

Getting closer to the stars!

Telescopes are used to see objects that are too far away to be seen with the naked eye. They also provide a closer view of distant things. Astronomers use large telescopes to study the planets, stars, and other objects in space. Without telescopes, we wouldn't know much about celestial bodies!

Lenses or mirrors?

Telescopes with lenses are called refracting telescopes. Lenses bend the light.

The largest telescopes use mirrors instead of lenses. Telescopes with mirrors are called reflecting telescopes. Mirrors reflect light.

Look through this end. The things you observe seem closer!

eyepiece: lens to view the image

focus adjustment: move this to make the image clearer



Some telescopes are small enough to be carried in one hand. Others can be huge, bowl-shaped radio telescopes, more than 300 metres in diameter. This is longer than three football pitches!

Optical telescopes consist of a long tube, with one end narrower than the other. They can “perceive” light, just like eyes.



tube

OOPS!
Wrong end!

objective lens: the lens closest to the object being viewed

How does a telescope work?

Objects reflect light. This light enters our eyes, and we see the object. Optical telescopes have an objective lens: a curved piece of glass at the wide end. This lens bends the light from the object so that it forms an image – a picture of the object – inside the telescope. The light from this image then goes through the eyepiece, at the narrow end of the telescope. The eyepiece bends the light back again, so the object looks big.



The Gran Telescopio Canarias (GTC), also called GranTeCan, is a 10.4 m reflecting telescope, located on a volcanic peak (2,400 metres) on the island of La Palma, Spain.

It took seven years to construct!

tripod: three-legged stand to support the telescope

Activities

1. **Galileo Galilei invented the telescope.** Why was this such an important discovery? What did astronomers know about the stars before then?
2. **Research. Have you heard of the Hubble telescope?** When was it built? Where is it? What pictures does it take?

The Universe

What do you remember?

- What are the points of light in this photo?
- What is the difference between ...
 - a star and a planet?
 - a moon and a comet?



Content objectives

In this unit, you will ...

- Learn about the characteristics of the Universe
- Calculate astronomical sizes and distances
- Analyse the components of the Universe
- Compare sizes: the Sun and the planets
- Create a constellation poster

Key language

Describing

Planets are spherical bodies which orbit the Sun.

Asteroids are rocky objects which are irregular in shape.

Comparing

Dwarf planets are smaller than planets.

The Earth is larger than Mercury.

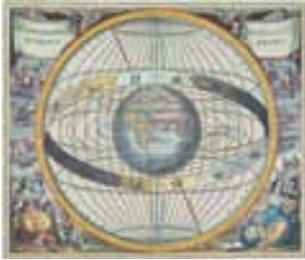
Giving instructions

Study the constellations.

Research more about them on the Internet.

1. What is the Universe like?

Scientists developed two different theories to explain what the Universe was like.



- **Geocentric theory**

2nd century BC: Ptolemy proposed that the Earth was the centre of the Universe. That is, the Sun, Moon and planets orbited the Earth.



- **Heliocentric theory**

In 1542, Nicolas Copernicus proposed that the Sun was at the centre of the Universe.

In 1610, Galileo Galilei invented the telescope, and proved the Heliocentric theory: the planets and stars revolve around the Sun.

What makes up the Universe?

The Universe is all the matter, energy and space that exists.

The Universe is made up of **galaxies** which contain stars. Stars can have planetary systems made up of planets and satellites. Galaxies are separated by vast spaces.

Galaxies are a vast collection of stars, dust and gases, held together by the gravitational attraction between the components. They appear in groups called **galaxy clusters**. Scientists think the vast spaces between the galaxies are empty. Our galaxy, the **Milky Way**, belongs to the **Local Group** galaxy cluster.

Stars form when clouds of gases are pulled together by gravitational forces. They are so hot inside that they emit heat and light. A galaxy can have up to five hundred thousand million stars. An enormous cloud of gas and dust, a **nebula**, surrounds the stars.

Planets are bodies which orbit some stars. They do not emit light; they receive light from the star. They make up **planetary systems**. Our planetary system is the **Solar System**. It is made up of eight planets and one star, the **Sun**, as well as moons, comets and asteroids. The Solar System is located on a spiral arm of the Milky Way.

Natural satellites orbit some planets. The Earth's natural satellite is the **Moon**.



Activities

1. Find ten words in the word search.

M	P	L	A	N	E	T	S
I	G	R	L	A	A	S	A
L	U	A	T	S	R	P	T
K	N	E	L	T	T	A	E
Y	S	E	N	A	H	C	L
W	O	H	B	R	X	E	L
A	T	M	S	U	N	Y	I
Y	M	O	O	N	L	G	T
K	E	S	W	C	P	A	E

2. Imagine an alien friend from another galaxy wants to write to you. Write your galactic address.

2. How big is the Universe?

The Earth seems huge, but, in reality, it is small compared to the Sun. The Sun is only one of the millions of stars in the Milky Way.

To imagine the size of the Universe, use these comparisons with everyday objects.

- Imagine the Sun is the size of a pea.
- The closest star is another pea, five hundred and forty kilometres away from the first pea.
- The Earth is like a particle of dust situated two metres away from the first pea.
- The Milky Way contains one hundred thousand million peas which form a circle with a radius of seven million kilometres.

What units of measurement do astronomers use?

- **Astronomical unit (AU).** This is the distance from the Earth to the Sun. Approximately **150 million kilometres**. Compare the distance of these planets from the Sun:
 - Mercury: 0.4 AU
 - Mars: 1.5 AU
 - Pluto: 39.4 AU
- **Light-year.** This is the distance light travels in one year. Light travels 300,000 km in one second or **9.5 trillion km in one year.**

Activities

- Express the distance of Mercury, Mars and Pluto from the Sun in kilometres.



