# 9.4 Small solar system bodies

Planets, dwarf planets, stars and constellations aren't the only things in the sky. There are thousands of chunks of rock and ice out there too. These chunks are commonly known as asteroids and comets. In 2006, the IAU (International Astronomical Union) grouped these chunks together and gave them the name small solar system body (or SSSB).

INQUIRY science 4 fun

## Liquid craters

Yes

Meteor strikes have marked the Moon with many craters. Many have peaks in their centre. What forms them?

### Collect this ...

- glass or 250 mL beaker
- drinking straw
- water

### Do this ...

1. Put a small amount of water in the glass or beaker.
2. Place one end of the straw in the water and then block the other end with your finger.
3. Keep your finger on the straw while you remove it. It should be holding some of the water.
4. Release the pressure of your finger so that a couple of drops fall back into the glass or beaker.
5. Carefully observe what happens to the surface of the water as the drop falls in, particularly at its centre.

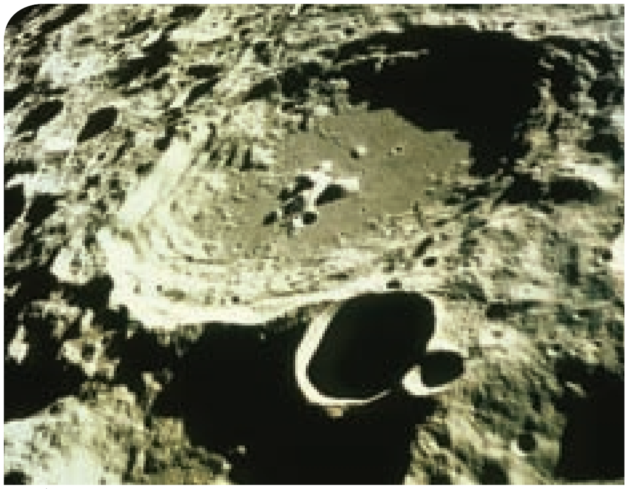


Figure 9.4.1 The energy of some meteorites is sometimes so high that it melts the Moon's rock, causing it to slosh around and to form a small peak in the centre of the crater. Droplets form a similar peak when they hit liquid water.

### Record this ...

**Describe** what happened.
**Explain** why you think this happened.

# Comets

**Comets** are among the most spectacular sights in the sky. Figure 9.4.2 shows the image of a comet as recorded by a German artist in 1664. Some have been so bright that they could be easily seen with the naked eye, even during the day. From the earliest times, superstitious people have seen the appearance of a comet as an omen of disaster or history-making events.

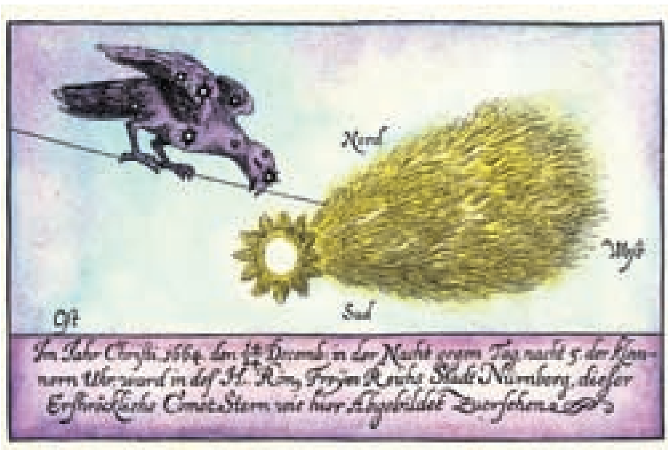


Figure 9.4.2 This German painting records the appearance of a comet for 10 days in December 1664.

When viewed from Earth, comets:

