CHAPTER 9

Neighbours in space

The Sojourner rover was only 63 cm long. It sent back images from Mars for three months.

You will discover

What causes the tides on Earth

Why the Moon seems to change its shape

Why we have night and day, and different seasons

Why the stars seem to move in circles in the sky

Exploring Mars

The planet Mars is one of Earth's closest neighbours. No reliable evidence of past or present life on Mars has yet been found. But the curiosity about Mars remains.

The first close-up television pictures of the surface of Mars were taken in 1965 by the space probe ***Mariner 5***. These pictures showed a very dry surface with lots of thick red dust. There was no sign of life or water. There were, however, icecaps at the poles.

The first soft landing on Mars was made in 1971 by the Russian space probe ***Mars 3***. It sent back TV pictures from the surface. Much more information about Mars was gathered in 1997 as part of NASA's ***Mars Pathfinder*** mission. For three months, a small Earth-controlled rover called ***Sojourner*** explored the surface and sent back images.

Other space probes continue to take images of Mars. And perhaps it won't be too long before a human lands on Mars!

1 Why do you think Mars is sometimes called the 'red planet'?

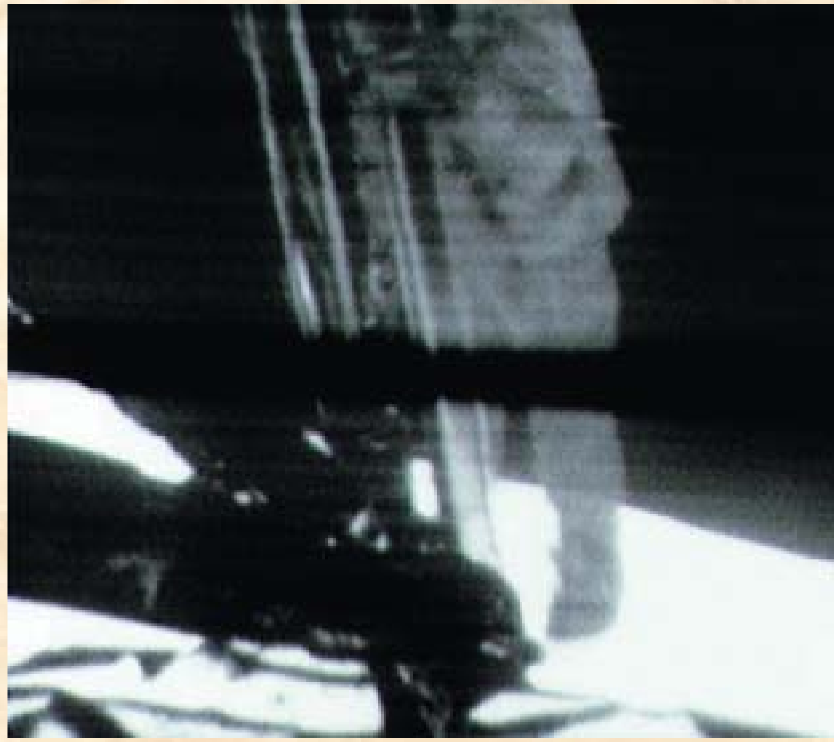
2 Can you locate the icy poles of Mars?

3 In what way are our space missions like the journeys of the world's past explorers?

THE DAILY SATELLITE

MONDAY 21 JULY 1969 WEATHER: WARM 63°F

MAN ON MOON



'That's one small step for man'.

This picture is from the live television broadcast of Neil Armstrong's first walk on the Moon. The remote-controlled camera was attached to one of the legs of the landing module. The black bar in the photo was caused by a communications fault back on Earth.

At 10.56 pm last night, millions of people throughout the world watched on television as Neil Armstrong slowly climbed down the ladder of the lunar landing module to become the first human to set foot on the Moon. As his first foot touched the surface, he said, 'That's one small step for man'. Less than a second later, when his second foot touched the surface, he added, 'One giant leap for mankind'.

Armstrong described the surface as fine and powdery as he kicked it, sending a cloud of dust upwards. It fell slowly, but straight down — not a sign of wind. He also described the surface as being covered with lots of 'little impact craters'. About 20 minutes later, Buzz Aldrin climbed down the ladder to join his fellow astronaut on the surface. They spent over two hours collecting rocks and setting up scientific experiments before returning to the landing module for a rest.

Both astronauts took quite a while to get used to the smaller pull of **gravity** on the Moon. It is about one-sixth as much as it is here on Earth. In fact, they had to lean forward to balance and had to walk slowly so that they could stop quickly if they needed to.

While Armstrong and Aldrin were 'moon-walking', the third astronaut of the *Apollo 11* team, Michael Collins, was in orbit **about** 100 km above the surface. Even though he was closer to the Moon than the millions of people on Earth watching television, he did not see his companions on the surface. He had no video monitor and could only listen by radio.

After some well-earned rest and a chat to President Nixon, Armstrong and Aldrin will climb down the ladder again to set up some more experiments. They'll also begin collecting samples of soil and rocks to bring back to Earth with them for analysis.

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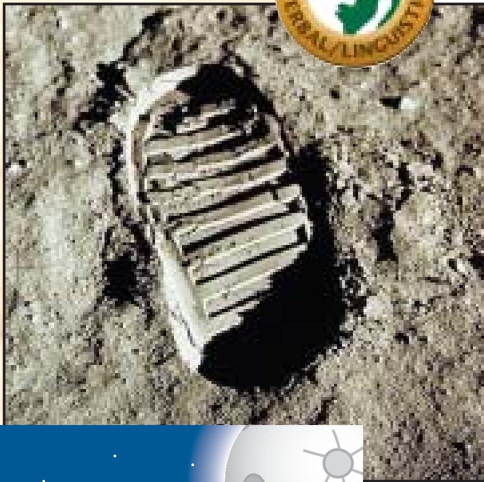
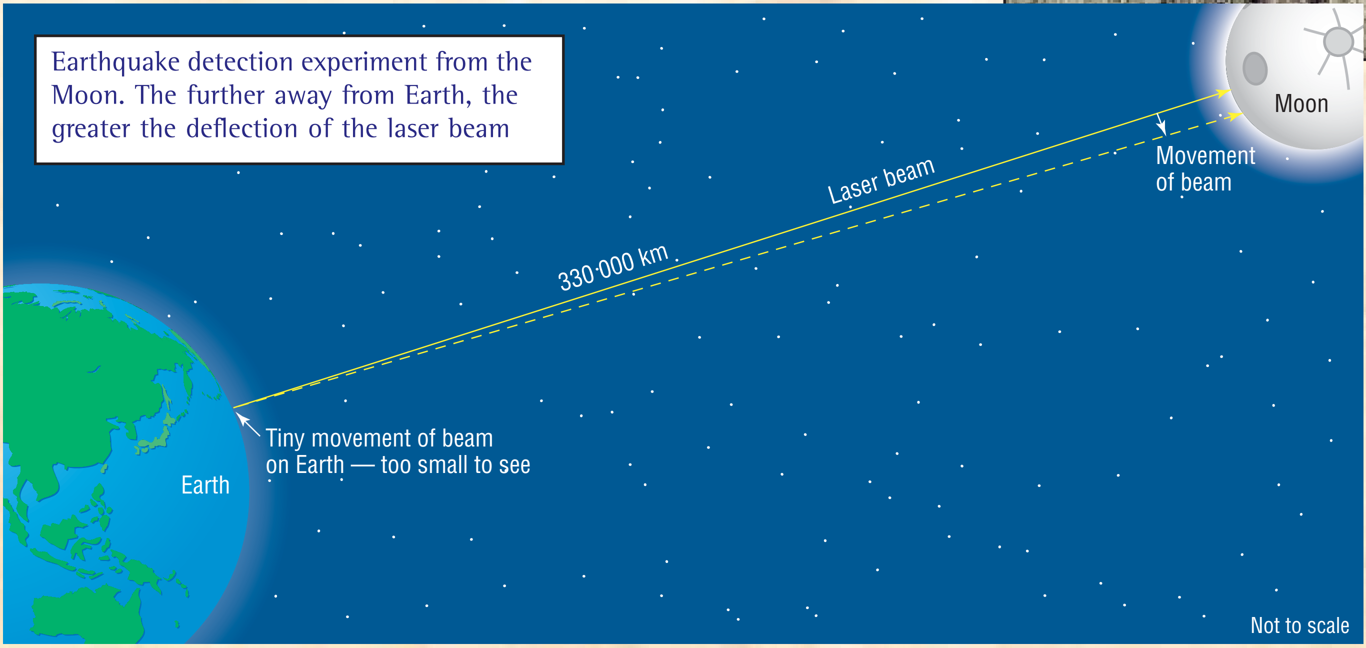
Checking for earthquakes

One of the experiments the astronauts are setting up will detect movements on both the Earth and the Moon. The experiment uses an earth-tremor recorder to detect small earthquakes on the Earth. The recorder receives a narrow laser beam coming from Earth. Because of the huge distance between the Earth and the Moon, even a tiny movement on Earth causes a large movement in the laser beam by the time it reaches the Moon.

Footstep record of history

According to space scientists, the first footprint ever made on the Moon will last for millions of years. Buzz Aldrin will photograph many footprints left by himself and Neil Armstrong before the lunar module returns to the command module and then heads back to Earth. The photographs are part of an experiment to find out how the dust on the Moon behaves when it is put under pressure.





Activities

REMEMBER

1. Describe the surface of the moon.
2. Why is it so easy to detect a tiny movement on Earth with a laser beam pointed at the Moon?

THINK

3. What do you think Neil Armstrong meant when he said 'That's one small step for man, one giant leap for mankind'?
4. The first footprint on the Moon will remain there for millions of years. How can it last that long?
5. Photographs of footprints are part of an experiment to find out how the dust on the Moon behaves when it is put under pressure. How could the results of this experiment be useful?
6. Why do you think that so much money was spent sending humans to the Moon?

IMAGINE

7. Imagine that a small colony is set up on the Moon. Up to 50 people at a time are allowed to live and work on the Moon for one year:
   (a) Sketch one way of making it easier for people to adjust to the gravity on the Moon.
   (b) Describe some of the difficulties that would have to be solved to allow the colony to be set up.

checklist

I can:
- ☐ describe the surface of the Moon
- ☐ discuss how the reduced gravity on the Moon affects movement
- ☐ discuss the purpose of a manned mission to the Moon.

The neighbourhood

In the film *Titanic*, Leonardo DiCaprio said he felt like he was 'king of the world'. Think what a huge kingdom that would be — the whole world! Now, think again — the world, Earth, is just a tiny, tiny part of a very large neighbourhood.

The neighbours

The Earth is the fifth biggest of nine planets in our **solar system**. All of the planets **orbit** the Sun, our nearest star. The Sun weighs more than 300 000 times as much as Earth. It is made up mostly of hydrogen and helium. The hot gas swirling near its surface has a temperature of around 6000 °C. The temperature in the centre of the Sun is believed to be about 15 000 000 °C.

The orbit of all planets is not quite circular. All planets except Pluto, usually the most distant, orbit the Sun in roughly the same flat plane, or level. Pluto's orbit is at an angle to this plane. Its orbit is also more oval-shaped than the other planets. Sometimes Pluto can be as far away from the sun as 7304 million kilometres. At other times it can be inside the orbit of the planet Neptune, making Neptune the furthest planet.

Some of our neighbours are much smaller than the planets. **Asteroids** are small, irregular rocks that, like the planets, orbit the Sun. Most asteroids are found between the orbits of Mars and Jupiter. **Comets** are balls of dust, ice and frozen gases. They orbit the Sun, but their paths are not circular. As they approach the Sun, they develop a tail as the frozen gases heat up.

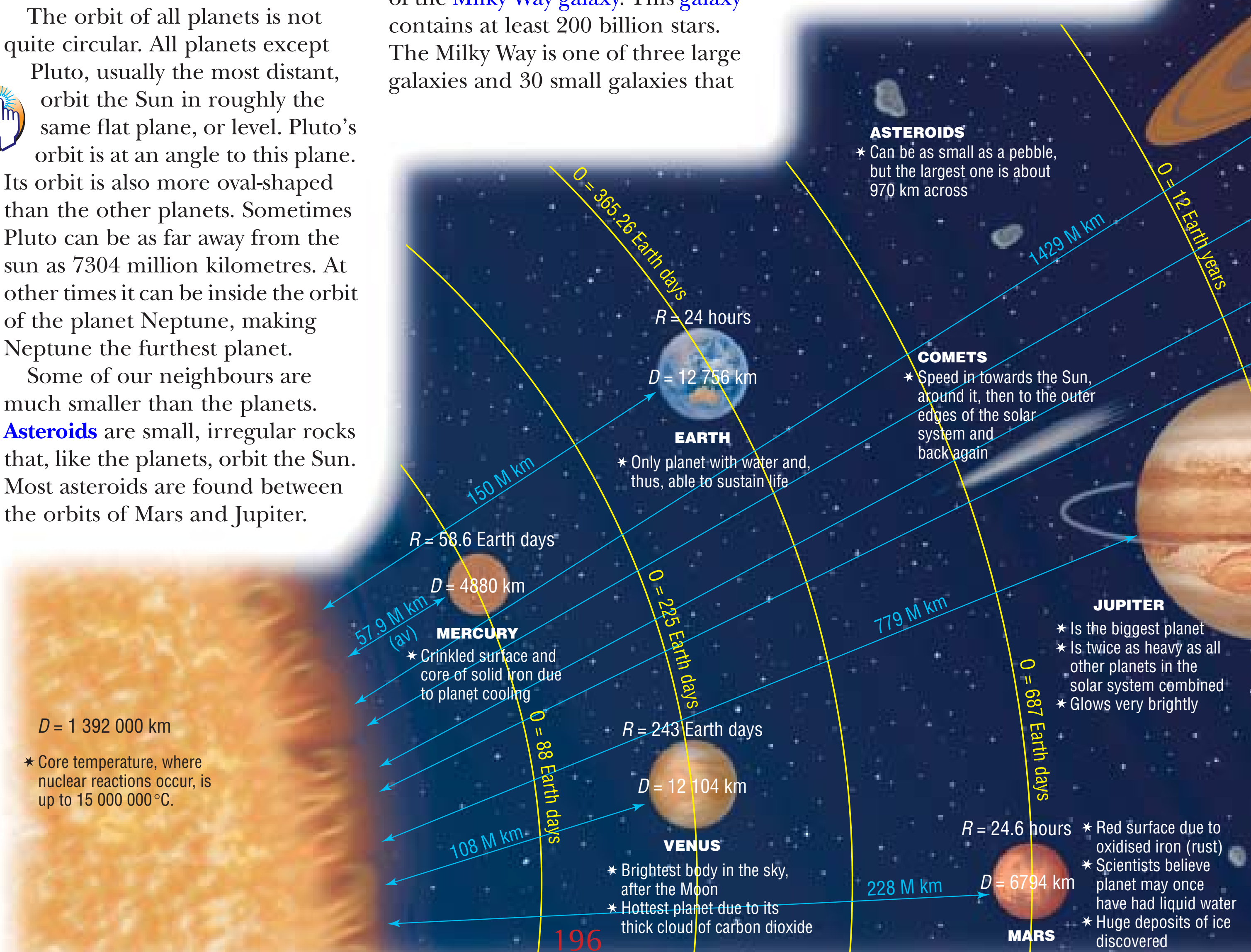
Going out further

Our solar system is part of the solar neighbourhood. The solar neighbourhood contains stars within 250 **light years** of Earth.