Mars



Mercury



Pluto

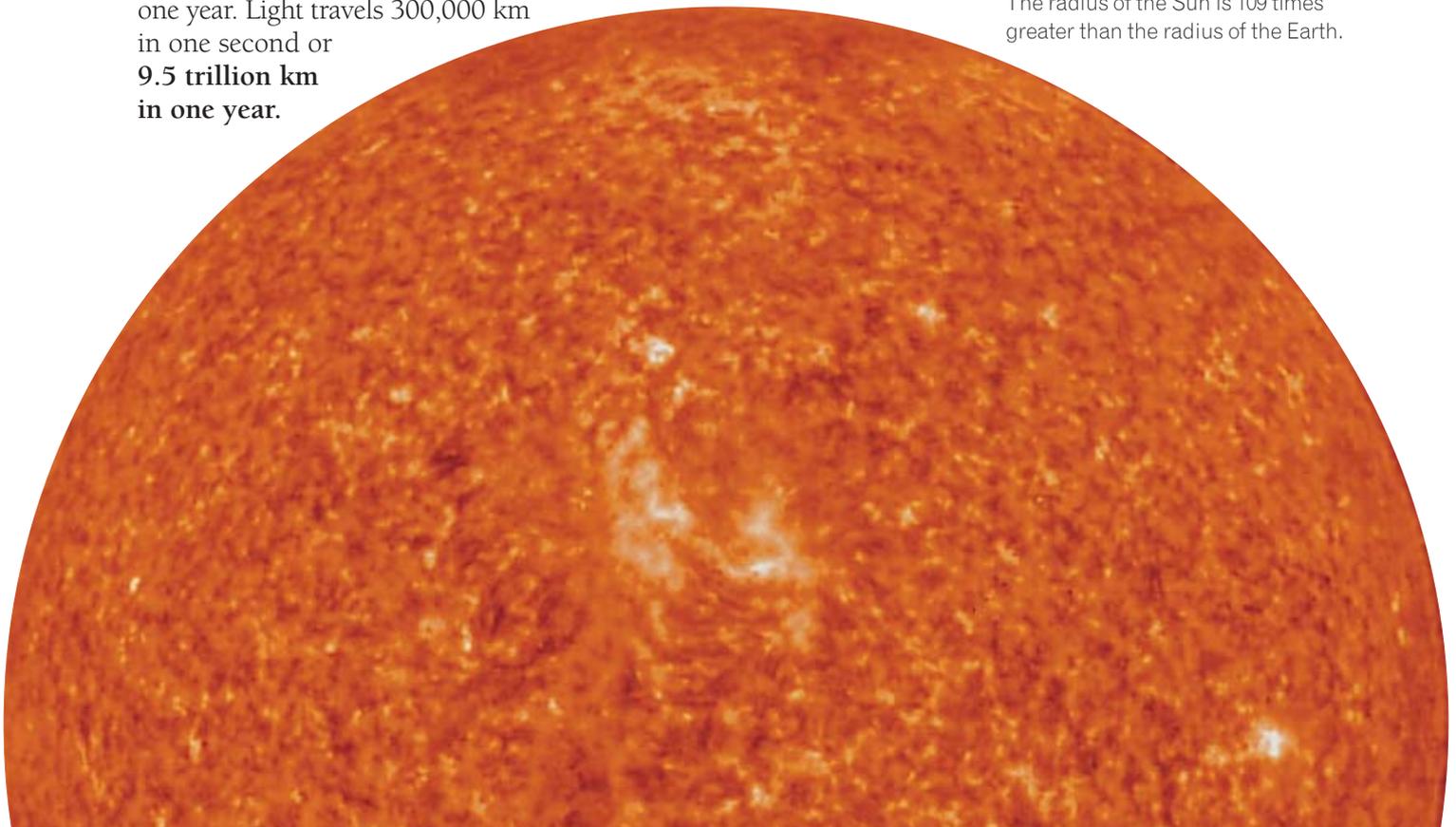
- Research the term *light-year*. Why is it used in astronomy?

Did you know that...?

Source of light	Time to reach the Earth
the Sun	8 mins. 20 sec
Centauri, the nearest star	4 light-years
Betelgeuse	500 light-years



The radius of the Sun is 109 times greater than the radius of the Earth.



3. What makes up the Solar System?

The Solar System was formed approximately five thousand million years ago from the gas and dust of a nebula.

Our Solar System is made up of the **Sun**, eight **planets** with their **satellites**, **dwarf planets** and **small solar system bodies**. The Sun is the central body.

- The **Sun** consists mainly of two gases: **hydrogen** and **helium**. It is the closest star to Earth.
- **Planets** are spherical bodies which revolve around the Sun. They all move in elliptical orbits, held by the gravitational force of the Sun. Planets are much larger than other celestial bodies which orbit the Sun. **Mercury**, **Venus**, **Earth** and **Mars** are made up mainly of rock. **Jupiter**, **Saturn**, **Uranus** and **Neptune** are made up mainly of gases.
- **Dwarf planets** are spherical bodies which orbit the Sun. They are smaller than planets.
- **Small solar system bodies** are other celestial bodies which orbit the Sun. They include **asteroids**, **comets** and **satellites**. Satellites orbit planets and consist of rock.

How do the planets move?

Celestial bodies like the Earth, have two types of movement:

Rotation. Celestial bodies spin or rotate on an invisible axis. This invisible line is called the **rotational axis**.

Revolution. Celestial bodies **revolve** around other celestial bodies.

Orbit. A curved path which a celestial body follows in its revolution around another celestial body. The orbit of the Earth around the Sun is an **ellipse**.

