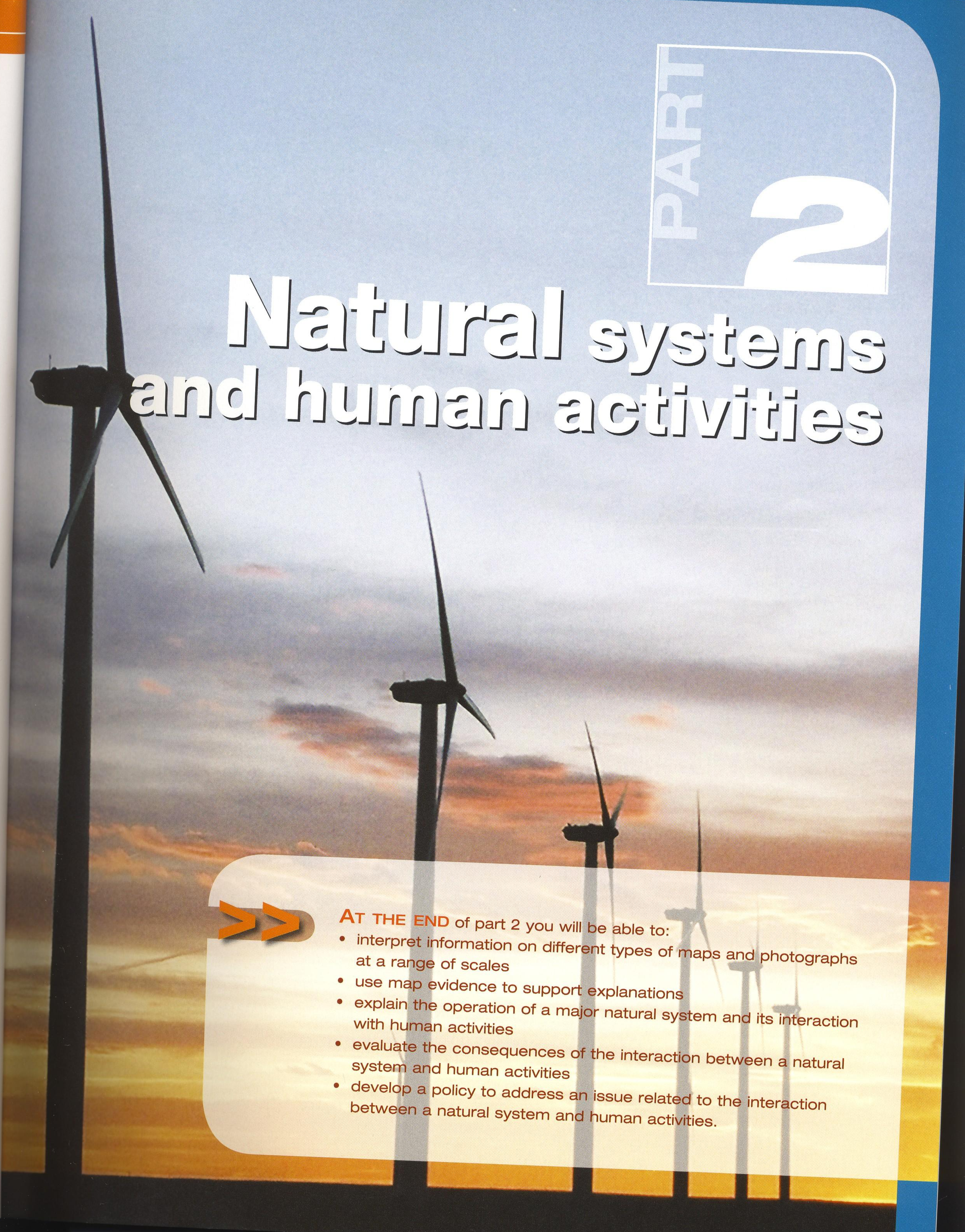
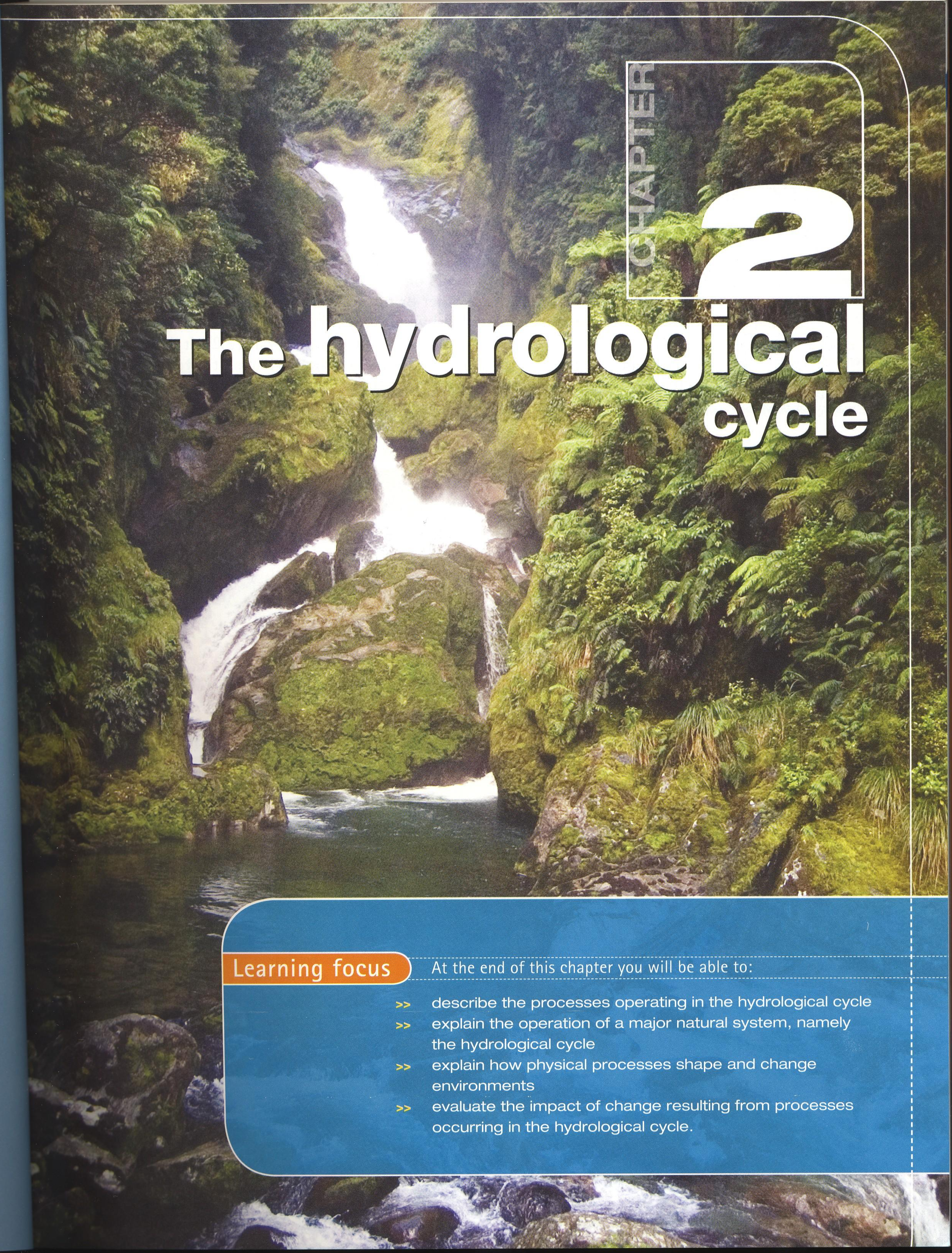


PART 2

Natural systems and human activities

>> **AT THE END** of part 2 you will be able to:

- interpret information on different types of maps and photographs at a range of scales
- use map evidence to support explanations
- explain the operation of a major natural system and its interaction with human activities
- evaluate the consequences of the interaction between a natural system and human activities
- develop a policy to address an issue related to the interaction between a natural system and human activities.



CHAPTER 2

The hydrological cycle

Learning focus

At the end of this chapter you will be able to:

- >> describe the processes operating in the hydrological cycle
- >> explain the operation of a major natural system, namely the hydrological cycle
- >> explain how physical processes shape and change environments
- >> evaluate the impact of change resulting from processes occurring in the hydrological cycle.

Atmospheric processes

condensation water vapour (gas) changed back into liquid form (droplets)

precipitation all forms of moisture that reach the Earth's surface

infiltration moisture absorbed or percolating into the soil

run-off the water that flows over the Earth's surface

evaporation moisture drawn up into the atmosphere and converted into water vapour

transpiration moisture transferred into the atmosphere from plants

The two most important elements influencing atmospheric processes are water and the sun.

The water cycle

One of the most significant elements of atmospheric processes is water.

When you think about the weather or turn on the tap have you ever wondered where all the water comes from and where it goes?

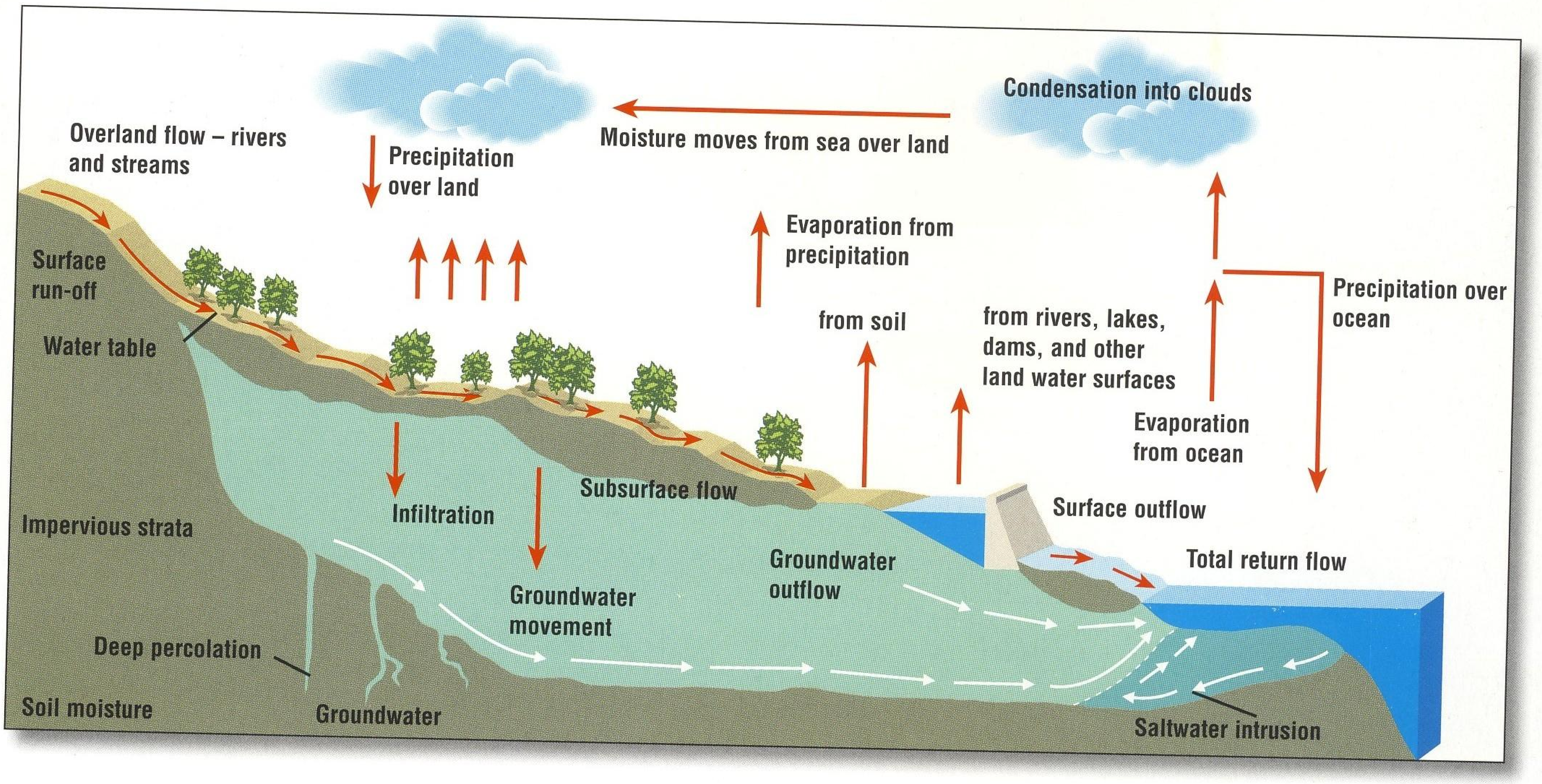
Water actually moves in a cycle, known as the water cycle [2.2]. It moves through the atmosphere, the land, the rivers, lakes and oceans. It involves processes such as **condensation**, **precipitation**, **infiltration**, **run-off**, **evaporation**, and **transpiration**. The main energy source for the water cycle is the sun.

[2.1] Clouds are evidence of the condensation phase of the water cycle

Think about this

Ocean bodies cover about 71 per cent of the Earth's surface, which has a total area of 510 million square kilometres

[2.2] The water cycle



solar radiation
energy from the sun that heats the Earth

solstice
the longest or shortest day of the year (21 December and 21 June)

equinox
the date when day and night are equal (21 March and 21 September)

did you know?

The highest ever recorded temperature in the world was 57.7°C on 13 September 1922 at Al'Aziziyah in Libya.

The lowest ever confirmed temperature in the world was –89.2°C on 21 July 1983 at Vostok in Antarctica.

An unconfirmed temperature of –91°C was recorded during the winter of 1997 at Vostok.

The sun as a source of energy

The sun is the most important influence on our weather [2.3]. Energy, in the form of solar radiation, affects the Earth's surface. It heats the Earth's atmosphere and also affects the movement of both air and water. At the Equator the sun's rays are direct and so the atmosphere is heated more rapidly than other regions. At the Poles the sun's rays are less direct and spread out over a much larger area [2.4]. We can see that areas near the Equator are generally hot while areas near the Poles are generally cold.

Two other important facts affect solar radiation:

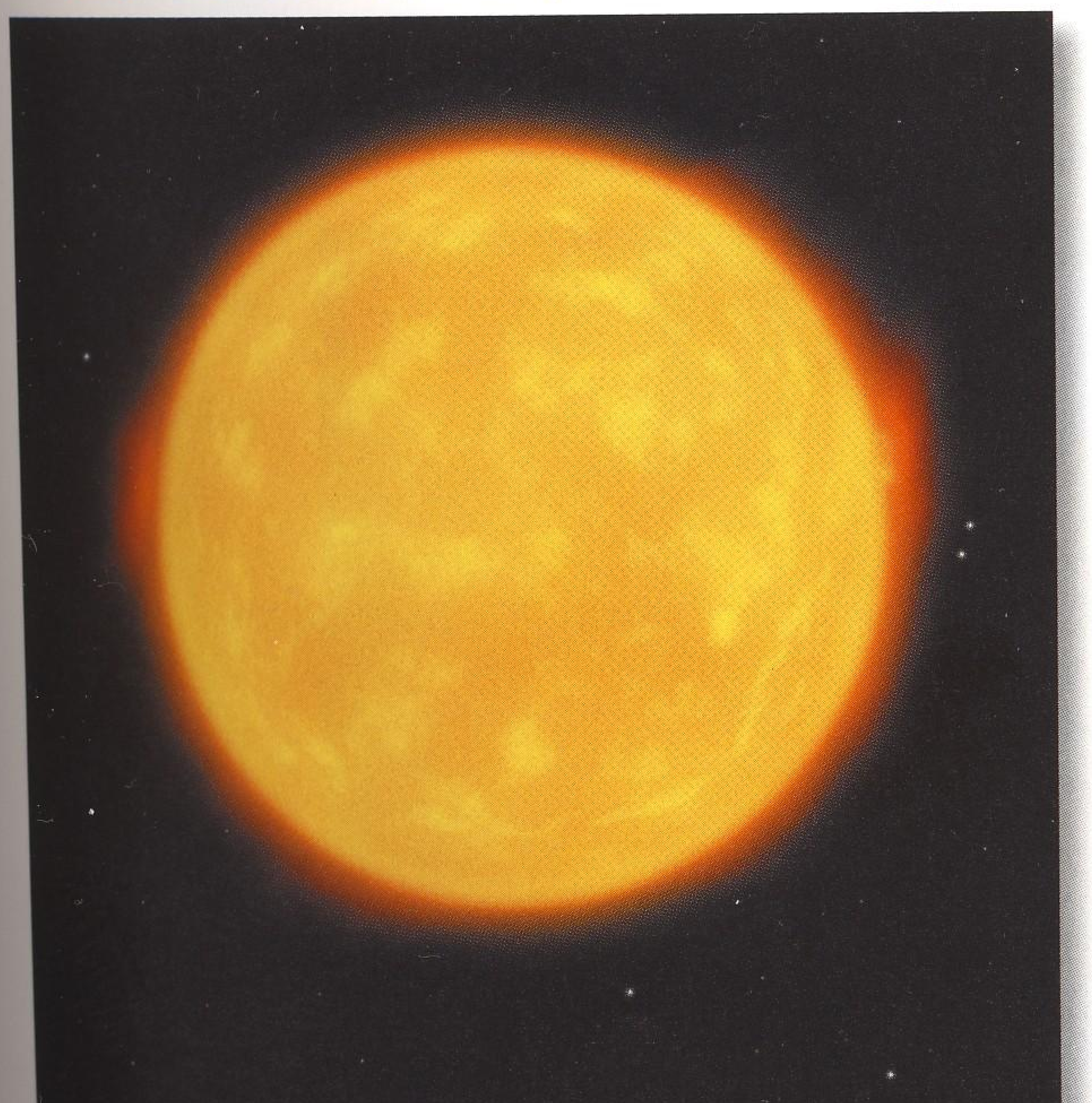
- the Earth revolves around the sun
- the Earth is tilted on its axis at an angle of 23½ degrees.

These two facts cause seasonal changes on the Earth's surface [2.5] and [2.6]. The mid-winter and mid-summer positions of the Earth in relation to the sun are called the winter and summer solstices. The word 'solstice' means 'sun standing still'. In the northern hemisphere, the winter solstice is on 21 December and the summer solstice is on 21 June. The reverse is the case in the southern hemisphere. Thus the summer solstice has the longest day and the winter solstice has the shortest day in the year. The spring and autumn equinoxes are on 21 March and 21 September. The word 'equinox' means 'equal night and day'.