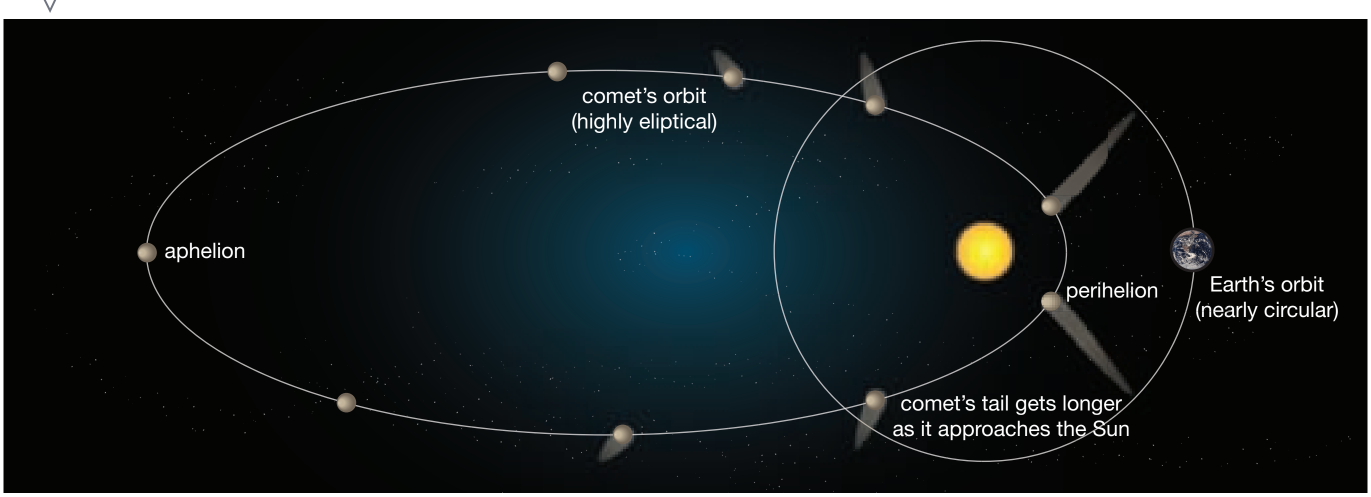
- gradually get brighter and then fade over a period of weeks
- have a distinctive **coma** (or fuzzy atmosphere) at their head and often a trailing 'tail'
- reappear periodically.

Comets are commonly referred to as 'dirty snowballs' since they are made primarily of ice mixed with frozen carbon dioxide and other carbon-based molecules. As Figure 9.4.3 shows, comets have highly elliptical orbits, with the **aphelion** (its point of furthest distance from the Sun) of many comets being beyond Pluto in a distant region of space known as the Oort cloud. As a comet approaches its **perihelion** (its point of closest approach to the Sun), it encounters both radiation from Sun and the solar wind. The **solar wind** is a stream of high-energy particles that is emitted from the Sun in all directions. The radiation causes the comet's surface to vaporise and form a thin atmosphere or coma. The solar wind also blasts heavier dust particles from the surface of the comet and pushes these, and molecules from the coma, into a 'tail'. Since the tail is created by the solar wind, it always points away from the Sun, regardless of whether the comet is moving towards the Sun or away from it.

## Halley's Comet

Halley's Comet was the first comet to be recognised as periodic, returning to the inner solar system at regular intervals. The eighteenth century English astronomer Edmund Halley recognised that descriptions of a comet that appeared in 1682 were almost exactly the same as the description of a comet observed earlier in 1531 and another seen in 1607. Halley proposed that these three observations were all describing a single comet that returned to the inner solar system approximately every 76 years. Halley died in 1742 and so was not able to witness the confirmation of his theory when the comet reappeared in 1758. Science historians have been able to identify sightings of Halley's Comet as far back as 240 BCE. Its most recent appearance was in 1986.

Figure 9.4.3 A comet's orbit is highly elliptical. Its tail always points away from the Sun.



## Comet Shoemaker-Levy 9

A comet discovered by Carolyn and Eugene Shoemaker and David Levy in 1993 came to international attention when it broke up and crashed into Jupiter in July 1994. Telescopes around the world turned to Jupiter to observe the impacts, which provided scientists with a wealth of information about the upper atmosphere of the gas giant. The impact scars from the collision lasted for many months. They can be seen as dark patches in Figure 9.4.4.

**Figure 9.4.4** The dark patches are impact scars from Shoemaker-Levy 9's crash into Jupiter.

# Asteroids

An **asteroid** is an irregular rocky object left over from the formation of the solar system. Most known asteroids orbit the Sun in a band known as the **asteroid belt** that lies between the orbits of Mars and Jupiter. Scientists believe that competing gravitational effects of Mars and Jupiter prevented these objects ever forming into a planet.

Over half of the mass of the entire asteroid belt is contained in its four largest asteroids. Ceres is the biggest of the asteroids. It is large and round enough to be classified as a dwarf planet. The relative sizes of Earth, the Moon and Ceres can be seen in Figure 9.4.5. An irregularly shaped asteroid called Ida is another large asteroid. With a length of 56 kilometres, Ida's gravity is high enough to have trapped another, smaller asteroid called Dactyl as a moon! Most asteroids are much smaller than Ceres and Ida.

The asteroid belt is a possible source of mineral resources for space settlements. One of the great challenges associated with building large structures in space is the enormous cost of sending the building materials up from Earth by rocket. It may be much cheaper to capture an asteroid and mine it.