The planets in the Solar System

Planet	Distance from Sun (AU)	Period of rotation	Period of revolution
Mercury	0.39	58.65 days	88 days
Venus	0.72	243 days	224.6 days
Earth	1.00	23 h 56 mins	365.25 days
Mars	1.52	24 h 37 mins	1.88 years
Jupiter	5.20	9 h 55 mins	11.86 years
Saturn	9.54	10 h 40 mins	29.46 years
Uranus	19.19	17 h 14 mins	84.07 years
Neptune	30.06	16 h 7 mins	164.82 years

Activities

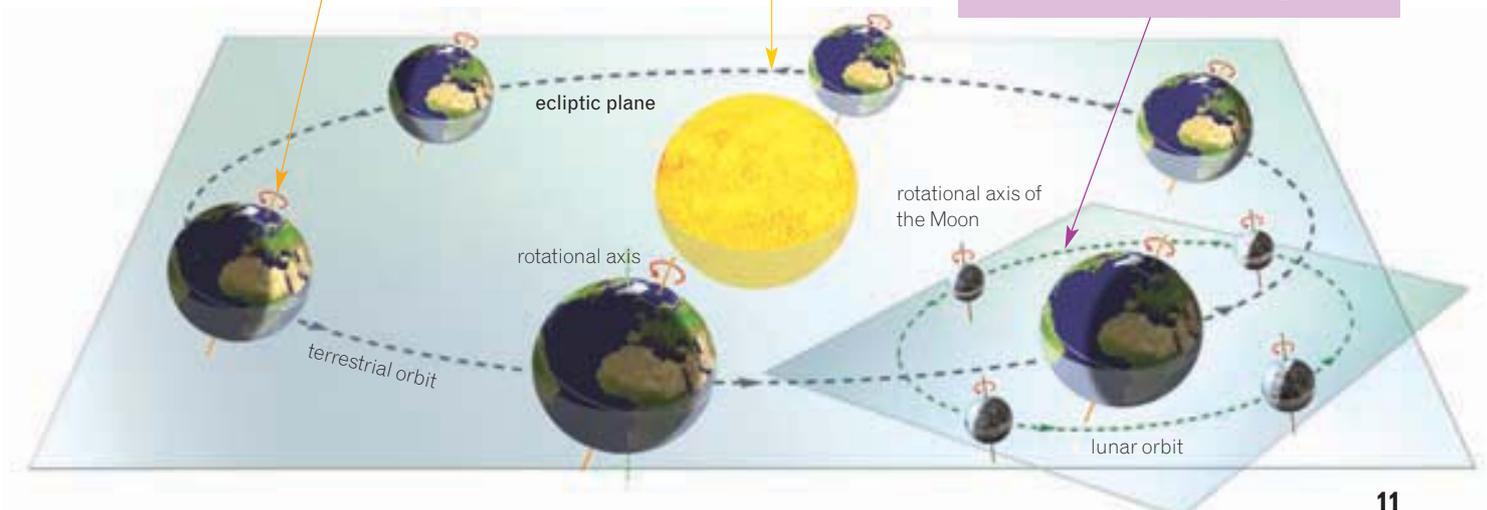
5. Which planet ...

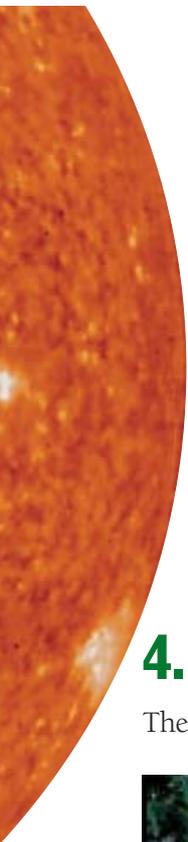
- takes the longest to orbit the Sun?
- is the fastest to orbit the sun?
- has the longest days?
- has the shortest days?

6. Why is a "day" on Venus longer than its "year"?

7. What is an orbit?

8. What do you call the imaginary plane of the Earth's orbit?





Mercury
Diameter: 4,880 km



Venus
Diameter: 12,104 km



Earth
Diameter: 12,740 km



Mars
Diameter: 6,794 km

4. Which are the inner planets?

The inner planets are the four planets closest to the Sun: **Mercury**, **Venus**, the **Earth** and **Mars**.



The Earth is the only planet that has life on it. The other planets are too hot or too cold.



In 2004, the robots Spirit and Opportunity landed on Mars. They investigated the possible existence of water.

Did you know that...?

Pluto, Ceres and Eris are dwarf planets. Pluto used to be considered a planet. In 2006, the International Union of Astronomers reclassified it as a dwarf planet.



Ceres

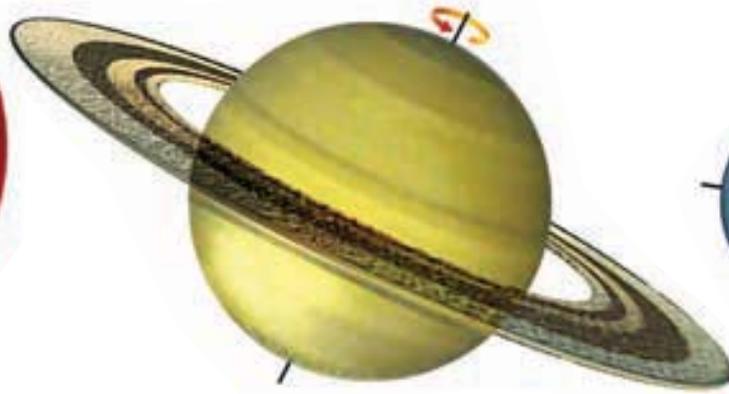
	INNER PLANETS			
	Terrestrial or rocky planets: the crust and mantle are made of rock. The core is metallic			
	Mercury	Venus	Earth	Mars
Diameter (Earth = 1)	0.382	0.949	1	0.532
Diameter (km)	4,880	12,104	12,740	6,794
Average surface temperature (°C)	-180 to 430 °C	465 °C	-89 to 58 °C	-82 to 0 °C
Atmosphere	none	CO ₂	N ₂ +O ₂	CO ₂
Satellites	0	0	1	2
Rings	no	no	no	no
Interesting characteristics	the smallest and closest to the Sun	rotates in opposite direction	the only planet with life	very thin atmosphere

CO₂ = carbon dioxide

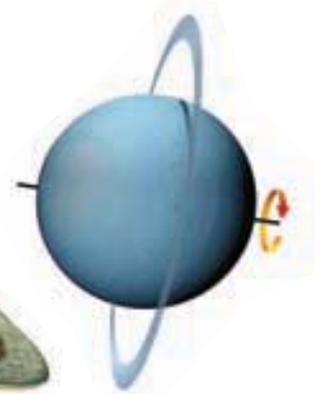
N₂ + O₂ = nitrogen + oxygen



Jupiter
Diameter: 142,984 km



Saturn
Diameter: 120,536 km



Uranus
Diameter: 51,118 km

5. Which are the outer planets?

Jupiter, Saturn, Uranus and Neptune are the four outer planets. They are called gas giants because they consist mainly of gases.



