OXFORD SCIENCE 9

AUSTRALIAN CURRICULUM

* EACH OF THESE OPTICAL DETECTORS WILL BE POSITIONED IN ARCTIC ICE AT A DEPTH OF UP TO 2400 M AND WILL DETECT CHARGED PARTICLES GENERATED WHEN NEUTRINOS FROM SPACE COLLIDE WITH THE ICE. ZEUTHEN, GERMANY

HELEN SILVESTER

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CONTENTS

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Using Oxford Science

Oxford Science is a series developed to meet the requirements of the Australian Curriculum: Science across Years 7 to 10. Taking a concept development approach, each double-page spread of Oxford Science represents **one concept** and **one lesson**.

What if?

Student-directed inquiry is encouraged throughout this series using a simple questioning technique. As the series progresses, students discover that their own *What if* questions are actually testable '*if and then*' hypotheses. For example, 'What *if the bubble is touched with a finger*' becomes 'If *the bubble is touched with a finger*, then *it will pop*'.

Concept development

Students are given access to the chapter concepts at the start of every chapter. Each double-page spread of this series represents **one concept**. Students explore concepts one-by-one, encouraging incremental learning and, by the end of the chapter, complete understanding.

The unit heading introduces the concept.

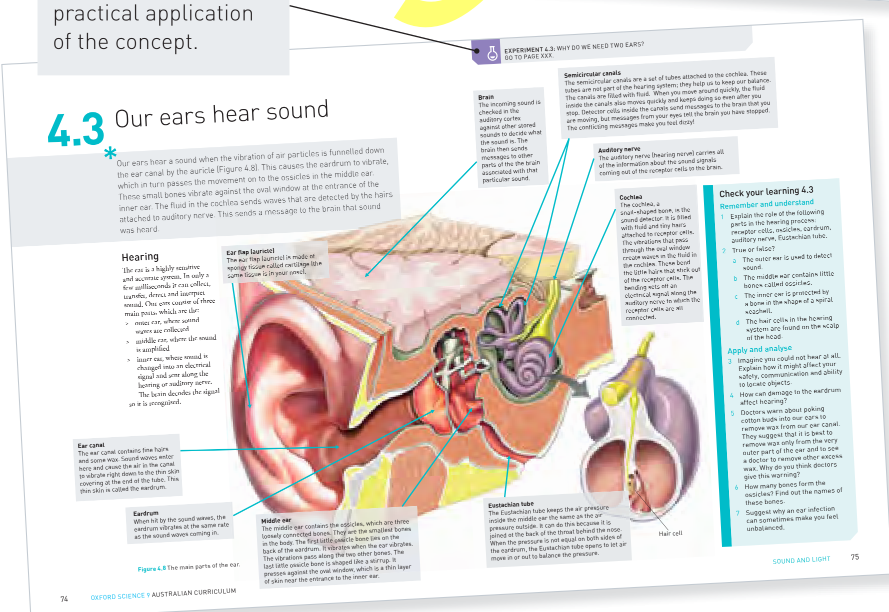
Each unit begins with a short summary of the concept.

Body text elaborates on the concept in clear and accessible language.

Every spread is linked to one or more experiment, challenge or skills task as a practical application of the concept.

Diagrams and photos are used to illustrate the concept and engage students.

Every double-page spread ends with **Check your learning** questions, allowing students to consolidate their understanding. Questions are graded according to Bloom's Taxonomy – catering for a range of abilities and learning styles.



Accessibility and engagement

Oxford Science has been engineered to be accessible to all science students. We believe that science students are served best when they are free to focus on learning the knowledge and skills of science in simple accessible language, crafted into short sentences. Students will be engaged by the inclusion of stunning photography throughout.

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Science as a human endeavour

Concepts are linked to real-world applications in the highly engaging **Science as a human endeavour** spreads. The **Extend your understanding** questions on these spreads are designed to be used flexibly as either homework tasks or an extended project.

Experiments

Uniquely, experiments are organised at the end of the book in an extended experiments chapter, rather than being confined to each double-page spread. There is a link on most double-page spreads to an experiment, challenge or inquiry task to ensure that practical activites remain aligned to the content.

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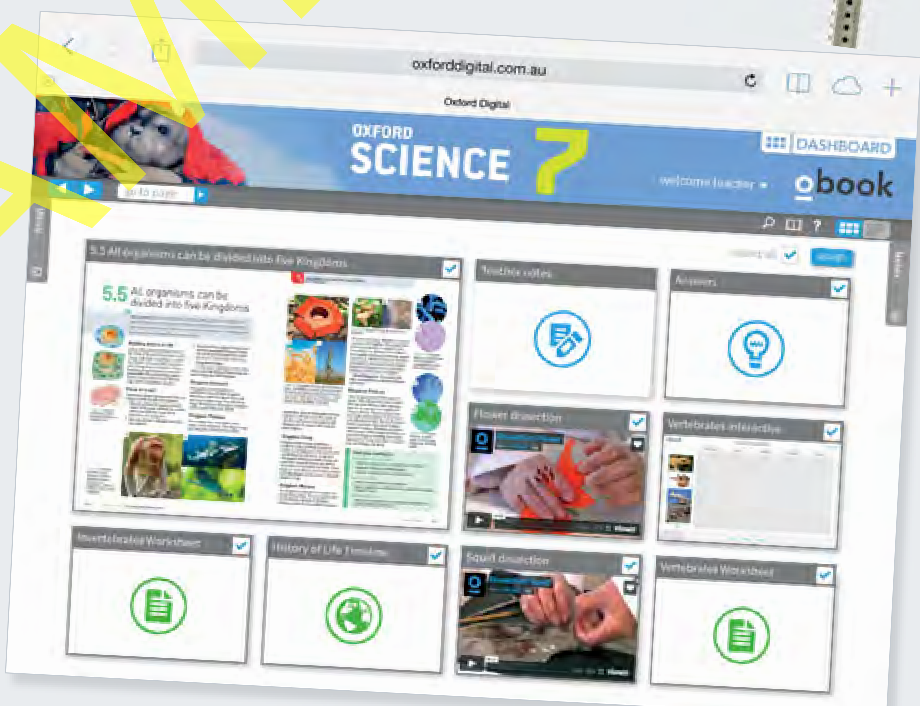
Integrated teaching and learning support

obook assess

obook assess provides an interactive electronic version of the student book in an easy-to-read format. It features multimedia links, interactive learning objects, videos, note-taking, highlighting and bookmarking tools, and live question blocks. **obook** is compatible with laptops, iPads, tablets and IWBs, and also offers page view (in flipbook format) that can be used offline. **assess** provides 24/7 online assessment designed to support student progression and understanding.



DASHBOARD

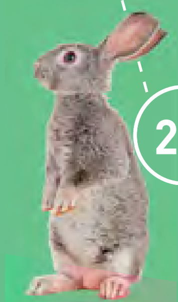
Oxford Science is supported by teaching strategies, lesson ideas, planning tips, assessment advice and answers to all activities. **obook assess** allows teachers to manage their classes by assigning work, tracking progress and planning assessment. Teacher Dashboard is your online lesson control centre, which allows you to instantly preview or assign related teacher resources to deliver incredibly engaging digital learning experiences. Students can also toggle from their **obook** to the Dashboard to interact with student resources for each topic.

ECOSYSTEMS 2

2.1 All living things are dependent on each other and the environment around them

2.2 Relationships between organisms may be beneficial or detrimental

2.3 Population size depends on abiotic and biotic factors



2.4 Introducing a new species may disrupt the balance in an ecosystem

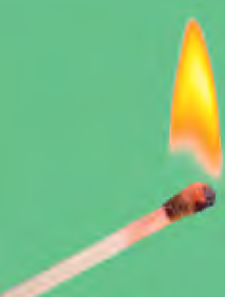
2.5 Energy enters the ecosystem through photosynthesis

2.6 Energy flows through an ecosystem

2.7 Matter is recycled in ecosystems

2.8 Natural events can disrupt an ecosystem

2.9 Human activity can disrupt an ecosystem



2.10 Human management of ecosystems continues to change

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What if?

Yeast cultures

What you need:

spatula, dried yeast, warm water, sugar, test tube, ruler, thermometer, timer

What to do:

1. Add 1 spatula of dried yeast and 1 spatula of sugar to the test tube.
2. Add 5 mL of warm water to the test tube.
3. Measure the temperature of the water.
4. Measure the height of the yeast culture (an indication of the number of yeast cells) from the base of the test tube. This is the measurement at $t = 0$ minutes.
5. Measure the height of the culture every minute for 15 minutes.
6. Draw a graph of your results.

What if?

» What if hot water was added to the culture? (Would the number of yeast cells increase faster?)

» What if ice cold water was added to the culture?

» What if twice as much sugar was added?

» What if no sugar was added?

2.1 All living things are dependent on each other and the environment around them

An ecosystem is a community of living organisms (biotic) and their non-living surroundings (abiotic). It is the basic unit of ecology. Ecology is the study of the interrelationships of organisms with other organisms and with their non-living environment. Groups of organisms live together in communities. Many different species may live in a community. They share the same environment because they find their requirements there. A group of organisms of the same species in the environment is called a population.

Figure 2.1 Wetlands such as those in Kakadu National Park in the Northern Territory are an example of an ecosystem.

The biosphere – a home for our ecosystems

The **biosphere** describes the living world. It is where all of the plants, insects and animals live. The biosphere extends to any place that life, of any kind, can exist on the Earth. The biosphere can be thought of as the intersection between the atmosphere (gases), the hydrosphere (water) and the lithosphere (land). Since the biosphere is large, and its relationships are so complex, we normally study smaller components of the biosphere, called **ecosystems.**

Ecosystems

Ecosystems vary in size. They can be as small as a puddle or as large as the Earth itself. Any group of **biotic** (living) and **abiotic** (non-living) things interacting with each other in a self-sustaining way is an ecosystem. Ecosystems are made up of **habitats**. A habitat is the place where a population of organisms lives. Habitats vary in size depending on the amount of food, water and shelter they provide. A **population** is a group of living organisms that are the same species, living in the same place at the same time. When different populations interact with each other, they are called a **community**. For example, a population of humans can live in a town together. When all the plants in their gardens and their pets are included, then it becomes a community.

The habitat must supply all the needs of the organisms, such as food, water, warm temperatures, oxygen and minerals. These make up the non-living, abiotic conditions of the habitat. If the abiotic conditions are not appropriate for a population, then the individuals in that population will move to a better habitat or will die out.

Benefits of an ecosystem

Humans depend on ecosystems for survival. Ecosystems provide a number of benefits to ensure our continual existence.