Our solar neighbourhood is part of the Milky Way galaxy. This galaxy contains at least 200 billion stars. The Milky Way is one of three large galaxies and 30 small galaxies that make up the Local Group. Some groups have over 2000 galaxies!

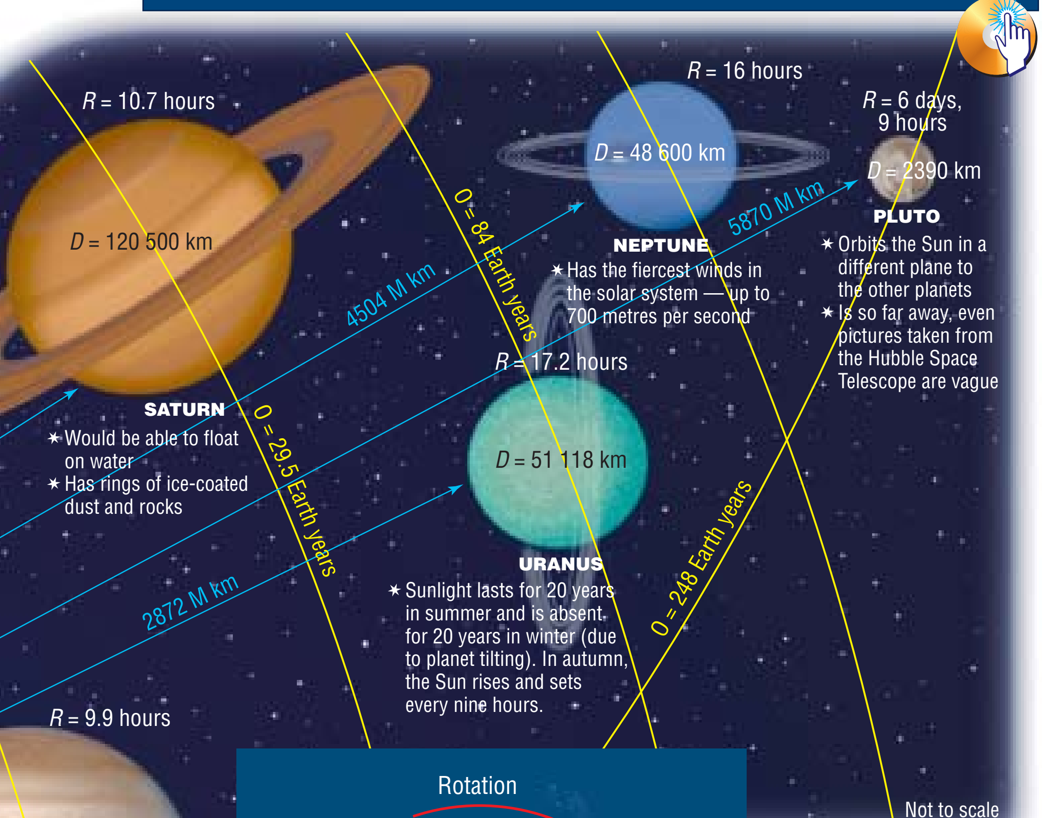
And further!

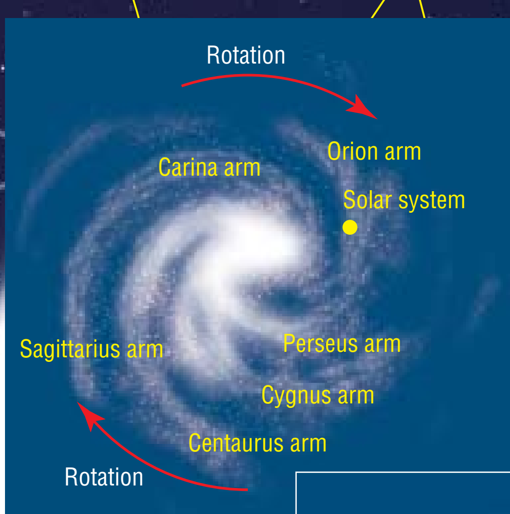
The Local Group is, in turn, part of a super cluster. And, guess what? There are millions of super clusters in the **universe**! The universe includes everything, from the tiniest specks of dust, to the most distant stars more that 10 billion **light years** away.



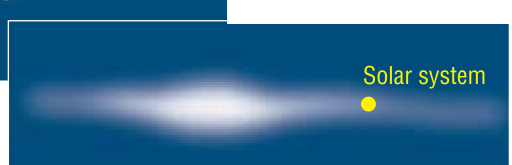
A star which is 250 light years away doesn't sound too far away. Let's see, though, what this means. A light year is the distance light travels in one year. We know that light travels at close to 300 000 km/s and that there are 31 536 000 seconds in a year (365 days × 24 hours × 60 minutes × 60 seconds). Multiplying these two figures gives us the number of kilometres in one light year — about 9 500 000 000 000 kilometres. So a star 250 light years away is about 2 400 000 000 000 000 kilometres away.

Key
D = diameter at equator
R = time taken for a single rotation (i.e. 'one day')
O = time taken to orbit the Sun
M = million; av = average
— = orbital path
✶ = special feature





View from above



View from side

The Milky Way galaxy

The solar system is just a very small part of the Milky Way galaxy.

Activities

REMEMBER

1. What is a light year?
2. Describe the differences between asteroids and comets.

INVESTIGATE

3. Where is the solar system in the Milky Way? Describe how big it is compared to the Milky Way.

USING DATA

4. Look at the illustration of the solar system.
   (a) How far is Earth from:
      (i) Mars?
      (ii) Venus?
      (iii) Jupiter?
   (b) How much closer to the Sun is Mars than Neptune?
   (c) How much longer does Pluto take to orbit the Sun than Uranus?
   (d) Which planet takes
      (i) the longest and
      (ii) the shortest time to complete one rotation?
   (e) What is so unusual about the seasons on Uranus?
5. A star is six light years away from Earth. How far is this in kilometres?

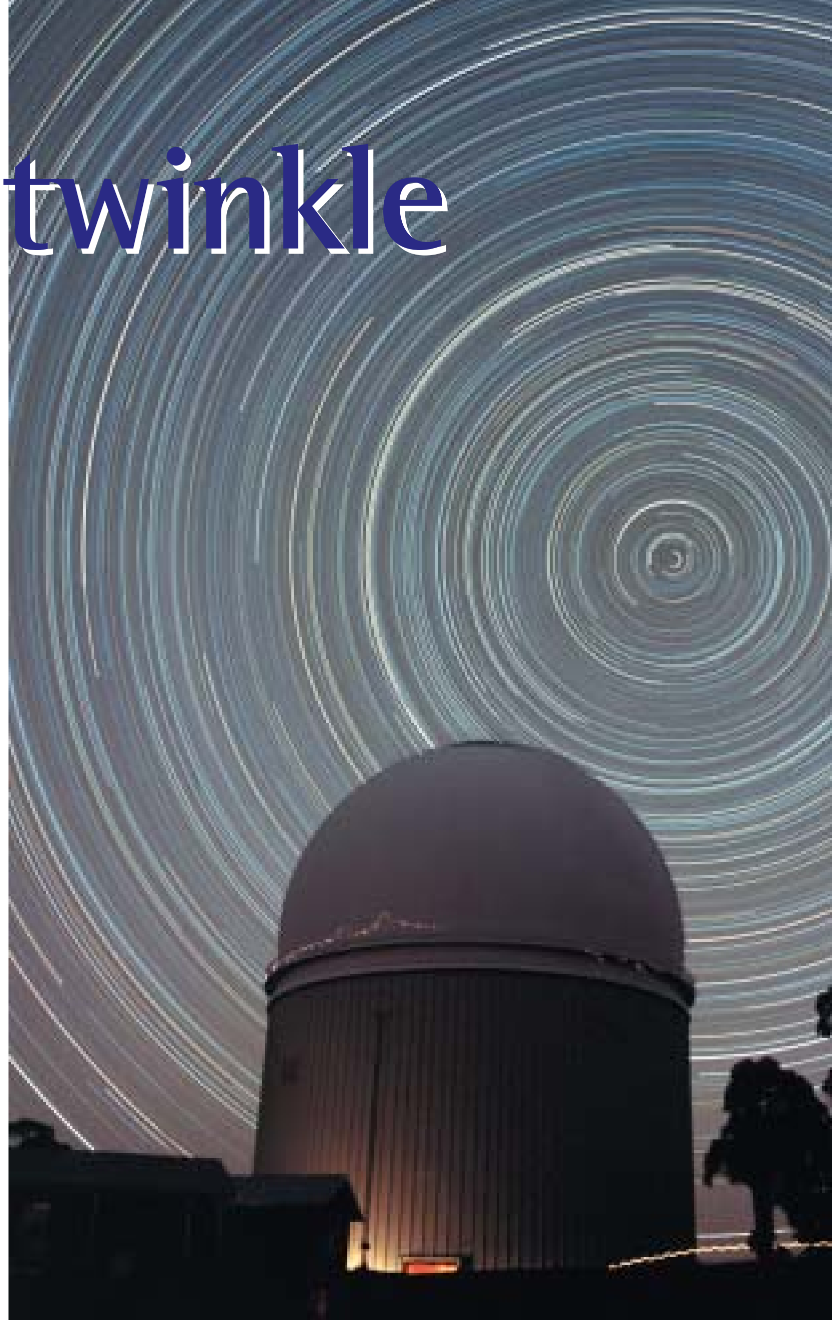
CREATE

6. Work together as a class for this activity. Use balls of varying sizes, wire and string to create a model of the solar system. Try to give some idea of the different sizes of planets and their different distances from the sun. Remember, though, it won't be to scale.

checklist

I can:
- ☐ compare the size of Earth and the solar system with other parts of the universe
- ☐ appreciate the relative sizes of galaxies, super clusters and the universe.

Twinkle . . . twinkle



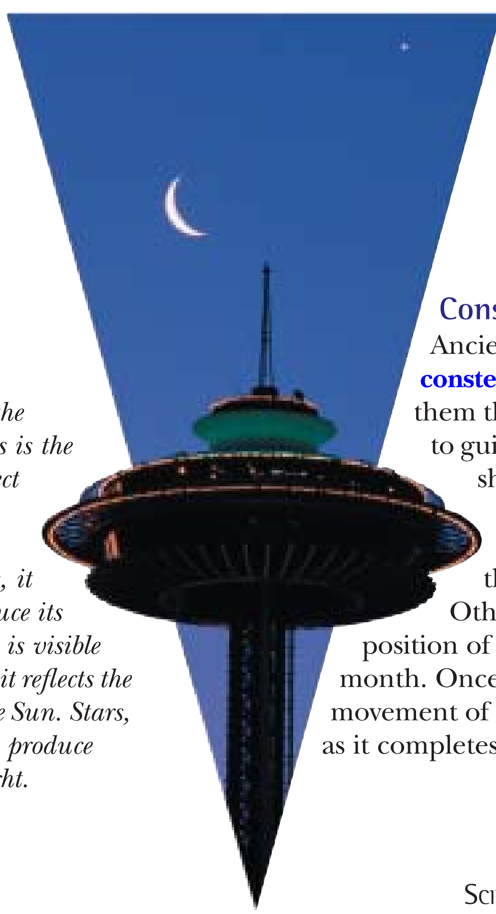
Twinkling stars have been the stuff of many fairytales, nursery rhymes and folk songs. There may be more than 200 billion billion stars. They are grouped in **galaxies** throughout the **universe**. The stars that we see in the night sky seem to be on the move. In fact it is the Earth that moves — not the stars.

Star spotting

Stars shine all the time. However, we can see them only at night when the sun has set. During the day, the light from the Sun is so bright that no other star is visible.

If you had the patience to watch the sky all night, you would notice the stars seem to move. From Australia, they seem to move in a circular path about a point in the southern sky. The movement is too slow to see unless you watch for a couple of hours. In the northern hemisphere, they seem to move about a point in the northern sky. The stars are not moving. The apparent circular movement of stars is due to the **rotation** of the Earth.

The apparent circular movement of the stars. The camera's shutter was left open for some hours to 'catch' the trail of light.



Not a star

Apart from the Moon, Venus is the brightest object in the night sky. But like other planets, it doesn't produce its own light. It is visible only because it reflects the light from the Sun. Stars, like the Sun, produce their own light.