Saturn's rings are made up of small particles, mostly ice.



Neptune
Diameter: 49,492 km

OUTER PLANETS			
Gas giants: they consist mainly of gases			
Jupiter	Saturn	Uranus	Neptune
11.209	9.44	4.007	3.883
142,984	120,536	51,118	49,492
-150 °C	-170 °C	-200 °C	-210 °C
H ₂ +He	H ₂ +He	H ₂ +He	H ₂ +He
63	59	27	13
yes	yes	yes	yes
largest planet, most satellites	system of rings	rotational axis is almost horizontal	greatest distance from the Sun

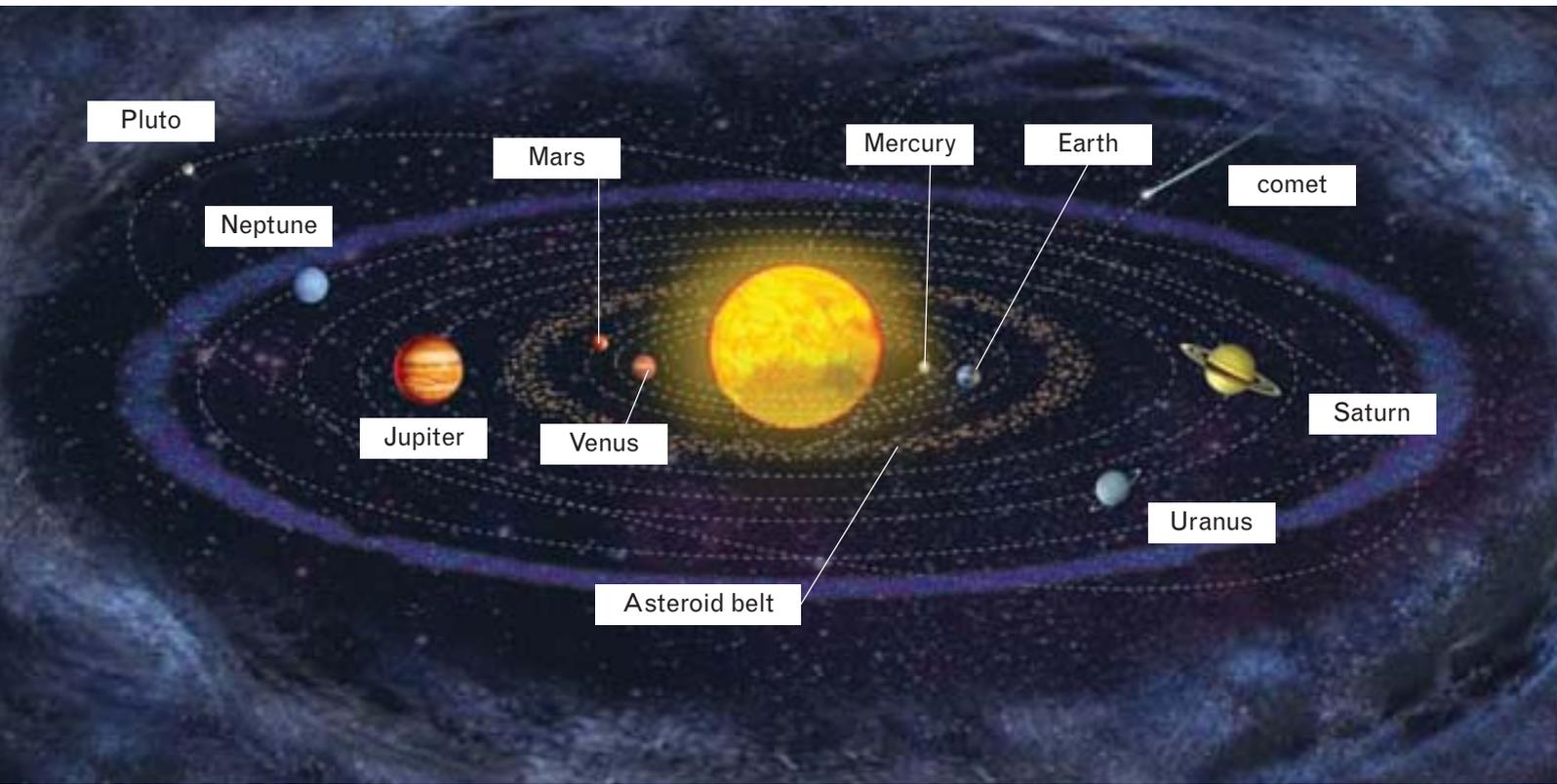
H₂ = hydrogen He = helium

Activities

9. Which planet ...

- has the most satellites?
- is closest to the Sun?
- supports life?
- is the largest in the Solar System?
- spins on its axis in the opposite direction?

10. If you live on Venus, will the Sun rise in the East and set in the West?



The Solar System. Observe the elliptical paths of the planets' orbits around the Sun. Notice that the orbit of Pluto, a dwarf planet, is more inclined.

6. What are small Solar System bodies?

There are two main types: asteroids and comets. They orbit the Sun.

- **Asteroids** are rocky objects which are irregular in shape. They can be several hundred kilometres in diameter, but most are only a few metres wide. Asteroids orbit around the Sun. Most of them are between the orbits of Mars and Jupiter. This area is called the **asteroid belt**.
- **Comets** are small bodies that travel around the Sun in highly elliptical orbits. They are irregular in shape. The **nucleus** is made up of a mass of ice, dust and gas. When comets travel close to the Sun, some of the ice evaporates, creating the long, bright tails of the comets.



