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David Rogers is an Assistant Headteacher in Brighton, responsible for Teaching and Learning. He is also a multi-award winning geography teacher and author of educational resources, and sits on the RGS’s Education Committee.
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Global ecosystems

What is an ecosystem?

Ecosystems are natural areas in which plants, animals and other organisms are linked to each other, and to the non-living elements of the environment, to form a natural system. Each ecosystem is made up of biotic and abiotic elements.

- Biotic elements comprise all of the living parts of the ecosystem including plants, animals and bacteria. In the natural world, plants are known as flora and animals are known as fauna.
- Abiotic elements are the physical, non-living parts of the ecosystem, including temperature, water and light.

Large-scale ecosystems, known as biomes, spread across continents and have types of plants and animals that are unique to them. For example, polar bears are unique to the Arctic tundra and orang-utans are unique to the tropical rainforest. Biomes cover a wide area and are identified by their climate, soils, plants and animal species. Each of these factors is reliant upon all the others. This is known as interdependence (Figure 1). Climate has the greatest influence over vegetation and soil within an ecosystem. During a period of low rainfall, less vegetation will grow, meaning that there is less food for some animals. Increasingly, however, ecosystems are being changed by human activity.

Figure 1: The interdependence of ecosystems

- Animals found in a woodland include many species of insects and birds, and mammals such as rabbits, squirrels and foxes.
- Plants include trees, wild flowers, grasses, mosses and algae. They provide food and shelter for many animals.
- Rocks help in the formation of soils and rock type is important. Weathering releases nutrients stored in rocks into the ecosystem.
- Sunshine and rain are needed for photosynthesis, so they are essential to the ecosystem. Other climatic elements such as wind and frost are also important.
- Micro-organisms such as fungi and bacteria are decomposers. They help to break down dead plants and animals, releasing nutrients into the ecosystem so they can be recycled.

Figure 2: The biotic and abiotic components of an ecosystem

<table>
<thead>
<tr>
<th>Key</th>
<th>Legend</th>
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<tr>
<td>Living (biotic) components of ecosystem</td>
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</tr>
<tr>
<td>Non-living (abiotic) components of ecosystem</td>
<td></td>
</tr>
</tbody>
</table>
Where in the world are the major biomes?

Climate and latitude are important factors which contribute to the location of the world’s major biomes, which broadly match the world’s climate zones (see Chapter 1, pages 4–5). The world contains eight major biomes. Each biome has its own climate characteristics which create distinct environments for a range of plants and animals to survive.

Figure 3: Global distribution of the major biomes

Figure 4 shows the distribution of biomes according to temperature. **Temperate** simply means a region characterised by milder temperature; they are neither hot nor cold regions.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>World ecosystem</th>
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</thead>
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<tr>
<td>Tropical</td>
<td>1. Tropical rainforests</td>
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<td></td>
<td>2. Tropical grasslands</td>
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<tr>
<td></td>
<td>3. Hot deserts</td>
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<tr>
<td>Warm temperate</td>
<td>4. Mediterranean</td>
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<tr>
<td>Cool temperate</td>
<td>5. Temperate deciduous forest</td>
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<tr>
<td></td>
<td>6. Temperate grasslands</td>
</tr>
<tr>
<td>Cold</td>
<td>7. Coniferous forest</td>
</tr>
<tr>
<td></td>
<td>8. Tundra</td>
</tr>
</tbody>
</table>

Figure 4: Classification of world ecosystems

Activities

1. Research the places in the world that contain the ecosystems listed in Figure 4.
2. Describe the global distribution of two contrasting ecosystems using Figure 3 and an atlas to help you.
From pole to pole: how do the two polar regions vary?

How does their location vary?

The climate of both polar regions consists of long, cold winters and short, cool summers. They are covered by snow and ice throughout the year, though the extent of this ice varies with the seasons. Antarctica is covered by an ice sheet 2.8 miles thick in some places. Temperatures rarely rise above freezing in these high-latitude regions. This is largely due to the low angle of the Sun in the sky. Due to the tilt of the Earth, the polar regions spend half of the year in darkness and half of the year in daylight. Polar regions tend to be dry, receiving as little as 250 mm of rainfall per year. This is because the descending air is unable to pick up moisture to form clouds and snowfall.

