UNIT 1 LANDFORMS AND LANDSCAPES

TOPIC 4
Desert landscapes

4.1 Overview
Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

4.1.1 Introduction
Approximately one-third of the Earth’s land surface is desert — arid land with little rainfall. These arid regions may be hot or cold. The actions of wind and, sometimes, water shape the rich variety of landscapes found there.

Arches in a desert landscape, Utah, United States
4.2 What is a desert?

4.2.1 Defining a desert

A desert is a hot or cold region with little or no rainfall. Around one-third of the Earth’s surface is desert and is home to about 300 million people.

Although they receive little rainfall, most deserts receive some form of precipitation. When it does rain, it is usually during a few heavy storms that last a short time.

<table>
<thead>
<tr>
<th>Rainfall (mm/year)</th>
<th>Type of desert</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25</td>
<td>Hyper-arid</td>
<td>Namib; Arabian</td>
</tr>
<tr>
<td>25–200</td>
<td>Arid</td>
<td>Mojave</td>
</tr>
<tr>
<td>200–500</td>
<td>Semi-arid</td>
<td>Parts of Sonoran Desert</td>
</tr>
</tbody>
</table>

TABLE 1 Types of deserts
4.2.2 Hot deserts
Most of the world’s hot deserts are located between the Tropic of Cancer and the Tropic of Capricorn (see figure 3). They have very hot summers and warm winters. Temperature extremes are common, because cloud cover is rare and humidity is very low; this means there is nothing to block the heat of the sun during the day, or prevent its loss at night. Temperatures can range between around 45 °C and –15 °C in a 24-hour period.

4.2.3 Cold deserts
Cold deserts lie on high ground generally north of the Tropic of Cancer and south of the Tropic of Capricorn (see figure 3). They include the polar deserts. Any precipitation falls as snow. Winters are very cold and often windy; summers are dry and cool to mild.
4.2.4 Deserts of the world

FIGURE 3 The distribution of the world’s deserts.

1 **Gobi Desert**: Asia’s biggest desert, the Gobi, is a cold desert. It sits some 900 metres above sea level and covers an area of some 1.2 million square kilometres. Its winters can be freezing.

2 **Turkestan Desert**: The cold Turkestan Desert covers parts of south-western Russia and the Middle East.

3 **Arabian Desert**: This hot desert is as big as the deserts of Australia. Towards its south is a place called Rub al-Khali (meaning ‘empty quarter’), which has the largest area of unbroken sand dunes, or erg, in the world.

4 **Takla Makan Desert**: The Takla Makan Desert is a cold desert in western China. Its name means ‘place of no return’. The explorer Marco Polo crossed it some 800 years ago.

5 **Thar Desert**: The Thar Desert is a hot desert covering north-western parts of India and Pakistan. Small villages of around 20 houses dot the landscape.

6 **Kalahari and Namib deserts**: The Namib Desert extends for 1200 kilometres down the coast of Angola, Namibia and South Africa. It seldom rains there, but an early-morning fog often streams across the desert from the ocean. The dew it leaves behind provides moisture for plants and animals. It joins the Kalahari Desert, which is about 1200 metres above sea level.

7 **Antarctic Desert**: The world’s biggest and driest desert, the continent of Antarctica, is another cold desert. Only snow falls there, equal to about 50 millimetres of rain per year.

8 **Atacama Desert**: The Atacama Desert is the driest hot desert in the world. Its annual average rainfall is a tiny 0.1 millimetre.

9 **Patagonian Desert**: The summer temperature of this cold desert rarely rises above 12 °C. In winter, it is likely to be well below zero, with freezing winds and snowfalls.

10 **Iranian Desert**: Two large deserts extend over much of central Iran. The Dasht-i-Lut is covered with sand and rock, and the Dasht-i-Kavir, mainly in salt. Both have virtually no human populations.

11 **North American deserts**: The desert region in North America is made up of the Mojave, Sonoran and Chihuahuan deserts (all hot deserts) and the Great Basin (a cold desert). The Great Basin’s deepest depression, Death Valley, is the lowest point in North America.

12 **Australian deserts**: After Antarctica, Australia is the driest continent in the world. Its deserts are generally flat lands, often vibrant in colour.

13 **Sahara Desert**: The largest hot desert in the world, the Sahara stretches some nine million square kilometres across northern Africa over 12 countries. Only a small part is sandy. It is the sunniest place in the world.
4.2 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What climate conditions are needed for hot and cold deserts to form?
2. Where is the sunniest place in the world?
3. Name three deserts in the Asia–Pacific region.

Explain
4. Describe key differences between hot and cold deserts.

Discover
5. Look carefully at the map in figure 3, and the text.
   (a) Which continent has the largest area of hot desert?
   (b) Which continent has the largest area of cold desert?
   (c) What is the largest hot desert in the world?
   (d) What is the largest hot desert in the Asia–Pacific region?
   (e) Which is the driest continent in the world?
   (f) Which continent contains the driest hot desert?
   (g) Which North American desert contains the lowest land on the continent?

