6 Exploring space

Planning page

Getting started

6.1 Observing the night sky page 116 — Activity page 117

6.2 Exploring the solar system page 120 — Activity page 126; Activity page 127

6.3 Stars and galaxies page 131 — Activity page 134; Assessment task 6 An astronomy survey

Main ideas — Chapter 6 crossword

Review — Chapter 6 test

Essential Learnings for Chapter 6

Essential Learnings	*References*		
	Student book (page number)	***Workbook (page number)***	***Teacher Edition CD (Assessment task)***
Knowledge and understanding *Earth and beyond* Scientific ideas and theories offer explanations about the earth that extend to the origins of the universe	pages 131–133		
Science as a human endeavour People from different cultures contribute to and shape the development of science	pages 116–118	Exercise 4 page 49	Assessment task 6 An astronomy survey
Ways of working Evaluate data, information and evidence to identify connections, construct arguments and link results to theory	pages 120–128 pages 131–134 Activity page 134		
Draw conclusions that summarise and explain patterns, and that are consistent with the data and respond to the question	pages 126–127	pages 48–52	
Reflect on different perspectives and evaluate the influence of people's values and culture on the applications of science	Activity page 134		

QSA *Science Essential Learnings by the end of Year 9*

Vocabulary

artificial
asteroid
astronomer
atmosphere
brochure
comet
composition
dwarf
elliptical
galaxy
irregular
meteor
meteorite
orbit
planetary
protostar
revolve
rotate
satellite
spiral
supernova
telescope
universe

Focus for learning

Discuss aliens, stars and planets (page 115).

Equipment (per group)

Activity page 117	pencil, large sheet of thick paper or cardboard, magnetic compass, Blu-tack
Activity page 127	access to internet
Activity page 134	access to internet

6 Exploring space

Getting Started

Do aliens exist? If so, where do they come from? How much do you know about the solar system and the universe? Form a group and discuss the questions below.

- If aliens exist somewhere in the universe, where are they likely to live? Describe the body features they would have to have to live in these places.
- The nearest star is 4.3 light-years away. What does this mean? Could we get to this star using our present methods of space travel? Suggest other ways of travelling to stars.
- You know that Pluto is a dwarf planet on the outer edge of our solar system, but to your great-grand-parents Neptune was the furthest planet. How can you explain this difference?

Starting point

This topic is one that students have probably encountered several times already. As a result, students will already have an opinion on this topic. You will therefore need to re-engage them and develop new ideas and concepts. Asking students questions to determine the amount of knowledge they already have will prove important. Those students who have a good understanding of some of the concepts in this chapter can become group leaders in activities for those with more limited knowledge. Gauge your audience and do not dwell too long on things that students may already understand.

There are many interactive software applications available on the internet which can be used throughout this chapter. Try compiling a list of websites to hand out for the students to explore in their own time. Maybe ask them to find out some specific facts about the universe such as the name of our sun, what type of galaxy our solar system is or whether there are planets around stars other than our Sun.

Hints and tips

Often students find it difficult to comprehend such vast time frames and enormous magnitudes. A timeline mapped out around the room can be used to illustrate the distance from initial astronomical ideas/discoveries to the present day (see Learning experience below).

The expanse of the universe can be illustrated by describing the Earth as a student sitting in the classroom: the room they are in is the solar system, the whole school is the galaxy, other schools are different galaxies and everything, including the expanse between galaxies, is the universe.

Reinforce the difference between astronomy and astrology.

6.1 Observing the night sky

When you gaze into the night sky you are looking at part of the **universe**. Astronomers (scientists who study objects in space) describe the universe as space and everything in it. However, they are not sure how big the universe is. They do know that it is made up of billions of stars, millions more than the few thousand that you can observe by looking at the night sky.

Inferences from observations

Most cultures throughout history have had very important beliefs about the visible objects in the universe. The Egyptians, 4000 years ago, believed that the sky was the body of the goddess Nut. The stars were shiny jewels on her dress, while the planets were shiny boats that drifted across the sky. At about the same time the Babylonians thought that the Earth was the centre of a huge sphere, with the Sun, Moon and planets moving around the Earth. Many people also thought that the Earth was flat.

In most cultures the beliefs were based on a central Earth with the other objects moving around it. These beliefs or inferences were based on the observations that the Sun, Moon, planets and stars all move in a *westerly* direction around the Earth.

In AD 140 the Greek astronomer Ptolemy (TOLL-em-ee) wrote an encyclopaedia of astronomy detailing the motion of the moon, the five known planets (Mercury, Venus, Mars, Jupiter and Saturn), the sun and the stars all revolving around the Earth. Ptolemy and other astronomers of his time were very influential, and their ideas went unquestioned for about 1400 years.

In 1543, Nicholas Copernicus (ko-PER-nick-us) published a book containing the idea that the Earth was *not* the centre of the universe. Using very detailed observations gathered over 40 years, he inferred that the planets revolve around a central sun. Even though his inference was not new, it proved to be a bombshell because it was contrary to the traditional belief that the Earth is the centre of the universe.

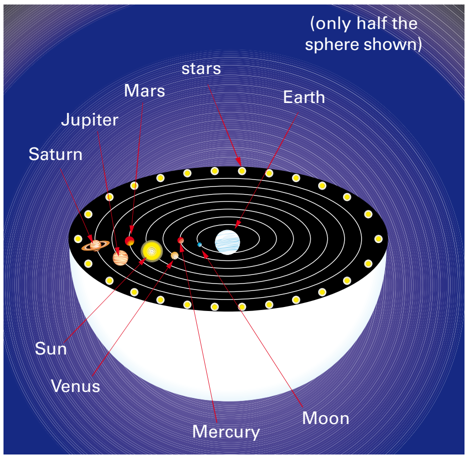


Fig 2 The Babylonians thought that the Earth was at the centre of a huge sphere, with the stars set like jewels on its inner surface.

Fig 3 In 350 BC most people believed that the Earth was flat. But the Greek mathematician Aristotle inferred that the Earth was a sphere after observing its circular shadow on the Moon during an eclipse.

Learning experience

Give the students a group-work challenge by asking them to defend scientifically why the Earth is spherical and not flat. It is advisable to sort them into mixed ability groups to ensure each group can adequately meet the challenge.

Learning experience: timelines

Break the class into small groups and, using butcher's paper and coloured markers, have the groups develop timelines showing the development of ideas about the solar system. Ask students to illustrate ideas or beliefs with diagrams.

Alternatively, ask each group to role play a scene which presents people's understanding of space and our universe during a particular period in time. Allocate a different era to each group. Once groups have planned their play, ask them to dress up and perform it for the class.

Activity

For this activity you will need a pencil, a large sheet of stiff paper or cardboard, a compass and some Blu-tack.

a Place the paper on some flat, level ground. Use the compass to find north and position a long side of the paper to face north.
Mark north in the corner of the paper.

b Put a piece of Blu-tack on the blunt end of the pencil, and place the pencil about 5 cm in from the north edge of the paper, as shown in the photo.

c Place an ✗ at the end of the shadow, and write the time next to it.

d Do this every half an hour for as long as you can. (If you only have a lesson, mark the shadow every 5 minutes.)

e Join up the ✗s on the paper and show in which direction the shadow moved.

What shape is the line joining the ✗s?

How does the movement of the shadow relate to the rotation of the Earth?

Predict how the line would change throughout the year.

Another breakthrough in astronomy occurred in 1609 when Johannes Kepler published his First Law of Planetary Motion. This supported Copernicus' inference and suggested that the planetary paths are ellipses rather than circles. These paths are called **orbits**. His inference was based on incredibly accurate planetary observations collected over 30 years by his teacher, Tycho Brahe (pronounced Bray).

Invention of the telescope

In 1610 Galileo built a telescope using lenses, and observed the surface of the Moon for the first time. He saw mountains, craters and large flat plains. He also observed the planets Mars, Venus and Jupiter, and discovered that they were round and disc-like, unlike stars, which were just points of light in the sky.

When observing Jupiter, Galileo also noticed four moons revolving around the planet. He used these observations to support the inference that the Sun was at the centre of the solar system.

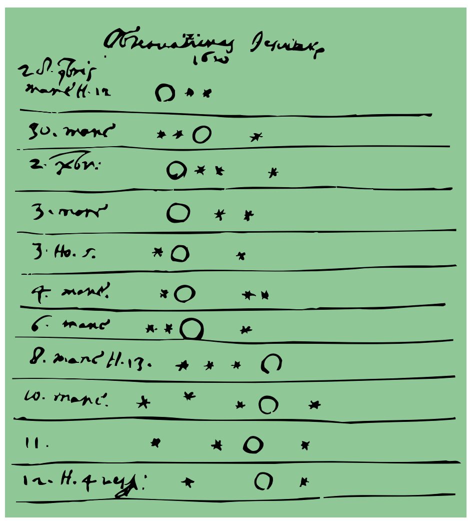


Fig 5 Some of Galileo's observations of the moons of Jupiter. The date is on the left and the moons that were visible on each night are marked beside Jupiter (the circle).

Hints and tips

Galileo Galilei is generally remembered for building the telescope, which was an improvement on the spyglass. Galileo's life is very interesting and he was accused of being a heretic. The inquisition arrested Galileo, but because of his poor health he was put under house arrest. Bring some articles in for the students to investigate why he was arrested.

Learning experience: make a telescope

Each group will need two convex lenses. (Note: one of the convex lenses needs to have a long focal length, 200–300 mm, and the eyepiece lens a shorter focal length, about 50 mm.) They will also need two cardboard tubes (one slightly larger in diameter than the other) and small pieces of Blu-tack to hold the lenses in place.

Place a lens at the end of each tube. Then insert the small tube inside the larger tube, using some foam for packing if necessary, and ensure that the centres of the two lenses are in line. There should be a lens at each end of the 'telescope'. Focus the telescope by sliding the smaller tube in and out until an image can be seen through the eyepiece lens. With a 300 mm convex lens, students will see the image upside down and magnified about six times.

Hints and tips

Draw a table on the board listing the planets in order, starting with those closest to the Sun. Next to each planet, write down who discovered it and when. This table could be added to throughout the chapter to include relevant data about each planet.