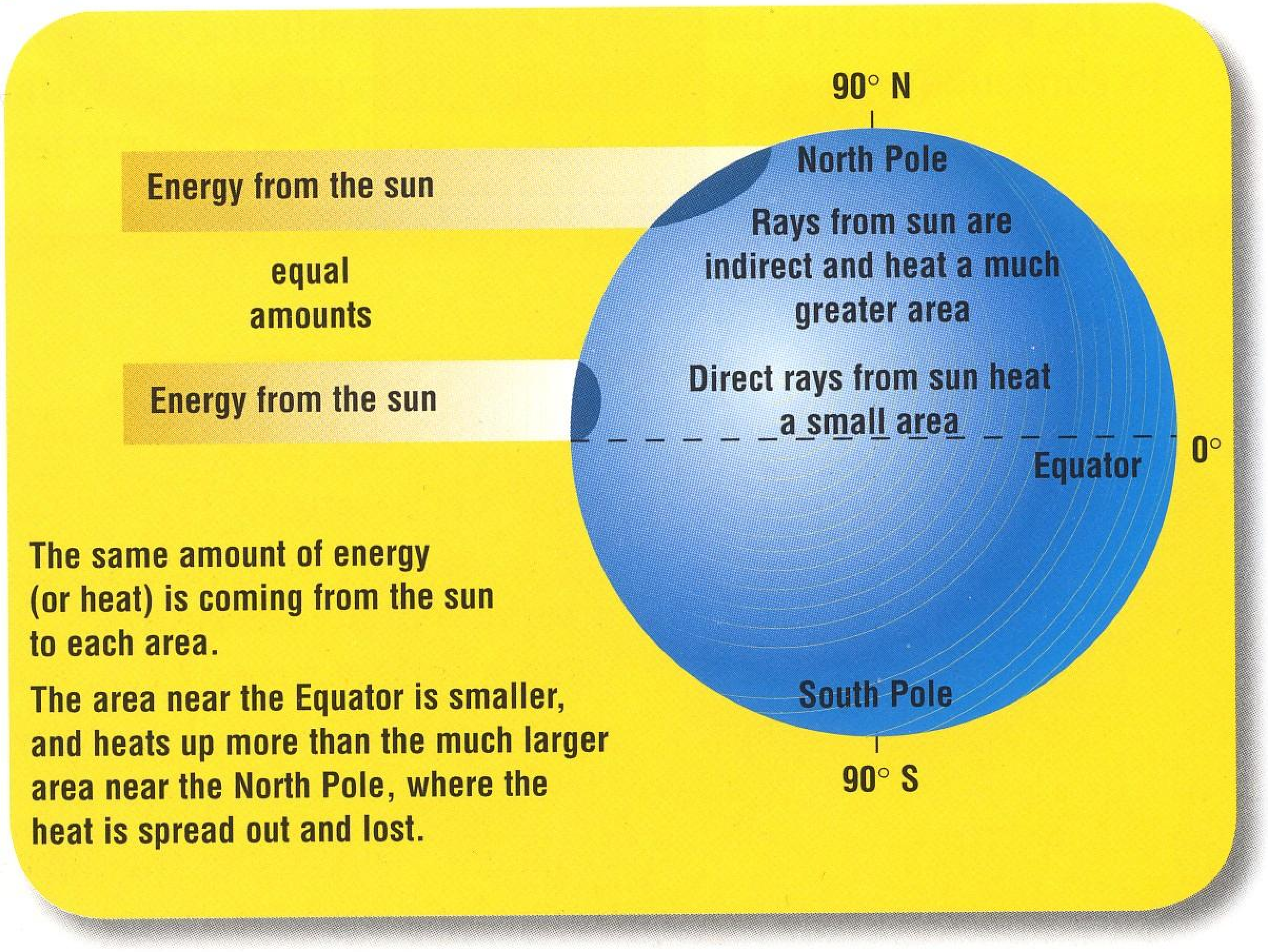
At the Equator there is very little change with the seasons. The further away from the Equator, the greater are the differences between summer and winter. This is also the case with the number of daylight hours.

At the Equator there are approximately 12 hours of daylight and 12 hours of darkness every day.

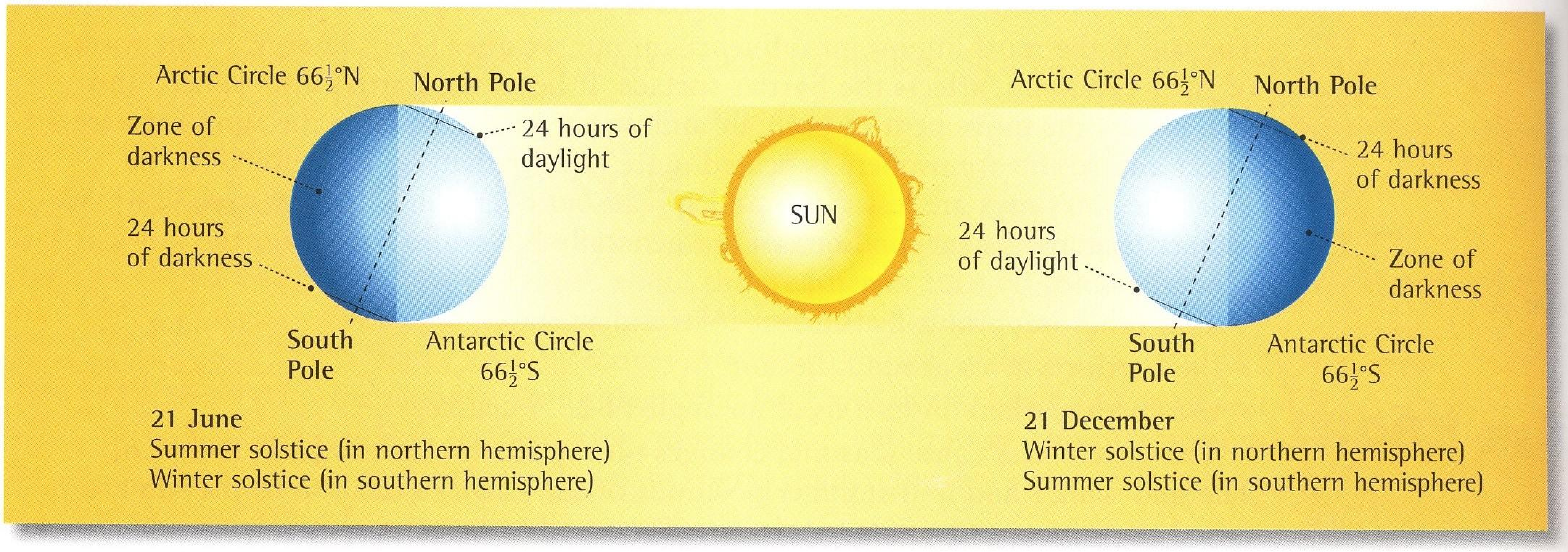
[2.3] The sun is an enormous powerhouse of energy



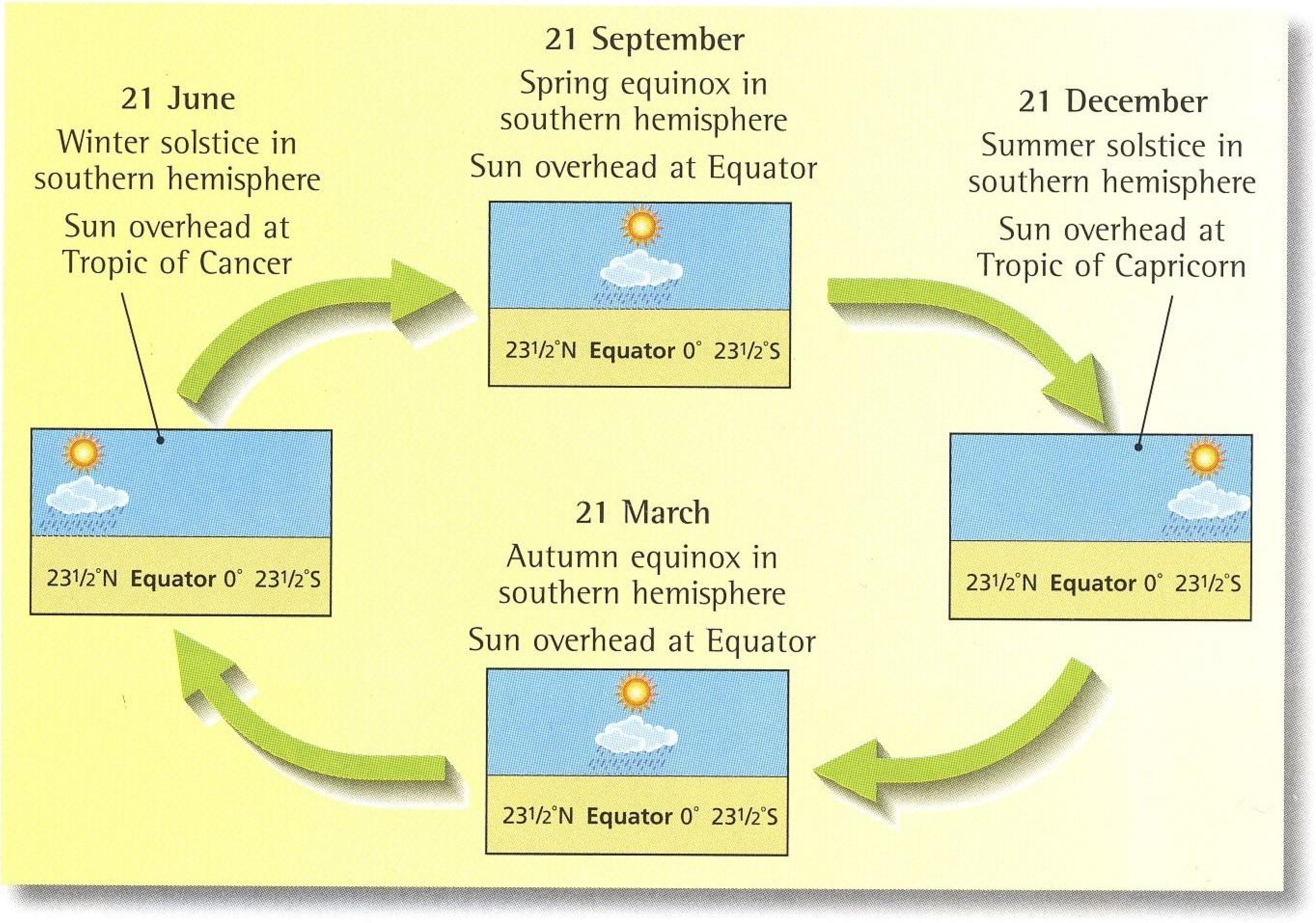
[2.4] Differences in solar radiation



[2.5] The summer and winter solstices



[2.6] The four seasons in the southern hemisphere



Closer to the Poles, there are more hours of daylight in summer and more hours of darkness in winter. In fact, north of the Arctic Circle and south of the Antarctic Circle, the sun never sets in mid-summer and never rises in mid-winter. This gives rise to almost 24 hours of daylight for a week or so over summer and a similar 24 hours of darkness in winter [2.5].

Learning activities

2.1 What is the water cycle?

2.2 Use diagram [2.2] to write a paragraph of four or five sentences describing the operation of the water cycle.

2.3 What is solar radiation? Why is it so important?

2.4 Explain the meaning of the following terms:
- a equinox
- b solstice.

2.5 What are the dates for the summer and winter solstice in Australia?

2.6 Explain why we have seasons. In what areas of the world are the seasons most pronounced? Use diagrams to assist your explanation.

2.7 As a class, or in groups, use a globe of the world and a torch to show how the seasons are caused.

Weather and climate

Climate is what you expect and weather is what you get.

weather
the day-to-day condition of the atmosphere at a particular location

humidity
water vapour in the atmosphere

climate
the average conditions of the atmosphere for a particular area of the Earth over a long period

meteorology
the scientific study of the weather

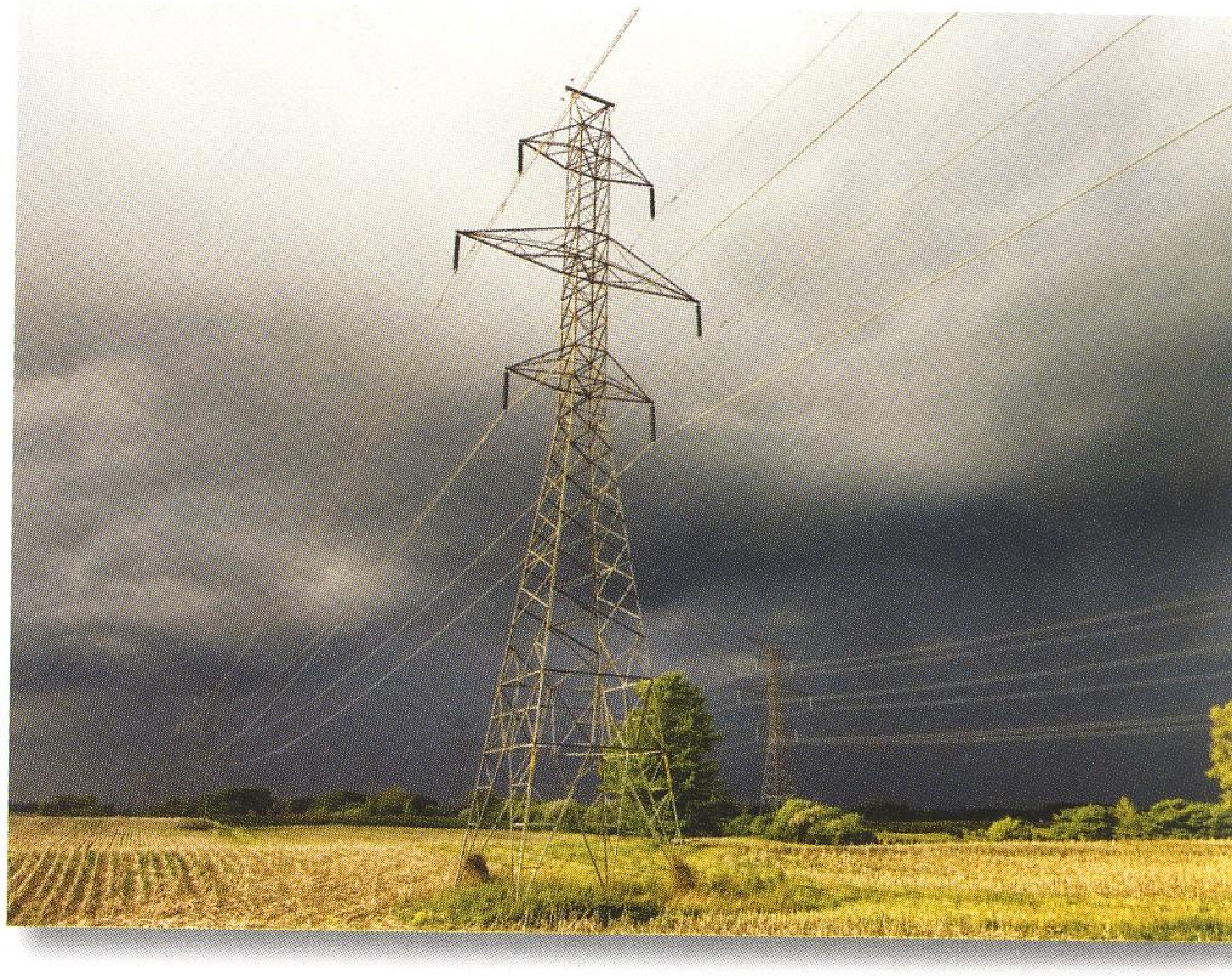
Weather is the day-to-day condition of the atmosphere. It involves such elements as temperature, precipitation, humidity, wind direction and speed, and air pressure. The climate of an area is the average atmospheric conditions over a period of thirty years or more for that particular location. Climate is concerned with seasonal changes that occur from summer to winter and changes that occur over longer periods of time.

Observing the weather

The weather is probably the most popular topic of conversation in the world. It is easy to make some simple observations—is it hot or cold? raining or dry? windy or calm?—yet there is a lot more to weather observation than meets the eye. The scientific study of weather is known as meteorology.

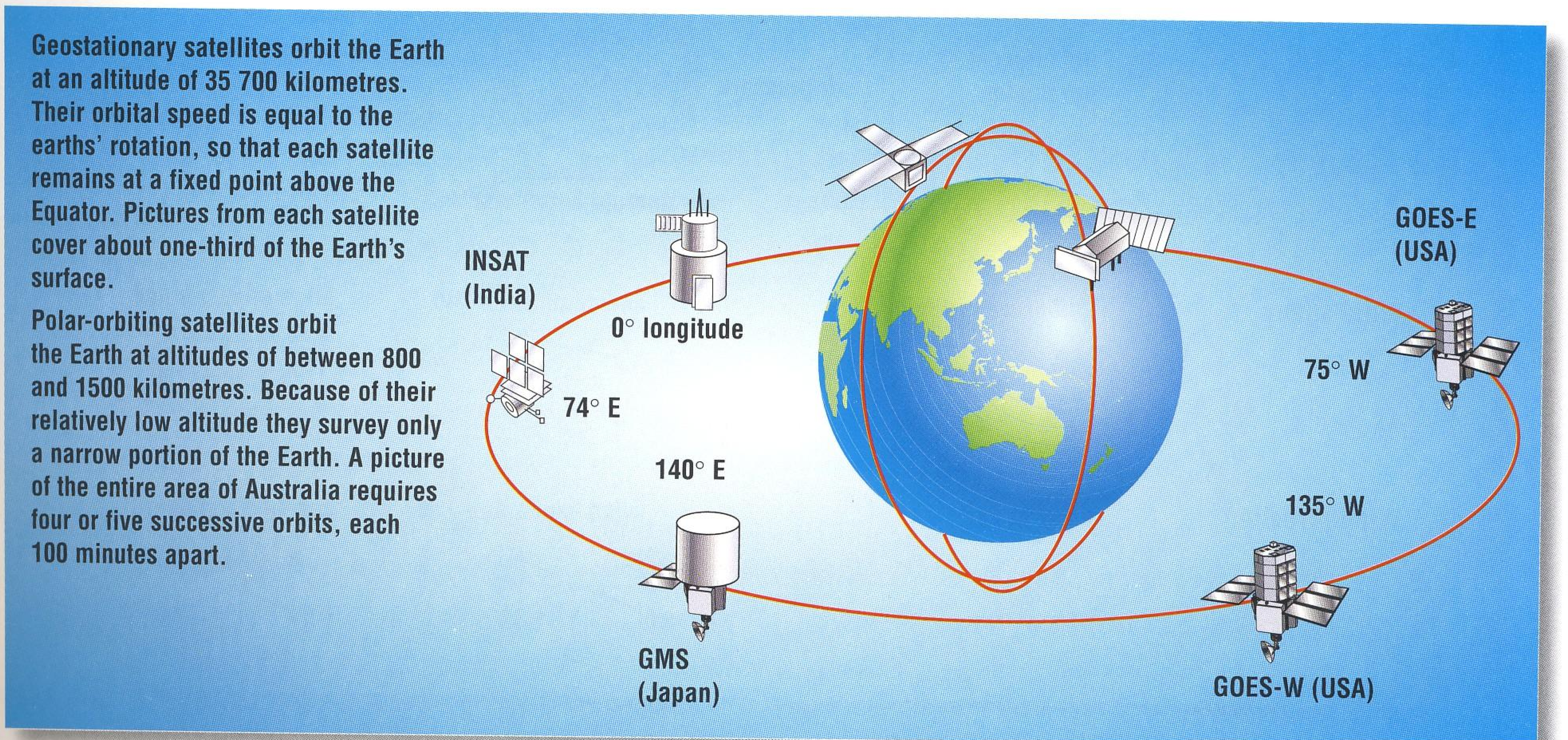
In 1950 the World Meteorological Organisation (WMO) was established to set standards and develop a global system of cooperation in weather observation. With the development of satellites in the 1950s, weather observation and recording rapidly became precise and scientific.