The Arctic is much warmer than Antarctica. The North Pole winter temperatures vary from −46 °C to −26 °C whereas the South Pole temperatures range from −62 °C to −55 °C. But why is there such a difference in temperature?

- The sea in the Arctic does not fall below −2 °C, which means that the whole Arctic region stays warmer than Antarctica.
- The weather in the Arctic travels south and relatively warm weather from the south travels north into the Arctic region. This is known as the Gulf Stream.
- All of the weather in Antarctica is kept within the continent due to the circumpolar winds and currents travelling around the coastline.
- Antarctica has an average height of 2300 metres, making it the highest of all the continents in the world. Temperature falls as altitude increases. In fact, with every 100 metres in altitude, the temperature falls by 1°C.
What flora and fauna are found in the polar regions?

The polar region to the north is characterised by what can grow in the **tundra**. This is a vast area of 11.5 million km² that consists of permafrost, which means that the ground is permanently frozen. Consequently, it is a treeless area. There are, however, low shrubs, reaching a height of around 2 metres, along with mosses, grasses and alpine-like flowering plants. There are approximately 1700 species of plant living in the tundra. Land mammals include polar bears, wolves, foxes and reindeer and sea mammals include walruses and whales. As the Arctic is part of a land mass, some animals are able to migrate southwards during the winter months.

Plant life in Antarctica is much less plentiful due to only about one per cent of the continent being ice free. There are some exposed rocks on which the hardiest of plants can grow. There are around 100 species of moss and 300–400 species of lichen. Both the Arctic and Antarctica have very productive seas due to large volumes of phytoplankton. Many animals that feed in the sea come onto land for part or most of the time, including large numbers of penguin species such as gentoo, emperor and Adélie. Likewise, fur seals, Weddell seals and elephant seals live in Antarctica.

![Figure 7: A killer whale hunting a seal in the Antarctic](image)

### Activities

1. **Draw a climate graph for Vostok, Antarctica**, using the data below (see Chapter 1, Figure 11 on page 5 for an example).

<table>
<thead>
<tr>
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<th>Feb</th>
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<th>Apr</th>
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2. **Compare the climate graph for Iqaluit, Canada** (Figure 6) with your graph for Vostok, Antarctica.

3. **Explain why Antarctica is a colder polar region than the Arctic.**
What are the characteristics of tropical rainforests?

Where are they located?

Tropical rainforests are found within the Tropics of Cancer and Capricorn (23.5° north and south of the Equator). Tropical rainforests are found in:

- South America in the Amazon River basin
- Africa (Zaire basin, small area in West Africa and eastern Madagascar)
- Southeast Asia
- New Guinea
- Queensland in Australia
- west coast of India.

Rainforests now cover less than six per cent of the Earth’s land surface, though this figure was once much higher. Despite this small area, it is thought that the tropical rainforests contain 50 per cent of all plant and animal species.

Tropical rainforests are being destroyed at an alarming rate, with trees cut down on a large scale. This is known as deforestation (see Chapter 7, page 108).

What is the climate like?

Temperatures in the tropical rainforest are high and remain constant throughout the year because the Sun is always high in the sky. It is a hot and wet climate. There are no seasons like you would find in the temperate forest (see page 101). In fact, the mean monthly temperatures only vary by 2°C from 26°C to 28°C. Each day has a reliable 12 hours of daylight and 12 hours of darkness.

Annual rainfall totals are very high; often over 2000 mm. A heavy, thundery downpour can be expected most afternoons in the rainforest. This is because of the meeting of trade winds at the ITCZ where warm, moist air is forced to rise rapidly, cool and condense to form frequent rain. Due to the large amounts of moisture in the
air from both rainfall and transpiration from the dense vegetation, the atmosphere is very humid and sticky. This can make it a rather unbearable climate for even the most intrepid of explorers.

What flora and fauna are found in tropical rainforests?

The climate creates the perfect environment for a wide variety of species to survive. The growing season is constant throughout the year as the climate does not vary. Fifteen million plant and animal species have been identified successfully and many more have yet to be discovered.

Vegetation consists mainly of trees. In Amazonia, there may be as many as 300 species of tree in any one km², including mahogany, ebony and rosewood. There are distinct layers to the vegetation of the tropical rainforest, as shown in Figure 10.

