9 Earth in space

HAVE YOU EVER WONDERED…

- why the Sun rises in the east and sets in the west?
- why we have seasons?
- why sometimes there is a full Moon and other times none at all?

After completing this chapter students should be able to:

- explain lunar and solar eclipses, seasons and phases of the Moon
- compare times for the rotations and orbits of the Earth, Sun and Moon
- model the relative movements of the Earth, Sun and Moon
- explain why different regions of the Earth experience different seasonal conditions
- explain how gravity keeps planets in orbit around the Sun
- outline how advances in telescopes and space probes have provided new evidence about space
- research the development of different models of the solar system
- research developments in the understanding of astronomy.

9.1 The night sky

Look into a clear night sky and you will see stars, cloudy blurs of light made up of even more stars, and most probably part of the Moon. A few of those starry points of light aren't stars at all but are planets. A couple of 'stars' might even shoot across the sky. They aren't stars either, but are meteoroids. The night sky is Earth's view of the rest of the universe, its stars, constellations, planets, dwarf planets, moons, meteoroids, asteroids and comets.

INQUIRY science 4 fun

Skywatch

Yes

Collect this…

- sky map (from Activity Book 9.1 or similar)
- binoculars (if available)

Do this…

1. Wait until the Sun has been down for at least half an hour.
2. Find a spot outside where you can see the sky and where there are as few street and house lights as possible.
3. Face south and try to find the Southern Cross and the pointers. The Cross may be upside down or lying in an unusual orientation.
4. If the Moon is in the sky, observe it (using binoculars if possible).
5. Use a sky map to identify a number of constellations.

Record this…

Describe what you saw.
Explain what you think caused each of the features you saw.

Observing the night sky

Although most people can see about 2000 stars in the night sky with the naked eye, the exact number depends on the weather, how close you are to the bright lights of a city, and whether or not the Moon is in the sky.

Not all those bright points of light are the same: some have different colours, some are much brighter or much dimmer than others and some move at different speeds. If you use a telescope, then some of these differences become even more apparent. These visible differences arise because not every point of light in the night sky is a real star. While most points of light are stars, a handful are planets, and a few might be meteors or comets.

Stars

Stars are massive burning balls of hydrogen gas. Hydrogen is explosive but the light and heat that comes from stars is not from 'normal' hydrogen explosions. It comes from nuclear explosions instead! A nuclear reaction (called a fusion reaction) converts hydrogen into helium, releasing untold amounts of energy as heat, light and radiation as it does so.

The nearest star to Earth is the Sun, being 'only' 150 million kilometres from us. At this distance, the light and heat from those nuclear explosions takes just over 8 minutes to reach us.

The Milky Way

A band of light runs across the night sky from one horizon to the other. In ancient times, people thought that this looked like a road made of milk. That's why it was named the **Milky Way**. You can see it in Figure 9.1.1. Scientists now know that this white band is the light from more than 200 billion stars. Most of these stars are too far away to be seen distinctly or individually from Earth, but their combined glow is one of the most spectacular features of the night sky.

Of the few thousand stars that can be made out distinctly, only a few are bright or significant enough to have been given their own names. Most stars are named as part of the **constellation** to which they belong.

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Starry, starry day

The stars are always there in the sky whether it's night or day. However, you can't see them in daylight because they can't compete with the intense brightness of the Sun.