Think
6. Use the information in this subtopic to design a quiz of 10 questions entitled ‘Deserts of the world’. Test your friends and family.
7. Draw up and complete a table like the one below to show your understanding of the locations and features of desert environments. Look for photos on the internet.

<table>
<thead>
<tr>
<th>Name of desert</th>
<th>Mountain range</th>
<th>Continent</th>
<th>Ocean current</th>
<th>Photos</th>
</tr>
</thead>
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learnON RESOURCES — ONLINE ONLY

Try out this interactivity: Great deserts of the world: Use this interactivity to check your knowledge of some of the main hot and cold deserts of the world

Searchlight ID: int-3106
4.3 SkillBuilder: Using latitude and longitude

WHAT IS LATITUDE AND LONGITUDE?
Latitude and longitude are imaginary grid lines encircling the Earth. The lines that run parallel to the equator are called **parallels of latitude** and are measured in degrees. Lines of longitude run from north to south from the North Pole to the South Pole. These are called **meridians of longitude** and are also measured in degrees. Lines of latitude and longitude are drawn on maps to help us locate places.

Go online to access:
- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

learnon RESOURCES — ONLINE ONLY

- Watch this eLesson: Watch this video to learn how to use latitude and longitude. Searchlight ID: eles-1652
- Try out this interactivity: Use this interactivity to learn how to use latitude and longitude. Searchlight ID: int-3148

4.4 What type of climate forms deserts?

4.4.1 The subtropics
Deserts form in many different parts of the globe: the subtropics; continental interior areas at middle latitudes; on the leeward side of mountain ranges; along coastal areas; and in the polar regions. The only common factor is their low rainfall — but why do these areas experience low rainfall?

Most of the world’s greatest deserts are found in the subtropics near the Tropics of Cancer and Capricorn.

Because of the way the Earth rotates around the sun, areas around the equator receive more direct sunlight than anywhere else on Earth. This means the air there is always very hot. Hot air can hold much more moisture than cold air, so the humidity in these areas is always very high. (If you have ever visited...
or live near a tropical rainforest or northern Australia, you will have experienced this hot humidity.) Hot air also rises. As the air heads upwards into the atmosphere above the equator, it drifts away, heading north and south.

The higher the air gets, the cooler it becomes. Cool air can’t hold as much moisture, so it releases it as rain. Areas around the equator and to the immediate north and south of it (the tropics) receive frequent heavy downpours (see figure 1).

With its moisture gone, the cool, dry air continues moving north and south away from the equator until it meets zones of high air pressure around the tropics. Here, it is forced downwards. The more the dry air descends, the warmer it gets. This means it can hold more moisture and it is likely to absorb any moisture that already exists in this environment. It is like using a sponge to wipe up some water on the kitchen bench; a dry sponge will absorb more of the spill than a wet sponge. This is how the subtropical deserts form.

Temperatures in these deserts are usually high all year round. In summer the heat is extreme, with daytime temperatures often going above 38 °C and sometimes as high as 49 °C. At night — with no clouds to provide insulation — temperatures drop quickly to an average of 21 °C in summer and sometimes below freezing during winter.

4.4.2 Rain-shadow deserts

Rain shadows form on the leeward side of a mountain range (opposite the windward side that faces rain-bearing winds). Deserts commonly form in rain shadows.

• Moist air blowing in from the ocean is forced to rise up when it hits a range of mountains. This cools it down. As cool air cannot hold as much moisture, it releases it as precipitation (see figure 3).
• By the time the air moves over the top of the range and down the other side, it is likely to have lost most, if not all, of its moisture. It will therefore be fairly dry.
• The more the air descends on the other side of the range, the more it warms up. Hence, it can hold more moisture. So, as well as not bringing any rain to the land, the air absorbs what little moisture the land contains.
• In time, as this pattern continues, the country in the rain shadow of the mountain range is likely to become arid.

An example of this is the Great Dividing Range in Australia; cool moist air produces winds on the eastern side of these mountains and desert to the west. The Mojave Desert in the south-western United States is located on the leeward side of the Sierra Nevada mountain range (figure 4).

4.4.3 Coastal deserts

Currents in the oceans are both warm and cold, and are always moving. Cold currents begin in polar and temperate waters (with moderate temperatures), and drift towards the equator. They flow in a clockwise pattern in the northern hemisphere, and in an anticlockwise pattern in the southern hemisphere. As they move, they cool the air above them (see figure 5).

If cold currents flow close to a coast, they can contribute to the creation of a desert. This occurs because cold ocean currents cause the air over the coast to become stable, which stops cloud formation. If the cool air the currents create blows in over warm land, the air warms up; it can then hold more moisture. It is therefore not likely to release any moisture it contains unless it is forced up by a mountain range. Large coastal deserts, including the Atacama Desert in Chile (figure 6) and the Namib Desert in Namibia (figure 7), are formed in this way.

4.4.4 Inland deserts

Some deserts form because they are so far inland that they are beyond the range of any rainfall. By the time winds reach these dry centres, they have dumped any rain they were carrying or have become so warm they cannot release any moisture they still hold. The air that enters such areas is usually extremely dry and the skies are cloudless for most of the year. Summer daytime temperatures can rise as high as those of subtropical deserts. In winter, however, temperatures are much lower. Average daily temperatures below freezing are common during winter.