Constellations

Ancient people knew that different groups of stars, called **constellations**, appeared in the sky at different times. This reminded them that the seasons were changing. Some used the constellations to guide them when travelling. They were named according to the shapes their stars seemed to form in the sky. There are 88 constellations with names agreed on by scientists.

We can't see all of the constellations. Some of them, like the Southern Cross, can be seen from Australia all year round. Others are visible in the night sky for only part of the year. The position of constellations in the sky at nightfall changes from month to month. Once again, this apparent change in position is due to the movement of the Earth. This time, it is due to the movement of the Earth as it completes its year-long **orbit** of the Sun.

How can I track the apparent movement of constellations?

You will need:

torch covered in red cellophane (to help your night vision)

star chart for the southern hemisphere night sky (Go to www.jaconline.com.au/science/weblinks and click on the Sky Map link for this textbook to access the star charts for the most recent month, and the following month.)

Make your observations on clear nights. Pick a flat area, well away from bright lights.

- Check the star chart for your starting month to find out where the constellations Crux (Southern Cross) and Triangulum Australe should be at 10.00 pm around the middle of the month. Also note the position of the bright star Alpha Centauri.
- Try to locate these two constellations and star in the sky. Check the sky at 10.00 pm around the middle of the month. Let your eyes get used to the dark for about 15 min before searching.
- Repeat this task for the following month.

1. In which direction did the constellations and star you located seem to move between one month and the next?
2. Explain why the movement occurred.
3. Why was it important to check the sky at the same time as in the sky chart?

Activities

REMEMBER

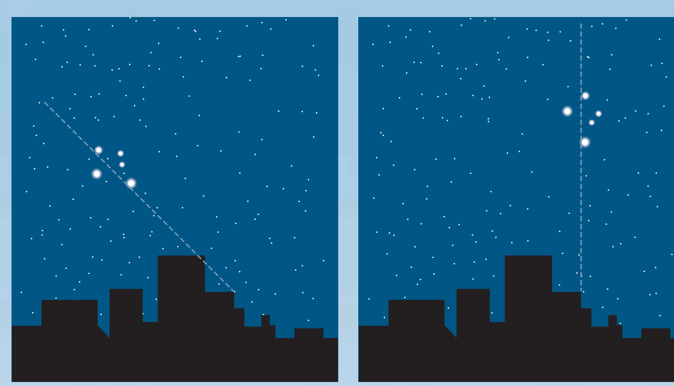
1. Why do the stars appear to move slowly in a circle at night?
2. How is a star different from a constellation?
3. Why does the position of constellations change from month to month.

THINK

4. Explain why you can see stars only at night.
5. Why can certain constellations only be seen:
   (a) in one hemisphere or the other?
   (b) at certain times of the year, looking either south or north?
6. Ancient people used the stars the way we use calendars or clocks. Suggest what activities might have depended on their observation of the stars.

INVESTIGATE

7. Investigate the movement of the constellation Crux (Southern Cross) over a three-hour period. Use landmarks on the horizon to help you estimate the approximate angle the constellation has moved through in this time. Sketch your observations. (See the example below.)



7.00 pm 10.00 pm

These diagrams show how the Southern Cross appears to move early in May.

CREATE

8. Set up a model to explain, in simple terms, why the stars appear to move in circular arcs each night.

checklist

I can:

- ☐ measure and explain the apparent nightly movements of stars
- ☐ explain why constellations appear to move from month to month
- ☐ use a star chart to locate constellations in the night sky.

Spacetrek

Ancient people tried to explain what they saw in the skies. To them, the stars, the Moon, the Sun and the change of seasons had to be the gods at work! Today, we know a lot more. Over the last few hundred years, many important things have been found out about space. We've used telescopes and **space probes** to explore the **solar system** and beyond. Yet, there is still so much more to learn.

The Sun was a great mystery to ancient people. To them, it looked like a moving ball of fire. It provided warmth and light and made their crops grow. It rose and fell in the sky each day. In some parts of the world it even went away for months at a time.

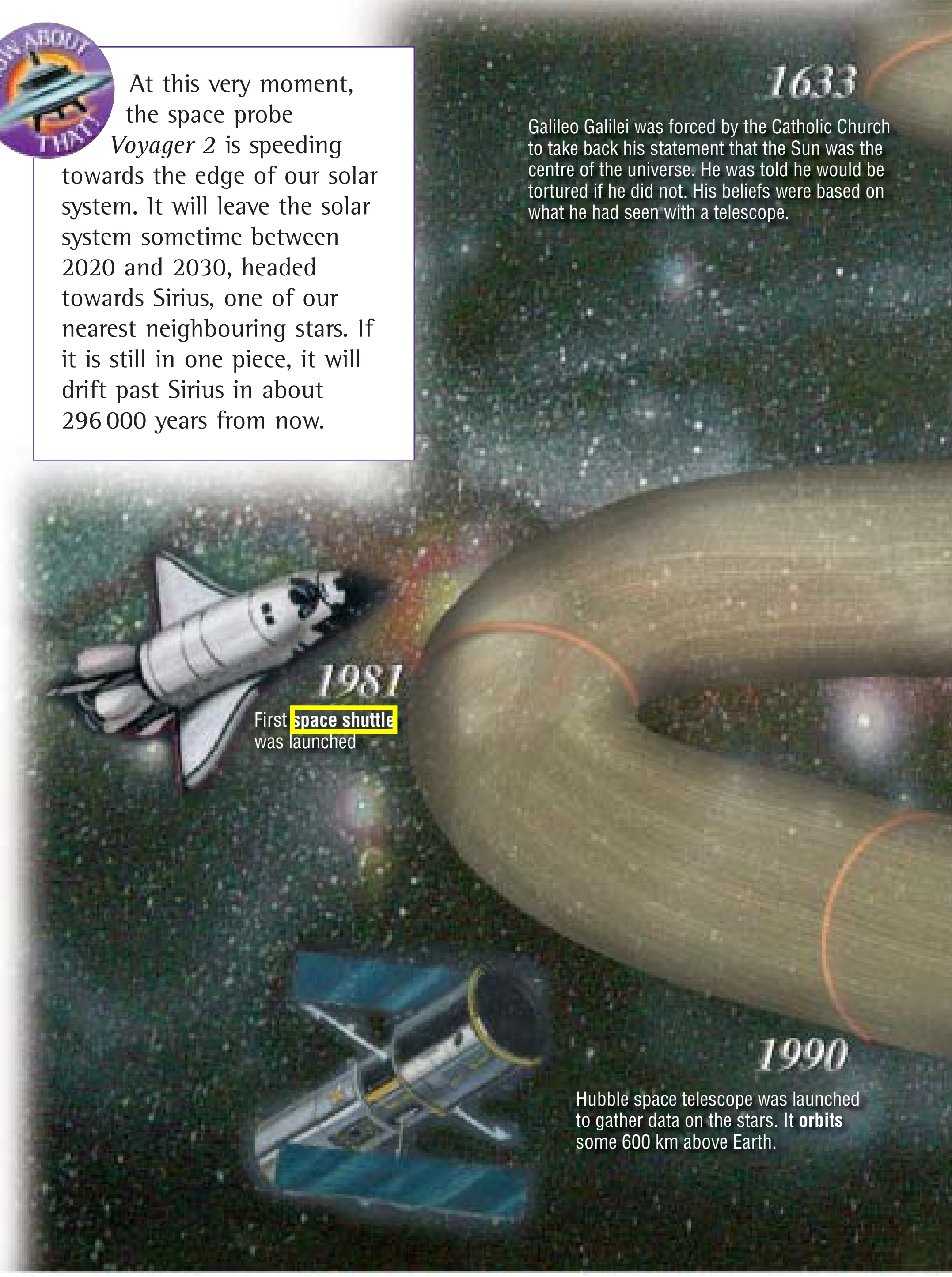
Many treated the Sun as a god.

- To the ancient Egyptians, the Sun was their god Ra, who sailed across the heavens each day in a fiery boat.
- The Indians in North and Central America, and the Vikings of Scandinavia, all held special feast days for the Sun. At these, they danced and sometimes killed animals.
- The Sun god was one of the most important of the Hindu gods.
- The Japanese once believed their emperor came from their Sun god.
- Many Aboriginal stories tell of people who became the Sun.

It was not until the seventeenth century, after the invention of the telescope, that people were able to see detail in the night sky. Knowledge about space grew quickly after that time. But most things we know about space today have been found out in the last 50 years. Space probes and satellites have given us much of this information. Some finds, though, have been made by amateurs. Other things have been found out by accident!

HOW ABOUT THAT!

At this very moment, the space probe *Voyager 2* is speeding towards the edge of our solar system. It will leave the solar system sometime between 2020 and 2030, headed towards Sirius, one of our nearest neighbouring stars. If it is still in one piece, it will drift past Sirius in about 296 000 years from now.



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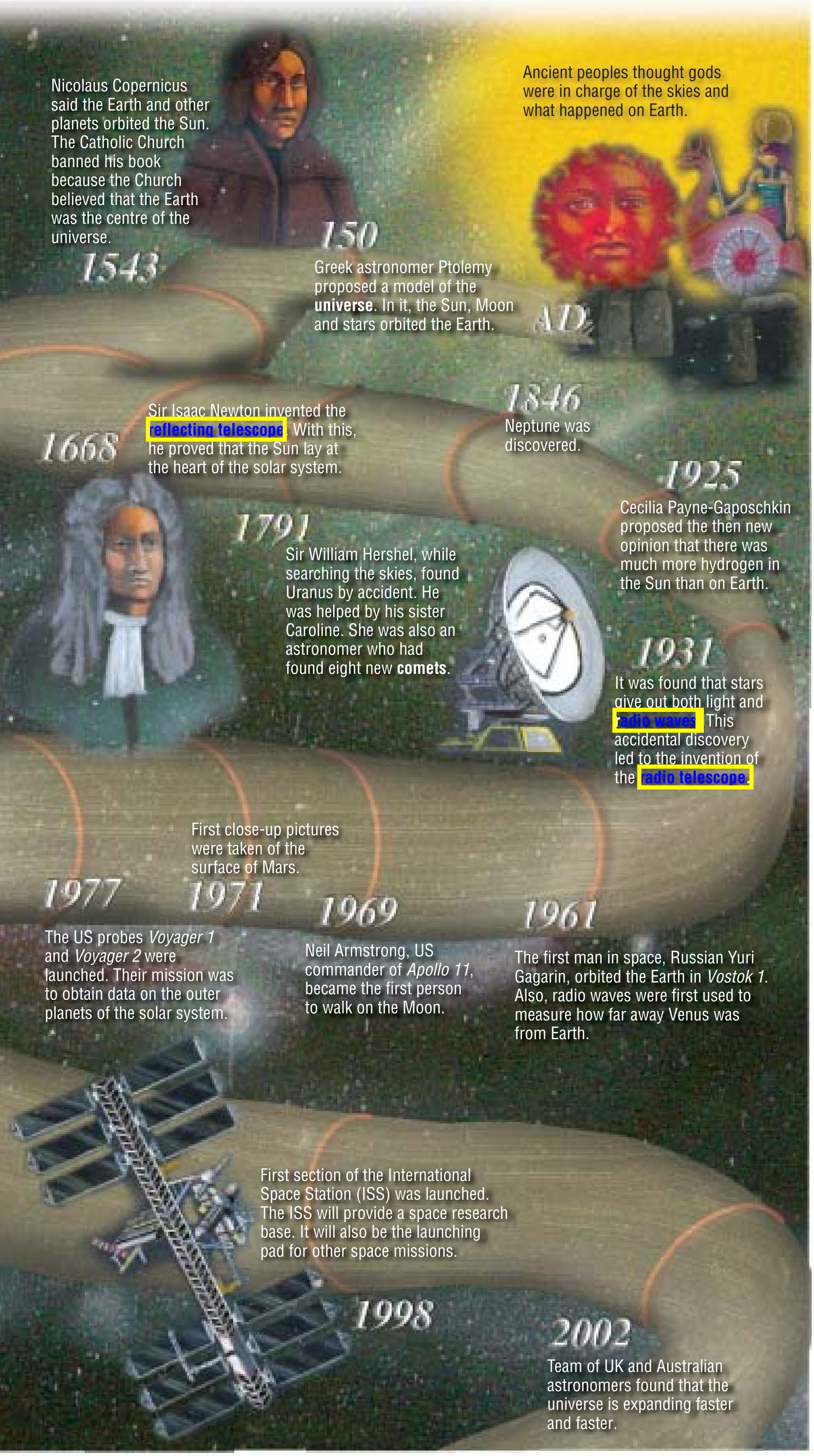
MI BODILY/KINAESTHETIC



AD

Ancient peoples thought gods were in charge of the skies and what happened on Earth.

150

Greek astronomer Ptolemy proposed a model of the **universe**. In it, the Sun, Moon and stars orbited the Earth.

1543

Nicolaus Copernicus said the Earth and other planets orbited the Sun. The Catholic Church banned his book because the Church believed that the Earth was the centre of the universe.

1668

Sir Isaac Newton invented the reflecting telescope. With this, he proved that the Sun lay at the heart of the solar system.

1791

Sir William Hershel, while searching the skies, found Uranus by accident. He was helped by his sister Caroline. She was also an astronomer who had found eight new **comets**.

1846

Neptune was discovered.

1925

Cecilia Payne-Gaposchkin proposed the then new opinion that there was much more hydrogen in the Sun than on Earth.

1931

It was found that stars give out both light and radio waves. This accidental discovery led to the invention of the radio telescope.

1961

The first man in space, Russian Yuri Gagarin, orbited the Earth in *Vostok 1*. Also, radio waves were first used to measure how far away Venus was from Earth.

1969

Neil Armstrong, US commander of *Apollo 11*, became the first person to walk on the Moon.

1971

First close-up pictures were taken of the surface of Mars.

