CHAPTER 2

The evolution of Australian flora and fauna

The changes in Australian flora and fauna over millions of years have happened through evolution

Variation and evolution

2.1

This chapter deals with the changes in living organisms (**biota**) in Australia over millions of years. The theory of evolution cannot be conclusively proven, since it occurred over millions of years, and so scientists gather evidence to support (or backup) the theory. Evidence shows that millions of years ago living things on Earth were simpler and less varied than those living today. As time went on, a greater variety of new types of organisms appeared and often the new organisms were more complex and more advanced than previous ones. In this chapter, we investigate what could have led to the changes and look for evidence in fossil remains of **extinct** organisms, as well as in **extant** organisms (present-day living organisms).

- ***discuss examples of variation between members of a species***
- ***identify the relationship between variation within a species and the chances of survival of species when environmental change occurs***

Variation

In any population, although offspring resemble their parents, they are not identical to them (and are seldom identical to each other). The term **variation** applies to the *differences* in the characteristics (appearance or genetic make-up) of individuals within a population: not all humans look exactly alike and neither do all dogs or all cats or all elephants. Why do similar members of a population have *differences*? (See Fig 2.1.)

When plants or animals reproduce, the offspring resemble their parents in their basic characteristics. For example, adult elephants give rise to baby elephants and adult humans give rise to human babies, but adult elephants do not give rise to human babies! This rather absurd example gives us the idea that **heredity** is evident within living organisms. Heredity is the transmission of *similar* characteristics from parents to offspring (see Fig. 2.2).

Figure 2.1 Variations that are not inherited: a malnourished adult and a body builder

Environment and variation

The concept of variation itself is not remarkable—differences in nutrition and lifestyle while we are growing up can have noticeable effects on our appearance; underfed children in third world countries have very thin arms and legs and bloated bellies, and those that survive to become adults will probably not reach their full potential height as a result of malnutrition. Body builders who work out at the gym regularly and eat high-protein food, have a resulting increase in body size due to muscle development and increased bone density. These examples of variation are due to interaction with the environment and are *not* passed on from parents to offspring.

Hereditary and variation

There is a second type of variation that *is* remarkable—the type of variation that can be passed on from parents to offspring. Some of the differences between individuals are *hereditary,* passing from parents to offspring. Red hair, blue eyes, close-set eyes and a protruding bottom lip are all examples of variations that seem to run in families. Inherited variations occur in all types of plants and animals (see Fig. 2.3) and it is these inherited characteristics that are important in our studies of evolution. Organisms in a population may vary in appearance, physiology (functioning) and behaviour. *Heredity* and *variation* are both essential for evolution to occur. Variations which may pass from one generation to another are often produced in a population as the result of *mutation* (a change in the genetic make-up of an individual).

At the time when the scientists Charles Darwin and Alfred Wallace proposed their theory of evolution by natural selection, there was no knowledge of *what* was responsible for the differences in individuals within a population or of *how* such characteristics could be passed on from one generation to the next. Today, with our knowledge from studies of genetics, we know that *genes* on *chromosomes* determine characteristics that are inherited and that *sex cells* or *gametes* carry these characteristics from parents to offspring. When gametes combine, they may bring together two different varieties of the same gene (e.g. the gene for eye colour from each parent). Some genes have more than two varieties within a population; for example, the genes for eye colour and hair colour in humans have many more than two colours. It is these different types of genes in a population that bring about the type of variation that can be inherited in individuals, an essential ingredient in the process of evolution.

Figure 2.2 Heredity—adult animals/humans and their young

(a)

(b)

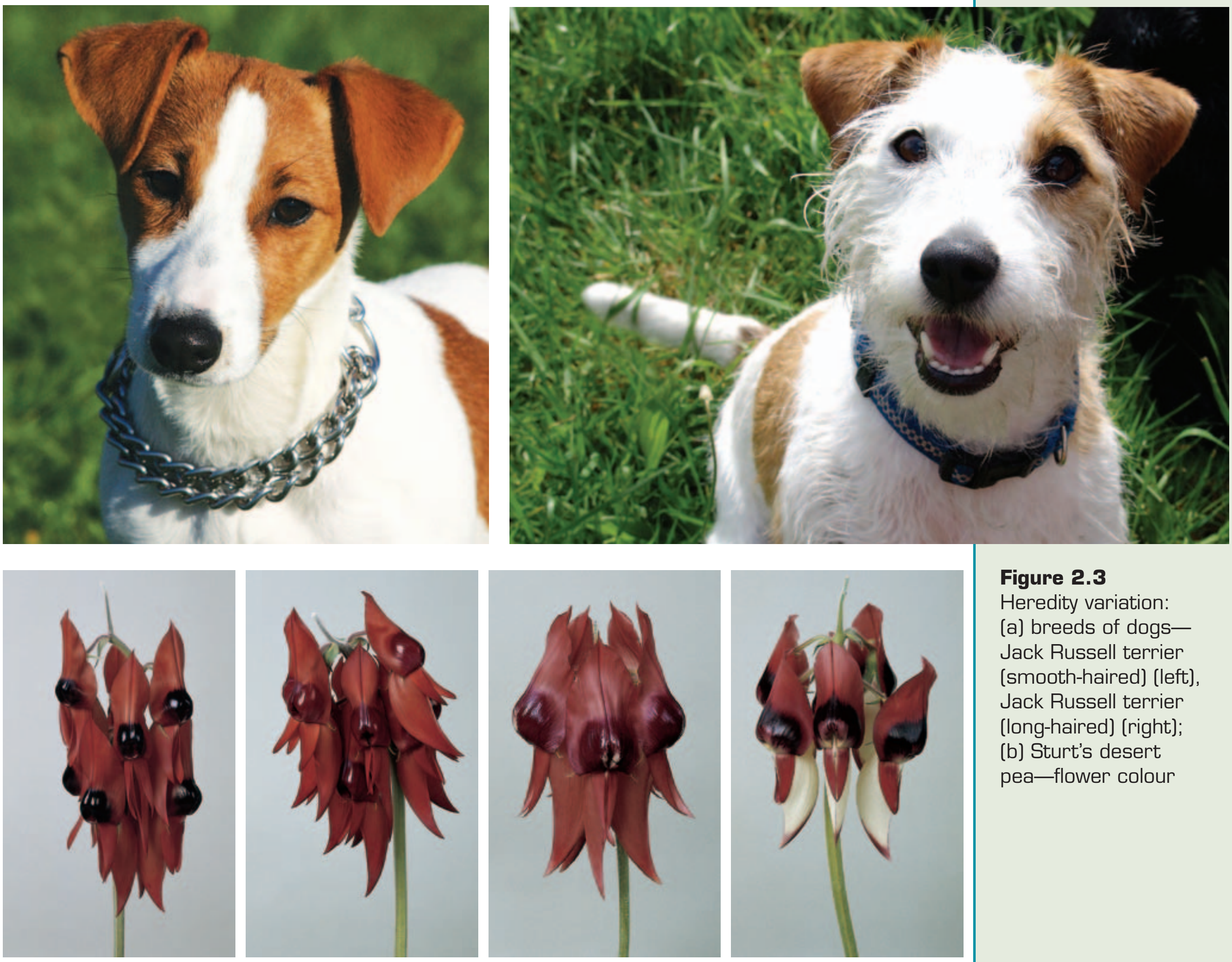


Figure 2.3
Heredity variation: (a) breeds of dogs—Jack Russell terrier (smooth-haired) (left), Jack Russell terrier (long-haired) (right); (b) Sturt's desert pea—flower colour

Sometimes a combination of the environment influencing hereditary factors may lead to variation—the fur of many arctic animals changes to white when they are exposed to the extremely low temperatures of arctic winters; the ability of the fur to change colour is inherited, but the actual change only comes about if exposed to extreme cold.

So we see that, within a population, variation may have one of three origins:

- genetic
- environmental
- or a combination of both genes and the environment.

Variation and survival of populations

The variation in the **gene pool** of a population (all the *possible varieties* of a gene within a group of *interbreeding organisms*) is important in determining the chances of survival of that population. If there is a sudden *change in the environment*, those individuals in the population that randomly possess a variation that is of *advantage* are more likely to survive the changed conditions. Individuals that do not possess that variation may be unable to compete and survive. Those *that survive are more* likely to reach an age where they can reproduce and pass their favourable characteristic on to their offspring. Individuals with *less favourable variations* will eventually be eliminated from the population as they are out-competed. If individuals within the population become so different that they can no longer interbreed with individuals from the original population to produce fertile offspring, then the population is considered to be a new **species**. Therefore variation in a population is extremely important, because it gives the population a better chance of surviving a sudden environmental change.

Examples:

- if the climate became hotter and drier, those individuals (plant or animal) with a natural variation that allowed them to retain more water would be at an advantage and survive
- if a disease was to sweep through a population, those individuals with a natural resistance to the disease would survive.

These individuals would live to pass on their favourable variation to offspring. We say that these organisms have **adaptations** which enable them to survive—that is, they are adapted to the new environment. (Refer back to 'A Local Ecosystem' where you studied *adaptations* of organisms within your local area.)