- The tallest trees are known as **emergents** and can reach as high as 50 metres. Below this are three layers that compete for sunlight.
- The **canopy** is the next layer below the emergent layer and receives 70 per cent of the sunlight and 80 per cent of the rainfall. It is a continuous blanket of leaves. These trees are approximately 30 metres high.
- The next layer is the **under canopy**, consisting of trees growing up to 20 metres.
- The **shrub layer** is the lowest layer where only small trees and shrubs that have adapted to living in the shade can survive. Less than five per cent of sunlight reaches the forest floor.

The tallest trees are supported by buttress roots (see Figure 9). These emerge over 3 metres above the ground level to give the tree support. Trunks are usually thin and branchless as they compete for space. Leaves are dark green and smooth and often have ‘drip-tips’ to shed excess water. Vine-like plants, called lianas, grow around and between tree trunks and can reach lengths of 200 metres. These vines help to connect layers of the rainforest for the many animals that live there.

The tropical rainforest is filled with beautiful colours and patterns. Most of the birds, animals and insects live in the canopy layer. Insects make up the largest single group of animals, ranging from camouflaged stick insects to vast colonies of ants. Other species found in the tropical rainforest include toucans, jaguars, monkeys, chameleons, frogs and snakes. The rainforests of Borneo are one of the last habitats of the orang-utan.

There is an abundance of amphibian species. The poison dart frog is brightly coloured to warn predators. It has poison on its back and, when touched, can kill almost instantly. A single poison dart frog has enough poison to kill ten full-grown men!

Rainforests have 170,000 of the world’s 250,000 known plant species.

More than 2000 different species of butterfly live in South America.

Around 8000 different species of plant are found in Central Africa.

### Activities

1. In which of these locations would you not find tropical rainforests?
   A. Amazon River basin
   B. Southeast Asia
   C. Namibia in southern Africa
   D. Queensland, Australia

2. Describe, using examples, how plants have adapted to survive in the tropical rainforest.
Why are coral reefs such a unique ecosystem?

Where are coral reefs found in the world?
Coral reefs are found within 30° north and south of the Equator in tropical and sub-tropical oceans. Locations include:

- the western Atlantic Ocean including Bermuda, the Bahamas, Belize, Florida and the Gulf of Mexico
- an Indian and Pacific Ocean region extending from the Red Sea and Persian Gulf through to the western coast of Panama
- some areas of the Gulf of California
- the Great Barrier Reef off the eastern coast of Australia. This is the largest reef at 1500 km long and covering an area of 284,300 km². It is broken up into 2900 different reefs.

In total, 109 countries in the world have coral reefs in their waters.

What are the ideal environmental conditions for coral reefs to grow?
For coral to grow, there needs to be warm water all year around with a mean temperature of 18°C. The water also needs to be clear and shallow – no deeper than 30 metres. Beyond this, there is not enough sunlight for photosynthesis. Coral reefs are located on the seabed around the land, before the water depth increases. This is known as the continental shelf.
What flora and fauna are found in coral reefs?

Coral reefs are some of the most productive and diverse ecosystems on Earth. In fact, they are known as the ‘rainforests of the oceans’. Less than one per cent (about the size of France) of the world’s ocean surface is made up of coral reefs, yet it is estimated that they contain 25 per cent of all marine life. These species depend on the reef for food and shelter.

Coral reefs are made up of thousands of coral polyps which live together in reefs or colonies. Although coral may look like a plant, it is actually an animal related to the jellyfish. A single polyp is 2–3 cm in length and feeds on tiny organisms such as plankton. Each polyp is a small and simple organism consisting of a stomach topped with a mouth and tentacles. They can secrete calcium carbonate to make a mineral skeleton which helps to build the structure of the reef. Corals take a long time to grow, averaging between 0.5 cm and 2 cm per year.

There is a relatively small range of plant life in coral reefs. The algae on the coral produce energy through photosynthesis, giving the coral its vibrant range of colours. Sea grasses such as turtle grass and manatee grass are commonly found in the Caribbean Sea. Unlike algae, sea grasses are flowering plants. They provide shelter and a habitat for reef animals such as the young of lobsters and provide food for herbivores such as reef fish.