[2.7] One aspect of weather—an approaching thunderstorm



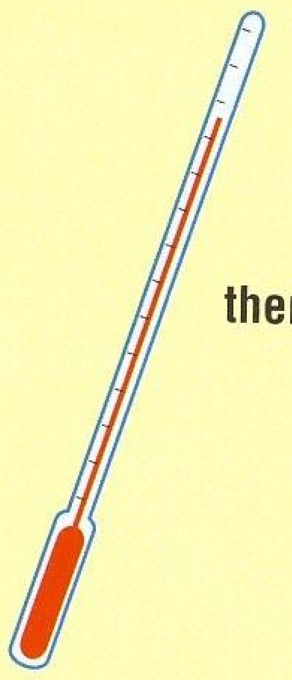
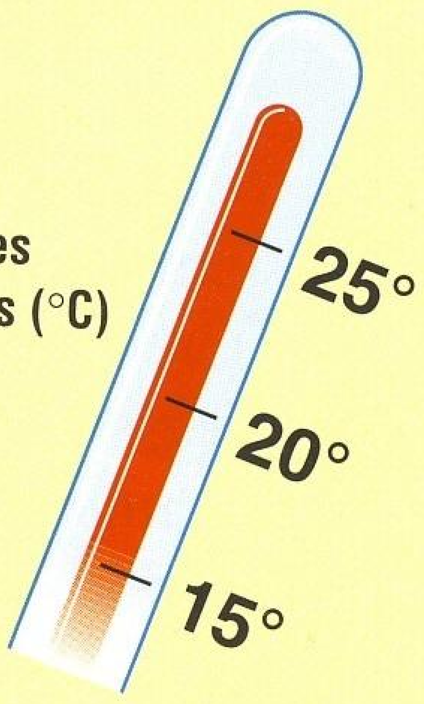
Weather observation now involves satellites, both orbiting and stationary [2.8], radars, automatic weather stations, ships, aircraft, balloons, and many thousands of people who read recording instruments [2.10].

[2.8] Global satellite systems (each has its own identifying name)

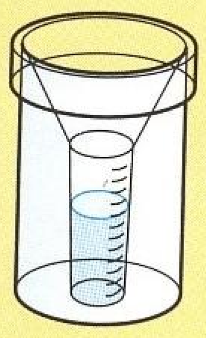
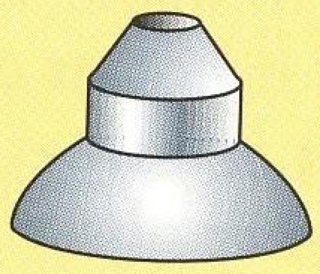
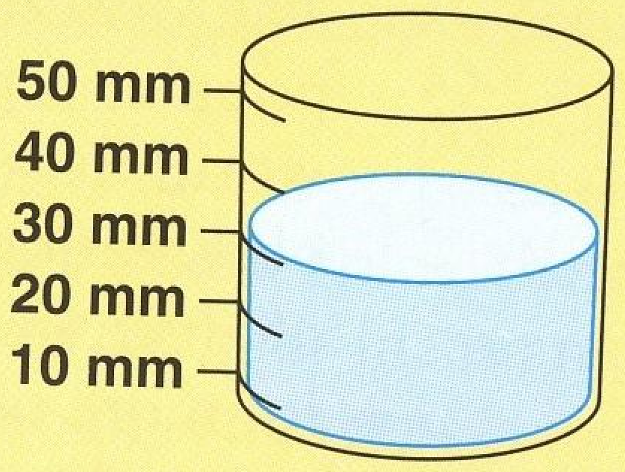


[2.9] The elements of weather and how they are measured

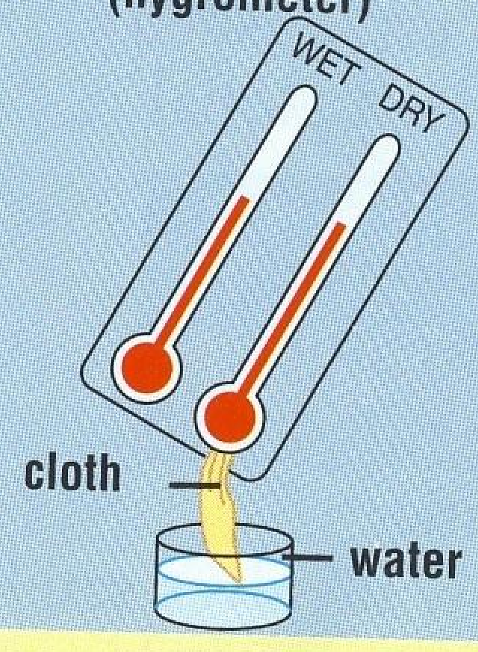
Element		Instrument		Units of measurement
Temperature	is measured with a	thermometer	in	degrees Celsius (°C)

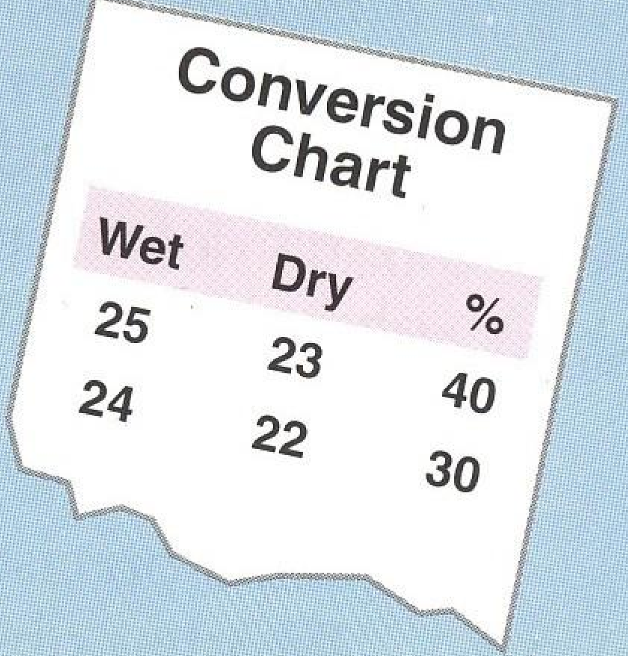



Element		Instrument		Units of measurement
Rainfall	is measured with a	rain gauge or pluviometer and pluviograph	in	millimetres (mm)

Element		Instrument		Units of measurement
Relative humidity	is measured with a	wet and dry bulb thermometer (hygrometer)	as a	percentage (%)

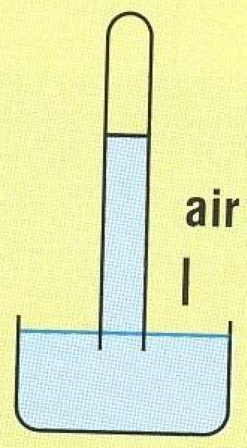


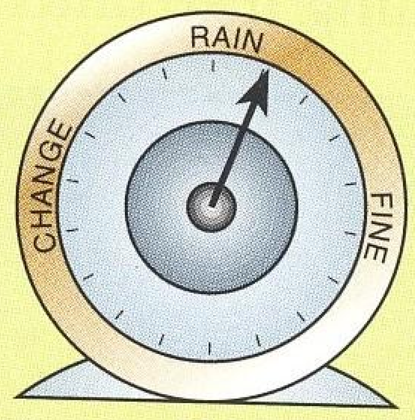


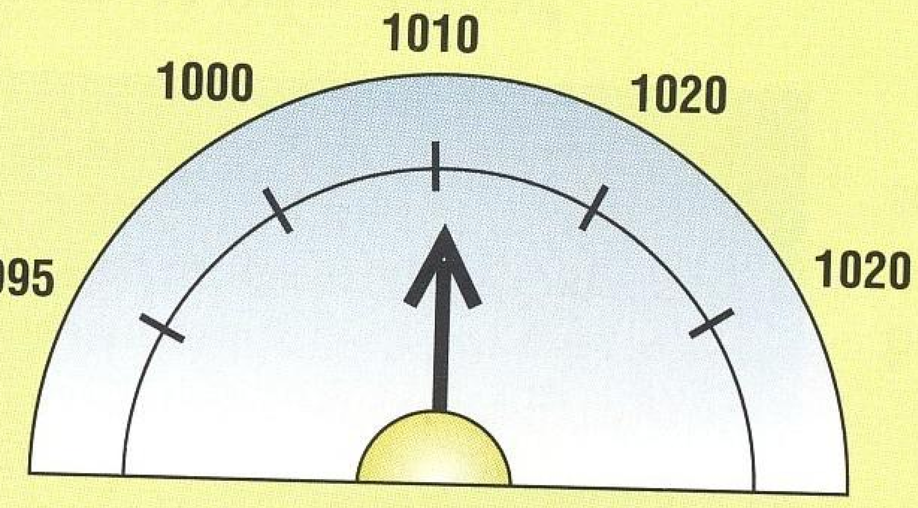
Conversion Chart

Wet	Dry	%
25	23	40
24	22	30

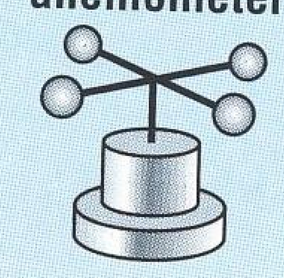
Element		Instrument		Units of measurement
Air pressure	is measured with a	barometer (old mercury barometer; new aneroid barometer)	in	hectopascals (Hpascal)





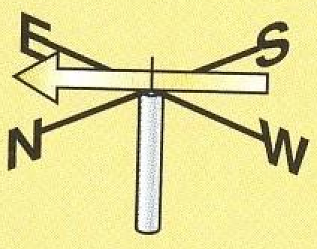


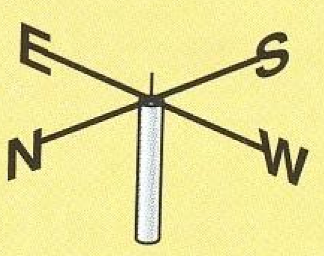
Element		Instrument		Units of measurement
Wind speed	is measured with an	anemometer	in	kilometres per hour



27 km/h

Element		Instrument		Units of measurement
Wind direction	is shown by a	wind vane	as	compass points





Fieldwork: setting up your own weather station

A weather station could be set up quite easily at your school. If you have access to some of the instruments in [2.9], [2.10] and [2.11] it is possible to make weather recordings. But even with the most basic of instruments such as a thermometer and a rain gauge, observations can be made about the state of the atmosphere over a short period of time. Many people and farmers in particular, keep their own simple records of temperature and rainfall.

Thermometer

You will need to buy a basic thermometer. There are many kinds available. You will need to have one that has a range from about –15°C to 45°C. To protect the thermometer, and to avoid unnecessary handling that can affect accuracy, it can be mounted onto a board, attached with wire.

Rain gauge

A simple rain gauge can be made from a tin can. Provided it is the same size at the top as the bottom, the overall size does not matter.

The rain gauge should be placed out in the open to collect the rainfall. It should be located away from buildings and trees, which could interrupt the fall of rain. The amount of rainfall can be measured directly. To do this, a ruler can be placed in the collected rain, and its height in millimetres measured. However, this may prove clumsy.

A better way is to obtain a small narrow jar. Get a strip of paper and create a line scale at 5, 10, 15, 20, 25 and 30 millimetres. Paste this strip of paper up the side of the jar, so when you pour any quantity of water from the tin can rain gauge, it is relatively easy to record the rainfall. Any rain collected should be measured in the glass jar at regular times of the day.

Barometer

A class member may be able to bring a barometer from home. It is important to record what is happening to air pressure, whether it is rising or falling. Regular recordings should be undertaken say at 9 am, noon and 3 pm. The results should be represented on a line graph. This will allow you to see whether the pressure is rising or falling, and the speed at which it is changing.

Stevenson Screen

The thermometer and barometer need to be located outside, but in a place that is shaded from direct sunlight. They also need free movement of air around them.

The piece of equipment in which they are usually housed is called a Stevenson Screen. It is essentially a white box made of wooden louvre-boards. These allow air to pass through the openings in the sides but the instruments are protected against direct sunlight by a double roof. The door is always placed on the southern side so that direct sunlight does not enter when it is opened.

A simple version of a Stevenson Screen [2.11] could be made in school using these principles. It should be painted white, have a double roof and have some means of allowing air to circulate. When it is placed in the schoolyard it should be one metre above ground level to ensure the instruments are measuring atmospheric conditions, not those on the ground.

Wind indicators

Professional weather stations have anemometers to measure wind speed. Your weather station can make use of the Beaufort Scale [2.12]. This allows assessment of wind speed from observation.

For wind direction, a simple wind vane can be made from a piece of plywood or stiff cardboard. It must be set up so that it can turn freely. The arrow that turns in the wind must be shaped so that the tail is much larger than the tip of the arrow. The arrow will then turn so that it points to the direction from which the wind is blowing.

Recordings

Your weather instruments need to be read at regular intervals say at 9 am, noon and 3 pm. At each time, the results should be recorded accurately. They can they be graphed over a few weeks so patterns can be observed.

If these statistics are combined with your own notes on the kind of weather for each day, or a collection of weather maps from the newspaper over a period of two weeks, then the significance of the weather recordings can be seen.

[2.10] Recording the daily amount of precipitation received is particularly useful to farmers

[2.11] Weather instruments at Norah Head, NSW. The Stevenson Screen (white box) holds the thermometer, and the rain gauge is at the front.

[2.12] The Beaufort Scale

Force number	Wind speed in km/h	Description	Observation
0	Under 1	Calm	Smoke rises vertically
1	1–5	Light	Smoke drifts
2	6–11	Light breeze	Wind felt on face; leaves rustle
3	12–19	Gentle breeze	Small twigs move
4	20–28	Moderate breeze	Raises dust and paper; small branches move
5	29–38	Fresh breeze	Small trees sway
6	39–49	Fresh breeze	Large branches move; overhead wires whistle
7	50–61	Moderate gale	Whole trees move
8	62–74	Gale	Twigs break off trees; walking is difficult
9	75–88	Strong gale	Tiles blown off roofs
10	89–101	Storm	Trees and overhead wires blown down
11	102–120	Violent storm	Widespread damage
12	Over 120	Hurricane	Extreme damage

Australia's weather patterns

Australia has a distinctive weather pattern, influenced by seasonal changes from summer to winter and dependent on latitude, altitude and ocean influences. Weather maps are the main tool for examining day-to-day weather patterns.

Weather maps

synoptic data weather observations and measurements such as maximum and minimum temperatures, air pressure, rainfall, winds and cloud cover

synoptic chart a weather map, providing a range of weather data collected from weather observation stations around the country

isobar lines on weather map that join places of equal air pressure

The best-known weather map is the mean sea level analysis, compiled from hundreds of weather observations—synoptic data—taken simultaneously around the country. It is seen daily on television and in the newspapers. A weather map cannot show all of the features associated with our weather. For example, it does not always show the conditions in the upper atmosphere. It is a fairly simple representation of past and probable future locations of surface weather systems such as highs, lows and fronts. A weather map or synoptic chart, however, is still a useful guide to the weather. The main features of a weather map are shown in [2.13].

The lines on weather maps are called isobars and they join all places of equal air pressure. In high pressure systems isobars are numbered higher towards the centre and in low pressure systems they are numbered lower towards the centre. The measurement unit is a hectopascal (sometimes abbreviated to hPa). Also, the closer together the isobars are, the stronger the wind.

[2.13] Typical weather map, 9 October 2004

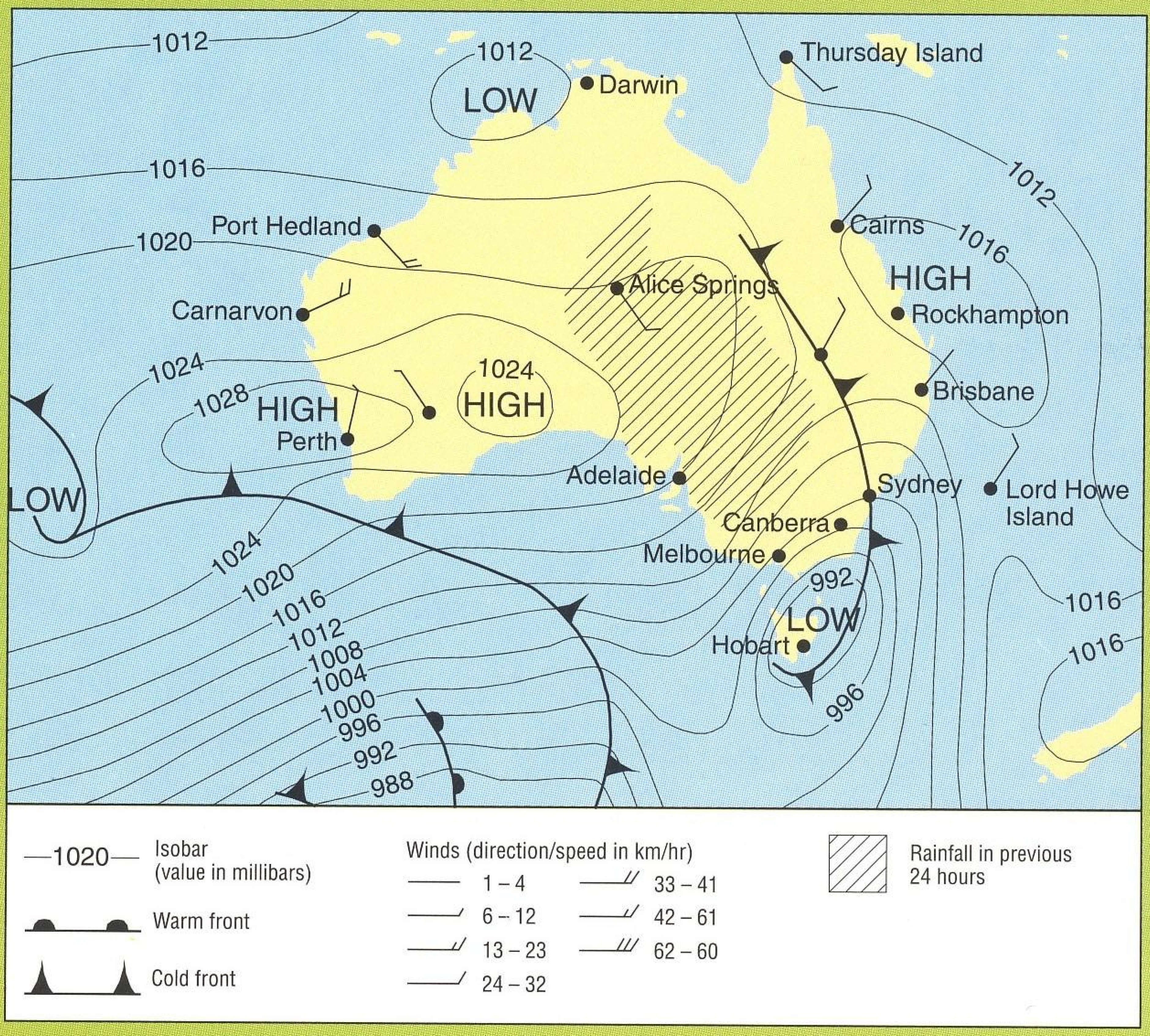
A **cold front** is the boundary where cold air moves to replace, and undercut, warmer and less dense air. Cold fronts are most frequent over southern Australia. As a cold front approaches a region, winds freshen from the north or north-west and pressure falls.

Warm fronts are not common in Australia and are usually found in high latitudes such as the Southern Ocean. Warm fronts progressively displace cool air by warmer air.

Isobars are lines of equal atmospheric pressure. Generally the air pressure is measured in hectopascals. It can also be measured in millibars.

