Chapter 8

Our Neighbours in Space

CONTEXT AREA

- Our home planet, Earth, is home to all people and all other living things. Without Earth, we would not be here. How does the Earth move in space? What are its companion planets? How do they affect us?
- By watching the changing patterns of stars at night, early people could predict the changes in the seasons on Earth. We can now explain why these changes happen.
- This chapter demonstrates why night and day occur and why there are seasons, and looks at our companion planets in the solar system.

PRESCRIBED FOCUS AREAS

4.1 identifies historical examples of how scientific knowledge has changed people's understanding of the world

4.2 uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena

4.3 identifies areas of everyday life that have been affected by scientific developments

DOMAINS

KNOWLEDGE AND UNDERSTANDING

4.9.1 the Newtonian model of the solar system

4.9.1 **a** describe qualitatively relative sizes, distances and movement of components of our solar system
b describe relative movements of the planets, moons and Sun
c explain night and day in terms of Earth's rotation
d explain the seasons in terms of the tilt of Earth's axis and its revolution around the Sun

4.9.5 **b** describe the effect of the forces of the Sun and Moon on the hydrosphere

SKILLS

4.16 accesses information from identified secondary sources

4.17 evaluates the relevance of data and information

4.19 draws conclusions based on information available

4.22 completes a variety of individual and team tasks with guidance

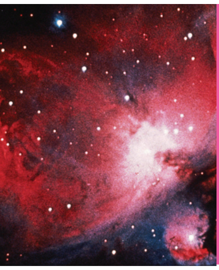
VALUES AND ATTITUDES

4.24 respects differing viewpoints and is honest, fair and ethical

4.26 recognises the role of science in providing information about issues being considered and in increasing an understanding of the world around them

CONCEPTS

Ancient astronomy	Ptolemy and Newton model of solar system
	Struggle for acceptance of Sun centred model
How Earth moves in space	Explanation of night and day, year
	Explanation of the seasons
Time	Sundials
	Calendar
The Moon	Moon orbits the Earth
	Phases of the Moon
Observing an eclipse	Lunar and solar eclipse
	Legends about eclipses
Our solar system	Features of the Sun
	Asteroids
Exploring the planets	Features of each planet
The night sky	Changing sky over each night
	Changing sky over the year
Satellites	Uses of satellites



8.1 Ancient astronomy

For many thousands of years, people studied the night sky. The night sky changed predictably according to the time of night and the time of year. Occasionally a comet would cross the sky. A knowledge of the stars was important because it could be used to predict the changing of the seasons, the time to plant new crops and the migration of animals.

Ancient civilisations kept records and charts of the movement of the sky and stars they called wanderers. We call them planets. Some civilisations built observatories to study the locations of stars.

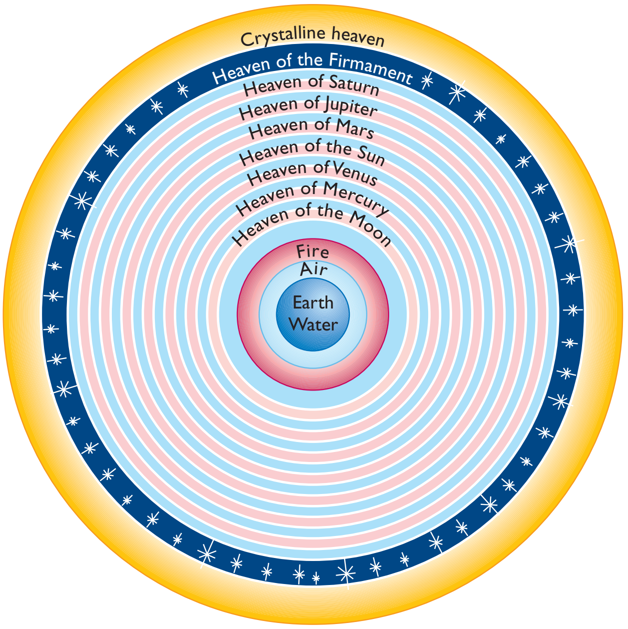
A knowledge of astronomy was important to navigation. Navigation is being able to steer a ship across an ocean so that you arrive at the right place. This was essential if people were to trade and settle in new lands.

The ancient Greeks determined that the Earth was round. They developed a model of the universe with the Earth at the centre. Around it orbited the Moon, the Sun and planets. Beyond that was all the stars in fixed positions. This model was refined by Ptolemy ('TOL-emmy'), and was called the Earth-centred model. Sometimes this is called the Ptolemaic model.

The Arabs were excellent astronomers. They developed new instruments and used Arabic numerals, which were less clumsy than Roman numerals. Like the ancient Greeks, the ancient Arabs believed that the Earth-centred model was true.

The invention of accurate clocks allowed more precise measurements to be made. Then the discovery of the telescope allowed people to look closely at the Moon and planets.

Copernicus ('Co-PER-ni-cus'), showed that the Earth was not the centre of the universe or the solar system. Galileo was the first person to use a telescope in astronomy, and his observations supported the theory of Copernicus and not Ptolemy. The Sun was at the centre of our solar system, and not the Earth as everyone believed. This is the Sun-centred, or heliocentric, model of the solar system.



Ptolemy's model of universe

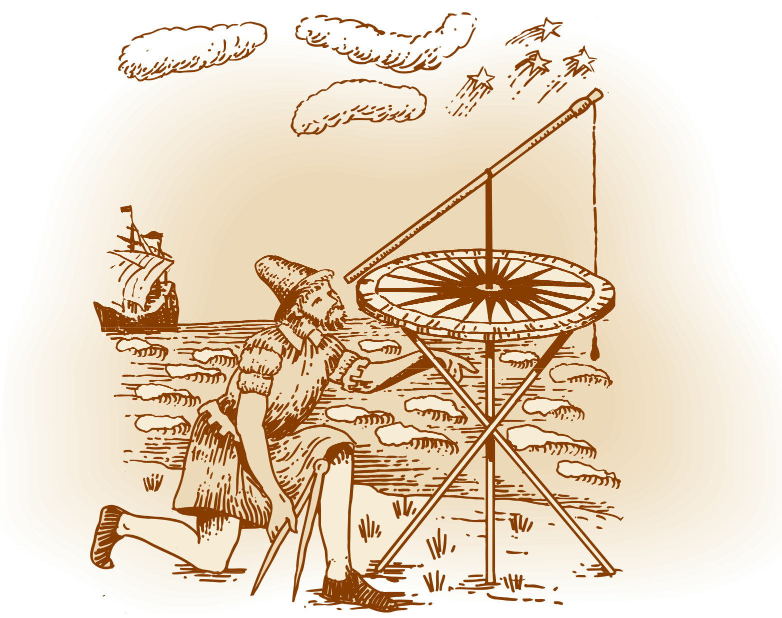
Further proof of the Sun-centred model of the solar system came from the calculations of Johann Kepler ('YO-harn KEP-ler'). Kepler used the accurate observations of a Danish astronomer called Tycho Brahe (pronounced TIE-ko BRAR-hee).

Brahe realised that the much younger Kepler, a brilliant mathematician, was the only person who could analyse his measurements and explain how the planets moved. Kepler used Brahe's accurate measurements to show that the Sun-centred model was true. Kepler explained the motion of the planets when he realised that they travel around the Sun in an ellipse, not a true circle. He summarised the motion of the planets in three mathematical laws.

But there was still a problem. What held the planets in place as they orbited the Sun? Isaac Newton introduced the idea of gravity, or gravitational attraction, to answer this problem. The Sun, the planets and their Moons all attract each other with their gravity, and their speed stops them from falling towards each other. This model is called the Newtonian model.

The Sun-centred model of the solar system is now accepted as true. The measurements of the distances and speeds of the planets agree with the theories of Galileo, Kepler and Newton. Well, almost. When more accurate instruments were developed, small errors in the predicted positions of the planets were found. This problem was solved by Albert Einstein when he explained space and time in a different way.

A knowledge of astronomy was very important to early explorers. They needed a way of finding their location on Earth. Accurate charts had been drawn up showing the location of the stars at different times. With a clock, a sextant (to measure the angle to the Sun and stars), and a chart or table of astronomical dates, explorers could locate and map foreign lands. The colonisation of parts of the world by Europeans could not have been possible without a knowledge of astronomy.



Measuring the positions of stars helped early sailors work out their ship's position

CHECKPOINT:

COPY AND COMPLETE

The ancient Greeks developed a _____ of the universe with the _____ at the ______. This model was refined by _______ and was called the _____ ________ model.

Copernicus showed that the _____ was not the ______ of the ________ or the _____ system. Galileo Galilei was the first person to use a _________ in _________, and his observations supported the theory of __________ and not _______.

Kepler used _____'s accurate measurements to show that the ___-_______ model was true. ______ explained the motion of the _______ and __________ them in _____ laws.

Isaac Newton __________ the idea of _______. The ___, the _______ and their _____ all attract each other with their _______, and their _____ stops them from ________ towards each other. This model is called the _________ _____.

QUESTIONS

1 Why was a knowledge of the night sky important for the survival of early societies?

2 Place these models in the correct order in time, from earliest to latest. Say whether each was Earth-centred or Sun-centred.
- Newtonian model
- Ptolemaic model
- Copernican model

3 Which two inventions allowed European astronomers to become world leaders in astronomy in the 1500s and 1600s?

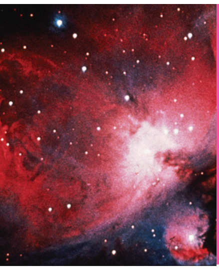
4 Draw a diagram showing how the Earth and Sun move, according to Ptolemy and Newton.

5 What is one hundred and thirty four in Arabic numerals? What is it in Roman numerals? Which is easier to write and use in calculations?

6 Why are these astronomers remembered? (Use notes from this section only.)
   a Copernicus
   b Galileo
   c Brahe and Kepler
   d Newton

7 How did a knowledge of astronomy help in the exploration of Earth hundreds of years ago?

8 Discuss the impact of science upon navigation.



8.2 How the Earth moves in space

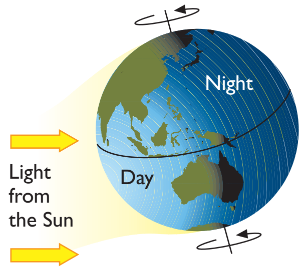
The Earth is rotating (spinning) as it orbits (goes around, or revolves about) the Sun. These motions give us night and day, and the seasons, and explain why we see different stars in the night sky. The Moon orbits the Earth, and this causes changes in how the Moon looks.

Day and night

At any time, only half of the Earth is in sunlight. The other half is in shadow. The part which faces the Sun is having daytime, and the part away from the Sun is having night. The Earth rotates towards the east. We know this because, as the Earth spins, we see the Sun rise above the horizon in the eastern sky.

Seasons

The Earth is slightly tilted as it orbits the Sun. The seasons are caused by this tilt. Australian experiences summer when the southern hemisphere is facing the sun. Rays from the Sun hit the Earth at right angles. The sun is seen high in the summer sky. Europe and Asia experience winter at the same time that Australia has summer. The rays from the Sun are spread out, and the Sun is not overhead in the sky.



Day and night on a rotating Earth

Year

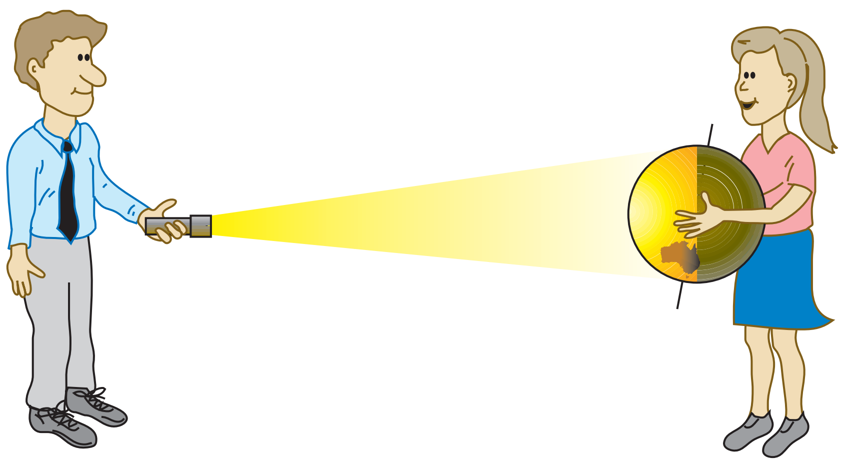
A year is the time it takes for the Earth to go around the Sun once. This is why we have only one summer and one winter every year. The summer solstice occurs on 21 December, in the southern hemisphere, when the Sun is the highest in the sky. This is the longest day and the shortest night. The winter solstice occurs on 21 June. The equinox occurs where there are exactly twelve hours of night and day. These dates are 21 March and 21 September.