Halley's comet has a bright tail. It was named after the English scientist Edmund Halley. He was the first scientist to calculate the orbit of this comet. Halley's comet will next be visible from Earth in 2061.

Activities

11. Compare the main characteristics of the inner and outer planets.
12. Describe an inner or outer planet. Your partner will identify it.

<i>This inner planet This outer planet</i>	<i>is smaller / larger than is the largest / smallest. has (no)</i>	<i>the Earth. ... satellites.</i>
<i>The atmosphere</i>	<i>is made up of</i>	<i>carbon dioxide. helium. ...</i>

Hands on

Prepare a constellation poster

Constellations are imaginary patterns of bright stars. All societies have invented constellations. The Ancient Greeks invented the constellations we call the twelve signs of the zodiac.

There are 88 official constellations. However, most of them do not really look like the mythical figures they represent.

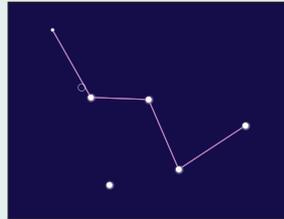
The night sky looks different in the Northern and Southern Hemispheres. The position of the constellations changes with the seasons because of the movement of the Earth.

1. Study these constellations. Which ones can you see in the night sky where you live?

The constellation Orion



Orion represents the hunter.
The three stars in the middle are his belt.
His sword hangs from his belt.
You can see his sword and his bow.



Cassiopeia



Orion



Ursa major



Gemini

2. Choose one of the constellations and make a poster.
 - a. Find more information in encyclopedias or on the Internet.
 - b. Draw the constellation, or cut out a drawing or a photo of it.
 - c. Write some sentences about the constellation.

Activities

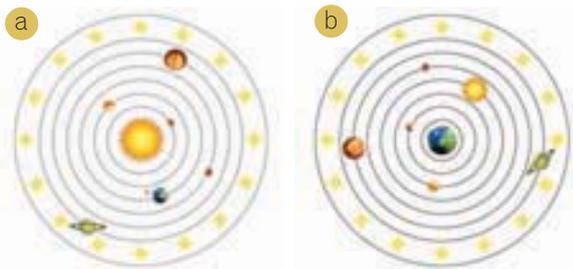
13. Look up the constellation for your sign of the zodiac.
 - a. Find out where and when it is most clearly visible in the sky. Is it in the Northern or the Southern Hemisphere?
 - b. Write the dates associated with this sign.
14. Choose another constellation.

Research more about it on the Internet.

Activities

15. Label each diagram with the name of ...

- a. a theory of the universe
- b. the person who proposed the theory.



16. Make a drawing of the Solar System and label it: the Sun, the inner planets, the outer planets, Pluto and the asteroid belt.

17. Make a timetable of your daily activities on these planets. Give an approximate duration for each.

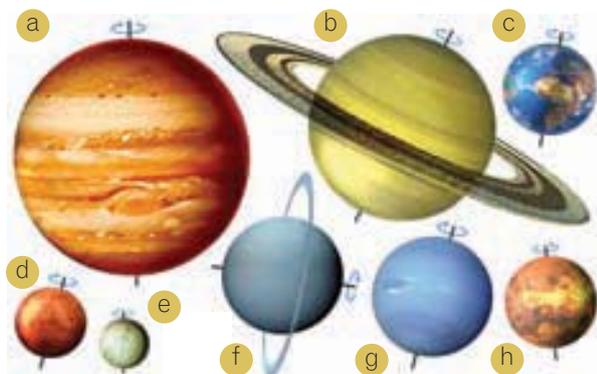
- Earth. Rotation: 24 hours
- Mercury. Rotation: 58.65 Earth days
- Jupiter. Rotation: 9.841 Earth hours

Activities	Duration on ...		
	Earth	Mercury	Jupiter

18. What two types of movement do all planets have? Describe them.

19. Describe the composition, temperature and movement of the Sun.

20. Make an illustrated list of the planets. Write them in order: start with the closest one to the Sun.



21. Talk about astronomical distances with a partner.

How far away is ... from ...?

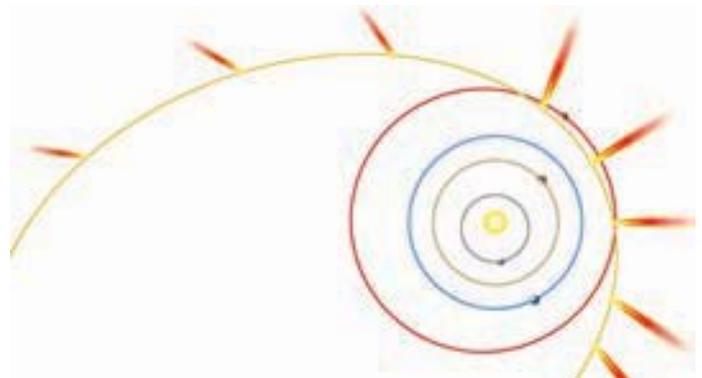
It is ... km | ... light-years away.

Astronomic distances from the Earth	
Object	Distance
space station	300 km
weather satellite	36,000 km
the Moon	384,000 km
the Sun	150,000,000 km
Pluto	6,000,000,000 km
Alpha Centauri	4 light-years

22. Research the latest astronomic discoveries. Report your findings to the class.

23. This drawing shows the positions of a comet in orbit.

When a comet gets close to the Sun, why does it develop a tail? Why does an asteroid not?



24. Draw a diagram of the Solar System seen from above. Include the rotation and revolution movements of each planet.

25. Copy and complete to situate the Moon in the Universe:

The Moon is a satellite of ... which belongs to the planetary system called The star of this planetary systems is It belongs to a galaxy called This galaxy is part of the galaxy cluster called

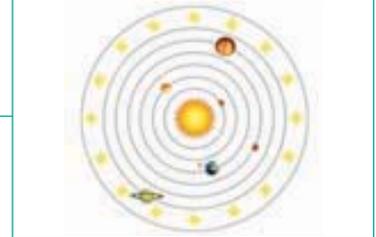
What should you know?