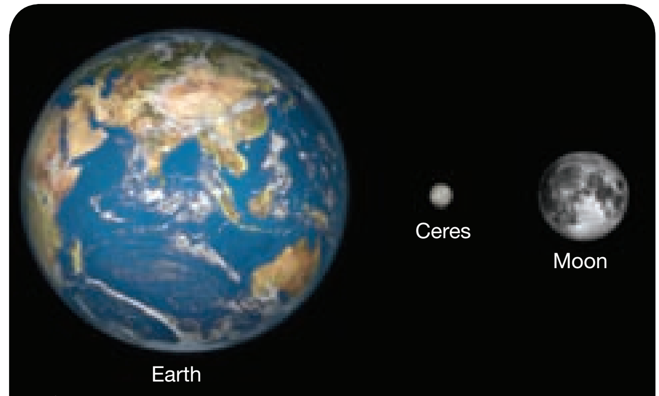



**Figure 9.4.5** This artist's impression compares the size of Earth, the Moon and Ceres. Although it is classed as a dwarf planet, Ceres is much smaller than the Moon.

# Meteoroids

Occasionally, the path of an asteroid will bring it close enough to the Earth for it to be captured by the Earth's gravitational field. As this lump of space rock falls through the Earth's atmosphere, friction between it and the air generates enormous amounts of heat. This turns the asteroid into a blazing fireball known as a **meteoroid**, or more popularly a 'shooting star'. These can be among the most exciting sights in the night sky, particularly when a group of meteoroids enter the same part of the atmosphere at the same time, producing a **meteor shower**. Meteor showers often occur when the Earth passes through the tail of a comet.

Fortunately, most meteoroids are so small that they burn up completely in the atmosphere, in which case they are known as **meteors**. If a meteoroid is very large, then a part of it might reach the ground before it has completely burnt up. The part that reaches the ground is called a **meteorite**. Most meteorites are tiny, but on very rare occasions Earth is struck by a large meteorite. When this happens, the results can be devastating. Meteorites usually travel at very high speeds and the impact can create a massive crater (such as the one shown in Figure 9.4.8 on page 359) and cause widespread destruction. There is strong evidence to suggest that a major meteorite impact caused the extinction of the dinosaurs 65 million years ago. In 1908 a meteor about 50 metres across exploded above Tunguska in Siberia, flattening about 2000 square kilometres of forest.

Meteorite impacts can also be very useful. By studying impact craters on the Moon and rocky planets such as Mercury and Mars, scientists can learn much about the history of these bodies.

1 p360
2 p361

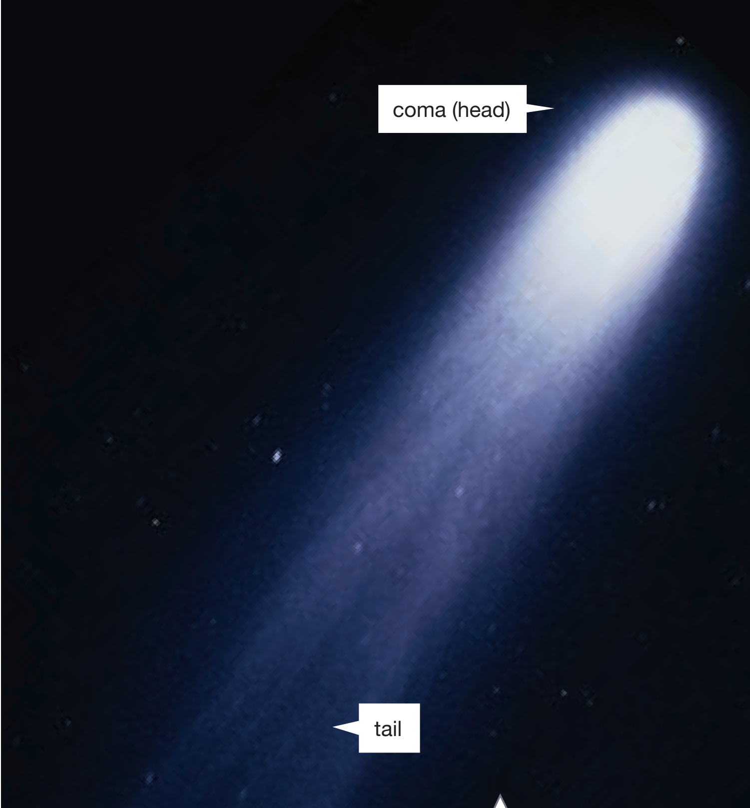



Figure 9.4.6 Halley's Comet returns every 76 years. It has been visited by four space probes.

# SCIENCE AS A HUMAN ENDEAVOUR

## Use and influence of science

### Exploring comets and asteroids

Comets and asteroids can tell astronomers a lot about what the solar system was like before it condensed into the star and planets we have today. Scientists have sent numerous spacecraft to fly by, photograph and land on various small solar system bodies. Table 9.4.1 gives a summary of some of these important missions.