1977

The US probes *Voyager 1* and *Voyager 2* were launched. Their mission was to obtain data on the outer planets of the solar system.

1998

First section of the International Space Station (ISS) was launched. The ISS will provide a space research base. It will also be the launching pad for other space missions.

2002

Team of UK and Australian astronomers found that the universe is expanding faster and faster.

Activities

REMEMBER

1. Why did the knowledge about space grow more quickly after the seventeenth century?
2. Name one space discovery found by accident.
3. Name one way in which a woman has helped us to find out more about space.

THINK

4. Why do you think so much effort is being made today to find out what lies beyond our Earth? Do you think it is worth it? Why?
5. Suggest why the Sun might have been such a common part of the beliefs and practices of ancient peoples.

IMAGINE

6. Imagine you were visited by an alien. How do you think people might react if you said you had seen an alien?
7. After stating that the Earth orbited the Sun, Galileo was forced by the Church to deny this in public. He spent the rest of his life under house arrest in his home. Write a letter that he might have written to a fellow astronomer during this time.

CONNECT

8. Use the Internet to find out more about one of the people or events shown on the timeline opposite. Write a short report of about 200 words on your findings.

✓ checklist

I can:

- ☐ understand why the Sun was an important part of ancient religions
- ☐ justify an opinion about the value of space research.

Mysteries in the sky

Some people today confuse the terms 'astronomy' and 'astrology'. Perhaps this is not so strange. Until a few hundred years ago there was hardly any difference between them. But now they are quite different. **Astronomy** is the scientific study of our **solar system**, and its place in the **universe**. **Astrology** is a study of how the positions of the Sun, Moon and planets are said to affect our lives.

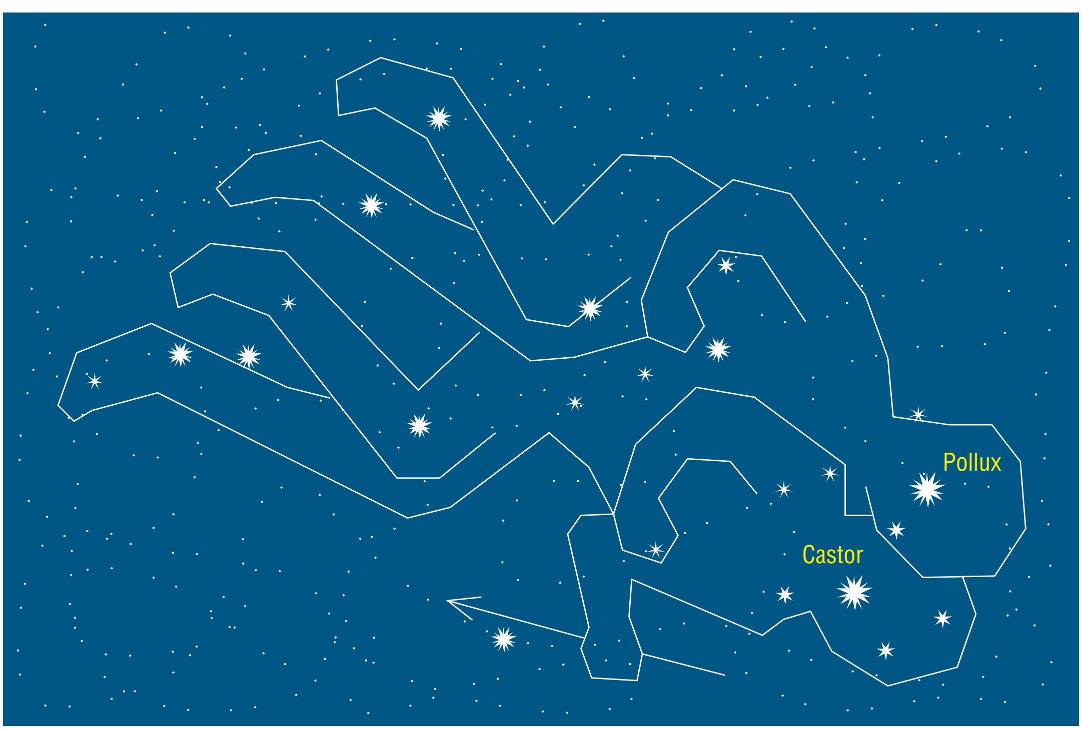
Before people began to understand the science of space, they thought events in the skies were the work of gods. **Eclipses**, **comets**, a full Moon, or the return of the Sun after a long winter were signs from the gods for people to take action, or to make decisions.

Zone of the zodiac

Looking at the sky from Earth, the Sun, Moon and planets follow a set path in the sky. This path is called the **ecliptic**. It crosses the heavens in front of 12 well-known **constellations** — Aries, Taurus, Gemini, Cancer, Leo, Virgo, Scorpio, Libra, Sagittarius, Capricorn, Aquarius and Pisces. It also passes in front of the lesser known constellation Ophiuchus. The part in space that includes the ecliptic and these constellations is called the **zodiac**.

The ancient Greeks believed that events on Earth (such as a person's birth) were influenced by whatever constellation the Sun was in front of at the time. These beliefs gave rise to what we call **horoscopes**. In a horoscope, each of the zodiac's 12 constellations becomes a 'star sign'. Each has its own symbol and special features.

A horoscope prediction for a 'Gemini' — someone born between 22 May and 21 June



The zodiac symbol for each 'star sign' comes from the way the stars lie in their constellation. The Gemini symbol — the twins — is formed from the Gemini constellation's two brightest stars, Castor and Pollux. Greek legend has it that the twins Castor and Pollux were born to a woman named Leda after she was visited by the god Zeus. He came to her as a swan.

The signs of the zodiac

Comparing astrology and astronomy

Astronomers are scientists. They make and use observations to learn more about the universe, including our solar system. Astrologers are not scientists. They make predictions about people's lives. Their predictions are based on star signs and observations of the Sun, Moon and planets. The dates listed in horoscopes are based on when the Sun seemed to pass in front of each constellation over 2000 years ago. Those dates have changed, but the dates in horoscopes remain the same.

HOW ABOUT THAT!

In 1979, a French psychologist offered free horoscopes to 150 people who agreed to complete a survey about their accuracy. He sent the horoscope for the birth date of Dr Petiot, a mass murderer, to all 150 people. When they were asked if the horoscope made accurate predictions about themselves, 94 per cent said yes.

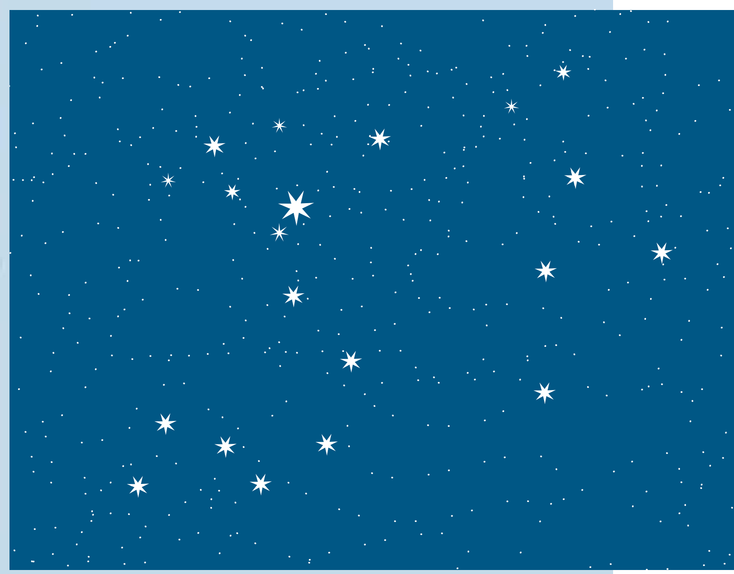
Activities

REMEMBER

1. What is the main difference between astronomy and astrology?
2. What is a horoscope?
3. Name the 12 constellations in the zodiac.
4. There are 88 named constellations. What is special about the 12 constellations of the zodiac?

THINK

5. Suggest some ways that astrologers helped the growth of knowledge about the stars and planets.
6. The following diagram shows how the stars in the Leo constellation look from Australia. First, check the horoscope opposite to find the symbol for Leo. Then suggest how the stars could be joined with straight lines to form a shape that looks like the Leo symbol.



Note that the diagram that you draw should be upside down. Because we live in the southern hemisphere, this is how we see the constellation Leo. The ancient people who created the star signs lived in the northern hemisphere.

CREATE

7. Draw the star sign symbols for a horoscope to be included in a teenage magazine. Be creative!

checklist

I can:

- ☐ explain the difference between astrology and astronomy
- ☐ show how a zodiac symbol is related to the layout of a constellation's stars.

Checkpoint

Days and seasons

Have you ever wondered why it gets dark? Or why the Sun rises later in Perth than in Melbourne? Or why Australia has a cold winter when Greece is having a hot summer? These things have all got something to do with the way the Earth moves and its position in space at a given time.

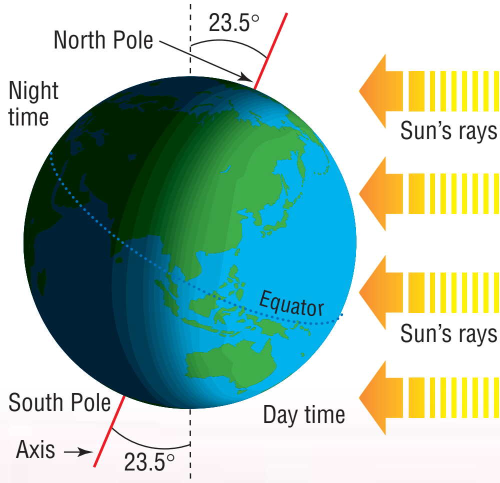
Three important things you need to remember about the movement of the Earth:

1. The Earth spins about an imaginary **axis**. It takes 24 hours to complete one **rotation**.
2. The Earth's axis is tilted at an angle of 23.5° to the vertical.
3. The Earth **revolves** once around the Sun every 365 and a quarter days.

Day and night

To us on Earth it seems that the Sun rises each day in the east and sets in the west. In fact, the Sun doesn't move across the sky at all. It is the Earth that moves — and quite fast, too! People living on the equator are moving at close to 1670 kilometres per hour! We don't sense we are moving as everything around us moves at the same speed.

Like a spinning top, the Earth rotates — spinning from west to east about its axis. One rotation takes 24 hours. We call the time for a complete rotation one day. As the Earth spins around, first one side and then the other faces the Sun and experiences daytime. The side facing away from the Sun gets no sunlight, so experiences night.

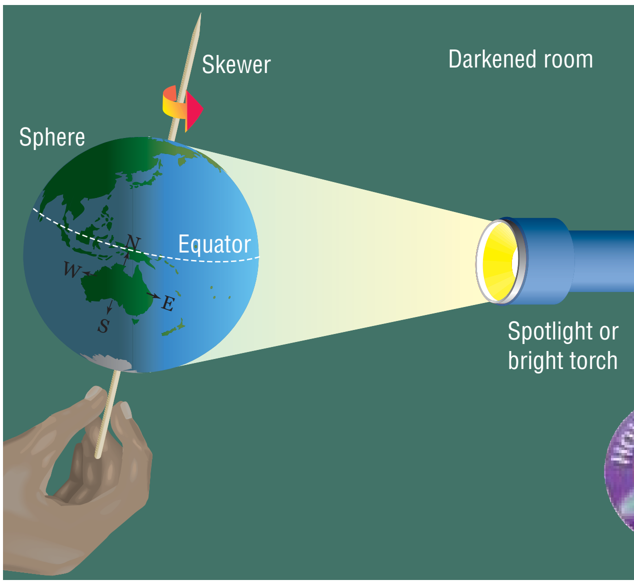


It is day time on the side of the Earth facing the sun. On the other side of the Earth, it is night time.

The Sun sets in the west behind a Melbourne skyline.

Why is it day time in Australia when it's night time in Africa?

You will need:
polystyrene (or similar) sphere (about the size of a small rockmelon)
metal or wooden skewer
pen
spotlight or bright torch.

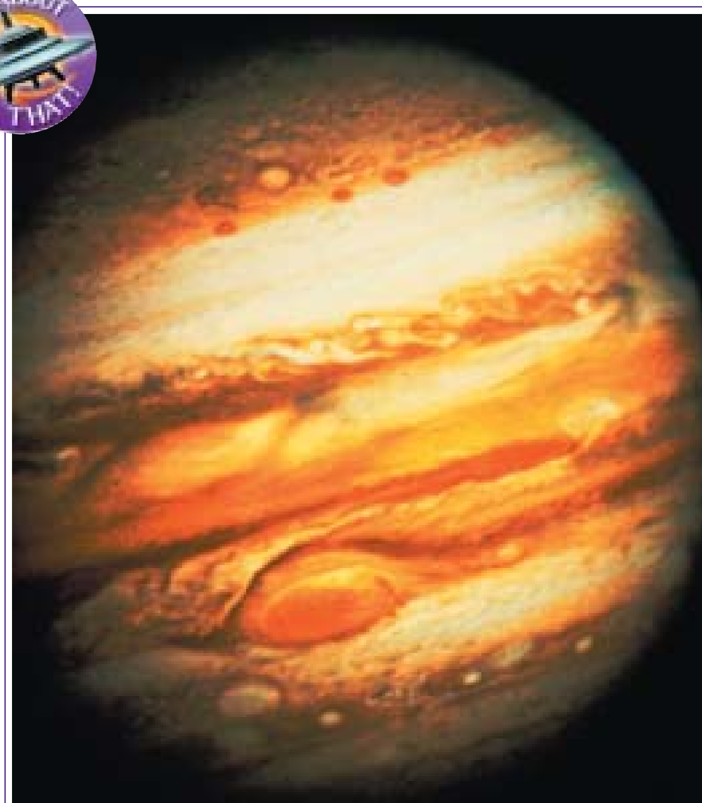


- Your sphere represents the Earth. Draw a line around the centre to represent the equator. Label the northern and southern hemispheres and mark in the North and South poles.
- Draw an outline of Australia and Africa on your sphere. Use an atlas to check the positions and approximate shape of each continent. Also note the position of north.
- Mark the four compass directions — north, south, east and west — around the outlines of each continent.
- Gently push a skewer through the centre of your sphere from bottom to top through the 'polar regions'. This skewer represents the Earth's imaginary axis.