Calm conditions are indicated by a coloured-in circle (not shown on this map).

Rainfall is shown by shaded areas on the weather map indicating that there has been rain in the previous twenty-four hours.



Wind speed is proportional to the distance between the isobars—the closer the lines, the stronger the winds. The wind speed scale is shown in the key of the weather map and is indicated by the number of vanes on the symbol.

Wind direction is shown by arrows that have a series of barbs on their tails to indicate speed. Winds are named after the direction from which they are blowing. If the wind is blowing from the south-west, it is called a 'south-west wind' or a 'south-westerly'.

A **high pressure system** occurs where isobars (as measured in hectopascals) are higher towards the centre.

A **low pressure system** occurs where isobars (as measured in hectopascals) are lower towards the centre.

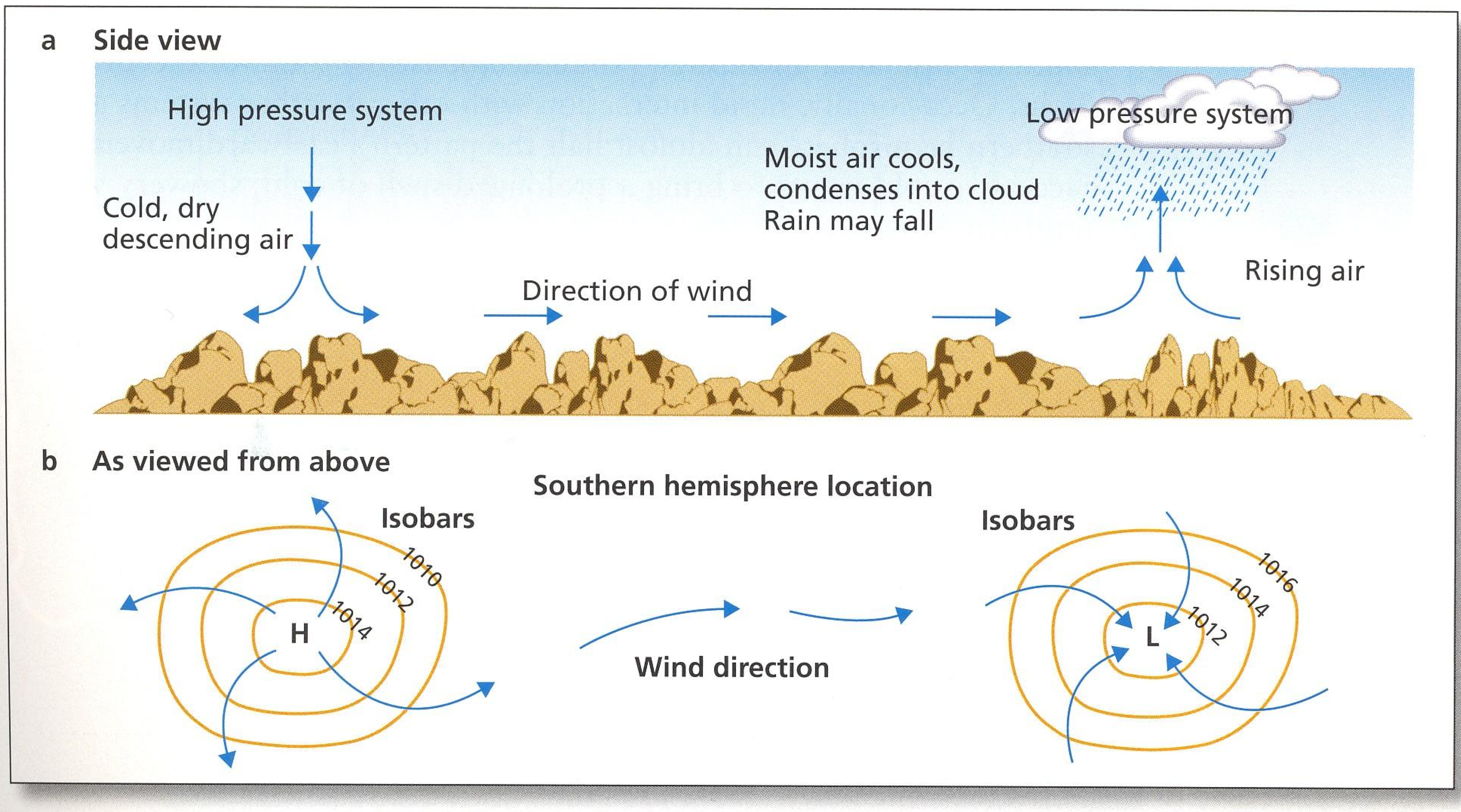
High and low pressure systems

Air moves away from areas of high pressure and towards areas of low pressure. This movement of air is called wind and is the result of the differences in pressure that occur across the Earth's surface at any time [2.14].

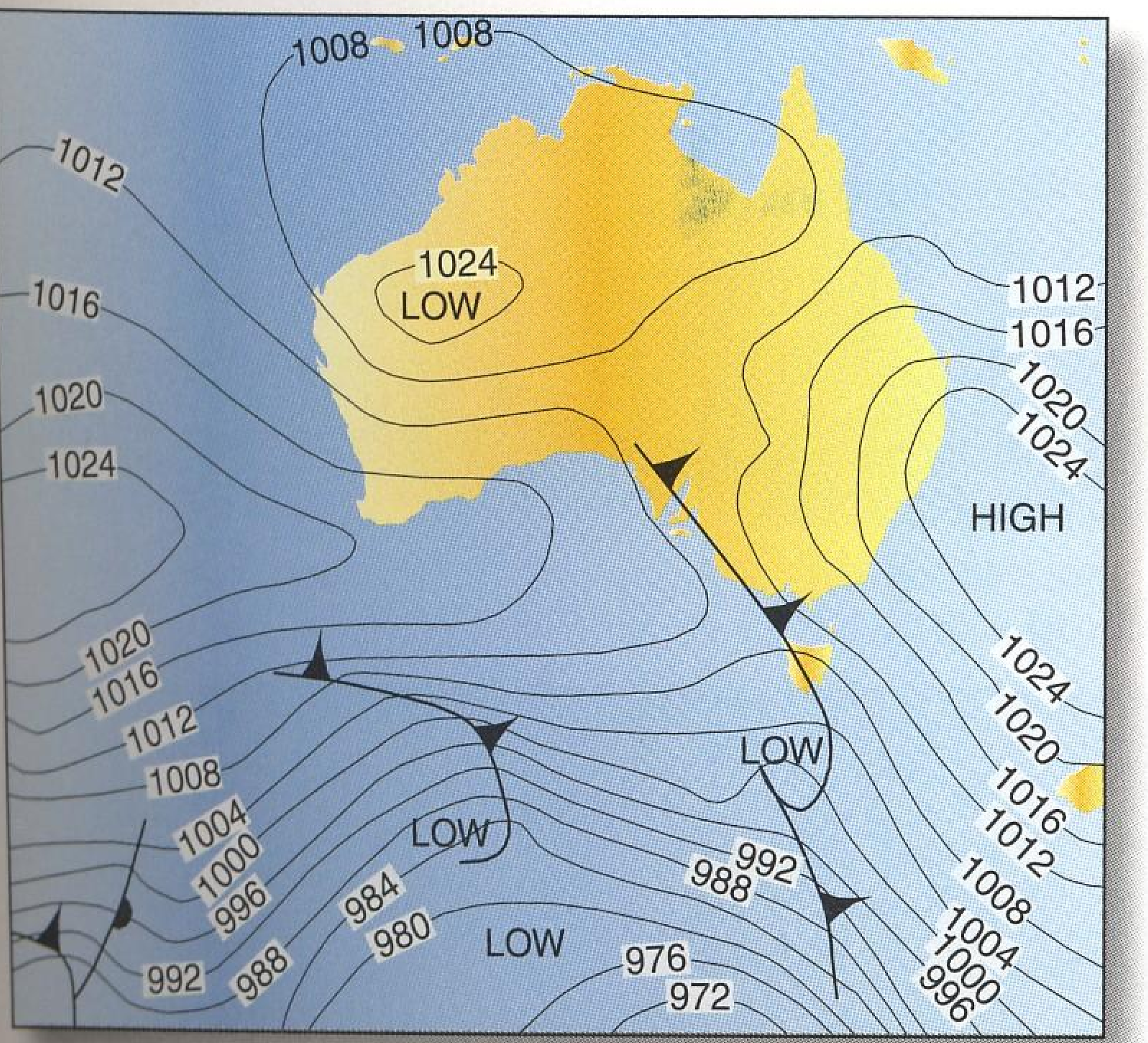
The Earth is spinning on its axis, so winds do not blow in a straight line between an anti-cyclone (high pressure) and a depression (low pressure). In the southern hemisphere, the Earth's rotation causes air to flow clockwise around low pressure systems and slightly inwards, and anti-clockwise around high pressure systems and slightly outwards. The opposite applies in the northern hemisphere.

The weather normally associated with a high pressure system is light winds, dry air, clear skies, hot days and cool nights in the summer; mild days and cold nights in the winter. The weather normally associated with a low pressure system is strong winds, cloudy skies, rain and mild temperatures.

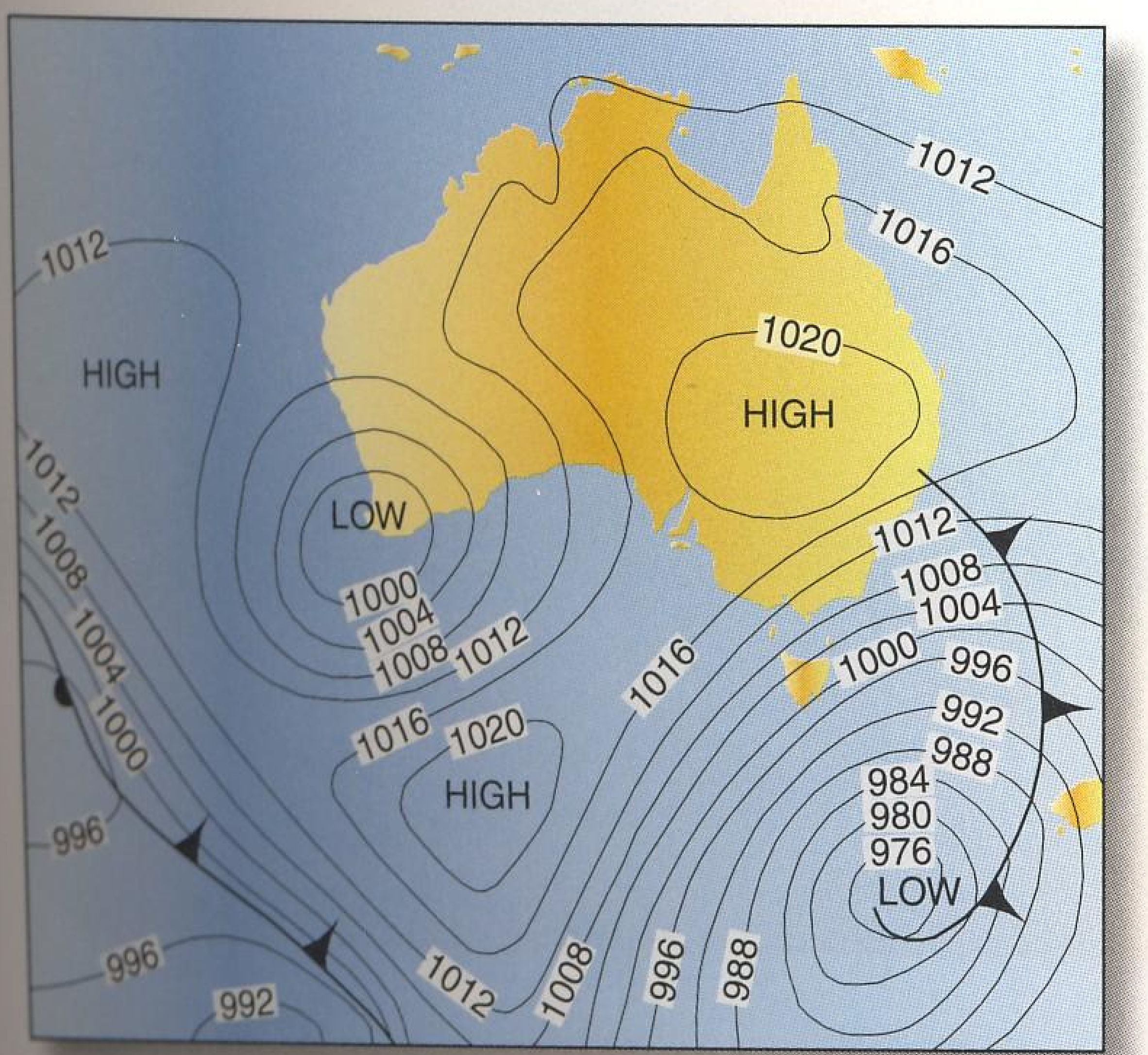
[2.14] Pressure systems



[2.15] Typical summer weather map



[2.16] Typical winter weather map



Typical summer weather map

The typical summer weather conditions experienced over Australia can be interpreted from the synoptic chart shown in [2.15].

- Northerly winds blow over eastern Australia on the western flank of a Tasman Sea high. They carry hot, dry air from inland Australia southward over Victoria and Tasmania. With winds strengthening ahead of an approaching front, this represents a classic weather situation with extreme bushfire risk.
- The moist, easterly airflow from the Coral Sea onto the Queensland coast causes very warm, humid and sultry weather east of the Great Dividing Range. This air is unstable and often leads to the development of showers and thunderstorms as shown in [2.17].
- The cold front passing South Australia replaces the hot, dry north-westerlies with southerlies carrying cooler, often relatively humid air, from waters south of the continent. Such summer fronts are usually quite shallow and may not penetrate far inland, particularly if they are distorted and slowed over the Victorian alps.

Typical winter weather map

The typical winter weather conditions experienced over Australia can be interpreted from the synoptic chart shown in [2.16].

- Very cold, unstable air flows from well south of Tasmania northwards over Tasmania, Victoria and south-east New

South Wales, reducing normal day temperatures typically by 5°C or more.

- There is a cold front and deep low-pressure system (below 976 hectopascals) south of Tasmania and a high (1020 hectopascals) south of the Great Australian Bight. Occasionally, rapid interaction with other weather systems around the southern hemisphere can almost halt the pattern's eastward movement, causing successive cold fronts to bring a prolonged spell of cold, showery weather to southern Australia.

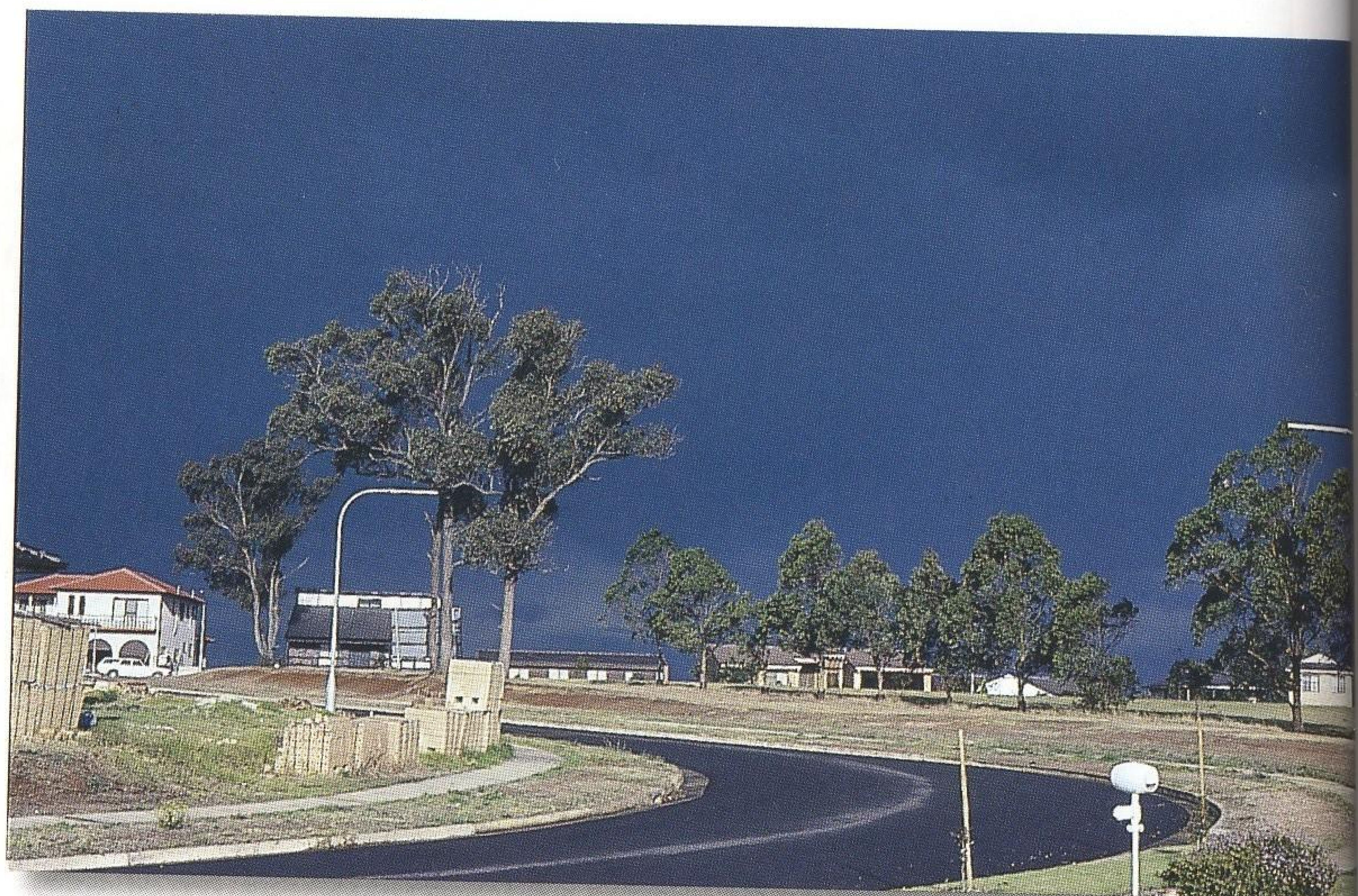
[2.17] Lightning flashes across Melbourne

did you know?