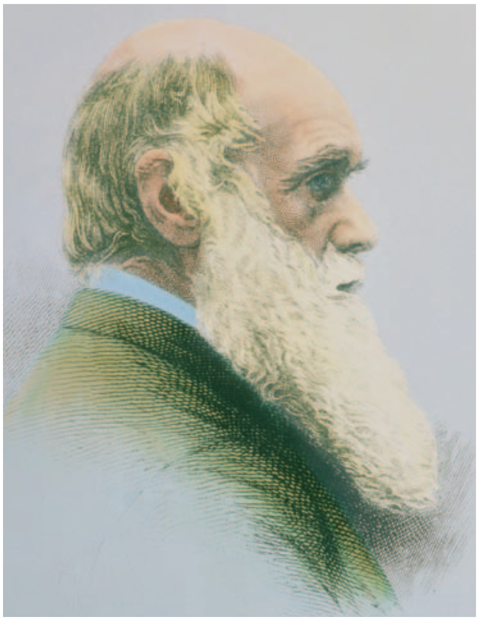
The Darwin–Wallace theory of evolution by natural selection

In 1858, based on their independent studies and observation of flora and fauna over many years, both Charles Darwin and Alfred Wallace proposed the same mechanism for evolution—the mechanism of **natural selection**.

Their theory of evolution by natural selection is based on four main points:

1. variation—individuals within a population that reproduce sexually, show *variations* that can be passed from one generation to the next
2. natural selection—**selective pressure** (e.g. change in the environment) puts constraints on organisms (e.g. resources become limited). These constraints are called *selective pressures* and determine which individuals are best suited to the prevailing conditions

(a)



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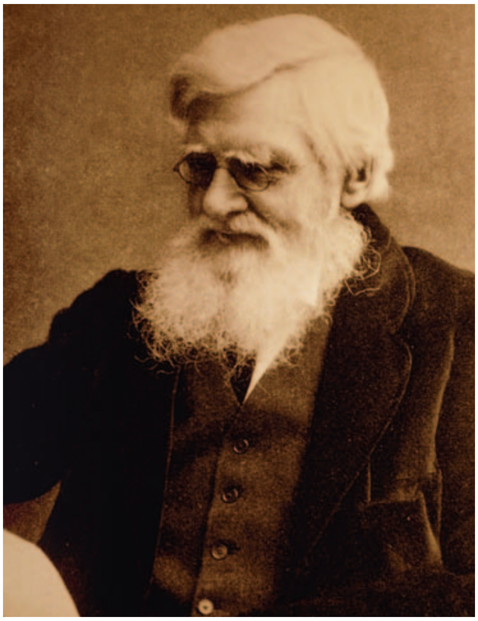

Figure 2.4
(a) Charles Darwin;
(b) Alfred Wallace

3. **survival of the fittest**—more individuals are produced within a population than can survive; those individuals with favourable variations have a greater chance of survival because they out-compete those with less favourable variations (there is a 'struggle for survival'). Organisms that do survive to reproduce will pass their genetic *variations* on to their offspring
4. **isolation**—if a population is isolated from the original population, interbreeding will be prevented over a period of time. This is necessary for evolution of a new species to occur.

Darwin and Wallace's two main ideas

- Natural selection and isolation are the *mechanisms* by means of which organisms evolve: the environment selects individuals, *based on variations* that favour their suitability. When resources in the environment become limited, these individuals survive, reproduce and pass on their characteristics.
- **Speciation**, the formation of a new species, occurs when a population becomes *isolated* from the original group of organisms. Only those individuals that have variations that favour their survival under the changed conditions will reproduce and pass on their characteristics to the next generation. Eventually, the population becomes so different from the original population that they are no longer able to interbreed and produce fertile offspring. A *new species* has been formed.

Variation in living species

FIRST-HAND INVESTIGATION

BIOLOGY SKILLS

P12.1; P12.2; P12.4
P13

- ***Perform a first-hand investigation to gather information of examples of variation in at least two species of living organisms***

Variation is quite easily observed in different members of the same species. One simply has to look around the classroom to detect variations within the human population.

Introductory task

On a piece of paper, list:

- at least three inherited characteristics that make us 'human' and distinguish us from all other animals (e.g. speech is one such characteristic). These characteristics represent the heredity aspect of our species
- as many variations amongst humans as you can (take 1 to 2 minutes to do this, the list is endless). Try to work out which of these variations are hereditary, which are due to environment and which are a combination of genes and the environment
- in the form of a table, list three genetic variations amongst your class group and count the number of people that possess each type of variation.

Task

You are required to carry out a first-hand investigation to gather information of examples of variation in at least two species of living organisms.

Several examples of variations in Australian species have been listed below, but you may come up with your own and study variations in any population of organisms in which you are interested. Remember that the group of organisms you choose to study must belong to the *same species*. For example you could study variations in race horses (*Equus caballus*), but not variations between the race horse and wild horses, which belong to different species. Information on variations in other pets such as dogs, budgerigars or cats may also be gathered.

Variations within a plant species are also easy to study—look at the number of variations in a selected plant group (e.g. roses, gerberas or carnations) including the colour of flowers, number of petals, distribution of thorns or distribution of leaves.

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Additional information and websites on variation in Australian species

Aim

Read the information below and then, with your specific choice of plants and animals in mind, write your own aim for this investigation. Record the results of your investigation in a suitable format.

Examples of variation in some Australian species

Magpies vary in body shape and size, beak shape and size and in the colour of plumage (feathers) on their backs, depending on their geographical distribution. Several different suggestions have been made as to the reasons for these variations, but evidence is inconclusive.

Koalas in northern Australia have smaller bodies, shorter hair and a lighter coat colour than koalas in southern Australia. Mammals that are larger tend to survive better in colder climates, because they have less body surface area compared with their volume and so they can conserve heat more efficiently. Wombats, koalas, kangaroos and possums of Tasmania are all larger than those of the same species found further north on the mainland.

Snow gum trees (*Eucalyptus pauciflora*) commonly growing in high altitude areas in and around the Snowy Mountains, tend to be shorter and have a shorter leaf length than trees that grow at sea level. There is a gradual decrease in height and leaf length with an increase in altitude. To prove that these differences are not just variations as a result of environmental differences, seeds from the different gum trees have been grown under standard conditions. Their height showed the same differences as when they were grown at different altitudes, implying that the variation was genetic.

Further references for Australian examples can be found on the Teacher's Resource CD and the Student Resource CD.

(a) (b)

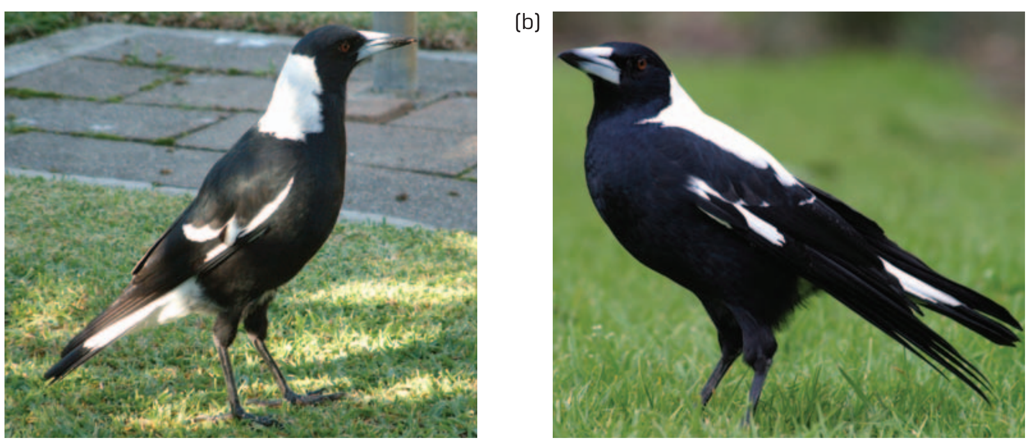

Figure 2.5 Magpies: (a) black-backed variety; (b) white-backed variety

2.2 The evolution of Australian flora and fauna

As Australia broke away from Antarctica and began to drift northwards, the continent became hotter and drier. The changes in climate led to changes in the vegetation (flora) on the continent, where only plants that could manage the hot dry conditions survived. Fire became a common feature of the land and this resulted in further change to vegetation. The changed flora led in turn to changes in the animals (fauna) which were dependent on the vegetation for food shelter and protection. All of these changes took place over a very long period of time—spanning millions of years.

Timeline: the formation of the Australian continent

SECONDARY-SOURCE INVESTIGATION

BIOLOGY SKILLS

P12.3; P12.4
P13.4

- ***gather, process and analyse information from secondary sources to develop a timeline that identifies key events in the formation of Australia as an island continent from its origins as part of Gondwana***

Drawing a timeline

Revise instructions for drawing up a timeline (see page 79). The timeline you are required to develop for this part of the course spans millions of years and then the time scale changes to thousands of years. To indicate this, the parts of the timeline should be connected with a dotted line (see the Student Resource CD for sample layout of timeline).

