge of the effects of fire to **explain** how wattle trees may become more common in an area that is burned frequently.

15 **Demonstrate** that flooding can be an advantage in ecosystems.

16 **Use** your knowledge of food chains to **explain** how a cumulative poison such as DDT that is sprayed onto crops could kill predatory birds, such as eagles.

Analysing

17 *Salvinia* is a plant that floats on the water surface, spreading rapidly and covering the whole surface of a lake. The weed's roots take oxygen out of the water. Any oxygen produced by photosynthesis in the leaves is released into the air, not the water.
   a **Discuss** whether this weed would cause problems for other plants in the water.
   b **Discuss** why this weed would be a problem for consumers that live in the water.

Evaluating

18 When cropping native species such as western rock lobsters, there are laws that control:
   - what size the lobsters must be
   - the breeding condition of the lobsters.

   Justify how each of these laws may assist in the conservation of the rock lobster.

19 Large areas of the Amazon rainforest are being cut down. **Propose** what effect this could have on the Earth's atmosphere.

20 Australia has laws that count a strip of the seas 12 nautical miles around the Australian continent as our territory. (A nautical mile is equal to 1852 metres.) This area is called Australian Territorial Waters. Our navy intercepts any fishing vessels from overseas that come inside this limit. **Propose** why we do this.

Creating

21 Many scientists believe that limiting human population growth is necessary to control environmental damage. **Construct** an argument for or against this statement.

Inquiring

1 Salinity of farmland is a major environmental problem in Australia. Research why farmland is turning salty, and what is being done to try to solve the problem.

2 Survey the pesticides that you have at home. (*Warning*: many pesticides are toxic. Wash your hands if you touch them.) Check insect sprays, cockroach baits, mothballs, etc. Write down the brand names and the name of the chemical ingredients. Search the internet and the labels for information on the toxicity of these substances to humans, pets and wildlife.

9.3 Practical activities

1 Wastes

Purpose

To investigate the effect of wastes on water communities.

Materials

- 5 mL of each of 25%, 50%, 75% and 100% milk solutions
- dry yeast
- teaspoon
- methylene blue indicator solution in a dropper bottle
- 20 mL measuring cylinder
- 5 small test-tubes
- test-tube rack
- 100 mL beaker
- marking pen
- timer with a split button
- stirring rod

Procedure

1. Mix half a teaspoon of yeast and 20 mL of warm water in the beaker. Leave this to stand. (Yeast is a microorganism that feeds on food materials in the milk. When it has food, it uses oxygen to grow.)
2. Mark each test-tube with a line 1 cm from the bottom and a line 3 cm from the bottom. Number the test-tubes 1–5.
3. Pour the 100% milk solution into test-tube 1 up to the 1 cm mark.
4. Repeat the process with the 75%, 50% and 25% milk solutions in test-tubes 2–4 respectively.
5. In test-tube 5 place tap water up to the 1 cm mark.
6. Add 8 drops of methylene blue to each tube and mix well. The tubes should appear blue because there is plenty of oxygen in the water. Methylene blue turns colourless when there is no oxygen.
7. Pour the yeast solution into each test-tube up to the 3 cm mark and mix each test-tube well. Do this as quickly as possible. Each tube should be done at the same time. If this is not possible, then record the time when each tube was mixed.
8. Use the split button on the timer to record how long each tube takes to lose its blue colour. Record this in a suitable table.

Discussion

1. **Explain** what caused the colour change from blue to colourless.
2. **Describe** the relationship between milk concentration and time taken to lose the blue colour in the test-tube.
3. **Explain** what could happen in a swamp ecosystem if human food wastes got into the water and the microorganisms reacted like the yeast in this practical.

2 Detergents and plants

Purpose

To design an experiment to investigate whether pollution with detergent could affect the health of water plants.

Materials

- materials as requested by students

Procedure

1. Researchers suspect that water plants could be damaged by detergents entering our waterways. In your group, your task is to design a way of testing whether this is true.
2. In your group, decide on aspects of your design, such as:
   - a how you will decide that plant health is damaged
   - b how you will apply the detegent and how much you will use
   - c how many plants to use and how long the experiment will last.
3. When you have done some research, draw a diagram of your set-up and show it to your teacher. Carry out your experiment if the teacher agrees.

Results

Collect all the results in the class.

Discussion

Evaluate the results of your experiment and present a report on your experiment.

9 Chapter review

Remembering

9.8

1 **List** the components of an ecosystem.

2 **List** the major ways in which humans are damaging the environment.

3 a **Name** five feral animals in Australia.
  b **Specify** the type of damage they do in ecosystems.

Understanding

4 **Explain** why biodiversity is important.

5 **Explain** why all organisms in an ecosystem are interdependent.

6 **Discuss** ways of protecting and managing ecosystems.

7 **Discuss** why it is important to protect ecosystems.

8 **Explain** why termites are important in Australian ecosystems, and how they manage to perform their role.