1

THE UNIVERSE

Early concepts

- Geocentric theory: the Earth is the centre of the Universe. The Sun, Moon, stars and planets revolve around the Earth.
- Heliocentric theory: the Sun is the centre of the Universe. The Earth, planets and stars revolve around the Sun.



Components

- Galaxies are grouped together in galaxy clusters.
- Galaxies contain thousands of millions of stars.
- Stars are massive spherical bodies of gases. Some stars have planetary systems with planets, satellites, asteroids and comets.



Units of measurement

- Astronomical unit (AU): the distance between the Earth and the Sun, about 150 million kilometres.
- Light-year. The distance that light travels in one year: about 9.5 trillion kilometres.

The Solar System

The Solar System is the planetary system of our Sun. It consists of:

- The Sun: a medium-sized star in the Milky Way galaxy.
- Planets:
Inner: Mercury, Venus, Earth and Mars. All are rocky.
Outer: Jupiter, Saturn, Uranus, and Neptune. All are gaseous.
- Dwarf planets: Pluto, Ceres, Eris
- Natural satellites: celestial bodies which revolve around planets and dwarf planets.
- Small Solar System bodies
Asteroids: small rocky bodies which orbit the Sun. Some form belts. The asteroid belt: a band of asteroids between the orbits of Mars and Jupiter. Comets: masses of ice and rock found beyond the orbit of Pluto.



Projects

INVESTIGATE: Could Mars support life?

First, list the factors that make life possible on Earth.

Then, investigate this website: <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Mars>

 **WEB TASK:** Do you want to visit Mercury, Jupiter or Mars?

Planet Earth

What do you remember?

- In this photo, what does each colour correspond to?
- Is the Earth an outer or an inner planet?
- What is the interior of the Earth like?
- Where does life exist on Earth: in the geosphere or the biosphere?



Content objectives

In this unit you will ...

- Learn about the Earth's characteristics
- Identify lunar phases
- Describe the geosphere
- Learn about the Earth's "spheres"
- Reproduce conditions of solar and lunar eclipses

Key language

Describing

Water exists in three states.

It takes 28 days to orbit the Earth.

Expressing cause and result

This causes the sequence of day and night.

This makes the seasons occur.

Comparing

The days get shorter.

Ocean trenches are the deepest areas.

1. What is the Earth like?

The Earth is special for many reasons. The Earth is the only planet with:

- an atmosphere containing oxygen
- an average temperature of 15°C
- a water cycle
- life as we know it

All these characteristics make the Earth a unique planet in the Solar System.

- The **atmosphere** consists of a mixture of gases. **Nitrogen** and **oxygen** are the most abundant. Oxygen is essential for plant and animal respiration. There is also **carbon dioxide**, essential for photosynthesis.
- The **average temperature is 15°C** on the Earth's surface. This is possible because of the distance from the Sun and the composition of the atmosphere.
- Water exists in three states (ice, liquid, water vapour) due to temperature variations. These variations make the **water cycle** possible.

Activities

1. Draw a diagram of the Earth, as seen from space. Draw two people: one at the North Pole and one at the South Pole.
2. Find out the mixture of gases and the average temperatures of Venus and Mars. Why do you think life is only possible on Earth?

- The Earth has a relatively large **natural satellite**, the Moon. The gravitational attraction of the Moon causes ocean tides.
- The Earth's **magnetic field** protects living beings from dangerous solar radiations.
- Conditions exist for **life**. Thousands of millions of years of evolution have produced the variety of species there are today. This includes humans.
- There is considerable **geological activity** on the Earth: earthquakes, volcanoes, mountain building, erosion, etc.



Photo of the Earth and the Moon taken by satellite.

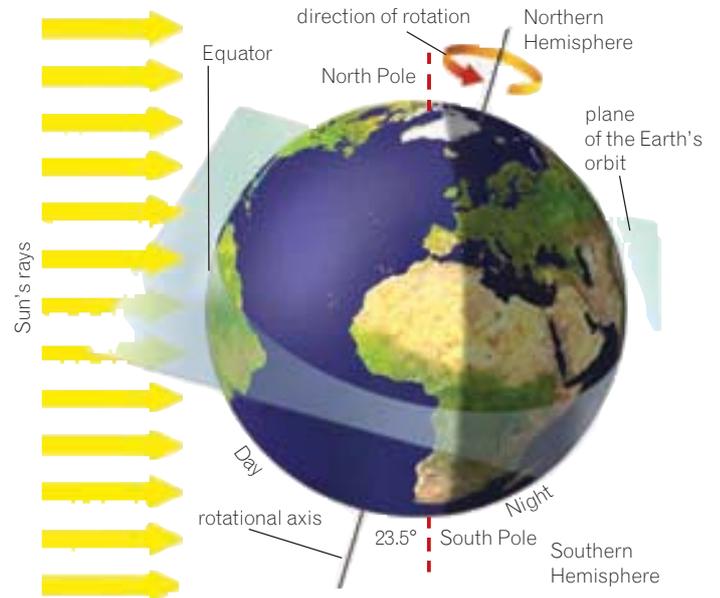


Volcanoes are proof of intense geological activity.