Plants and animals work together to help maintain the balance of gases in the air

Plants and animals continuously cycle gases among themselves, the soil and the air. For example, during the day, plants take in carbon dioxide from the air and release oxygen into the air during a process called photosynthesis. Animals, including humans, use the oxygen in cellular respiration and release carbon dioxide into the air.

SAMPLE

CHALLENGE 2.1: MAKING A BIOSPHERE
GO TO PAGE 179.

EXPERIMENT 2.1: PURIFICATION OF WATER
GO TO PAGE 180.

Figure 2.2 Dolphins come to the surface of the water to breathe in air and release carbon dioxide through an air hole.

Insects, birds and bats help pollinate plants

Plants and animals interact in their search for food. Bees and other insects, as well as some birds and bats, transfer pollen from plant to plant. Pollination not only helps wild plants, it is also important for crop plants. Over 70% of plant species worldwide, including fruits and vegetables, are pollinated by animals, insects or birds.

Some organisms decompose organic matter

Some living organisms, called **decomposers**, get the food they need by feeding on the dead. Decomposers not only prevent dead organisms from piling up, they also take the nutrients from the dead body to use when building their own bodies. The nutrients will then be passed on to other organisms that eat the decomposer organisms. Also, the nutrients that pass through the decomposers as waste end up in the soil in simpler forms that plants can absorb into their roots.

Figure 2.4 Fungi are important decomposers. These fungi are feeding off a rotting log.

Figure 2.3 The forested water catchment areas around Melbourne are vital for keeping its water supply clean.

Wetlands and forests clean water

If you poured dirty water through a filter, you would expect cleaner water to come out. A similar situation happens in nature when water passes through a forest or wetland ecosystem. By slowing the flow of water, the plants and animals in the ecosystem trap some of the pollutants and sediments.

Figure 2.5 Pollination involves the transfer of pollen from the male parts of flowers to the female parts of other flowers of the same species. Animal pollinators, such as bees, small mammals or birds, visit the flowers for food such as nectar, and transfer pollen when they visit other flowers. Pollen may also be carried by wind or water.

Check your learning 2.1

Remember and understand

1 What three systems interact to form a biosphere?

2 What is the scientific word for non-living components of an ecosystem? Give three examples of these components.

3 What is the difference between a population and a community?

4 Give some examples of the benefits that ecosystems provide.

Apply and analyse

5 Why does Melbourne have such good drinking water? Figure 2.3 may help to answer this.

Evaluate and create

6 Imagine someone walked up to you and asked 'Why is the environment so important?' Draft a reply, taking into account the key concepts covered here.

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2.2 Relationships between organisms may be beneficial or detrimental

All organisms interact with each other in a community. Individuals in a population may need to collaborate and mate to ensure the species survives. This may also cause competition for food or shelter. Although some organisms do not affect other organisms in an ecosystem, most organisms are part of a large network of living things. These relationships may be beneficial or detrimental. Relationships may be between organisms of the same or different species. Sometimes two organisms from different species form a close relationship with each other. This type of relationship is called symbiosis. Symbiotic relationships include mutualism, commensalism and parasitism. Both organisms benefit in mutualism; only one organism benefits in commensalism; and one organism benefits and the other is harmed in a parasitic relationship.

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Relationships within a species

There are three types of relationships between organisms of the same species.

1. **Collaboration** occurs when organisms cooperate with each other to ensure their survival. For example, ants leave a trail of scent when they look for food so that other ants can find the food too.
2. **Mating** between members of the same species produces offspring, thus ensuring the survival of the species.
3. **Competition** occurs when organisms use the same limited resource. For example, seedlings from the same species compete with each other for light and space as they grow.

Relationships between different species

Symbiosis

Symbiosis is a close physical and long-term relationship between two organisms of different species. Mutualism, commensalism and parasitism are all examples of symbiosis.

Mutualism is a relationship between two organisms in which both organisms benefit.

Commensalism is a relationship in which one organism benefits and the other organism is not affected. Commensalism is relatively rare in the natural world because it is unlikely that an organism will not be affected in some way by a relationship with another organism.

Parasitism is a relationship in which one organism (the parasite) lives in or on the body of another (the host). The parasite benefits but the host is harmed.

EXPERIMENT 2.2: WHAT IF MORE SEEDS WERE PLANTED IN A POT?
GO TO PAGE 181.

Figure 2.6 Mutualism. A lichen is an alga and a fungus, although you cannot see the two organisms separately (except under a microscope).The alga produces energy for both through photosynthesis, and the fungus provides support and other nutrients.

Figure 2.7 Mutualism. The anemone fish hides within the tentacles of the sea anemone where it is camouflaged from its predators. The sea anemone is cleaned of algae by the fish.

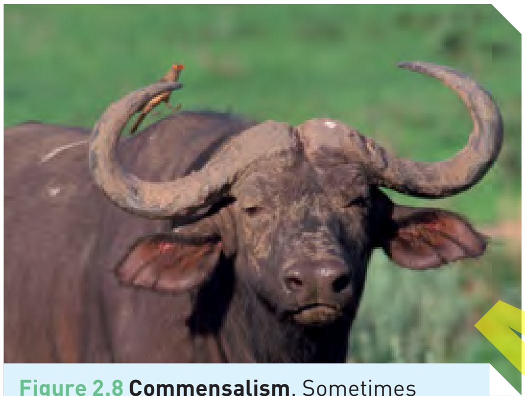

Figure 2.8 Commensalism. Sometimes herbivorous animals such as cattle and water buffalo flush insects out of the grass as they wander through. Birds such as cattle egrets feast on the insects.

Figure 2.9 Commensalism. Certain plants rely on passing animals to disperse their seeds. The seeds have tiny hooks that attach to animal fur and they will usually fall off a distance from their parent plant.

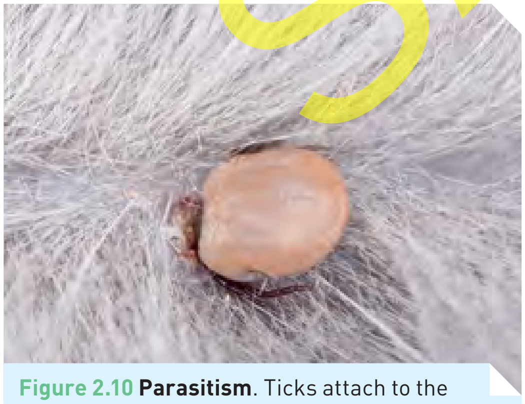

Figure 2.10 Parasitism. Ticks attach to the skin of animals and slowly drink their blood. Bacteria from the digestive system of the tick can infect the animals.

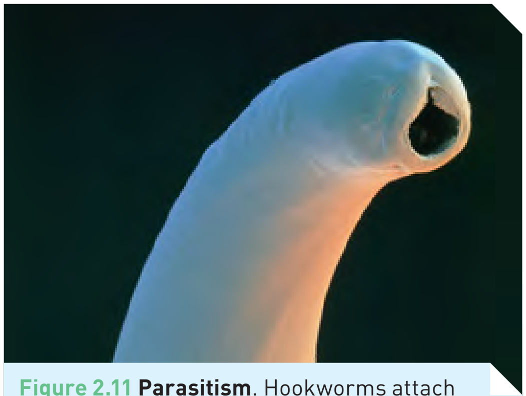

Figure 2.11 Parasitism. Hookworms attach themselves to the inner lining of the human intestine, feeding on nutrients as they pass by. If the host doesn't eat enough, the worm has been known to burrow out of the intestines and travel to other organs, where significant damage can be done.

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Non-symbiotic relationships

Two non-symbiotic relationships are predator–prey relationships and competition.

In a predator–prey relationship, one organism (the predator) eats another (the prey). Therefore one benefits and the other is harmed. It is not symbiotic because the relationship between the organisms is not long term and it only happens when a predator has the opportunity. Predators and their prey have a balanced relationship with each other. If all the prey are eaten, then the predator will starve. A graph of predator–prey numbers (Figure 2.12) shows a typical pattern.

Competition may also exist between members of different species that share a resource such as food (Figure 2.13).

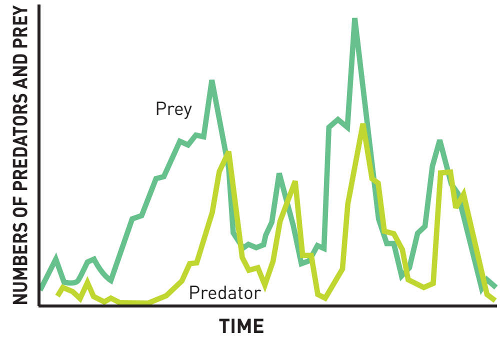

Figure 2.12 A predator–prey graph. The scales aren't shown but the prey numbers are mostly greater than those of the predators. Notice that the increase and decrease in prey numbers usually comes before the increase and decrease in predator numbers.

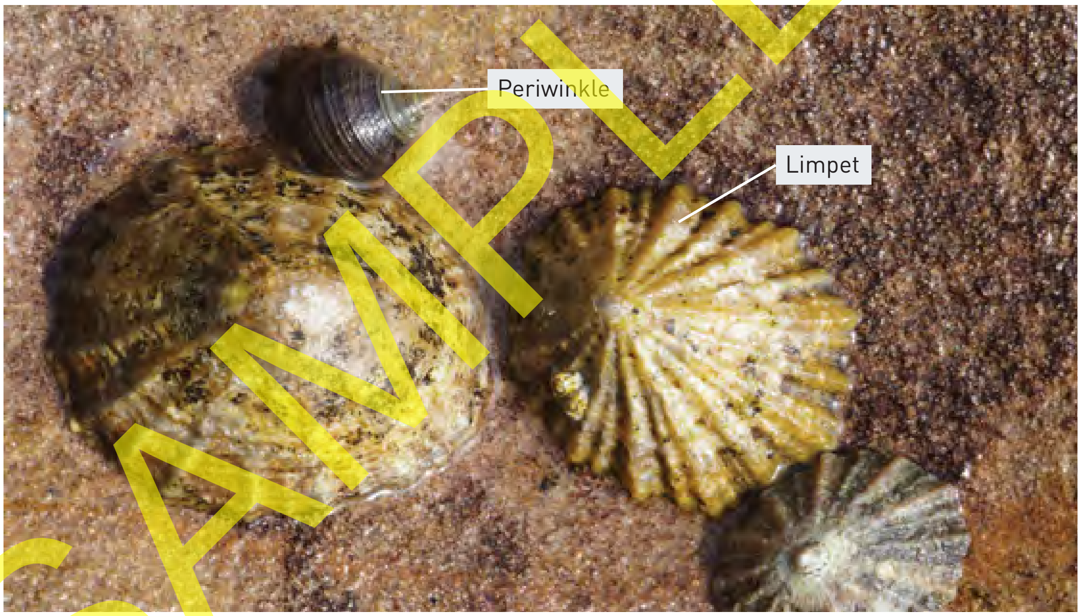

Figure 2.13 A black periwinkle (*Nerita*) competes for food with the limpet (*Cellana*) on a rock platform – both feed on algae growing on the rocks. The periwinkle moves faster but feeds less efficiently than the limpet, so both can survive because the periwinkles usually leave some algae behind for the limpets. However, when the periwinkles are removed, the limpet population increases.