Examples of inland deserts are the central deserts of Australia (see figure 8), the Thar Desert in north-west India and the vast Gobi and Takla Makan deserts of Central Asia.
4.4.5 Polar deserts

Polar deserts are areas with a precipitation rate of less than 250 millimetres per year and an average temperature lower than 10 °C during the warmest month of the year. Polar deserts cover almost five million square kilometres of our planet and consist mostly of rock or gravel plains. Snow dunes may be present in areas where precipitation occurs. Temperatures in polar deserts often alternate between freezing and thawing, a process that can create patterned textures on the ground as much as five metres across.

4.4.6 Desert climate

Temperature

One geographical characteristic of many deserts is the high temperature, which quickly evaporates any water that might be around. The Earth’s highest recorded temperature — 58 °C — occurred at El Azizi in the Libyan Desert of northern Africa on 13 September 1922.

During the summer of 1923–24, the semi-arid town of Marble Bar in Western Australia (average rainfall 361 mm per year) experienced temperatures of more than 37.8 °C for 160 days in a row, from 31 October 1923 to 7 April 1924. This set an Australian temperature record, and possibly a world record. During that summer the temperature at Marble Bar peaked at 47.5 °C on 18 January 1924.

Rainfall

Although low rainfall is a characteristic of deserts, rain does fall and violent storms can sometimes occur. A record 44 millimetres of rain once fell within three hours in the Sahara. Large Saharan storms may deliver up to one millimetre of rain per minute. Normally dry stream channels, called arroyos or wadis, can quickly fill after heavy rains, and flash floods make these channels dangerous.

Monthly data for rainfall and temperature can be used to create climographs for other desert locations such as Khormaksar in Yemen and Alice Springs in Australia (see table 1).
4.4 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. Decide whether the following statements are true or false. Rewrite the false statements to make them true.
   (a) The cooler the air, the more moisture it can hold.
   (b) Rain shadows often contain dry areas of land.
   (c) Cold ocean currents cool the air above them.
   (d) Deserts do not form along coastlines.

Explain

2. Use figure 1 to explain why deserts form around areas near the tropics but not at the equator. Alternatively, form small groups and create a short drama performance to explain the process.

3. Use figure 3 and any other information in this subtopic to write a paragraph explaining why deserts tend to form in rain shadows. Alternatively, form small groups and create a short drama performance to explain the process.

4. Why do temperatures in deserts drop so much at night after being so high during the day?

Discover

5. Use the Desert rain weblink in the Resources tab to watch a video about desert rain, and then answer the following questions.
   (a) What is a flash flood?
   (b) What happens to water as it flows over sand? Think of what happens to water at the beach.
   (c) How do animals and plants respond to these rare water events?
   (d) Describe how the landscape quickly changes once there is water in the desert.

Think

6. Draw a diagram to explain how cold ocean currents influence the formation of a desert environment along the Western Australian coastline.

7. Use tables 1a and 1b to draw climate graphs for Khormaksar, Yemen, and Alice Springs, Australia.

<table>
<thead>
<tr>
<th>TABLE 1 Climate data for (a) Khormaksar, Yemen, and (b) Alice Springs, Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Khormaksar, Yemen</td>
</tr>
<tr>
<td>Jan</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>25.0</td>
</tr>
<tr>
<td>(b) Alice Springs, Australia</td>
</tr>
<tr>
<td>Jan</td>
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<td>------</td>
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<tr>
<td>28.5</td>
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</tbody>
</table>
4.5 What are the processes that shape desert landforms?

4.5.1 Shaping the desert

Although most people imagine a sea of sand when they think of deserts, sand covers only about 20 per cent of the world’s deserts. Sand is the end product of millions of years of erosion of other landforms such as rock and plateaus that, over time, are worn away by extremes of temperature, wind and water.

The landforms and patterns of a desert are created by a number of natural processes. The unprotected land surfaces are prone to erosion. After heavy rain, often a long distance from the desert flood plains, erosion of ancient river channels can be major. Extreme temperatures, along with strong winds and the rushing water that can follow a desert rainstorm, cause rocks to crack and break down into smaller fragments. This process is called weathering.

Erosional landforms

The process of erosion removes material such as weathered rock. Most erosion in deserts is caused by wind and, at times, running water. During heavy rainfall, water carves channels in the ground. Fast-flowing water can carry rocks and sand, which help to scour the sides of the channel. As vegetation is usually sparse or non-existent, there are few roots to hold the soil together. Eventually, deep gullies called wadis can form.

Erosion can also result from the action of wind and from chemical reactions. Some rock types, such as limestone, contain compounds that react with rainwater and then dissolve in it. Wind is a very important agent of transport and deposition, and can change the shape of land by abrasion — the wearing down of surfaces by the grinding and sandblasting action of windborne particles.