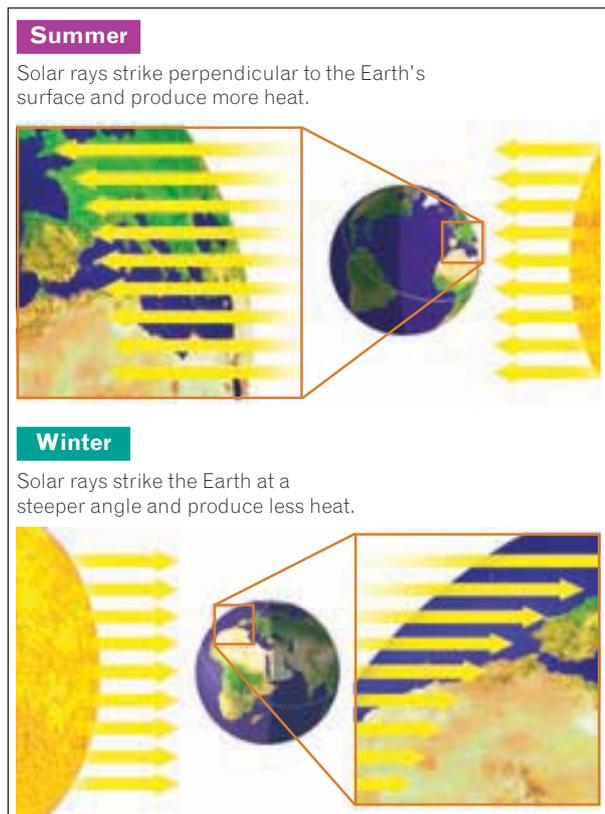
2. How does the Earth move?

The Earth moves in two different ways:

- **Rotation:** The Earth rotates on a slightly tilted axis, always in the same direction. This rotation causes the sequence of **day** and **night**.
- **Revolution:** The Earth's revolution around the Sun is an ellipse. It takes $365 \frac{1}{4}$ days to complete the revolution. This is one year.



The rotation of the Earth. It is day on the half of the Earth facing the Sun. It is night on the half facing away from the Sun.



What causes the seasons on Earth?

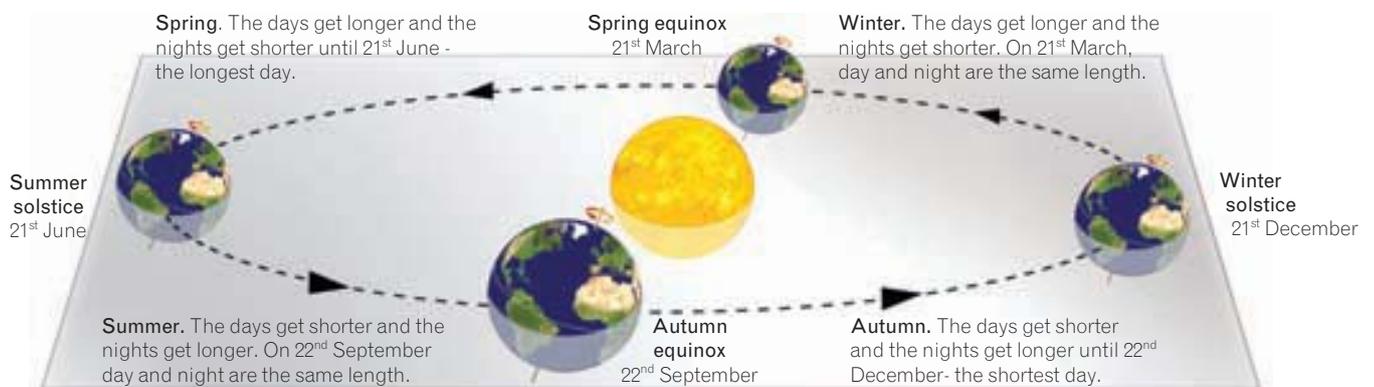
Two factors combine to cause the seasons:

- the revolution of the Earth around the Sun
- the Earth's axis is tilted at an angle of about 23.5°

The tilt of the axis causes differences in temperature and in the duration of day and night.

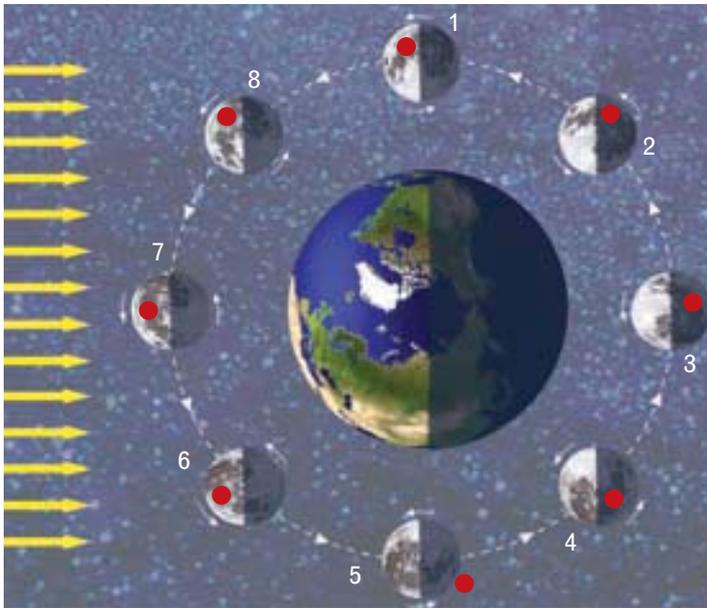
The Sun's rays strike the Earth in different ways depending on the seasons.

The tilt of the axis makes the seasons occur at different times of the year in the Northern and Southern Hemispheres.



The seasons in the Northern Hemisphere

3. How does the Moon move?



The same side of the Moon always faces the Earth. The red dot indicates the dark or hidden side. It is never visible from Earth.