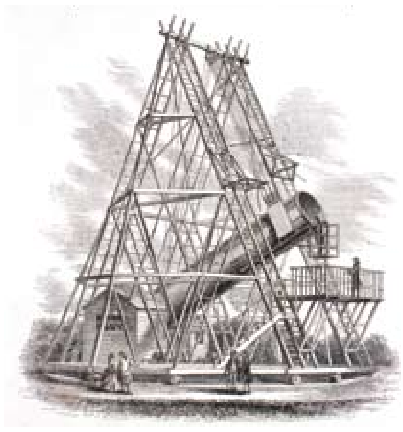
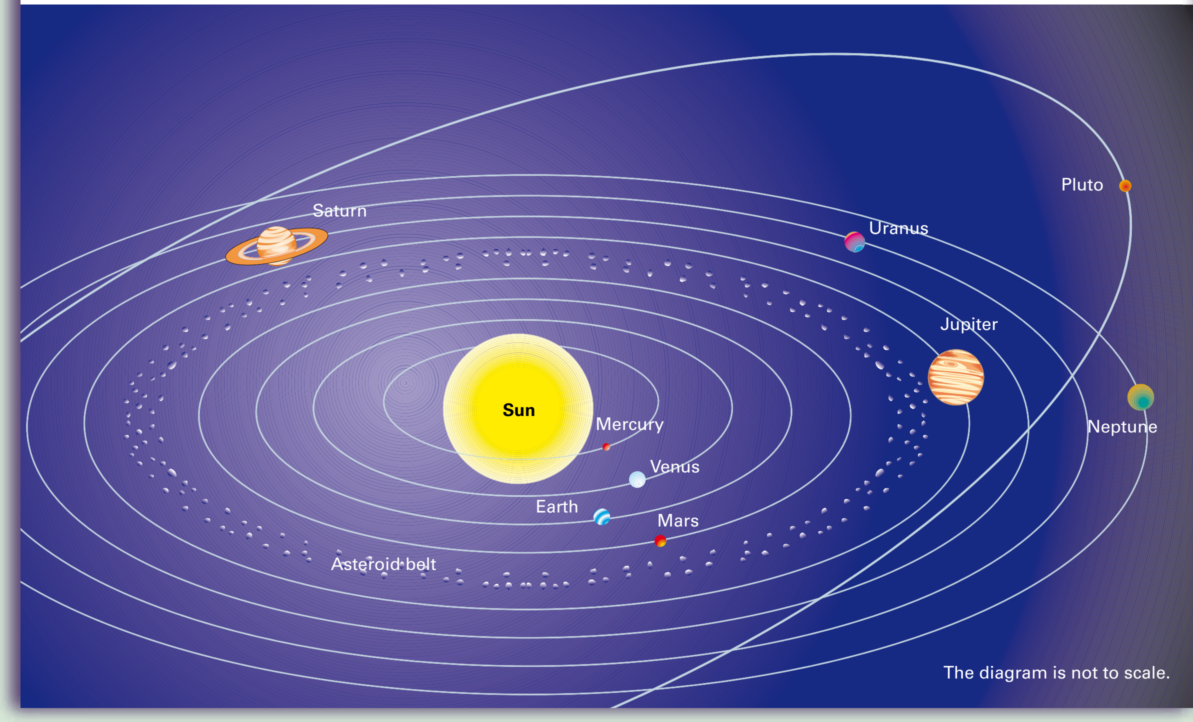


Fig 6 William Herschel's telescope used in the discovery of Uranus in 1781.

After Galileo's small telescope, larger and more powerful telescopes were built to scan the night sky. In 1781 William Herschel discovered the planet Uranus using a very large telescope. In the early 1800s astronomers observed unusual changes in Uranus' movements and inferred that they were caused by an unknown planet. After many years of careful observation, the new planet's position in the sky was predicted by English and French astronomers. Then in 1846 the new planet was discovered by the German astronomer, Johann Galle. It was called Neptune.

The American astronomer Percival Lowell had predicted the presence of a ninth planet in 1905. However, it was difficult to observe with a telescope because it was so far away from Earth. Eventually Pluto's existence was confirmed when it was observed in 1930 using newly invented photographic methods. It is now classified as a *dwarf planet*.

Fig 7 The arrangement of the planets in the solar system. The planets revolve around the Sun in orbits that are roughly in the same plane. However Pluto's orbit is tilted and crosses the orbit of Neptune. It is in the Kuiper Belt, with at least 70 000 other small icy bodies.



Homework

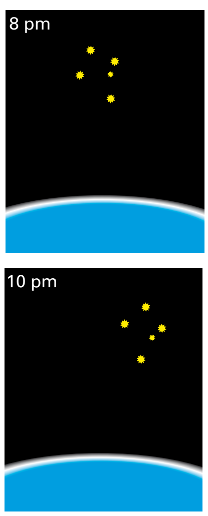
Have students choose an important astronomer and research their contributions to science. They should then think about how important their contributions were to the development of our understanding of the solar system and the universe.

Learning experience

Add the inventions and discoveries on pages 116–117 to the timelines created by groups in the previous learning experience on page 116.

Check!

1. How does the ancient Egyptian model for the universe differ from that of the Babylonians?
2. Ptolemy's ideas about the structure of the solar system are based on an incorrect inference about the movement of the Sun, Moon and planets. What is this inference?
3. In the late 1600s people began to accept a new idea about the arrangement of the solar system. What was this new idea?
4. What is an orbit? What general shape is it? What is so unusual about the orbit of Pluto?
5. Which planets cannot be seen with the naked eye? When was each one discovered?
6. The word 'planet' comes from the Greek word meaning 'wanderer'? Suggest why this is a good term to describe these bodies in space.
7. Suggest why it took so long to discover the dwarf planet Pluto.
8. Suppose you were observing the stars in the Southern Cross one clear night. You recorded the position of the stars and the time. Two hours later you observed the Southern Cross again and recorded its position.
   Make an inference to account for the difference in the observations.



challenge

1. Look at Fig 5 on page 117. This is Galileo's record of his observations of the moons around Jupiter.
   - **a** On the night of the 10th he observed four moons, but on other nights he observed three and sometimes two.
     Make an inference to account for the differences in these observations.
   - **b** Over how many nights did Galileo make observations? What assumptions did you make to answer this question?
2. Galileo observed four moons orbiting Jupiter. In 1908 astronomers recorded seeing the eighth moon. Today, astronomers have 'seen' 63 moons, some of which are only 20 km in diameter.
   From 1610, it took 300 years to find four more moons, and from that date only 90 years to find another 57.
   - **a** Suggest why this occurred.
   - **b** Do you think that astronomers have actually 'seen' the smaller moons of Jupiter? Give reasons for your answer.
3. Below is a 14th century woodcut of Ptolemy's map of the universe. The names are written in Latin.
   - **a** What is at the centre of the universe?
   - **b** The first seven circles represent the objects in the solar system. What are the English names for these seven objects? Name them in order from closest to furthest.
   - **c** What do you think is represented by the outer three circles?

Check! solutions

1 The Egyptians thought that the sky was the body of a goddess with stars as tiny jewels and that the planets were shiny boats which drifted about. The Babylonians, on the other hand, thought that the Earth was the centre of a huge sphere with the Sun, Moon and planets moving around the Earth.

2 The Greek astronomer Ptolemy made the incorrect inference that the planet Earth was at the centre of the solar system and that the Sun and stars revolved around it.

3 The new idea which was proposed by Johannes Kepler was that the Sun was at the centre and the planets moved around it in elliptical orbits.

4 An orbit is the path followed by a planet as it revolves around the Sun. Its general shape is not circular but egg-shaped or elliptical. The orbit of Pluto is unusual because it cuts across the orbit of Neptune and is actually closer to the Sun than Neptune for some of the time.

5 There are three planets which cannot be seen with the naked eye and can be seen only with a telescope. They are Uranus, which was discovered by William Herschel in 1781; Neptune, which was discovered by John Galle in 1846; and Pluto, which was first predicted and then discovered by the Lowell Observatory in 1910.

6 The ancient Greeks used the word 'planet' because they appeared to wander about when observed on different nights of the year. Stars, on the other hand, appeared to be in the same places.

7 It took so long to discover Pluto because it is so small and so far away. It was only discovered using newly invented photographic techniques.

8 The inference is that the apparent movement of stars is due to the rotation of the Earth. In this case we can also infer that the Earth has rotated about 30 degrees from right to left.

Challenge solutions

1 a An inference to explain Galileo's observations is that there are at least four moons but that sometimes one or more of these moons are behind Jupiter and cannot be seen.

b It seems that Galileo made his observations over 15 nights. His writing is a bit hard to understand and you need to assume that the first number is 28 and the month has 30 days.

2 a The reason this occurred is that the moons are only visible with improved telescopes and spacecraft.

b It is likely that not all of these moons have actually been seen by astronomers. Images of the moons have been recorded by computers using other types of telescopes.

3 a The centre of the woodcut is the planet Earth.

b The English names in order from the centre are Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn.

c The outer circles represent various stars and groups of stars.

6.2 Exploring the solar system

Look back at the diagram of the solar system on page 118 showing the planets orbiting a central sun. We know at present that there are eight planets in our solar system, plus the dwarf planet Pluto.

Mercury, **V**enus, **E**arth, **M**ars, **J**upiter, **S**aturn, **U**ranus, **N**eptune and **P**luto

The planets are usually divided into two groups: the *inner planets* and the *outer planets*.

Inner planets

These are sometimes called the rocky planets and include Mercury, Venus, Earth and Mars. They are the ones closest to the Sun, they have rocky surfaces and are all relatively small.

Outer planets

The outer planets, Jupiter, Saturn, Uranus and Neptune, are giant planets and are often called the gas planets. They consist mainly of the gases hydrogen, helium and methane. However, these planets are so cold that the gases are compressed to a liquid or solid state. Pluto ia s dwarf planet found out in the fringes of the solar system beyond the gas planets, in the Kuiper Belt.

You can use the following memory jingle (or mnemonic) to help you remember the order of the planets.

My **V**ery **E**asy **M**emory **J**ingle **S**eems **U**seful **N**aming **P**lanets

The two groups of planets are separated by hundreds of thousands of tiny chunks of metallic rock called **asteroids**. They orbit the sun between Mars and Jupiter in what is called the *asteroid belt*. There are so many asteroids in this belt that there is always a danger of collision for passing spacecraft.

Most planets have a layer of gas, called an **atmosphere**, covering them. The inner planets have a relatively thin atmosphere, while the gas planets have a much thicker atmosphere. Earth's atmosphere is a mixture of nitrogen and oxygen and smaller amounts of carbon dioxide and water vapour. Jupiter's thick atmosphere, on the other hand, consists mainly of hydrogen and helium.