**FIGURE 1 Desert landforms**

1. A butte is the remaining solid core of what was once a mesa. It often is shaped like a castle or a tower.
2. Crescent-shaped barchan dunes are produced when sand cover is fairly light.
3. An arch, or window, is an opening in a rocky wall that has been carved out over millions of years by erosion.
4. An alluvial fan is the semicircular build-up of material that collects at the base of slopes and at the end of wadis after being deposited there by water and wind.
Depositional landforms

Materials carried along by rushing water and wind must eventually be put down. Over time these materials build up, forming different shapes and patterns in the desert. This process is called deposition. Depositional landforms in deserts include alluvial fans, playa lakes, salt flats, and various types of sand dunes (see figure 1).

4.5.2 Sand dunes = depositional landforms

Different dune shapes are created by the action of the wind (see figure 2). These include crescent, linear, star, dome, and parabolic. The most common are the crescent-shaped dunes that are formed when the wind blows in one direction (figure 3). They are usually wider than they are long and can move very quickly across desert landscapes.

Linear dunes are a series of dunes running parallel to each other. They can vary in length from a few metres to over 100 kilometres. It appears that winds blowing in opposite directions help create these dunes. The Simpson Desert in central Australia has linear dunes (figure 4).

A playa lake may cover a wide area, but it is never deep. Most water in it evaporates, leaving a layer of salt on the surface. These salt-covered stretches are called salt pans.

Clay pans are low-lying sections of ground that may remain wet and muddy for some time.

The rippled surface on transverse dunes is the result of a gentle breeze blowing in the one direction.

An oasis is a fertile spot in a desert. It receives water from underground supplies.

A mesa is a plateau-like section of higher land with a flat top and steep sides. The flat surface was once the ground level, before weathering and erosion took their toll.

Sand dunes often start as small mounds of sand that collect around an object such as a rock. As they grow larger, they are moved and shaped by wind.

An inselberg is a solid rock formation that was once below ground level. As the softer land around it erodes, it becomes more and more prominent. Uluru is an inselberg.

A chimney rock is the pillar-like remains of a butte.

Star dunes are produced by wind gusts that swirl in from all directions.

Strong winds blowing in one direction form longitudinal dunes.
Star dunes have ‘arms’ that radiate from a high central pyramid-shaped mound (figure 5). They form in regions that have winds blowing in many different directions and can become very tall rather than wide — some are up to 500 metres high.

Dome dunes are made up of fine sand without a steep side. These rounded structures tend to be only one or two metres high and are very rare (figure 6).

Parabolic dunes have a U shape and do not get very high (figure 7). They often occur in coastal deserts. The longer section follows the ‘head’ of the dune (the opposite process to the formation of crescent dunes) because vegetation has anchored them in place. The arms can be long — in one case, measured at 12 kilometres.

4.5.3 Playas and pans = another depositional landform

A desert basin may fill with water after heavy rains to form a shallow lake, but for the majority of the time the often salt-encrusted surface is hard and dry. Such expanses of land are known as playas, saltpans or hardpans. The flat terrains of pans and playas make them excellent race tracks and natural runways for aeroplanes and spacecraft. Ground-vehicle speed records are commonly established on Bonneville Speedway, a race track on the Great Salt Lake hardpan (figure 8). Space shuttles land on Rogers Lake playa at Edwards Air Force Base in California in the western United States.
4.5 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. List the agents of erosion and weathering in a desert. How does each process cause change in a desert?
2. Name two erosional and two depositional landforms in a desert.
3. Name the most common dune shapes that are formed in deserts.

Explain
4. Explain the difference between a mesa and a butte.
5. How does vegetation help to prevent erosion in a desert?
6. What wind conditions are needed to create a:
   (a) star dune
   (b) longitudinal dune
   (c) parallel dune?
7. Why do you think oases are such fertile places?
8. What do chimney rocks and arches have in common?

Discover
9. Locate all the desert places named in this subtopic. Use Google Maps to create your own map of these locations, and add some interesting facts and images of each location. Email a link to your completed map to your teacher.

Predict
10. Study the landforms labelled 1, 3 and 9 in figure 1. Sketch what each of these may look like in the future as erosion and weathering continue to occur.

Think
11. What do playa lakes and saltpans have in common?
12. Draw up a table like the one below.
   Continue to add the landforms shown in figure 1 to your table. Add examples of other desert landforms that you have found when researching this topic.

<table>
<thead>
<tr>
<th>Name of landform</th>
<th>Picture of landform</th>
<th>Location</th>
<th>Type of erosion (wind or water)</th>
<th>Type of deposition (wind or water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butte</td>
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<tr>
<td>Mesa</td>
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<td>Inselberg</td>
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13. Work in small groups to create a model of a desert (using plasticine or playdoh, for example) that contains a number of desert forms and patterns. Use figure 1 as a guide. Show your completed model to the other groups, then provide and respond to constructive feedback.
4.6 What are the characteristics of Australia’s deserts?

4.6.1 The location of Australia’s deserts

Australia is the world’s driest inhabited continent. Over 70 per cent of the country receives between 100 and 350 millimetres of rainfall annually, which makes most of Australia arid or semi-arid.

Australia’s deserts are subtropical and are located mainly in central and western Australia, making up about 18 per cent of the country (see figure 1). They are hot deserts, which means they are areas of little rainfall and extreme temperatures — rainfall can be less than 250 millimetres per year and temperatures can rise to over 50 °C. The average humidity is between 10 and 20 per cent. The desert terrain is very diverse and can range from red sand dunes to the polished stones of the gibber plains – the term gibber comes from an Aboriginal language word for stone.