EXPERIMENTS

AIM: To show how the Earth moves in space

The Earth in space

Your teacher can show night and day, the seasons, and a year in a simple demonstration. Your class will need a model of the Earth. This can be a globe, an Earth ball, or a balloon with the continents drawn on it with a felt pen.



The Earth is tilted as it orbits the Sun

Night and day

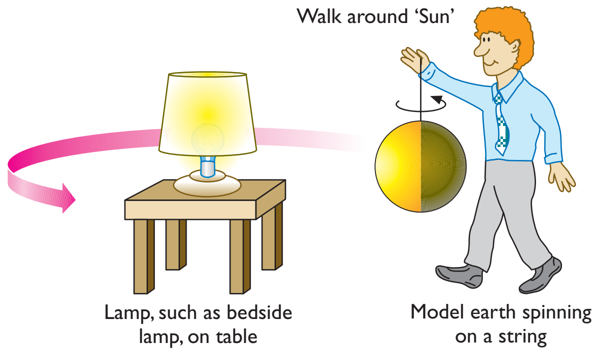
Make your classroom as dark as possible, and shine a light from a torch or a projector onto the model of the Earth. This shows the model Earth in night and day. It is daytime on the part of the Earth with the light shining on, and it is night on the part of the Earth in shadow.

Rotate the globe so that dawn, then dusk, then dawn appears. Which direction does the Earth spin? Hint: it is dawn in Sydney two hours before the Sun comes up in Perth.

One year

Darken your room, and set a single light bulb on a stand in the middle of the room. This will be our model of the Sun. It shines light in all directions.

Hold your model of the Earth, and walk in a circle around the lamp. This is the Earth going around the Sun. One circle or orbit is one year. To be a reliable model, you should spin the Earth as it orbits the Sun. How many times does the Earth spin in one orbit?



One circle around the lamp represents one year

The seasons

The Earth is tilted as it orbits the Sun. Hold your model Earth so that it is tilted slightly. Your teacher will show you how much to tilt it. Do not change this tilt during the experiment.

Walk slowly in a circle around the lamp, moving the model Earth so that it always faces the lamp. Make sure the tilt always points in the same direction. The illustration shows the Earth when it is summer in Australia. Notice that the Sun is almost overhead. In winter the sunlight arrives at an angle and is more spread out.

When you have walked half a circle around your Sun, stop and look at the model Earth. How is it different? Which part of the Earth is having summer?

Model of the seasons

CHECKPOINT:

COPY AND COMPLETE

At any time, only ____ of the _____ is in sunlight. The other half is in ______. The part of the Earth in sunlight is having ___, and the ____ in shadow is having _____. The Earth is slightly ______ as it orbits the Sun. The _______ are caused by this tilt. A year is the ____ it takes for the ___ to go around the Sun ____.

QUESTIONS

1 What is the meaning of the words rotate and orbit? Which word is closest in meaning to revolve?

2 Match the word with the explanation.

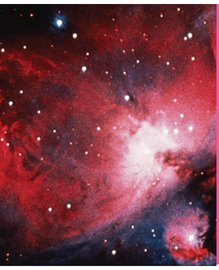
length of day	*caused because the Sun can be overhead, or at an angle at different times of the year*
night	*the Earth spinning once every 24 hours*
season	*time for the Earth to orbit the Sun once*
year	*on the part of the Earth is facing away from the Sun*

3 What is special about the equinox? What is special about the solstice?

4 How long does it take:
a for the Earth to spin once?
b for the Earth to go around the Sun once?
c from one equinox to the next?
d from one solstice to the next?
e from the winter solstice to the next equinox?

5 Use the motion of the Earth around the Sun to explain why it is hotter in January than July in Australia and other countries in the southern hemisphere.

6 Many geologists believe that in the past the days were shorter and that they have gradually increased to their present length. If this is true, is the Earth is spinning faster or slowing down?



8.3 Time

Before clocks and watches were invented, people used the regular movement of the Sun across the sky to show them the time.

Sundial

The sundial uses a shadow to show the time of day. The most common sundial consists of a flat plate. This has numbers for the hours of the day written on it. The shadow stick or gnomon ('NO-mon') casts a shadow on the plate. The time of day is shown by the number that is closest to the edge of the shadow.

Calendar

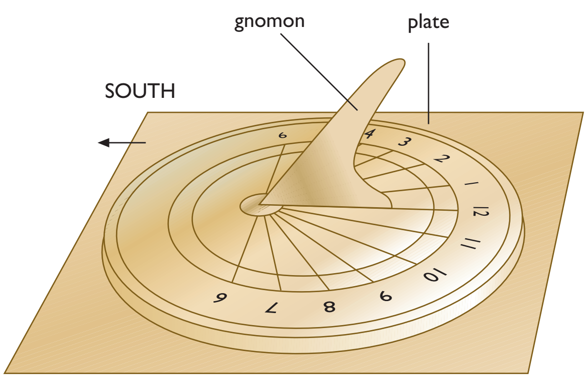
A calendar is a way of recording time. Our calendar is based on days and years. Calendars were especially important to ancient civilisations, who needed to know the coming of the seasons and the seasonal rains in order to plant their food crops. Many stone monuments, such as Stonehenge in England, are thought to have been used as calendars. They can be used to plot the rising and setting of the sun, and its height in the sky. This allows observers to identify the solstice and equinox.

As the earth orbits the sun, it is also spinning. Each spin is one day. One full year is recorded by the earth's position relative to the stars in the sky. One year is 365.242199 days, or 365 days, 5 hours, 48 minutes and 46 seconds. The Julian calendar consisted of $365\frac{1}{4}$ days. Each fourth year was a leap year, which used the quarter day. But this year was 11 minutes and 14 seconds too long. In 1582 the calendar according to the stars and the calendar used by people were out by ten days.

The Gregorian calendar was introduced in Europe in 1582, and in 1752 in England and the English colonies. In 1582 in Europe, Thursday, 4 October was followed by, Friday 15 October. Ten days were eliminated to bring the calendar in line with the stars and seasons. To further keep the calendar in line, some leap years were eliminated. There was a leap year in 2000 and 2004, but there will not be a leap year in 2100, 2200 or 2300. Accurate clocks now match the Earth's motion in space to our calendar, and occasionally leap seconds are introduced to keep the two in exact sequence.

The date given to the years in the Gregorian calendar was decided by Dionysius Exiguus (di-on-ee-see-us ex-idge-you-us) between 500 and 550. He introduced the system of dating years Anno Domini, or 'in the year of the Lord (Jesus)'. He changed the years so that Jesus was born in the year 1. Any date before this was called BC, or 'before Christ'. Events in 66 BC happened after events in 500 BC.

Different societies in different parts of the world have different calendars. In the middle of the year 2000 in the Gregorian calendar it was 2057 in Nepal, 1419 in Islamic countries, 7507 in the Byzantine era, and 5758 in the Jewish calendar.



The completed sundial

Stonehenge, on Salisbury Plain in England, was used as an observatory for predicting events such as eclipses

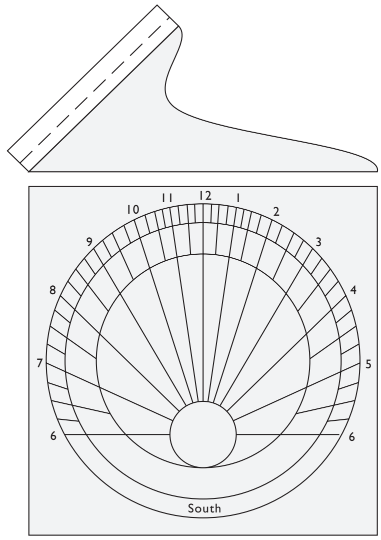
EXPERIMENT

AIM: To make a sundial

Ask your teacher to photocopy the diagram of the face of the sundial in the back of this book. Most ornamental sundials are about 30 cm square, but any size will work. Glue the base plate onto stiff cardboard. Cut out the gnomon and glue it onto thin cardboard.

This sundial is drawn for a latitude of 35° south of the equator. This is the latitude for Sydney, but the sundial will work well enough for other places in New South Wales. Check in an atlas to see the latitude where you live.

For your sundial to work, you will need to mount it on flat ground, or on the top of a flat, level post. It should be in a sunny position, pointing north-south as shown.



Parts of the sundial

CHECKPOINT:

COPY AND COMPLETE

Before ______ and _______ were invented, people used the regular ________ of the ___ across the sky to show them the ____. The _______ uses a shadow to show the ____ of day. The most common _______ consists of a flat plate. The ______ stick or gnomon casts a shadow on the _____.

A calendar is a way of recording ____. Our calendar is based on ___ and ____. Calendars were especially important to ancient ______________, who needed to know the coming of the _______ and the seasonal _____ in order to plant their ____ _____. Many stone monuments, such as __________ in _______, are thought to have been used a calendars.

QUESTIONS

1 What is a sundial used for?

2 What do we call the type of calendar that we currently use? When was it developed?

3 Our calendar has a leap year every fourth year. Why is this? When is the next leap year?

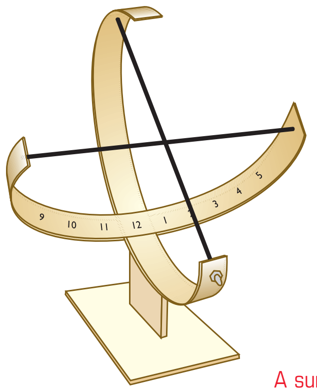
4 Many areas of the world use daylight saving time for part or all of the year. What is daylight saving?

5 The drawing shows an equatorial sundial.

How does it work? Which part faces north? Where does the shadow fall? What would the shadow look like? How would you adjust this sundial?

6 Not every culture uses the calendar which we use. What are the current years in the Jewish, Islamic and Hindu calendars? Why do some newspapers in India have two dates on each issue?

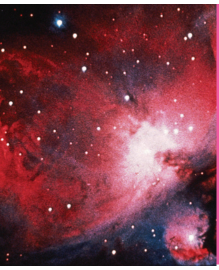
7 Why is it important that a sundial faces north?



A sundial

8 A common puzzle is as follows: A baby born in England on Wednesday, 2 October was two days old on Thursday, 14 October.
   a Explain the puzzle.
   b What was the purpose of leaving ten days out of the calendar?

9 List some problems that would be encountered if ten days were eliminated from our calendar this year.



8.4 The Moon

The Moon is the Earth's natural satellite. It is a ball of rock which slowly spins as it orbits the Earth, while the Earth spins and orbits the Sun. The Moon spins once in exactly the time it takes to go around the Earth, so that the same side of the Moon is always seen from the Earth. We can never see the back of the Moon from Earth.

The Moon rises and sets, just like the Sun. The Moon rises about 50 minutes later each day. The Moon is in the sky in the daytime just as much as it is in the night-time.

The Moon has a weak gravity, and there is no atmosphere. Astronauts must take their own air, water and food, and have to talk by radio.

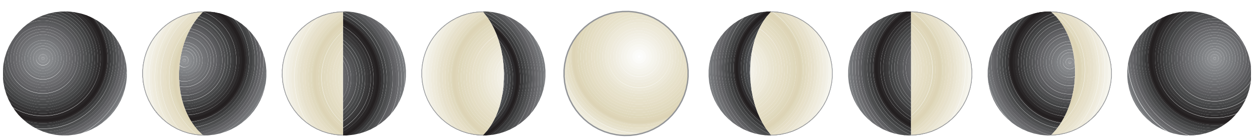
Neil Armstrong and Edwin 'Buzz' Aldrin were the first humans to walk on the Moon. This was in July 1969. In all, 12 astronauts have walked on the Moon. They brought back about 2000 samples of Moon rock, weighing about 400 kg. Some of these have been used for scientific study, and some are in museums around the world. Moon rocks are very similar to Earth rocks, except that there are no sedimentary rocks. All moon rocks are volcanic.