The gases in the atmosphere are held close to a planet by its gravity. On a large planet like Jupiter, where the gravity is 2.6 times greater than on Earth, the lightest gases (hydrogen and helium) are held in the atmosphere. On Earth, however, these gases escape into space. Mercury is so small and hot that it has no atmosphere at all.

Fig 12 Mercury is the second smallest planet in the solar system after Pluto, and is closest to the sun. Like our Moon, much of its surface is covered by impact craters.

Learning experience

Place some detailed information sheets about the planets around the room. Get the students to design a series of information cards or write a ten-point summary about each planet. Then ask each student to recite one of their points to the class (a different point for each student).

Learning experience

Ask students to work out their own memory jingle (mnemonic) to help them to remember the eight planets (without Pluto).

Learning experience: life on another planet

Using research and their knowledge of the planets, ask students to write a story about life on a particular planet. They should imagine they live on the chosen planet. They will need to describe what they look like and why. What do they wear? What do they eat? They should also say what they do on a normal day, and describe their environment and atmospheric conditions.

Ask students to be as creative as possible but make sure they also use factual information they have found in their research. Diagrams can also be used and are useful for those students who find it difficult to explain things in text.

This creative writing task can be conducted in groups. Students could enact their story in front of the class or present it individually as a Word document or PowerPoint presentation.

The inner planets

The Earth's two neighbours, Venus and Mars, have been the most observed and studied of all the planets in the solar system. In the next 20 years many spacecraft will land on Mars' surface and gather information for a possible human landing. Venus, on the other hand, has a very thick, acidic atmosphere and may be unsuitable for a human landing.

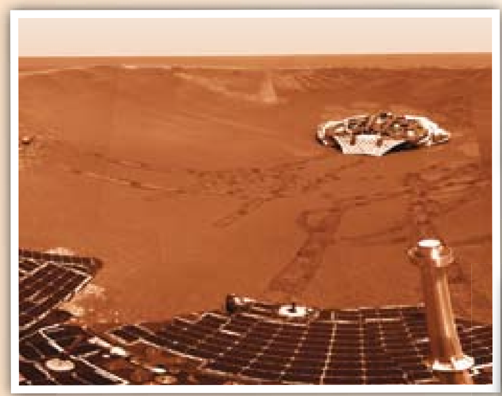


Fig 13 The Mars Exploration Rovers *Spirit* and *Opportunity* landed on Mars in 2004 and have sent thousands of high-quality images back to Earth.

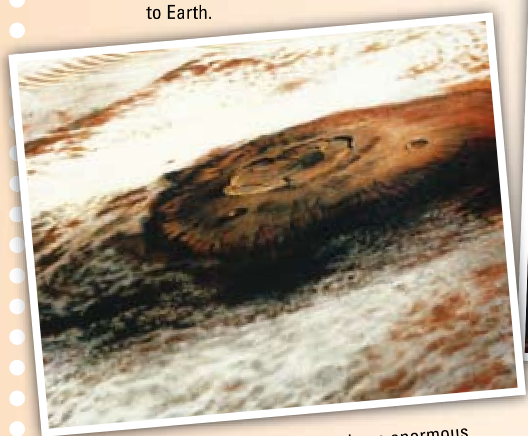


Fig 14 Olympus Mons on Mars is an enormous volcano 600 km across.

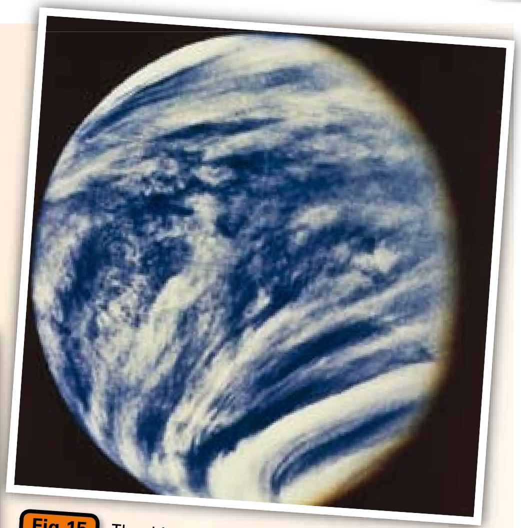


Fig 15 The thick clouds of Venus' atmosphere can be seen swirling around the planet.

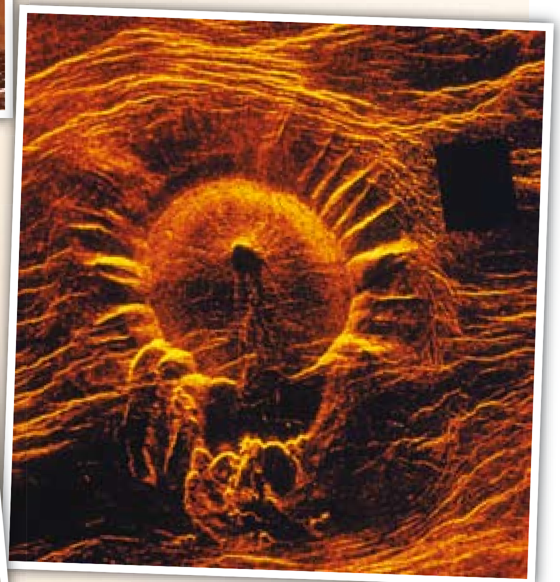


Fig 16 The Tick volcano on Venus is 66 km across and has radiating ridges on the sides. The rim at the bottom seems to have been broken by a dark lava flow.

Learning experience

There are many videos available in schools or libraries that can be used to reinforce the students' learning about the planets.

You will find that many students already have a good knowledge of the planets; they may have done posters or research in previous years. This may be a good opportunity to ask students to teach others what they already know. Allow students to take turns being the teacher for a few minutes of the lesson and let them pass on their knowledge.

Learning experience: quiz

Students enjoy quizzes and they can be a good way to gauge how much the class knows about a topic. Design and implement a 'Who wants to be a millionaire?' or 'What am I?' quiz to test the students' knowledge of the topic. Set a time limit for the quiz. Although these types of quizzes generally are based on knowledge, try to come up with some higher-order thinking questions for bonus points. An extension activity may be used for students to develop their own quiz.

The outer planets

Each of the four outer gas planets has a feature that makes it different from the other planets. Jupiter is the giant planet and is over twice as heavy as *all* the other planets put together. Saturn has distinctive rings around it. Uranus is a pale green-blue colour and has faint rings. Its axis of rotation is nearly at right angles to the other planets, which means that the planet is lying on its side. Neptune is also a green colour, but its most striking feature is its Great Dark Spot.

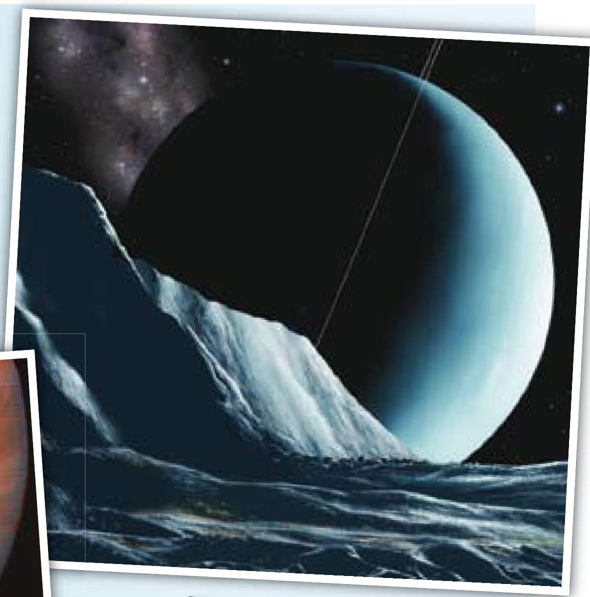


Fig 17 An artist's impression of Uranus with its faint rings from one of its moons (Miranda) in the foreground.

Fig 18 Jupiter's Great Red Spot photographed from a distance of 21 million km. Io, one of Jupiter's moons, can be seentop right.

Fig 19 A composite view of Saturn and six of its moons. The photos were taken by the *Voyager II* spacecraft in 1980.

Learning experience

Challenge the students to design an astronomy board game. For the less creative students suggest they make a *Trivial Pursuit* style game. This exercise works well with groups of about three students.

Learning experience: make a model solar system

Divide the class into eight groups and allocate each a planet. Each group will create a papier mâché planet. To do this you will require balloons of varying sizes, old newspapers, flour (add water to make glue) and ice-cream containers. This does get messy, so make sure students are wearing their lab coats.

As a class, discuss the relative sizes of the planets and come up with a table of dimensions for each of the model planets. Students will need to research the planet's colouring, number of moons, planetary rings, surface features etc.

When groups have completed their planets, they can be suspended from the ceiling, forming a mini solar system at scaled distances away from each other.

What is a planet?

The discovery of Pluto

After the 1846 discovery of Neptune, astronomers were expecting to find another planet beyond Neptune. However, even after 60 years of searching, no new planet was found. The unknown planet was called 'Planet O', and was actually photographed in 1919 but not noticed because it was smaller than astronomers had expected.

In February 1930, the American astronomer Clyde Tombaugh identified a new planet in photographs taken a month earlier. The new planet was called Pluto after the Roman god of the dead and ruler of the underworld.

Is Pluto a planet?

Astronomers discovered two very odd things about Pluto's orbit. Firstly, all the other planets orbit the sun in approximately the same plane. Pluto's orbit, however, is inclined at 17° to that plane. Secondly, Pluto's orbit is much more elliptical than the orbits of the other planets, and actually overlaps Neptune's orbit.

But is Pluto a planet? Pluto is 6 times smaller than Earth and also smaller than our moon. Pluto's moon Charon, discovered in 1978, is larger in proportion to its planet than any other in our solar system.

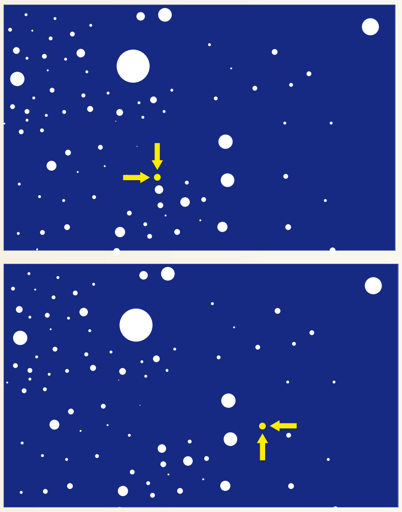


Fig 20 Photos taken on 23 January 1930 (top) and 29 January 1930 show how Pluto had moved relative to the stars.