Great Victoria Desert
The Great Victoria Desert, Australia’s largest, covers 424 400 square kilometres. It is not a desert of dunes, but has some desert-adapted plants including marble gums, mulga and spinifex grass. Part of this desert has been named a Biosphere Reserve by UNESCO and is one of the largest arid zone biospheres in the world.

Great Sandy Desert
The Great Sandy Desert makes up 3.5 per cent of Australia. The red sands of this desert reach almost to the Western Australia coast, where they join with the white sand of Eighty Mile Beach south of Broome.

Simpson Desert
The Simpson Desert is in one of the driest areas of Australia, with rainfall of less than 125 millimetres per year. It is located near the geographical centre of Australia. Dunes (see figure 2) make up nearly three-quarters of the desert. Long parallel dunes (see figure 4 in subtopic 4.5) form in a north–north-west/south–south east direction; some can be straight and unbroken for up to 300 kilometres and can be 40 metres high. The space between the dunes can vary from 100 metres to 1000 metres.

Strzelecki Desert
This desert is located within three states — far northern South Australia, south-west Queensland and western New South Wales. The dunes support vegetation such as sandhill wattle, needlebush and hard spinifex.

Tanami Desert
Located to the east of the Great Sandy Desert, this desert is mostly characterised by red sand plains with hills and ranges.
Little Sandy Desert
The Little Sandy Desert is located in Western Australia and borders three other deserts. Its landforms are similar to those in the Great Sandy Desert. It includes a vast salt lake called Lake Disappointment.

Sturt Stony Desert
The Sturt Stony Desert, located in north-eastern South Australia, is a harsh gibber desert covered in closely spaced glazed stones (figure 3). These are left behind when the wind blows away the loose sand between the dense covering of pebbles. The desert also contains some dunes and hills that are resistant to weathering.

Tirari Desert
This small desert covers almost 1600 square kilometres and is located in far northern South Australia, east of Lake Eyre. It contains many linear (parallel) dunes and salt lakes. Cooper Creek runs through the centre of the desert, as do many other intermittent creeks. Where there is enough water — usually in waterholes — river red gums and coolabah gums will grow. Tall, open shrubland also occurs in some areas.

Gibson Desert
The fifth largest in Australia, the Gibson Desert is located in Western Australia and borders three other deserts. It consists of sand plains and dunes plus some low, rocky ridges. Some small salt-water lakes are also present in the south-western part of the desert.

Pedirka Desert
The Pedirka Desert in South Australia is Australia’s smallest desert, located north-east of Oodnadatta. The lines of parallel red dunes run north-east to south-west, and the space between the dunes can be up to one kilometre. Hamilton Creek is located in this desert and its banks are home to river red gums, coolabah, mulga and prickly wattle. Other vegetation includes satiny bluebush, weeping emubush and spiny saltbush. Common grasses include woollybutt, broad-leaf wanderrie, mulga grass and bandicoot grass.
4.6 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Name the deserts bordered by:
   (a) the Gibson Desert
   (b) the Little Sandy Desert.
2. What is a gibber desert?
3. What percentage of Australia is arid or semi-arid?

Explain
4. Look at figure 1 showing the distribution of Australia’s deserts. Where are they located in terms of the tropics?

Discover
5. Several plants are listed in the descriptions in this subtopic on Australia’s deserts. Choose two different plant types (for example, a grass and a tree) and research how they are adapted to desert conditions.
6. Research the characteristics of the Biosphere Reserve declared by UNESCO that is located in the Great Victorian Desert.

Think
7. Use an atlas to find the locations of Brisbane, Geraldton and Exmouth. These places are located at the same latitude as many of Australia’s deserts. Use the BOM weblink in the Resources tab to find the average temperature, rainfall and humidity of these places.
   (a) How do these characteristics compare with the temperature, rainfall and humidity in Australia’s deserts?
   (b) How can you account for the differences?

4.7 SkillBuilder: Calculating distance using scale

WHAT DOES IT MEAN TO CALCULATE DISTANCE USING SCALE?
Calculating distance using scale involves working out the actual distance from one place to another using a map. The scale on a map allows you to convert distance on a map or photograph to distance in the real world. A linear scale is the easiest to use.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 Calculating distance using a linear scale on a map
4.8 How did Lake Mungo become dry?

4.8.1 Where are Lake Mungo and the Willandra Lakes located?

Lake Mungo, in Mungo National Park, is just one of 13 ancient dry lake beds in a section of the Willandra Lakes Region World Heritage area in semi-arid New South Wales. There is no water there now, yet the lakes were once full of water and teeming with life, supporting Aboriginal peoples since the beginning of the Dreamings (more than 47,000 years by European estimates) — archaeological records show this continuous human presence. What happened to change this environment into the semi-arid landscape it is today?