The Earth is the closest planet to the Sun to have a Moon. The Earth's Moon is one of the largest moons in the solar system. It is about one-quarter as wide as the Earth. If you view the moon at night, you will see that it is covered in light and dark areas. Early astronomers who used telescopes called these areas terrae and maria, meaning land and sea. They thought that the surface of the moon was like the surface of Earth. Terrae are now referred to as highlands. Maria are dark coloured volcanic deposits, much like lava flows. They have filled many craters. Craters are found all over the moon, but are most prominent in the highlands areas. Many craters are between 20 and 50 km across, although some are larger.

The Moon is not perfectly spherical, but slightly elongated towards the Earth. The Earth's gravity has locked onto this, and now the Moon always shows the same side towards Earth. The surface of the Moon is made of fine grained and cohesive dust. It sticks together like damp sand. The footprints made by the Apollo astronauts should still be visible in a million years. There is no erosion to destroy them, but the footprints may be covered with dust from meteor impacts.

Phases of the Moon

Sometimes only a part of the Moon is visible. There might be half a Moon, or a crescent, or a fully round Moon. Sometimes the Moon can't be seen at all, even though it is in the sky. These changes in the shape of the Moon are called the phases of the Moon. Of course, the Moon does not change shape. It is always round. What changes is the amount of the sunlit part of the Moon that we can see from Earth. We are really looking at the day and night parts of the Moon.



New Moon start of lunar month
Crescent Moon (4 days)
First Quarter (7 days)
Gibbous Moon (10 days)
Full Moon (14 days)
Gibbous Moon (18 days)
Last Quarter (22 days)
Crescent Moon (26 days)
New Moon (29 days)

The phases of the Moon during one lunar month

EXPERIMENT

AIM: To observe how the Moon changes

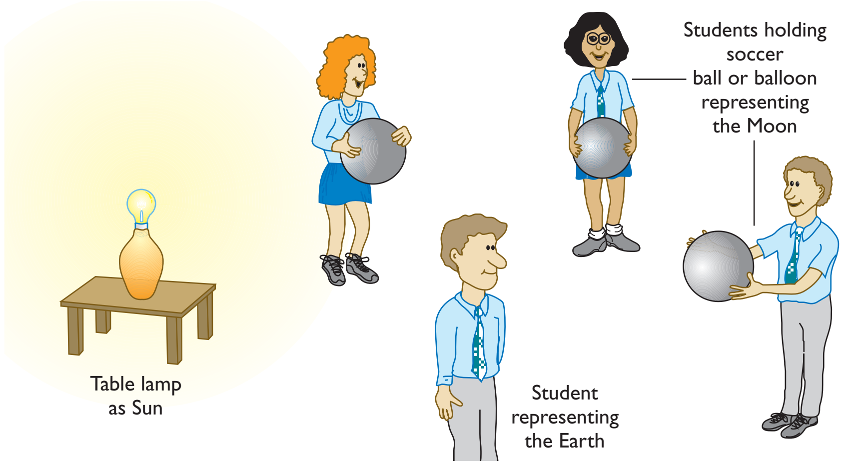
Set up a table lamp as in the illustration, and use a basketball or balloon to represent the Moon. You are the Earth.

What do you see of the 'Moon'? In other words, which part of it is in the light and which is in the shadow? How does this change when:

a the Moon is between you and the Sun?

b the Moon is out to one side?

c you are between the Moon and the Sun?



Phases of Moon experiment

CHECKPOINT:

COPY AND COMPLETE

The Moon is the Earth's natural __________. The Moon has a weak ________ and there is no ___________. Astronauts must take their own ___, ______ and _____, and have to talk by ______.

The Earth's Moon is one of the ________ in the solar _______, and it is about ___ ________ as wide as the ______.

The changes in the shape of the Moon are called the ______ of the Moon. The Moon does not change shape. What changes is the ______ of the ______ part of the Moon that we can ___ from Earth.

QUESTIONS

1 How does the Moon move in relation to the Earth?

2 Why is there no atmosphere on the Moon?

3 Who were the first humans to walk on the Moon? When did this occur? How many astronauts have walked on the moon?

4 What is the variation in moonrise each day?

5 What is meant by the term 'phases of the Moon'?

6 Explain why the Moon appears to change shape.

7 The diagram in the experiment shows three students holding models of the Moon. Using the diagram of the phases of the Moon at the bottom of the previous page, estimate the days elapsed since the new Moon. (Assume that the Moon moves clockwise in the drawing.)

8 The Earth has a diameter of 12 756 km, and the Moon has a diameter of 3476 km. The mean distance between the Earth and the Moon is 384 402 km.

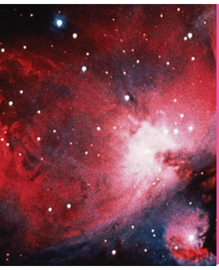
a Draw a diagram of the Earth and Moon to the same scale.

b Draw a scale diagram showing the correct size of the Earth, Moon and the distance between them.

9 The lunar (Moon) month is 29 days. This is the time taken for one complete cycle of the phases of the Moon.

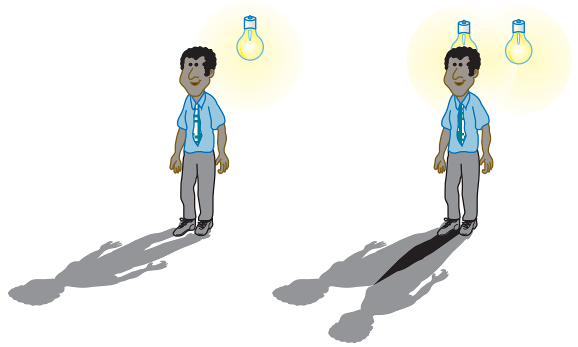
a Should a lunar month be called a lunar year? Explain.

b How long is a lunar day?



8.5 Observing an eclipse

When you are out in the Sun, your body casts a shadow on the ground. When there are two lights, there will be two shadows. Where the shadows overlap and it is darkest, it is the complete shadow, called the umbra. Where there is only a pale shadow it is called the penumbra. This is only a partial (part) shadow.



How an umbra and a penumbra are formed

In space, the Earth and Moon cast a shadow which extends far into space. An eclipse occurs when the Earth or Moon moves into a shadow, and appears dark instead of being lit by the Sun. The shadow could be an umbra or penumbra.

Lunar eclipses

Lunar refers to the Moon. A lunar eclipse is an eclipse of the Moon. It can only happen at full Moon, when the Moon is in line with the Earth. The shadow of the Earth moves across the Moon, so the Moon appears darker.

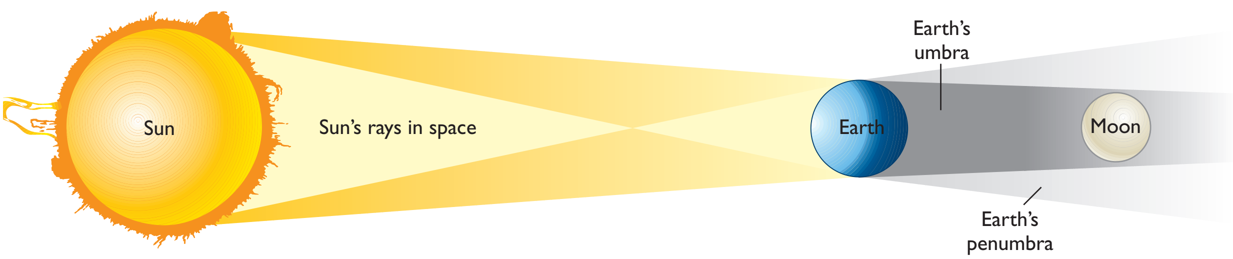
Lunar eclipses usually happen once or twice a year. They can be seen easily, but only from the half of the Earth which is in darkness (night). The Moon might move into the Earth's umbra (causing a full eclipse) or into its penumbra (causing a partial eclipse).

Solar eclipses

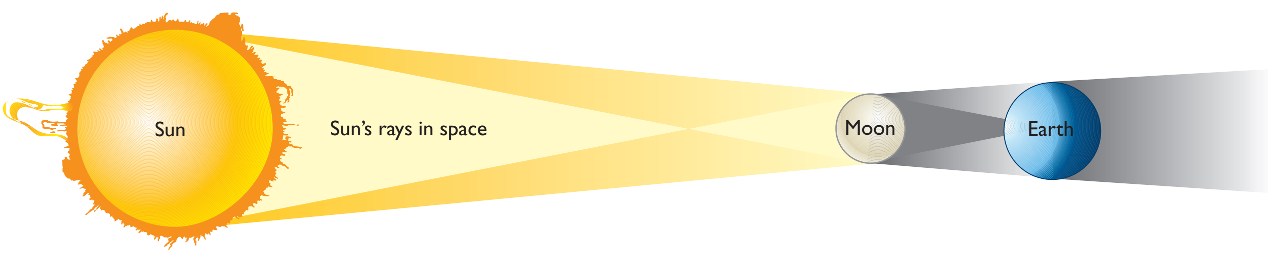
Solar refers to the Sun. A solar eclipse is an eclipse of the Sun. This happens when the Sun is blocked out by the Moon. The Moon blocks out the Sun exactly, because although the Moon is 400 times smaller than the Sun, it is 400 times closer to the Earth. An eclipse of the Sun is only seen in the daytime.

A total solar eclipse happens when a section of the Earth is in the umbra. In a total solar eclipse the sky becomes very dark. This can only be seen from a small part of the Earth, in a band 250 km wide. Outside this band, a partial solar eclipse is seen. Only part of the Sun is covered. The sky does not become completely dark, because that part of the Earth is only in penumbra.

As the Moon crosses the Sun, there is little change in the brightness of the day. Just when the Moon almost totally blocks the Sun, the last

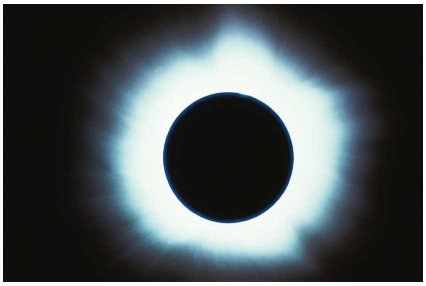


How a lunar eclipse occurs (not to scale)



How a solar eclipse occurs (not to scale) bit of sunlight shines between the bumps and hollows in the Moon's surface. Then the sky suddenly darkens and stars are visible.

Looking at the Sun is very dangerous, even during an eclipse. It can cause permanent blindness. Use cardboard with a tiny hole in it, and shine the image on a wall.



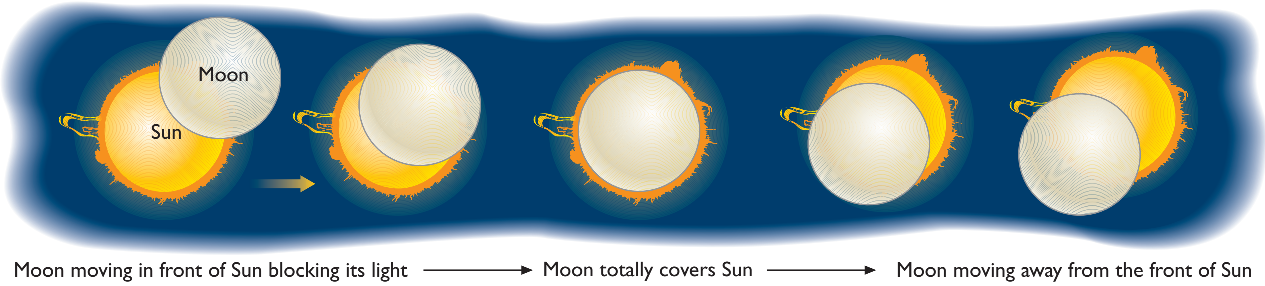
A solar eclipse

Beliefs about eclipses

Many societies have beliefs about solar eclipses. The ancient Chinese thought that a dragon was trying to swallow the Sun. The Vikings thought that two huge wolves chased the Sun and Moon. An eclipse happened when the wolves almost caught and ate the Sun and Moon.