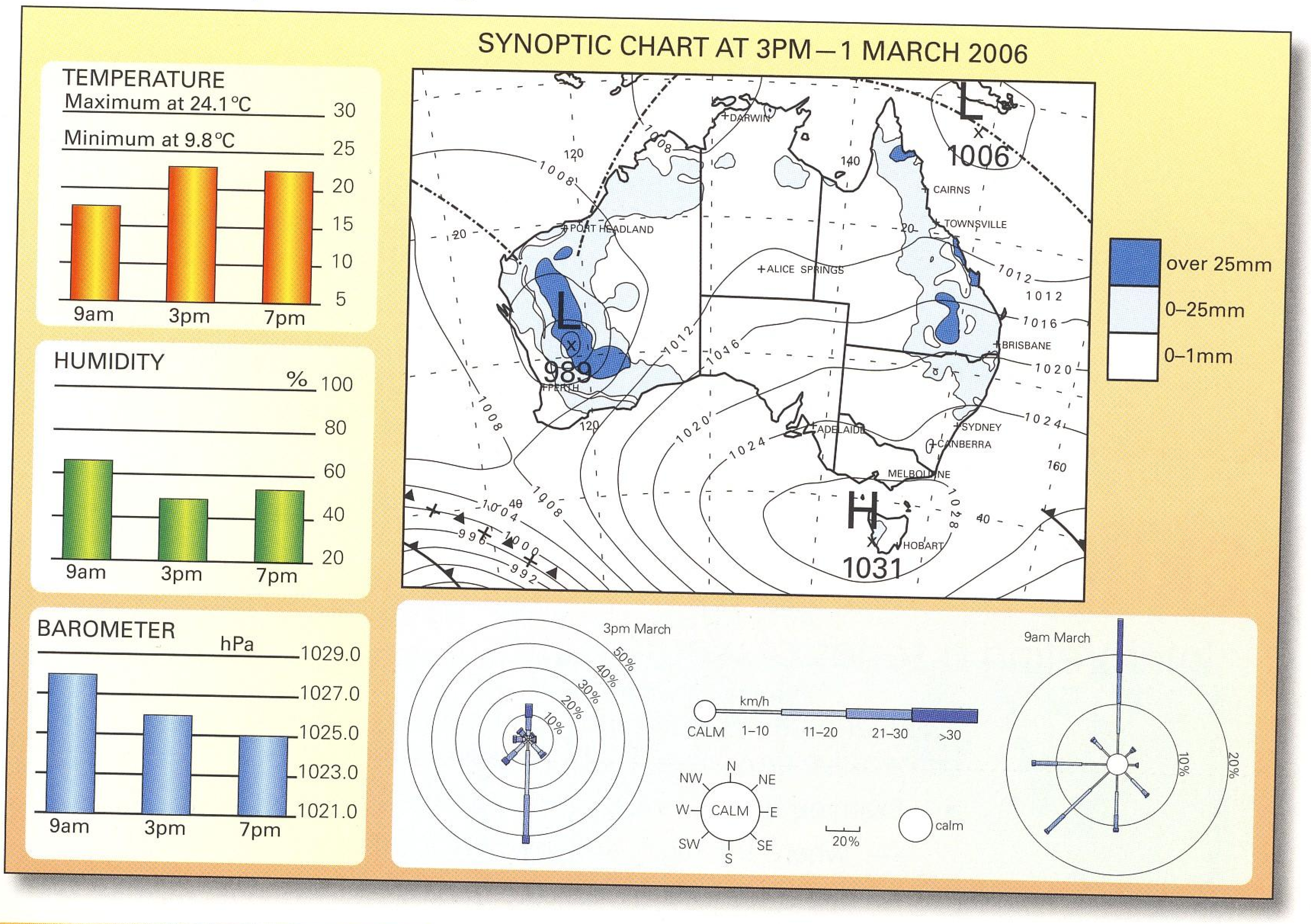
The coastline near Whim Creek in Western Australia holds a weather record—the most extreme variability of rain on Earth. A massive 747 mm in 24 hours was recorded on 3 April 1898 as a cyclone passed nearby. Yet in 1924, Whim Creek recorded just 4 mm of rain in the whole year—one of the lowest annual totals ever recorded in the world.

[2.18] Snowfalls are typical of winter weather in Australia's southern alpine regions

[2.19] An approaching storm



[2.20] Weather map and related data



Learning activities

2.8 What is the difference between weather and climate?

2.9 Use [2.9] to copy and complete the following table of weather instruments:

Element	Instrument
Temperature	
Rainfall	
	Barometer
	Anemometer
Wind direction	
Humidity	

2.10 What are the lines on a weather map called?

2.11 What is another name for a weather map?

2.12 How does one identify areas on the weather map where strong winds are likely to occur?

2.13 Study the weather map and other weather information for Australia on 1 March 2006 shown in [2.20].

a What pressure system was over Tasmania and the Victorian coast? What effect did it have on the weather in Melbourne?

b What was Melbourne's maximum temperature on 1 March 2006?

c What was the barometer reading?

d What was the relative humidity at 9 am?

e What weather was the east and north-east areas of Australia experiencing? What wind system would have caused this weather?

f What weather was the central areas of Western Australia experiencing? What atmospheric pressure pattern would have caused this weather?

g What weather was Tasmania experiencing? What atmospheric pressure pattern would have caused this weather?

2.14 Build a mind map with the theme 'weather'.

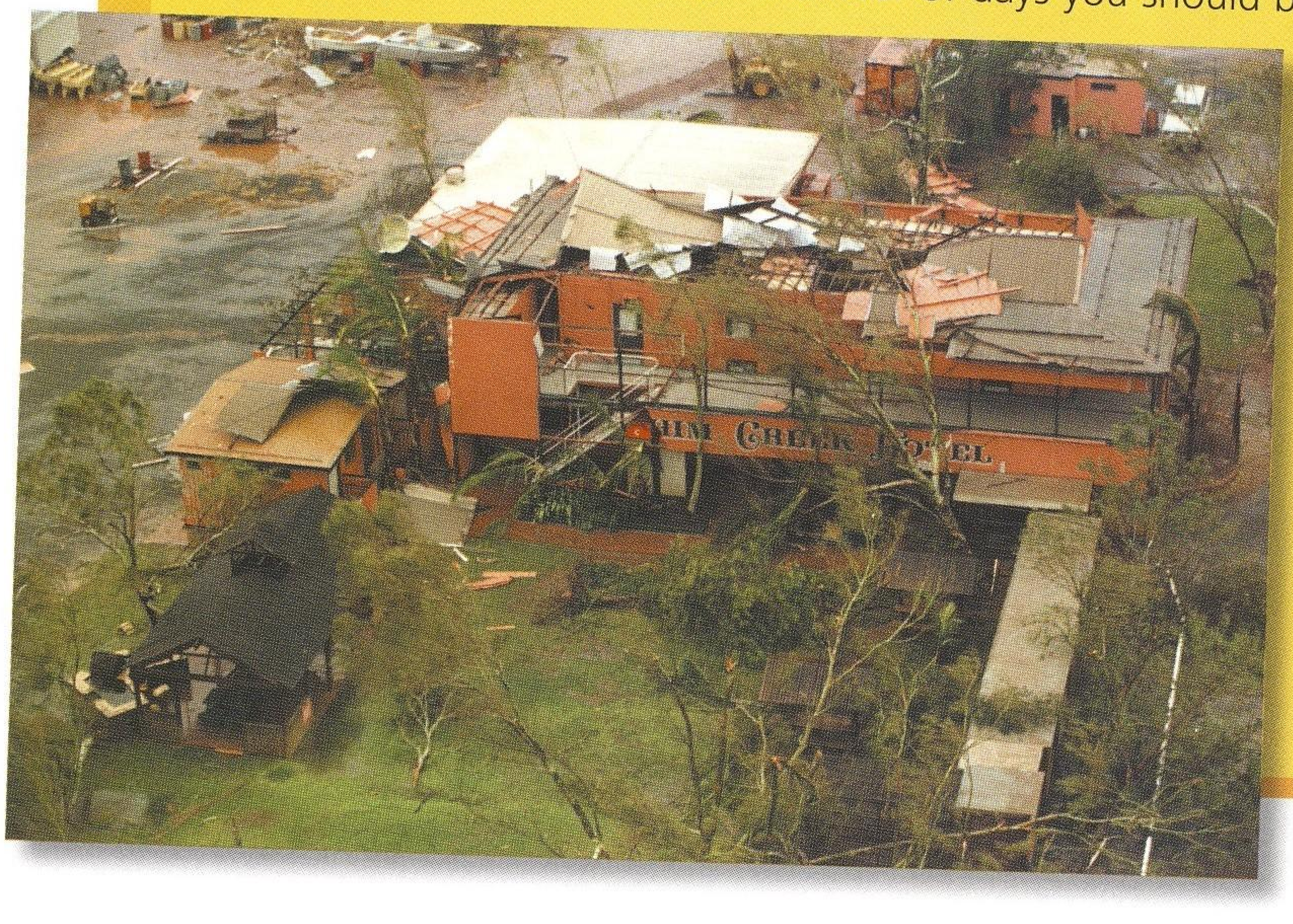
WWW 2.15 Use the internet to research weather reports from the Bureau of Meteorology at <www.bom.gov.au>. Write a brief description of the information.

Skills

Interpreting a series of weather maps

Weather patterns and trends can be observed from a series of weather maps over several consecutive days as in [2.22]. Here are some handy hints:

- Examine the first weather map in the series. Identify:
  - — where the highs and lows are located
  - — the distance between the isobars (an indication of wind speed)
  - — the direction of the wind
  - — the presence or absence of rain.
- Look at the second map to see:
  - — where the pressure systems are centred, and how and where they have moved (remember that pressure systems in Australia generally move from west to east)
  - — whether the pressure systems have intensified or not (whether the isobars are closer together or wider apart)
  - — changes in wind direction
  - — changes in the pattern of rain.
- Examine the remaining weather maps and continue systematically looking for changes. Check any finer details shown on the maps for clues. Use the key to assist.
- Forecast the weather for the next day. By closely studying what has happened over a number of days you should be able to predict what is likely to happen next. Forecasting the weather is not always easy. However, it is worth a try as it tests your knowledge. You may well get it right!



[2.21] A property destroyed by Cyclone John in December 1999, Whim Creek

Tropical Cyclone 'John' was a category five storm that hit Western Australia on 15 December 1999 with wind speeds of near 290 kilometres per hour. It crossed near Whim Creek, which, although sparsely settled, caused damage to the properties there, as shown in [2.21].

The series of weather maps in [2.22] show that John formed into a rain depression and drifted across the continent bringing widespread heavy rainfall.

Skills

Activities

Examine the four maps in [2.22].

a What changes can you identify from Tuesday 14 December to Wednesday 15 December?

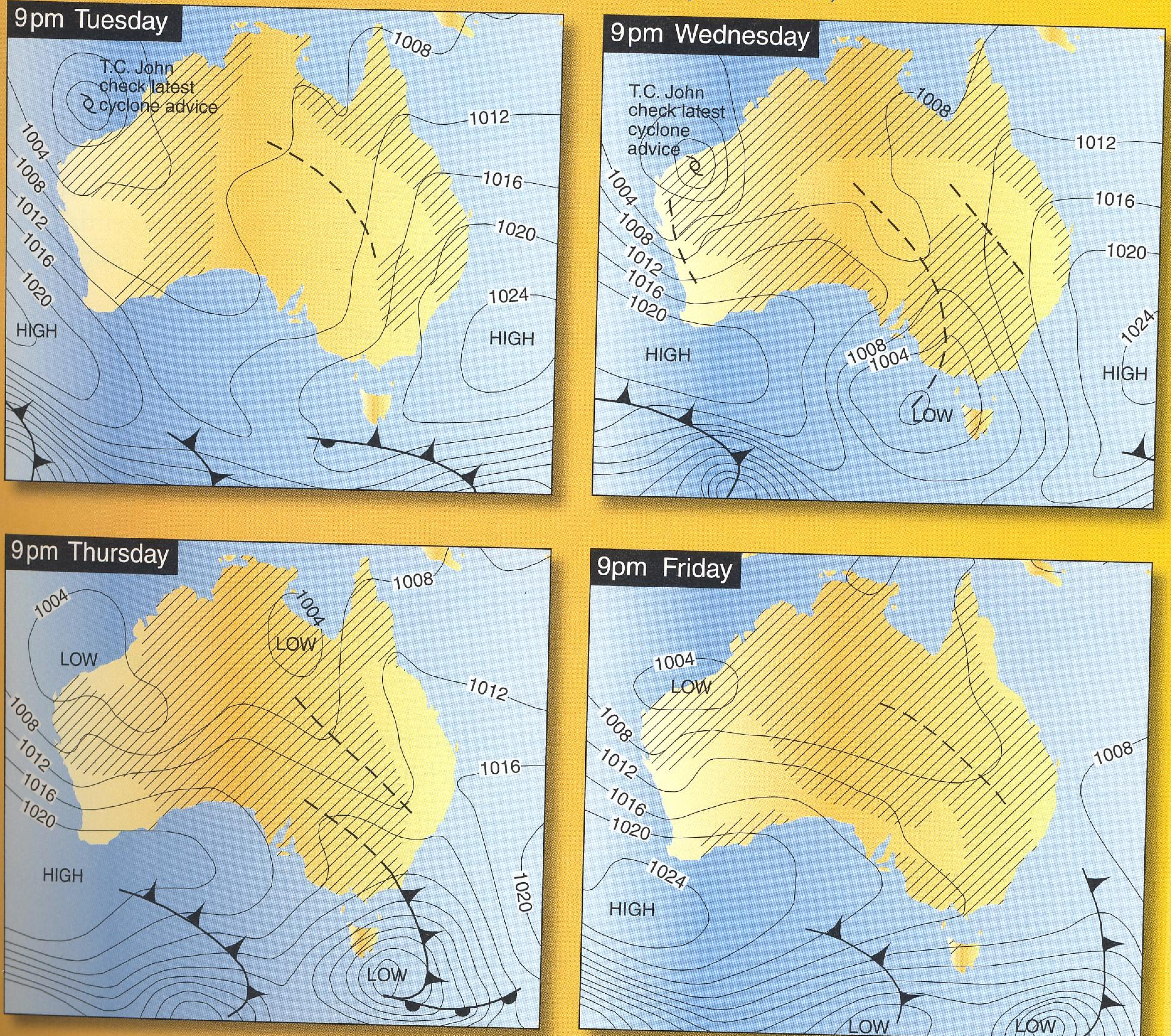
b What happened on Thursday 16 December?

c How is the weather map for Friday 17 December different from the day before?

d What can you say about the movement of the tropical cyclone over the four days?

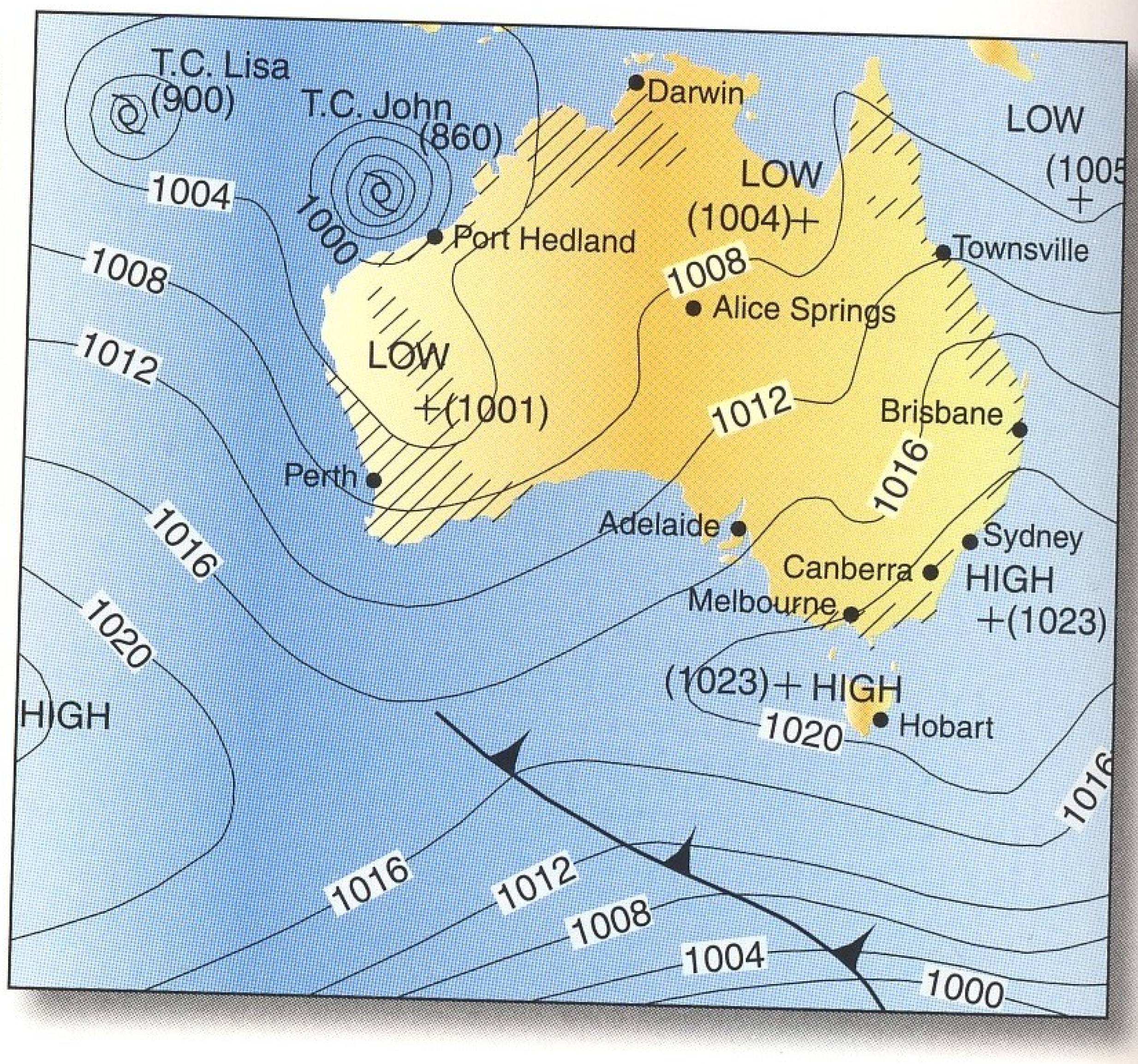
e What do you think happened a few days later? Why?

[2.22] Four weather maps of Australia, 14–17 December 1999 (Tuesday was the 14th)



Weather satellite images

Weather forecasters often use satellite images of Earth taken from space. They do not show as much detail as standard weather maps. However, they are useful in allowing forecasters to interpret cloud patterns and identify weather systems on a continuous basis so that subtle changes can be observed.



[2.23] Satellite image and associated weather map for 13 December 1999 showing the eye of a severe tropical cyclone moving towards the Western Australian coast

These subtle changes then enable weather forecasters to analyse the current sequence of events and possibly activate early warning signs of potentially disruptive weather. Local residents can then be warned of any precautions that need to be taken.

Examples of patterns that can be identified are:

- fronts—shown by narrow bands of dense clouds
- depressions—shown by a circular swirled pattern of clouds
- anti-cyclones—an area with generally clear skies.

Learning activities

2.16 What is synoptic data? Give examples.

2.17 What is a synoptic chart?

2.18 What do isobars measure?

2.19 Study the typical weather map [2.13].

- a Name the feature approaching Melbourne.
- b What weather is usually associated with this feature?
- c Name the feature influencing Darwin's weather.
- d What weather is usually associated with this feature?
- e What is the unit of measurement used to show differences between the isobars on the map?
- f What is the highest air pressure shown on the map?
- g Describe the weather that Perth experienced on 9 October 2004.
- h Identify the regions of Australia that received rainfall on 8 October 2004.

i Refer to the pressure system influencing Hobart's weather and indicate from which direction the wind is blowing.

j State the wind speed and direction at:

  i Cairns   ii Port Hedland.

k Name two places in Australia experiencing calm weather.

l Is this map typical of a summer or winter Australian weather map? Explain.

2.20 What is a satellite image?

2.21 List three patterns that can usually be identified on a satellite image.

2.22 Refer to the weather map and satellite images [2.23]. Describe how the following features appear on the satellite image:

a Tropical Cyclone John

b the low pressure system below the tropical cyclone

c the high pressure system east of Sydney

d the cold front to the south of Australia.