The Moon moves in two different ways:

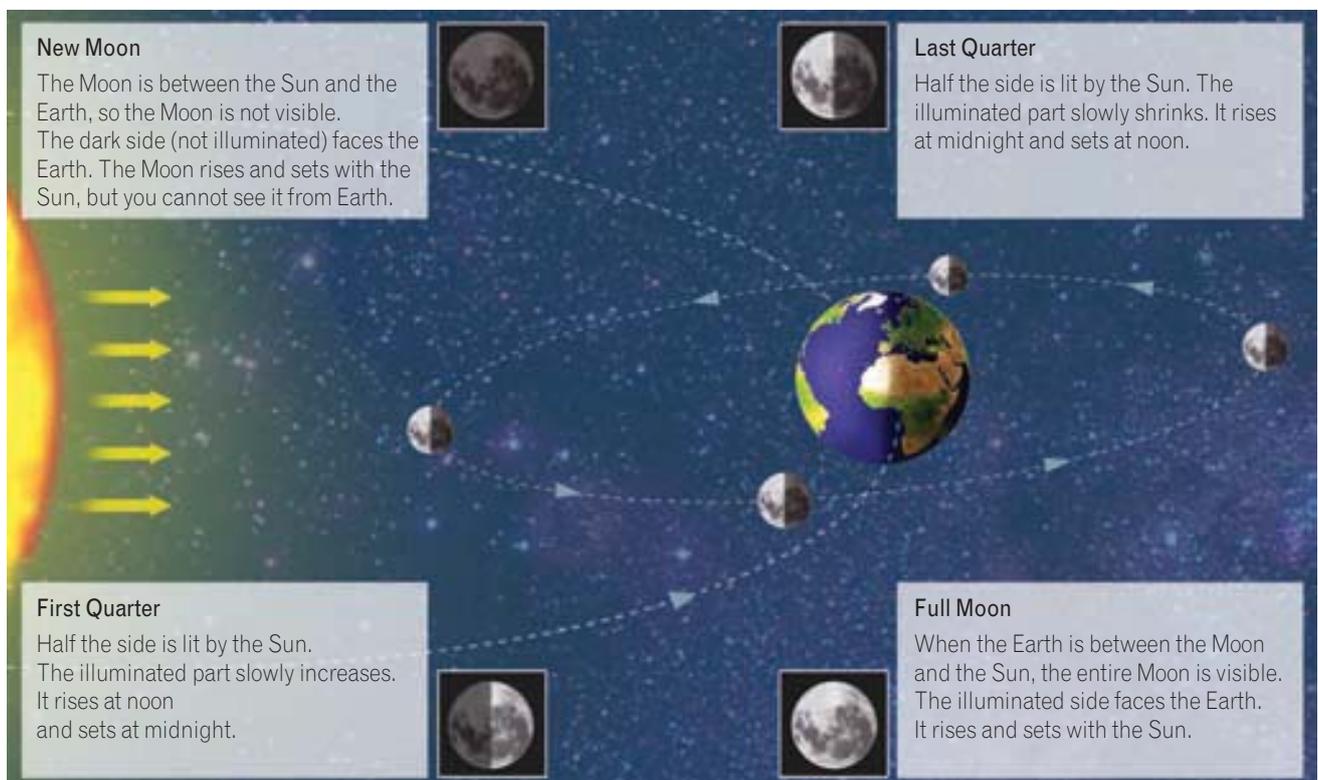
- **Rotation.** The Moon takes 29.5 days to **rotate** once on its axis: a “lunar day”.
- **Revolution.** The Moon takes about twenty-eight days (twenty-seven days and eight hours) to **orbit** the Earth once.

A “**lunar month**” is the period of time between two new moons. It is about 29.5 days. A “lunar day” is as long as a “lunar month”. As a result, the same side of the Moon always faces the Earth.

Activities

3. Draw a diagram to show the phase of the Moon in the Northern Hemisphere today.
4. When is there a New Moon?
5. Draw a diagram of the phases of the Moon in the Southern Hemisphere.

The phases of the Moon



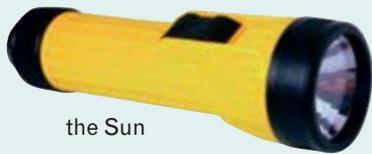
Hands on

Reproducing eclipses

If the Moon passes between the Sun and the Earth, and blocks off the sunlight, a **solar eclipse** occurs.

If the Moon passes behind the Earth, so the Earth prevents sunlight from reaching the Moon, a **lunar eclipse** occurs.

Materials



the Sun

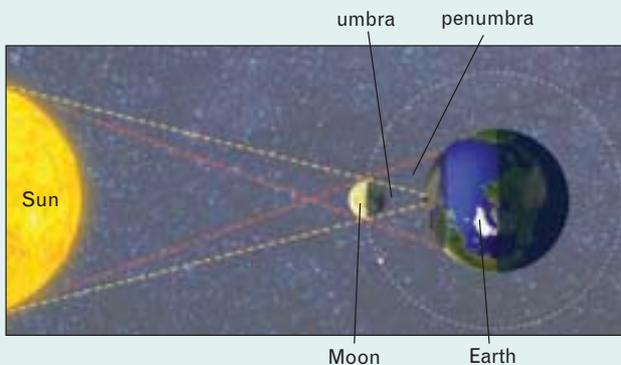


the Moon

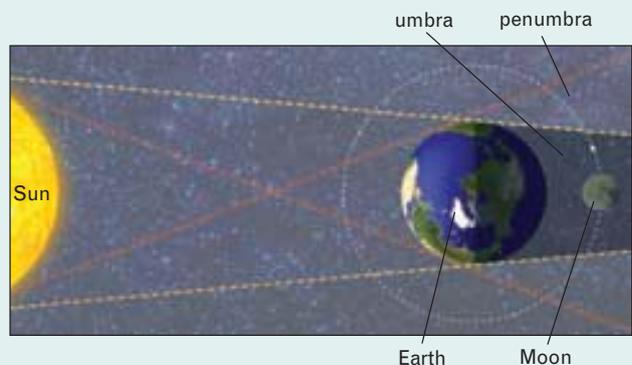


the Earth

1. Reproduce a solar eclipse. Position the planets: the Moon should block the Sun's light and project a shadow on the Earth.
2. Reproduce a lunar eclipse. Position the planets: the Earth should block the Sun's light and project a shadow on the Moon. Remember: a lunar eclipse can only take place during a full moon.
3. In your notebooks, copy the diagrams for both eclipses.



Solar eclipse



Lunar eclipse

Activities

6. Find out when the next solar and lunar eclipses will take place.
Visit this site:
<http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html>
7. How must you protect your eyes when observing a solar eclipse?