Carry out this experiment in a darkened room. This will help you see more clearly the contrast between light and dark.

- Turn on the spotlight in a dark room. Its light represents the Sun's light. Hold the skewer so it leans a little away from the vertical. This represents the Earth's tilt.
- Turn your sphere very slowly in the light, making sure you keep the skewer slightly tilted all the time. Turn it in an anticlockwise direction (as seen from above). Watch what happens from side on.

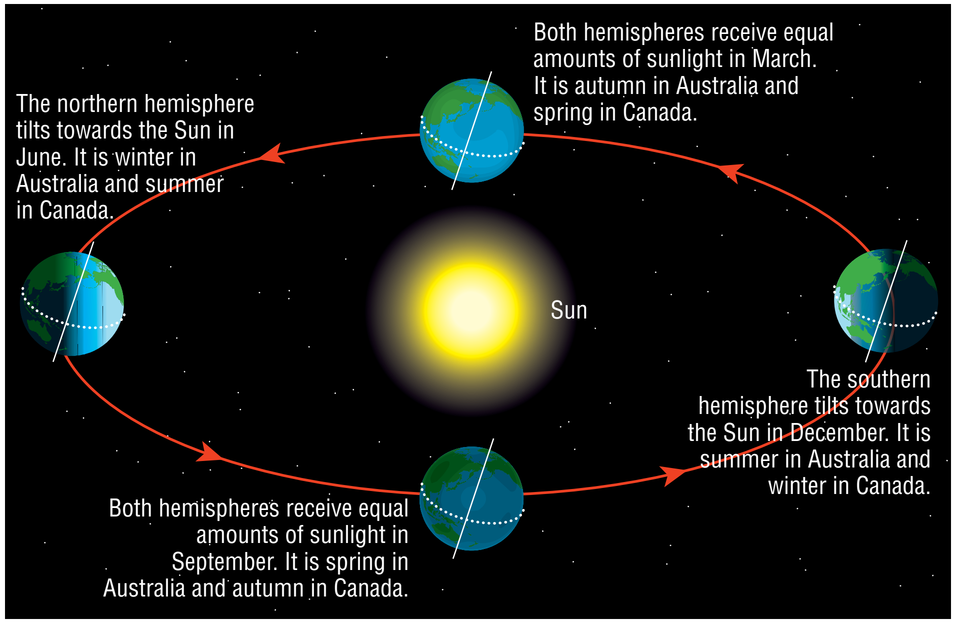
1. In which direction is the 'Earth' rotating — from east to west or west to east? Check the compass directions you marked on your sphere.
2. In which direction does the 'Sun's' light seem to move around the 'Earth'? How does this explain the apparent movement of the Sun across the sky?
3. Where is Africa when Australia is lit up? Where is Australia when Africa is lit up? Explain why this occurs.
4. How does this experiment help to explain why night falls in Perth about two hours later than in Melbourne?



A day on Jupiter is less than 10 hours. This means it takes under 10 hours to complete one rotation. But this giant planet, made mostly of gas, is about 13 000 times bigger than Earth. So when it rotates, its outermost clouds move at close to 45 000 kilometres every hour!

The seasons

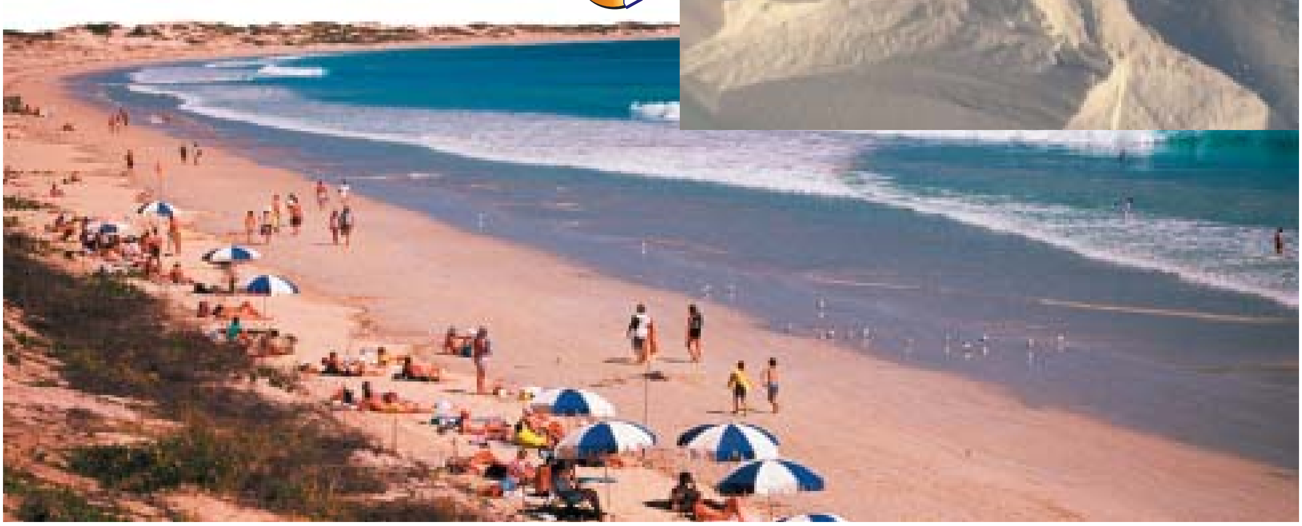
The Earth takes 365 days (or 365 and a quarter days to be more exact) to complete one **revolution** of the Sun. As the Earth completes its **orbit**, the tilt of its axis does not change. (It leans either to the right or the left, depending from which way you are 'looking' at the orbit.) This means that at certain times during the Earth's orbit, one hemisphere or the other is leaning more towards the Sun.



Because of the tilt of the Earth, seasons change as the Earth completes its orbit of the Sun.

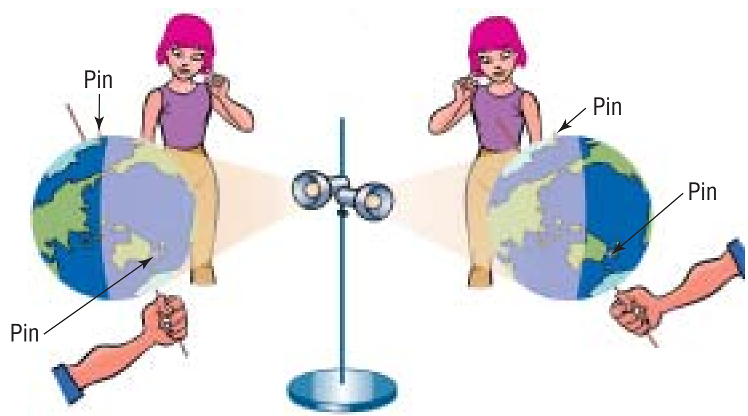
When a hemisphere tilts towards the Sun, it is 'hit' more directly by the Sun's rays. So it heats up faster and the days are warmer. This hemisphere experiences summer. When a hemisphere tilts away from the sun, the Sun's rays 'hit' it at more of an angle. So the heat from the Sun is spread out more. This means it takes longer for that hemisphere to heat up. Days are colder. This hemisphere experiences winter. When neither hemisphere tilts towards the Sun, which happens in autumn and spring, each receives the same amount of the Sun's rays. So there is not much difference between, say, a northern hemisphere spring and a southern hemisphere autumn.

(a) In January, when the northern hemisphere tilts away from the Sun, it is winter in Canada.



(b) In January, when the southern hemisphere tilts towards the Sun, it is summer in Australia.

Why do days not always have the same amount of daylight and darkness?

You will need:
the equipment you used for the earlier experiment on page 205
2 pins with coloured heads.



As you did before, carry out this experiment in a darkened room. This will help you see more clearly the contrast between light and dark.

- Hold the skewer vertically. Push two pins into your sphere — one about where Sydney is and the other directly above it at the top of the sphere, near the skewer.
- Set the spotlight up in a central place (e.g. on a table you can move around).
- Stand to the left of the spotlight. Turn on the spotlight. Hold the skewer so it leans away to the left from the vertical. The southern half of your sphere should be leaning more towards the light.
- Slowly turn your sphere in the light, making sure you keep the skewer slightly tilted. Turn it in an anticlockwise direction. Watch what happens from side on. Watch the side of the sphere you can see as you turn it. A partner should watch the other side.

1. Which pin comes into the light first? Ask your partner which pin moves out of the light first?
2. What does this tell you about the number of daylight hours in each hemisphere when the southern hemisphere tilts towards the Sun?

- Now stand to the right of the spotlight. Keep your skewer tilted to the left as before. This time the northern half of your sphere should be leaning more towards the light. Repeat what you did for the last dot point above.

3. Which pin comes into the light first this time? Ask your partner which pin moves out of the light first.
4. What does this tell you about the number of daylight hours in each hemisphere when the northern hemisphere tilts towards the Sun?

- Repeat the whole procedure above two more times. The first time, look at what happens at each of the poles. The second time, look at what happens at the equator.

5. What is the length of day and night at the equator in each season?
6. Suggest why the Sun never sets at certain times of year at the North and South Poles. What season is the southern hemisphere experiencing when the South Pole has six months of darkness?

Activities

REMEMBER

1. Explain how you would use two balls — one representing the Earth and the other the Sun — to explain the difference between the Earth's rotation and revolution.
2. Why do we have day and night?
3. During which season in Australia does the southern hemisphere tilt towards the Sun?
4. Explain why it is warmer on a summer's day that it is on a winter's day.

THINK

5. If the axis of the Earth were vertical and not tilted:
   (a) How would this affect weather patterns at the equator and the poles?
   (b) How would this affect where you live?
6. What season are we having in Australia when:
   (a) it is autumn in England?
   (b) it is summer in Canada?
   (c) the Sun does not set at the South Pole?
7. What season is Australia shown as having in the figure on the bottom of the opposite page?

INVESTIGATE

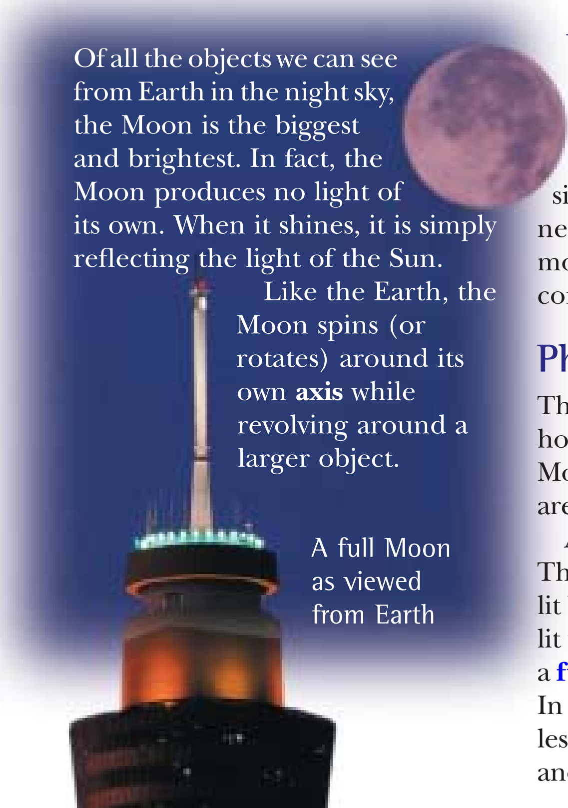
8. Check the Internet or library resources to find out when and why we have leap years. Write a paragraph in your notebook to explain this.

checklist

I can:
- ☐ explain the ways in which the Earth moves
- ☐ understand why we have days and seasons
- ☐ contribute to a class discussion on life in the polar regions.

Moon shapes

The Moon is our nearest 'space neighbour'. It is about 384 000 kilometres from Earth. Its changing shape in the night sky was a great mystery to ancient people. Today, we know that the **phases of the Moon** are caused by light from the Sun falling on the Moon as it **orbits** the Earth.



Of all the objects we can see from Earth in the night sky, the Moon is the biggest and brightest. In fact, the Moon produces no light of its own. When it shines, it is simply reflecting the light of the Sun.

Like the Earth, the Moon spins (or rotates) around its own **axis** while revolving around a larger object.

