Biology and Geology

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Biology and Geology 1 is a collective work, conceived, designed and created by the Secondary Education department at Santillana, under the supervision of **Teresa Grence Ruiz**.

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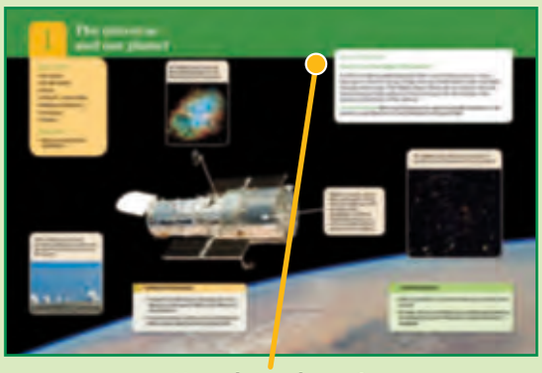
Do not write in this book. Do all the activities in your notebook.

SANTILLANA Richmond

FIND OUT ABOUT

Key competences

- Linguistic competence
- Competence in Mathematics, Science and Technology
- Digital competence
- Social and civic competence
- Cultural awareness and expression
- Learing to learn
- Initiative and entrepreneurship



How do we know?

Work with the image

Cooperative project **Know how to**

1 The universe and our planet

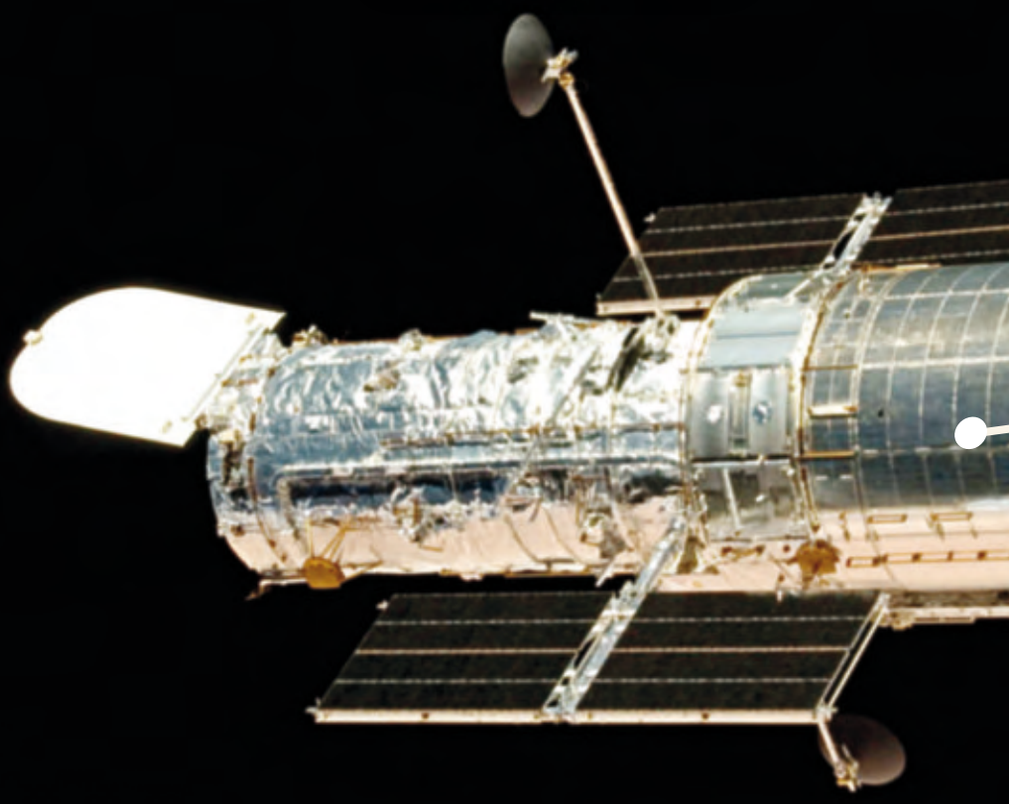
FIND OUT ABOUT

- The universe.
- The solar system.
- The planets.
- The Earth – a unique planet.
- The movements of the Earth.
- The seasons.
- The Moon.

KNOW HOW TO

- Observe and describe the constellations.

The Hubble Space Telescope takes detailed images of very distant objects in the universe.



Radio telescopes are large parabolic antennas located on the ground. They detect radio waves from space.

WORK WITH THE IMAGE

- Compare the Hubble Space Telescope and a radio telescope on the ground. What are the differences and similarities?
- A space telescope can observe very distant objects. What do those objects look like from the Earth?