Pluto was always thought to be a planet until the mid 1990s when hundreds of Pluto-like objects were discovered in a region beyond Neptune known as the Kuiper Belt (see the next page). Many of these objects are greater than 100 km in diameter. So in August 2006 astronomers decided to reclassify Pluto as a dwarf planet.

The day our solar system got bigger

In early January 2005, Mike Brown from the Californian Institute of Technology was analysing photographs of objects in the far reaches of the solar system when he found a planet-like object. Further analysis showed that this 'planet' is larger than Pluto and is about 97 times further from the Sun than Earth.

This Kuiper Belt object is called Eris, the largest of the dwarf planets. It has an odd elliptical orbit like Pluto's, but its exact size is unknown at present. It is very bright, but its greyish surface colour may reflect more light than Pluto's reddish surface.

Then in September 2005, other astronomers discovered a moon around Eris.

An artist's impression of Eris with our Sun in the distance

Hints and tips

Eris (previously known as 2003 UB313) has a diameter of about 2400 km, compared with Pluto's 2274 km.

Learning experience

Ask the students to come up with their own definition of a planet, writing their responses in dot-point form.

Homework

Theories about the formation of the universe are discussed in *ScienceWorld 2*. However, you might like to ask students to research ideas about the formation of the solar system while working on this chapter. Ask students to research the Big Bang theory and then explain in their own words how the planets and our solar system formed. Ask them to research other theories that explain how the solar system formed and continues to exist.

science bits

The Kuiper Belt

In the early 1990s astronomers began discovering many objects in space beyond Neptune. These objects were found in a band orbiting the sun.

The band was named the Kuiper Belt after the Dutch-American astronomer Gerard Kuiper (pronounced KY-per). He had suggested in the 1950s that comets and asteroid-like matter existed beyond Neptune.

Kuiper's hypothesis

Using the results of astronomical investigations, Kuiper hypothesised that when the planets were forming, strong gravitational forces swept up all the matter and formed the planets as we know them. In the region beyond Neptune, the gravitational forces were weaker and there should be lots of smaller bodies including comets.

In the late 1990s, using terrestrial and space telescopes, astronomers found many Kuiper Belt Objects. These observations supported Kuiper's hypothesis.

Questions

1 Explain in your own words why astronomers thought there might be many objects beyond Neptune.
2 Do you think Pluto should be called a dwarf planet rather than the ninth planet? Give reasons for your opinion.
3 Suggest why Gerard Kuiper did not actually observe any Kuiper Belt Objects.

WEBwatch

Go to www.scienceworld.net.au and follow the links to the website below.

The Kuiper Belt and Oort Cloud

You can also search the internet under *Kuiper Belt*.

Missions in space

The very first spacecraft, an artificial satellite called *Sputnik 1*, was launched by the then USSR in 1957. Since then spacecraft have landed on our Moon, and the planets Venus and Mars. They have also flown close to and photographed all the planets and their moons in the solar system except the dwarf planet Pluto.

The first major missions into space were two *Voyager* missions launched in 1977. They sent back an incredible amount of new information on Jupiter, Saturn, Uranus and Neptune. Prior to these missions it was thought that Jupiter had 13 moons; now more than 60 have been observed. Uranus was thought to have five moons but *Voyager 2* discovered another 10. The spacecraft also discovered rings around Uranus similar to, but much fainter than, those around Saturn. The cameras on board *Voyager* were able to send close-up images of Uranus' moon, Miranda, showing deep canyons. These cameras were so good that they could photograph a newspaper headline about one kilometre away!

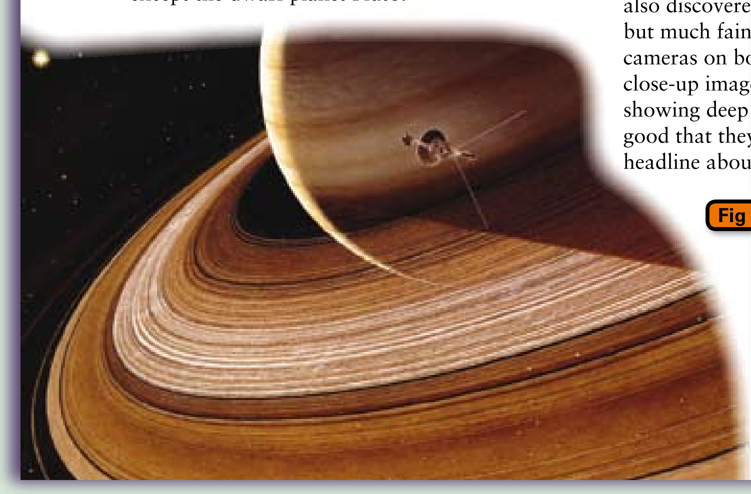


Fig 21 The *Voyager 2* spacecraft was launched in 1977. In 1979 it travelled past Jupiter, then past Saturn in 1981. Now 30 years later, it is passing the outer edge of the solar system and into the empty space beyond.

Homework

Have students research the incredible race that occurred in the 1960s when the USA and the USSR each tried to be the first nation to send a man into space and eventually land on the Moon. Students could produce a time line of these events and the later missions into space. Use the WebWatch on page 125 to help with this research.

Learning experience

Several space movies, for example *Apollo 13*, can be used to raise interest in space travel. Once students have seen the movie, ask them to write a synopsis of the movie or alternatively ask them to describe the scene that they enjoyed the most and explain why.

Many new products used in everyday life have resulted directly from space travel. Ask students to research some technologies, such as cordless drills, freeze-dried food, foil blankets (hypothermia blankets), pacemakers etc.

Getting information on space

Our knowledge about the solar system constantly changes as space missions reveal new information about planets and their moons. A very good source of up-to-date information is the internet. Newspapers, magazines and journals are another source.

To do the activities on the following two pages you will need current information about the planets and their moons, as well as about past, current and future space missions. The websites listed in the box below are just some of the many that are available, and many of these websites also have links to other sites.

You can find other websites using a search engine. For example, if you type in *Jupiter's moons*, a number of sites will be listed, of which some may be suitable.

When you write a report, make sure you list the websites you use. In this way, other people can check the accuracy of your information.

Helpful hints on units

Some of the technical information you will find on the websites below contains units that may be unfamiliar to you. Websites from the USA often use miles and miles per hour (mph). The conversions are listed below.

1 mile = 1.6 km

1 mph = 1.6 km/h

Some temperatures are given in the Fahrenheit (°F) scale. To convert degrees Fahrenheit to degrees Celsius, subtract 32 then multiply by 0.56. That is:

$$°C = (°F - 32) \times 0.56$$

Astronomers often use the Kelvin scale to measure temperatures. To convert Kelvin to degrees Celsius subtract 273.

$$°C = K - 273$$

WEBwatch

Go to www.scienceworld.net.au and follow the links to the websites below.

NASA Solar System Exploration
Current information on the planets as well as news, missions, science and technology reports.

NASA Human Spaceflight
Gives up-to-date information and news about the space shuttle, the International Space Station and other space missions.

Mars News
Information on past, current and future space missions to Mars.

The ~~Nine~~ Planets
A multimedia tour of the solar system. Good information on the planets and space missions.

Science@NASA Headline News
Excellent site for current news on space science and astronomy.

Voyager
Information on the *Voyager* missions and images of Jupiter, Saturn, Uranus and Neptune and their moons. Has an excellent Planetary Tour animated movie.

Windows to the Universe
Information on the planets, space missions, and myths about the planets and the universe. Has links to other sites.

Welcome to the planets
Profiles on the planets and a link to the planetary photojournal.

Solar system exploration
Has answers to questions on the planets, comets, asteroids and space missions.

Hints and tips

You could construct a half-page worksheet for students on converting lengths (miles to kilometres) and temperature (Fahrenheit to Celsius, and Kelvin to Celsius). It is worth briefly explaining the Kelvin temperature scale.

Learning experience

Develop a class space exploration scrapbook or noticeboard and ask students to collect articles, pictures and high-interest information. Add items throughout the unit and eventually make up collages for the room. Spend the first five minutes of each lesson discussing any articles or facts that were brought in by students.

Hints and tips

Some students may have problems drawing graphs. They may need support in determining the scale on each of the axes. Put students in pairs for this activity, and try to pair students who have developed good graphing skills with those who are still struggling.

Web links set up on **www.scienceworld.net.au** will save students time and give them some direction in finding information for their fact sheets.

Activity

In this activity you will work in a small group of three or four people to complete the tasks below.

You will need to use the library (including the internet) to find information on the solar system.

Task 1

Prepare a planetary facts sheet. The facts sheet should list the planets, their average distance from the sun, their diameter, the number of moons, the surface temperature, the composition of the atmosphere and any other interesting information.

Remember to list the names of the books, magazines, articles or websites you used to find your information.

Prepare a rough draft first, discuss it with your group, modify it where necessary, then prepare your final copy.

Working with technology Use a computer database such as Excel to make your facts sheet.

Task 2

Use the data to plot the following graphs.

Draw a bar graph to show the planets in order on the horizontal axis and the diameter of the planets on the vertical axis.

Draw a line graph to link the diameter of the planets (horizontal axis) and the number of moons around each planet (vertical axis).

Use the graphs to answer the following questions.

Write a generalisation linking the diameters of the planets with their distances from the Sun.

Write a generalisation linking the diameter of the planet with the number of moons.

Task 3

Compare the length of a day and the length of a year for each planet in the solar system. Record the information in a table.

What pattern can you see in the lengths of the years of the planets as you move away from the Sun?

Task 4

Gravity is the force of attraction between two bodies. It is this force which keeps you on the Earth, and it is the force that keeps planets and their moons in orbit.

The table below gives the mass of each planet and the gravity on the planet's surface, compared with Earth.

Planets	Mass (Compared with Earth = 1)	Gravity (Compared with Earth = 1)
Mercury	0.06	0.4
Venus	0.8	0.9
Earth	1	1
Mars	0.1	0.4
Jupiter	318	2.5
Saturn	95	1.1
Uranus	14.6	0.9
Neptune	17.0	1.1
Pluto	0.002	0.07

Write a generalisation about the mass of the planet and the gravity on its surface.

As the gravity decreases so does your weight. On which planets would your weight be less than on Earth?