A full Moon as viewed from Earth

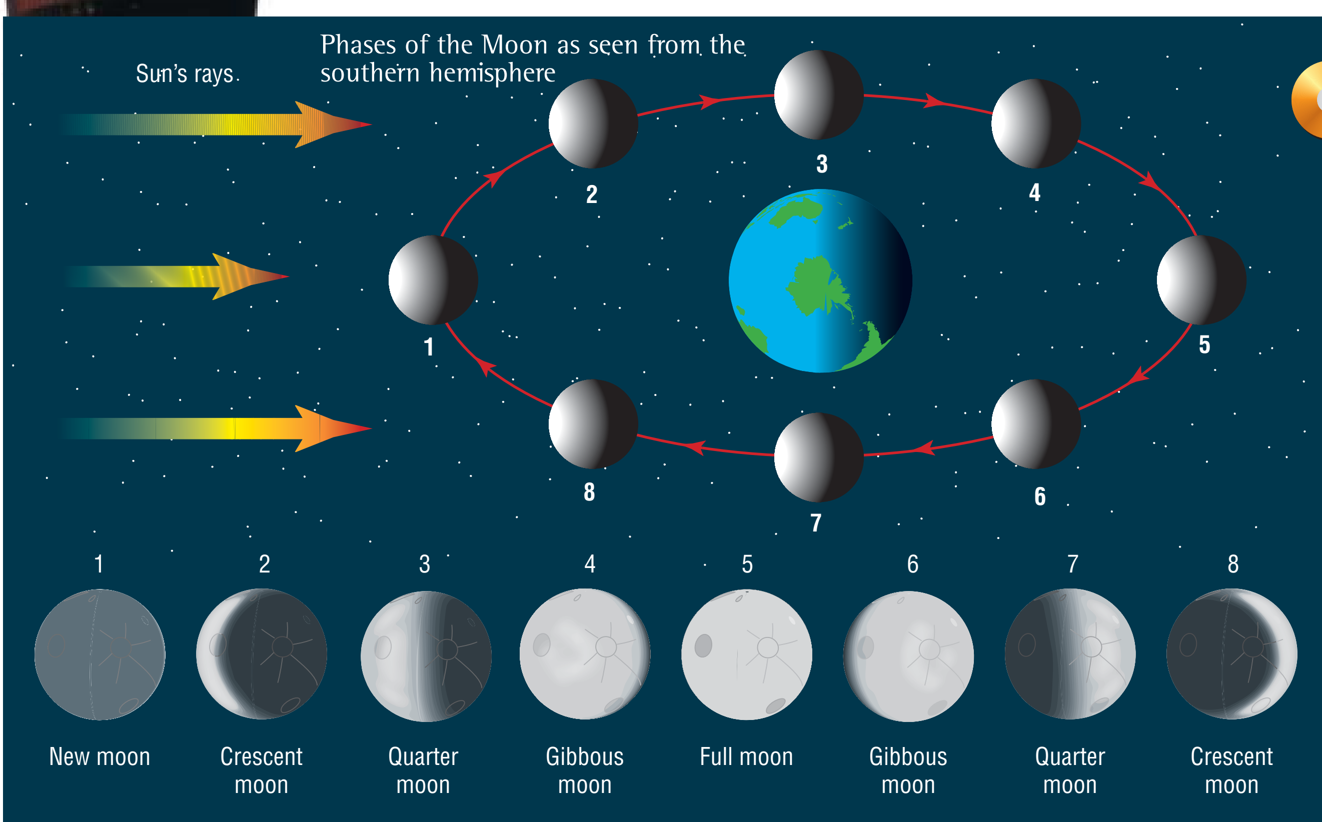
Far side of the Moon

When you look at the Moon from Earth you only ever see the same side. It is called the **near side**. It was not until 1959 that scientists first saw **space-probe** images of the other side, called the **far side**. The far side is the most mountainous of the two, and has more craters than the near side. The reason you can't see the far side from Earth is because the moon takes about the same time to complete one **rotation** as it does to complete one **revolution** of the Earth.

Phases of the Moon

The Moon doesn't change its shape. What does keep changing, however, is how much of it we see lit up by the Sun. This, in turn, depends on where the Moon is on its orbit around the Earth. The different views we see of the Moon are called phases of the Moon. There are eight of them.

A **new Moon** occurs when the Moon lies between the Sun and the Earth. The side of the Moon we see, the near side, is dark. The far side is the one lit by the Sun. As the Moon moves further around the Earth, the near side is lit up more and more by the Sun. Finally, it is completely bright. We call this a **full Moon**. This occurs when the Earth lies between the Sun and the Moon. In the second half of the Moon's orbit, the lit-up part of the near side gets less and less wide. Finally, the near side is completely dark again and there is another new Moon. It takes 29.5 days from one new Moon to the next.



Why can't I see the far side of the Moon from Earth?

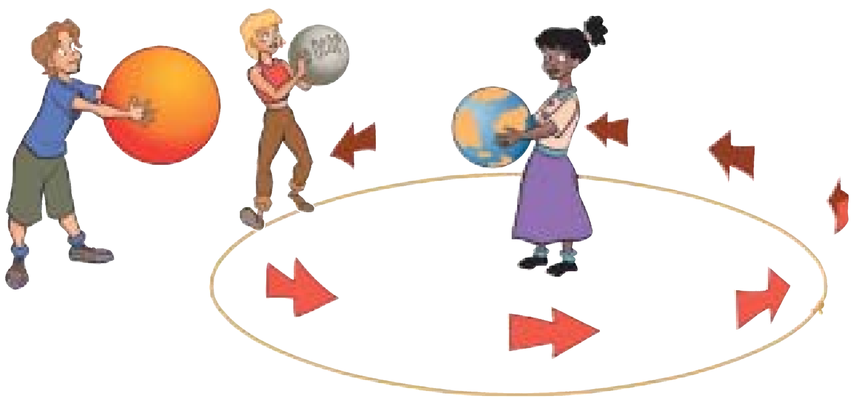
You will need:

3 polystyrene balls of different sizes:

- the largest one painted yellow (to represent the Sun)
- the medium one painted blue and green (to represent the Earth)
- the smallest one marked by the words 'near' on one side and 'far' on the other.

3 people, one to hold each of the balls

6 m or more of string.



- Lay out the string in a circle. It represents the Moon's orbit of the Earth.
- The 'Sun' stands at a point well outside the circle. The 'Earth' stands in the centre of the circle. The 'Moon' stands on the string between the Sun and the Earth, with the side labelled 'near' facing the Earth. This is the start position.

1. What phase of the Moon does the start position represent? What would people on Earth see, and why? Which side of the 'Moon' is lit by the Sun?

- The 'Moon' slowly follows the string around, back to the starting point. Hold the 'Moon' so that the 'near' label always faces Earth.

2. At what position around the circle would people on Earth see a full Moon? Why? Which side of the 'Moon' would now be lit up by the Sun?
3. As the 'Moon' completes one orbit of the 'Earth', count the number of rotations the 'Moon' makes. What do you notice?

- Repeat this experiment a second time. This time as the 'Moon' moves around the string, always make sure that the 'Far' side is facing the Sun. This means that although the 'Moon' is orbiting the 'Earth', it is not rotating.

4. If the Moon did not rotate, what side of the moon would face Earth during (a) a new Moon and (b) a full Moon?
5. If the Moon rotated very quickly — say 40 times during every orbit of the Earth — what do you think people on Earth (with telescopes) might see during a full Moon?

Go to worksheet 43

Activities

REMEMBER

1. Name and draw the eight phases of the Moon as we see them from Australia.
2. What phase of the Moon do we see when:
   (a) the Earth is between the Sun and the Moon?
   (b) the Moon is between the Sun and the Earth?
   Explain why each of these phases occurs.
3. How many days are there between one new Moon and the next?

THINK

4. Why are there more craters on the Moon than the Earth, even though the Earth is a bigger target?
5. What is the far side of the Moon, and why can't we see it?
6. How much of the far side of the Moon is lit by the Sun when we can see a quarter Moon?

INVESTIGATE

7. Start your investigation a day or two after a new Moon. Check the sky soon after sunset every second night for a month. Record in words and sketches:
   - where the Sun set (it might help to pick out landmarks on the horizon)
   - where the Moon rose
   - the shape of the lit part of the Moon.

   (a) Did you see all phases of the Moon?
   (b) What links were there between the Sun's position and phases of the Moon?

checklist

I can:

- ☐ describe the phases of the Moon and explain why they occur
- ☐ explain the difference between the near and far sides of the Moon.

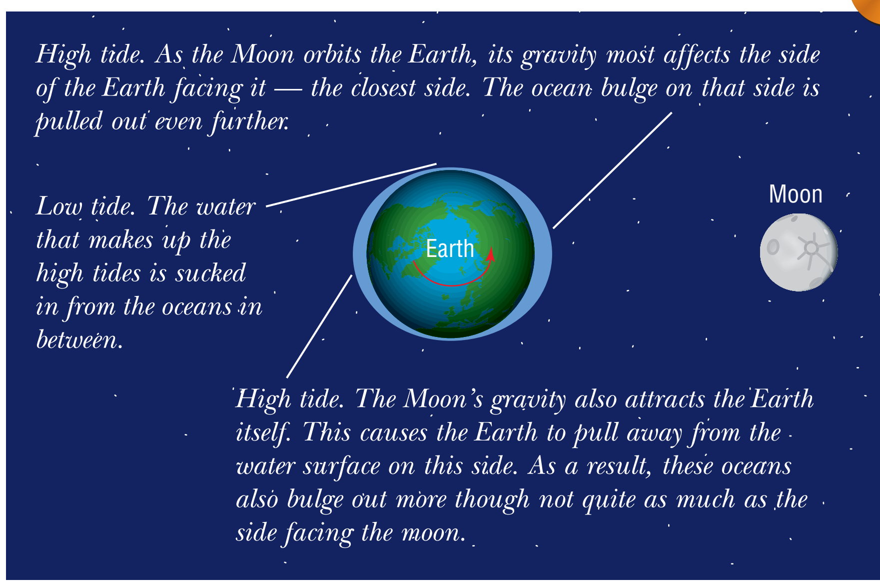
Ebb and flow

Day after day, the waters of the Earth's oceans rise and fall against the coastlines of islands and continents. These changes in sea level are called tides. They are caused by the **gravitational attraction** of the Moon and Sun on the Earth.

When the Earth rotates about its **axis**, its waters spin outwards. It is a bit like the way clothes fling out during the spin cycle in a washing machine. This action creates a bulge of water around the Earth. Why, you might ask, does the bulge not fly out into space? It is held back by the Earth's **gravity**.

Bulge in … bulge out

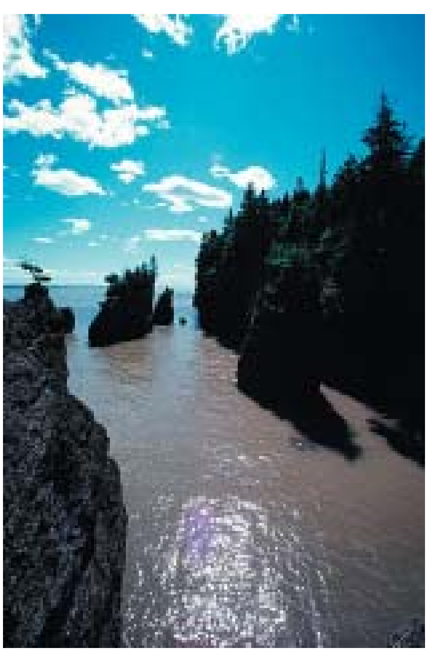
The size of the bulge is not the same everywhere. The bulge in the oceans gets larger and smaller because of the pull of gravity of the Sun and the Moon. It is the change in size of the bulge that we call tides. High tide occurs where the bulge is large. Low tide occurs where the bulge is small.

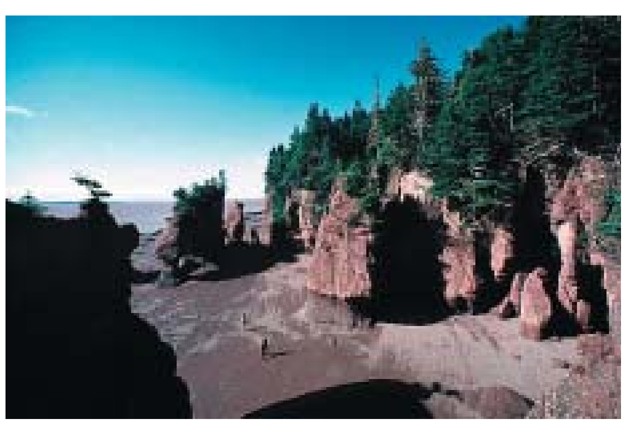


Looking down on the Earth from above the North Pole. As the Earth rotates different places experience high tide.

Gravity is a force of attraction between any two bodies in the **universe** that have **mass**. How big this force is depends on two things: the mass of the bodies and how close they are. The Sun and the Moon each pull on the Earth. Even though the mass of the Moon is 27 million times less than the Sun, it pulls more on the Earth than the Sun because it is very much closer to Earth.

In theory, every place on Earth has two high tides and two low tides on most days. Sometimes, though, other factors cause strange events to happen. For example, the extremes of tides in the Bay of Fundy in Nova Scotia are caused by its geography.





High and low tide in the Bay of Fundy. Its **tidal range** — over 16 m — is the biggest in the world. The bay has a very wide mouth that allows a lot of water to rush in as the tide rises. But the bay gets much narrower as it cuts into the land. The huge volume of water has nowhere to go but up!

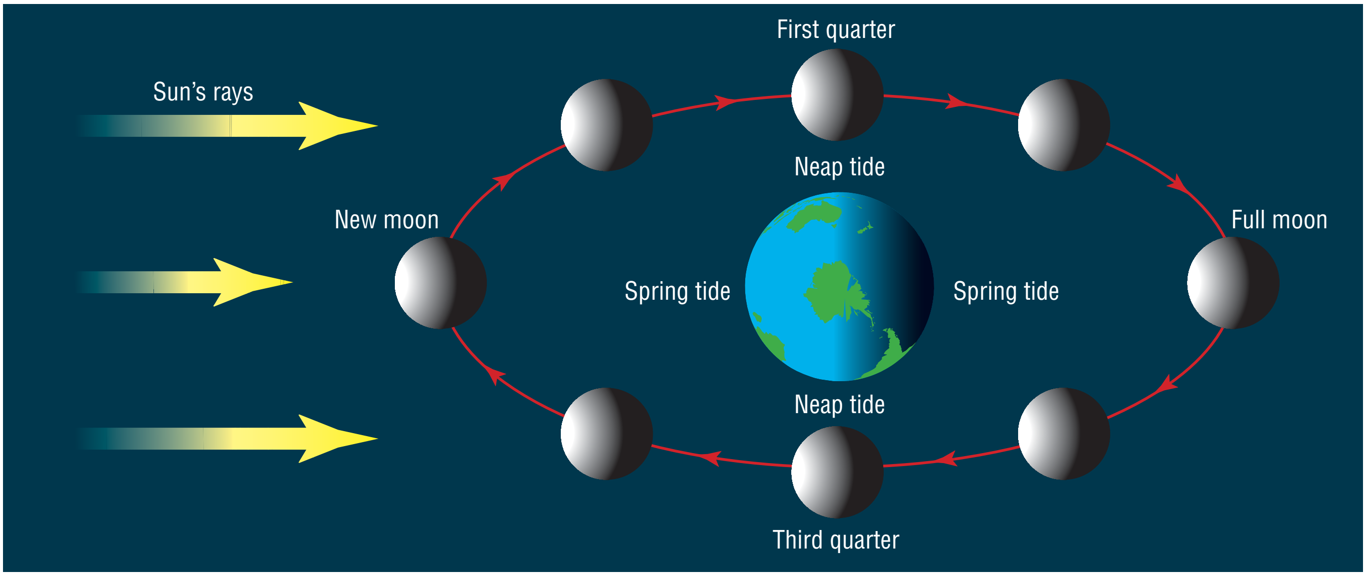
Go to worksheet 44

LOGICAL/MATHEMATICAL

Spring and neap tides

Twice each month the Moon, Sun and Earth line up. This occurs when there is a full Moon and a new Moon. At these times, the pull on the Earth and its waters is much stronger as the gravity of the Sun and Moon combine. Hence, the ocean bulges contain even more water. This means the **tidal range** is much greater. These tides are called **spring tides**.