9 **Explain** how seasonal changes in temperature, water availablity and sunlight can affect ecosystems.

Applying

10 a **Identify** five biotic factors and five abiotic factors that affect you.
  b **Explain** how they affect you.

11 **Use** your knowledge of energy in ecosystems and of pyramids of biomass to **explain** why food chains are usually fairly short, with perhaps only four levels of consumer.

12 A dingo and a wedge-tailed eagle both prey on rabbits. The dingo is infested with fleas. **Use** the following terms to **identify** the relationships between these four animals: parasitism, predation and competition.

Analysing

13 **Compare** the effect that any two biotic and abiotic factors have on you and a plant in your garden.

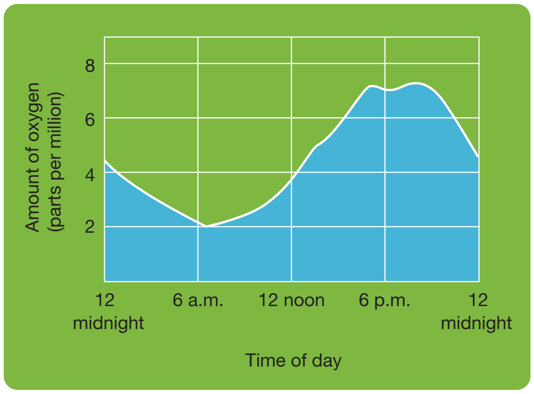
14 Choose an ecosystem close to where you live.
  a From your knowledge, **name** two different species of animals in the ecosystem.
  b **Identify** an environmental factor that you think must affect the two species.
  c **Compare** how the two species are adapted to that particular environmental factor.

15 a **Compare** the concepts of sustainability and protection of the environment (conservation).
  b **Discuss** how they are interdependent.

16 The ecological footprint for Australia is about nine times greater than that for India. **Analyse** what this means for the sustainability of our lifestyles in Australia.

17 Figure 9.4.1 shows the changes in oxygen content in a lake. Assume temperature changes had minimal effect on oxygen solubility. **Interpret** the changes in oxygen content over the 24 hours.

Figure 9.4.1



18 a **Compare** the ghost bat (Figure 9.1.15 on page 286) and the large-eared horseshoe bat (Figure 9.1.18 on page 287).
  b **Describe** any differences you see in their heads and relate this to how efficient they probably are at echolocation.

Evaluating

19 **Justify** the argument that photosynthesis is the most important process in ecosystems.

Creating

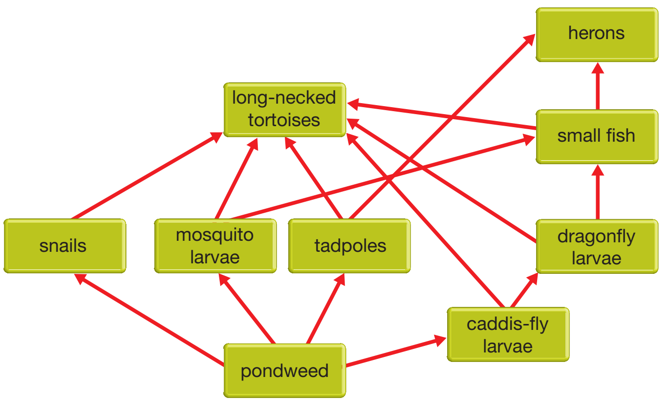
20 **Design** an experiment to test whether tomato plants or basil plants, when grown together, are affected more by competition than if they are grown apart.

21 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

biotic factors	abiotic factors
environment	adaptations
structure suits function	food webs
biodiversity	conservation
human impacts	natural impacts

Thinking scientifically

Questions 1 to 4 are based upon the following food web.



Q1 Identify which of the relationships in the following table is correct.

Answer	Predation	Competition
A	Small fish and mosquito larvae	Tadpoles and dragonfly larvae
B	Snails and pondweed	Heron and small fish
C	Heron and small fish	Heron and long-necked tortoise
D	Long-necked tortoise and tadpoles	Tadpoles and small fish

Q2 If the lake was sprayed to control mosquitoes, identify the most likely effect.

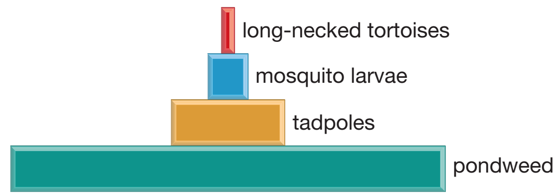
- **A** The biomass of pondweed would decrease.
- **B** The tadpole population would decrease.
- **C** Most of the herons would migrate out of the area.
- **D** The population of small fish would decrease.

Q3 If a disease killed most of the long-necked tortoises, identify a likely short-term change in the ecosystem.

- **A** rapid increase in the numbers of small fish
- **B** decrease in the numbers of heron
- **C** rapid increase in the biomass of pondweed
- **D** no change in the biomass of caddis-fly larvae

Q4 Identify which of the following is a correct pyramid of biomass that could be drawn for this ecosystem.