2.23 Working in groups, collect a different series of Australian weather maps over four consecutive days. Each group should give the first three maps to another group and ask them to predict the weather for the fourth day and to draw a likely synoptic chart. When finished, each group should check with the actual weather map for the fourth day to see how accurate the group's weather forecasting was. You could make this into a competition by awarding points for the degree of accuracy in forecasting.

2.24 Look up the following internet websites and write a brief comment about how useful each website is in learning about the weather in Australia:

WWW

a Bureau of Meteorology at <www.bom.gov.au>

b Learn About Meteorology at <www.bom.gov.au/info>

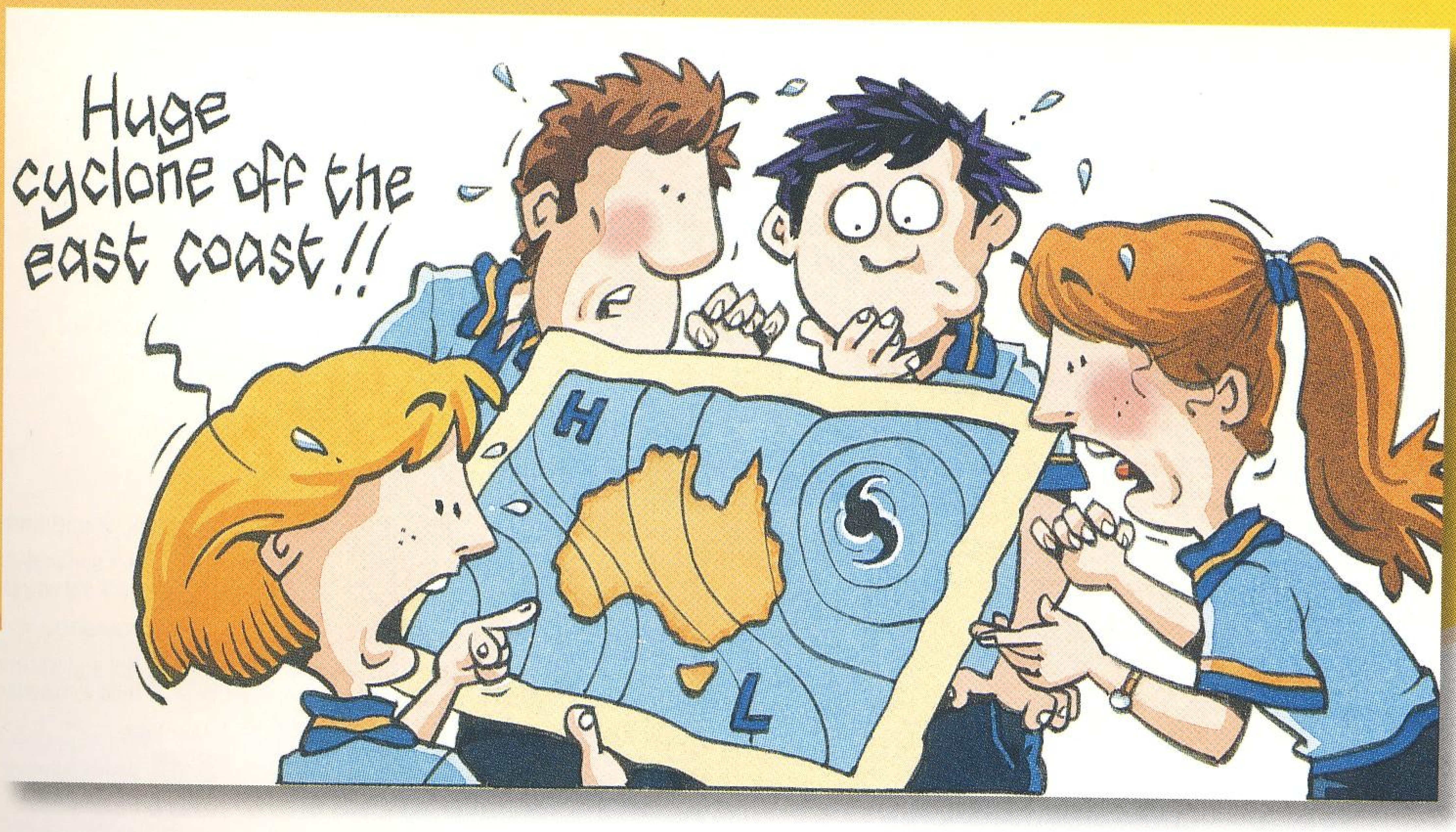
c Australian Severe Weather Association at <www.severeweather.asn.au>.

2.25 Make a video recording of the weather report for a given day on at least two television channels. Working in groups, analyse the similarities and differences between the two reports.

a Which television channel provided the most detailed information?

b Which television channel had the clearest graphical presentation?

2.26 Working in groups design your own television weather report. You may wish to record it on video and show it to the rest of the class. Class members could then make constructive comments on your presentation.



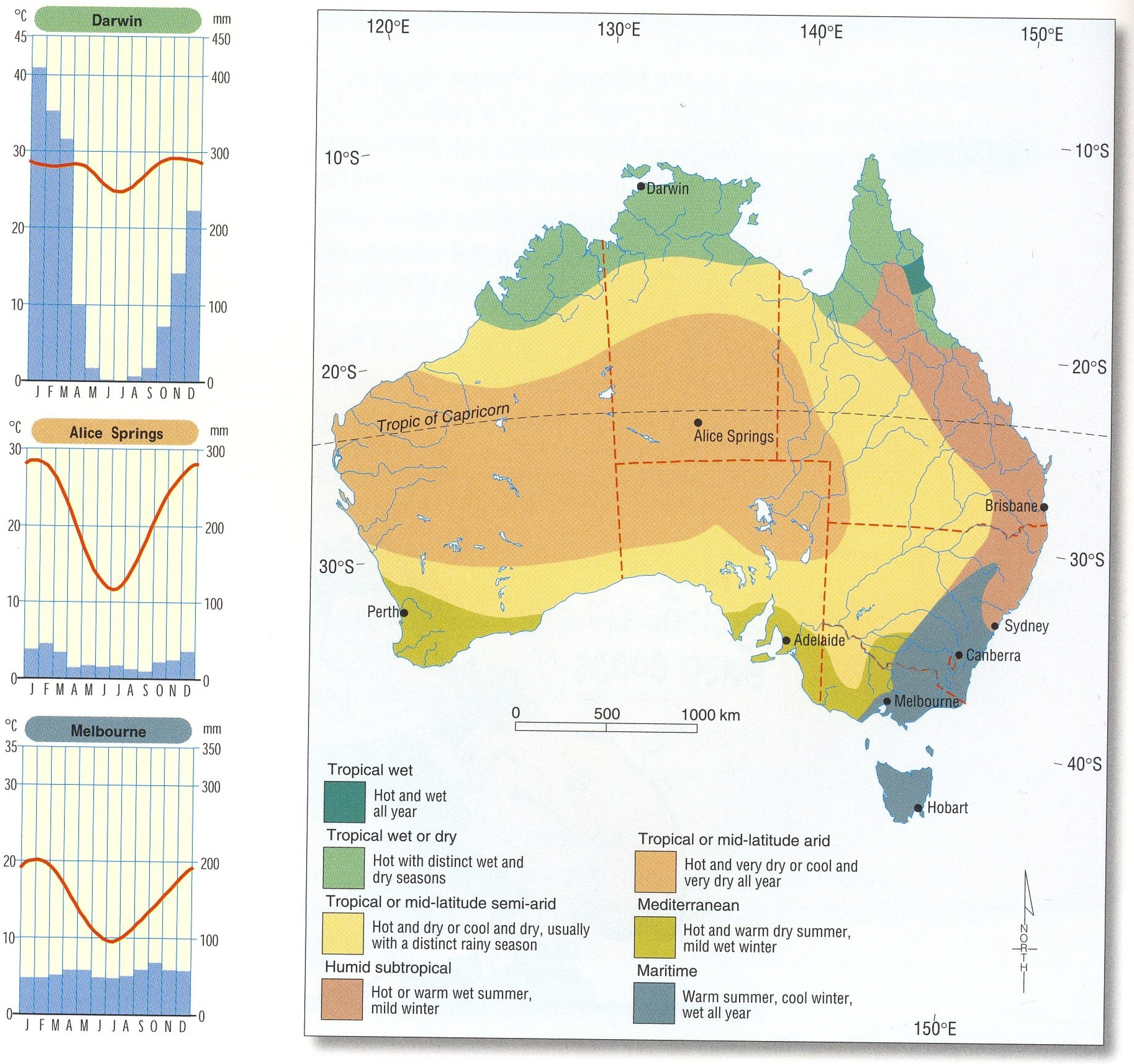
[2.24] Analysing weather maps

Australia's climate

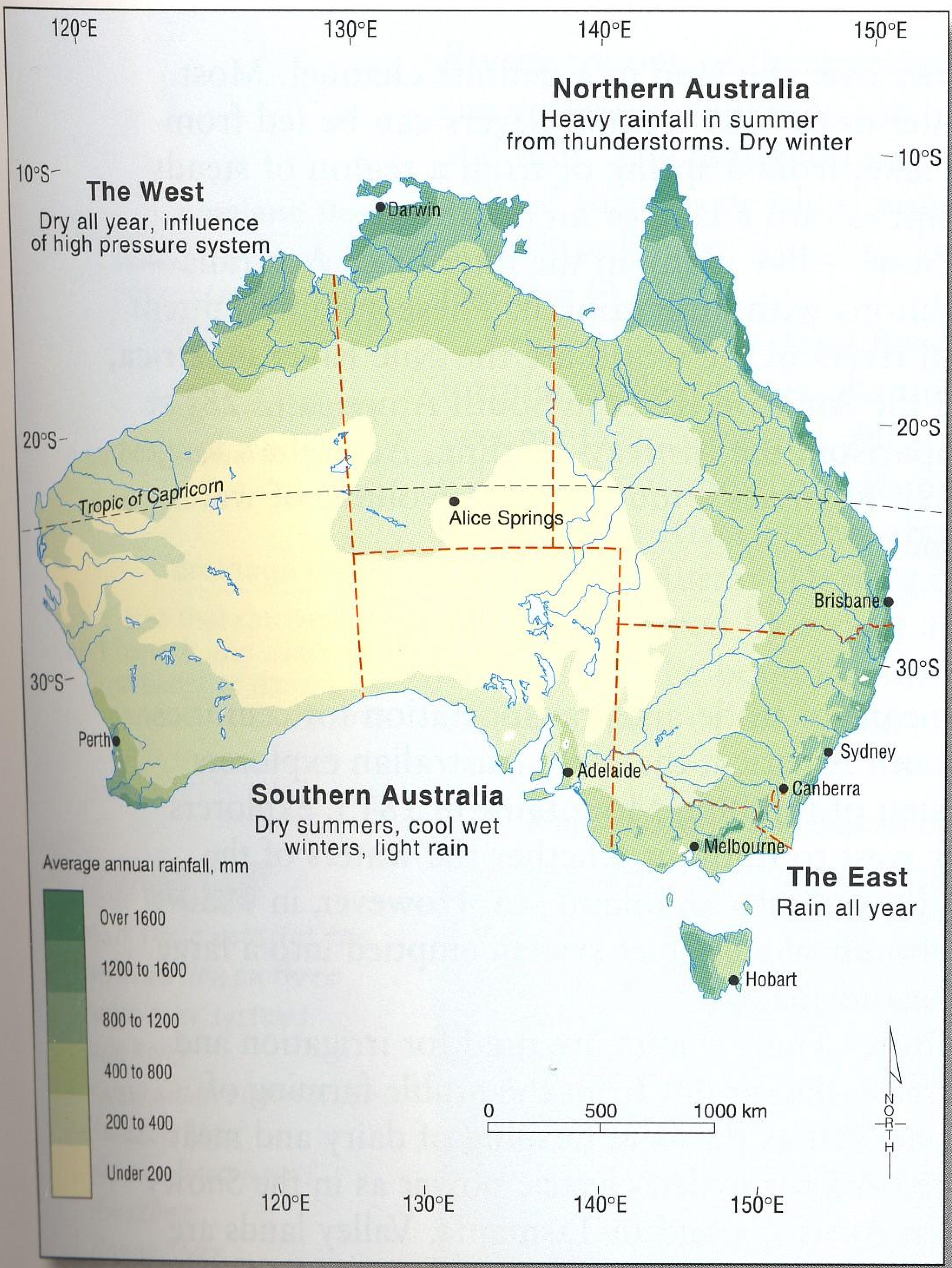
Because of its size, Australia has a variety of climates [2.25]. However, the most significant feature is its dryness. Rainfall in Australia is not only low but also very unreliable [2.27]. About two-thirds of Australia's land surface is classed as desert or semi-desert. Large areas of the inland have an average of less than 250 millimetres of rainfall a year [2.26].

Northern Australia lies in the tropics and has warm to hot temperatures throughout the year. Southern Australia has much cooler temperatures, especially in Tasmania and in the Snowy Mountains. Summer and winter variations in climate are the result of the way pressure systems operate. In summer, northern Australia receives heavy rainfall, mainly in the form of thunderstorm activity from low pressure systems. Southern Australia is generally dry with mild to warm temperatures. In winter, northern Australia experiences fine, sunny and warm conditions while southern Australia has cool, wet winters with light misty rain. Eastern Australia is generally wetter all year than the western part of the continent, which is influenced by stable high pressure systems [2.26].

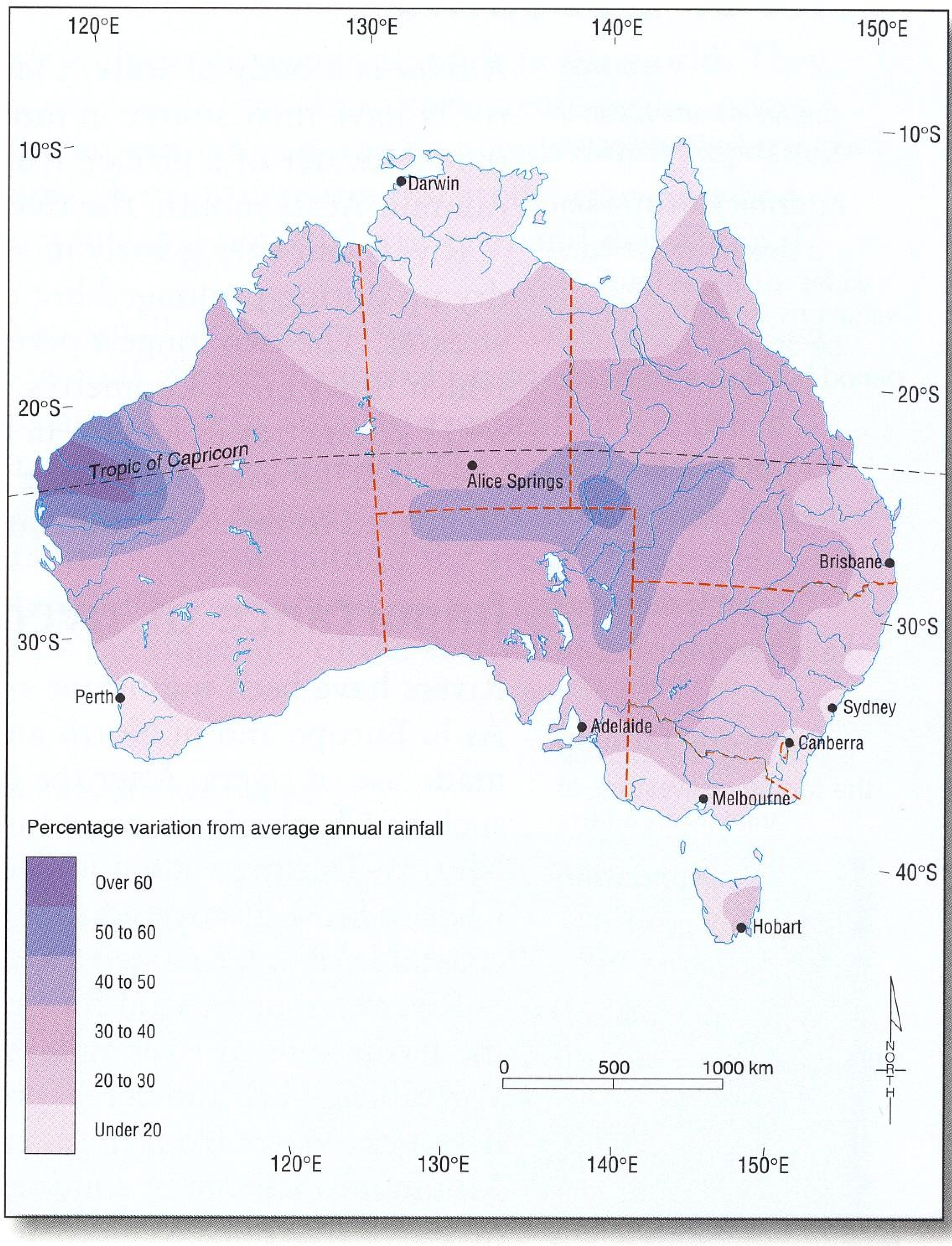
[2.25] Australia's climatic zones



[2.26] Australia's average annual rainfall



[2.27] Australia's variability of rainfall



Learning activities

2.27 Why does Australia have a variety of climatic types?

2.28 How would you describe Australia's rainfall?

2.29 How is northern Australia's climate different from that of southern Australia? (Mention both temperature and rainfall in your answer.)

2.30 Study the three maps on Australia's climate [2.25], [2.26] and [2.27].

- a Describe briefly the climate for:
  - i Darwin
  - ii Sydney
  - iii Adelaide
  - iv Hobart
  - v Alice Springs
  - vi Brisbane.
- b In which season would Melbourne normally receive most rain?
- c In which season would Cairns normally receive most rain?
- d What is meant by rainfall variability? Why is it useful in describing climate?
- e Which areas of Australia experience the greatest variability of rainfall? Suggest possible reasons for this.

2.31 Working in groups prepare a collage of photographs depicting Australia's variable climatic types.

2.32 As a class build up a mind map using the theme 'Australia's climate'.

www **2.33** Visit the internet website for the Bureau of Meteorology at <www.bom.gov.au>. Describe the range of information provided by this site. Check the page links.

River systems

source
the area from which a river's first flow originates

intermittent stream
a stream whose flow varies usually as result of variations in rainfall; it may be dry in a low rainfall period but flow after heavy rainfall

perennial river
a river that flows all year round

arable farming
the growing of crops on ploughed land

pastoral farming
the raising of livestock or animals on a farm

inundation
flooded or covered by water

percolation
the downward movement of water through the pores, joints and crevices in the soil and rock

A river is a body of water that flows over the land in a definite channel. Most rivers have their **source** in mountainous or hilly terrain. Rivers can be fed from the meltwater of a glacier, from a lake, from a spring or from a region of steady rainfall. At its mouth, the river empties into a lake or an ocean.

Rivers can vary greatly in size. Some—like many in the interior of Australia—dry up during prolonged hot conditions with little rainfall. These are **intermittent streams**. The two longest **perennial rivers** in the world are the Nile River in Africa, which flows 6671 kilometres, and the Amazon River in South America [2.28] at 6437 kilometres in length. In comparison, the Murray–Darling, Australia's longest river, is 2589 kilometres long [2.29]. It carries a much smaller volume of water compared to the Nile and Amazon.