Task 5

Find out about the origin of the names of the planets.

Choose any five planetary moons and find out about the origins of their names. You may also like to research the myths and legends of the solar system from different groups or cultures around the world.

Learning experience

With your students, explore reasons why the gravity of Uranus is less than Earth's gravity even though its mass is larger. This could be turned into a Think/Pair/Share activity*. This is a very good extension exercise for keen or gifted students. You may need to show them Newton's law of universal gravitation:

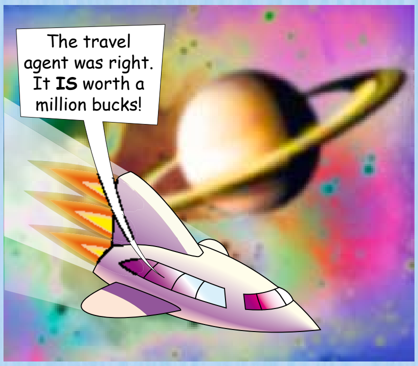
$$F = G\frac{m_1 m_2}{r^2}$$

Where F is the gravitational force between two objects with masses m_1 and m_2 separated by a distance r. G is the gravitational constant.

*A Think/Pair/Share activity is a technique used to encourage student participation in a non-threatening context. The students individually think about the posed question, discuss their answer with a partner and share their conclusion with the class.

Activity

The interplanetary travel agency
You are a travel agent with Interworld Travel who specialise in taking people to Mercury, Venus and Mars, and on flybys of Jupiter and Saturn.



Write an itinerary for tourists who wish to travel to these planets. Use the guidelines below to do this.

- Use library research to find out approximately how long it would take to reach each of the planets. (Your Space SuperBus travels at 200 000 km/h.)
- Write a brochure about the surface conditions of the planets. For those planets on which the tourists are to land, give information about the special equipment they need to wear or take with them.
- In your itinerary, write about some of the planetary features you think that the tourists would find interesting. You may think that some of the moons are also worth mentioning.
- Write a list of safety points (similar to a current airline safety list) which you think all passengers should know before they land on planets or moons.

Other objects in our solar system

Asteroids

In 1989 the spacecraft *Galileo* was launched to study the atmosphere of Jupiter and its moons. One year later it entered the Asteroid Belt and came close to the asteroid Gaspra.

Gaspra is a small asteroid about 19 km long. It is composed of rock and metal typical of most of the many other thousands of asteroids that are found orbiting the sun in a wide belt between Jupiter and Mars. About 100 000 asteroids are large enough to be seen from Earth. The largest is Ceres, which is 800 km in diameter, and is classified as a dwarf planet.

Fig 23 The 19 km long asteroid Gaspra photographed in 1991 by the spacecraft *Galileo* from a distance of 16 000 km.

Astronomers once thought that the asteroids may have formed from the collision of planets which shattered into small pieces. However, when added together, the mass of the asteroids is less than half the size of our moon. A more widely accepted idea is that they are debris left over after the formation of the planets billions of years ago.

WEBwatch

Search the internet under *Gaspra*. You will find many interesting Gaspra websites. Try searching *asteroid* to find out about other asteroids.

Activity note

Book the class into a computer room so they can produce their final draft of the assignment with a more professional presentation. Try to print the assignments on a colour printer. This way, students can add colourful graphics. Pair students on the computers; this will allow them to develop new ideas and new computer skills with their partner.

Hints and tips

See if any student knows what meteors or comets are and how they are different from asteroids. They may like to investigate what a 'shooting star' really is. You could develop a homework task around these astronomical objects.

Meteorites

The craters on many of the planets and moons in the solar system are caused by collisions with **meteorites**. These pieces of rock or iron vary in size from millimetres to thousands of kilometres in diameter. In space these objects are called *meteoroids* and in a planet's atmosphere they are called *meteors*. If they strike a planet they are called meteorites.

The atmosphere around a planet protects it from meteorite strikes. The Earth and Venus have fairly thick atmospheres and very few craters. Mercury, with an extremely thin atmosphere, has thousands of craters on its surface.

Comets

Other members of our solar system which we occasionally see in the sky are **comets**. These objects orbit the Sun in long, narrow elliptical orbits. They are thought to come from the Kuiper Belt, or even further out in the Oort Cloud. The most famous is Halley's comet which orbits the Sun every 76 years, but the Great Comet of 1864 will not come back for another 2.8 million years!

The core of a comet is made of rock and dust stuck together with ice and frozen gases such as ammonia and methane. The core is usually quite small—about 10 km in diameter—but when it approaches the Sun, the frozen gases warm up and evaporate. The light from the Sun hits the gases and is reflected, giving the comet a glowing tail sometimes millions of kilometres long. This tail always points away from the sun.

Sometimes comets collide with planets. In 1994 Comet Shoemaker-Levy 9 crashed into Jupiter. The core of this comet shattered into 20 fragments following a close approach of Jupiter in 1992. As each fragment hit the planet, it exploded in the atmosphere releasing an enormous amount of energy.

WEBwatch

Search the internet under *Comet Shoemaker-Levy*. You will find a number of websites with information, images and movies.

Fig 24 This photo shows the giant fireball that erupted when a fragment from Comet Shoemaker-Levy 9 hit Jupiter in 1994.

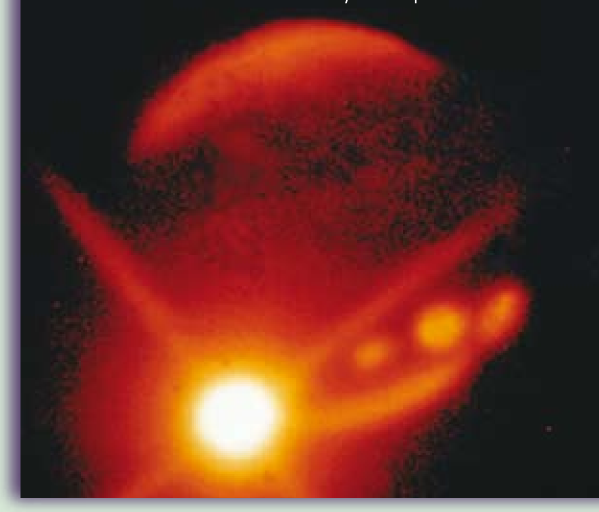


Fig 25 Halley's comet was photographed for the first time in 1910. It was last seen in 1986 and will be back in 2062. It was seen by Julius Caesar in 87 BC, Genghis Khan in 1222 and William Shakespeare in 1607.

Learning experience

Ask the students to investigate where on Earth (in particular Australia) meteorites have landed. What is the evidence for each, and how long ago do scientists believe the meteorite struck the Earth?

Learning experience: investigating craters

If students have not done this activity in previous years, now may be a good time to do so.

- Add sand or plaster of Paris powder to a shallow baking tray.
- Gently tap the tray on a bench to create a flat surface.
- Drop a marble, pebble or ball bearing into the sand or plaster powder from varying heights.
- Remove the marble with forceps. This avoids leaving any additional marks in the surface of the sand or plaster.
- Ask students what they have observed from this experiment and what conclusions or inferences they can make.

Check!

Use the information about the planets which you gathered for the activities on pages 126 and 127 to answer questions 1 to 9.

1 The planets can be divided into two main groups: the inner planets and the outer planets. Place the eight planets into these two groups.

2 Which is the smallest planet and which is the largest planet in the solar system?

3 Decide which of the following statements are true and which are false. Correct the false ones to make them true.
   a Saturn is between Jupiter and Neptune.
   b Venus is larger than Mercury but smaller than Uranus.
   c Mars takes about twice as long as Earth to orbit the Sun.
   d Some of the moons of Jupiter are larger than the dwarf planet Pluto.
   e The atmosphere of Venus contains hydrogen, methane and ammonia.

4 Which planet has the largest number of moons, and which have no moons at all?

5 On which planets have spacecraft landed? Why would it be difficult to land a spacecraft on Jupiter?

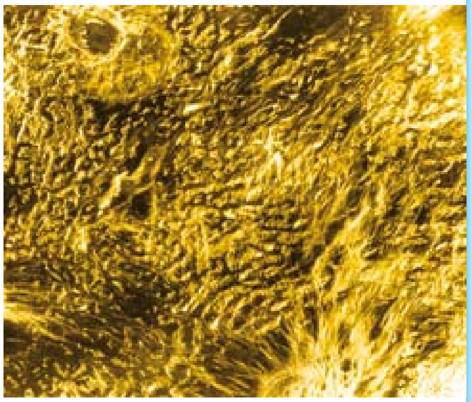
6 Suppose you are 13 years old on Earth. How old would you be in Jovian (Jupiter) years? How old would you be in Mercurian years?

7 Suggest why Pluto is now called a dwarf planet.

8 Most planets rotate from west to east, but one of our near neighbours rotates the other way. Which planet is it? In which direction would the Sun rise on this planet?

9 Which planet am I?
   a I am very hot. People think I am mysterious because of the clouds that cover my surface.
   b I am lying on my side with my south pole pointing towards the Sun.
   c I have a very large number of moons and small particles of rock and dust that form thousands of spectacular rings.
   d In 1976 a spacecraft landed on my surface, took soil samples and sent close-up television images back to Earth.
   e I am named after the Roman god of the sea because of my sea-green colour caused by the methane in my atmosphere.

10 The photo below shows a plains region on Venus. Apart from a few volcanoes, there are no major craters on the surface. Suggest why Venus has fewer craters than Mercury or Mars.



11 The gravity on Mars is about two-fifths that on Earth, while Jupiter's gravity is 2.5 times greater. How could the gravity affect humans and spacecraft?

12 Sir William Halley (1656–1742) used mathematics and his observations through telescopes to calculate the orbits of 24 comets, one of which is named after him. Use the data in the text and in the caption of Fig 25 on page 128 to find out whether Halley observed this comet in his lifetime. Was it Halley's comet that King Harold saw just before the Battle of Hastings in 1066? (Why did the English think comets were bad luck and the French think they were good luck?)

Check! solutions

1 The inner (or rocky) planets are Mercury, Venus, Earth and Mars. The outer (or gas) planets are Jupiter, Saturn, Uranus and Neptune. The dwarf planet Pluto does not fit this pattern very well.

2 The smallest planet in the solar system (other than Pluto) is Neptune and the largest planet is Jupiter.

3 a False. Saturn is positioned between Jupiter and **Uranus**.
   b True
   c True
   d True
   e False. The atmosphere of Venus contains **mainly carbon dioxide and sulphuric acid.**

4 The planet with the largest number of moons is Saturn with at least 18, and the planets with no moons are Mercury and Venus.