Some estimates suggest that there are up to two million species living in coral reefs and 4000 species of fish alone. Some species include:

- parrot fish – feed directly on polyps, tearing coral to get to them
- starfish – produce digestive juices that they squirt into the polyps, then suck out the middle like a soup
- clams – settle on the coral bed and filter plankton from seawater
- eels – live within the coral, pouncing on small fish
- molluscs, worms, crustaceans and sponges
- larger mammals such as dugongs, which are related to elephants; they consume large quantities of sea grass.

**Figure 13:** Coral sea, Queensland in Australia

---

**Activities**

1. Annotate a world map with the main locations of coral reefs in the world. Add the lines of latitude.
2. Describe the distribution shown on your map.
3. What is a polyp?
4. Suggest how two species have adapted to survive in the coral reef.
5. Why are coral reefs often compared to tropical rainforests?
What are the characteristics of tropical grasslands?

Where are they located?
Tropical grasslands, also known as savannah, are located between the latitudes of 5° and 30° north and south of the Equator, within central parts of continents. This includes:

- most of central Africa surrounding the Congo Basin
- parts of Venezuela
- the Brazilian highlands
- Mexico
- northern Australia.

What is the climate of the tropical grasslands?

The savannah region ranges from the fringes of the rainforest to the beginnings of the desert ecosystem. Consequently, the climate can range from tropical wet to tropical dry. Temperatures are high throughout the year. Cloud cover is limited for most of the year, allowing for daily temperatures of 25°C. The main characteristic of the climate in tropical grasslands is that there are two seasons: a longer dry season and a shorter wet season.

The annual range of temperatures is slightly larger than that of tropical rainforests as a result of the reduced angle of the Sun in the sky for part of the year. The wet, or rainy, season occurs when the Sun moves overhead, bringing with it the ITCZ (also known as the heat equator; see Chapter 1, Figure 28 on page 14). This is a belt of low pressure which brings bursts of heavy rainfall. In fact, 80 per cent of the annual rainfall occurs in the 4–5 months of the wet season. As the ITCZ moves away, the dry season begins. During the longer dry season, rainfall can be as low as 100 mm. Figure 16 shows how the ITCZ shifts to create the two seasons.

| Figure 14: Climate graph for Kano, Nigeria |

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</table>

**Key**
- Rainfall (mm)
- Temperature (°C)

**Figure 15: The movement of the ITCZ, creating wet and dry seasons**
What flora and fauna are found in tropical grasslands?

The length of the growing season depends on how long the rainy season lasts. With the summer rain, the grasses, such as the tall and spiky pampas grass, grow very quickly to over 3 metres in height. The baobab tree has adapted to the climate of the tropical grasslands by growing large swollen stems and a trunk with a diameter of 10 metres (see Figure 17). The root-like branches hold only a small number of leaves to reduce the loss of water vapour by a process called transpiration. The bark of baobab trees is thick to retain moisture and roots are long to tap into supplies of water deep within the ground. Many trees are also drought-resistant (xerophytic) or fire-resistant (pyrophytic) as a means of surviving the long dry season.

The savannah grasslands of Africa contain the world’s greatest diversity of hoofed animals with over 40 different species. The grasslands are home to herds of plant-eating animals known as herbivores. Antelopes are very diverse, and include gazelles and impalas. Up to 16 grazing species can live in the same area of grassland, including elephants, giraffes, wildebeest, zebras and rhinos. African elephants are the largest mammals in the world. The carnivores (meat-eating animals) in this ecosystem stalk the herds; these include cats such as cheetahs, lions and leopards as well as dogs and hyenas.

Activities

1. How does the baobab tree survive in the tropical grasslands?
2. What is the difference between xerophytic and pyrophytic trees?
3. Using Figures 15 and 16, explain how the movement of the ITCZ affects the climate.
What are the characteristics of temperate grasslands?

Where are they located?
Temperate grasslands lie in the centre of continents, between the latitudes of around 40–60° north of the Equator. The major temperate grasslands include the:
- plains of North America
- veldts of Africa
- pampas of South America
- steppes of Eurasia.