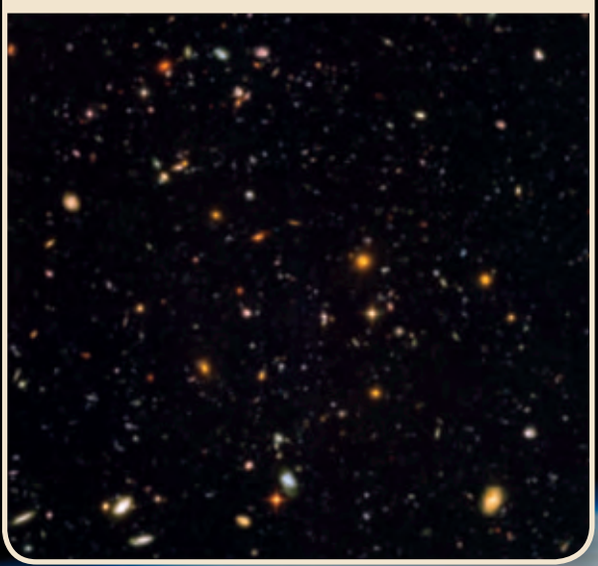
HOW DO WE KNOW?

How do we learn about the universe?

In 1610, the Italian mathematician Galileo was the first person to use a telescope to observe the sky. Today, there are Earth-based radio telescopes and space telescopes. The Hubble Space Telescope can observe the most distant regions in the universe. It has increased our knowledge of the structure and history of the universe.

GIVE YOUR OPINION. Which type of telescope can make more detailed observations of the universe: a space telescope or a radio telescope on the ground? Why?

The Hubble Space Telescope has made it possible to see the structure of our universe.



Hubble is a large, optical telescope in space which orbits the Earth above the distortion of the atmosphere. It detects visible light in space, as well as invisible infrared and ultraviolet radiation.

STARTING POINTS

- What can we find in our universe? What can you identify in the picture?
- The Earth, the Sun and the Moon are celestial bodies. What type of celestial body is each? What other celestial bodies do you remember?

LEARNING OBJECTIVES

- Describe the main components of the universe and the theory of its origin.
- Give examples of astronomical units of measurement.

1 The universe

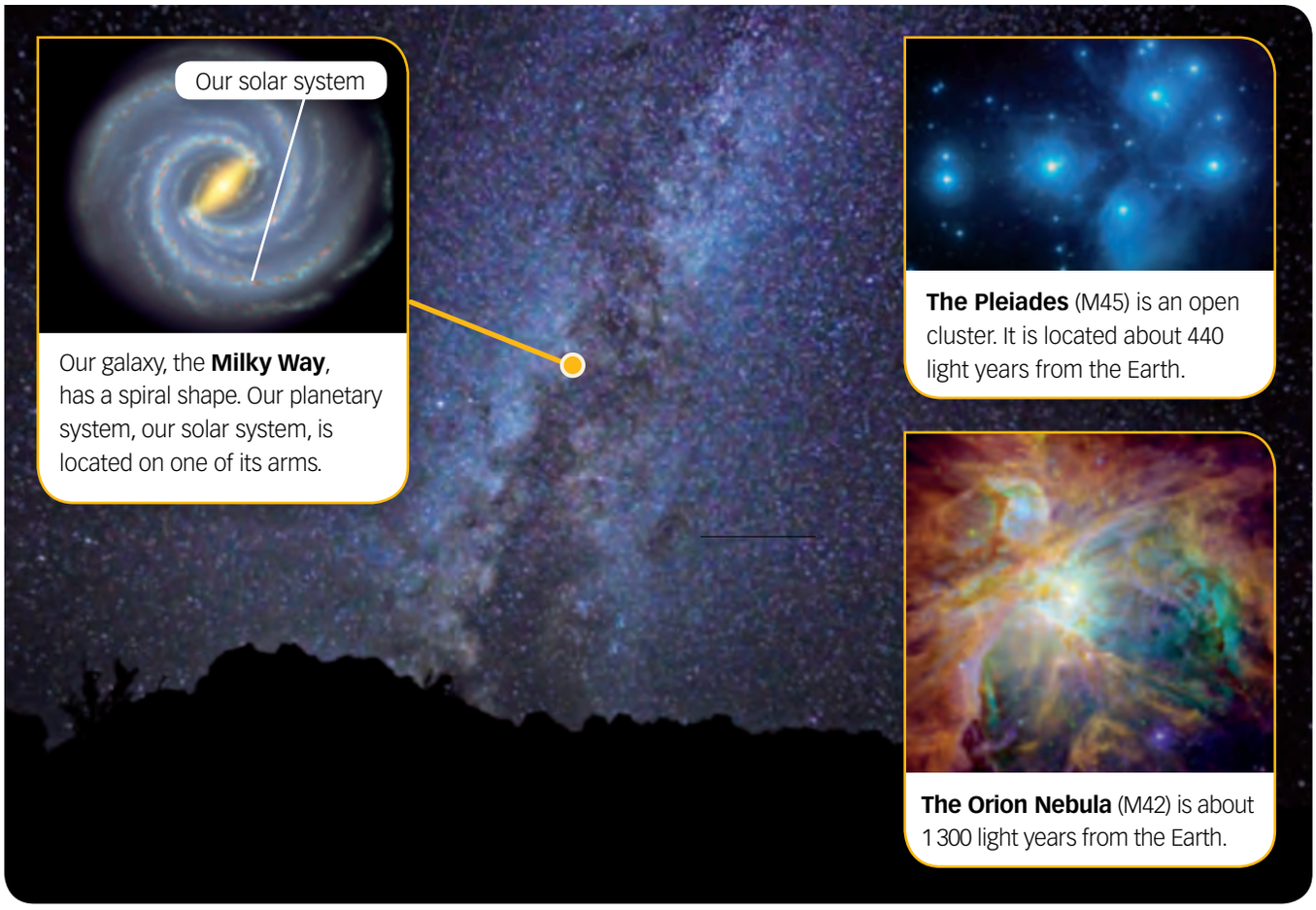
The universe is made up of hundreds of billions of **galaxies**. They are separated by enormous distances and the space between them is empty. Galaxies are usually found in groups or **galaxy clusters**.