In South American Indian mythology, a puma devours the Sun. To prevent the Sun's death, the puma is frightened away by the screams of children. To the Aymara Indians of Bolivia, the Sun is sick and has lost its power. So they light fires and explode fireworks to give the Sun back its strength.

Christopher Columbus was the first European explorer to discover America and open it for European colonisation (settlement). On his fourth and last voyage to America, Columbus was stranded when his ships became riddled with woodworm and were almost sinking. The native Indians were resentful of Columbus and his crew of more than 100 men. They refused them food. Christopher Columbus knew that a lunar eclipse was due in a couple of days, on February 29, 1504. Columbus told the Indians that God would punish them by making the Moon dark unless they promised to provide him and his crew with food. The Indians refused until the eclipse began and the Moon became black. Then they brought lots of food. This kept Columbus and his crew alive until they were rescued.



The stages in a total solar eclipse

CHECKPOINT:

COPY AND COMPLETE

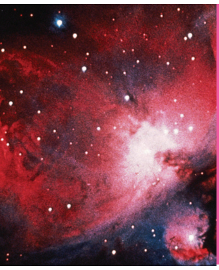
A lunar eclipse is an eclipse of the ____. The ______ of the _____ moves across the Moon, so the Moon appears ______.

A solar eclipse is an eclipse of the ___. This happens when the ___ is blocked out by the ____.

Looking at the ___ is very _________. It can cause permanent _________.

QUESTIONS

1 What do the words lunar and solar refer to?
2 What is an eclipse?
3 Explain the difference between an umbra and a penumbra.
4 What is the difference between a full eclipse and a partial eclipse?
5 If there was a total solar eclipse tomorrow, explain what would happen. How long would it last?
6 Christopher Columbus was saved from starvation by an eclipse. Was this an eclipse of the Moon or an eclipse of the Sun?
7 Why is it dangerous to look directly at the Sun?
8 By coincidence, the Moon and the Sun appear to be the same size. What effect does this have on the appearance of an eclipse?
9 Eclipses provide evidence that the Earth is round. Explain this statement.



8.6 Our solar system

Our solar system consists of the Sun and nine planets, plus the many moons and asteroids. The Sun is at the centre of our solar system, and the planets revolve around it. Our solar system is almost flat. The planets revolve around the Sun, like marbles rolling around a big flat dinner plate. We say that they are in one plane. The only exception is Pluto. It is sometimes higher or lower than the other planets. Sometimes Pluto is closer to the Sun than Neptune is.

The Sun

Our Sun is a star. It is the closest star to Earth, and it provides all the energy needed to maintain our planet.

The Sun is a huge ball of hot gas. It is more than 100 times as wide as the Earth. The Sun's energy comes from nuclear fusion reactions. During these reactions, hydrogen atoms are converted into helium atoms. Lots of energy is made at the same time. The energy which reaches the Earth we call solar energy. Without this energy there would be no life on Earth. The Earth would be frozen and barren, with a temperature of –270°C.

Our Sun is an average star. It is yellow and has a temperature of about 5500°C at the surface. It is believed that the temperature at the centre is 14 million degrees Celsius. Many stars are different colours because they are hotter or cooler than our Sun.

The planets

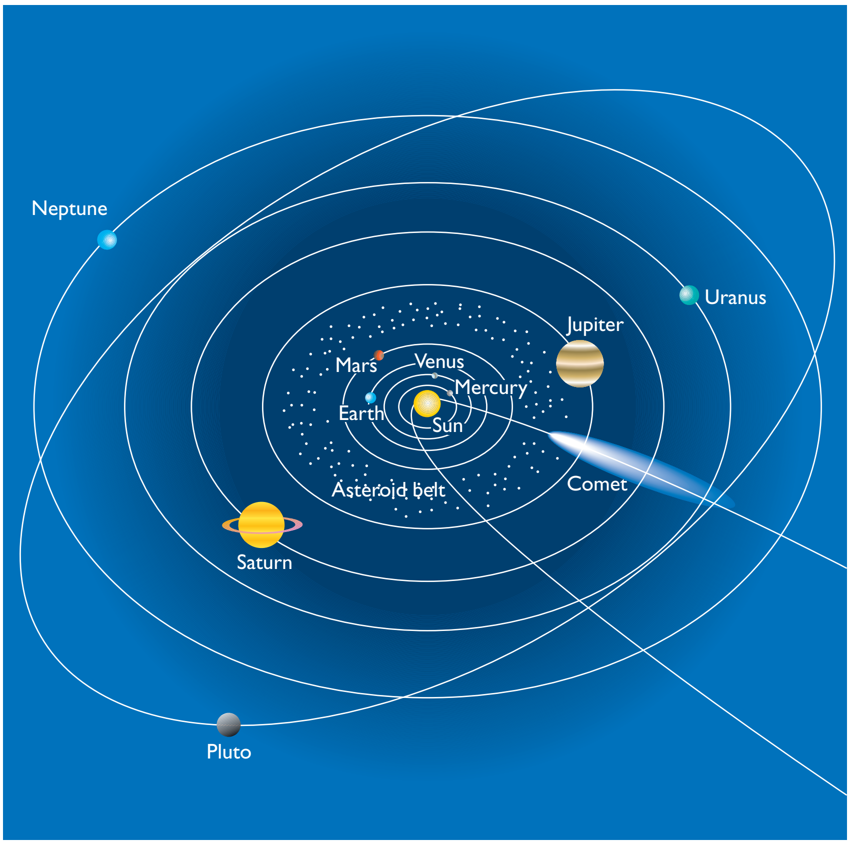
There are nine planets in our solar system. They are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Their names (except Earth) come from gods in ancient Greek or Roman legends. You can read more about the planets on the next page.

Asteroids

At the end of the 18th century, astronomers thought that there must have been a planet between Mars and Jupiter. A search using telescopes found hundreds of large rocks. These are the asteroids and they orbit the Sun in the asteroid belt.

The largest asteroid is called Ceres, and it is 933 km across. It was the first asteroid to be discovered. This was in 1801. Now there are over three thousand asteroids which have been discovered and named. Their orbits have been plotted (mapped).

The solar system does not end with the most distant planets. Beyond them lie clouds of dust and ice called the Oort Cloud. It is thought that comets originate in these areas, break free and are attracted by the gravity of the sun. We see comets as they pass through the inner part of our solar system.



The solar system, showing the orbits of the planets

EXPERIMENT

AIM: To model the solar system

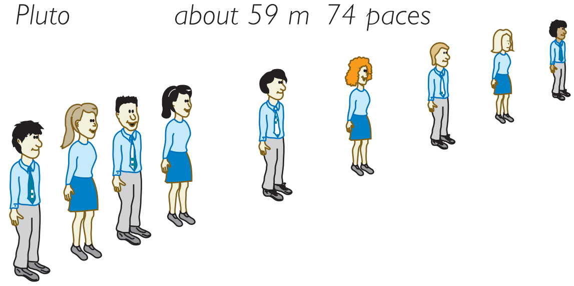
We can model the solar system and simulate (copy) the movements of the planets.

1 How big are the planets compared to each other? The table below shows the size of the planets when they have been reduced in size by 200 000 000 times. These are the sizes, compared to common objects, for reference.

Planet	Size for model	Common object of the same size
Mercury	*2.1 mm*	*half a grain of white rice*
Venus	*5.3 mm*	*ball from bean bag*
Earth	*5.5 mm*	*ball from bean bag*
Mars	*3.0 mm*	*grain of rice or small black peppercorn*
Jupiter	*62.0 mm*	*tennis ball*
Saturn	*52.0 mm*	*billiard ball*
Uranus	*24.2 mm*	*large glass marble*
Neptune	*20.8 mm*	*large glass marble*
Pluto	*1.0 mm*	*grain of white sugar*

2 How far apart are the planets? Most of the drawings you see in this book and others show the planets as being large and close together. This is not the case. If you could shrink the solar system by 100 billion times, which is 100 000 000 000 or 1×10^{11}, this is how far apart the planets would be (based on an 80 cm pace):

Planet	Distance from model sun	
Mercury	*0.58 m*	*3/4 pace*
Venus	*1.08 m*	*1 1/4 paces*
Earth	*1.50 m*	*2 paces*
Mars	*2.28 m*	*3 paces*
Jupiter	*7.78 m*	*10 paces*
Saturn	*14.27 m*	*18 paces*
Uranus	*28.70 m*	*36 paces*
Neptune	*44.97 m*	*56 paces*
Pluto	*about 59 m*	*74 paces*



If you measure or pace out the distances of the solar system according to this table, each planet would be only one five hundredth of its size in Part 1. Jupiter, for instance, instead of being the size of a tennis ball (62 mm), would be 0.12 mm, or as large as the tiniest grain of salt you could pick up on your finger.

CHECKPOINT:

COPY AND COMPLETE

Our solar system consists of the ___ and ____ planets, plus the many _____ and __________. The ___ is at the centre of our _____ system, and the ________ revolve around it. Our solar system is almost ____.

Our Sun is a ____. It is the closest ____ to Earth, and it provides all the ______ needed to maintain our ________.

The Sun is a huge ball of ___ ___. The Sun's energy comes from ________ ______ reactions. During these reactions, hydrogen atoms are converted into ______ atoms. Lots of ______ is made at the same time.

QUESTIONS

1 If our Sun is a star, like the ones you see at night, why is it so bright?

2 How much larger is the Sun compared with the Earth?

3 What would the Earth be like if there was no Sun?

4 How does the Sun obtain its energy?

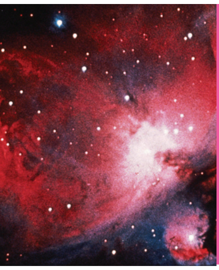
5 What is the temperature of the Sun?

6 What are the asteroids? How big are the largest and smallest asteroids? What are the names of three asteroids?

7 Compare the size of the planets with the size of the solar system.

8 Describe what the Earth would look like from Mars.

9 What is the Oort Cloud?



8.7 Exploring the planets

Our Sun has a family of nine planets which orbit around it. The four closest planets, Mercury, Venus, Earth and Mars, have a hard surface. They are called the rocky planets. The next four planets do not have a hard surface which you could walk on. They are called gas giants, because of their composition and their size. It is thought that these planets have a solid core but the pressure of the gas around it would crush any visitor from Earth. The ninth planet, Pluto, is rocky: not much is known about it.

Mercury

Mercury is the closest planet to the Sun. It can be seen from Earth when it is not in line with the Sun. Being so small, it does not have a strong gravity. It is too weak to hold any gases to make an atmosphere. Without air, sound cannot travel, so Mercury is a silent planet. It also has the greatest temperature range of all the planets, because it has no atmosphere to retain the heat. On the sunny side of Mercury the temperature is 400°C but on the dark side it gets down to –200°C. The surface of Mercury is rock, with many craters.

Venus

Venus can be seen easily from Earth. It is the brightest object in the sky after the Sun and Moon. It is called the 'evening star' or 'morning star' because it is the first star seen when the Sun sets, and the last star to fade into the morning light at dawn.