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Inhibition is a particular type of competition that occurs when one organism produces a chemical that directly inhibits or hinders the growth and development of another (Figures 2.14 and 2.15).

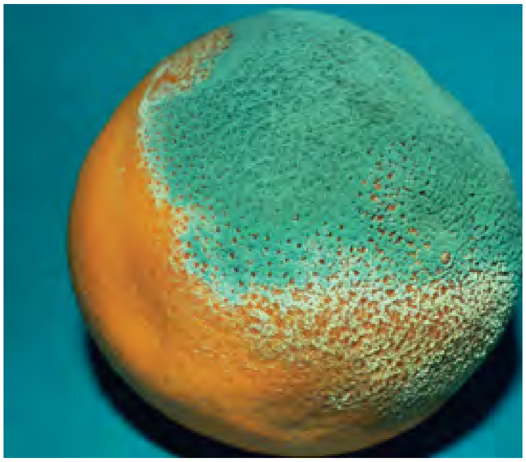


Figure 2.14 *Penicillium* mould (fungus, seen here growing on an orange,) produces an antibiotic called penicillin that inhibits the growth of many species of bacteria.

Figure 2.15 The *Lantana* plant was introduced into Australia and has become a weed. It releases a chemical in the soil that inhibits the growth of native plant species.

Check your learning 2.2

Remember and understand

1. State one similarity and one difference between a predator–prey relationship and parasitism.
2. How can a large plant that produces a lot of shade prevent smaller plants from growing?

Apply and analyse

3. Give an example of the following relationships.
   a. Predator–prey
   b. Mutualism
   c. Commensalism
   d. Parasite–host
4. Some eucalyptus trees have mistletoe plants living on them. Mistletoe has very similar leaves to eucalyptus leaves. Mistletoe can make their own food but their stems send suckers into the eucalypt to obtain water and minerals. If too much water and minerals are removed, the eucalypt can die. What type of relationship is this? Give a reason.
5. Epiphytes are plants, such as ferns and some orchids, that grow high in the branches of other trees, especially rainforest trees. The epiphytes obtain sufficient light to make their own food, collect water from the moist air and obtain minerals from the decaying leaf litter that they catch at their leaf bases. The tree is not affected by these plants. What type of relationship is this? Why?

SAMPLE

2.3 Population size depends on abiotic and biotic factors

The number of organisms in a population can be affected by many different factors. Competition for food within a species and between different species can make it difficult for an organism to survive. An increase in the number of predators will cause a population to decrease. A drought or a bushfire can also have long-term effects on a population.

SAMPLE

A dynamic balance

All organisms live in a complex web of interrelationships – with each other and with their environment. An ecosystem needs to be able to maintain a balance so that all species can exist at their optimum population size.

At its simplest, gains due to reproduction and immigration must balance the losses due to death and **emigration** (leaving).

Consider the food web for an ecosystem shown in Figure 2.16. If the number of frogs decreased in this ecosystem, consequences could include:

> increase in grasshopper numbers and thus depletion of grass
> initial increase in praying mantis numbers because of more grasshoppers
> decrease in lizard numbers
> diversion of birds towards a diet of praying mantises rather than frogs and lizards
> consequent decrease in praying mantis numbers
> further increase in grasshopper numbers and intensified depletion of grass. If this was severe enough, the ecosystem would be at risk as it depends on a good supply of grass.

The most likely outcome is that the bird population will decrease so that all species will return to balance with reduced population sizes. A positive effect is that it might enable the frog population to recover.

Ecosystem balance is a type of dynamic equilibrium. Changes may upset the equilibrium, but another equilibrium becomes established. Often, it is not greatly different from the original. Changes in ecosystems occur naturally but they may be intensified by external factors such as floods and bushfires. Reproduction, death, **migration**, natural events (for example, seasonal changes), disasters (floods, droughts, earthquakes) and human intervention occur regularly.

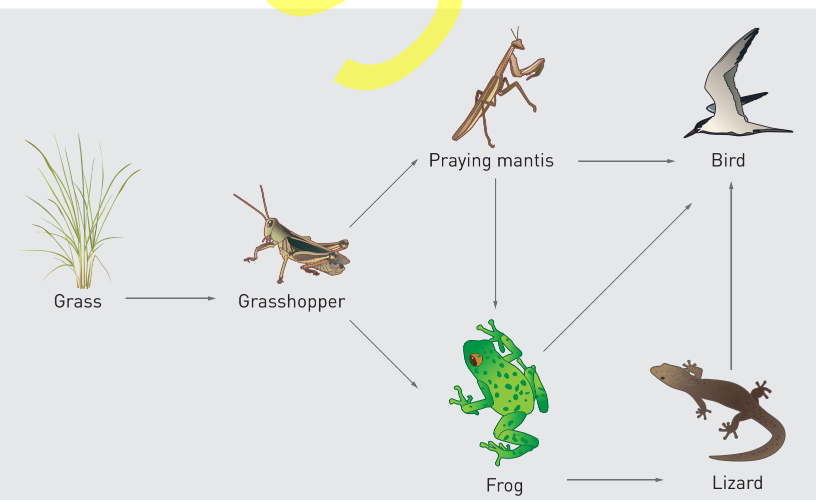


Figure 2.16 A food web for an ecosystem.

Population dynamics

Population dynamics is the study of the changes in population numbers within ecosystems. Scientists can make predictions and take certain precautions to conserve species if they have an approximate idea of how many of each species are in a certain location. Regular sampling provides information about

CHALLENGE 2.3: DELICIOUS COUNTING
GO TO PAGE 182.

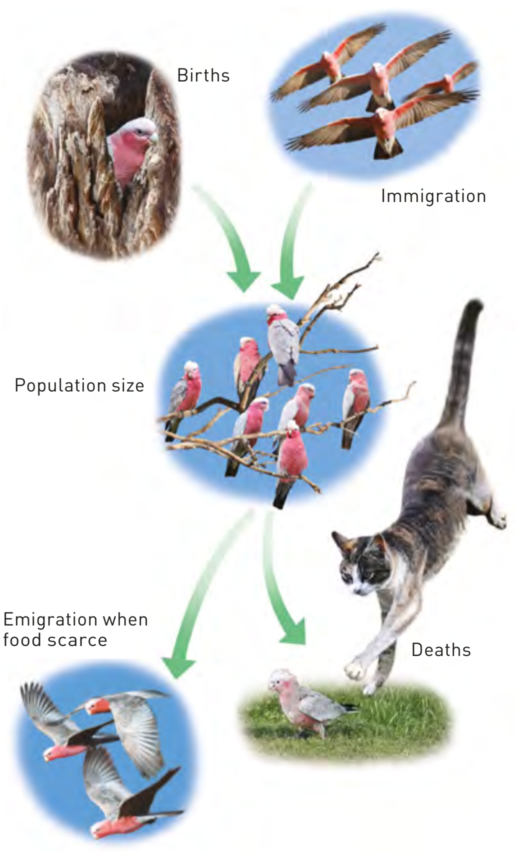


Figure 2.17 The size of a galah population in a particular area depends on the food available and the number of births and deaths.

increases and decreases in population numbers, and causes can be identified.

Counting organisms

There are a number of ways to determine the size of a population. The 'simplest' way is to count all the organisms, but in practice this is rarely possible. Estimates are more easily achieved by counting from helicopters or using quadrats or capture–recapture methods. For human populations, a census is the usual method.

For plants and stationary animals, **quadrats** (randomly selected square plots) are marked in an ecosystem. The organisms in each plot are counted, an average is obtained and then (knowing the total area of the ecosystem) the estimated number of organisms in the ecosystem is calculated. This method works well if a large number of quadrats are used and the organisms are evenly spread throughout the ecosystem.

For animals that are mobile, **capture–recapture** is a popular method. Animals are captured in traps and marked with tags, liquid paper or permanent marker on their tails. The number counted on the first capture is N_1. The animals are then released and it is assumed that they disperse evenly throughout the population. Another capture (recapture) is made one or two days (or nights) later. The number of animals in this second capture that are marked are counted (M_2), as well as the total number caught in the second sample (N_2). An estimate of the population is then obtained using the following formula:

$$\text{Total number of animals} = N_1 \times N_2 \div M_2$$

Capture–recapture is a suitable technique for estimating the population size of small Australian mammals such as the marsupial *Antechinus* or the common bush rat. Because most native Australian mammals are nocturnal, the traps may be set at night and checked the next morning.

Figure 2.18 Using a quadrat.

Figure 2.19 Marking a captured animal.

SAMPLE

Check your learning 2.3

Remember and understand

1 Describe suitable methods for estimating the size of populations of:
   a plants and stationary animals
   b other animals.
2 What are the advantages and disadvantages of the methods you described in question 1?

Apply and analyse

3 Students on a field trip with a national park ranger set traps for a small nocturnal marsupial, *Antechinus stuartii*, in a heathland ecosystem. They captured eight animals on the first night and marked white dots on their tails. Then they released them. On the second night, they captured 10 animals, of which four were marked.
   a What is the estimation of the population size of *A. stuartii* in this ecosystem?
   b How could the students increase the accuracy of this experiment?
4 Is growth in population size always desirable? Discuss.
5 Ecosystems are said to be in a state of equilibrium or balance. It appears that nothing is changing. But is there change?
6 Explain how predator–prey relationships achieve a state of balance. Why is this balance essential for the:
   a prey?
   b predator?

//SCIENCE AS A HUMAN ENDEAVOUR//

2.4 Introducing a new species may disrupt the balance in an ecosystem

Introducing or removing a species from an environment can have devastating effects on other populations in an ecosystem. Before a species is introduced as part of biological control of pests, scientists must model the possible effects on populations that compete for the same food source or the predators that may prey on them. Ecosystems must establish a balance between all organisms in the community.

Figure 2.21 Rabbits bite tusks of grasses very close to the ground. Combined with digging extensive burrows, this makes the soil more prone to erosion.

SAMPLE

Introducing rabbits

The European rabbit travelled to Australia on the First Fleet in 1788. The 250-day journey ensured that the rabbits were well domesticated on arrival. The rabbit population around Sydney did not grow very quickly. However, when they were introduced into Tasmania, populations of thousands quickly became established.

Rabbits breed very quickly. A single female rabbit can have up to 14 babies every litter. If the average female rabbit produces one litter a month, and these new babies are able to breed within six months, the population can grow rapidly (see Figure 2.20).