Task

Refer to at least three secondary sources (including the information in Chapter 1, page 79, to develop a timeline which begins when Pangaea split into Laurasia and Gondwana, and ends with the Australian continent in its current position as we know it today). Listed below are some key events to guide you on the type of information that you should include on your timeline:

- Pangaea splits into Laurasia and Gondwana
- Gondwana begins to break up
- Gondwana splits into:
  —Africa and South America
  —Australia, New Zealand, Antarctica and New Guinea
  —India
- New Zealand separates
- Australia begins separating from Antarctica
- Australia becomes a separate continent
- Australia reaches its current position.

Later in this module, once you have completed the sections from 'Changing habitats' (page 258) to 'Arrival of humans' (page 267), use the text as well as other secondary sources to add the following interesting events to your timeline:

- megafauna extinction begins
- first small groups of people begin to arrive in Australia
- climate warms and ice caps recede, sea levels rise and Australia is isolated from the rest of the world again
- moisture-loving plants and animals become restricted to coastal regions
- flora and fauna evolve in isolation.

Colour code your timeline to show which events record the change of the Australian continent and which represent the change in biota (living things).

This website allows you to open a web page on each era, with information on Australia's position, climate, vegetation and animals for each. It is written in student-friendly language and is a reliable source: www.lostkingdoms.com/snapshots/geological_time.htm

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Websites

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Sample layout of a timeline

Further task: putting it all together

As you continue with this unit of work, you will begin to see connections how the change in Australia's position impacted on the major changes in climate, flora and fauna. A table of comparison has been developed for you on the Student Resource CD which you can complete to create an integrated understanding of how these events fit together.

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Student activity—timeline table comparing changes in Australia: formation of the continent, climate change, change in flora and change in fauna

2.3 Changing habitats

- ***identify and describe evidence of changing environments in Australia over millions of years***

- 220–110 mya (dinosaur age): Australia was still joined to Antarctica as part of Gondwana. It had a cool, wet climate similar to that of Antarctica today, and could experience semi-darkness for many weeks in winter. A large proportion of inland Australia was covered by shallow sea.
  —*Evidence*: Fossils of club mosses, which grew in swamps, have been found in Narrabeen shales (200 mya), providing evidence that present-day land in Australia was covered by shallow water.
- 45 mya: Australia became a separate continent with dry land, but great lakes remained in the interior.
  —*Evidence*: Fossils of aquatic organisms such as crocodiles have been found in areas that are inland and dry in present-day times, suggesting the presence of lakes in the interior in the past.
- 20 mya: Australia was isolated from the other southern continents and as it slowly drifted northwards, its climate began to grow warmer, although it was still wet.
  —*Evidence*: Tree rings are circular patterns made up of alternating light and dark bands of woody tissue. They reflect rapid growth in summer or warm temperatures and slow to no growth in winter or cool temperatures. Fossilised remains of trees give information in their ring patterns that support the described changes in climatic conditions.

(Additional fossil evidence which supports the more recent changes in climate as described in the following text can be found under 'Evidence of changes in flora and fauna' in Section 2.5 on page 261.)

- Eight mya: Australia drifted further northwards and became much drier, as the water was captured in large ice sheets when Antarctica froze over.
- 100 thousand years ago (time of megafauna): Australia had drifted very close to its present-day position and the decreased sea levels led to it being temporarily connected by land bridges to Tasmania (in the south) and New Guinea (in the north).
- Up until ten thousand years ago: Australia would go through cycles of higher and lower sea levels as the polar ice caps fluctuated—they would melt and then refreeze. Land bridges would form and then be submerged. Australia's climate also became slightly wetter and drier. (It was thought that humans arrived during this period, approximately 40 thousand years ago, 'island hopping' from the north.)
- Five thousand years ago: Australia's climate continued to dry and most of the interior of the continent gradually became the arid, water-scarce climate that we know today.
  —*Evidence*: Plants of Australia's present-day open forest, woodland and heath habitats show adaptations to dry, harsh climatic conditions. No fossil remains of these plants (e.g. waratahs) have yet been discovered, implying that they are recent vegetation and were not part of the Australian vegetation millions of years ago. This provides further evidence that Australia's climate as we know it today is very different from that of the past.

(Also refer to Section 2.5 on page 261.)

2.4 Variations in temperature and water availability

- ***identify areas within Australia that experience significant variations in temperature and water availability***

Australia's climate has become hotter and drier as the continent has drifted north, resulting in increasing aridity (dryness) as you move inland from the coast. The temperature decreases from the north to the south of the continent. It is interesting to note that there is generally a reduced floral diversity from north to south. Climate can be classified, based on temperature and rainfall. This in turn determines the native vegetation of an area.

Variation in the temperature and/or water availability within the Australian environment has acted as one of the major selective pressures in Australia. Organisms that have random variations that suit them to particular habitats out-compete others.

Figure 2.6 illustrates the climate classification of Australia, showing different climatic regions (temperature) and rainfall zones (water availability).

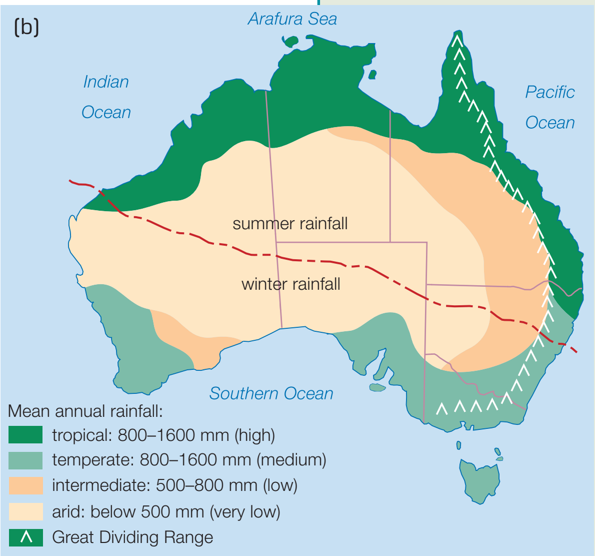

Figure 2.6 Maps of Australia: (a) major seasonal rainfall zones of Australia; (b) Australian climatic regions

STUDENT ACTIVITY

On the map of major Australian ecosystems provided on the Student Resource CD, colour each of the major rainfall areas, using Figure 2.6b and the information in Table 2.1 as a guide.

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Map of major Australian ecosystems

Table 2.1

Ecosystem	**Rainfall**	**Temperature location**	**Vegetation**
1. Rainforest	Annual rainfall is high and occurs throughout the year; tends to be along the coastline	Rainforests may be: ▪ *tropical*—hot and humid (e.g. Far North Queensland) ▪ *subtropical* (e.g. southern Queensland and New South Wales) ▪ *temperate* (e.g. New South Wales to eastern Gippsland, Victoria) ▪ *cool temperate* (e.g. Tasmania and Victoria).	Contains many 'primitive' plants that are direct descendents of the earliest Gondwanan species
2. Eucalypt forest ▪ wet sclerophyll forests ▪ dry sclerophyll forests	Requires more water than woodlands, but less than rainforests	Coastal hills, ridges and slopes of the Great Dividing Range	▪ Tall moisture-loving trees, compete for sunlight therefore tall; epiphytes are common ▪ Dominated by eucalypts of short to medium height. Has 'hard-leaved' shrubs growing beneath trees
3. Woodlands	Drier than eucalypt forests	Woodlands in drier climates—trees more sparse, western slopes	Many evergreen trees including eucalypts
4. Shrubland: ▪ mallee—low to tall shrubland ▪ mulga—tall shrubland, dominated by acacias	Semi-arid; hot dry summers, mild winters with unreliable rainfall	Southern parts of Australia, temperate areas (mild summer and cold winter)	Contains saltbush, bluebush, acacias and multi-stemmed eucalypts; low shrublands where soil is saline; open forest with stunted trees
5. Grassland	Semi-arid; typical summer rainfall, heavy storms may occur and frequent fires	Hot and dry; temperature variation is seasonal, but within a narrow range	(Includes cultivated species such as wheat, oats, barley, corn and rice, and pasture for cattle and sheep). Much of the original grasslands are now modified as a result of farming
6. Desert	Very little moisture; rainfall is low (less than 250 mm per year)	Largest temperature fluctuations from hot during the day to freezing at night	Sparse covering of grasses (e.g. spinifex); flowering drought resistant plants

Table 2.1 describes ecosystems from those with regular rainfall (at the top of the table) to those with the greatest variation in rainfall (at the bottom of the table). Temperatures also vary within these biomes. Not shown on the map are the alpine rainforests—these occur between the limit of tree growth (the tree line) and the zone of permanent ice and snow. It also has great variation in (and extremely cold) temperatures. The mean annual temperature in the warmest months is 10°C (south-eastern highlands, Mt Kosciusko, and the 'snow country' of Victoria and Tasmania). Snow gum woodlands grow in these areas at the lower altitudes.

In general the Australian climate can be described as follows:

- temperature—hot
- rainfall—low
- aridity—high
- topography—flat
- soils—eroded and infertile
- fires—frequent.

A hostile environment such as this provides many selective pressures which would lead to natural selection and the survival of uniquely adapted flora and fauna.