Importance of rivers

Rivers have been important as a means of trade and transportation for centuries. As in Europe and in North and South America, the early Australian explorers made use of rivers. After the crossing of the Blue Mountains in 1813, explorers such as Charles Sturt went further west to find out whether the waters of the Murray–Darling system joined or flowed into an inland sea. However, in 1830 Charles Sturt discovered that the mouth of this river system emptied into a large coastal lake, later named Lake Alexandrina.

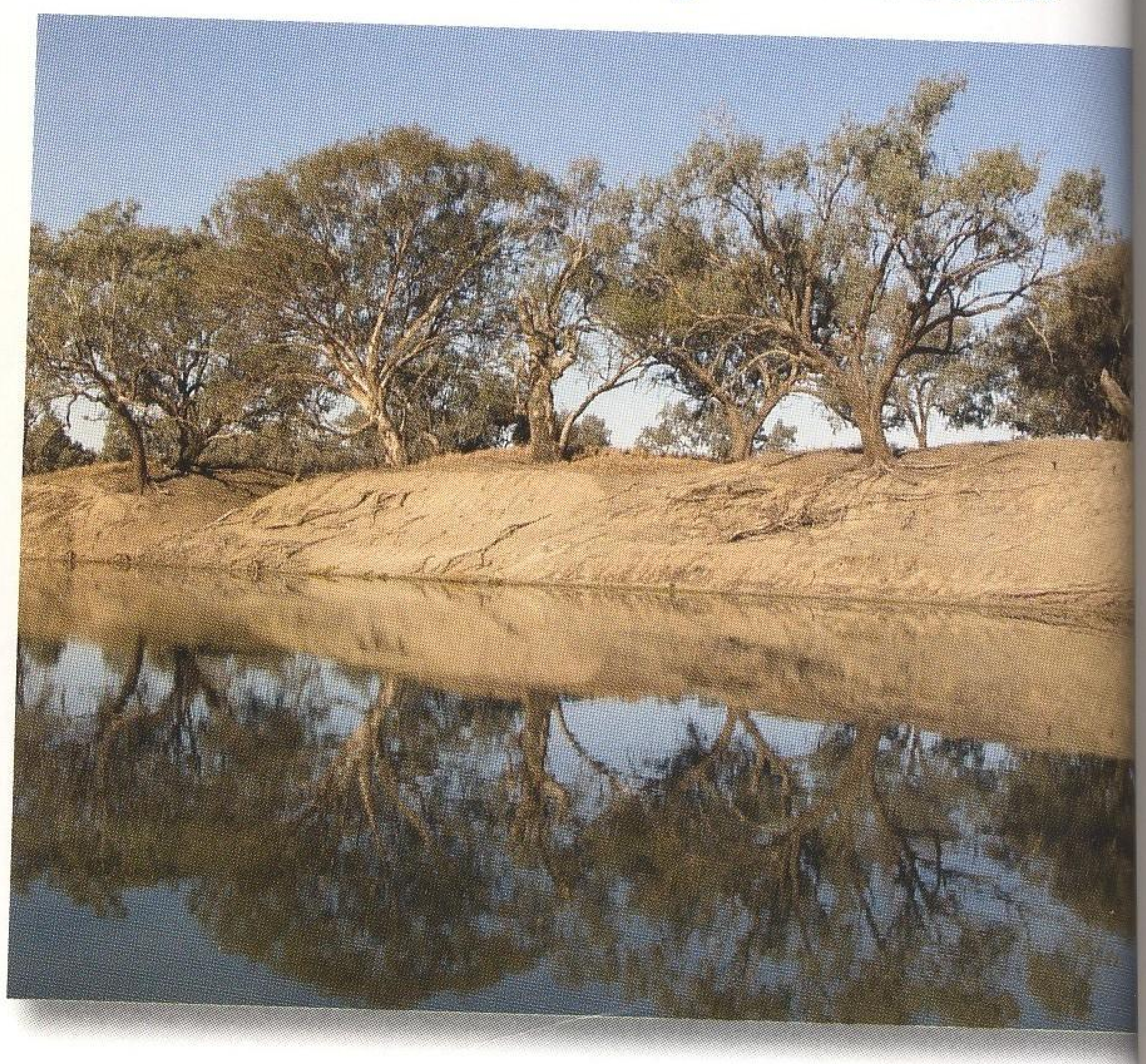
Rivers are often vital for agriculture. Their waters are used for irrigation and the fertile soils of river valleys increase the output from the **arable farming** of vegetables, fibre and cereal crops, as well as **pastoral farming** of dairy and meat livestock. Water from rivers can be used for hydro-electric power as in the Snowy Mountains Scheme of south-eastern Australia and in Tasmania. Valley lands are favoured locations for settlement and industry. Yet despite the beneficial effects of water use, heavy rainfall or the rapid melting of snow can cause rivers to break their banks and flood. This may result in the washing away of fertile soil, transport and communication lines, the **inundation** of farming lands, the destruction of homes and other buildings, together with human injury or even death.

Think about this

Each year some 96 000 cubic kilometres of water falls onto land surfaces over the globe. This may fall as rain, hail, sleet or snow. About 56 000 cubic kilometres of water evaporates back into the atmosphere. This leaves some 40 000 cubic kilometres of water to become run-off (water flowing back to the sea through rivers), or to infiltrate or **percolate** into the soil to be temporarily stored as groundwater.

[2.28] High volume of the Amazon River

[2.29] Part of the Murray–Darling River near Bourke



Erosional and depositional features created by rivers

Rivers are one of the greatest earth sculpturing agents at work in the world. They can carve out valleys in the highlands and as they do so they create peaks, ridges and hills. The material removed is transported from the highlands and is deposited around them as gently sloping plains. A river therefore can erode, transport and deposit sediment. These processes result in a range of erosional and depositional features [2.30].

overland flow
surface run-off that is not concentrated into individual channels

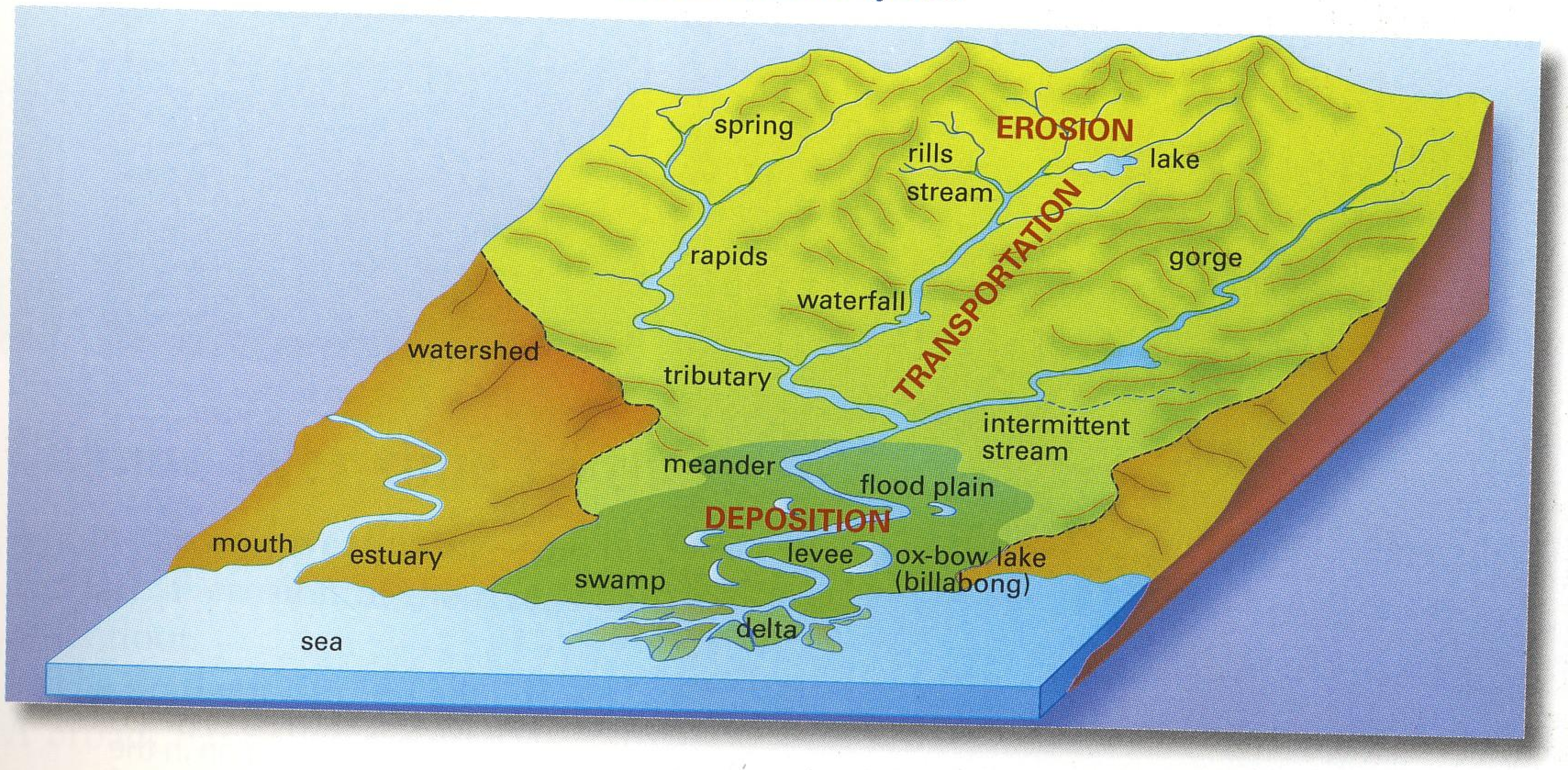
tributary
a stream or river that joins a larger one

drainage basin
the area that catches rain and feeds it into rivers and streams, or dams (also known as catchment)

At its source **overland flow** erodes small streamlets that eventually join together forming wider, deeper channels downhill. These channels in turn combine to become larger streams. All streams are joined by smaller streams that are called **tributaries**, as they contribute water to the main channel. The drainage basin of the Amazon River covers about seven million square kilometres and the catchment area of the Murray–Darling covers nearly one-seventh of the area of Australia. The area drained by a river and its tributaries is known as a **drainage basin** or **catchment**. The boundary formed by the ridge line of the surrounding highland is the watershed of the basin.

WWW
Visit these websites for information on three large river systems:
Nile River <www.mbarron.net/Nile>
Amazon River <www.mbarron.net/Amazon>
Congo River <www.congo-pages.org/congo.htm>

[2.30] Major erosional and depositional features of a river system



Learning activities

2.34 Write a short paragraph describing what river systems are and their importance.
2.35 Explain why river systems vary in size.
2.36 Describe the erosional and depositional work done by rivers.

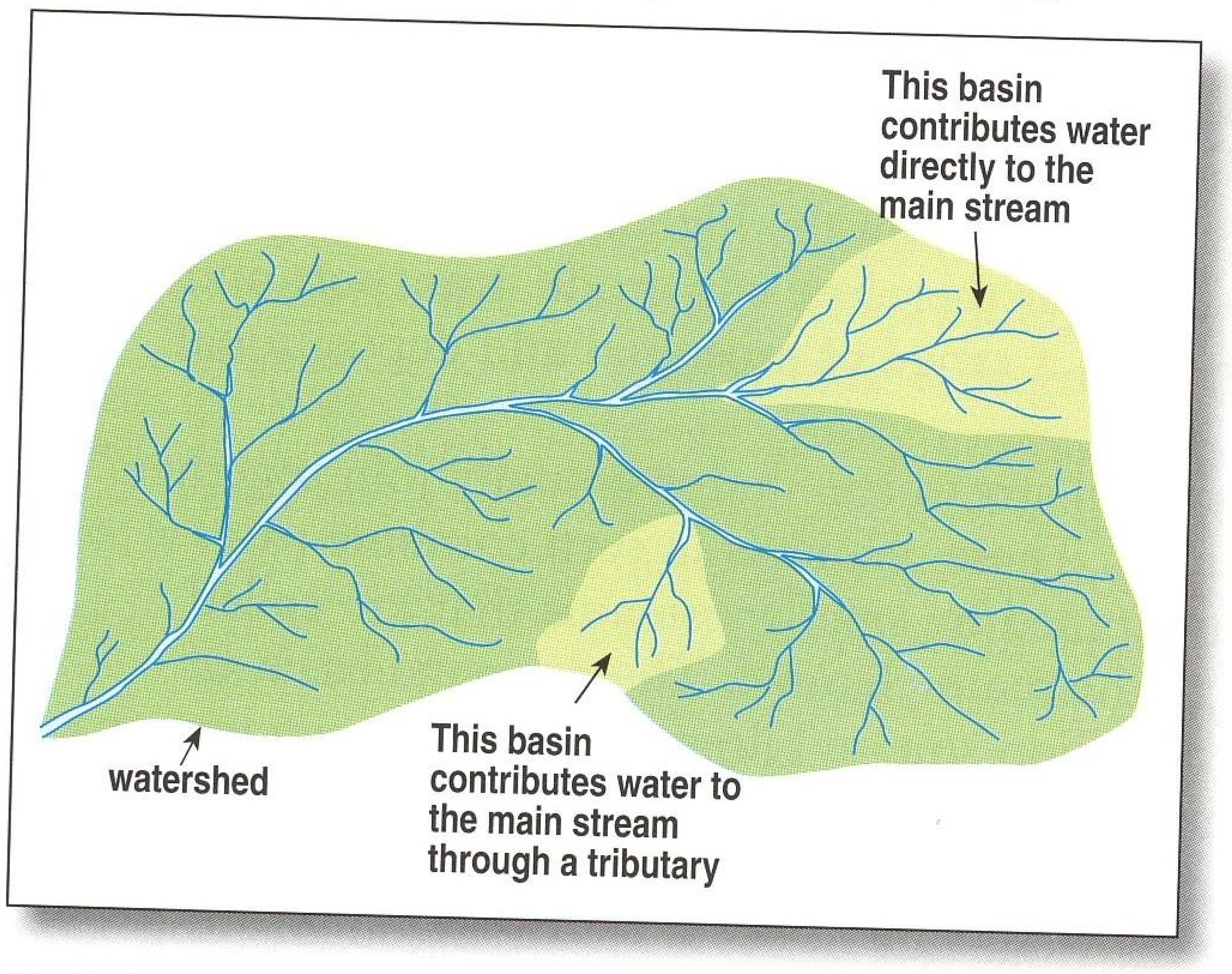
Drainage patterns

The smallest streams collect water from a slope or particular set of slopes and this catchment forms part of a larger catchment area [2.31].

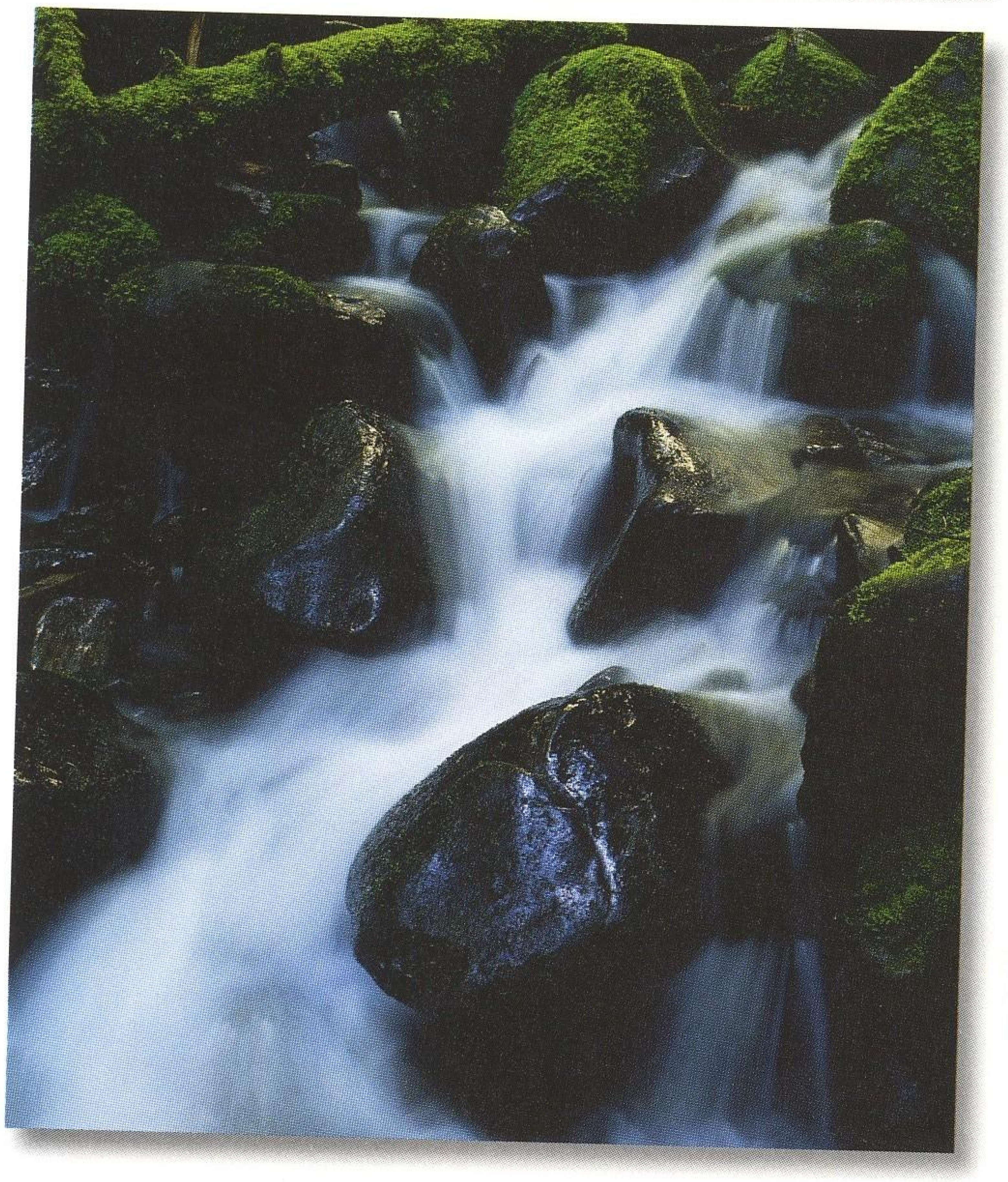
drainage pattern
the arrangement of the main river and its tributaries

The river system develops a **drainage pattern** that is related to the geological structure of the basin. Common drainage patterns are dendritic (like the branches of a tree), parallel, radial (radiating from a central point) and trellis [2.32].