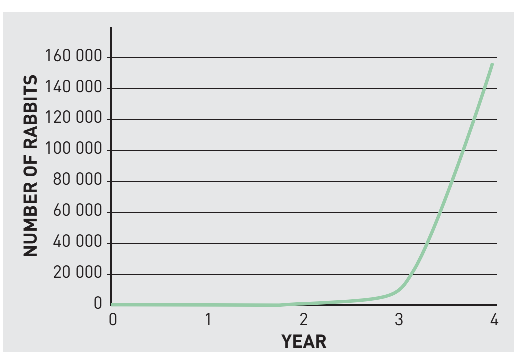


Figure 2.20 The growth of a rabbit population over four years from a single female rabbit (assuming unlimited food and no predators).

Rabbits for sport

In 1859, farmer Thomas Austin requested 24 wild rabbits be sent from England, along with partridges, hares and sparrows, for hunting. These were released near Geelong. This time the rabbits were better equipped to survive. In England, the winters were very cold and these abiotic conditions slowed the growth of rabbit populations. In Australia, the winters were much warmer and the clearing of the scrubland created large areas of farmed grasses for food. There were also few predators for the rabbits. Over the next 40 years, the rabbits spread as far as Queensland, Western Australia and the Northern Territory.

Controlling rabbit population

By 1887, rabbits were causing so much damage to the environment that the New South Wales government offered a reward for any new method to decrease the population. Rewards were offered for each rabbit killed, and even a rabbit-proof fence across large sections of Western Australia was trialled.

CHALLENGE 2.4: RABBIT AND FOX CHASEY
GO TO PAGE 183.

The increase in rabbit population had a large impact on the local ecosystems. The rabbits competed with the local marsupials for food, and destroyed large sections of the habitat with their burrows. Predators of the rabbits (such as dingos and eagles) grew in numbers due to the increase in food. Unfortunately, these increased numbers of predators also ate the local marsupials, causing their populations to decline. All these factors contributed to the permanent loss of several species of native plants and animals.

Macquarie Island rabbits

In 1985, scientists on Macquarie Island (halfway between Australia and Antarctica) devised a plan to remove all the non-native cats that had been introduced to the island since the early 19th century. It was thought this would increase the native burrowing bird populations on the island. However, when the cats were removed, the island rabbit population increased dramatically, destroying native plants and affecting many other organisms native to the island. Scientists needed to find a way to control the rabbits.

Biological control

All efforts to control the rabbit population by physical means were unsuccessful. In 1938, CSIRO scientists studied a way to control the disease using a living organism (**biological control**). They tested a virus called *Myxoma* for its ability to cause **disease** in rabbits. This virus causes a disease with symptoms including fevers and swellings around the head of the rabbits. Death occurs within 14 days. *Myxoma* was eventually released in the wild and quickly killed almost all of the rabbits that caught the infection. This increased Australia's wool and meat production within two years. A small percentage of rabbits were unaffected by the disease. These rabbits survived and were able to breed a new population of rabbits that were **immune** to the disease. New viruses, such as the caliciviruses, have been tried with similar results.

Before any species is introduced or removed from a population, scientists must ensure they are aware of all the possible implications for the ecosystem.

Figure 2.22 In 1907, a rabbit-proof fence was built between Cape Keraudren and Esperance in Western Australia.

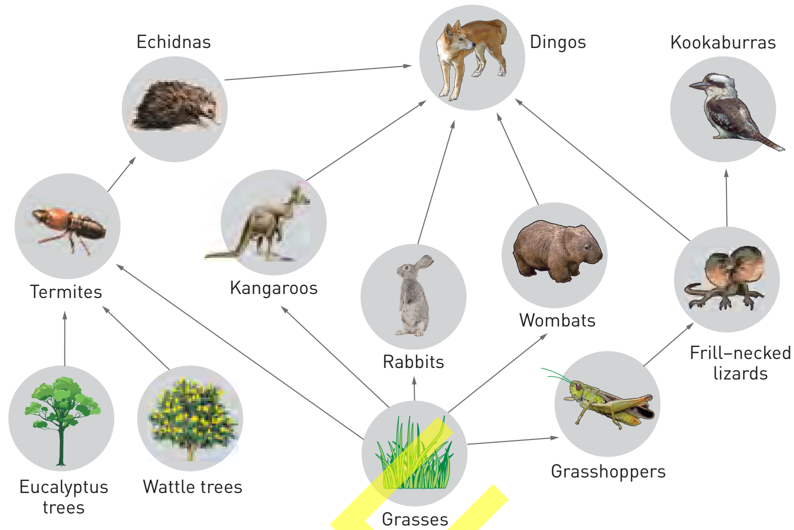


Figure 2.23 Rabbits compete with grasshoppers, wombats and kangaroos for grass.

Figure 2.24 (a) (Before): This slope on Macquarie Island had vegetation as recently as 2007. (b) (After): The same slope a few years later – it has been ravaged by rabbits since non-native cats were eradicated.

Extend your understanding 2.4

1. Why are rabbits referred to as an introduced animal in Australia?
2. Suggest two reasons why the rabbit population was able to increase so quickly when first introduced to Australia.
3. Use the food web in Figure 2.23 to suggest two populations that will increase as a result of the introduction of rabbits.
4. What effect does a high rabbit population have on the ecosystem in Figure 2.23?
5. What is a biological control?
6. Why is *Myxoma* no longer effective in controlling rabbit populations?

SAMPLE

CHALLENGE 2.5: PHOTOSYNTHESIS ROLE PLAY
GO TO PAGE 184.

2.5 Energy enters the ecosystem through photosynthesis

Ecosystems rely on the transfer of energy from one part to another. The first source of energy in most ecosystems is solar energy via photosynthesis. Animals cannot directly use energy from the Sun. Even in caves and other places where there is no light, the energy may be from dead plants and animals, which originally obtained their energy from the Sun. An exception is the chemosynthetic bacteria on the ocean floor and craters of volcanoes, which trap the energy from chemicals and chemical reactions occurring under the Earth's crust.

What is photosynthesis?

Living things need energy to grow and repair, to defend themselves, and to move around. The energy in an ecosystem usually originates from the Sun. Plants, some algae and some bacteria are able to transform this light energy into chemical energy through a process called **photosynthesis**. In this process, water and carbon dioxide is converted into glucose (a sugar) and oxygen. The overall equation for photosynthesis is:

carbon dioxide + water → glucose + oxygen + water

$$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

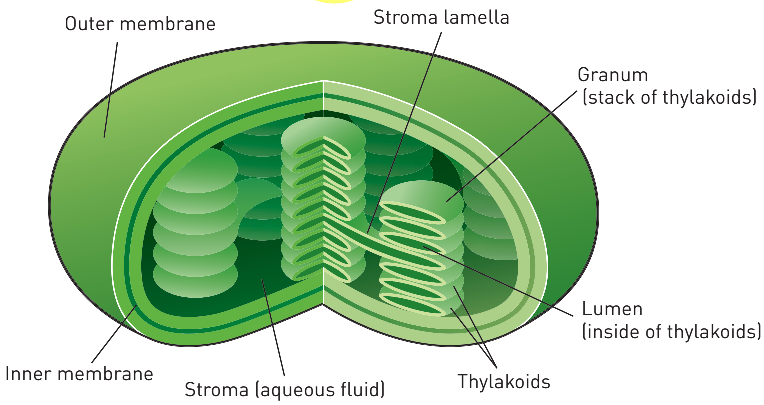


Figure 2.25 The structure of a chloroplast.

Where does photosynthesis happen?

On average, a plant leaf has tens of thousands of cells. A single cell contains 40–50 chloroplasts, which contain the green pigment chlorophyll. Chlorophyll captures the Sun's light energy and traps it in the chemical bonds of glucose.

Because plants cannot breathe like we do, they must take in carbon dioxide through microscopic pores called stomata (singular 'stoma') in the leaves. The water needed for photosynthesis enters through the roots and travels to the leaves through xylem vessels.

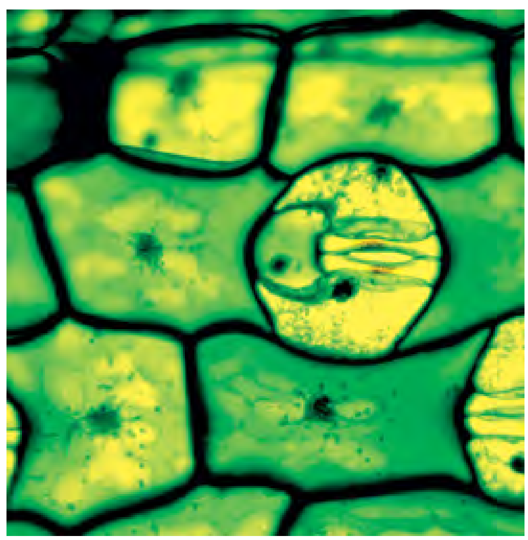


Figure 2.26 Guard cells open and close the stomata of a plant.

SAMPLE

EXPERIMENT 2.5A: INPUTS AND OUTPUTS OF PHOTOSYNTHESIS
GO TO PAGE 184.

EXPERIMENT 2.5B: EFFECT OF CARBON DIOXIDE ON STARCH PRODUCTION
GO TO PAGE 185.

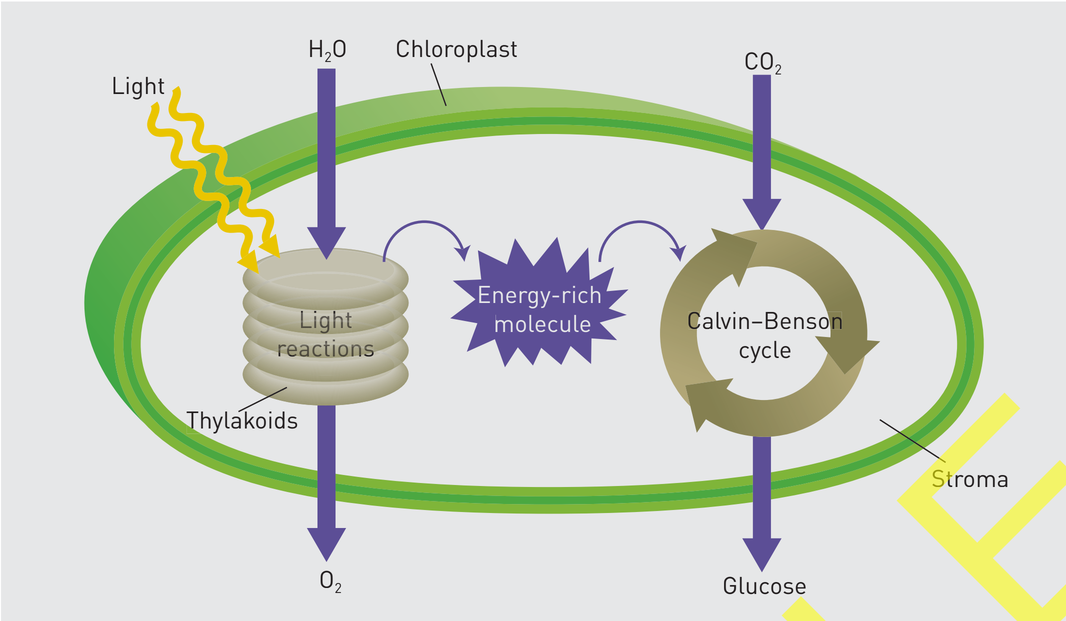


Figure 2.27 The light and dark reactions occur inside chloroplasts.