The Willandra Lakes are located in far south-western New South Wales and the region is part of the Murray–Darling River Basin. Lake Mungo is 110 kilometres north-east of Mildura, Victoria. The lakes were originally fed by water from Willandra Creek (see figure 1), which was a branch of the Lachlan River. The average rainfall in this area is 325 millimetres per year, making it a semi-arid desert region.

4.8.2 How has Lake Mungo changed over time?

40,000 years ago

During the last ice age, huge amounts of water filled the shallow lake. At its fullest, Lake Mungo was 6–8 metres deep and covered 130 square kilometres (more than twice the area of Sydney Harbour). The lakes were rich with life, including water birds, freshwater mussels, yabbies and fish such as golden perch and Murray cod. Giant
kangaroos, giant wombats, large emus and the buffalo-sized Zygomaturus — all now extinct — grazed around the water’s edge. Remains of more than 55 species have been found in the area and identified — 40 of these are no longer found in the region, and 11 are extinct.

Aboriginal peoples lived here in large numbers — evidence for this has been found in more than 150 human fossils, including ‘Mungo Lady’ discovered in 1968 and ‘Mungo Man’ in 1974, both believed to be over 40000 years old. The youngest fossil is 150 years old.

30 000–19 000 years ago

A west wind blows across this landscape. During low-water years, red dust and clay were blown across the plains to the eastern side of the lake and they mixed with the sand dunes on the edge of the lake (formed when the lake was full). This began the formation of lunettes (crescent-shaped dunes) on the east side — called ‘the Walls of China’ in Lake Mungo. Vegetation covered the dunes, protecting them.
19 000 years ago
The lakes were full of deep, relatively fresh water for a period of 30 000 years — with cycles of wet and dry occurring — which came to an end 19 000 years ago when the climate became drier and warmer. Eventually, the water stopped flowing into the lake system and it dried out.

Present day
Today, the lake beds are flat plains covered by low saltbush and bluebush as well as grasses. Grazing cattle and sheep (now no longer allowed in the national park) and rabbits have caused erosion of the lunettes and sand dunes, exposing the human and animal fossils that have since been discovered.

4.8.3 World Heritage listing
The Willandra Lakes Region, which includes Lake Mungo, is listed as a World Heritage Area. This region is important because of its archaeology (human skeletons, tools, shell middens and animal bones make up the oldest evidence of burial places in the world) and geomorphology (ancient and undisturbed landforms and sediments).

4.8 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What makes Lake Mungo and the Willandra Lakes region a semi-desert?
2. When did Lake Mungo dry up?
3. What is a lunette?

Explain
4. Describe how the lunettes formed over time.
5. Outline the evidence that shows that many Aboriginal peoples lived in this area.
6. What human activity caused the lunettes to erode? What did the erosion unearth?
7. Research what World Heritage listing means in terms of protecting this place. Why is it important?

Discover
8. Work in small groups to create an identification brochure with pictures and facts about these three extinct animals that once lived at Lake Mungo.
   - *Genyornis newtoni* (giant emu)
   - *Protemnodon goliah* (giant short-faced kangaroo)
   - *Zygomaturus tilodus* (Zygomaturus)

Think
9. Use the Timetoast weblink in the Resources tab, the information in this subtopic and images you find through online research to create your own colourful digital timeline of these changes that occurred at Lake Mungo.
4.9 How do people use deserts?

Access this subtopic at www.jacplus.com.au

4.10 Is Antarctica a desert?

4.10.1 Some facts about Antarctica

Like hot deserts, polar deserts are areas with annual precipitation of less than 250 millimetres, but they have a mean temperature during the warmest month of less than 10 °C. Polar deserts are found in both the Arctic and Antarctic regions of the world. Not only is Antarctica a desert — it is also the driest, coldest and windiest continent on Earth.

Australia is the driest inhabited continent on Earth. However, Antarctica is even drier. Much of Australia’s interior receives less than 250 millimetres of precipitation per year. The interior of Antarctica receives less than 50 millimetres. The coastal areas receive the highest levels of precipitation, but this is still only about 200 millimetres.

Most of Antarctica is too cold for rainfall; the majority of the precipitation falls as snow. Some valleys in Antarctica have received no rain for two million years. It also snows very little in Antarctica, particularly in the interior.

In places, the ice sheet in Antarctica is 4.8 kilometres deep (see figure 1). Most of the ice that covers the continent has been there for thousands of years. In winter, as the surrounding oceans freeze, the area of Antarctica is almost double that in summer.

How dry is dry?

Covered in ice, Antarctica may seem like the wettest place in the world, but it’s actually drier than the Sahara Desert. Despite this, Antarctica’s ice holds 70 per cent of the world’s fresh water supply.
Most places in Antarctica receive no rain or snow at all. Very cold air does not have the capacity to hold enough water to create rain or snow. This means that Antarctica is the world’s biggest desert. All drinking water in Antarctica is obtained by melting the ice. Unlike in hot deserts, there is little evaporation from Antarctica, so the relatively small amount of snow that does fall doesn’t disappear. Instead it builds up over hundreds and thousands of years into enormously thick ice sheets.