Changing flora and fauna

2.5

- ***identify changes in the distribution of Australian species, as rainforests contracted and sclerophyll communities and grasslands spread, as indicated by fossil evidence***

Origins of flora and fauna

If the climate in a habitat changes, the distribution and abundance of living things within that habitat also tends to change. Organisms that are better suited to the new environment survive and new species may evolve.

The distribution and abundance of present-day *plants* in Australia have three main origins:

- those already on the continent when it split from Gondwana
- those that dispersed from South East Asia to Australia
- introduced species (e.g. with the arrival of humans).

The origins of *animals* that led to the present-day fauna (see Fig. 2.9) are:

- 'original residents'—those that were on the continent when it split from Gondwana (e.g. frogs, reptiles, monotremes, marsupials, emus and lyrebirds)
- Asian 'immigrants' that arrived when sea levels were low—15 mya and again 40 000–30 000 years ago (e.g. poisonous snakes, back-fanged snakes, rats, mice and bats)
- those introduced by immigrant traders or late arrival aborigines—4000 years ago (e.g. dingos)
- those introduced by European immigrants—120 years ago.

This section of the course requires us to start our description of the changes in flora and fauna from the time when rainforests contracted. Some fossil evidence is described in the text below and other fossil evidence is in the secondary source investigation which follows (page 267).

Changing flora and fauna

- 65 mya: Moist climates supported rainforests which formed the dominant vegetation type (before Australia separated from Gondwana). Rainforests had replaced the towering conifer forests of the previous eras. The climate was wet and warm and there was a large variety of flora and fauna. (Animals included the early relatives of many of the animals we know today, such as koalas, kangaroos, bats, crocodiles and possums.)
- 45 mya: As Australia separated from Antarctica and began drifting north, the climate dried out and the Australian rainforests contracted, remaining mainly in the coastal regions of Australia. The inland areas which were drying out had more open forests and woodlands. (Animals diversified and varieties that were more similar to the animals we know today developed—kangaroos that hopped rather than walking, large herds of animals that resemble modern-day wombats and carnivorous predators such as the thylacines and marsupial lions.)
  —*Evidence*: Fossils at Riversleigh in north-western Queensland demonstrate the change from rainforest to dry habitats (see page 271). They show that inland forests dried up and vegetation changed from forest to woodlands. Some living plants (e.g. the southern beech, *Nothofagus*) are remnants of a time when Australia's climate was much more tropical.
- As the continent continued to dry out, gum trees and wattles became common in Australia's forests and many wild flowers bloomed. Newly developed fauna included salt water crocodiles and budgerigars. This era formed the link between ancient and

modern vegetation. Conifers and cycads were decreasing in importance as flowering plants bloomed.

- The climate then went through a period of fluctuation from wet to dry and the pattern of forests, grasslands and desserts kept changing. The megafauna abounded, with huge diprotodons (wombat-like animals) and giant goannas *(Megalania)*.
- Indigenous people arrived and used fire to clear vegetation for movement across the land and to burn off particular areas of bushland.
  —*Evidence*: Fossils show an increase in the incidence of carbon deposits which coincided with the arrival of humans.
- About 5000 years ago, Australia's climate became consistently drier and has continued to do so. The dry climate meant that there was lightning which gave rise to fires, possibly influencing the change to fire-resistant species which began to flourish.
  —*Evidence*: Carbon deposits dating from that time and the presence of the pollen of fire-resistant species, reveal a 'fire–vegetation' relationship.
- This further shaped the flora of Australia. Rainforest was replaced by more fire-tolerant open forests, including vegetation such as eucalypts which had woody fruits that burst open as a result of the heat of fire.

Figure 2.7 Fire is an important part of the present and past Australian environment

  —*Evidence*: Unique Australian plants have evolved in isolation, showing adaptations to the dry, harsh climatic conditions (e.g. leathery leaves of eucalypts). Modern Australian plants have a relatively short history with the earliest recorded pollen from a eucalypt dating back to 23 mya.
- In the interior of Australia, grasslands developed. As sea levels have risen and fallen, Australia has experienced a lot of erosion and so nutrients have leached from the soil, resulting in soils which are nutrient-poor.

(a)

(b)

Figure 2.8 Changing Australian biomes—rainforests contract and grassland and sclerophyll communities spread: (a) rainforest; (b) grassy woodland

continued . . .

(c) (d)

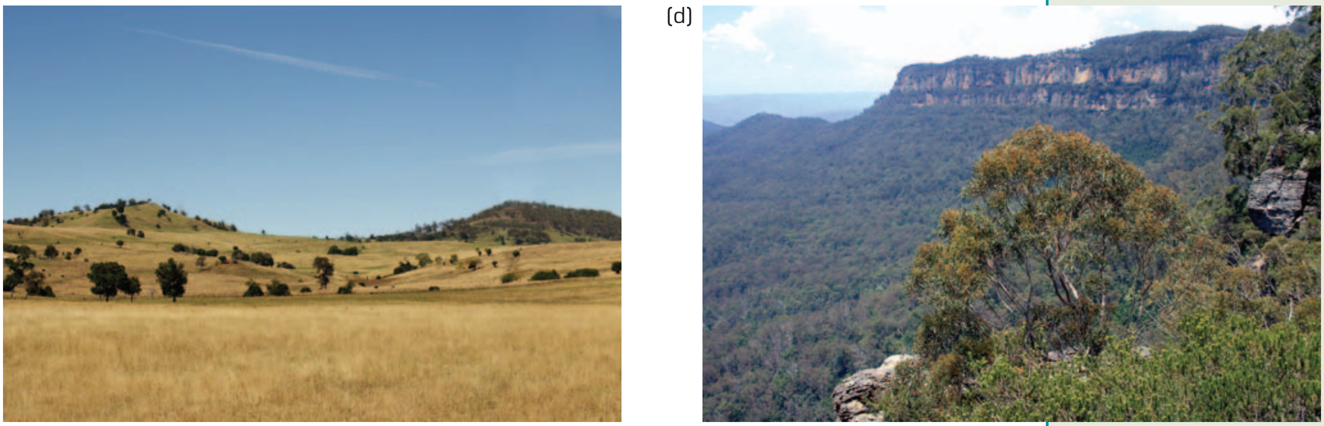


Figure 2.8 Changing Australian biomes—rainforests contract and grassland and sclerophyll communities spread: (c) grassland; (d) dry sclerophyll

Australia's unique flora

Plants which are able to withstand fire and grow in soils lacking nutrients are now characteristic of Australia. Dry sclerophyll plants (e.g. eucalypts and acacias—also known as wattles) and grasses that typically grow in nutrient-poor soils on rough terrain, such as the slopes of mountains. The term 'sclerophyll' means 'hard leaf' and these plants have evolved in many ways to allow them to use low levels of nutrients. Some developed **mutualistic** relationships involving their roots and soil bacteria and fungi (e.g. waratahs, wattles and banksias). The presence of such diverse species in such barren soils continues in present-day Australian flora. Heathland species are *fire-resistant* and their seedlings only emerge following a fire. Many of their seeds are dispersed by ants.

The arrival of the Europeans with their millions of sheep also influenced Australia's vegetation. A massive loss of edible perennial plants occurred as a result of *over-grazing*, erosion followed and dust storms killed off several native mammals. Europeans began clearing land for agriculture and rainforests diminished further. The modern remaining rainforests in New South Wales are very *diverse* and contain many plants that are direct descendants of the original Gondwanan species.

Modern-day flora is very different from that on other continents, with many species found *exclusively in Australia*. The familiar Australian native species such as wattles, eucalypts, banksias and she-oaks (casuarinas) all possess *adaptations* that allow them to thrive in soils that are nutrient poor, areas that are arid (short of water) and where fire is common.

Australia's unique fauna

Australia has a wide variety of marsupial fauna today, including bandicoots, Tasmanian devils, koalas, wallabies and kangaroos. Most living marsupials today are found in Australia and only a few species exist in South America. There are no remaining living species of marsupials on any northern continents or southern continents other than Australia and South America. This can be explained in terms of the theory of continental drift. When Africa and South America first broke away from Antarctica, the tip of South America was still very close to Antarctica. At that time marsupials are thought to have been evolving in Laurasia. They spread south to Gondwana as the split was occurring and continued southwards, eventually reaching the southern tip of South America, where they could cross the land bridge that still existed, to reach the Antarctica/Australia continent.

—*Evidence*: Marsupial fossils that are 100 million years old have been found in North America and fossil records show that marsupials were common throughout South America.