A closer look at photosynthesis

Although the overall equation for photosynthesis is shown as one reaction, it is really two.

1 The light reaction needs sunlight and takes place in the grana in chloroplasts. Sunlight causes charged particles (electrons) to become excited, and the bonds within water molecules are broken, releasing oxygen and forming energy-rich molecules.

2 The dark reaction does not require sunlight and takes place in the stroma of chloroplasts. The energy-rich molecules formed in the light reaction, together with carbon dioxide, are used to make carbohydrate molecules, such as glucose. This process is called the Calvin–Benson cycle, or carbon fixation.

What happens to the glucose?

Plants are sugar factories, making millions of glucose molecules during daylight hours. Plants require a constant supply of glucose for energy to grow and repair damage. During daylight, more glucose is made than can be used directly by plants, so excess glucose is stored in the form of starch and other carbohydrates in the roots, the stems or the leaves. Starch is stored in underground storage organs, such as roots and tubers (for example, potatoes, carrots and parsnips) all store starch in this way.

Figure 2.28 Starch is stored in roots and tubers. During the night, there is no sunlight for photosynthesis but plants still need energy to stay alive. Plants break down starch into glucose so that they can survive the night.

SAMPLE

Check your learning 2.5

Remember and understand

1 Where does photosynthesis occur?

2 What is essential for photosynthesis?

3 What are the raw materials needed for photosynthesis? How do they enter a plant?

Apply and analyse

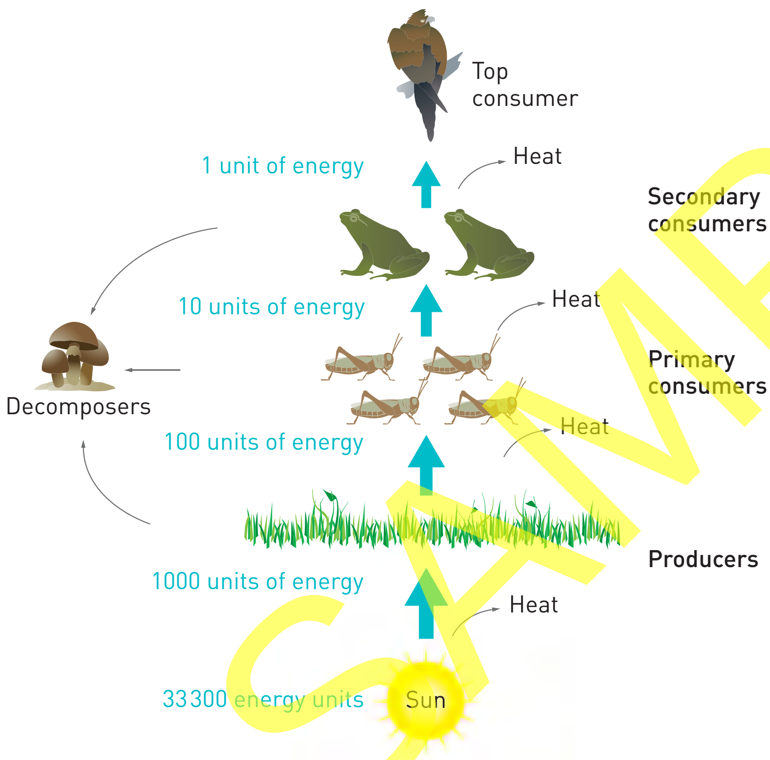
4 Explain why it is fair to say that photosynthesis is the most important metabolic process on the Earth.

5 Draw a flow diagram showing the inputs and outputs of photosynthesis.

6 Name some plant foods that we eat because they are stores of starch.

2.6 Energy flows through an ecosystem

Sugars contain energy locked in the bonds of their molecules, but this energy cannot be used directly by organisms. They must convert it into other forms in a process called cellular respiration. This transformation process is not efficient. Only 10% of the energy is passed on to the next level in a food chain. Waste energy in the form of heat is produced.



Living systems continuously take in energy from the Sun. When one organism eats another, it takes the energy that was stored in the cells and tissues. Of this energy, 90% is transformed into movement, or stored again as the organism grows and repairs its own cells. Only 10% of the energy gets passed from one organism to the next in a food chain. Energy in an ecosystem flows in only one direction.

Energy for work

Many energy transformations keep a living organism alive and carry out metabolic processes (chemical reactions that keep cells working). We can describe these processes as the work of living organisms. Some of the types of 'work' performed by living organisms are shown in Table 2.1.

Figure 2.29 The movement of energy along a food chain can be represented by an energy pyramid. The size of each level represents the amount of energy being passed on to the next level in the food chain.

Table 2.1 The 'work' of living organisms

TYPE OF WORK	EXAMPLES
Building compounds	All organisms use energy to build and replicate molecules so they can manage metabolic processes, grow and pass information on to offspring.
Communication inside an organism	Energy is needed for communication within and between cells.
	Electrical and chemical energy are used when nerves transmit information throughout the body.
Physical movement	Energy is supplied for physical movement, such as movement of leg or arm muscles, and involuntary movement such as contraction of the heart.
	In plants, energy is used for movement towards sunlight.
Transport	Energy is required to move nutrients and wastes throughout an organism's body.
	Electrical potential energy is needed to transport materials into and out of cells.

SAMPLE

CHALLENGE 2.6: FOOD FOR THOUGHT
GO TO PAGE 186.

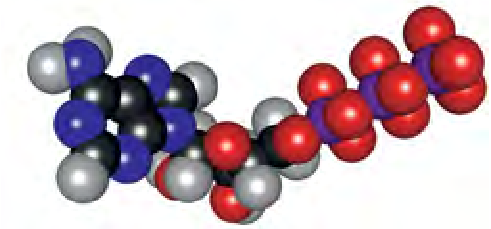


Figure 2.30 ATP (adenosine triphosphate) is the energy currency of organisms.

What is cellular respiration?

Whenever we burn a fuel, such as wood or oil, we release the energy that has been chemically stored in the molecules. This energy in the fuel molecules is organised, or ordered, because it is tied into the bonds in the molecule. Burning requires oxygen and is a rapid process, releasing the energy as heat energy. Carbon dioxide and water are also produced.

Cellular respiration is similar to burning. Glucose is the molecule that our body uses for fuel. Each cell uses oxygen to burn glucose and convert the energy into ATP (adenosine triphosphate). ATP is much easier for our bodies to use for energy. Fats and proteins can also be converted into ATP in cellular respiration.

Oxygen is used during cellular respiration, and carbon dioxide and water are waste products. Because oxygen is needed for this process, it is often called **aerobic respiration**.

The process occurs in the mitochondria of all plant cells.

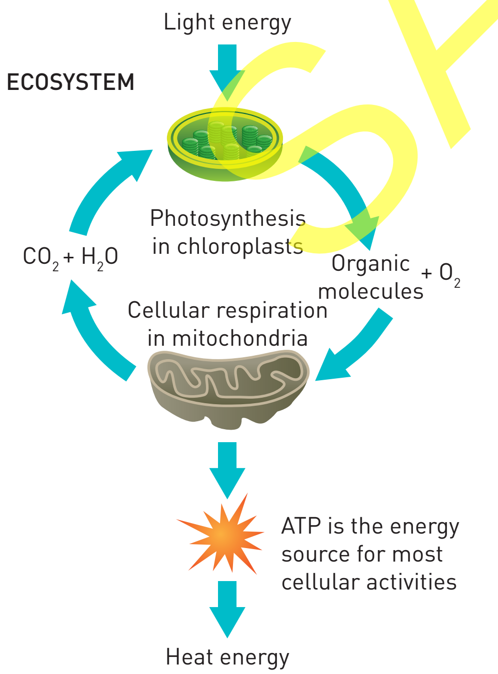


Figure 2.31 Energy flows into an ecosystem as sunlight and it leaves as heat. Matter is recycled.

A closer look at cellular respiration

The energy stored in the chemical bonds of glucose ($C_6H_{12}O_6$) is transferred into ATP during cellular respiration. The general equation for cellular respiration is:

glucose	+ oxygen	→ carbon dioxide	+	water	+	energy
$C_6H_{12}O_6$	+ $6O_2$	→ $6CO_2$	+	$6H_2O$	+	36ATP

The breakdown of glucose to carbon dioxide and water requires two major steps.

1 Glycolysis occurs in the cytoplasm and produces 2 ATP molecules and pyruvate.
2 Aerobic respiration occurs in the mitochondria in aerobic conditions (when oxygen is present). It produces 34 ATP molecules.

When we exercise, our muscle cells can run out of oxygen for aerobic respiration. The cells switch to producing energy anaerobically (without oxygen) and lactic acid is produced as a waste product. This does not produce as much energy as aerobic respiration, which is why our muscles feel weaker. In yeast cells, anaerobic respiration (known as fermentation) produces alcohol and carbon dioxide.

Figure 2.32 The fermentation of yeast is used to produce beer.

Photosynthesis and respiration

Photosynthesis and respiration are effectively the opposite of each other. Photosynthesis traps energy from the Sun into chemical bonds, such as those of glucose. Respiration moves the energy out of glucose and into the bonds of ATP, which can then be used by cells. Many of the molecules in the two reactions are the same, but they are on different pathways. Glucose is a product of photosynthesis, whereas it is a reactant in respiration.

Check your learning 2.6

Remember and understand

1 Explain why cellular respiration is constantly occurring in cells.
2 Draw a diagram that illustrates the water cycle.
3 Living systems continuously take in energy from the sun. How is this different from the flow of matter in an ecosystem?
4 Where does cellular respiration take place in cells?

Apply and analyse

5 How are cellular respiration and photosynthesis related?
6 Do plants undergo aerobic respiration? Explain your answer.
7 If a plant is able to convert 50 joules of energy through photosynthesis, how much energy will a herbivore obtain when it eats the plant?