**How cold is cold?**

On 29 July 1983, Russian scientists at Vostok Base, high on Antarctica’s polar plateau, recorded a temperature of –89.2 °C, the lowest on record. During the coldest months (July to August), the average temperature at the South Pole is –60 °C. During the warmest months (December to January), it rises to –28 °C.

**Why is Antarctica so cold?**

There are three main reasons:

1. Antarctica’s position on the globe means that the sun’s rays strike the Earth’s surface at a low angle, and therefore have a much larger area to heat than at other places on the planet.
2. Most of the sun’s heat that does reach Antarctica is reflected back into space by the white ice that covers the continent. This also explains why you must always wear sunglasses or goggles in Antarctica.
3. Antarctica is surrounded by the cold waters of the Southern Ocean.

**How windy is windy?**

Australia’s greatest polar explorer, Douglas Mawson, called Antarctica ‘the home of the blizzard’. He should know. He lived in a wooden hut for two complete Antarctic winters, in the strongest winds ever recorded. Mawson’s measurements revealed an average wind speed of over 70 kilometres per hour and gusts of over 300 kilometres per hour! The men in his expedition team always carried an ice axe with them to avoid being blown into the sea.

**Why is Antarctica so windy?**

As the air over the polar plateau becomes colder, it becomes more dense. Finally gravity pulls it down off the plateau towards the Antarctic coast. This creates very strong winds, called *katabatic winds*, which can blow continually for weeks on end and carry small pellets of ice. These winds combined with the severe cold can be fatal; at –20 °C, exposed human flesh begins to freeze when the wind reaches only 14 kilometres per hour.

Katabatic winds also cause *blizzards*, which sweep up loose snow and blow it about ferociously. Such blizzards were the cause of death among many early Antarctic explorers.

The winds also shape the landscape, carving it into irregular shapes called *sastrugi* (see figure 3). These shapes range in height from 150 millimetres to two metres. Travelling across sastrugi is extremely difficult.
4.10 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. List three facts about Antarctica that you found the most surprising.
2. Why does Antarctica double in area every winter?
3. What is the coldest temperature ever recorded in Antarctica, and in which place did this occur?

Explain
4. Antarctica is sometimes described as the world’s biggest desert. Why?
5. Describe and explain why Antarctica is so dry, cold and windy.
6. Examine the photograph in figure 3 and describe how this landscape has been formed. How does this environment pose a risk to people?

Discover
7. Use the Antarctic weather and BOM weblinks in the Resources tab to describe the weather conditions now at the South Pole. Compare these to the conditions where you live.
8. Use an atlas to measure the distance from Antarctica (coastline) to South America, Australia and South Africa.

Predict
9. What might happen to Antarctica if the ice shelves on top of the mountains were to melt? What changes might happen to sea levels around the world? Work with a partner to construct a concept map to record all your ideas.

Think
10. Use the information in table 1 to draw a climograph of McMurdo Station. How does it compare to Mawson Base (see figure 2)? Find climate data for the place where you live and draw another climograph for that location. Compare this to the two Antarctic climographs. Outline the similarities and differences and provide reasons for these.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Climate data for the American McMurdo station in Antarctica: latitude 77.88°S, longitude 166.73°E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>Feb</td>
</tr>
<tr>
<td>Average daily temperature (°C)</td>
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</tr>
<tr>
<td>−2.9</td>
<td>−9.5</td>
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<tr>
<td>Mean monthly rainfall (mm)</td>
<td>15</td>
</tr>
</tbody>
</table>

Learnon RESOURCES — ONLINE ONLY

Explore more with this weblink: Antarctic weather
Explore more with this weblink: BOM
4.11 How do people use Antarctica?

4.11.1 Introduction

Antarctica and the seas that surround it contain valuable resources. Antarctica is also the temporary home of more than 4000 people in summer and 1000 in winter. Most are scientists and support staff. These people work in more than 66 research stations representing 30 different nations.

![Image of Esperanza, an Argentinian research base in Antarctica](image)

4.11.2 Mining

There are great difficulties in looking for mineral deposits in rocks that lie beneath thousands of metres of ice. Therefore, most exploration has taken place in the ice-free areas of Antarctica. Scientists now believe there are deposits of many valuable minerals in Antarctica, including coal, iron ore, copper, lead and uranium, and traces of minerals such as gold and zinc. There are also mineral beds lying under the continent’s Transantarctic Mountains, and large areas that may contain deposits of oil and gas (see figure 2).

Despite the presence of these valuable minerals, there are no operating mines in Antarctica. Given the conditions — the extreme cold, the rough seas and the wind — mining operations would be very difficult and potentially dangerous to the environment. Mining (other than for scientific purposes) is banned under the Antarctic Treaty. This is to prevent the possibility of polluting the environment (for example, through an oil spill or by digging a quarry).

The Antarctic Treaty

By the mid-1950s, Australia, New Zealand, the United Kingdom, France and Argentina were actively exploring Antarctica. These countries declared territorial claims over parts of Antarctica while others were fishing, whaling and conducting scientific research and mineral exploration in the region.
People began to realise that this unique wilderness needed to be protected. In 1958, 12 countries agreed to preserve Antarctica. This led to an international agreement called the Antarctic Treaty, which came into force in 1961. The **treaty** covers the area south of 60°S latitude. It has been signed by more than 52 countries who meet regularly to discuss issues affecting Antarctica. The treaty:

- prohibits military activity
- protects the Antarctic environment
- fosters scientific research
- recognises the need to protect Antarctica from uncontrolled destruction and interference by people.