5 Spacecraft have landed on Venus and Mars. It would be very difficult to land a spacecraft on Jupiter because it is a 'gas' planet consisting of hydrogen and helium, and any spacecraft would simply disappear towards the centre of the planet.

6 A year on Jupiter is equal to 11.9 Earth years. A person who is 13 years old would be one year old on Jupiter. A year on Mercury is only 88 days so the same person would be 53 years old on Mercury.

7 Pluto is unusual because it is much smaller than the other planets. It also has a much more elliptical orbit which is inclined at about 170 degrees to the plane of the orbits of the other planets.

8 The planet which rotates in the 'wrong' direction is Venus and the Sun would rise in the west rather than the east.

9 a Venus
   b Uranus
   c Saturn
   d Mars
   e Neptune

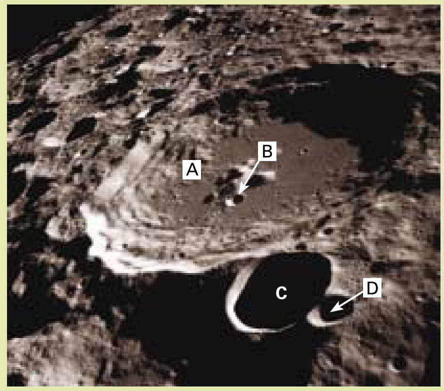
10 The most likely reason is that the planet Venus has much more atmosphere than Mercury or Mars. As meteors pass through the atmosphere, the friction causes heat which burns them up before they reach the surface of the planet as meteorites.

11 Humans and spacecraft will weigh about two-fifths as much on Mars and 2.6 times as much on Jupiter as on Earth. On Mercury the lower gravity would allow you to float in the air as you walked. On Jupiter you might develop back and muscle problems.

12 Yes, Sir William Halley did see the comet during its visit in 1683. It was not Halley's comet that King Harold saw in 1066. Since then the English people have considered comets to be bad luck probably because they lost the Battle of Hastings, and the French have considered them to be good luck because they won the Battle of Hastings!

challenge

1 The photo below shows a number of meteorite craters. Four of these are labelled A, B, C and D.



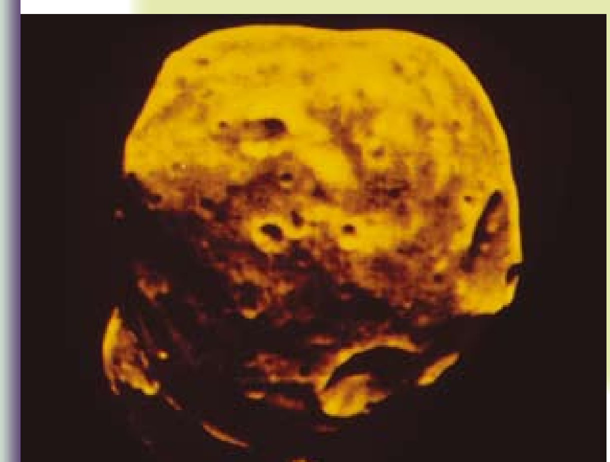
a Which crater was caused by the largest meteorite?

b Infer which is the oldest crater. Give reasons for your inference.

2 The two moons of Mars—Deimos and Phobos—both have an irregular shape and are composed of a rocky material which is quite different from the material on the surface of Mars.

Both moons are quite small. Deimos has a diameter of 12 km, while Phobos (below) is 23 km across.

a What is the origin of the names Deimos and Phobos? Suggest why the moons were given these names.



b Astronomers think that both moons were asteroids that came close to Mars and were captured by Mars' gravity. What evidence may have led to this inference?

3 The table below shows information about 17 of the currently known moons of Jupiter.

a Can you identify the four groups of Jovian moons? Write a description for each of the four groups of moons.

b Is there a relationship between the size of the moon and the date of discovery? Write a generalisation for this.

c Compare the sizes of the largest moons of Jupiter with the three smallest planets in the solar system.

Some of the moons of Jupiter

Moon	Discoverer	Diameter (km)	Distance from Jupiter (km)
Metis	*Voyager*, 1979	49	127 600
Adrastea	*Voyager*, 1979	35	134 000
Amalthea	Barnard, 1892	166	181 300
Thebe	*Voyager*, 1979	75	222 000
Io	Galileo, 1610	3632	421 600
Europa	Galileo, 1610	3126	670 900
Ganymede	Galileo, 1610	5276	1.1 million
Callisto	Galileo, 1610	4820	1.9 million
Leda	Kowal, 1974	8	11.1 million
Himalia	Perrine, 1904	170	11.5 million
Lysithea	Nicholson, 1938	19	11.7 million
Elara	Perrine, 1905	80	11.7 million
Ananke	Nicholson, 1951	17	20.7 million
Carme	Nicholson, 1938	24	22.4 million
Pasiphae	Melotta, 1908	27	23.3 million
Sinope	Melotta, 1914	21	23.7 million
Callirrhoe	Spacewatch, 1999	5	24 million

WEBwatch

Go to www.scienceworld.net.au and follow the links to the website below.

Jupiter: Moons

Contains information about Jupiter's known moons and links to other websites.

Challenge solutions

1 a The crater caused by the largest meteorite is the one labelled A because it is the largest.

b A is the oldest crater because B has been formed inside of it. It also appears that C is younger than A because it is formed on the top of its rim. However, it is difficult to tell if B is more recent than D.

2 a The name Mars was given because it is the name of the Roman god of war. The planet's two moons were given suitable names to go with war—Phobos meaning 'fear' and Deimos meaning 'terror'.

b Both moons are an irregular shape, which suggests that they were not formed by cooling. They are also composed of quite different materials from the planet Mars.

3 a The four groups of Jovian moons are:

i those that are very small and closest to the planet

ii the Galilean moons, which are the largest and were discovered in 1610

iii those that are approximately 11–12 million kilometres from the planet

iv those that are relatively small and over 20 million kilometres from the planet.

b Generally it is true to say that the smaller the moons, the later they were discovered. This is because of better telescopes and the use of space probes.

c The largest moons of Jupiter measure 5276 km, 4820 km, 3632 km and 3126 km in diameter respectively. The smallest planets are Pluto (2200 km), Mercury (4900 km) and Mars (6800 km). There are four moons bigger than the smallest planet and one moon bigger than the two smallest planets.

6.3 Stars and galaxies

The few thousand stars which you can see with your eyes belong to our **galaxy** called the *Milky Way*. It contains more than 100 000 million stars, but it is just one of millions of galaxies in the universe. A galaxy is a collection of stars and dust held together by huge gravitational forces. Galaxies are separated from each other by vast regions of space.

Until the turn of the 20th century, the Milky Way was thought to be the whole universe. A giant spiral called Andromeda, which can be observed with a small telescope, was thought to be in the Milky Way. However, in 1923 the American astronomer Edwin Hubble showed that Andromeda was in fact another galaxy about 2.2 million light-years away, well outside our own galaxy. Hubble's discovery encouraged other astronomers to search for galaxies and now more than 100 million have been identified!

Star distances

The distance to our closest star, the Sun, is 150 000 000 km. (It would take about 3 months to reach the sun if you travelled in a current spacecraft.) The next closest star is 41 000 000 000 000 km away, or 270 000 times the distance to the sun.

The distances to the stars are enormous, and the numbers are far too large to measure in kilometres. Instead, a unit of distance called the **light-year** is used. This is the distance light travels in one year.

Light travels at about 300 000 000 metres per second (3×10^8 m/s), so in one year light travels about 9 500 000 000 000 km or 9.5×10^{12} km.

When you look at stars you actually look back in time. The light from the closest star in the Southern Cross left that star 220 years ago. In other words, you are seeing the star as it used to be in the 1780s!

Fig 31 This spiral galaxy is similar in shape to our Milky Way galaxy and the Andromeda spiral. Over half the galaxies in the known universe are spirals.

Galaxies can be classified into three main types—*spiral*, *elliptical* and *irregular*. There are three galaxies that we can see easily from Earth—the Andromeda spiral and two irregular galaxies called the Large and Small Clouds of Magellan near the Southern Cross.

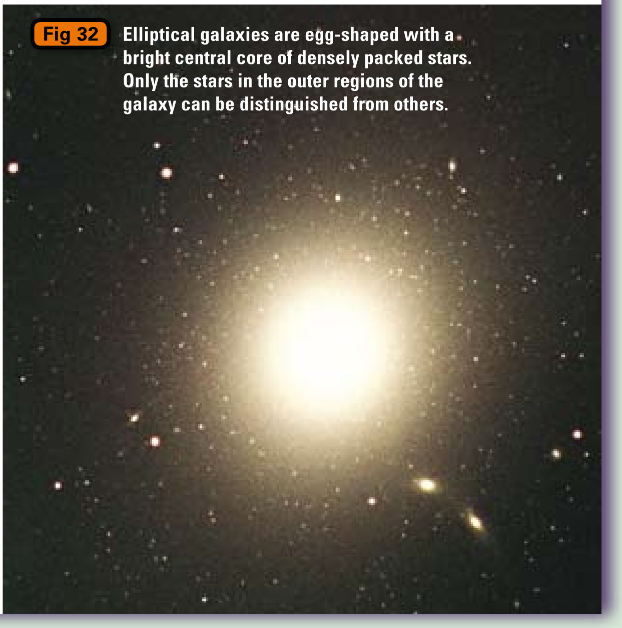


Fig 32 Elliptical galaxies are egg-shaped with a bright central core of densely packed stars. Only the stars in the outer regions of the galaxy can be distinguished from others.

Learning experience

If your school has access to telescopes, why not organise a star search evening? Set the telescopes up on the school oval and watch the sky at night. Invite parents and have a sausage sizzle. If you don't feel confident running the event and pointing out stars, satellites and planets in the night sky, find an expert. Call your local university or observatory. They are always willing to share their knowledge and help schools.

Some universities and observatories offer a star lab dome that can be set up at your school at a small cost to the students. This dome allows students to sit inside and see the night sky. The convener or facilitator will target the lesson to the teacher's needs. This is a great experience and students will find themselves lost in the night sky. The star lab dome is probably a better alternative for city schools as it is sometimes difficult to see the full night sky due to the glow of the city lights.

Learning experience: light-year

Students often think a light-year is a time measurement. Reinforce that it is an astronomical unit of distance.