About seven days after a spring tide, the Moon and Sun are at right angles to each other with respect to the Earth. In this position, their forces of gravity work against one another, rather than together. So, the tidal range is narrow. These tides are called **neap tides**.



During a **tidal month**, there will be two spring tides and two neap tides.

Activities

REMEMBER

1. What is gravity?
2. Why does the Moon's gravity have a stronger pull on Earth than the Sun's?
3. Explain with the aid of a diagram the difference between a spring and a neap tide.

THINK

4. What sort of tide will occur when there is a full Moon? Why?
5. If the height of the highest tide on a particular day was 6.5 m and the tidal range was 4.2 m, what was the height of the lowest tide?
6. Suggest why one high tide on any given day is always higher than the other one.
7. Imagine that you tied a small fishing boat to a pier in the Bay of Fundy using a two-metre rope. The pier is two metres above the water level at high tide. Draw a labelled diagram to show the position of the boat at high and low tides.

CREATE

8. Design a role-play involving at least four people that shows how the movement of the Earth around the Sun, and the Moon around the Earth, cause tides. A narrator could be used to give a commentary of the role-play.

checklist

I can:

- ☐ explain how the Moon and the Sun cause tides on the Earth
- ☐ explain why there are two high tides and two low tides on most days
- ☐ describe the difference between spring and neap tides.

Block out!

When you stand in the Sun, you cast a shadow. That's because your body is blocking some of the Sun's light. This is similar to what happens when an **eclipse** occurs. Something is blocking the light of the Sun. Sometimes the Moon blocks the light, casting a shadow on the Earth. At other times, the Earth blocks the light, casting a shadow on the Moon.

A lunar eclipse may last for about four hours.

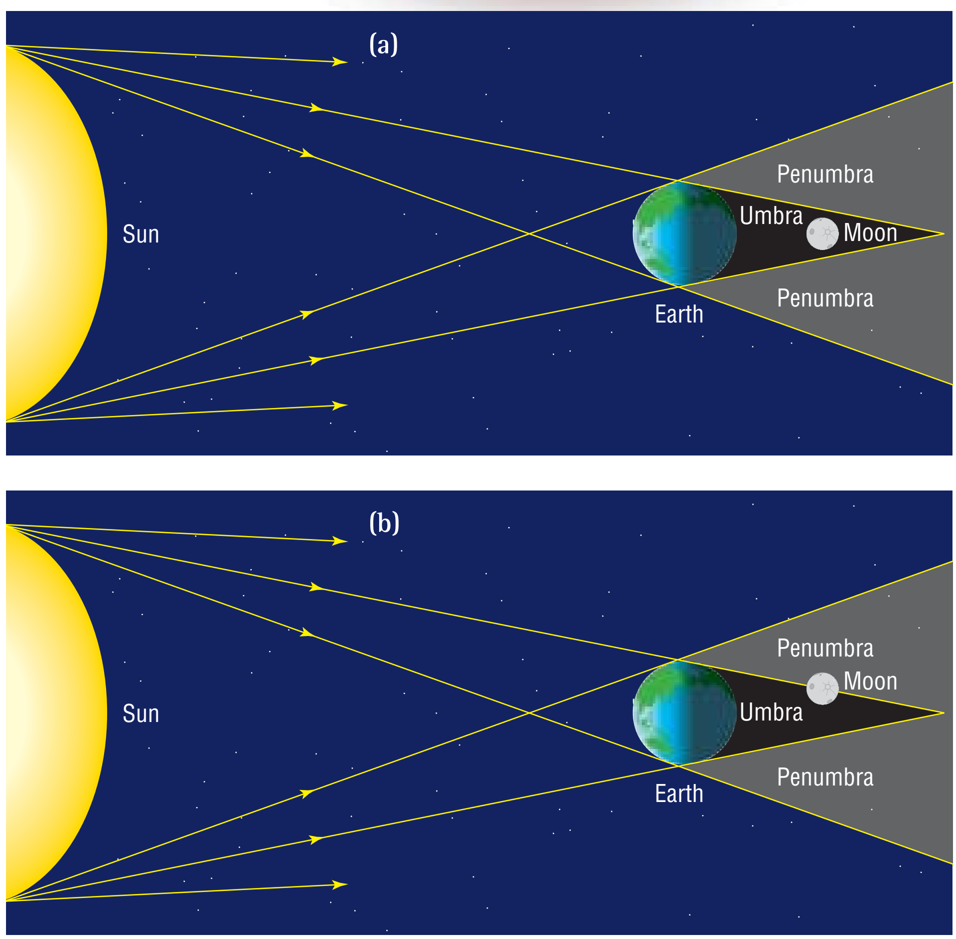
The darkest part of a shadow is in the centre, where most light is blocked out. Towards the edges, shadows are less dark. The dark middle section is called the **umbra**. The lighter part of the shadow is called the **penumbra**.

When we see a lunar eclipse, we are seeing the Earth's shadow on the Moon. When we experience a solar eclipse, we on Earth are in the shadow of the Moon. Eclipses happen once or twice a year — and some years not at all. They occur only when the Earth and Moon are in certain positions in their **orbits** with respect to the Sun.

Lunar eclipses

Lunar eclipses occur when the Earth's shadow falls on the Moon's surface. This happens when the Earth lies between the Sun and the Moon. The Earth fully or partly blocks the sunlight that makes the Moon's surface shine with reflected light.

A total lunar eclipse occurs when the Moon is totally covered by the darkest part of the Earth's shadow (the umbra). This happens only when the Sun, Moon and Earth lie in a straight line. A total eclipse can occur only during a **full Moon**. A partial eclipse occurs when the Moon is partly covered by the umbra of the Earth's shadow and partly by the penumbra.



(a) Total lunar eclipse (b) Partial lunar eclipse

Go to worksheet 45

Solar eclipses

Solar eclipses occur when the Moon lies between the Sun and the Earth. This means that the Moon's shadow falls on the Earth. People on Earth within the umbra of the Moon's shadow see a total eclipse of the Sun. Those within the penumbra see a partial eclipse.

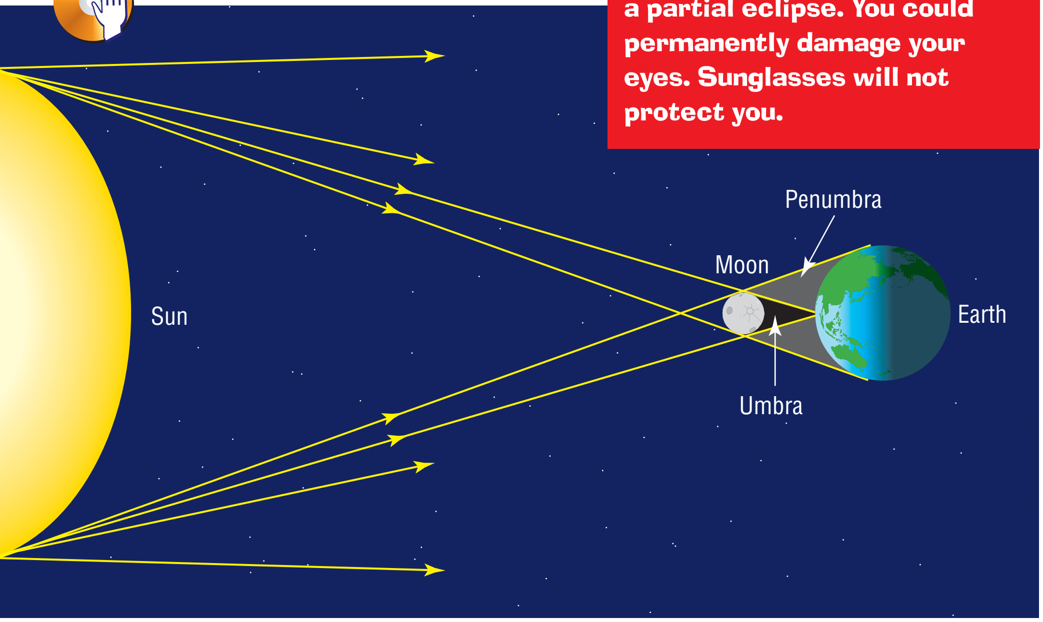
Total eclipses occur only when there is a **new Moon**. They are not seen often as the Moon casts only a narrow shadow on Earth. The umbra may be only about 100 km wide. It may fall in the middle of an ocean. It may even miss the Earth altogether.

HOW ABOUT THAT!

King Louis of Bavaria became so terrified at seeing an eclipse of the Sun in AD 840 that he died of fright. His three sons fought to gain control of his throne. To keep the peace, the kingdom was divided into three regions, which are known today as Germany, France and Italy.

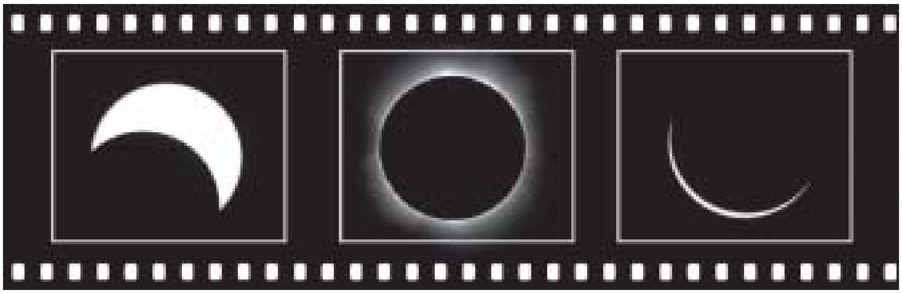
WARNING

You must NEVER look directly at an eclipse of the Sun — even a partial eclipse. You could permanently damage your eyes. Sunglasses will not protect you.



Total and partial solar eclipse

During a total eclipse, the area within the umbra on Earth becomes quite dark for a few minutes. You might even see some stars. The Sun's **corona**, or atmosphere, can still be seen. The corona is not normally seen because the Sun is so bright.



A total solar eclipse — the Sun's light is blocked as the Moon passes in front of it.

Activities

MI VISUAL/SPATIAL

REMEMBER

1. What is the difference between a solar eclipse and a lunar eclipse?
2. What can be seen from Earth during a total eclipse of the (a) Moon and (b) Sun?
3. Why must you never look directly at a solar eclipse?

THINK

4. Why do you think the Moon does not block out the Sun's corona during a total eclipse of the Sun?
5. Explain, using a labelled diagram, the difference between a shadow's umbra and penumbra.
6. Suggest why a total lunar eclipse occurs only when there is a full Moon.
7. Suggest why a solar eclipse only occurs when there is a new Moon.

IMAGINE

8. Imagine that you are an astronaut on the Moon during a total lunar eclipse. Prepare a one-minute speech to Earth control to describe what it's like on the Moon, and what you see when you look towards Earth.

INVESTIGATE

9. Work in small groups to model what happens during a total lunar eclipse. Your 'Sun' can be a spotlight or bright torch. Your Earth could be a basketball and your Moon a tennis ball. Use the diagram of the total lunar eclipse opposite to help you. Discuss what you see happening.

checklist

I can:

- ☐ describe and explain what happens during lunar and solar eclipses
- ☐ illustrate the difference between a shadow's umbra and penumbra.