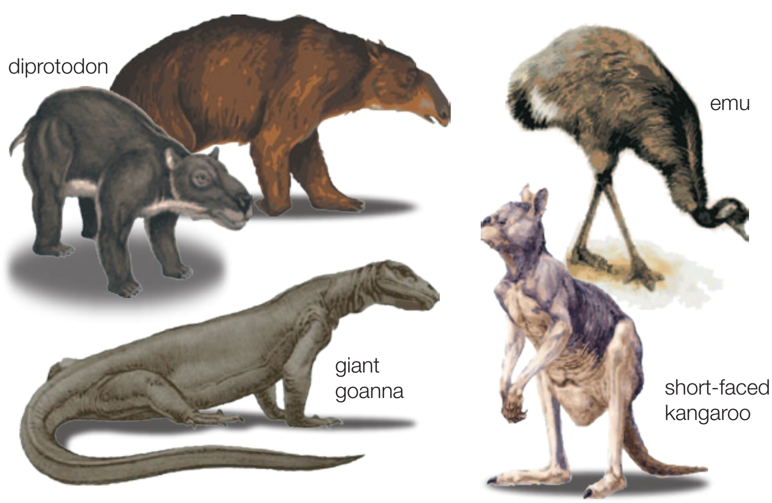
Once Antarctica drifted southwards and became cooler, the marsupials could not survive. Australia drifted northwards and became warmer and the marsupials flourished in these conditions.

—*Evidence*: This is borne out by living evidence—the fact that Australia has the greatest variety of marsupials that occur in every niche normally occupied by placental mammals on other continents.

The lack of the continuation of marsupial survival on the northern continents is thought to be as a result of them being out-competed by placental mammals. Africa split away from Antarctica before the marsupials crossed from America. It has been suggested that by the time the placental mammals reached the tip of South America, it had separated from Antarctica/Australia and so the placental mammals could not move onto those continents. There is still some speculation over this. The only remaining marsupials in South America are the opossums, which must have been able to survive the invasion of the placental mammals—perhaps they occupied different niches or the opossums were adapted well enough to co-exist with them.

As well as the wide variety and large number of unique marsupials in Australia, there are also large numbers of placental mammals—bats, rodents and seals, dugongs and dolphins. Bats, rats, mice and some poisonous snakes are thought to have been introduced by Aborigines who arrived later than the first group and by traders from Indonesia. Europeans introduced foxes, rabbits and dogs, as well as cattle and sheep.

(a)



Gondwanan remnants lived in Australia from 200 000 years ago (diprotodon) until the megafauna extinction 30 000–20 000 years ago (except the emu which is still living today).

(b)

Asian immigrants: Some poisonous snakes, rats and bats reached Australia 15 mya and some with the arrival of the first people—ancestors of today's Aborigines, 40 000 years ago.

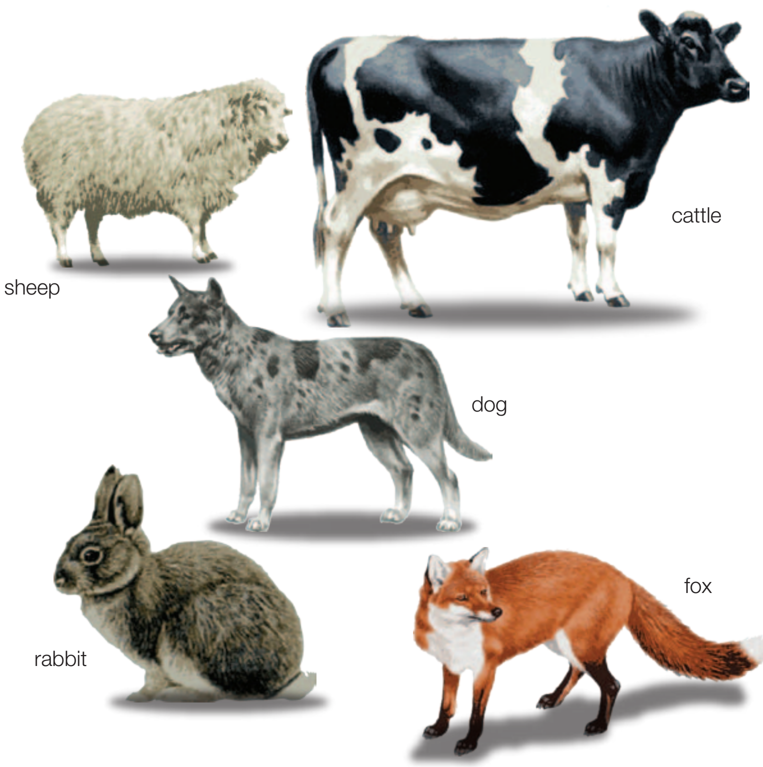
(c)

Asian: Introduced by Aboriginal immigrants or traders from Indonesia about 4000 years ago

Figure 2.9 Changing Australian fauna: (a) 'original residents'—Gondwanan remnants; (b) and (c) Asian immigrants

continued . . .

(d)



European: introduced by European immigrants (1778 onwards)

Figure 2.9 Changing Australian fauna: (d) introduced by European immigrants

Figure 2.10 Present-day (a) marsupials; (b) placental mammals

(a)
(b)

2.6 Current theories to account for changes: Climate change versus the arrival of humans

■ *discuss current theories that provide a model to account for these changes*

There is an ongoing debate as to what led to the changes in the Australian flora and fauna, in particular the extinction of the megafauna. Until recently, many supported the theory that it was the result of climate change associated with the last ice age. Opponents of this theory proposed that it was humans alone who have caused almost all extinctions of animals throughout the world. Current researchers tend to think it may be a combination of the two—initiated by the change in climate, with human impact delivering the final blow.

Theory 1: Changes in climate

- The continent dried out due to the ice age.
- Rainforests were contracting due to a drying climate. Because rainforests had stored moisture and returned an enormous amount to the atmosphere as a result of transpiration, monsoon rains once penetrated south and kept the rivers and lakes in Australia full. As the rainforests diminished and were eventually replaced by eucalypt forests—these were less efficient at retaining water—less water was returned to the atmosphere.
- As the climate became hotter and drier, fires broke out, initially due to lightning strikes and drier vegetation caught alight easily. Those plants and animals that could survive drought and fire, reproduced and flourished, bringing about a change to the flora and fauna.

Arguments supporting climate change

- Large animals such as megafauna, which were dependent on an ample supply of water, would have died out when water became scarce. They may also have died out because they could not manage the sudden change in temperature, their breeding seasons may have been affected and possibly the plants that they ate became less freely available and/or less palatable.

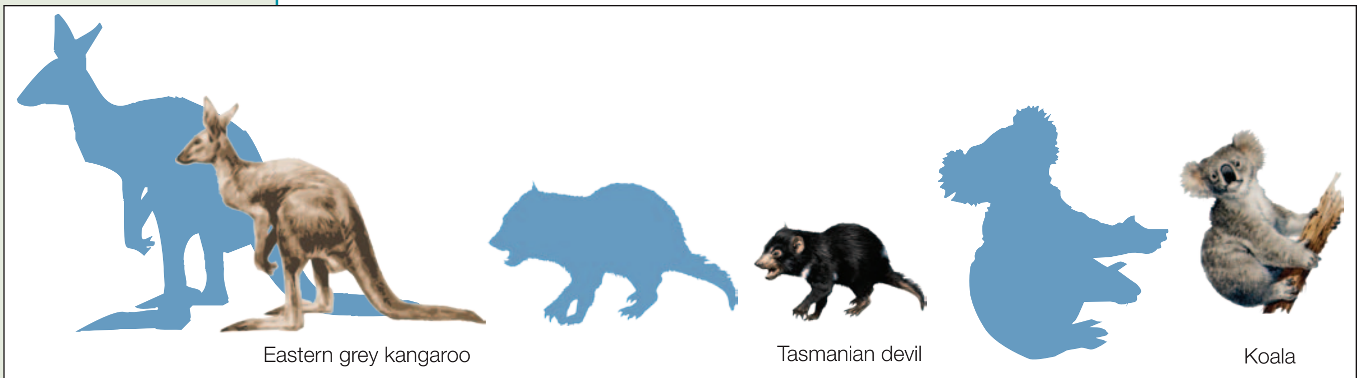
Arguments against climate change

- The last ice age was probably similar to previous ice ages. If so, why would the last one have had such an immense effect, when there is no evidence that the previous ice ages had a similar result? Also, the earlier extinctions seem to have occurred before the peak of the last ice age.
- Climate change today does not seem to select against large, slow-moving species.

Theory 2: The arrival of humans

Aborigines arrived in Australia about 40 000 years ago, probably having 'island-hopped' from the north. They were extremely successful predators.

Figure 2.11 Comparative sizes of extinct megafauna and extant similar species today (extinct species shaded)



They used fire to burn back the bush—'fire-stick' farming techniques involved burning the bush to regenerate grasses for the animals and for themselves, since increasing an abundance of animals meant that there would be more available for hunting.

Humans hunted the megafauna and, because the larger animals were slower, they were the ones that were killed. The smaller, faster animals that escaped survived to pass their genes on and so the species evolved to become smaller.

It appears that the original indigenous people killed off most of the Australian terrestrial animals that were larger than they were. The introduction of the dingo may have also led to a decrease in the diversity of carnivore predators—it is possible that the dingos drove the thylacine and Tasmanian devil to extinction on the mainland.

Arguments against the arrival of humans

- There is no fossil evidence of kill sites and very little evidence of humans and megafauna coexisting.
- If you consider the size of the animals, there is an overlap in the size of the smallest extinct species and that of the largest present-day species.

Arguments supporting the arrival of humans

- Main evidence for the theory of the arrival of the humans at the same time as the increase in fires is that the increase in carbon deposits in fossils coincides with the time of the arrival of humans (40 000 years ago).