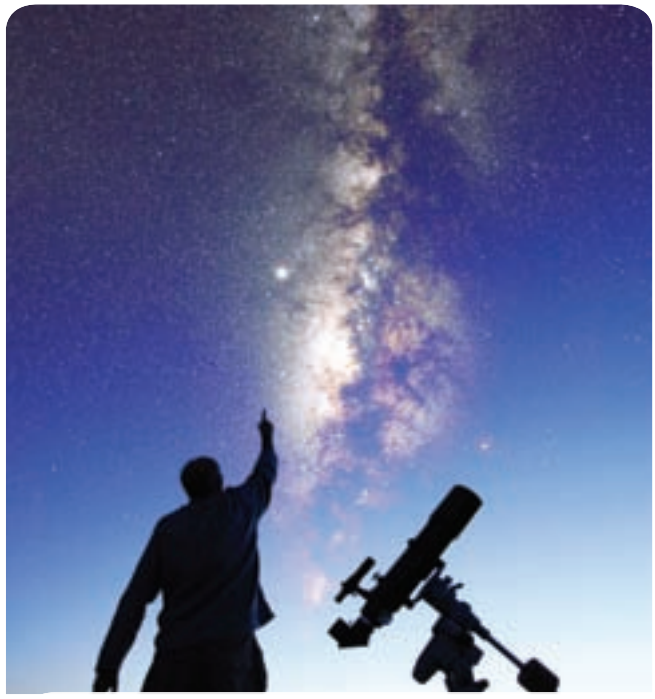

Figure 9.1.1 The Milky Way. The light pollution caused by city buildings and street lighting means that many Australians have never seen this breathtaking sight in its full glory.

Constellations

A constellation is a group of stars that forms a recognisable pattern when viewed from Earth. The stars in Figure 9.1.2 show the Southern Cross, perhaps Australia's most recognisable constellation.

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Figure 9.1.2 The Southern Cross is a constellation that can only be seen from the southern hemisphere. It can therefore be seen from Australia, New Zealand and the countries of southern Africa and South America.

Different groups of people in different parts of the world have looked at the same stars and grouped them together in different ways to form patterns and pictures relevant to them and their culture. The most famous set of constellations in Western culture are the signs of the zodiac.

SKILL BUILDER

Finding south

Ancient navigators used the Southern Cross to find which direction is south. You can do this too, using two different methods. Both methods locate the position of the south celestial pole. This is the point in the night sky around which all the stars seem to rotate. Once this is located, a line is dropped to the horizon. Where it hits is directly south from where you are.

Method 1: Locate the south celestial pole by extending the main axis of the Southern Cross four times.

Method 2: Locate the south celestial pole by extending the main axis. Construct another line out from the middle of the pointers as shown in Figure 9.1.3. The south celestial pole is where the two lines meet.

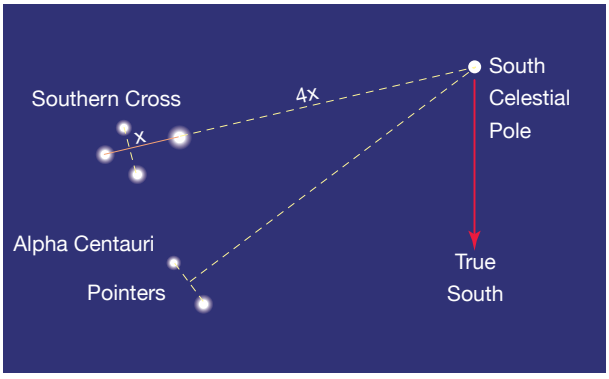

Figure 9.1.3 How to use the Southern Cross to find true south

The zodiac

The twelve constellations that make up the zodiac are considered special by many because they are the only constellations that the Sun appears to move through. These are the famous 'star signs' such as Leo, Scorpio and Sagittarius that are referred to in the astrology columns of newspapers or on the internet. Figure 9.1.4 shows the signs of the zodiac with the dates traditionally associated with them. These dates were originally assigned by the ancient astronomer Ptolemy to correspond to the time when the Sun appeared to move through each constellation.

9.1

9.2

20 January–18 February	Aquarius	♒
19 February–20 March	Pisces	♓
21 March–19 April	Aries	♈
20 April–20 May	Taurus	♉
21 May–20 June	Gemini	♊
21 June–22 July	Cancer	♋
23 July–22 August	Leo	♌
23 August–22 September	Virgo	♍
23 September–22 October	Libra	♎
23 October–21 November	Scorpio	♏
22 November–21 December	Sagittarius	♐
22 December–19 January	Capricorn	♑

Figure 9.1.4 The zodiac is made up of the 12 constellations through which the Sun appears to travel.

Astrology is the belief that the positions of the Sun, stars and planets affect a person's personality and the day-to-day events of their life. There is no scientific or statistical evidence that suggests that is true. In contrast, **astronomy** is the scientific study of stars, planets and other objects seen in the night sky. In astronomy, as in other sciences, theories and models must be supported by evidence. If they are not the theories or models must be changed or discarded. This chapter is concerned with astronomy and not astrology.

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Change to the zodiac

The Sun's apparent position has changed since Ptolemy invented the zodiac 2000 years ago. This means that the dates given in magazines no longer match the position of the Sun. For example, 29 October is said to fall in Scorpio. However, on that date the Sun is really in Libra!