**Table 9.4.1 Missions to explore comets and asteroids**

| Year | Spacecraft | Target | Type of mission | Notes | Fate of spacecraft |
|---|---|---|---|---|---|
| 1985 | *ICE* | Comet Giacobini-Zinner<br>Halley's Comet | Fly by | *ICE* stands for International Cometary Explorer (it was originally International Sun-Earth Explorer 3) | Shut down in 1997. Will return to vicinity of Earth in 2014 |
| 1986 | *Vega 1* and *Vega 2* | Halley's Comet | Fly by | Both Vega spacecraft dropped landers onto Venus before flying by Halley's Comet | *Vega 1* headed out into deep space<br>*Vega 2* put into a heliocentric orbit |
| 1986 | *Giotto* | Halley's Comet | Fly by | Also flew by Comet Grigg-Skjellerup | Put into hibernation in 1992 |
| 1986 | *Suisei* and *Sakigake* | Halley's Comet | Fly by | Twin Japanese probes | *Suisei* was shut down in 1998<br>*Sakigake* lost contact with Earth in 1995 |
| 1991 and 1993 | *Galileo* | Asteroid Gaspra (1991)<br>Asteroid Ida (1993) | Fly by | Gaspra was the first asteroid ever to be closely approached by a spacecraft. It was discovered that Ida has a small moon, which was named Dactyl | Deliberately crashed into Jupiter in 1994 |

| | | | | | |
|---|---|---|---|---|---|
| 1994 | *Clementine* | Asteroid Geographos | Fly by | Mission failed due to instrument malfunction—thrusters misfired leaving the craft tumbling uncontrollably | Mission terminated in 1994 with craft in heliocentric orbit |
| 1997 and 2001 | *NEAR—Shoemaker* (**N**ear **E**arth **A**steroid **R**endezvous) | Asteroid Mathilde (1997)<br>Asteroid Eros (2001) | Fly by (Mathilde)<br>Fly by and landing (Eros) | After its launch, the probe was renamed in honour of the astronomer Eugene Shoemaker. This was the first spacecraft to land safely on an asteroid. It transmitted experimental data from the surface of Eros for over 2 weeks | Still on Eros. Efforts to contact it in 2002 were unsuccessful |
| 1999 and 2001 | *Deep Space 1* | Asteroid Braille (1999)<br>Comet Borrelly (2001) | Fly by | Fly by was only partially successful due to camera malfunctions | Shut down in December 2001 |
| 2002 | *CONTOUR* (**CO**met **N**ucleus **TOUR**) | Comet Encke, Schwassmann-Wachmann 3<br>Comet d'Arrest | Fly by | Intended to investigate the nuclei of several comets | Broke apart shortly after launch |
| 2004 | *Stardust* | Comet Wild 2 | Fly by | Collected dust samples from the comet's coma and returned them to Earth | Extended mission: Stardust will fly by Comet Tempel 1 in 2011 |
| 2005 | *Hayabusa* | Asteroid Itokawa | Sample return | Contact with *Hayabusa* was lost in December 2005 and then regained in 2006 | Returned to Earth in June 2010, landing in South Australia |
| 2005 | *Deep Impact* | Comet Tempel | Fly by and impact | First mission to eject material from a comet's surface. Provided important information about composition of comets | Mission continues. Flew past Comet Hartley 2 in 2010 |
| Launched in 2004 | *Rosetta* | Asteroid Steins (2008)<br>Asteroid Lutetia (2010)<br>Comet Churyumov-Gerasimenko (2014) | Fly by, orbit and land | Will release a lander called Philae on to the surface of the comet to record changes as it approaches the Sun | Mission ongoing |
| Launched in 2007 | *Dawn* | Asteroid Vesta (2011)<br>Dwarf planet Ceres (2015) | Fly by | Will be first spacecraft to orbit two objects in the asteroid belt | Mission ongoing |

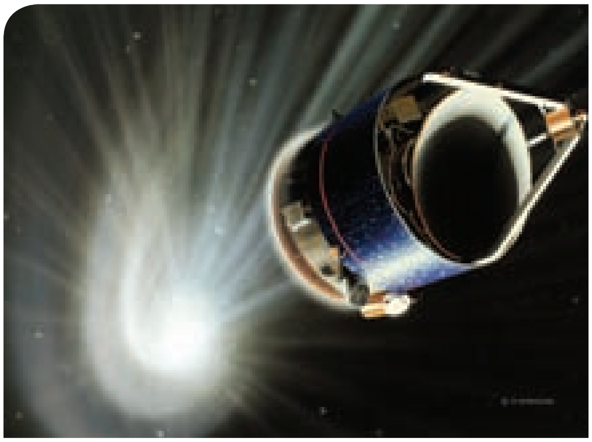


Figure 9.4.7 Artist's impression of *Giotto* and Halley's Comet. *Giotto* was Europe's first deep space mission.