A galaxy is a large group of **stars**: between 100 000 and 500 million. Towards the centre of the galaxy, the stars are close together, but in the outer areas of the galaxy they are farther apart. Stars are made up mainly of hydrogen and helium, the two most abundant gases in the universe.

Many stars have planets that revolve around them forming **planetary systems**, like our solar system.

Within a galaxy or at its edge, we can find groups of stars that were formed from the same molecular cloud. They are relatively close to each other and are called **open clusters**.

In addition to stars, galaxies contain nebulae. A **nebula** is a huge cloud of dust and gases, mainly hydrogen and helium.



The origin of the universe

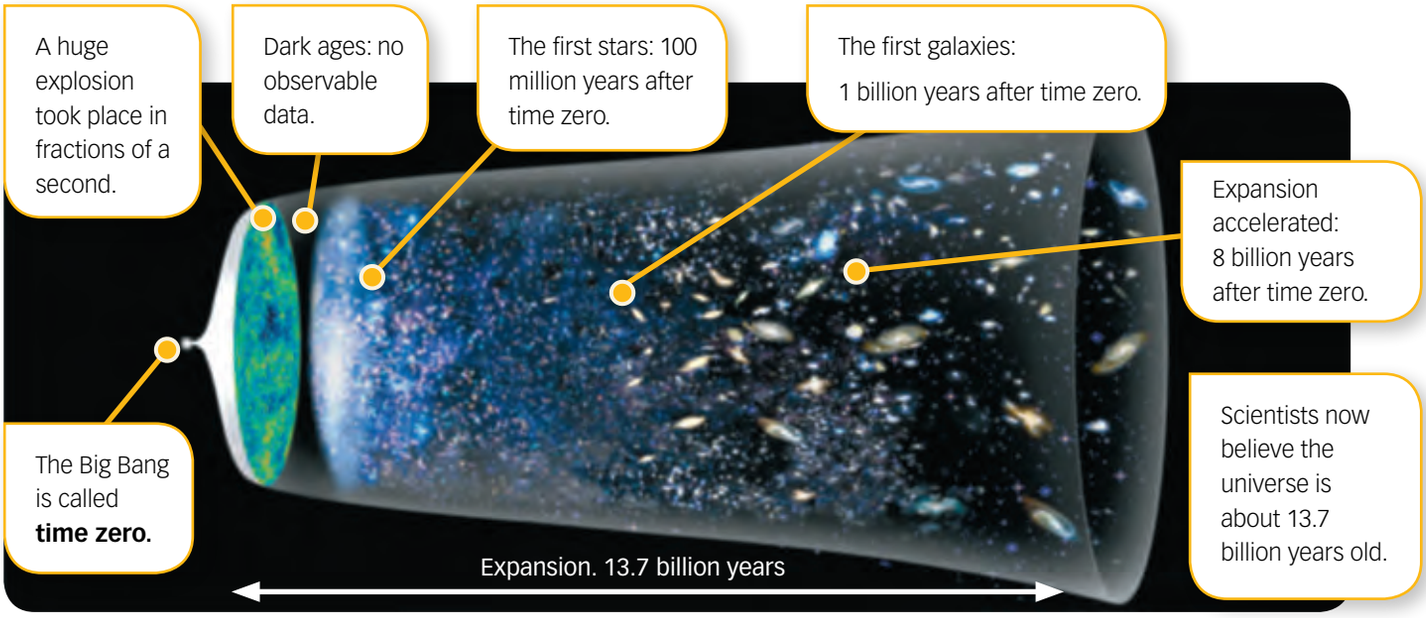
In 1965, scientists discovered that the galaxies were moving away from each other at increasing speed. In other words, millions of years ago, the galaxies were closer to each other.