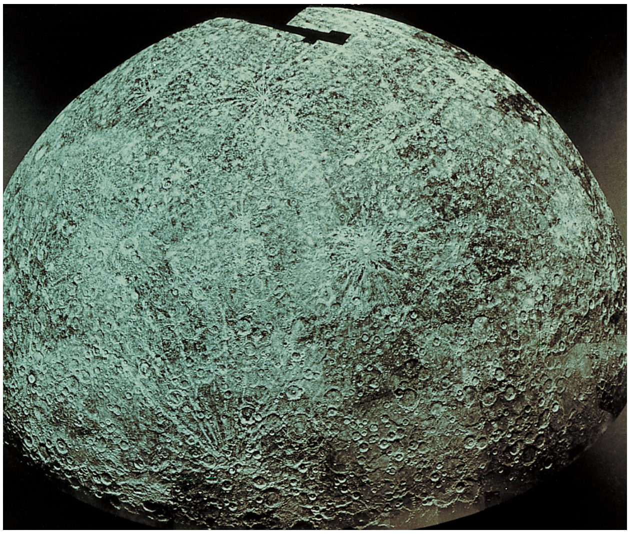
Venus has a hot desert with volcanoes, highlands and lowlands. On the surface the temperature is 480°C because the atmosphere traps the Sun's energy like a greenhouse. The atmospheric pressure at the surface is 90 times that of Earth, and would easily crush a person. Venus rotates so slowly that its day is longer than its year. Venus is also the only planet which rotates backwards. On Venus, the Sun rises in the west and sets in the east.

Earth

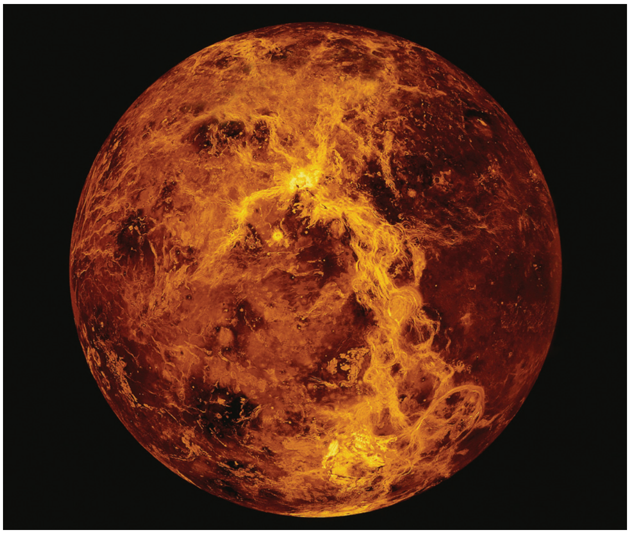
Earth is our home planet. It is special in many ways. Firstly, it has water on its surface. Secondly, it has oxygen in its atmosphere. Some oxygen has formed the ozone layer which filters the dangerous ultraviolet rays from the Sun. Thirdly, our atmosphere is thin enough to let through sunlight but thick enough to burn up meteorites. The atmosphere retains some of the Sun's warmth throughout the night. Lastly, our Earth is the only place we know about that can support life.

Mars

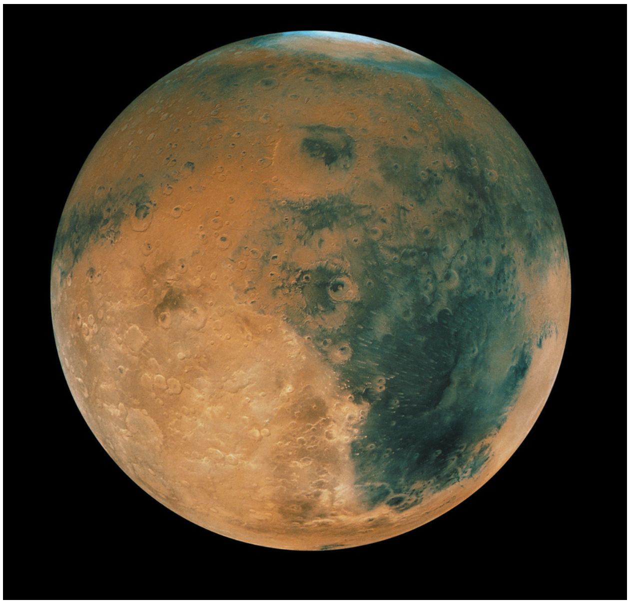
Mars is often called the 'red planet'. Its gravity is only half as strong as Earth, so the planet can



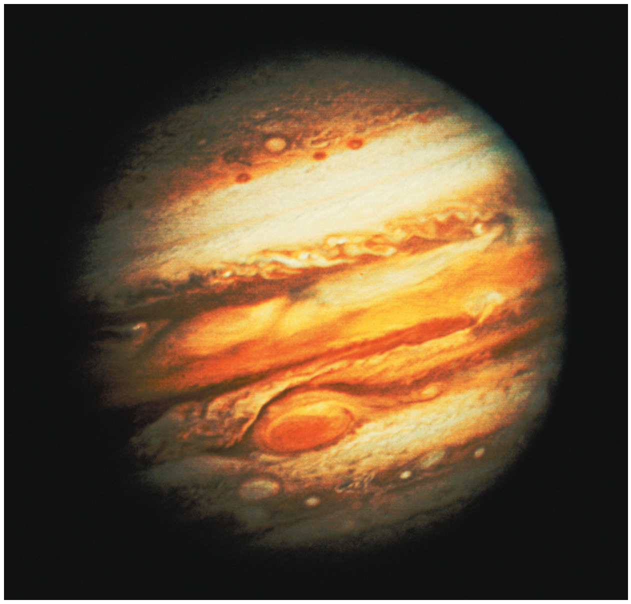
Mercury, the closest planet to the Sun



Venus was the first planet to be visited by a space probe

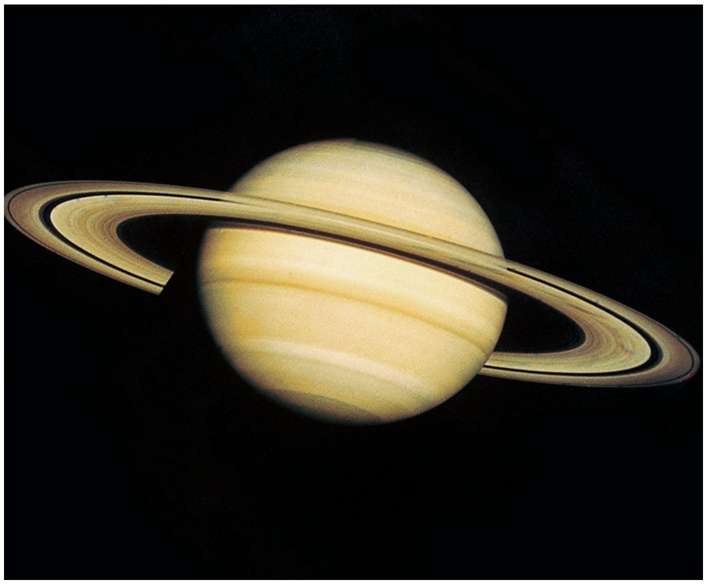


Mars, the 'Red Planet', has had several space probes land on its surface



Jupiter, showing the Great Red Spot

The Earth from space



Saturn, showing its famous rings

only hold onto a thin atmosphere. The surface is covered with rusty red rocks and dust. Winds up to 100 km/h can blow the dust into the atmosphere, and it can take months to settle. This causes the sky to look red from the surface of Mars.

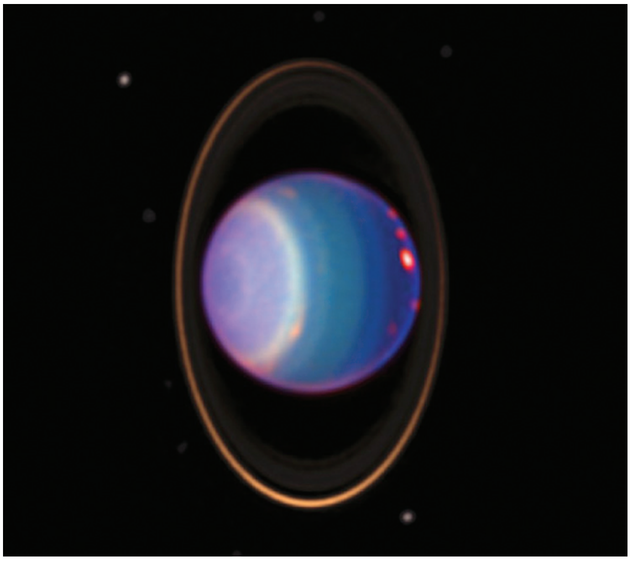
Mars has seasons, like on Earth. The polar ice caps, which are made of solid carbon dioxide (dry ice), melt in summer but form again in winter. The largest volcano in the solar system is on Mars. It is called Olympus Mons. It is 700 km across and 27 km high.

Jupiter

Jupiter is by far the largest planet in the solar system. It has a tiny core surrounded by a thick atmosphere of hydrogen and helium. Large planets like this are called gas giants. There is no solid surface on Jupiter.

Jupiter takes just under 10 hours to rotate. This fast spinning causes high speed winds, which create the coloured bands we see from Earth. The Great Red Spot, more than twice the size of Earth, is the largest cyclone in the solar system.

Galileo Galilei, the famous Italian astronomer, discovered four moons around Jupiter in 1610. We now know that Jupiter has 16 moons, and maybe more small ones. Much of our knowledge of Jupiter comes from the space probe called Galileo. It was launched in 1989 and explored Jupiter in December 1995 and its moons in 1996.



Uranus is a gaseous planet, and is extremely cold

Saturn

Saturn is famous for the rings which surround it. Like Jupiter, it is a gas giant with no firm surface. Its density is seven-tenths that of water. This means that if you could float Saturn in a bucket of water, seven-tenths of it would be in the water and three-tenths would be out of the water.

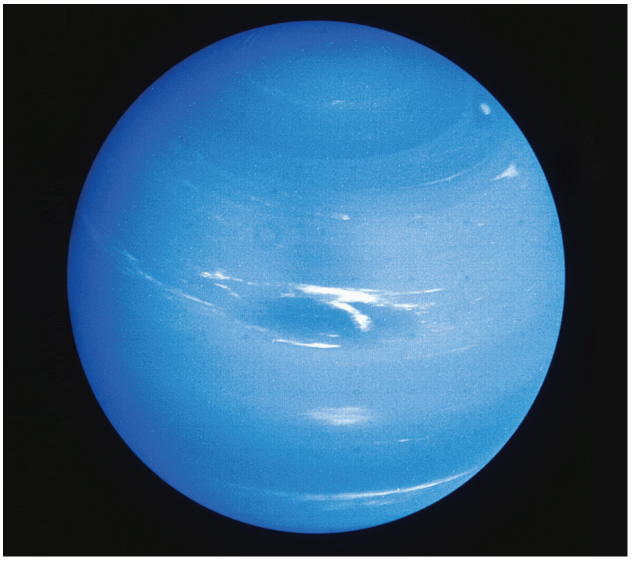
Saturn has 33 moons—more than any other planet. The rings are made of rocks that range in size from dust to big boulders. Jupiter, Saturn, Uranus and Neptune all have rings, but Saturn's are the largest and easiest to see.

Uranus

Uranus was discovered by accident in 1781. From Earth, even with the most powerful telescopes, all we see is a fuzzy blue-green ball. Most of what we know about Uranus was discovered by the Voyager 2 space probe in 1986. Uranus is also a gaseous planet, with no hard surface. Its highest temperature is a very cold –200°C. Uranus is a planet on its side. No one knows why it is so different to the other planets.

Neptune

Neptune is the most distant gas giant planet. From Earth it is a blue colour flecked with white. Neptune's structure and atmosphere are similar to Uranus, but Neptune is windier. Winds can reach an incredible 2160 km/h. The Voyager 2 space probe passed Neptune in August 1989 and discovered most of what we know about the planet.



Neptune is similar to Uranus, but is windier

Pluto has a rocky surface, and a different orbit to the other planets

Pluto

Pluto is the only planet not to have been visited by a space probe. But we know enough about Pluto to be sure it is strange. Firstly, it is rocky and not a gas giant like its nearby planets. Secondly, it has one large moon which is very close to the planet. Thirdly, its orbit is different to the other planets. Sometimes Pluto is closer to the Sun than Neptune. Some astronomers now think that Pluto should not be called a planet at all.

Sedna

In November 2003 a team of astronomers announced the discovery of Sedna. Sedna is regarded as a planetoid, or large asteroid, and not as the tenth planet of our solar system. It is the most distant known object in our solar system, being three times further from the Sun than Pluto. It takes 10 500 years to orbit the Sun. Another smaller planetoid, Quaoar, was discovered in the outer regions of our solar system by the same team of astronomers in 2002.