# 9.4 Unit review

## Remembering

1 **State** what the acronym SSSB stands for.

2 **List** the distinguishing features of a comet.

## Understanding

3 **Use** a diagram to **define** the terms ‘aphelion’ and ‘perihelion’.

4 **Explain** why a comet’s tail always points away from the Sun.

5 **Explain** why comets and meteor showers are often observed together.

6 **Outline** why the term ‘shooting star’ is not an appropriate name for a meteor.

## Applying

7 Encke’s Comet was the second comet (after Halley’s) to be identified as periodic. It was last seen in April 2007 and is expected again in early August 2010. **Calculate** its orbital period, the time the comet takes to complete one complete orbit.

8 Halley’s Comet last appeared in 1986. Given that it has an orbital period of 76 years, **calculate** the years in which the next three sightings should occur.

## Analysing

9 **Compare** the composition of an asteroid with the composition of a comet.

10 Unlike comets, asteroids and meteors do not have a ‘coma’. **Discuss** why.

## Evaluating

11 Some historians have suggested that Halley’s Comet may have been the ‘Star in the East’ seen by the three wise men in the story of the birth of Jesus. Halley’s Comet was observed by Chinese astronomers in 240 BCE and has an orbital period of 76 years.

  a **Use** this information to **calculate** the years Halley’s Comet would have appeared between 100 BCE and 100 CE.

  b **Evaluate** the likelihood of Halley’s Comet appearing in the year of Jesus’ birth, which most historians think was either 4 or 6 BCE.

12 Some scientists estimate that in the next 100 years there is a 10% chance of Earth being hit by something large from space, such as a meteor, asteroid or comet.

  a **Identify** arguments for and against research that uses telescopes to search for large objects in space that are heading our way.

  b **Assess** whether the risk justifies this research.

Figure 9.4.8 Meteorite impact crater in Arizona, USA. The crater is 275 m deep and 1.26 km in diameter. The meteoroid that caused it was around 60 m in diameter and has a mass of more than 10 000 tonnes.

## Creating

13 **Construct** a poster that explains the difference between the terms ‘meteor’, ‘meteoroid’ and ‘meteorite’ and gives a realistic assessment of the dangers associated with a meteorite impact.

## Inquiring

1 Research other famous comets such as Comet Hale-Bopp and the Great January Comet of 1910. In particular, find out how different people reacted to the appearance of these comets.

2 Research the documented sightings of Halley’s Comet throughout history. Are these all exactly 76 years apart?

3 Research more information about spacecraft that have visited asteroids or comets. Find out which of these spacecraft are still operating.

4 Research the meanings of the terms ‘minor planet’ and ‘planetoid’.

# 9.4 Practical activities

## 1 Simulating impact craters

### Purpose

To determine what information about meteorite impacts can be determined from impact craters.

### Materials

- 4 cups of damp sand or flour
- small plastic box or tray (such as a lunch box or take-away food container)
- several marbles or ball bearings (of various sizes if possible)
- tweezers
- piece of tissue paper or cloth
- large sheet of plastic (to clean up mess)

### Procedure

1. Lay out the tray on the large sheet of plastic or set up outside.
2. Fill the tray with flour or sand to a depth of 2–3 cm. Keep at least one cup aside for later.
3. Drop a marble or ball bearing into the flour or sand to make an impact crater.
4. Using tweezers, carefully remove the marble or ball bearing. Avoid changing the shape of the crater.
5. Repeat steps 3 and 4 with marbles of different sizes from different heights until a pattern of overlapping craters has been formed.
6. Sketch or photograph the crater pattern.
7. Simulate volcanic activity by sprinkling the remaining flour or sand over a section of the crater pattern. Sketch or photograph this section.
8. Simulate erosion by lightly dragging the tissue or cloth over a section of the tray.
9. Sketch or photograph the crater pattern.
10. Simulate earthquakes by lightly tapping the side of the tray.
11. Drop several more marbles or ball bearings.
12. Sketch or photograph the crater pattern.

### Results

Can you tell from the crater patterns you made which craters were formed earlier and which were formed later? If so, **explain** how.