A



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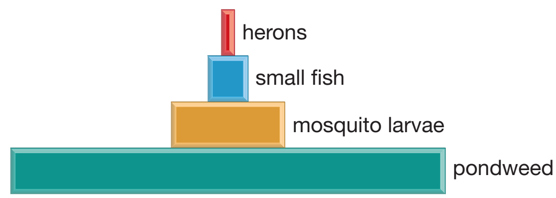

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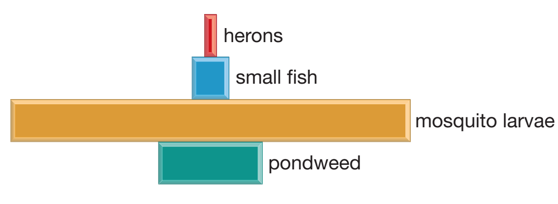
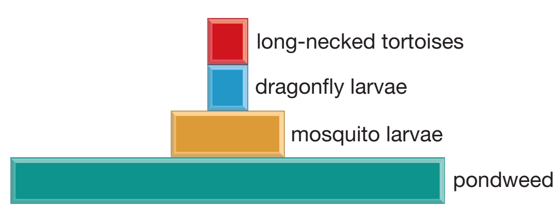


D



Glossary

Unit 9.1

Adaptation: a feature that an organism has that enables it to survive

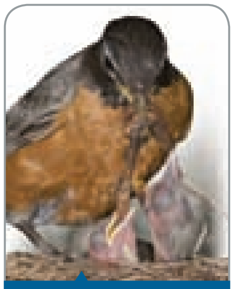
Abiotic factor: a non-living factor of the environment

Biotic factor: a living factor of the environment

Commensalism: relationship between two organisms, where one benefits and the other is unharmed

Community: all the living organisms in an ecosytem

Competition: relationship between organisms that are trying to use the same limited resource



Competition

Ecology: the study of how organisms interact with each other and with their environment

Ecosystem: a place where organisms and their physical surroundings form a balanced environment that is different from others nearby

Ectothermic: animals that obtain body heat from outside their body

Endothermic: animals that can generate body heat internally

Environment: all the factors in an organism's surroundings that affect it

Habitat: where an organism lives

Interdependence: relationship between organisms, where each affects the other's survival

Mutualism: relationship between two organisms living closely together, where each benefits the other

Mutualism

Parasitism: relationship between two organisms, where one organism lives on or in the other and feeds off it

Photosynthesis: the process by which plants make their food

Physical factor: a non-living factor (also called abiotic)

Predation: relationship between two organisms, where one organism kills and eats the other

Unit 9.2

Biodiversity: the range of different species in a community

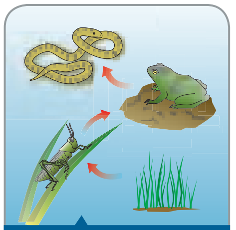
Consumers: organisms that require a ready-made source of food

Decomposers: organisms such as some bacteria that break down the bodies of dead organisms and animals wastes and recycle material

Ecological footprint: the area of land and water needed to provide resources necessary for survival

First-order consumer: in a food chain, the position of a herbivore

Food chain: a sequence of organisms feeding on each other



Food chain

Food web: all the linked food chains in an ecosystem

Keystone species: species that are critical to the survival of an entire ecosystem

Producers: organisms that make food for the community

Productivity: how well an area supports life

Pyramid of biomass: a diagram that shows the total mass of organisms at each stage of a food chain

Second-order consumer: the animal feeding on the first-order consumer

Sustainable living: for humans, living in a way that ensures that resources do not run out and the natural ecosystems are not damaged

Third-order consumer: the animal feeding on the second-order consumer

Unit 9.3

Bushfire: a fire that burns natural vegetation in forests, woodland or grassland

Chemical pollution: chemicals escaping into the environment that can damage ecosystems

Drought: an extended period of no rainfall in an area, even in seasons when it normally rains

Epicormic growth: growth of new shoots from the stems of trees and shrubs after fires

Feral animal: an introduced species of animal that has become established in the wild

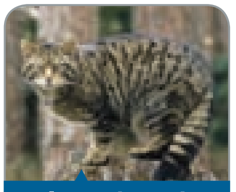
Firestick farming: a hunting method used by Australian Aboriginal people, in which vegetation is burned to flush out animals and to rejuvenate the land

Flood: an event where water covers the land and does not soak in for a long time

Global warming: the increase in the temperature of the Earth's atmosphere

Habitat destruction: damage caused to the factors in the environment that an organism depends on for survival

Introduced species: animals and plants brought to Australia from other countries



Introduced species

Lignotuber: a swollen underground stem of eucalypts that can resist fire

Mallee: a type of eucalypt that has lignotubers

Overcropping: killing more animals than the population can replace by its normal breeding cycle

Overpopulation: when there are too many of a species for the ecosystem to support them and remain sustainable