Moons

Seven planets in our solar system have a moon around them. The Earth is the closest planet to the sun to have a moon. The Earth's moon is unusual because it is so large in comparison to the planet Earth and so close to the planet. The large and gaseous planets, especially Jupiter and Saturn, have many moons. Small moons are still being discovered around these planets.

Life on other planets

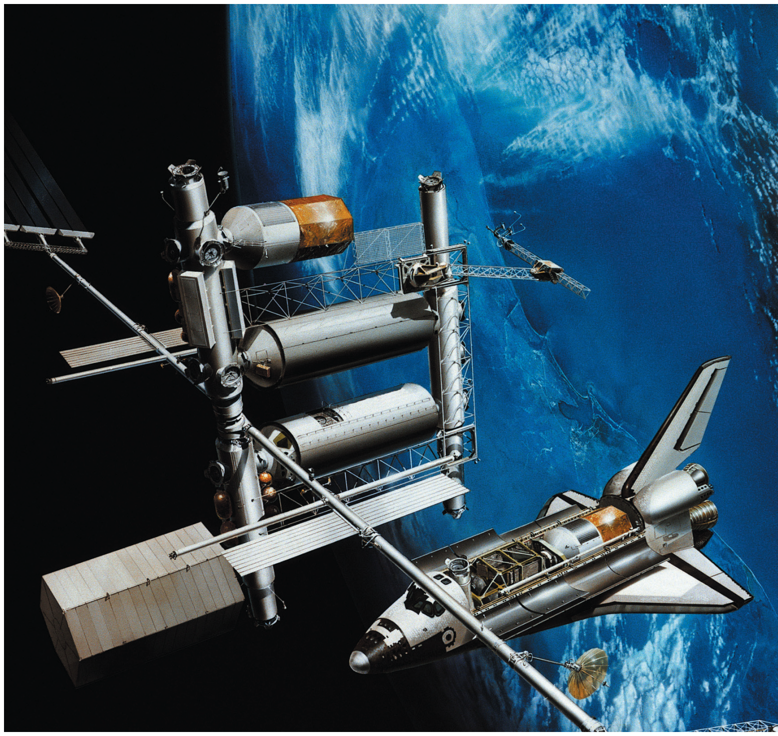
Is there life on other planets in our solar system? At one stage, people believed that there may have been life on Mars. The evidence was the similarity of Mars to Earth, and the lines called canals which could be seen on the surface. Space probes which have been to Mars show it to be rocky and barren.

Recent explorations on Mars have looked for the presence of water and evidence of bacterial life. Other places to look for life are on moons. It is thought that some of the moons of Jupiter have conditions that are suitable for life as we know it. Some of the molecules needed for life, such as amino acids that make proteins, have been found on comets and meteors. This has led to speculation that life may exist elsewhere.

Colonising the planets

Could people live on other planets? There is no known planet with the atmosphere, temperature, water and gravity of Earth. Even living in a self contained space station would be difficult when the air pressure, temperature, gravity, food supply and wastes have to be carefully controlled. With our present technology it takes six months to reach Mars in a tiny spaceship, and over two years to reach Jupiter.

If the problems of distance and environment could be overcome, the best places to live may be the moons of Jupiter. Jupiter and Saturn are gaseous planets and have no hard surface to land on. One of Jupiter's moons, named Europa, is currently the best choice. Europa is thought to consist of liquid water with a covering of broken ice. The water could be used for life support and generating hydrogen for use as a fuel.



Painting of a space station above Earth

CHECKPOINT:

QUESTIONS

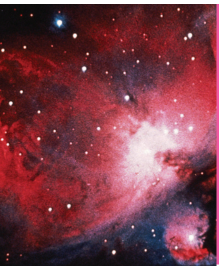
1 For each feature listed, name the planet it refers to:
- **a** the largest system of rings in the solar system
- **b** the largest cyclone in the solar system
- **c** the largest volcano in the solar system
- **d** orbits the Sun differently to the other planets
- **e** the highest temperature of any planet
- **f** the greatest range in surface temperature
- **g** the most moons
- **h** the only unexplored planet
- **i** a red surface and sky
- **j** spins on its side as it orbits the Sun
- **k** winds of more than 2000 km/h
- **l** water and oxygen in its atmosphere
- **m** days longer than its years
- **n** a large moon very close to the planet
- **o** the Sun rises in the west.

2 When astronomers and scientists talk about the Martian atmosphere or the Venusian day, they are referring to a planet. Look in a dictionary to find which planets are referred to by the following adjectives:
- **a** Martian
- **b** Venusian
- **c** Jovian
- **d** Terran.

3 Write three features about each planet. List them in point form below the name of the planet.

4 Pluto is regarded by many astronomers as not a planet at all, but two captured asteroids. What is the evidence to support their claims?

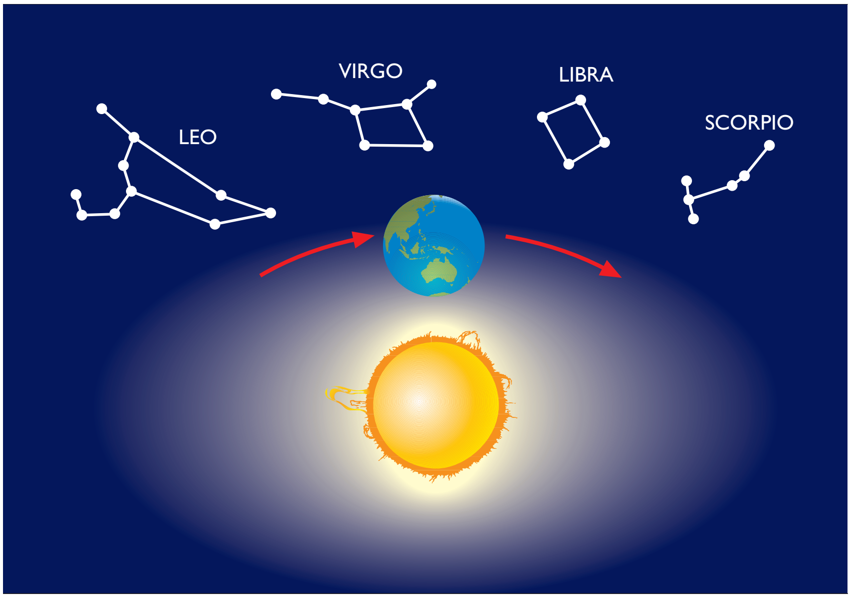
5 Make a list of the requirements that would be needed to sustain a colony of people living on a remote planet or moon. Which of these requirements would the space colonists take with them, and which could they hope to find?



8.8 The night sky

Everyone knows that the Sun rises in the east and sets in the west. So do the Moon, the stars and the planets. The movement of the stars is so regular that you could set your watch by them. In fact, the earliest use of stars was to set calendars and, later, clocks. Old civilisations knew that it was time to plant their crops when a certain star rose in the sky, or when the Sun rose in a certain location.

A group of stars that form a pattern in the night sky is called a constellation. Aboriginal legends gave names and shapes to the constellations, such as Mirra-booka, possums and eagles. Three thousand years ago the Assyrians named the patterns which they could see according to their legends, and we still use many of these today.



The Earth moves around Sun against background of stars

Why do the sky and stars seem to move? This is easily explained. When you ride on a bus, the scenery moves past you. Or does it? The scenery is really standing still, and you and the bus are moving. The scenery only looks like it is moving, in the opposite direction to the way we are going.

It's the same with the night sky. Most of the stars are fixed—they don't move much. Like the passengers on a bus, we are passengers on the Earth, and the Earth is moving. So the sky and stars look like they are moving.

Why do the stars move during the night?

Why does the night sky change between early evening and late evening? The Earth is spinning, and it spins once about every 24 hours. Because we are passengers on the Earth, the sky looks like it is turning. One whole turn takes about 24 hours.

Why do the stars change during the year?

This is explained by the orbit of the Earth around the Sun. The Earth goes around the Sun, like a person walking around an oval. Imagine that the person stops every few metres and looks outwards, away from the centre of the oval. This is like being on the Earth at night, looking away from the Sun. The scenery will change a little each time, as they go around the oval. The same is true of someone on the Earth. The stars we see at night (when they are facing away from the Sun) change as the Earth travels round the Sun.

In Activity 8.6 you learnt that the Sun and most of the planets are in the same plane, as if they were all on a huge flat dinner plate. The thin, circular part of the sky which is level with this imaginary plate is called the zodiac.

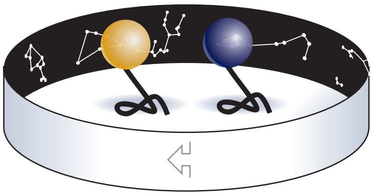
The Moon, Sun and planets are always in front of the zodiac. There are 12 constellations around the zodiac. These are the 12 signs of the zodiac that are used in astrology.

Astrology is the practice of predicting your future by the patterns of stars when you were born, and the locations of the stars each day. There is no scientific evidence that the locations of stars and planets has any effect on what happens to you each day on Earth.

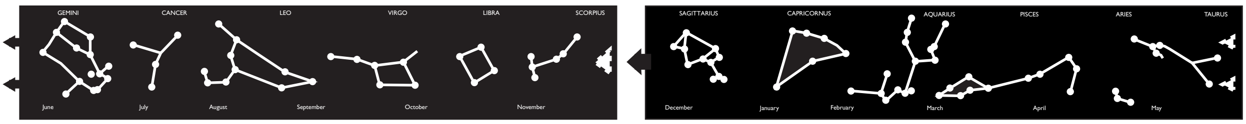
EXPERIMENT

AIM: To model how the Earth moves during one year

Your teacher will photocopy the two strips showing the constellations of the zodiac from the back of this book. Cut them out and glue them into a circle. The constellations should be on the inside of the circle.



The Sun and Earth with constellations of the zodiac



The zodiac

Using two paper clips and two pieces of plasticine, make models of the Sun and the Earth. Use yellow or orange plasticine for the Sun, and blue or green for the Earth.

Stand the Sun and Earth inside the circle. Make sure that the Sun is at the centre and that the Earth can orbit the Sun.

Move the Earth slowly around the Sun. Notice that Earth moves past different constellations. The section of the strip with the month shows the time of year when the constellation is overhead in the middle of the night in Australia. Note that we cannot see Virgo in March, because the Sun is between the Earth and the part of the sky called Virgo.

EXPERIMENT

AIM: To test predictions in astrology

Find yesterday's newspaper, and cut out the astrology section. It contains predictions of what should have happened to you yesterday. Cut out the predictions, being careful to cut off the star sign at the top. Ask your friends to select the prediction that best suits them for yesterday. How many people can select the prediction that matches with their star sign?

CHECKPOINT:

COPY AND COMPLETE

The earliest use of stars was to set ______ and, later, __________. Old civilisations knew that it was ____ to plant their _____ when a certain ____ rose in the sky, or when the ___ rose in a certain location.

A group of _____ that forms a ________ in the night ___ is called a ______________.

The Earth is spinning, and it spins once every __ hours. Because we are ___________ on the Earth, the sky looks like it is _________. One whole turn takes __ hours.

The stars we see at night change as the _____ travels around the ___.

QUESTIONS

1 If you wanted to see the Moon rise, in which direction would you look?

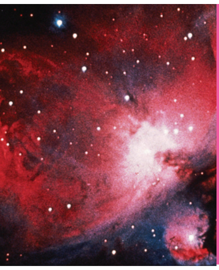
2 Explain why stars look like they are moving when they are not.

3 The zodiac is a part of the sky. What is special about it?

4 The stars in the night sky are different at different times of the night and at different times of the year. Explain why the stars, the Moon and the planets change position during a night, and why the night sky changes during a year.

5 In the experiment, we showed the constellations on a paper strip. This is good for a model, but it is not accurate.
   a What are the constellations made of?
   b How accurately does the model show their distance from the Sun and Earth?
   c What name is given to all the constellations in this strip?
   d Why isn't the constellation called the Southern Cross shown on the strip?