[2.31] Formation of a drainage basin or catchment



[2.32] Common drainage patterns:



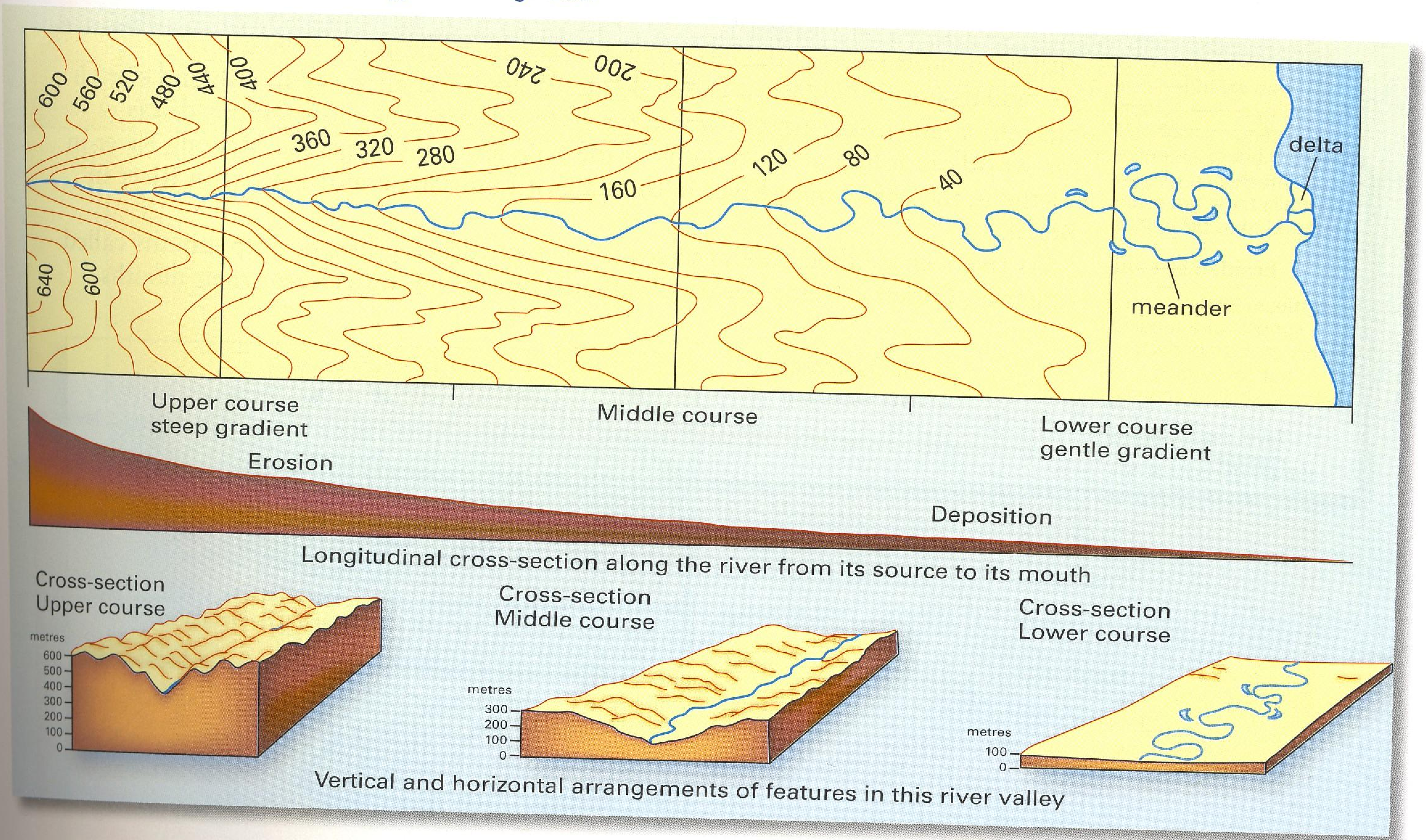
[2.33] Waterfalls are common in the upper parts of a river valley

River valley features

Near its source, in the upper part of its valley, the land is elevated so the stream has enormous erosive potential [2.34]. The stream bed also tends to be steeply sloping. This produces turbulent flow. The energy of the river cuts down deeply creating narrow, steep-sided V-shaped valleys. The valley floor may be broken by potholes, rapids and waterfalls [2.33]. Waterfalls occur where a river crosses a layer of hard, resistant rock. Softer rock downstream is eroded or worn away by the flow of water, leaving a steep drop in the channel. As water passes over the edge of the resistant rock strata, water falls to the lower part of the channel. Meanwhile, upslope, **headward erosion** extends the length of the stream above its original source.

headward erosion
the cutting back upstream of a valley above its original source

[2.34] Topographic features of a typical drainage basin



Change over time to the shape of valleys

weathering
the breakup of rock material into smaller pieces by exposure to the weather

lateral erosion
the erosion performed by a stream on its banks

floodplain
the flat landform formed from deposits after river flooding

levee
a natural bank built up by a stream along the edges of its channel especially during floods; when the water recedes the bank remains

As time passes, weathering—the breakdown of rock material on the valley sides—and lateral erosion of the river's banks by the river, widens its valley and the width of its floor.

The gradient of the valley floor is reduced so the river has less energy to erode. A broad, flat valley results. The initial bends in the river become more pronounced meanders. Lateral erosion continues to widen the valley. The gradient is further reduced and deposition begins. Layers of sediment are deposited by the river when it floods and these ultimately extend over the entire valley where they build up a gently sloping floodplain.

Floods can also spread fertile silt and mud over the land, creating natural levees or raised sections along the river's banks. Ox-bow lakes or billabongs may be left from former meanders. If the river divides into many channels due to the deposition of sediment, the streams may become braided.

The four diagrams in [2.35] summarise the changes that occur in river valleys over time.

ox-bow lakes or billabongs
the surviving part of a former meander loop formed by a river current cutting through the meander neck to abandon a crescent-shaped lake; in Australia these are often referred to as billabongs

braided stream
a stream whose course consists of a tangled network of interconnected, but converging and diverging shallow channel

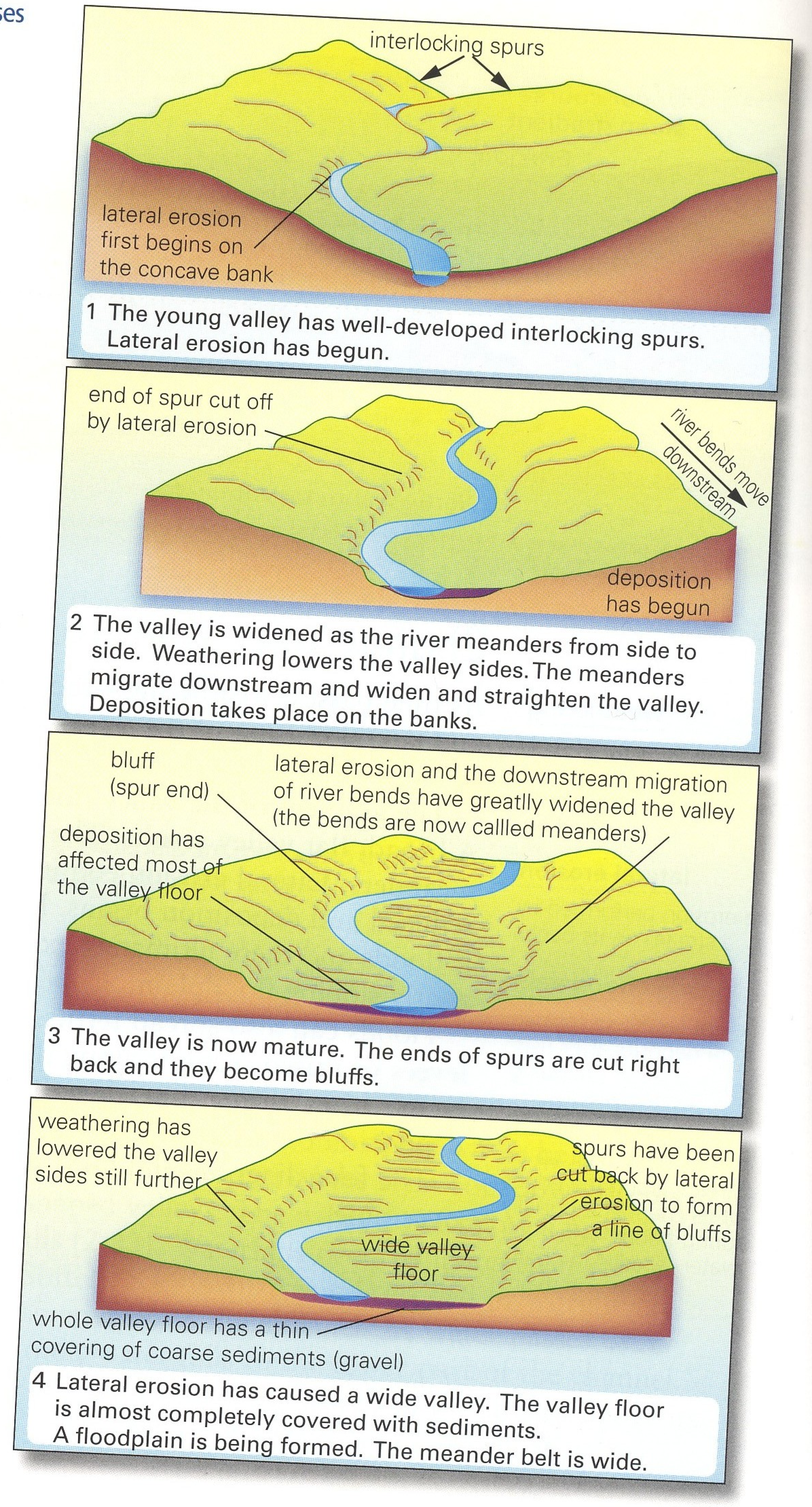
delta
the silt deposits at the mouth of a river

Closer to the river's mouth

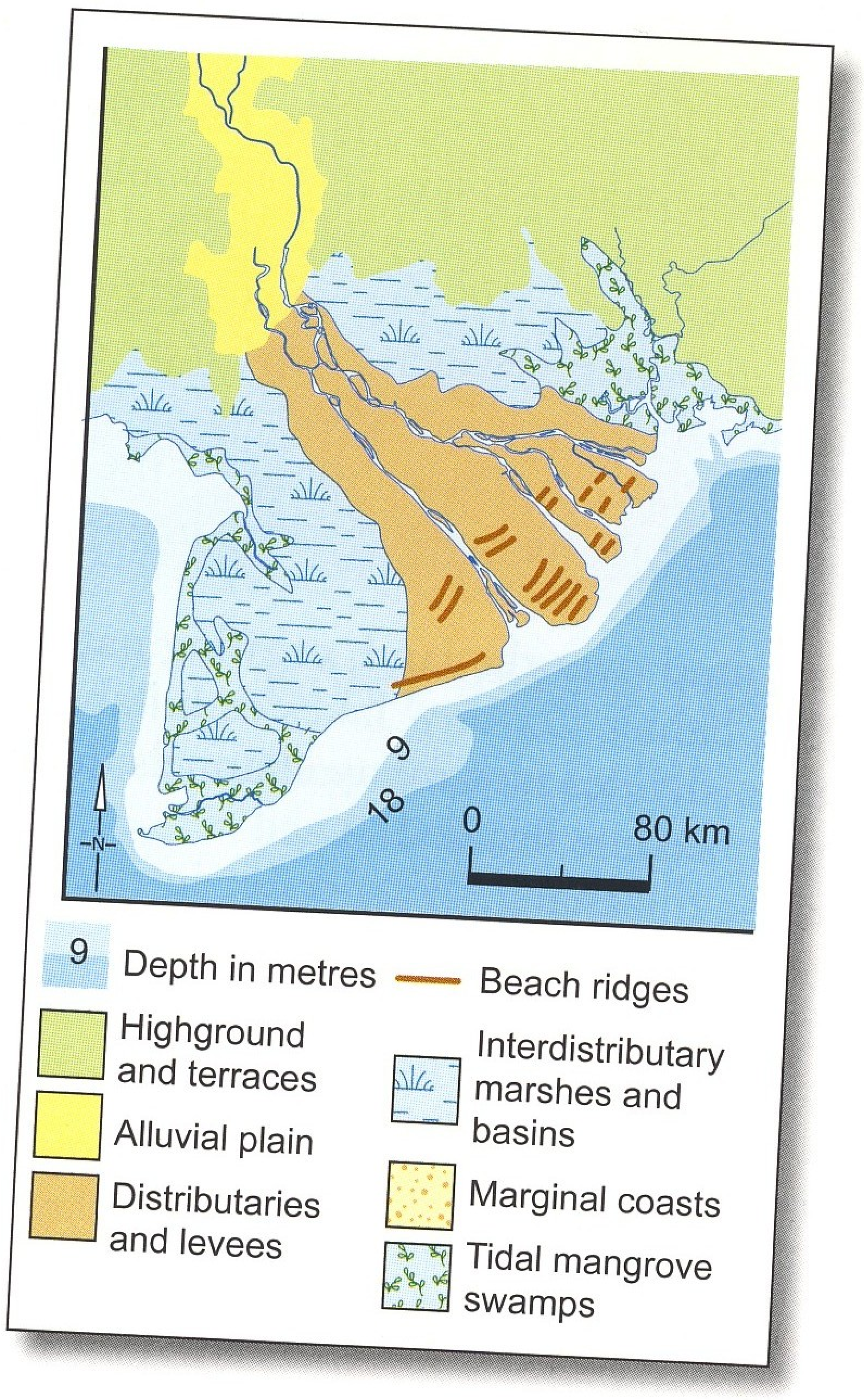
Further deposition near the mouth of a river can result in the formation of triangular-shaped landforms called **deltas**. These build up at the mouth and stretch out into a lake or ocean into which the river empties. The most famous deltas in the world are found at the mouths of the Nile River in Egypt, the Mekong River in Vietnam, the Mississippi River in the state of Louisiana and the Amazon River in Brazil.

As rivers erode their valleys to sea level, some develop broad, deep mouths called estuaries. Others develop areas of wetlands or shallow waters near their mouths.

[2.35] The processes of river widening



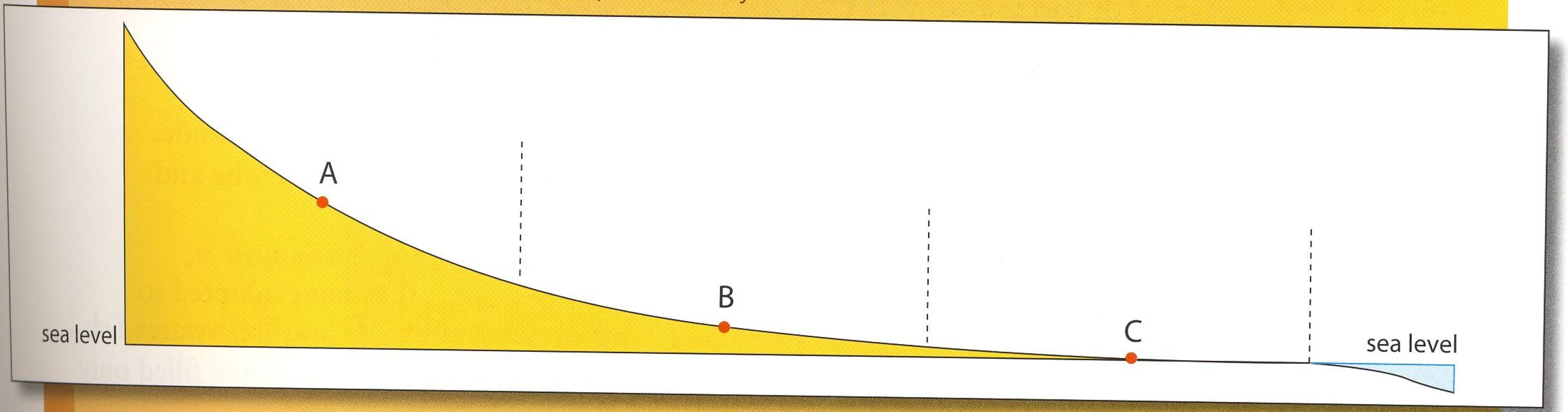
[2.36] The delta of the Mekong River in Vietnam



Learning activities

2.37 Below is a longitudinal profile of a river from its source to its mouth.

a Copy this profile into your notebook.



b Print the following words in the appropriate places on the diagram.

upper tract	middle tract	lower tract	mountain
rapids	transportation	flood plains	V-shaped valley
waterfall	sea	delta	deposition
erosion	ox-bow lakes	plain	natural levees

c Describe what is happening at each point.

A	B	C

2.38 Complete the following table to show your understanding of how the following erosional and depositional features are formed by rivers.

Some characteristic features found in the upper course of a river	Erosional or depositional features	How they were formed
deep, narrow V-shaped valleys		
pot holes		
waterfalls and rapids		
Some characteristic features of the middle and lower tracts of a river	**Erosional or depositional features**	**How they were formed**
meanders		
ox-bow lakes or billabongs		
floodplain		
natural levees		
deltas		
estuaries		

Wetland systems

wetland
any area where water levels remain near or above the surface of the ground for most of the year

Wetlands are specialised ecosystems. They usually occur in low-lying areas that collect fresh water from lakes, streams and rivers, or salt water along the coast. Wetlands can include marshes, lakes, billabongs, mud flats or mangrove swamps.

Types of wetlands

There are a number of different types of wetlands in Australia. They include:

- coastal wetlands, which are the habitats of many species of fish, crabs and shrimps
- riverine wetlands such as those along the Murray–Darling River system, which have specialised ecosystems with river red gums that have adapted to fluctuations in river levels; providing habitats for waterbirds and freshwater fish
- ephemeral wetlands such as those in the desert regions, which become filled only after heavy rainfall
- monsoonal floodplains in northern Australia such as those in Kakadu National Park, which are filled during the summer and become the home of crocodiles, waterbirds and a range of aquatic life.

ephemeral wetland
a wetland that has a short life span

[2.37] Wetlands under the Westgate Bridge in Melbourne

[2.38] Mangrove swamp

[2.39] Riverine wetlands along the Murray River at Barmah Forest

[2.40] Coastal wetland

Importance of wetlands

Wetlands have an important role in the natural environment. They are breeding grounds for fish, prawns, waterbirds and frogs. The mangrove swamps of Moreton Bay near Brisbane are breeding grounds for commercial fish stock. Waterbirds like ibis, cormorants, egrets and spoonbills congregate in the Barmah and Gunbower Forests along the Murray's floodplain in northern Victoria. The wetlands distributed along the western shorelines of Port Phillip Bay near Melbourne are home to endangered species such as the orange-bellied parrot.

Apart from supporting a wide range of wildlife, wetlands also help purify water, trapping potentially harmful sediments from agricultural run-off, viruses from sewage works, or industrial effluents such as **heavy metals** that may settle in the shallow water. They help regulate water flow after floods, holding water and then slowly releasing it downstream. In times of drought, they can provide a refuge for livestock and wildlife. They provide locations for a range of recreational activities such as birdwatching, swimming, boating, fishing, hunting and duck shooting. Yet human activities can also impact on the wetland ecosystem, especially in urban centres [2.41].

heavy metals potentially toxic metals such as mercury, lead and cadmium that may be released into waterways from industrial plants

Think about this

- Over half of Australia's wetlands have been destroyed since European settlement. The remaining wetlands are some of our most threatened areas.
- 2 February each year is World Wetlands Day. It marks the date of the signing of the Ramsar Convention on 2 February 1971.

Economically, wetlands can become major tourist attractions. Kakadu National Park, for example, attracted over 200 000 visitors in 2000 and visitor fees of more than $1.5 million annually help improve infrastructure not only for visitors but provide income for the traditional Indigenous owners of the region.

The common perception held in the past was that wetlands were ugly, worthless and mosquito-ridden. As a result, many have been reclaimed, drained or infilled. Many of the canal estates on Queensland's south-east coast for example, were developed on drained wetlands [2.42].

[2.41] Urban outfall pipe into a wetland

[2.42] The Sanctuary Cove development has impacted on the valuable mangrove ecosystem