Checkpoint

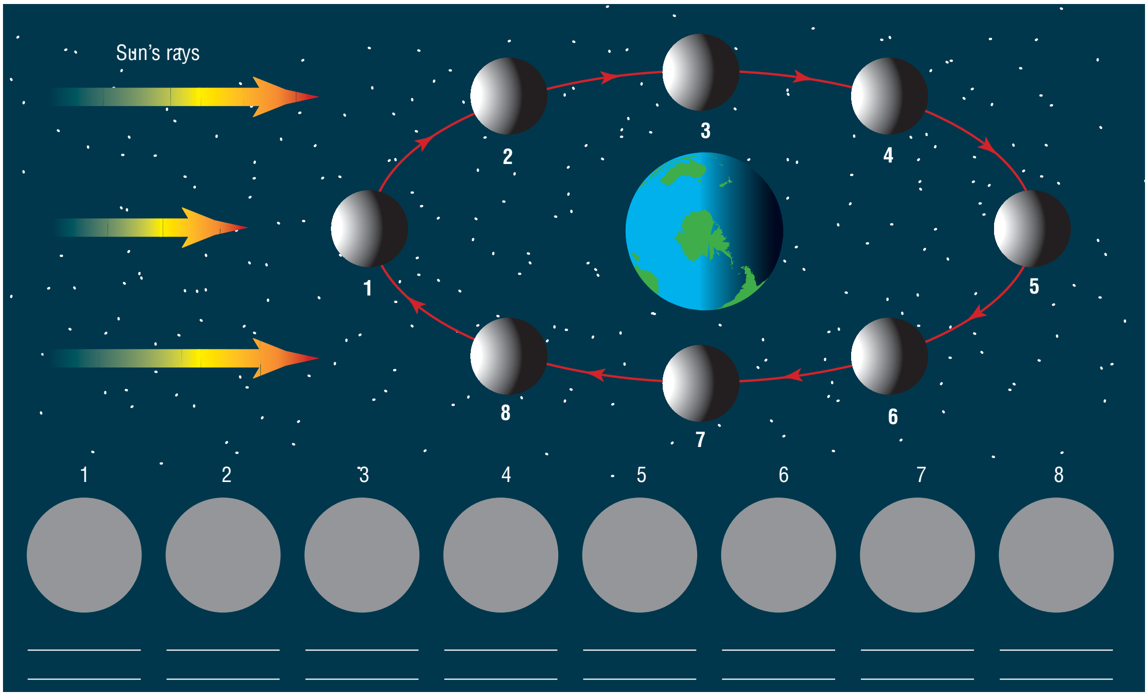
Check and challenge

Neighbours in space

Check

Tides and the phases of the Moon

1. Copy the diagram on the right in your workbook.
   (a) Fill in and label each of the phases of the Moon.
   (b) Put a red circle around the phases of the Moon that produce spring tides.
   (c) Put a blue circle around the phases of the Moon that produce neap tides.
   (d) Add labels to explain spring and neap tides and why they occur.
   (e) Label the near side of one of the Moons in orbit.
2. Explain why we have high and low tides on Earth.



Star moves

3. The stars appear to change their positions during each night and during each year:
   (a) Why do the stars appear to move in circular arcs during the night?
   (b) Why do constellations change their positions in the night sky during the year?

Space stories

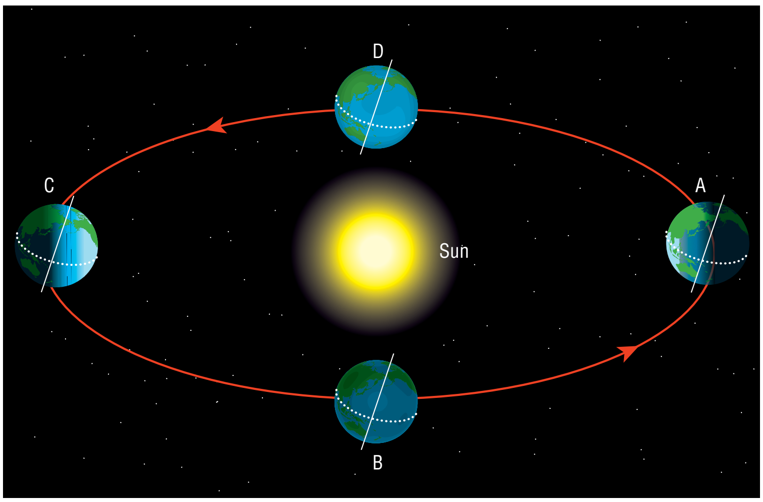
4. Why was the Sun such a key part of the myths and legends of ancient cultures?
5. How do you think people on Earth would react if news broke that another planet just like Earth had been found outside our solar system? Write a short story to describe the discovery and what happened next.

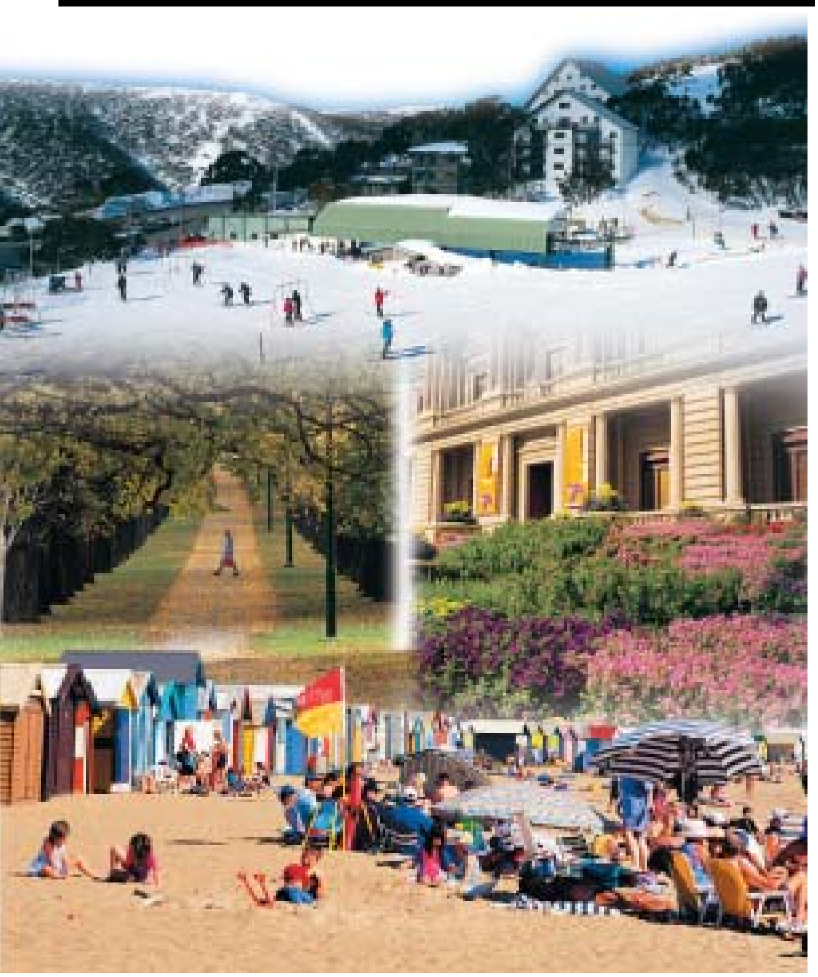
Our solar system and beyond

6. Name the nine planets in our solar system. Go to www.jaconline.com.au/science and follow the links to Neighbours in Space. Click on the web site given for the 'Solar system model'. Use the scaled-down distances given to demonstrate on the school oval or another safe place (using class members) how far away from the Sun each 'planet' is.
7. What do you think is the most interesting fact that has been discovered so far about space? Why?
8. Decide whether the following statements are true or false:
   (a) Buzz Aldrin was the first human to walk on the surface of the Moon.
   (b) Our solar system is in the Orion arm of the Milky Way galaxy.
   (c) Neptune was discovered 135 years before the first space shuttle was launched.
   (d) The first close-up pictures of the surface of Mars were taken in 1961.
   (e) The two smallest planets in our solar system are Pluto and Mercury.

The seasons

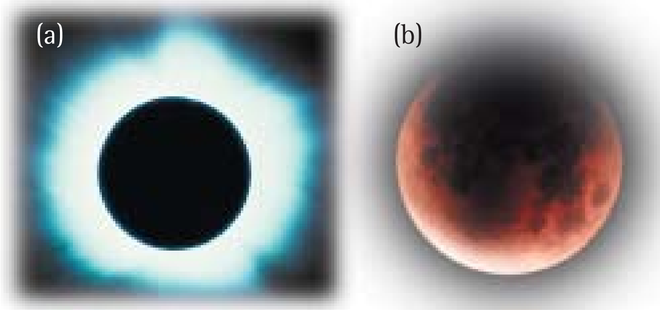
9. Discuss as a class what it would be like to live in the world's polar regions. There are places where for six months of the year the Sun never sets, and for the other six months there is constant darkness. Think how this would affect what you and your family and friends could do, and how you would feel about this.
10. Label each of the four pictures (showing the four seasons in Victoria) A, B, C or D to match the diagram below.





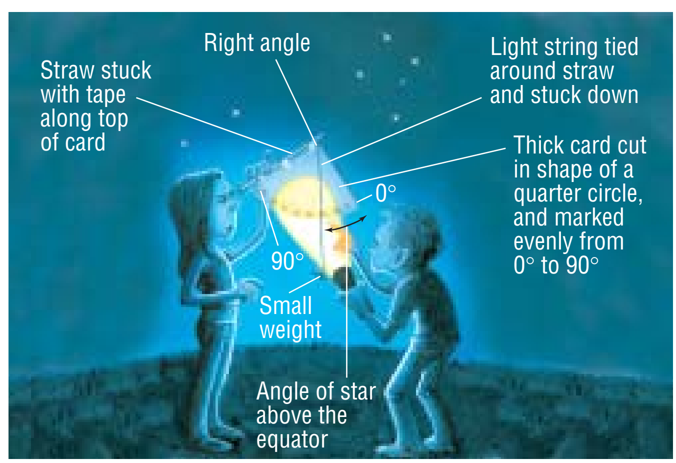
Earth on the move

1. Decide which of these photographs shows an eclipse of (a) the Sun and (b) the Moon. Use labelled diagrams to explain how each eclipse happens.



2. In ancient times, sailors used an instrument called an astrolabe to help them find their way at sea using the stars. They measured the angle of a star above the horizon (usually the North Star as it did not seem to move. It was directly above the North Pole). Once sailors knew the angle, they could work out how far away they were from the equator.

   Make your own astrolabe. Use it to demonstrate how the angle of the Southern Cross (or Crux constellation) changes over a three-hour period. (Check every half hour.) Measure the angle using the 'top' star of the constellation.



The universe

3. Cover a black sheet of A3 card with tiny white dots of different sizes. Find one interesting group of 'stars':
   (a) Join them with connecting lines to form the shape of a 'constellation'.
   (b) Give your 'constellation' a name and create a myth about that name.
   (c) Write a horoscope for your 'constellation' or 'star sign'.
4. Explain why it is impossible for us to draw the universe, even if scaled-down.

Summary of key terms

asteroid: one of the millions of rocky bodies that orbit the Sun. Some asteroids are like tiny pebbles; others may be hundreds of kilometres in diameter.

astrology: the study of how the positions of the Sun, Moon and planets are said to affect our lives. Astrologers claim that these predictions depend on where these bodies were in space on the day we were born.

astronomy: the scientific study of space, including the solar system and the stars. In fact, astronomy can involve anything outside the Earth's atmosphere.

axis: an imaginary line running through the centre of the Earth from north to south, about which the Earth rotates

comet: a body composed of rock, dust, ice. When close to the Sun, a comet has a tail which points away from the Sun.

constellation: a group of stars which has been given a particular name because of the shape the stars seem to form in the sky when viewed from Earth

corona: the Sun's bright, hazy atmosphere. It is only obvious when there is a total solar eclipse. You must never look at the Sun even for a brief moment. You could permanently damage your eyes.

eclipse: an eclipse occurs when a body in space blocks the light of the sun for a short while. A lunar eclipse occurs when the Earth blocks the Sun's light and makes a shadow on the Moon. A solar eclipse occurs when the Moon lies between the Earth and the Sun's light, casting a shadow on the Earth.

ecliptic: the invisible path across the sky that is followed by the Sun, Moon and planets, as seen from Earth

far side: the far side of the Moon. It is never seen from Earth because the Moon takes about the same time to spin around once as it does to orbit the Earth.

full Moon: the view of the Moon seen from Earth when the whole of its near side is in sunlight

galaxy: a very large group of stars held together as a system by gravity

gravitational attraction: an attraction that exists between any two bodies in the universe that have mass

gravity: the force of attraction that exists between any two bodies in the universe that have mass. The gravity at the Earth's surface is the pull of the Earth on objects at its surface.

horoscope: a set of predictions about what will happen to someone based on that person's star sign. There is no scientific basis for horoscopes.

light year: the distance that light travels in a year (9 500 000 000 000 km)

mass: the quantity of matter in an object (often measured in kilograms)

Milky Way: the galaxy of which our solar system is a very, very small part

neap tide: the tide that occurs when the Sun and Moon are at right angles with respect to the Earth (during the Moon's first and third quarters). The **gravitational attraction** of the Moon and Sun work against each other.

near side: the near side of the Moon, which is the side we always see from Earth (*see* **far side**)

new Moon: the phase of the Moon that occurs when the part facing the Earth is facing away from the sun. During a new Moon, the Moon's face is not visible from Earth, even when it is overhead.

orbit: the path that a body follows when it moves all the way around another body

penumbra: the lighter part of a shadow

phases of the Moon: eight different shapes the Moon seems to have (when viewed from Earth) while it completes one orbit of the Earth

radio telescope: a telescope that includes a huge dish, or a collection of smaller dishes, to pick up radio waves (not light waves) from distant stars and galaxies

radio waves: a type of energy that is created when electric and magnetic fields move together

reflecting telescope: a telescope that uses a curved mirror instead of a lens to collect light

revolves: what a body (e.g. the Moon) does when it moves right around, or orbits another body (e.g. the Earth or the Sun). One completed orbit is called a **revolution**.

rotation: one complete turn by a body around its imaginary axis. Such a body (e.g. the Earth), is said to rotate.

solar system: our Sun and everything that orbits it, including the nine planets (including Earth) and their moons, asteroids and comets

space probe: unmanned, remote controlled spacecraft which has a special mission (e.g. to find out more about Mars). Space probes carry many scientific instruments used to investigate objects in space.

space shuttle: a spacecraft with a plane-like orbiter that can be re-used. It is made up of the orbiter (the part which returns to Earth), liquid fuel tank and solid rocket booster.

spring tide: the very high tide that occurs when there is a new or full Moon. At such times, the Earth experiences the combined gravitational attraction of the Sun and the Moon because all three bodies are in the same straight line.

tidal month: the time it takes from one full Moon to the next. A tidal month is not the same as a calendar month (e.g. August).

tidal range: the difference between the highest of the high tides in a given day and the lowest of the low tides

umbra: the darker central part of a shadow

universe: every part of space

zodiac: the region that the Sun, Moon and planets seem, from Earth, to occupy as they pass in front of 12 constellations that make up what we call 'star signs'