6 Use the experiment to explain why you cannot see the constellation Sagittarius in June.

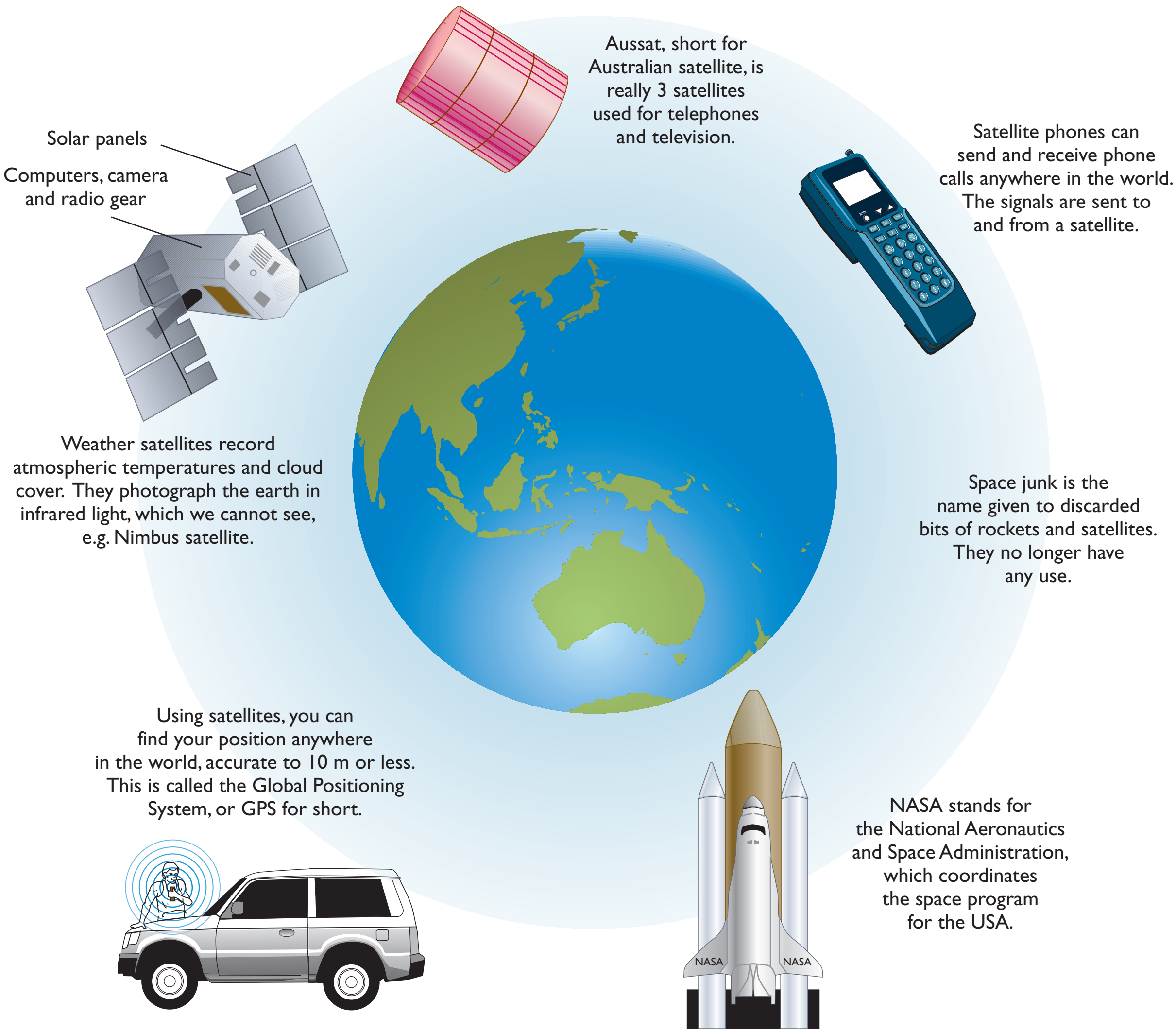


8.9 Satellites

Satellites are objects that orbit a planet. The Moon is a satellite of the Earth, orbiting the Earth once every 29 days. The Moon is the Earth's natural satellite.

The Moon is one of hundreds of satellites which now orbit the Earth. All the others are artificial satellites that people have launched into orbit. These satellites are used for communications, mapping and exploration, weather forecasting, and many other things. We use satellites for long-distance phone calls, television broadcasts from other countries, and for preparing the weather map seen on the television or in the newspapers every day.

Many countries launch satellites into orbit around the Earth. Sometimes groups of countries join together to pool resources, and share the cost of space exploration. An example is the European Space Agency.



Some ways that satellites are used

Satellites go around the Earth in different orbits, depending on the task the satellite does.

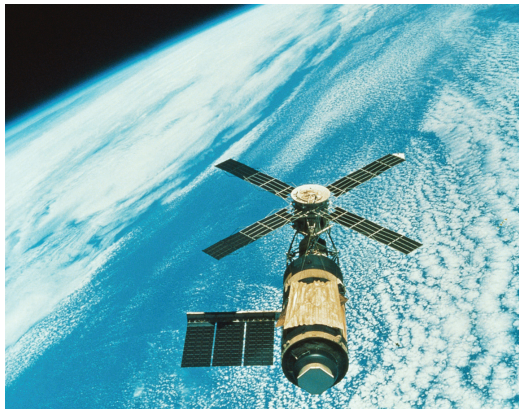
geostationary orbit Satellites in this orbit complete one orbit in the same time that the Earth completes one spin. They travel in the direction that the Earth spins, so they are always above the same point of the Earth. This is ideal for communications satellites that receive and send telephone and television signals. Geostationary satellites are 35 880 km above the Earth.

polar orbit This orbit passes over the north and south poles of the Earth. This is ideal for satellites used for mapping and weather forecasting, because they can scan the entire Earth as it spins beneath them.

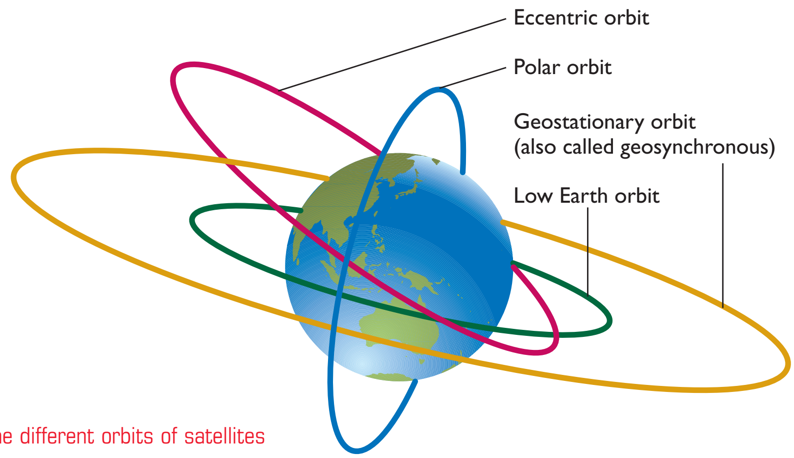
eccentric orbit This orbit is used for scientific satellites, which measure properties of the Earth such as its magnetism and electric fields. The satellite is at different distances from the Earth, so it can measure changes in these properties.

low Earth orbit This orbit is used by the Space Shuttles, space stations and the Hubble telescope. It is close to the Earth and easy to reach. Satellites in low Earth orbit travel very quickly. They might orbit the Earth every 90 minutes.

A satellite receiving station on the Earth is like a satellite television dish, only larger. It receives the messages from the satellite and sends them to other communication centres for processing.



A communication satellite



The different orbits of satellites

CHECKPOINT:

COPY AND COMPLETE

Satellites are objects that _____ a planet. The Moon is a _________ of the Earth, orbiting the Earth once every __ ____. The Moon is the Earth's _______ satellite.

Satellites are used for ______________, _______ and ___________, weather ___________, and many other things.

We use satellites for ____-________ phone calls, television __________ from other countries, and for preparing the _______ map seen on the __________ or in the ___________ every day.

Satellites in a _____________ orbit are always above the ____ point of the Earth. This is ideal for _____________ satellites.

A _____ orbit passes over the North and South Poles of the Earth. A ___ _____ orbit is used by the Space ________, _____ stations and the ______ telescope.

QUESTIONS

1. What are some uses of Earth satellites?
2. What is meant by these words and phrases: satellite, geostationary orbit, low Earth orbit?
3. **a** Another type of satellite is called an equatorial orbit. What path does this orbit have?

   b What type of orbit is best for a satellite which relays mobile phone messages?
4. Name some satellites and their uses.
5. Most satellites are launched from near the equator. Why is this?

Review and Research

Review questions

Answer these multiple choice questions. Select the best alternative.

1 The study of astronomy is:
- a predicting the future
- b dealing with the Earth
- c studying extinct animals
- d studying stars, planets and space

2 Venus is sometimes called the 'evening star'. This is misleading because:
- a Venus is not a star, it is a planet
- b Venus does not appear in the evening
- c Venus twinkles like stars do
- d Venus can only be seen with a telescope

3 Which old civilisations observed the stars and predicted their movements?
- a Chinese
- b Arabs
- c Ancient Greeks
- d all of the above

4 The correct date order for these famous astronomers, from earliest to latest, is:
- a Einstein, Galileo, Copernicus, Newton
- b Galileo, Copernicus, Einstein, Newton
- c Copernicus, Galileo, Newton, Einstein
- d Newton, Galileo, Copernicus, Einstein

5 Night and day is best explained by:
- a the Moon blocking out the light from the Sun
- b the Sun rotating on its axis
- c the rotation of the Earth on its axis
- d the tilting of the Earth as it spins

6 The seasons are caused by:
- a the extremely large size of the solar system
- b the distance from the Earth to the Sun
- c the tilt of the Earth as it goes around the Sun
- d the spinning motion of the Earth

7 The Earth's natural satellite is called:
- a Aussat
- b the Space Shuttle
- c the Moon
- d a comet

8 Eclipses are caused by:
- a the Moon and Earth moving into each other's shadow
- b the large size of the Sun and Moon
- c the enormous distances in space
- d the very strong gravity of the Sun

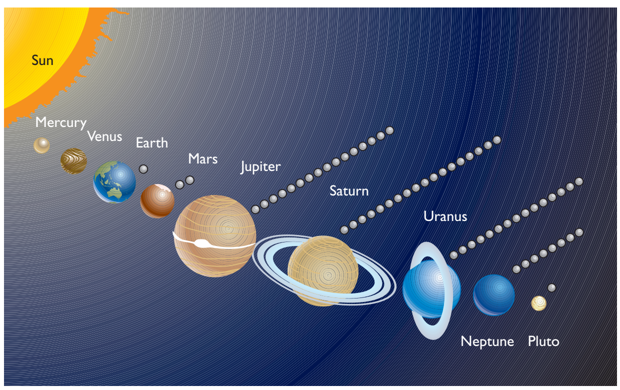
9 The hottest planet of those below is:
- a Jupiter
- b Venus
- c Mars
- d the asteroids

10 The purpose of a leap year is to:
- a keep the calendars and seasons in sequence over the centuries
- b ensure that the same event does not always fall on the same day
- c allow enough time every year for the Earth to rotate around the Sun
- d allow sundials to record accurate time year after year

The following questions have written answers.

11 Each of the statements below is incorrect. Change the underlined word to make the sentence correct.
- a The Sun is at the centre of the universe.
- b Venus is the closest planet to the Sun.
- c The Earth orbits once every 24 hours.
- d A solar eclipse is when the Moon is darkened.
- e Jupiter is the planet with visible rings around it.
- f There is one equinox each year.
- g There are twelve planets in our solar system.
- h The summer solstice is when the days are shortest.
- i The Earth has only one natural satellite, called the Sun.
- j The planet with the shortest year is Mars.

12 This question refers to the diagram below.



The planets and their moons

- a Name the planets in alphabetical order.
- b Name the planets in order of their number of moons.