To help the students comprehend just how fast light travels, measure out a distance of about 15 metres and see if they can run the length in one second. Now ask them to imagine running the length of a sports field in one second, and so on. Very soon they will realise just how fast light travels!

Fig 33 Irregular galaxies have no definite shape and appear as fuzzy clouds. They are the least common and make up only three per cent of all known galaxies.

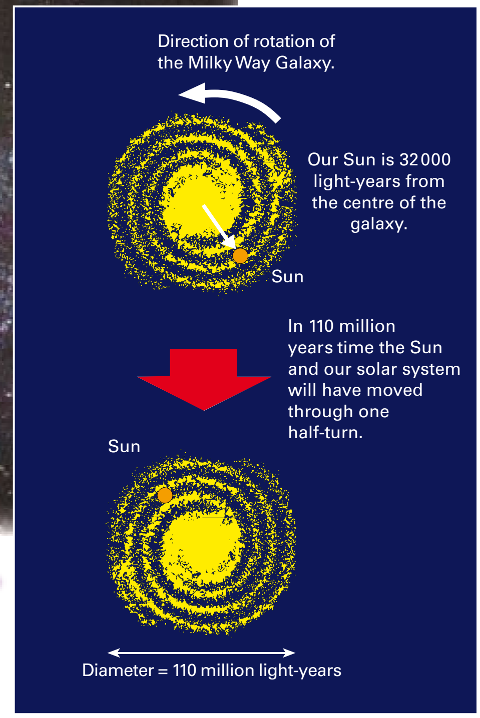


Fig 34 The Milky Way rotates slowly about its centre. This view of the Milky Way was produced from data gathered by a satellite orbiting the Earth.

Assessment task

Assessment task 6: an astronomical survey, found on the CD, could be set any time in this section.

WEBwatch

Go to www.scienceworld.net.au and follow the links to the websites below.

The Anglo-Australian Observatory

Good images and information about stars and galaxies.

Search *galaxies* or *Andromeda galaxy* in your internet search engine. You will find a number of websites with information, images and movies.

The Milky Way galaxy

The Milky Way galaxy is a flat spiral shape and the 'milky' band appearance is due to the fact that you are looking through the central part of the spiral which contains the most stars. The areas to the side of the band have very few stars.

The Milky Way has a diameter of about 110 000 light-years, which is smaller than our neighbouring spiral, Andromeda. Our Sun lies on one of the arms of the spiral, about 32 000 light-years from the centre. The spiral rotates about its centre in space like a Catherine wheel firework.

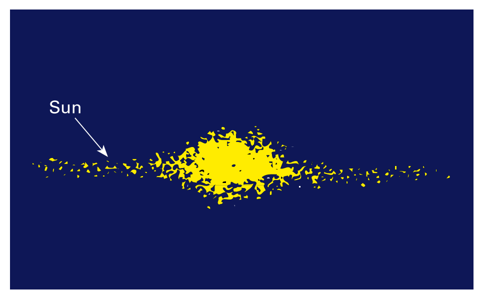


Fig 35 A side view of our Milky Way galaxy as seen from space. Notice that most of the stars in the galaxy are concentrated in the centre.

Homework

Ask students to research the names and shapes of other galaxies.

Learning experience

Ask the students to write a song or poem describing the Milky Way galaxy. (Maybe you could reward the students with *Milky Way* chocolate bars.)

The life of stars

In the summer of the year 1054, Chinese astronomers recorded seeing a bright star appear in the sky. It was so bright that it could be seen during the day. What these astronomers had recorded was a **supernova**—a spectacular explosion which ended the life of a giant, hot star.

The birth of a star

Astronomers believe that stars are born in clouds of gas (mainly hydrogen) and dust that occur throughout the universe.

Sometimes a gas cloud collapses on itself, becoming hotter and denser as the gravitational force increases. This is the stage in the life of a star known as a *protostar*. Eventually the gas becomes hot enough to start nuclear reactions and the star begins to glow.

Middle age

When a star about the size of our Sun forms, it initially glows very brightly. After about 10 million years, the star settles down to a long stable middle-life period of about 10 billion years.

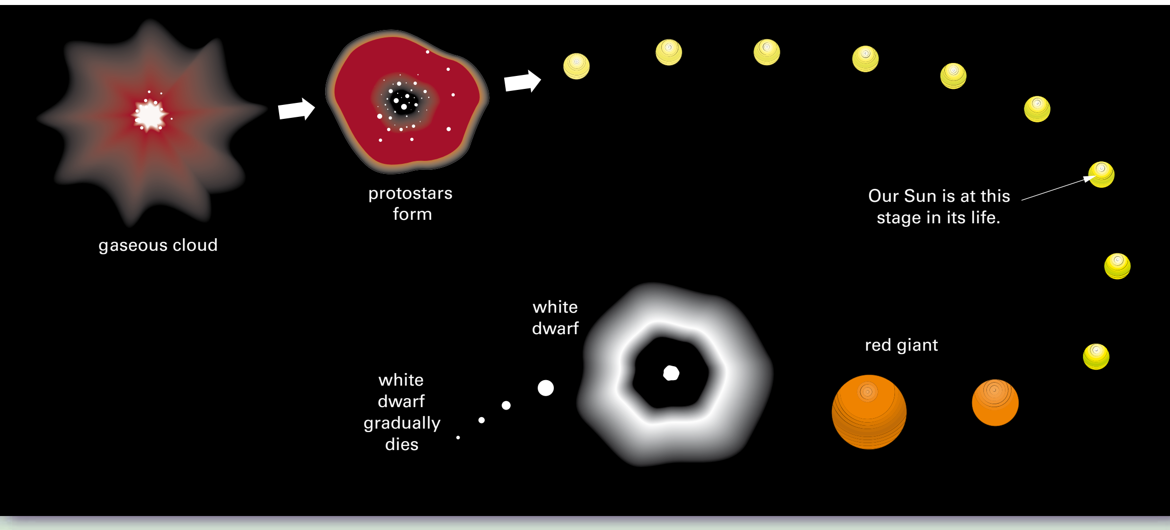
Our sun is now at midlife and has another 5 billion years to go before it runs out of fuel.

Fig 36 A **nebula** is a huge expanding cloud made up of dust and gases formed in a supernova. The Crab Nebula resulted from a supernova recorded by Chinese astronomers in 1054.

Old age and death

When all the hydrogen fuel is used up, the outer layers of the star expand and cool, and the star forms a *red giant*. After this, the gases in the outer regions drift into space and the remaining gases collapse into a very small, very dense object known as a *white dwarf*. Eventually the white dwarf cools down and fades away leaving a mass of gases in space.

Fig 37 The birth and death of a star similar in size to our Sun. Our Sun is in the middle of a stable period in its life and will last for another 5 billion years.



Hints and tips

If our Sun is a star, does this mean all other stars have solar systems as well? Explore this idea with the students. Get the students to generate lists of questions which would need to be investigated before arriving at any conclusion.

Research

Ask students to find out what a constellation is and name some constellations that can be seen in the Southern Hemisphere.

Learning experience

Construct planispheres (star charts) with the students and show them how to use them. Get the students to determine the position of the Southern Cross (Crux) at a set time and to then identify it in the night sky using the planisphere.

Activity

Up to the end of the 20th century the furthest humans had travelled in space was to the moon, a short 110 hours by rocket! Is it possible to travel further into space?

Work in a small group and discuss the following questions. You will need to refer to the table and you may need to use information in the websites listed below.

- Using present technology, which destination could be the furthest a human might reach?
- Suggest why humans would want to visit other planets in our solar system. Is it practical for humans to visit the gas planets?
- Could a planetary system exist around Alpha Centauri, our nearest star? Why would a planetary system be difficult for astronomers to detect?
- If aliens do exist, which planet or star system do you think they would come from?
- Is it possible for one of today's space-craft to travel to our closest galaxy, Andromeda? How could it be made possible? (Creative ideas needed here!)
- Develop an argument for (or against) spending millions of dollars on space research and travel. Could the money be better spent on getting rid of poverty?

Destination from Earth	Using current spacecraft (40 000 km/h)	At light speed (300 000 km/s)
Venus	1.4 months	2.3 minutes
Mars	2.6 months	4.4 minutes
Jupiter	22 months	35 minutes
Uranus	7.8 years	2.5 hours
Pluto	16.4 years	5.5 hours
Alpha Centauri	113 600 years	4.3 years
Crab Nebula	176 million years	6 500 years
Andromeda	6×10^{10} years	2.2 million years

WEBwatch

Go to www.scienceworld.net.au and follow the links to the websites below.

Space Travel Guide
Detailed information about types of rocket propulsion, space shuttle and future space travel.

SpaceWander
Animated journey from Earth to other galaxies.

Space Exploration (Wikipedia)
Information on the history of space travel, future developments and criticisms of space exploration.

Human Space Flight (NASA)
Information about missions, space stations, astronaut training and space shuttle.

Issues

Two of the biggest issues in space science today are the large amount of money spent on space research and the existence of life on other planets rather than on solving problems here on Earth. You might like to finish this chapter with a debate on one of the following topics.

- Millions of dollars are being spent on space research. Do you support this?
- Could humans exist on another planet?
- Has the study of space had any effect on my life?

Challenge solutions

1 The birth of a star involves the collection of hydrogen gas and dust which usually grows to a size where nuclear reactions begin and heat and light are produced. If the protostar does not get big enough, the reactions do not happen and a 'proper' star is never formed.

2 Telescopes on Earth have to receive light which has passed through the atmosphere and as a result become distorted. A telescope which is mounted in a satellite, however, can receive signals directly from deep space and will show much more detail. These signals

Check!

1 a Describe the shape of the Milky Way galaxy. Which other galaxy has the same shape?
  b Which type of galaxy is the most common in the universe? Which is the least common?

2 Explain the difference between a galaxy and the universe so that a 7-year-old child could understand the terms.

3 The bright star Canopus, which can be seen due south during autumn, is 98 light-years from our solar system.
  a How far away is Canopus in kilometres?
  b During which Earth year did the light you see from Canopus actually leave the star?

4 A cosmic year is the period of time it takes for the Milky Way to complete one revolution. How many Earth years are there in a cosmic year?

5 There is a vast amount of interstellar dust and gas (mainly hydrogen) in galaxies.
  a What do you think the word 'interstellar' means?
  b Astronomers believe that the interstellar dust and gas is the birthplace of stars. Describe the life cycle of a star about the size of our Sun.