The smaller species of megafauna which became extinct had short limbs which would have made them slow; the largest surviving of our present-day species are also among the fastest (e.g. red and grey kangaroos).

A third theory accounting for the survival of smaller animals is that there were such low levels of nutrients in the soils in Australia, that this may have caused a nutrient depletion throughout the food chain, resulting in smaller animals. The smaller size of mammals in Australia compared with their counterparts on other continents today could provide possible evidence.

Evidence of the evolution of Australian flora and fauna in fossils

SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P14

- ***gather information from secondary sources to describe some Australian fossils, where these fossils were found and use available evidence to explain how they contribute to the development of understanding about the evolution of species in Australia***

Aim

1. To gather information from secondary sources.
2. To describe some Australian fossils and where these fossils were found.
3. To use available evidence to explain how fossils contribute to the development of understanding about the evolution of species in Australia.

Background information

Australian fossils found from the past are an invaluable source of information looking at past relationships between organisms, evolutionary changes over time and commonality between extinct and present-day organisms.

This information not only tells us a lot about the changes in organisms over time and their relationships but also the changes in environments over time. Tables 2.2 and 2.3 describe examples of Australian animal and plant fossils found from varying periods of time in the past. One recent discovery in Australia (2007) is the first evidence of a new species of titanosaur, dated at approximately 96–100 million years. The remains, found in Eromanga, Queensland, included a 100 kg thigh bone spanning 1.5 m. This suggests the plant-eating dinosaurs were about 26 m long; by far the largest dinosaur bones ever found in Australia. This is a rare find because it is a complete bone.

SR TR

For photographs and websites on Australia's latest dinosaur bone

Fossils of Australian fauna

Examples of some fossils of Australian animals are summarised Table 2.2.

Table 2.2 Fossils of Australian animals

Period of time (million years ago)	Where found	Fossil name	Animal group	Description
345–280	Clarencetown, New South Wales	Brachiopod (lamp shells)	Brachiopod	Small organisms, only shell visibly preserved, grooves prominent in shell, semi-circular shell shape
230	Bellambi Colliery, New South Wales	Labyrinthodont	Amphibian	Five narrow toes (unlike dinosaurs that possess three toes) with thin sharp claws, only footprint of organism preserved
225–190	Hornsby, New South Wales	*Cleithrolepsis*	Fish	Small size (relative to a coin), tail fin and upper and lower rear fin are prominent, head structure clear, very clear side-on view of fossil detail
110	Lightning Ridge, New South Wales	*Steropodon galmani* (steropodon)	Mammal	Only fossilised jaw preserved with three molar teeth

Fossils of Australian flora

Examples of some fossils of Australian plants are summarised in Table 2.3.

Table 2.3 Fossils of Australian plants

Period of time (million years ago)	Where found	Fossil name	Animal group	Description
410–345	Mt Pleasant, Victoria	*Baragwanathia longifolia*	Club moss	Swamp plant with small, thin, feathery-type leaves protruding from a long main stem; only leaf and stem structure are preserved
280–225	Hunter Valley, New South Wales	*Glossopteris* (refer to Fig. 1.4 on page 240)	Tree fern	Tongue-shaped leaves with a midrib and net venation, found in swampy habitat; only leaf structure preserved
225–190	Beacon Hill, New South Wales	*Dicroidium*	Tree fern	Forked-frond seed fern; good clear outline of structure of frond preserved
190–120	Gulgong, New South Wales	*Pentoxylon*	Pine	Kauri pine with small, long narrow leaves; only remnants of stems with leaves preserved

Note: For photographs of fossils listed in Tables 2.2 and 2.3 see Mary E. White's *Australia's Prehistoric Plants and their Environment*, Methuen, 1984.

Contribution of fossils towards our understanding of evolution

The development of our understanding about the evolution of species in Australia can be largely contributed to by the discovery of fossils in the following ways.

- The sequence of fossils in different rock layers indicates the progressive sequence of change in plants and animals over millions of years.
- The dating of rocks and the disappearance of fossils at a certain date indicates the time period when extinction occurred. This time period could also be linked to events that happened over time which may have caused the extinction. Fossils help scientists to develop theories to explain the reasons for evolutionary changes, such as extinction. For example, the extinction of *Genyornis*, a bird. Was it the arrival of humans or the melting of ice caps? If it was the melting of the ice caps, we would expect to find fossilised eggs of the *Genyornis* in upper layers of rock, however, they are only found in lower rock layers. This suggests that they may have become extinct after humans arrived, but before the melting of the ice caps. Humans therefore may have been responsible for the extinction of the *Genyornis* (perhaps through hunting).
- The type of plant and animal fossilised indicates the type of environment in that area in the past. For example, finding fossils of crocodiles in areas that are now flat, arid

and have no water suggests that these areas once had water. In turn, in these areas there once existed aquatic organisms.

- By studying both the evolution of individual species and the terrestrial ecosystems through time, we can better understand our present environment and the conservation status of our fauna. For example, the Tasmanian tiger (*Thylacinus cynocephalus*). Fossil evidence found at Riversleigh provides warnings that the thylacine species decreased as sediments became more recent, showing a decline in diversity and geographic range over time. If we observe such warning signs early, we may be able to prevent extinction from occurring in other species.

SR TR

Tables 2.2 and 2.3

Websites

www.lostkingdoms.com (*Australia's Lost Kingdoms* online exhibition)
www.amonline.net.au (Australian Museum online)
www.austmus.gov.au (Australian Museum)
www.abc.net.au/science (ABC Science)
www.museum.vic.gov.au (Museum Victoria—megafauna)

Suggested Australian fossils

Plants

Phyllotheca (horsetail)
Lycopod (club moss)
Gangamopteris (tree fern)

Animals

Kambara implexidens (Tingamarra swamp crocodile)
Pengana robertbolesi (flexiraptor)
Obdurodon dicksoni (Riversleigh platypus)
Nimiokoala greystanesi (Riversleigh rainforest koala)
Dromornis stirtoni (Stirton's thunder bird)
Liasis species (Bluff Downs giant python)

Method

Part 1: Gather information from secondary sources

Refer to page 18 ('Searching for information') for suggestions and a reminder on how to go about gathering information from secondary sources.

Part 2: Description of Australian fossils and where they were found

Read the background information and use Tables 2.2 and 2.3 as guides for constructing a table to describe examples of Australian plant and animal fossils. Use the examples provided in Tables 2.2 and 2.3 as a start. Select two more fossil examples of your own and gather information from secondary sources to obtain the information required for your table. Attach a copy of the fossil photograph or drawing to your notes.

Part 3: Contribution of fossils to the development of understanding about the evolution of species in Australia

Read the background information that provides evidence of the contribution that fossils make in the development of our understanding about the evolution of our own Australian species. Search for any further available evidence to explain another possible way that fossils may contribute to our understanding.

Results

- Construct a table, similar to that provided in Tables 2.2 and 2.3, describing at least three plant and three animal fossil examples.
- Summarise into points the background information and extra evidence you were able to obtain for explaining the contribution of fossils in the development of understanding about Australian species evolution.

Discussion/conclusion

1. Identify two Australian plant fossils, where they were found and the period of time they existed, and provide a brief description.
2. Do the same as Question 1 for two *named* animal fossil examples.
3. Identify the common observations that were made regarding the quality of the fossil examples.
4. List four ways in which fossils contribute to the development of understanding about the evolution of species in Australia.
5. Select one of the fours ways you discussed in Question 4 and provide an example in support of this point.

SR TR

Student activity

Comparison of current and extinct Australian life forms

FIRST-HAND INVESTIGATION

BIOLOGY SKILLS

P14

■ ***perform a first-hand investigation, gather information of named Australian fossil samples and use available evidence to identify similarities and differences between current and extinct Australian life forms***

Aim

1. To perform a first-hand investigation.
2. To gather information of named Australian fossil samples.
3. To use available evidence to identify similarities and differences between current and extinct life forms.

Recommended class activity

The Australian Museum provides excellent first-hand experience with many Australian fossil samples.

Australia's Lost Kingdoms online exhibition: www.lostkingdoms.com

Method

Part 1: Perform a first-hand investigation

Make careful observations of three Australian fossil samples. Draw each one carefully then copy and complete Table 2.4. If you do not have any Australian fossil samples first-hand, use the secondary information provided in this text, information gathered from other secondary sources and websites or from information gathered during a class visit to the Australian Museum (or equivalent).

Part 2: Gather information of named Australian fossil samples

Use the information provided from the previous investigation (Tables 2.2 and 2.3, and the 'Suggested Australian fossils' list on page 269) and any further secondary source information, to gather details on three named Australian fossils in order to complete Table 2.4 in Part 3. Remember to gather comparative information on the modern day equivalent of each of your three named fossil organisms.

Part 3: Identify similarities and differences between current and extinct Australian life forms

Once you have gathered information on your three named Australian fossils and information on their modern day equivalent organisms, copy and complete Table 2.4 (see Student Resource CD). Two examples have been provided to get you started.