### Discussion

1. **Propose** what effect each of the following would have on the pattern of impact craters:
   a. volcanic activity
   b. erosion
   c. earthquakes.
2. It is possible to identify which impact craters were formed after volcanic activity, erosion and earthquakes. **Propose** what the landscape would look like if a crater was formed after each type of activity.
3. Use information gained from this activity to **predict** what astronomers could learn from the pattern of impact craters on a moon or a planet.

## 2 Toilet paper solar system

### Purpose

To construct two scaled models of the solar system that show the distance between the planets, the Kuiper Belt and the Oort Cloud.

### Materials

- 300-sheet roll of toilet paper
- pen or pencil (not a felt-tipped pen)

### Procedure

**Part A: The planets**

1 Unroll a little of the toilet roll. At the very start of the first sheet, draw and label the SUN.

2 Unroll the toilet roll a little further. At the end of the fourth sheet, draw a small planet. Label it MERCURY.

3 The table below shows where you need to draw and label the other planets of the solar system. The scale being used here is 1 sheet = 15 million kilometres or 1 : 15 000 000. Using this scale, Uranus should be drawn at the edge of the final sheet on the roll.

| Planet | Distance (millions of km) | Toilet sheets |
|---|---|---|
| Mercury | 58 | 4 |
| Venus | 108 | 6.5 |
| Earth | 150 | 10 |
| Mars | 228 | 15.5 |
| Jupiter | 778 | 52 |
| Saturn | 1427 | 95.5 |
| Neptune | 2871 | 193.5 |
| Uranus | 4498 | 300 |

**Part B: The Kuiper Belt and Oort Cloud**

4 Turn the roll over and again draw a dot to represent the SUN at the very start of the first sheet.

5 As before, mark the following features of the solar system as shown in the instructions below. This table uses the scale 1 sheet = 26 billion kilometres (the distance light travels in one day).

| Planet | Distance (km) | Instructions |
|---|---|---|
| Earth | 150 million | Draw a dot 0.5 mm from the Sun on the 1st sheet |
| Pluto | 5906 million | Draw a dot about $\frac{1}{4}$ of the way into the 1st sheet |
| Kuiper Belt | 5000 million to 40 billion | Draw a belt from Pluto to the middle of the 2nd sheet |
| Oort Cloud | 30 trillion | Draw a cloud on the 285th sheet |

### Discussion

1 **List**:

a the four terrestrial planets

b the four gas giants

c three dwarf planets.

2 **State** which of the following 'space rocks' come from the Oort Cloud.

A asteroids

B comets

C meteoroids

D dwarf planets

3 Despite its great distance, the Oort Cloud is still being influenced by the Sun's gravitational pull. **Describe** the evidence that supports this claim.

# 9 Chapter review

## Remembering

**1** **State** whether the following statements are true or false:
- **a** Only large masses like planets, stars and moons have a gravitational field.
- **b** The further you go out from a planet, the weaker its gravity becomes.
- **c** A day on Earth is the time it takes for Earth to revolve once around the Sun.
- **d** Earth has four seasons because of its tilted axis.
- **e** On Earth, we only see one side of the Moon.
- **f** Pluto is a planet.

**2** **List** the four planets that are known as:
- **a** terrestrial planets
- **b** gas giants.

**3** **Name** the two celestial bodies that affect the location and size of the tides on Earth.

## Understanding

**4** **Explain** why constellations vary from one culture to another.

**5** **Describe** the shape of an ellipse.

**6** The Moon can still be seen during a lunar eclipse. **Explain** why.

**7** **Explain** why Earth experiences four seasons each year.

**8** **Describe** how the day and year are related to Earth's movement.

**9** **Predict** what the world would be like if there were no time zones and the globe was all at exactly the same time.

**10** Copy and complete the table below to **summarise** some of the information from this chapter.

| Type of object | Definition | Example |
|---|---|---|
| Planet | Orbits the Sun | Earth |
| Dwarf planet | | Pluto |
| Comet | | |
| Asteroid | | |
| Meteor | | |
| Meteorite | | |

## Applying

**11** You are about to fly between Perth and Brisbane. **Identify** where in your flight gravity will be:
- **a** the least
- **b** the greatest.

**12** Sanjay is a Year 7 student. He roughly sketched the diagram of the solar system shown in Figure 9.5.1, but forgot to add labels and didn't draw every orbit. **Identify** which of the orbits he drew most likely represents that of:
- **a** Earth (an inner planet)
- **b** the Moon
- **c** Neptune (an outer planet)
- **d** Pluto
- **e** Halley's comet.