SAMPLE

2.7 Matter is recycled in ecosystems

Similar to energy, matter (such as atoms and molecules) flows through ecosystems. Plants absorb simple substances such as carbon dioxide, water and minerals, and convert them into sugars by photosynthesis. Animals eating the plants use the sugars and other compounds. When plants and animals die, the matter is rearranged by decomposers to obtain energy. In doing so, they break down the complex chemicals into simple compounds, which are reused by plants to grow, completing the cycle of matter. Also similar to energy, not all matter is passed on to organisms in food chains and webs. For example, cellulose in plant cell walls is not digested by some animals and is instead passed through the body unused. However, energy along a food chain, while the atoms in matter are recycled.

SAMPLE

Cycles of matter

Matter cannot be created or destroyed. This means matter must be recycled. The cycling of matter from the atmosphere or the Earth's crust and back again is called a biogeochemical cycle (*bio* means 'living'; *geo* means 'earth').

Decomposers are essential to the cycles of matter – they break down dead matter and convert it into simple substances that can be reused by plants.

Figure 2.33 Logging rainforests can affect precipitation.

Water cycle

The global water cycle is driven by heat from the Sun. Three major processes driven by solar heat – **precipitation** (rain, snow, sleet), **evaporation** and **transpiration** from plants – continuously move water between land, oceans and the atmosphere. On land, the amount of precipitation is greater than the amount of evaporation/transpiration, and the excess water feeds lakes, rivers and groundwater, all of which flow back into the sea.

Humans can alter the water cycle. For example, cutting down rainforests changes the amount of water vapour in the air (due to transpiration), which alters precipitation.

Water is not available equally in all ecosystems. Water that is evaporated from a desert may later fall as rain on a forest thousands of kilometres away. Australia is a good example of this situation: some areas may be in drought and others may have floods, and organisms in ecosystems in both areas may be affected.

Carbon cycle

Carbon is found as carbon dioxide in the air and in compounds such as sugars, proteins and lipids (such as fats) in the bodies of living organisms. Globally, the return of carbon dioxide to the air by respiration is balanced by its removal in photosynthesis. Other ways of returning carbon dioxide to the air include the burning of fossil fuels, bushfires, and the decomposition of dead matter. The natural balance of this cycle is disturbed by excess burning, which contributes to the **enhanced greenhouse effect**.

Termites recycle carbon

Plant cell walls are made of cellulose, a complex carbohydrate that is insoluble in

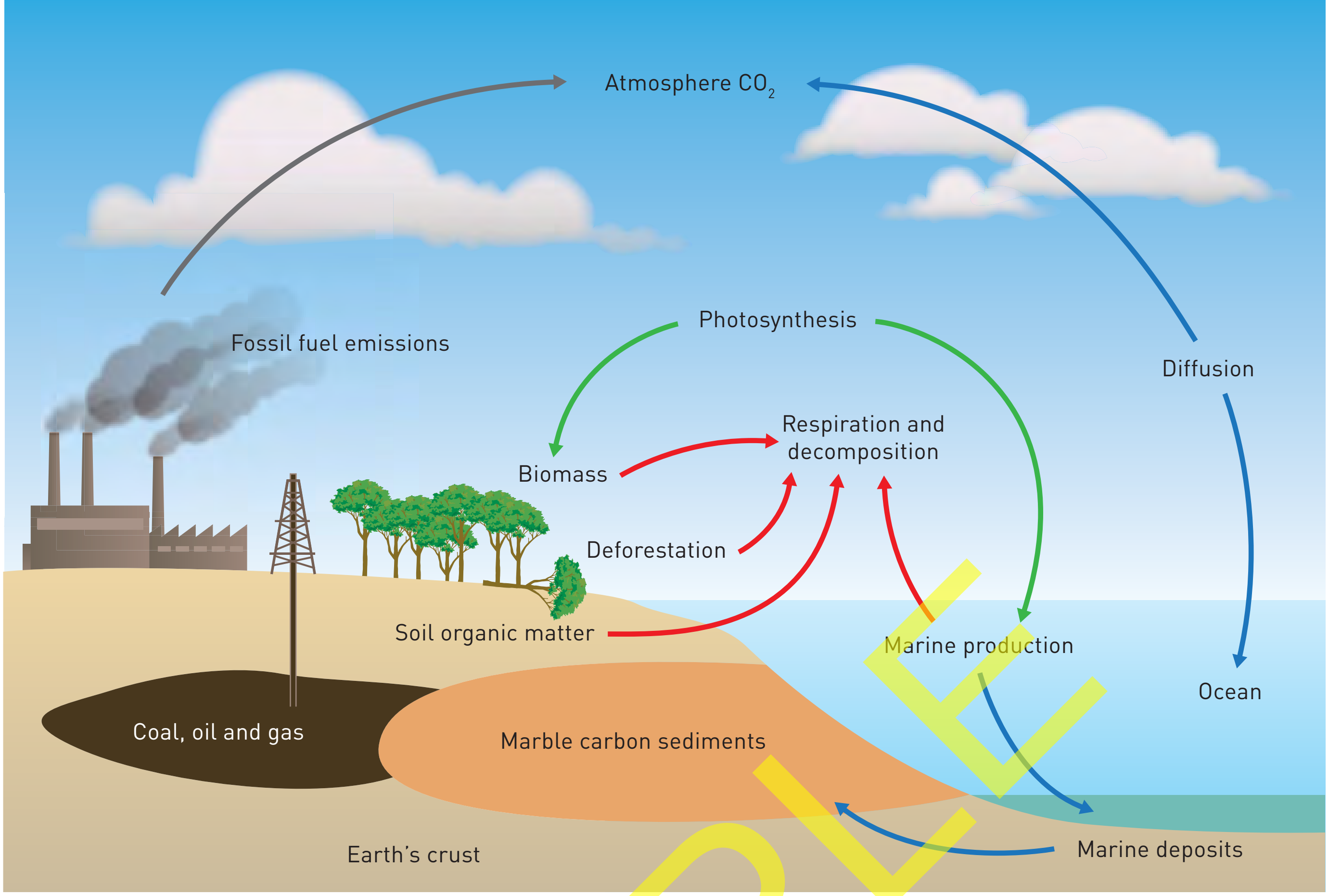


Figure 2.34 The carbon cycle.

water and does not break down easily. Fungi are able to break down cellulose and play a major role in the decomposition of wood, but fungi require a moist environment in which to live. In the drier areas of Australia, such as the forests and woodlands in tropical and subtropical areas, as well as the savannah grasslands, termites have a major role in the decomposition and recycling of carbon.

Termites are a social insect and live in nests. You may have seen termite mounds in drier parts of Australia. Microorganisms in the guts of termites break down the cellulose of plant material, such as grasses, plants and wood. Scientists have estimated that termites might recycle up to 20% of the carbon in ecosystems such as the savannah grasslands.

Figure 2.35 A termite mound in the savannah of northern Australia.

Check your learning 2.7

Remember and understand

1 What is matter?
2 Distinguish between energy and matter.
3 Distinguish between a flow of energy and a flow of matter in an ecosystem.
4 When scientists talk about the carbon cycle, what do they mean?

Apply and analyse

5 'You are eating the same atoms that were in dinosaur poo!' How accurate is this statement? Provide evidence to support your answer.

SAMPLE

2.8 Natural events can disrupt an ecosystem

The size of a population will increase and decrease as a result of many natural events. The limitation of resources, presence of predators, migration and emigration of the organisms will all affect population numbers. Natural disasters such as drought, floods and bushfires will also cause changes throughout the whole ecosystem. Some plants and animals have adapted to cope with these.

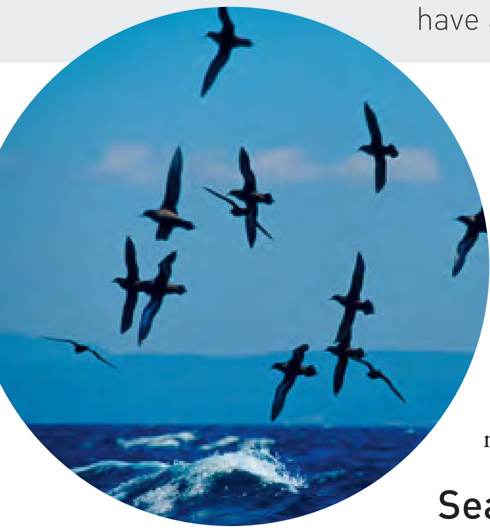


Figure 2.36 Short-tailed shearwaters leave their burrows on Montague Island on the southern coast of New South Wales and fly to feeding grounds in the area of the Bering Sea during the northern summer. They return for breeding in late September.

Limiting resources

As the size of a population reaches its maximum **carrying capacity** (ability of the environment to support it), some of its resources such as food, space and shelter will become limited. Some organisms will either die or emigrate (leave) and the population will stabilise (reach its maximum size).

Seasonal changes

When the weather becomes colder, many animals migrate to areas with warmer temperatures. As a result, their populations decrease in one environment and increase in another. During the breeding season, usually spring, numbers of animals will increase. Flowering plants will be pollinated and form seeds that spread throughout the environment, and later germinate.

Natural disasters

Australia has a widely fluctuating environment. Years of drought have been interspersed with torrential rains and flooding. When extreme natural change affects humans, we call these changes natural disasters.

Figure 2.38 The Black Saturday bushfires in Victoria in 2009 devastated entire communities.

Figure 2.37 Flooding in Queensland in 2011.

SAMPLE

CHALLENGE 2.8: NATURAL DISASTERS IN AUSTRALIA
GO TO PAGE 186.

Figure 2.39 Drought poses a great threat to life.

Figure 2.40 Lack of foliage indicates a lack of food and places to hide and shelter.

Impacts of floods and droughts

Floods are an overflow of water onto dry land, which has an immediate effect on the growth of plants and the germination of seeds. This is particularly noticeable after a drought during which plants have managed to survive and seeds have remained dormant. Marine ecosystems do not benefit from floods on land. Run-off brings sediment, pesticides and fertilisers into the marine ecosystem, causing some algal species to dominate the environment.

Floods can be a hazard for some animal life. Small mammals often escape to higher ground. Snakes are flushed out of their cover, as witnessed in the 2011 Queensland floods, and became a potential danger to humans. Aquatic animals benefit enormously from floods. Fish can breed in water bodies such as lakes. Water birds then have an abundance of fish, insects and waterweeds as sources of food, and they can breed in great numbers.

Droughts pose an even greater challenge than floods. During droughts, animals migrate elsewhere and manage to survive until conditions have improved. Some populations 'hang on' during drought, but other ecosystems are severely affected. For example, extremely dry topsoil was blown from central Australia to Melbourne and Sydney in recent years. This erosion removed essential nutrients for many plants, animals and agricultural ecosystems.