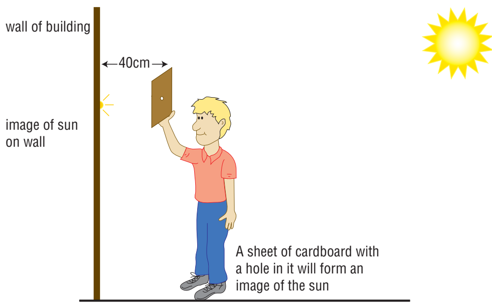
- **c** Name the planets in order of size (use this drawing as a guide).
- **d** Which planet is half as far from the Sun as Saturn?
- **e** Which planet is twice as far from the Sun as Saturn?
- **f** How are Saturn and Uranus different to the other planets?
- **g** How are Saturn and Uranus different to each other?
- **h** Which planet does not revolve in the same plane as the other planets?

13 The Moon has light and dark areas on its surface.
- **a** What are these areas called?
- **b** Which area is the flattest?
- **c** Which area has the most craters visible?

14 If the Earth stopped spinning, would there still be day and night? Explain.

15 If you pushed a stick into the ground, how would the shadow change from morning to midday to afternoon?

16 The diagram shows how to view an eclipse of the Sun. You put your back to the Sun, and view the image of the Sun on a screen.

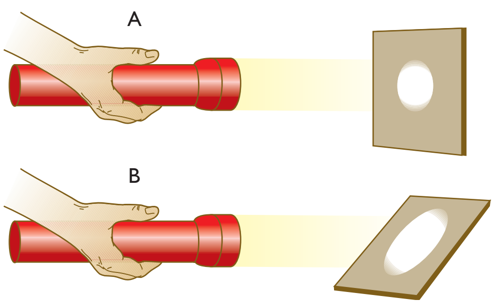


How to view a solar eclipse

- **a** Why is it unsafe to look at the Sun?
- **b** When are people tempted to look at the Sun?

Thinking questions

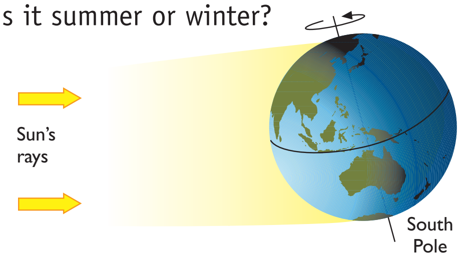
1 This illustration is used to show how the seasons occur. Answer A or B to each question.



Like the light from a torch, sunlight is spread over a larger area when it shines at an angle

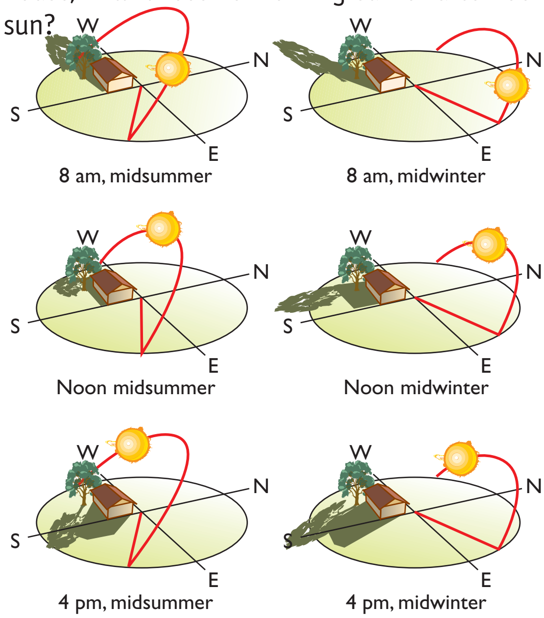
- **a** Which gives the more spread-out light?
- **b** Which of the two drawings represents summer?
- **c** If the piece of paper was the Earth, in which case would the Sun be most overhead?
- **d** If the piece of paper was the Earth, which one would give warmer days?

2 The following diagram shows Australia on the side of Earth. In relation to Australia,
- **a** is it night or day?
- **b** is it nearly dawn or dusk?
- **c** is it summer or winter?



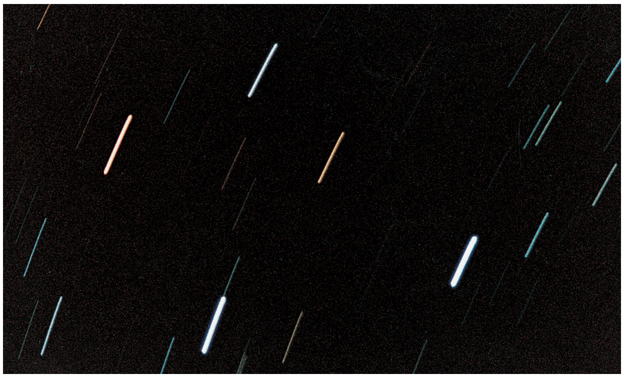
The spinning Earth

3 Study the diagram below, and answer these questions.
- **a** In what season do we get the longest shadows?
- **b** Which season gives the least opportunity for solar heating?
- **c** In which season does the Sun travel further across the sky?
- **d** On which side of the house is it best to grow plants which like sunlight?
- **e** If a plant is growing on the eastern end of a house, will it receive morning sun or afternoon sun?



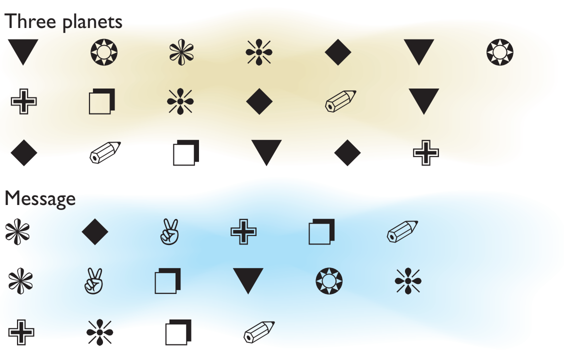
The path of the Sun across the sky in winter and summer

4 The photograph shows the five brightest stars in the Southern Cross. Each star is shown as a line. It was taken over five minutes. Why are the stars different colours? Why does each star look like a line, and not a dot?

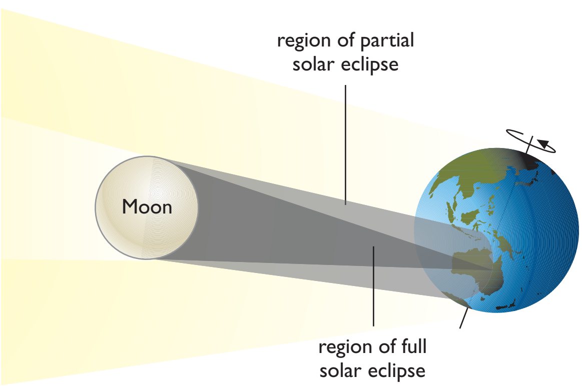


The stars of the Southern Cross

5 Written below, in code, are the names of three planets. Solve the code and then decode the message.



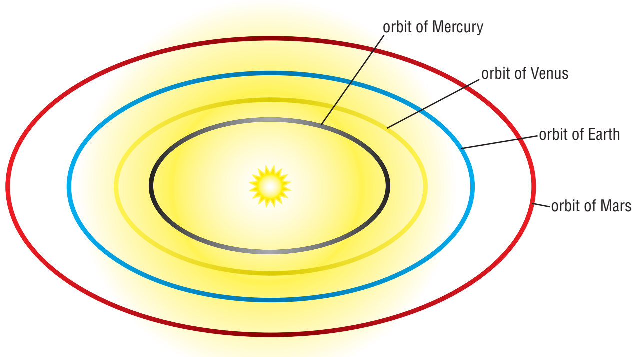
6 A young student has seen this diagram in a science book. Explain to her what the diagram shows. Use words like shadow, umbra, penumbra, and solar eclipse.



Umbra and penumbra formed during an eclipse of the Sun

7 Often the planets line up with each other, or with the Sun. This is similar to an eclipse. What is the meaning of a conjunction and a transit, and how are they different to an eclipse?

8 You will need to refer to a model of the inner solar system to answer these questions.



Orbits of the inner solar system

a Could Venus pass between the Earth and the Sun? Could Mars pass between the Earth and the Sun? Explain.

b In some months Mars is seen high in the night sky. At other times Mars is seen low in the sky at sunset or sunrise. Why does the position of Mars change?

c Why is Venus always seen close to the Sun at sunrise and sunset, and never high in the night sky at midnight?

Word check

asteroid	geocentric	rotate
astronaut	geostationary	satellite
astronomer	heliocentric	season
astronomy	lunar	solar
atmosphere	mythology	solstice
calendar	navigation	sundial
constellation	orbit	telescope
eccentric	penumbra	umbra
eclipse	phase	zodiac
equinox	polar	
fusion	revolve	

Concept map

The ideas in this chapter are great for making concept maps.

1 Draw a concept map of the solar system. Include the planets and models of the solar system.

2 Draw a concept map of the Earth, including day and night, the seasons, a year, the Moon and artificial satellites.

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Features of the planets

Read the following paragraphs, and record the data in a table. Draw a table like the example shown at the bottom of the page.

Mercury is the closest planet to the Sun, being 60 million kilometres from it. It orbits the Sun every 88 Earth days, the shortest 'year' of any planet. Mercury spins slowly—just once every 59 Earth days. The side of the planet facing the Sun reaches 400°C while the side in the shadow has a temperature of –200°C. Mercury has little or no atmosphere, and no moons.

Venus is about 110 million kilometres from the Sun. Venus approaches closer to Earth than any other planet. The surface of Venus is covered in thick clouds, with a temperature of about 480°C. The atmospheric pressure on Venus is about 90 times greater than that of Earth. Venus does not have any moons. A year on Venus, the time it takes for the planet to orbit the Sun once, is 225 Earth days. But it takes Venus 243 Earth days to rotate once, which is a day. Venus is the only planet where a day is longer than a year! Venus is also unique in that it spins backwards.

Earth orbits at about 150 million kilometres from the Sun. Its temperature ranges from –20°C to 60°C. It has an atmosphere consisting mostly of nitrogen and oxygen, with some carbon dioxide, water vapour and other gases. The Earth is the closest planet to the Sun with a moon. The Moon is the only natural satellite of the Earth.

Mars is 228 million kilometres from the Sun. It has a thin atmosphere, mostly carbon dioxide, and its temperature ranges from –70°C to 30°C. Mars has two moons. One day on Mars is 30 minutes longer than on Earth, but a year is about 22 months long. Mars is sometimes called the red planet because it looks red when seen from Earth.

Jupiter is 770 million kilometres from the Sun. Being so far from the Sun, it receives very little heat from it. Its surface temperature is about –150°C. Jupiter is by far the largest planet, and has an atmosphere of helium and hydrogen, with some ammonia and methane. Jupiter has 16 moons and a ring system. It takes nearly 12 years to orbit the Sun once, but only 10 hours to spin once on its axis.

Saturn is about 1400 million kilometres from the Sun, and its surface temperature is about –180°C. The atmosphere is similar to that of Jupiter. Saturn has 33 moons, and has a system of rings around the planet. It spins once every 10.5 hours. Its year is much longer: 29 Earth years.

Uranus is about 2900 million kilometres from the Sun. It has 15 moons and some small rings. Its atmosphere is similar to that of Neptune. Uranus is slightly warmer than Neptune at –210°C, and it takes 84 years to orbit the Sun. It spins once every 23 hours, so its days are nearly the same as on Earth. But because the Sun is so far away from Uranus, it would not give much heat and light.

Neptune is about 4500 million kilometres from the Sun. It is 17 times heavier than the Earth, takes 164 years to orbit the Sun, and takes 16 hours to rotate once. Its surface temperature is –220°C, and its atmosphere is mostly hydrogen, helium and methane. Neptune also has eight moons.

Pluto is very small and very dark. It is 5900 million kilometres away from the Sun, and takes 248 years to orbit the Sun. It takes 6.5 Earth days to rotate once. Its atmosphere is mostly methane, and its cold surface has a temperature of –230°C. Pluto has one moon, named Charon, which is quite large in comparison to the planet. Pluto's orbit is above and below the other planets, not level with them.

Planet	Distance from sun (million km)	Temperature Max/Min °C	Atmosphere made of	Length of day (hours)	Length of year	Number of moons	Other notes of interest