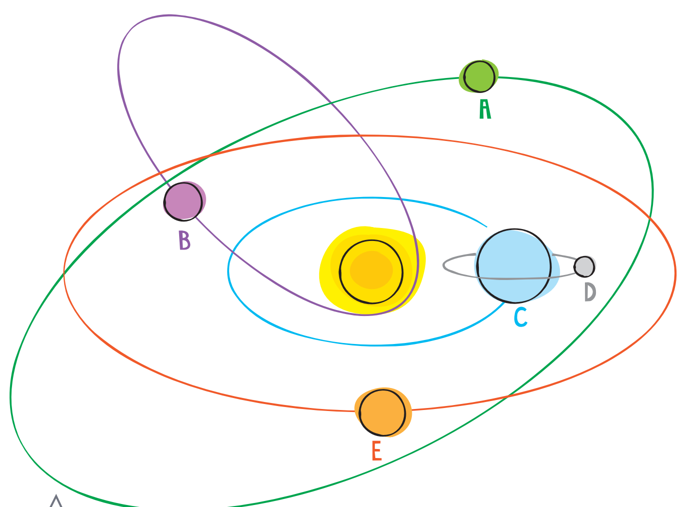



Figure 9.5.1

**13** Everything around you has its own gravitational field.
- **a** **Identify** what mass affects you the most.
- **b** **Explain** why other things like the wall or the person sitting next to you don't influence you much.

**14** **Use** a diagram to **clarify** the terms *aphelion* and *perihelion*.

## Analysing

**15** **Calculate** whether you were born in a leap year or not.

**16** **Contrast**

- **a** a comet with a meteor
- **b** the geocentric and helicentric models of the solar system
- **c** an eclipse with an ellipse.

## Evaluating

**17** Gravity always pulls you down. **Assess** whether this statement is true, false, or a bit of both.

**18** Geology is the study of the Earth, and the geocentric model has Earth at its centre. **Use** this information to **propose** a meaning for the prefix geo-.

**19** How should Australians prepare for the possibility of a major meteorite impact? **Propose** a set of measures for individuals and for the Federal Government.

**20** Below is a list of areas of astronomical research.

- **a** **Assess** which is most important.
- **b** **Justify** your answer.

- Search for extraterrestrial life
- Search for asteroids/comets that could collide with Earth
- Robot missions to the moons of Jupiter and Saturn
- A crewed mission to Mars

**21** The International Space Station (ISS) orbits Earth 340 km above its surface. On board, astronauts float around in 'weightless' conditions. Two Year 7 students are arguing about what this means. Joe says this proves there is no gravity at the height of the ISS. Sarah disagrees, saying that there must be gravity at that height.

- **a** Use the evidence given above to **draw** your own conclusion.
- **b** **Justify** your response.

## Creating

**22** A mnemonic is a way of remembering the order of something. **Create** your own mnemonic to help you remember the order of the planets of the solar system.

**23** **Construct** a diagram showing a comet at various points of its orbit. Clearly label the direction of motion of the comet and the size and direction of its tail.

**24** The ancients reacted to solar and lunar eclipses with amazement and fear because they did not know why they happened. Imagine you are one of the ancients seeing a solar eclipse for the first time. **Create** a short news item for your local newspaper *Neanderthal News* or a short news item for the current affairs show *Neolithic Nightly*. Your item must describe what you saw and how people around you reacted.

**25** **Use** the following ten key words to **construct** a visual summary of the information presented in this chapter:

stars, constellation, gravity, orbit, ellipse, Sun, Earth, Moon, tides, comet

# Thinking scientifically

The Bayer system is used to name stars within a constellation. It uses the Greek alphabet to name them, with alpha ($\alpha$) being the brightest star. Beta ($\beta$) is used for the next brightest, gamma ($\gamma$) for the next and so on.

The two pointers of the Southern Cross are $\alpha$-Centauri and $\beta$-Centauri. In another constellation are Alpha-Cygni and Beta-Cygni.

**Q1** Use this information to state which of the following stars would be the brightest.

- **A** $\alpha$-Centauri
- **B** $\beta$-Centauri
- **C** Alpha-Cygni
- **D** Beta-Cygni
- **E** $\alpha$-Centauri AND Alpha Cygni
- **F** $\beta$-Centauri AND Beta Cygni
- **G** $\alpha$-Centauri is brighter than $\beta$-Centauri and Alpha-Cygni is brighter than Beta-Cygni but there is not enough information to tell whether $\alpha$-Centauri is brighter than Alpha-Cygni or whether $\beta$-Centauri is brighter than Beta-Cygni.

The first six letters of the Greek alphabet are $\alpha$ (alpha), $\beta$ (beta), $\gamma$ (gamma), $\delta$ (delta), $\varepsilon$ (epsilon) and $\zeta$ (zeta).

**Q2** Use this information to identify which of the following lists its stars in the correct order from brightest to least bright.