Impacts of bushfires on ecosystems

Bushfires destroy both plant and animal life. Many native Australian plants have adapted for fire resistance and tolerance, and they may actually rely on fires to complete their life cycles. These adaptations include:

- thick bark that insulates and protects the growing and transporting tissue inside the trunk (stem)
- **epicormic buds** beneath the bark that can regenerate the branches when the fire has passed
- **lignotubers** within the roots that can grow into new shoots after fire.

Most *Eucalyptus* species have epicormic buds and lignotubers.

Animal populations in fire-prone areas are, in general, tolerant of fire. Some species can sense fire and escape to other areas or into underground burrows. The most vulnerable are small invertebrates and insects at the larval stage. The migration of animals will change the composition of the ecosystem in the fire area. Animals may not return to the area for a long time. The change in the vegetation and the soil conditions alters their food supply and sheltering options. The loss of shelter will increase the risk of predation in some cases.

SAMPLE

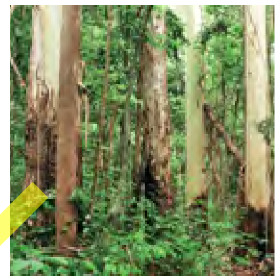


Figure 2.41 Native Australian trees have thick bark to protect them from fire.

Figure 2.42 Epicormic buds beneath bark can regenerate branches when fire has passed.

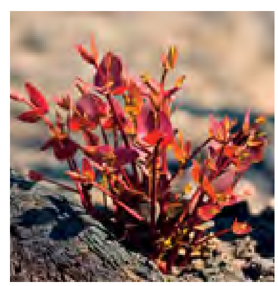


Figure 2.43 Lignotubers within roots grow into new shoots after fire.

Check your learning 2.8

Remember and understand

1. What does the carrying capacity of an ecosystem mean?
2. In relation to resources, what does 'limiting' mean? How does this differ from 'limited'?
3. Other than birds, what animals migrate due to seasons?

Apply and analyse

4. List some long-term effects on plants after a drought, bushfire or flood.
5. How might an animal survive a drought, bushfire or flood?

2.9 Human activity can disrupt an ecosystem

Humans can have a significant short-term or long-term impact on the well-being and survival of other species. We compete with plants and animals for resources. We change the ecosystem by removing vegetation, increasing erosion of topsoil and enhancing global warming.

Figure 2.44 Numbers of Murray cod, and other native fish, have decreased significantly due to irrigation. Some fish have now been declared rare or endangered.

Competition for resources

In 2014, the world human population was approximately seven billion and it is predicted to rise to about nine billion by 2050. This will cause an increased demand for food which means more pressure on the natural resources of the land and sea. These resources may be needed by other species. Water is used to irrigate the farms that produce our food in the Murray River Basin. This means there is less water for the ecosystems downstream. As a result, the river red gum forests that surround the Murray are placed under extreme stress during droughts.

Permanent removal of trees and other plants by humans can affect the animals that used them for food or shelter. These animals must migrate or perish. Removing even a few plants from an ecosystem may reduce pollination of similar species in the area.

Pollution

Human activity has introduced many unwanted chemicals into ecosystems. Certain chemicals can cause sickness and/or death of certain species and, in some cases, can result in the collapse of entire food webs. Many industries now have much more restrictive rules about the chemicals they can release into the environment.

SAMPLE

Figure 2.45 When James Cook sailed into Botany Bay near Sydney in 1776, it was a natural ecosystem. Today it is an urban ecosystem because of the many human-induced changes that have taken place.

CHALLENGE 2.9: FIELD TRIP
GO TO PAGE 187.

Figure 2.46 Phosphates in detergents and fertilisers on agricultural land wash into oceans, lakes, river and other water bodies. This leads to eutrophication – an increase in organisms that reduce oxygen levels in the water, harming other organisms.

Enhanced greenhouse effect

Increasing numbers of humans, increasing wealth and more sophisticated technology have resulted in the use of large amounts of fossil fuels for transport, industry, agriculture and electricity. The burning of these fuels is contributing to increases in atmospheric temperatures and a warming climate. This is called the enhanced greenhouse effect.

Ecological effects of climate change

Although many humans welcome the thought of warmer weather, small increases in average temperatures can have devastating effects on ecosystems (Table 2.2). In mountainous areas, plants and animals that need cooler environments to survive are losing their habitats as the snowline retreats higher up the slopes. One such animal is the mountain pygmy possum, which needs a snow depth of at least one metre to provide enough insulation for **hibernation**. Less snow means the cycle of hibernation and breeding is disrupted.

Table 2.2 Some of the main effects of climate change on ecosystems

CHANGE	EFFECT
Changes in distribution and abundance of species – migration of species north or south, to higher levels or more suitable locations, due to increasing temperatures	Genetic changes as species adapt to new climatic conditions
Changes in the composition of ecosystems (e.g. due to species competition for resources or invasion of weeds/pests)	Increased weeds and other invasive species (i.e. pests)
Changes in metabolic processes (e.g. cellular respiration, photosynthesis, growth and tissue composition)	Changes in life-cycle events (e.g. breeding, migration)
Ocean acidification	Increased coral bleaching and destruction of and/or changes to coral reefs
Changes in river flows, sediment formation and nutrient cycles	Flow-on effects, such as eutrophication and algal blooms
Drying of ecosystems	Decrease in coastal mountain rainforests

Check your learning 2.9

Remember and understand

1. List two ways humans compete with plants and animals for resources.
2. What does eutrophication mean?

Apply and analyse

3. Currawongs are birds that thrive in towns and cities because they can eat human food scraps and any bird seeds left out by humans. They also hunt smaller birds and drive them out of an area. Could it be said that the impact of currawongs on the populations of small birds is a human impact? Discuss.
4. What is the enhanced greenhouse effect?
5. Suggest two ways your local ecosystem will be affected by the enhanced greenhouse effect.
6. The green sea turtle lays its eggs in the warm sands of northern Australia. If the sand at is 29°C, half the turtles will develop into males and the other half will be female. Below 27°C, most of the turtles will be male. Above 31°C, most of the turtles will be female. What effect will enhanced global warming have on the green sea turtle population?

Figure 2.47 The mountain pygmy possum is listed as an endangered species.

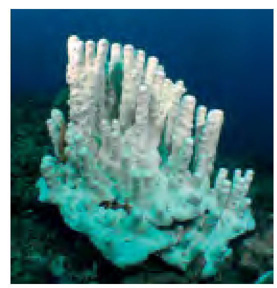


Figure 2.48 Increased carbon dioxide levels in the atmosphere causes the ocean to become acidic. As a result, the polyps in the coral die, causing bleaching.

SAMPLE

//SCIENCE AS A HUMAN ENDEAVOUR//

2.10 Human management of ecosystems continues to change

* Different communities have different views on how to manage their local ecosystems. The growing population needs food to support it. Maximising food production while maintaining resources such as soil and nutrients can be difficult. An ability to see an ecosystem from another's perspective can be useful.

Historical use of ecosystems

People first came to Australia at least 40 000 years ago. It is presumed they came from South-East Asia.

They were hunter–gatherers who respected the land because it provided them with the resources for life – food, water, shelter and medicine. The land was, and is, central to their spirituality.

Indigenous people were (and in many cases, still are) aware of the seasonal nature of plant and animal life in the ecosystems around them. They were prepared to move to areas where plant and animal foods were available at a particular time or season. These nomadic practices enabled vegetation to recover and animal populations to survive.

In some areas, Indigenous people used fires to maintain ecosystems. Australian soils are poor in nitrogen and phosphorus. Controlled burns produced ash, which provided nutrients for dormant seeds. Hence, the diversity of plants increased after fire as many new seedlings appear following germination. Burning also flushed out animals upon which native populations depended for food.

Land management methods of Indigenous people contrasts with European land management. Indigenous people disrupt natural ecosystems to a minimal extent while obtaining their resources. Their land management is based on shared ownership and a deep respect. As a former Indigenous Person of the Year, Bob Randall said, 'We do not own the land. The land owns us'.

Figure 2.49 The grass tree had many uses in traditional Indigenous communities.

European systems are based on individual ownership. Its practices involve clearing the land of native vegetation, planting crops, and introducing domestic animals. European systems introduced agricultural and urban ecosystems to Australia whereas land management of Indigenous people left ecosystems very close to their natural state.

Indigenous people were experts at using the resources of local ecosystems for numerous purposes. A good example is the varied uses for the grass tree (*Xanthorrhoea*). They used:

- the shaft as a spear
- resin from the plant for sticking things together
- nectar from the flowers for food
- leaf bases for food
- insects that feed on the flowers for food.

Modern needs

We need food for survival. When food is in short supply, people will fight for it. In Australia, we currently have plenty of food thanks to a strong agricultural community. Irrigation of large areas ensures that the large crops are able to survive. However, a major drought, a natural disaster or a war can suddenly plunge a community into famine.

SAMPLE

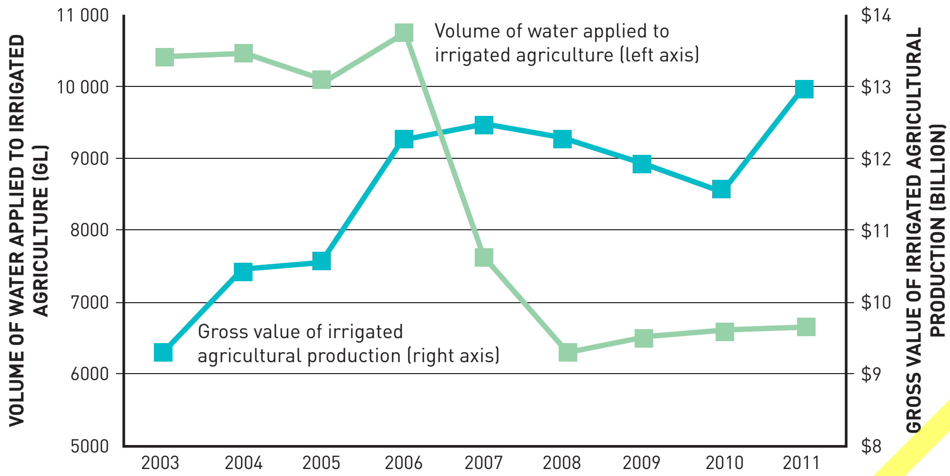


Figure 2.50 Modern farming involves using water more wisely.

Tropical Cyclone Larry in 2006 wiped out large numbers of banana plantations, causing a countrywide shortage. Enhanced global warming may cause storms of this magnitude to become more frequent and spread over larger areas. Some scientists predict that droughts may also become increasingly frequent in all areas of Australia. This will have an impact on the types of crops that can grow in many areas.