Analysis questions

1. Describe the Australian organism that has the greatest similarities between current and extinct forms.
2. Name the organism with the least similarities. Explain possible reasons why this organism has a greater amount of difference between extinct and current forms.
3. Identify one *named* Australian organism and describe the similarities and differences between its current and extinct forms.
4. Identify the main difference between Australian plants and animals from hundreds of millions of years ago and those found in the present day.
5. Explain why some fossils may have no similar living relative or modern day equivalent.
6. Describe how studying current and extinct Australian organisms can contribute to our understanding of evolution.

SR TR

Table 2.4

Results

Table 2.4 Comparison between current and extinct Australian organisms

Australian organism (current)	Australian organism (extinct)	When extinct organism lived	Similarities	Differences
Crocodile 	Tingamarra swamp crocodile (*Kambara implexidens*): skull found at Riversleigh in north-western Queensland 	55 million years ago	■ Diet: small vertebrate animals, small mammals, turtles, snakes and fish ■ Environment: swamp area in Queensland ■ Body structure: reptilian scales, long and strong tail, large snout and sharp carnivorous teeth	Tingamarra swamp crocodile was much smaller than the present-day freshwater and saltwater crocodiles being only 1.5 m in length
Platypus 	Riversleigh platypus (*Obdurodon dicksoni*): pieces of skull and other skeleton parts found at Murgon in south-eastern Queensland 	23–10 million years ago	■ Diet: insect larvae, yabbies and other crustaceans ■ Environment: freshwater pools surrounded by rainforest ■ Body structure: appears similar ■ Specialist organ: have electric sensors in their bill to find its underwater prey	Riversleigh platypus was larger in size, had a much larger bill, had large teeth (the present-day platypus has no teeth at all)

2.7 Darwin revisited

■ *discuss Darwin's observations of Australian flora and fauna and explain how they related to his theory of evolution*

Darwin travelled the world on a surveying ship, HMS *Beagle*, when he was in his early twenties. The ship circumnavigated the world in five years. During that time, Darwin spent many hours observing the wide range of living organisms in the various countries where they stopped. Many of his famous observations were made in the Galapagos islands and also some important ones in Australia. He read extensively while travelling, including books on geology by Lyell, who proposed that, based on *fossil records*, plant and animal *species changed* and at times died out. He also later read books by Thomas Malthus on organisms' 'struggle for existence' if they outgrew their resources such as their food supply, introducing the idea of *competition*.

His observations in Australia led him to question the conventional ideas of the time and prompted his thoughts on *evolution*. He visited Sydney and the Blue Mountains while the ship had anchored so that the crew could check the clocks at the observatory in Sydney. (Today there is a walking track in the Blue Mountains called 'Charles Darwin's walk'.)

Darwin's observations were meticulously recorded; he collected huge quantities of specimens to send back to England for classification, according to the relatively new Linnaean system. He asked penetrating questions and spent a long period of time 'pondering' what he had observed, leading to his proposal of the theory of evolution by natural selection. Alfred Wallace proposed a similar theory at the same time as Darwin, and both of their work was backed up by research and observations.

SR TR

For additional information on Darwin

Darwin tried to explain the similarities and differences (variations) that he observed. He believed that, rather than similar creatures being created independently, they could arise from a common ancestor, accounting for basically similar organisms changing to become different (**divergent evolution**). He also suggested that organisms that started off distantly related, but were subjected to similar environments could evolve similar features (**convergent evolution**).

Darwin had made numerous observations including these examples of the fact that similar environments in completely different parts of the world seemed to be inhabited by animals having similar adaptations, but obviously belonging to different species. His curiosity drove him to think about possible reasons for the resemblance: why would a creator bother to make two animals, so different in basic design and in the way that they produce and raise their young, rather than just one type of animal, since they live in such similar environments but in different parts of the world.

Observation forced him to discard the idea of fixed, unchanging species and so Darwin set out to try to find an explanation for his observations. He made many observations, both before and after his visit to Australia. Some of his most famous work included the study of finches and other birds, where he found that island populations may differ noticeably from mainland birds as a result of isolation and genetic drift. Darwin would have delayed publishing his ideas even longer if Wallace, who reached the same conclusions as Darwin, had not contacted him. Colleagues arranged for a joint publication of their papers.

Darwin's observations	How Darwin's observations related to his theory of evolution by natural selection
Magpies and crows are similar to jackdaws in the England, but obviously belonged to different species. The potoroo (rat kangaroo) is similar to the rabbit in England. It is a miniature kangaroo the size of a European rabbit, behaving somewhat like a rabbit, darting about in the undergrowth. The platypus is similar to water rats: 'I . . . had the good fortune to see several of the famous platypus. They were diving and playing in the water; but very little of their bodies were visible, so that they only appeared like so many water rats'.	Darwin's observations of birds, marsupials and monotreme mammals in Australia revealed similarities with mammals in Europe which lived in similar environments. This led him to the idea that organisms could evolve to become similar (convergent evolution). If organisms live in similar habitats, similar variations that they possess would be favoured by natural selection to enable them to survive and breed in those conditions. These favourable variations would then be passed on to the next generation.
Ant lions (same genus but different species?) to that of England: 'I observed a conical pitfall of a Lion-Ant: a fly fell in and immediately disappeared; . . . without doubt this predacious lava [sic] belongs to the same genus, but to a different species from the European one . . . Now what would the Disbeliever say to this? Would any two workmen ever hit on so beautiful, so simple and yet so artificial a contrivance? I cannot think so. The one hand has worked over the whole world'.	Their behaviour is similar to those in England. Same genus but different species?
Eucalypts: Darwin describes, 'the nearly level country is covered with thin scrubby trees, bespeaking the curse of sterility'. He also mentions 'the leaves are not shed periodically'.	In Darwin's observations of plant life in Sydney, he made the link between the harsh environment and the adaptations observed in the vegetation. He also mentions that many of the trees in Australia and other southern continents are evergreen as opposed to those in the northern hemisphere.

Source of quotes: Darwin, 1859, *On the Origin of Species*, http://Darwin.thefreelibrary.com/The-Origin-of-Species

Table 2.5 Darwin's observations in Australia

AUSTRALIAN



EUROPEAN



Figure 2.12 Darwin's observations of Australian flora and fauna

The Huxley–Wilberforce debate

SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P12.3; P12.4
P13
P14

- ***present information from secondary sources to discuss the Huxley–Wilberforce debate on Darwin's theory of evolution***

Background information

When Darwin and Wallace proposed their theory for a mechanism by means of which evolution could occur (natural selection), it created an uproar in scientific and religious circles, in fact in society in general. Despite being based on observations of an enormous number of plants and animals over a long period of time, in many different countries (including the Galapagos islands and Australia), the theory of evolution remained an extremely controversial issue. It brought into question the accepted beliefs of the time—that the world was created in six days, each species was created independently of another and that humans were created in the image of God. Darwin and Wallace's proposal that organisms gradually change over time and that one species could change into another, including the human species, was an extremely revolutionary idea.

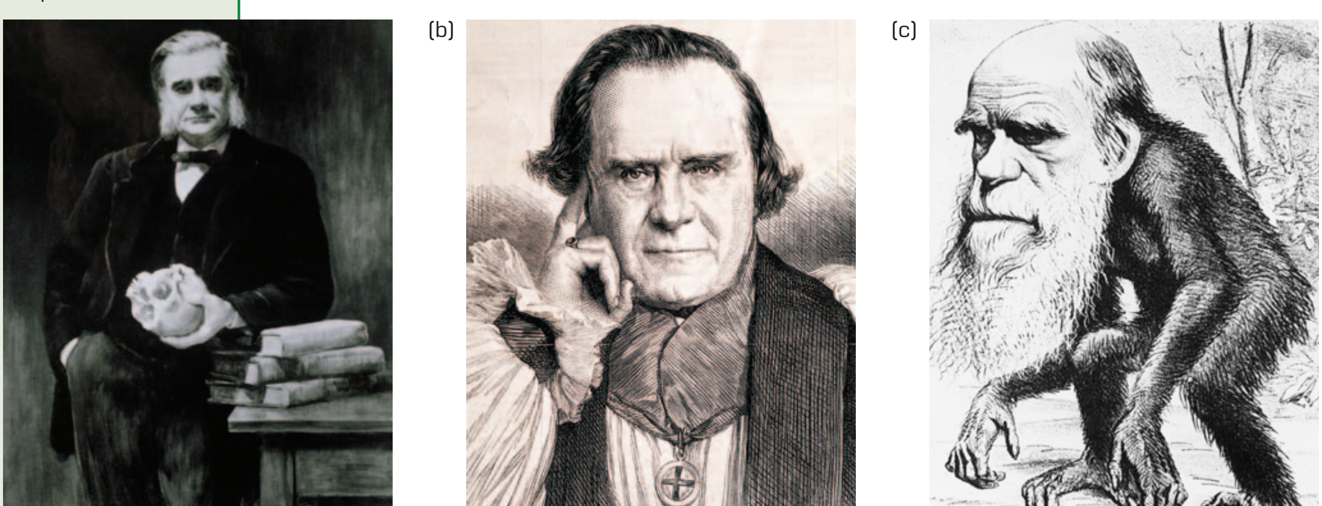
A famous debate took place between Bishop Samuel Wilberforce and Thomas Henry Huxley at a meeting of the British Association for the Advancement of Science in 1860. The purpose of the meeting was for the reading of a paper with reference to the views of Charles Darwin (and others) at that time, that organisms evolved by the law of natural selection. This paper was to be presented by an academic, Dr John Draper, of New York University. The presentation topic was a highly contentious issue at that time and the reading was well attended, with high-profile members of society forming part of the audience. Many that attended came to the presentation prepared to put forward and defend their own point of view and that of the sector of society which they represented. Following the reading of the paper, a lively and heated debate took place amongst members of the audience. With a fine display of polished debating skills, witty remarks and now-famous insults, strong opinions were voiced to contest the issue at hand. The reading of the paper faded into insignificance compared with the attention given to the heated debate that followed. Recounts of the famous debate that followed have been found in many forms:

- as articles reported in journals of the time (*The Guardian, The Athenaeum* and *Jackson's Oxford Journal*)
- in the form of four contemporary letters: Joseph Hooker to Charles Darwin; Richard Green to Sir William Boyd Dawkins, Balfour Stewart to David Forbes and Huxley himself to Henry Dyster.