### 4.11.3 Tourism

The number of tourists to Antarctica has increased significantly since the mid-1990s, with a peak of more than 45,000 in 2007–08. However, more people will attend one game of AFL football in Melbourne than will visit Antarctica in one year. Given the scale (size) of Antarctica, tourist numbers are therefore still small.

Most tourists go to Antarctica on board cruise ships. There are opportunities for people to land on the ice. This often requires use of a Zodiac inflatable boat between ship and shore. There are no tourist facilities on Antarctica — people must return to the ships, for example, to sleep, eat and shower.

Sightseeing is the main activity for tourists. Other activities include kayaking, visiting research stations, walking and snowboarding. Other types of tourism include flights over the continent and flights that include landing on the ice.

Tourism can create problems, such as pollution from oil spills and disturbance to animal colonies. Therefore, the International Association of Antarctica Tour Operators has set up rules to control tourism. For example, no more than 100 passengers from a cruise ship may be landed at a location in Antarctica at any one time.
Bases on ice

Most of Antarctica’s scientific bases are located on the coast so people and supplies can be brought in by boat or air (see figure 3). They are also situated on the two per cent of Antarctica not covered in ice, as bases built on ice tend to sink under their own weight. This is because the heat they generate can melt ice around and beneath them.

Some bases are inland. There is even a permanent scientific base at the South Pole: the American Amundsen–Scott Base. Australia operates three permanent bases in Antarctica — Casey, Mawson and Davis stations — plus one on Macquarie Island and five temporary summer bases.

In January 2008 an air link between Australia and Antarctica was officially opened. The Wilkins runway is a four-kilometre-long airstrip about 70 kilometres from Casey Station. Scientists can now get to Antarctica in a few hours from Australia rather than a few weeks on a ship. They can study the world’s weather, climate, marine and land biology, glaciers, magnetics, geology and the ozone layer, as well as human physiology. Ice cores can provide a record of climate change over a long period of time.

<table>
<thead>
<tr>
<th>Year</th>
<th>Tourist numbers</th>
<th>Year</th>
<th>Tourist numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996–97</td>
<td>7330</td>
<td>2006–07</td>
<td>29 823</td>
</tr>
<tr>
<td>1997–98</td>
<td>9604</td>
<td>2007–08</td>
<td>46 069</td>
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<td>1998–99</td>
<td>10 013</td>
<td>2008–09</td>
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<td>1999–2000</td>
<td>14 762</td>
<td>2009–10</td>
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<td>12 248</td>
<td>2010–11</td>
<td>33 824</td>
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<td>11 588</td>
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<td>26 509</td>
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<td>34 354</td>
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<td>2004–05</td>
<td>27 950</td>
<td>2014–15</td>
<td>36 702</td>
</tr>
<tr>
<td>2005–06</td>
<td>29 823</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: International Association of Antarctica Tour Operators

FIGURE 3 Davis is the most southerly Australian Antarctic station.
4.11 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note: Question numbers may vary slightly.*

**Remember**
1. List three ways in which the stations might have an impact on the Antarctic *environment*.
2. Why is there no mining in Antarctica? What problems would there be in extracting and transporting minerals from Antarctica?

**Explain**
3. Suggest the ideal location for a scientific base in Antarctica.
4. Why don’t tourists visit Antarctica during winter?

**Discover**
5. Working in groups of four, use the **Life in Antarctica** weblink in the Resources tab to investigate life at the Australian Antarctic stations. Choose one station.
   (a) What facilities are there at the station?
   (b) Describe the work activities that take place.
   (c) What do you think it is like to live there?
6. Use a spreadsheet program to draw a line graph using the tourism data in **table 1**. Describe how the numbers have changed over time and provide one possible explanation for the drop in numbers since 2008.

**Predict**
7. Use the **Antarctic article** and **Biosecurity fears** weblinks in the Resources tab to find out more about how foreign seeds are invading Antarctica. Write a list of rules for a company that would remove this risk.

**Think**
8. Do you think countries should be able to own pieces of Antarctica? Write a two-minute speech outlining the reasons for your point of view. Debate this topic as a class.
9. Would you like to visit Antarctica? Why? Discuss as a class, listening carefully to the opinions of others.

[**learnON RESOURCES** ONLINE ONLY]
- Explore more with this weblink: **Life in Antarctica**
- Explore more with this weblink: **Antarctic article**
- Explore more with this weblink: **Biosecurity fears**

[**myWorldAtlas**]
Deepen your understanding of this topic with related case studies and questions:
- **Antarctica: human features**

4.12 Review

**4.12.1 Review**
The Review section contains a range of different questions and activities to help you revise and recall what you have learned, especially prior to a topic test.

**4.12.2 Reflect**
The Reflect section provides you with an opportunity to apply and extend your learning. Access this subtopic at [www.jacplus.com.au](http://www.jacplus.com.au)