- **A** $\alpha$-Crucis, $\delta$-Crucis, Gamma-Crucis, Zeta-Crucis
- **B** $\beta$-Geminorum, Beta-Crucis, $\beta$-Cygnis, Beta-Orionis
- **C** $\delta$-Geminorum, $\delta$-Centauri, $\delta$-Cygni, $\delta$-Crucis
- **D** $\beta$-Geminorum, Gamma-Geminorum, Delta-Geminorum, $\varepsilon$-Geminorum

Density determines whether an object sinks or floats. Basalt rock has a density of around 3.0 g/cm$^3$ while the density of pure water is 1.0 g/cm$^3$. These densities suggest that a lump of basalt will sink when placed in water. The average density of a human is 1.01 g/cm$^3$. We are slightly denser than water and so will sink very slowly into it.

The table below shows the density of the eight planets of the solar system.

| Planet | Density (g/cm$^3$) |
|---|---|
| Mercury | 5.427 |
| Venus | 5.204 |
| Earth | 5.515 |
| Mars | 3.934 |
| Jupiter | 1.326 |
| Saturn | 0.687 |
| Uranus | 1.27 |
| Neptune | 1.638 |

Use the following key to answer questions 3 to 6.

- **A** Mercury, Venus, Earth, Mars
- **B** Mercury, Venus, Earth
- **C** Jupiter, Saturn, Uranus, Neptune
- **D** Saturn

**Q3** Identify the planet(s) that are most likely to be rocky.

**Q4** Identify the planet(s) you would most likely sink into.

**Q5** Identify the planet(s) on which a lump of basalt would sink.

**Q6** Identify which of the planet(s) would float on water.

# Glossary

## Unit 9.1

**Astrology:** the belief that the position of various celestial objects can directly affect the events of a person's life

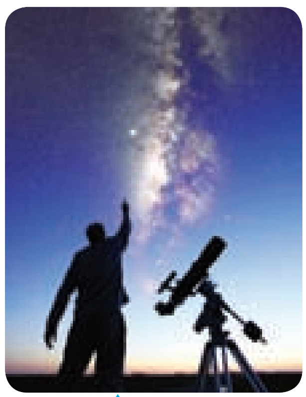
**Astronomy:** the scientific study of stars, planets and other celestial objects

**Constellation:** a group of stars that forms a recognisable pattern in the night sky

**Gas giants:** the large planets of the outer solar system: Jupiter, Saturn, Uranus, Neptune

**Milky Way:** the galaxy in which the solar system is located

**Terrestrial:** Earth-like, rocky. The terrestrial planets are Mercury, Venus, Earth and Mars



Milky Way

## Unit 9.2

**Artificial satellites:** satellites placed into orbit by humans

**Ellipses:** oval shape

**Geocentric model:** a model of the universe in which Earth is at the centre

**Gravitational force field:** invisible field that causes masses to be attracted to each other

**Gravity:** force of attraction between masses

**Heliocentric model:** model of the solar system in which the Sun is at the centre

**Lunar eclipse:** when the Earth blocks sunlight from reaching the Moon

**Mass:** matter

**Orbit:** path a planet takes around a star, or a moon or satellite takes around a planet

**Phases:** different shapes of the Moon as seen from Earth

**Retrograde motion:** apparent loop-like motion of the planets as seen from Earth

**Satellite:** a mass in orbit around another mass

**Solar eclipse:** when the Moon blocks sunlight from reaching the Earth

**Tides:** bulges in the ocean caused by the combined gravitational pull of the Moon and Sun

## Unit 9.3

**Axis:** the line connecting the north pole with the south pole. The Earth rotates around this axis

**Day:** the time a planet takes to rotate once completely on its own axis

**Leap year:** 366 days

**Revolution:** one complete orbit around the Sun

**Seasons:** caused by the tilt of a planet's axis

**Year:** the time a planet takes to revolve once around the Sun

Day

## Unit 9.4

**Aphelion:** point at which an object orbiting the Sun in an elliptical orbit is closest to the Sun

**Asteroid:** an irregular rocky object left over from the formation of the solar system; most are found orbiting the Sun between Mars and Jupiter

**Asteroid belt:** a group of asteroids orbiting between the orbits of Mars and Jupiter

**Comet:** a ball of ice, dust and rock that orbits the Sun in a highly elliptical orbit

**Meteor:** a meteoroid that burns up in the Earth's atmosphere

**Meteorite:** a meteoroid big enough to reach the surface of the Earth without burning up in the Earth's atmosphere

Comet

**Meteoroid:** a small piece of space rock that enters the Earth's atmosphere

**Perihelion:** point at which an object orbiting the Sun in an elliptical orbit is furthest from the Sun

**Solar wind:** stream of high-energy particles emitted from the Sun