However, there is no exact recording of the words used in the verbal exchange that took place and so these sources of information vary in their reporting of the actual wording of the content of the debate, but the general ideas and insults resound. In discussing this debate, it is interesting to look at the different accounts, each supposedly a record of the same happenings at the debate. This provides a good opportunity to evaluate the sources (both at that time and the sources we use) and to try to come up with indisputable facts (if any)

Figure 2.13
(a) Thomas Huxley;
(b) Samuel Wilberforce;
(c) cartoon of Darwin as an ape

(a) (b) (c)



about the debate. The debate is also of interest because journal reports of the verbal exchange gave evolution publicity, and knowledge of the theory of evolution spread.

Task

Research at least three current articles which address the Huxley–Wilberforce debate and answer the questions that follow. A table in which to record your answers is provided on the Student Resource and Teacher's Resource CDs.

Research questions

1. Which society hosted the debate? On what date? Where was it held?
2. Who was the invited guest speaker? What was the topic on which he spoke?
3. As a result of what circumstances did Wilberforce and Huxley end up speaking?
4. What position in society did Wilberforce and Huxley each hold?
5. Why was each one invited?
6. Which sector of society was represented by Huxley?
7. Which sector of society was represented by Wilberforce?
8. What was the issue being debated?
9. How well was each prepared for the debate?
10. What arguments were put forward by Huxley and by Wilberforce? (List at least three points made by each in support of their point of view. These should be reported in your own words.)
11. What was the insult that made the debate famous?
12. Was Darwin present at the debate? What was Darwin's reaction to the debate?

There are various accounts of the debate and the famous insult—refer to at least two accounts, preferably three.

To prepare for your discussion of the debate

- Note any inconsistencies in the telling of the story.
- Evaluate the reliability of *three* sources of information about the debate. (These may include current sources that you are using, as well as direct quotations from the letters written at the time of and after the debate.)
  —Note who wrote each source and the qualification of the author or the accomplishments and/or participation of the letter writer in the debate.
  —If you are using an Internet site or book as a secondary source, comment on the scientific standing of the publication.
  —Try to distinguish between fact and opinion in each of the three sources chosen for discussion. State whether the issues that show inconsistency are stated as fact or opinion and, if opinion, provide words used in the source to demonstrate that it is an opinion.
  —State any reasons why the source or authors may have been biased.

Discussion

Discuss the debate: look at recounts of the debate and discuss inconsistencies in how the debate is recorded. Explain how these inconsistencies arose. Acknowledge all your sources in the correct format of a bibliography. Remember to include the access date of any Internet sites.

SR TR

Student activity and websites

2.8 Current research

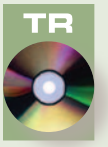
- ***discuss current research into the evolutionary relationships between extinct species (including megafauna) and extant Australian species***

(This dot point has been moved from Chapter 1.)

Current Australian scientists

As part of the requirements for the preliminary biology course, you are required to identify practising male and female Australian scientists in areas in which they are currently working and gather information about their research. (See skills outcomes P12.3e on page x.)

A large amount of work is being done in the area of evolution using current research techniques. This provides an ideal opportunity for you to meet these requirements. A large amount of work is being done at Adelaide University on extinctions of



Reference details and websites for publications

megafauna, impacts of climate change and evolutionary relationships of extinct species. You may also like to look into the work of Tim Flannery—Australian of the Year, 2007—who has studied the changing Australian climate and the impact of the arrival of humans in Australia. He is renowned for his research and many publications, amongst them two books on Australia past, present and future: *The Future Eaters* and *The Weather Makers*.

Current research

When researching into the evolutionary relationships between organisms, scientists previously had to rely solely upon fossil evidence and a comparison of the anatomy of each organism. Today, current research uses molecular biology techniques which are far more complex and accurate in providing information about genetic relationships between organisms from different times. The technique of DNA hybridisation, DNA sequencing and mitochondrial DNA sequencing (the details of these techniques will be covered in the HSC course) have become even more sophisticated since the 1980s so the accuracy of these studies is being improved all the time.

The Ancient DNA Laboratory at the Australian Centre for Ancient DNA (ACAD) is a new research initiative of the University of Adelaide. Currently, it is conducting research on the extinctions of **megafauna** and the evolutionary relationships between extinct species. The international standard facility provides laboratories isolated from other areas of molecular biology, so that they are protected from environmental contamination, allowing specialist work areas for ancient DNA studies (see Figure 2.17). Molecular biology techniques involve areas such as protein and DNA isolation methods, DNA sequencing and studies of DNA damage or modification, in addition to computer modelling programs.

Research is currently being conducted on bones of Pleistocene megafauna and extinct species. They are also looking at evolutionary relationships between extinct mammals and birds, such as the Australian megafauna (e.g. the thylacine). The thylacine research project uses ancient DNA preserved in fossil bones and museum specimens. The project is hoping to contrast thylacine information to that of the Tasmanian devil which managed to avoid extinction in Tasmania. Another area of research is being conducted on conservation genetics of extant and extinct Australian lizards and frogs, and also extinct and endangered Australian marsupials. An extant species is one defined as in existence, still existing, and not lost or destroyed.

The approach of these studies is to integrate ancient DNA sequence information with modern data from archaeology, climate studies and palaeontology, to analyse a variety of evolutionary processes.

Figure 2.14
Modern researchers are studying the extinctions of megafauna

Further information about this research can be obtained from the University of Adelaide website: www.adelaide.edu.au/acad

Table 2.5 lists examples of extinct and extant (still in existence) Australian species that may demonstrate evolutionary relationships. The difference between the two groups (extinct and extant species) is that the extant group for each species must have possessed adaptations that the extinct group did not, ensuring that it survived to continue the species up to the present day. Although they may share many common characteristics and genetics, there must have been a significant difference to enable one to survive and one not to survive.

Some scientists suggest that the size of the megafauna made it an easy target for hunting due to its slow locomotion, whereas the smaller organisms at the time were unaffected and avoided extinction. Climate change is also thought to be responsible for the extinction of the megafauna. In this case the extant species' adaptations must have been more climate-related. However, it may have been a combination of human impact and climate change that led to the extinction. Perhaps a number of different adaptations saved the extant species from extinction. Fortunately there was enough genetic variation amongst species to allow some organisms to survive to continue the species to present day.

Table 2.5 Examples of extinct and their respective extant Australian species

Extinct species	**Extant species**
Riversleigh platypus (*Obdurodon dicksoni*)	Modern platypus (*Ornithorhynchus anatinus*)
Perikoala palankarinnica *Litokoala kutjamarpensis* *Koobor notabilis* and *Koobor jimbarratti* Giant koala (*Phascolarctos stirtoni*)	Modern koala (*Phascolarctos cinereus*)
Diprotodon optatum	Common wombat (*Vombatus ursinus*)
Australian southern conifer (*Aganthis jurassica*)	Wollemi pine (*Wollemia nobilis*) Kauri pine (*Aganthis* sp.) Norfolk Island pine (*Araucaria heterophylla*)

REVISION QUESTIONS

1. Describe three examples of Australian fossils and identify where these fossils were found.
2. Identify similarities and differences between current and extinct life forms in two *named* Australian fossil samples.
3. Explain how fossils contribute to the development of understanding about the evolution of species in Australia.
4. Distinguish between *geological* evidence and *biological* evidence.
5. Clarify what is meant by the terms *extinct* and *extant*.
6. Clarify what is meant by 'relict' species and identify an example of relict species form each of the following groups:
   (a) bacteria
   (b) plants
   (c) animals.
7. Define the terms *heredity* and *variation*. Give an example of each.
8. Outline two current theories that could account for the changes in Australian species (including extinction of megafauna). State one argument for and one against each theory.
9. Outline the following points about the Huxley–Wilberforce debate:
   (a) topic of debate
   (b) Huxley's point of view
   (c) Wilberforce's point of view
   (d) the famous insult.

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Answers to revision questions