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Aboriginal constellations

This group of stars called Orion is easy to identify in the southern sky. Figure 9.1.5

When looking for patterns in the stars, people are naturally reminded of familar everyday objects. It is not surprising that people from different cultures with different lifestyles would identify different constellations. Also, different stars are visible from different parts of the Earth. For example, Polaris cannot be seen in Australia, despite being a very prominent star in the northern hemisphere. Likewise, the Southern Cross can only be seen in the southern hemisphere.

For example, consider the group of stars in Figure 9.1.5. The ancient Greeks called this group of stars Orion after a famous hunter from mythology. It's shown in Figure 9.1.6. The bright stars at the corners represent the hunter's hands and feet, the group of stars across the middle is his belt with a sword sticking out of it. The problem with this image for Australians is that it appears upside down when viewed from the southern hemisphere. Instead, many modern Australians call this constellation 'the saucepan'. Orion's sword is the handle of the saucepan, as shown in Figure 9.1.7. The Yolngu people of the Northern Territory know this group of stars as Djulpan or the canoe, shown in Figure 9.1.8. Here the sword/saucepan handle represents a fishing line trailing behind the canoe in the water.

Orion, the hunter Figure 9.1.6

Figure 9.1.7 The saucepan in Orion

Figure 9.1.8 Djulpan, the canoe, in Orion

Different cultural perspectives can also produce completely different ways of looking at the sky. The image in Figure 9.1.9 shows the Aboriginal emu-in-the-sky constellation. An unusual thing about this constellation is that it is seen by looking at the dark clouds of dust between the stars rather than at the stars themselves.

Figure 9.1.9 The emu-in-the-sky constellation and an engraving of it in Ku-ring-gai Chase National Park near Sydney. The constellation appears directly above the engraving as shown every autumn.

Planets

Planets are very different from stars. There are no nuclear explosions on the planets and so planets do not make their own light. Instead, they reflect light falling on them from the Sun. This allows us to see them in the night sky. They're seen as points of light that look very much like real stars.

As Figure 9.1.10 shows, Mercury, Venus, Earth and Mars are the closest planets to the Sun. These are known as the rocky planets or **terrestrial** (meaning Earth-like) planets. All these planets are rocky with a hard surface. Mercury, Venus and Mars are relatively close to Earth and are often seen in the night sky as a bright or coloured point of light. Mercury and Venus are usually visible before dawn as morning 'stars' or just after sunset as evening 'stars'. At these times, Venus is the brightest 'star' in the sky. Mars appears as a red-coloured 'star'.

The outer planets of Jupiter, Saturn, Uranus and Neptune are huge balls of gas with a small and rocky core. For this reason, they are commonly known as the **gas giants**. While Jupiter and Saturn can be seen as 'stars' with the naked eye, Neptune and Uranus can only be seen from Earth using a telescope.

Dwarf planets

Pluto was classified as a planet when discovered in 1930. However, it was an extremely odd one: it is very small, has a moon nearly the same size, and it travels around the Sun with an orbit that is in a different plane to the orbits of all the other planets.

In 2006, the International Astronomical Union (IAU) created a new category of dwarf planets. Like planets, **dwarf planets** are roughly spherical and travel around the Sun. Unlike 'normal' planets, dwarf planets don't have enough mass and have insufficient gravity to clear their neighbourhood of dust and rocks. For this reason, Pluto is now classified as a dwarf planet. Astronomers have since found a number of other dwarf planets (Haumea, Eris and Makemake). You can see them in Figure 9.1.11. They are located a little beyond Pluto in a region of icy rock fragments called the **Kuiper Belt**. Another dwarf planet is the asteroid Ceres, located between Mars and Jupiter.

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Seeing stars?

Sometimes you will see a 'star' that is moving slowly across the sky. It's not a star or a planet—it is a large piece of space junk or a satellite reflecting sunlight. It may even be the International Space Station.