In 2010, Australia's chief scientist made some recommendations to enable us to maintain the food production needed to feed Australia and the rest of the world while minimising the impact on the ecosystem.

- Coordinate programs that maintain current food production levels.
- Research methods and crops that would be able to cope with drought conditions.
- Develop methods that allow more efficient use of water and nutrients in agricultural areas.
- Encourage more scientists and engineers to work in agriculture.

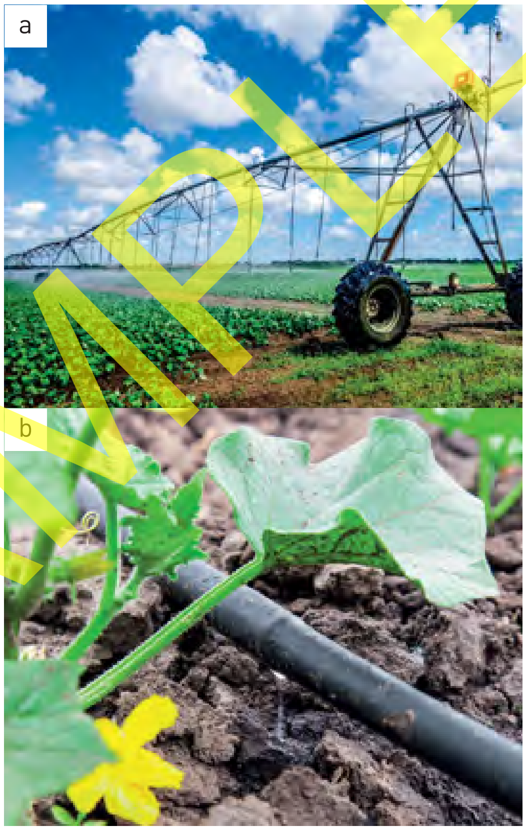


Figure 2.51 Scientists are developing ways to use water more efficiently. (a) Traditional irrigation (b) Modern micro-irrigation system.

SAMPLE

Extend your understanding 2.10

1 'Indigenous people manipulate the environment to their advantage without changing it significantly'. Discuss this statement in terms of:
   a nomadic existence over the centuries
   b use of fire.
2 Compare traditional land management systems of the Indigenous people with those of modern Australians.
3 Would these traditional land management methods be vulnerable to the increased intensity of storms caused by enhanced global warming?
4 Prepare three arguments for and against the statement: 'Traditional land management of Indigenous people is better than modern methods of farming'.
5 Some park rangers carry out controlled burns to remove old-growth plants. Explain how this will encourage new plants to grow.

2

Remember and understand

1 State two ways of defining an ecosystem.
2 What do mutualism, parasitism and commensalism have in common? How are they different?
3 What is photosynthesis?
4 What products of photosynthesis are essential for cellular respiration?
5 Can competition occur between members of the same species and members of different species? Explain using examples.
6 If only 10% of the energy is transferred along a food chain (such as Figure 2.29 on page 28), where is the rest of the energy?
7 Respiration in your cells provides the energy for all your metabolic processes. Make a list of six different cellular processes that require energy from respiration.
8 Find some examples of how humans, especially since European settlement, have changed ecosystems because of introduced species.
9 What makes environmental conditions in Australian ecosystems so challenging for populations of living organisms?
10 Describe the adaptations to fire of many Australian plants.
11 The Queensland floods of 2011 caused enormous destruction and some deaths. Explain some ways these floods affected the ecosystems in coastal and inland Queensland.

Apply and analyse

12 Draw a concept map showing how photosynthesis and respiration are connected using the following terms (plus any others that you think are appropriate): glucose, energy, oxygen, carbon dioxide, ATP, water
13 Observe your school ground or your home garden for one week. Keep a journal listing any examples of interrelationships between organisms.

Evaluate and create

14 Explain how a small seed is able to grow and form a huge log of wood that we can burn or use to make furniture.
15 Analyse the marine Antarctic food web in Figure 2.52.
   a What is the relationship between:
      i orca whales and seals?
      ii penguins and seals?
   b If overfishing rapidly decreases deep sea fish numbers, what pressures could this place on the:
      i seal population?
      ii humpback whale population?
16 The human population was fairly stable until approximately 1 CE. In the past century, it has almost quadrupled. What are the likely effects of population increase on world ecosystems?
17 Find out the conditions that cause an animal or plant species to be classified as endangered. List some examples of endangered species in Australia. Evaluate whether measures to protect them are adequate.

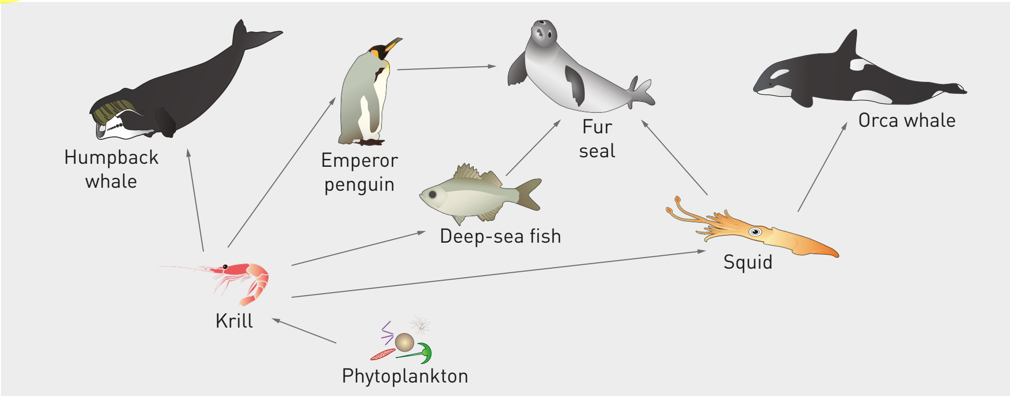


Figure 2.52 A marine Antarctic food web.

SAMPLE

18 Seed banks are an important way of preserving plant species that are at risk of decreasing populations or extinction. Research the establishment and maintenance of seed banks. How might a seed bank contribute to sustainable ecosystems and to biodiversity?

19 Limpets graze on algae on a rock platform. The large limpet *Lottia* is found in a territory containing micro-algae; the smaller species *Acmea* is found on the edge of this territory (Figure 2.53).

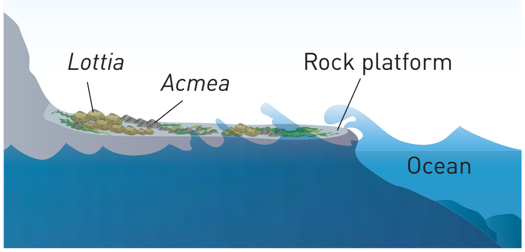


Figure 2.53 *Lottia* and *Acmea* on a rock platform.

a Suggest one possible hypothesis (reason) for this situation.

b Describe an experiment you might set up to test if your hypothesis is correct.

Ethical behaviour

20 In terms of resource use, many would argue that one person cannot make a difference. Do you agree?

Critical and creative thinking

21 Imagine it is your job to find out if soil is 'consumed' as plants grow. Design an investigation to test this idea. How will you tell if the plant(s) have actually 'consumed' the soil? What evidence do you need to collect? What variables do you need to control? How will you control these variables? What is your hypothesis?

22 Scientific understanding of the relationship between plants and animals in an ecosystem is an important area of scientific research. Ecologists are scientists who specialise in this area of research. Find out what an ecologist does. Write a paragraph that describes the highlights of working as an ecologist plus some of the disadvantages.

Research

23 Choose one of the following topics for a research project. Some questions have been included to help you begin your research. Present your report in a format of your own choosing.

> **Biological control**
Australian native plants and animals have adapted to life on an isolated continent over millions of years. Since European settlement, native animals have had to compete with a range of introduced animals for food, habitat and shelter. Some native species have also faced new predators. Rapid changes in land usage, such as increased crop-growing areas, have also affected our soils and waterways. Research the meaning of the term 'biological control'. Find some more Australian examples of successful and not-so-successful examples of biological control.

> **Frozen Ark Project**
In the story of the floods in the Bible, Noah protected and conserved animals by building an ark. The Frozen Ark Project is a modern-day project named after this story. What is the Frozen Ark Project? What are its goals? How is it working towards achieving these goals?

> **Carbon capture and storage**
One measure that is proposed to decrease the amount of carbon dioxide that we are adding to the atmosphere is to capture and store carbon dioxide. What does this mean? How will it work? Explain some of the options being considered for storing carbon dioxide.

SAMPLE

2 *KEYWORDS

abiotic
all the non-living components of an ecosystem; for example, light, temperature, water

aerobic respiration
second step in the breakdown of glucose to carbon dioxide and water; occurs in the mitochondria when oxygen is present and produces 34 ATP molecules

biological control
releasing a living organism (a parasite or consumer) into an ecosystem in order to control a population

biosphere
the intersection between the atmosphere, hydrosphere and lithosphere

biotic
all the living organisms in an ecosystem

carrying capacity
the maximum number of organisms in a population that can be sustained by an ecosystem

capture–recapture
a method of estimating the number of organisms in an ecosystem by capturing, marking and releasing organisms

commensalism
a relationship between two organisms from different species; one organism benefits; the other organism is not affected

community
different populations living in the same place at the same time

competition
a relationship between organisms using the same limited resources in an ecosystem

decomposer
an organism that gains nutrients by breaking down dead organisms into simpler nutrients

disease
a disorder or condition that interrupts normal functioning of an organism

ecosystem
a community of living organisms (biotic) together with their non-living (abiotic) factors

emigration
when an organism leaves an ecosystem

enhanced greenhouse effect
an increase in carbon dioxide and other heat-capturing gases in the atmosphere, that results in increased warming of the Earth

epicormic bud
a small growth beneath the bark of a plant that allows regeneration after a fire

evaporation
the process of liquid water gaining thermal energy and changing into gas

habitat
the place where a population of organisms live

hibernation
when an organism becomes inactive, usually as a result of low temperatures

immune
able to fight an infection as a result of prior exposure

lignotuber
a small growth in the root of a plant that allows regeneration after a fire

matter
anything that has space and volume is made of matter; matter is made of atoms

migration
the movement of a single organism or a population from one ecosystem

mutualism
a relationship between two organisms of different species in which both organisms benefit

parasitism
a relationship in which one organism (parasite) benefits and the other organism (host) is harmed

photosynthesis
the process in plants in which glucose is made from water and carbon dioxide

population
a group of the same species living in the same place at the same time

precipitation
the process in which water vapour in the upper atmosphere becomes liquid water in the form of rain, snow or sleet and falls to the ground

quadrat
a randomly selected square plot used to estimate the number of organisms

symbiosis
a close physical relationship between two members of different species

transpiration
the process of water evaporating from plants

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