What is the climate of the temperate grasslands?
The climate of the temperate grasslands is cooler than that of the savannah. It is an ecosystem of extremes. Summers are very hot and winters are very cold. Summer temperatures can reach over 38°C and winter temperatures can plummet as low as −40°C. Average rainfall varies from 250 mm to 750 mm. Around 75 per cent of this rainfall occurs during the summer growing season. Snow acts as a reservoir of moisture to help the start of the summer growing season as it melts. The summer months can bring periods of drought and the occasional fire which helps to maintain the grasslands.

What flora and fauna are found in temperate grasslands?
The length of the growing season depends on the temperature. Vegetation does not grow as rapidly or as tall as that of the tropical grasslands. Trees and shrubs struggle to grow, but some trees, such as willow and oak, grow along river valleys where more water is available. Tussock grasses reach heights of 2 m and are found in clumps on the landscapes. Grasses, such as buffalo and feather grass, grow more evenly across the land, up to around 50 cm in height. Flowers including sunflowers and wild indigos can grow among the grasses.

The grasses provide a good habitat for burrowing animals such as gophers and rabbits and large herbivores such as kangaroos, bison and antelopes. Bison are typically found in the prairies of North America (Figure 17). The carnivores in temperate grasslands include coyotes and wolves as well as large birds such as eagles and hawks.

### Activity

1. Copy and complete the following table by summarising the key characteristics of tropical and temperate grasslands.

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<th>Tropical grasslands</th>
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</tbody>
</table>
What are the characteristics of the temperate forest ecosystem?

Where are temperate forests found?
Temperate forests are found between 40° and 60° north and south of the equator. Temperate refers to the temperature; it gets neither too hot nor too cold. It means 'not to extremes'. Temperate forest covers a wide range of forest types and their native flora and fauna, but the forests are mostly made up of deciduous or evergreen trees (see Figure 21). It is also possible to find temperate rainforests and temperate coniferous (needle-like leaves) forests in the world.

<table>
<thead>
<tr>
<th>Deciduous</th>
<th>Evergreen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Moist, warm summers and frosty winters</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Reliably high, year-round rainfall</td>
</tr>
<tr>
<td>Locations</td>
<td>Northern hemisphere including eastern North America, eastern Asia and western Europe (including the British Isles)</td>
</tr>
<tr>
<td></td>
<td>New Zealand, parts of South America, eastern Australia, southern China, Korea and Japan</td>
</tr>
</tbody>
</table>

What is the climate like in temperate forests?
Due to the tilt of the Earth, the Sun's rays hit different parts of the planet more directly at different times of the year. This has created four seasons of equal length: winter, spring, summer and autumn. This is where temperate forests thrive. Summers are warm and winters are mild. Rainfall ranges from 750 mm to 1500 mm and the average annual temperature is 10°C. An insulating layer of cloud cover helps to keep the temperature mostly above freezing. Precipitation falls throughout the year. Snow is common in mountainous areas during the winter, but is unlikely to settle at lower levels.

The temperate forest ecosystem has the second highest rainfall after tropical rainforests. This is largely due to their location at the meeting point of the Ferrell and polar cells. The warm tropical air is forced to rise over the denser, cold polar air. This creates an area of low pressure and subsequent rainfall (see Chapter 1, pages 2–3).

▲ Figure 20: Comparisons between different types of temperate forest

▲ Figure 21: Climate graph for Kilkenny, Ireland

▲ Figure 22: Red deer under an oak tree in Richmond Park, England
What flora and fauna are found in temperate forests?

There are relatively few tree species when compared with the rainforest. Trees have a growing season of 6–8 months and may grow only 50 cm per year. Deciduous trees shed their leaves during the winter season. Leaves turn a spectacular range of reds, oranges and yellows during the autumn before they fall to the ground. In Britain, oak trees can reach heights of 30–40 metres. A single oak tree can produce 90,000 acorns in one year. Elm, beech, sycamore and chestnut trees grow less tall and have broad, thin leaves. Beneath this canopy is a lower shrub layer, known as the understorey. Trees and shrubs here vary in height from 5 metres for hawthorns to 20 metres for ash and birch trees. Unlike the rainforest, branches of the higher trees are more open and allow enough sunlight through to enable smaller trees to grow. The forest floor is often covered with brambles, grass, bracken and thorns.