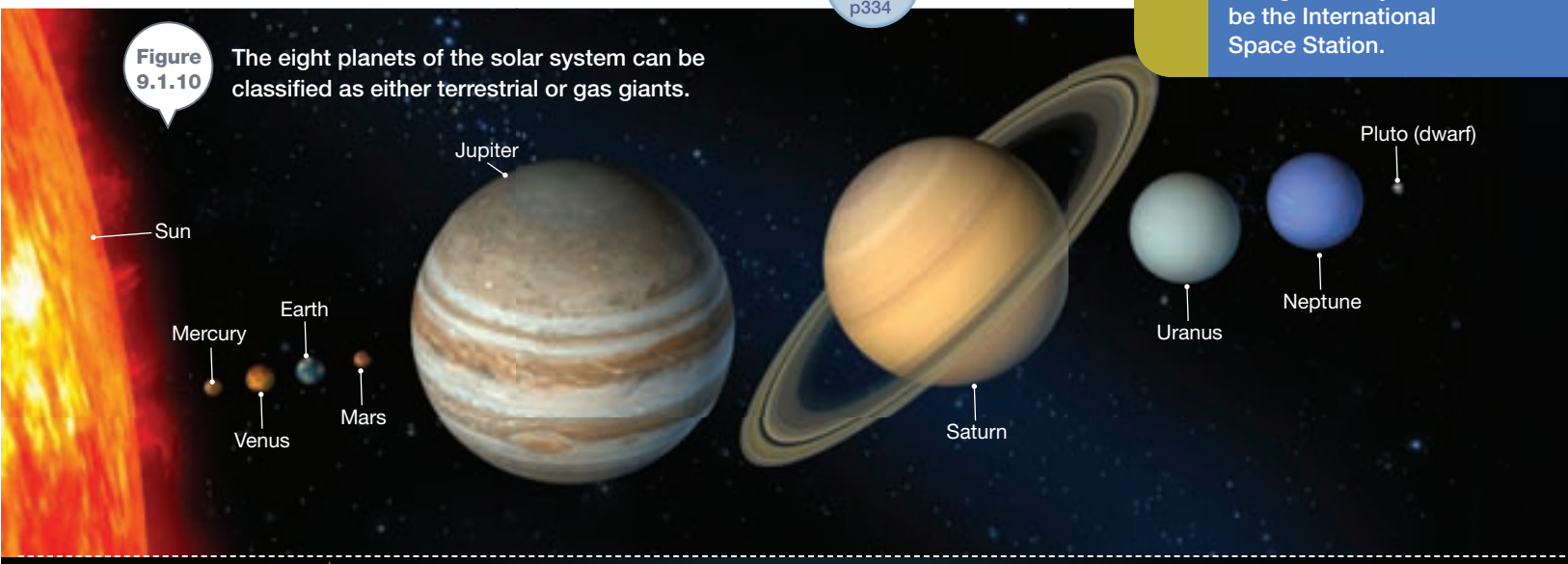

Figure 9.1.10 The eight planets of the solar system can be classified as either terrestrial or gas giants.

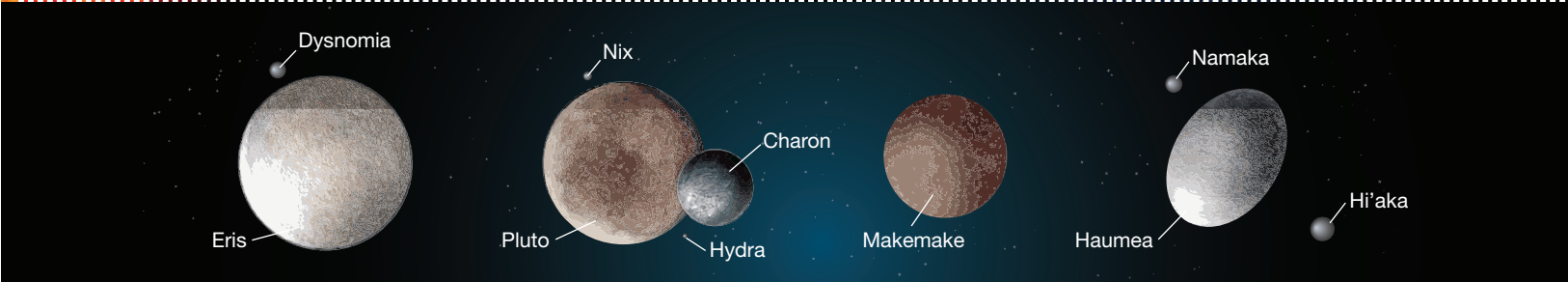

Figure 9.1.11 The Kuiper Belt contains a number of dwarf planets and similar-sized objects.