6 From our observations on Earth, the Sun appears to move across the sky from east to west. However, how would you observe the movement of the Sun and the planets from a neighbouring galaxy? (A diagram will help.)

challenge

1 Astronomers think that some protostars, which have very small masses, do not form stars. Suggest a reason for this.

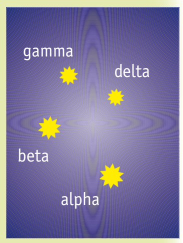
2 The Hubble Space Telescope was placed in orbit around the Earth in 1990. Suggest why this telescope has detected objects in space that were previously unknown.

3 Data collected using the Hubble Space Telescope suggests that the Crab Nebula is about 6500 light-years from Earth. Use the information on page 133 to work out when, in Earth years, the actual supernova took place.

4 a The Sun is 1.5×10^8 km from Earth. How long does the light from the Sun take to reach the Earth?
  b Pluto is about 5.9×10^9 km from the Earth. Why don't we use light-years to measure the distance to Pluto?

5 a What is the connection between a supernova and a nebula?
  b Suppose you are an astronomer and you are asked to predict whether a particular star will form a supernova or a red giant. What answer would you give?

6 Groups of stars are called constellations. Astronomers call the brightest star in a constellation the alpha-star, the next brightest the beta-star, then the gamma-star, then the delta-star and so on. The four main stars of the Southern Cross all appear to be the same distance away from Earth. However, the table below shows that they are not.



Star	Distance from Earth (in light-years)
alpha-star	370
beta-star	490
gamma-star	220
delta-star	570

  a Which star is closest to Earth?
  b If the beta-star and gamma-star were the same distance from Earth, would the beta-star still look the brighter? Give reasons for your answer.
  c Does the information in the table tell you which star is the largest?

Check! solutions

1 a The Milky Way galaxy is a flat spiral shape. The other similar galaxy which is visible from Earth is Andromeda.
  b Spiral galaxies are the most common and irregular galaxies are the least common.

2 One way to explain it is to say that the planet Earth goes around the Sun, which is a star. The Sun and many millions of other suns and their planets and all of the space in between make up our galaxy (the Milky Way). All other galaxies, including those that have not even been discovered, are called the universe.

3 a Each light-year is 9.5×10^{12} km.
  Canopus is $98 \times 9.5 \times 10^{12}$ km
  $= 931 \times 10^{12}$ km
  $= 9.31 \times 10^{14}$ km
  b The light we see today left Canopus in about the year 1900 AD.

4 There are about 220 million Earth years in a cosmic year. (See Fig 34 on page 132.)

5 a 'Interstellar' means the space between the stars. ('Stellar' means star.)
  b The life cycle of a star generally begins with a gaseous cloud that is mostly hydrogen gas. This then collapses to form a protostar which eventually increases in size and begins to produce heat. This is what we call a star and our Sun is a good example. In about five billion years it will run out of fuel and cool down to form a 'red giant' and eventually die to form a 'white dwarf'. (See Fig 35 on page 132.)

6 From a neighbouring galaxy the planets in our solar system would seem to be orbiting around the Sun. The Sun is also moving as our galaxy rotates. (See Fig 7 on page 118.)

are then relayed back to Earth by way of radio waves which are not distorted. This explains why the Hubble telescope has been so successful in detecting new objects in space.

3 The Crab Nebula actually exploded about 6500 years before it was observed in 1054 AD by the Chinese astronomers. This means that it actually occurred in about 5500 BC.

4 a Light travels at 3×10^8 m/s or 3×10^5 km/s. You can use the formula

$$t = \frac{d}{v}$$
$$= \frac{1.5 \times 10^8 \text{ km}}{3 \times 10^5 \text{ km/s}}$$
$$= 500 \text{ seconds}$$
$$= 8 \text{ mins } 20 \text{ seconds}$$

  b Light will only take about 5.3 hours to reach Pluto and this is only a very small fraction of a year.

5 a A supernova is a huge explosion which gives out a lot of light and ends the life a star. This leaves behind a huge expanding cloud called a nebula.
  b The answer you give will depend on the size of the star. Generally stars much larger than our Sun produce supernovas and the smaller stars form red giants.

6 a The star which is closest to Earth is the gamma star, which is 220 light years away.
  b The beta star is brighter than the gamma star even though it is much further from Earth. So if it was the same distance from Earth it would appear to be even brighter!
  c The brightness of a star seen from Earth depends on how large it is, how old it is and its distance from Earth. Since only the distance from Earth is given we cannot be certain which star is the largest.

Main ideas solutions

1 Earth, solar system, Sun
2 planets
3 rock and metal, core
4 galaxies, spiral
5 stars, supernova

Review solutions

1 C—see page 116.

2 B

3 a The inner planets and the outer planets. The inner planets have rocky surfaces and are relatively small. The outer planets, except Pluto, are all relatively large and consist of gases.

b Pluto is difficult to classify because it has the features of the inner planets yet it is the outermost planet of the gas planets.

4 A

5 D—see page 128.

MAIN IDEAS

Copy and comlete these statements to make a summary of this chapter. The missing words are on the right.

1 Ancient astronomers incorrectly inferred that the _____ was the centre of the _____. This inference was replaced by the idea of a central ____ with the planets revolving around it.

2 Spacecraft have considerably increased our knowledge about the eight _____ in the solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

3 Asteroids, comets and dwarf planets like Pluto are also parts of our solar system. Asteroids are made from _____, while comets have a small frozen _____ and have a large tail when they approach the sun.

4 _____ are groups of millions of stars held together by gravitational forces. They have three basic shapes: _____, elliptical and irregular.

5 _____ form in clouds of dust and gas. Some stars glow for billions of years, but larger stars have much shorter lives and end their lives in a _____.

core
Earth
galaxies
planets
rock and metal
solar system
spiral
stars
Sun
supernova

Try doing the Chapter 6 crossword on the CD. Working with technology

REVIEW

1 Until the early 1600s, most people believed that:
A the Sun was the centre of the solar system.
B all the planets revolved around Jupiter.
C all the planets revolved around the Earth.
D the solar system contained eight planets.

2 Which of the following is in the correct order?
A Mercury–Mars–Venus–Jupiter
B Mercury–Venus–Earth–Mars
C Mars–Venus–Jupiter–Saturn
D Venus–Earth–Jupiter–Saturn

3 a Into which two main groups can the planets in our solar system be classified? Describe the features of each group.
b Which planet is difficult to classify? Give reasons for your answer.

4 A light-year is:
A the distance light travels in one year.
B the distance from the Sun to the nearest star in our galaxy.
C the distance the Earth travels in one year.
D the distance from the Milky Way galaxy to the nearest galaxy.

5 The Earth has very few meteorite craters compared with Mercury and Mars. Which of the following inferences best explains this?
A These planets are smaller than the Earth.
B These planets attract meteorites from space.
C These planets are in the paths of meteorites.
D These planets have little or no atmosphere to protect them from meteorites.

REVIEW

6 Spacecraft have landed on Venus and Mars. Why would it be difficult for spacecraft in the future to land on Jupiter or Saturn, but relatively easy to land on Mercury?

7 The table below shows the distance of each of the planets from the Sun and the speed at which they travel through space as they orbit the Sun (orbital speed).

Planet	Distance from the Sun (million km)	Orbital speed (km/s)
Mercury	58	48
Venus	108	35
Earth	150	30
Mars	228	24
Jupiter	778	13
Saturn	1249	10
Uranus	2871	7
Neptune	4504	5
Pluto	5914	5

a Write a generalisation about the orbital speed of the planets and their distance from the Sun.

b Compared with Venus, Jupiter takes:

A the same time to orbit the Sun

B a longer time to orbit the Sun

C less time to orbit the Sun

Give a reason for your answer.

8 The object in the photo below is found deep in space and was photographed by a space telescope. The object is called:

A an asteroid

B a nebula

C a comet

D a spiral galaxy

9 The object in the photo above resulted from a supernova of a star. Explain why this is unlikely to happen to our Sun.

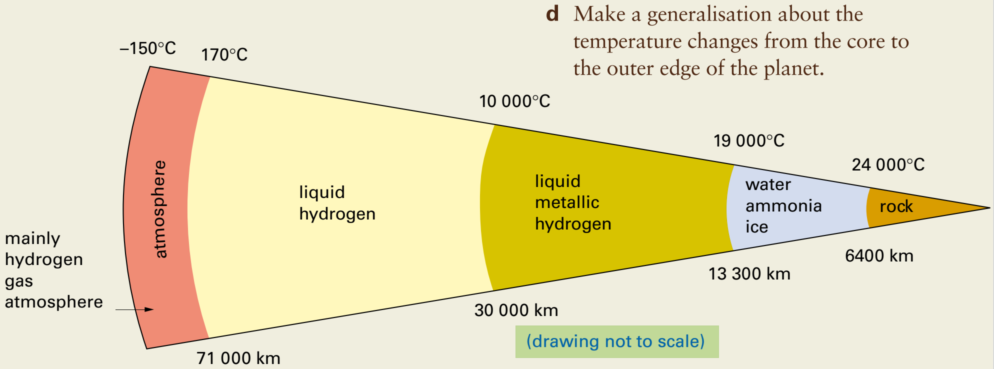
10 The diagram below is a cross-section of the planet Jupiter showing its inferred composition.

a Write a description of the composition of Jupiter. Which element do you think is the most abundant?

b How thick do astronomers believe Jupiter's solid rocky core is?

c Which is the thickest layer? How thick is it?

d Make a generalisation about the temperature changes from the core to the outer edge of the planet.



Check your answers on pages 301–302.

6 Jupiter and Saturn are gas planets and have no known solid surface on which a spacecraft could land. Mercury, on the other hand, has a solid surface.

7 **a** As the distance from the Sun increases, a planet's orbital speed decreases.

b **B**—Jupiter's orbital speed is slower than that of Venus. It is also further from the Sun, making its orbital path longer.

8 **B**—see page 133.

9 Supernovas occur to end the lives of giant, hot stars. Our Sun is only a medium-sized star and will end its life as a red giant, then a white dwarf.

10 **a** Jupiter is composed mainly of hydrogen in gas and liquid states. It also contains some water and ammonia, with a small rocky core.

b Jupiter's solid core is estimated to be 12 800 km in diameter (6400 km × 2).

c The thickest layer is the liquid hydrogen layer which is 41 000 km thick.

d The temperature decreases as the distance from the centre increases.