Animals must adapt to cope with the colder winters and warmer summer months. Some animals migrate to warmer places and others hibernate to escape the cold. The types of fauna often depend on the region of the world. Many species are native to certain places, so they may only be found there. For example, Australia’s temperate forests contain marsupial species such as koalas and opossums which are not found anywhere else in the world.

Black bears are found in the temperate forests of North America. They have adapted well to the conditions here. They have a heavy coat made of many layers of fur and build up a five-inch layer of fat before hibernating for the winter. Black bears also have long claws to climb trees and are omnivores. This means that they eat can plants and animals.

In the northern hemisphere, squirrels are widespread. Owls and pigeons are found in almost all temperate forests as are an abundance of other bird species. In Britain, rabbits, deer, mice and foxes are commonly found animal species.

What are the characteristics of the hot deserts?

Where are deserts found?

Deserts cover one-fifth of the Earth’s land surface. They are located between 5° and 30° north and south of the Equator, around the Tropic of Cancer and the Tropic of Capricorn. They are usually found on the west coast of continents. The extensive Sahara and the Arabian desert cover the African and Asian land mass, respectively. The Sahara covers a staggering land area of 9 million km², that is the same size as 37 UK!

What is the climate like in hot deserts?

Due to their location near the tropics, deserts experience a fairly high number of daylight hours ranging from 14 hours in the summer to 10 hours in the winter. During the day, temperatures can reach 36°C, with extremes of 50°C recorded. At night, however, temperatures plummet to well below freezing. During the day, high levels of input from the Sun raise the temperatures. Bare rock and sand will also heat up. The lack of clouds in the sky means that the heat from the day escapes readily into the atmosphere during the night, causing temperatures to fall dramatically to −12°C or lower.
Annual precipitation is around 40 mm and extremely unreliable. In Death Valley in California, rain may fall only once every 2–3 years. The baked ground makes infiltration, the process where water passes through the surface of the ground, very limited. As a result, the water sits on the surface and evaporates rapidly in the heat of the day.

What flora and fauna are found in hot deserts?
In desert climates, vegetation needs to be resistant to the lack of moisture and intense heat. Most plants are xerophytic, meaning that they have adapted to an environment with very little water. Cacti and yucca plants are found in the driest and hottest places. Where the rainfall is slightly higher, thin grasses grow. Where bushes grow, they are far apart to avoid competition for water.

Cacti absorb large amounts of water during the rare periods of rain. They have thick, spiky, waxy leaves to reduce the loss of water through transpiration and to prevent animals from trying to eat them. Roots of xerophytes do one of two things. They are either very long, like those of the acacia tree with roots exceeding 15 metres to tap into groundwater supplies, or they are near the ground’s surface and spread over a large area to take advantage of any rain that falls.

When a storm occurs, the desert bursts into life. Plant seeds then lie dormant for many months or years, awaiting the next downpour.

The lack of food in the form of plants makes it difficult for deserts to support many animal species. The desert ecosystem is very fragile as animals do not have alternative food sources which may be available in other ecosystems. Many animals are small and nocturnal, meaning that they only come out at night. With the exception of camels, animals would not be able to survive in hot sun so are likely to burrow into the sand during the heat of the day.

Animals have adapted considerably to survive in the desert.

- Meerkats, which live in the harsh land of the Kalahari Desert in southern Africa, occupy complex underground tunnel systems. They have adapted to the limited food sources by feeding on scorpions, whose venom they are immune to. They also eat lizards and small rodents.
- Camels have humps on their backs that store fat and water. They also have thick hair on their ears, long eyelashes for keeping out the sand and wide feet that act like snowshoes.
- Sidewinder rattlesnakes are found in the Mojave Desert in southwest USA and the Namib Desert in southern Africa. Their unusual sideways motion helps them to keep moving in shifting sands and ensures that only two parts of their body are touching the hot ground at any one time.

Activities

1. Suggest two reasons to explain why the temperature varies so much during a day in the desert.
2. For either flora or fauna, explain how species have adapted to survive in the hostile desert climate.

Take it further

3. Choose one major desert in the world. Create a fact file, or a class presentation, about your chosen desert. Create three to five of your own enquiry questions to guide your research.