9.1 Unit review

Remembering

1 **Name** the type of nuclear reaction that powers stars.

2 a **Name** the nearest star to Earth.
b **State** how long it takes its light to reach Earth.

3 **Name** the bright band of light that can be seen in the night sky.

4 a **State** how many stars are visible to the naked eye.
b **List** factors that affect the number of stars able to be seen.

5 **Name** a star or constellation that can only be seen in:
a the southern hemisphere
b the northern hemisphere.

6 **List**:
a the rocky planets
b the gas giants
c the dwarf planets.

7 You see many bright points of light in the night sky. **List** the different types of things they could be, from most likely to least likely.

Understanding

8 **Explain** why planets are sometimes mistaken for stars.

9 **Explain** why Pluto is no longer considered a planet.

Analysing

10 **Contrast**:
a a planet with a star
b astronomy with astrology.

Evaluating

11 Three constellations based on the same group of stars are shown in Figures 9.1.6, 9.1.7 and 9.1.8 on pages 330 and 331.
a **Assess** which best fits the pattern of stars.
b **Justify** your answer.

12 It would be easy for astronauts to move about on the surface of Mars but it would be impossible for them on Jupiter. **Propose** reasons why.

Creating

13 **Construct** a diagram showing how true south can be located using the Southern Cross.

14 **Construct** a letter or email to the editor of your newspaper in which you propose some ways in which people living in your nearest capital city can reduce light pollution to create better conditions for amateur astronomy.

15 **Construct** and **name** a new constellation that would fit the star pattern shown in Figure 9.1.12.

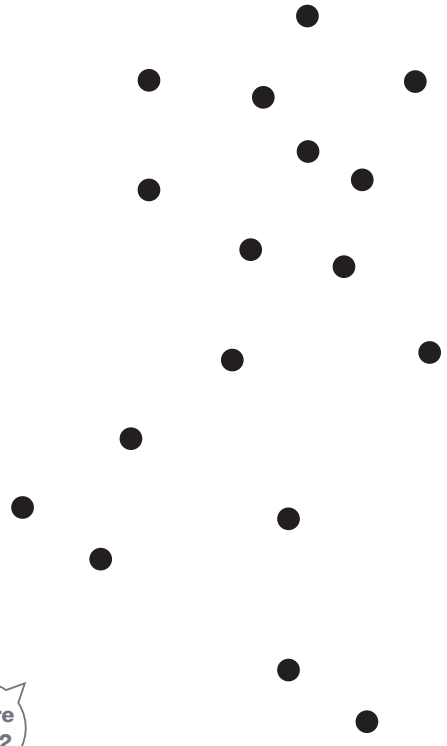

Figure 9.1.12

Inquiring

Research the constellations recognised by different cultural groups living in your local area.

9.1 Practical activities

1 Seeing constellations

Purpose
To use simulation software to observe constellations.

Materials
- computer
- a planetarium program such as SkyGlobe, Stellarium, Celestia or WorldWide Telescope. These can usually be downloaded as freeware or accessed online.

Procedure
1. Set the program to show the sky as it will appear at 8 pm tonight from your home town.
2. Most programs will have a function that superimposes constellations over the pattern of stars. Switch this on.
3. Choose a constellation. Sketch it.
4. Switch the constellation function off. Sketch the stars that make up the constellation. Use different-sized dots to represent the relative brightness of the stars.
5. Repeat steps 2–4 for another three constellations.
6. Tonight, try to find these constellations in the night sky.

Discussion
1. **Describe** how difficult it was to find the real constellations in the night sky.
2. **List** the factors that make it difficult for you to see constellations in the sky clearly.

2 Visiting dwarf planets

Purpose
To use simulation software to observe a number of dwarf planets.

Materials
- computer
- a planetarium program such as SkyGlobe, Celestia or WorldWide Telescope

Procedure
1. Set the program to show the sky as it will appear at 8 pm tonight from your home town.
2. Search for Ceres.
3. Zoom in until the image of the dwarf planet fills the screen. Sketch it.
4. Zoom out to identify and sketch any moons orbiting the dwarf planet.
5. Repeat steps 2–4 for other dwarf planets, such as Pluto, Eris, Makemake, Haumea.

Discussion
1. **List** the three characteristics of a planet.
2. Dwarf planets lack one of those characteristics. **Describe** the feature that most lack.