One of the most accepted theories of the origin of the universe and this expansion is the **Big Bang Theory**. According to this theory, the universe came into existence about 13.7 billion years ago as a result of a very rapid expansion.

At first, the temperature of the universe was very high. Gradually it cooled, which made it possible for stars and planets to form.

WORK WITH THE IMAGE

1. What do these components of the universe look like?
   • *galaxy* • *planetary system*
   • *nebula* • *open cluster*
2. Compare the characteristics of the universe at three different times. How has it changed?



Distances and units of measurement in astronomy

The universe is so huge that special units of measurement are used to express distances within it:

- **Astronomical unit (AU).** This is the distance from the Earth to the Sun, approximately **150 million km**. This unit is used to express distances within the solar system. For example, compare the distance of these planets from the Sun: Mercury: 0.4 AU; Neptune: 30.6 AU.
- **Light year.** This is the distance light travels in one year. Light travels at a speed of 300 000 km per second, so in one year it travels about 9.5 trillion km. Light years are used to measure distances of objects outside the solar system. For example, the closest star to the Sun, Alpha Centauri, is about 4 light years away. The Milky Way has a diameter of about 100 000 light years.

ACTIVITIES

3. Make a model of the Big Bang. Draw constellations on a balloon and then inflate it.
4. Ask questions about distances: *How far away is ... from the Sun / the Earth?*
5. Why are AU and light year used to measure distances in the universe?
6. A commercial airliner travels at 1 000 km/h. How long would it take it to reach the Sun?

LEARNING OBJECTIVES

- Understand the differences between three models of the universe and the solar system.
- Describe the structure of the solar system.

WORK WITH THE IMAGE

1 What planets are missing from each model of the universe? How can you explain this?

2 Ask questions about the objects in the solar system: *Where is/are ... found? What is the ...?*

2 The solar system

Our understanding of the universe has changed throughout history. The ancient Greeks proposed a **geocentric model**. According to this model, the Earth was the centre of the universe and the Sun, Moon and planets orbited the Earth.

This model had its basis in observations of the Sun and the Moon. They appear in the east and move across the sky until they disappear in the west.

The geocentric model was accepted until about 500 years ago. Then in 1542, Nicolaus Copernicus proposed a **heliocentric model**. In this model, the Sun was the centre of the universe, and the planets and stars revolved around it. In 1610, Galileo Galilei invented the telescope and proved the heliocentric theory.

Geocentric model

Heliocentric model

ACTIVITIES

3 Ask about earlier models of the universe: *Who proposed / invented / proved ...?*

4 Why is today's model of the universe different from earlier ones?

Our understanding of the universe has changed thanks to the development of astronomy and the use of more and more sophisticated equipment like telescopes and artificial satellites.

Today, we have a different model. We know now that the Sun is a small star and that our solar system is a small part of a galaxy called the Milky Way. We also know that our galaxy is one of many, many galaxies in the universe.

At present, the majority of experts agree that there is no single place that can be considered the centre of the universe.

The structure of the solar system

The solar system was formed approximately 4.5 billion years ago from a nebula composed of gas and dust. It is divided into two parts: the inner solar system extends from the Sun to Neptune, and the outer solar system lies beyond Neptune.

The solar system also consists of a huge number of smaller objects: moons, comets, asteroids, dwarf planets.

Asteroids, small rocky fragments, are found primarily in the **asteroid belt** between Mars and Jupiter, and in the **Kuiper Belt** beyond Neptune.

Every object in the solar system moves around the Sun in orbits that are almost circular.

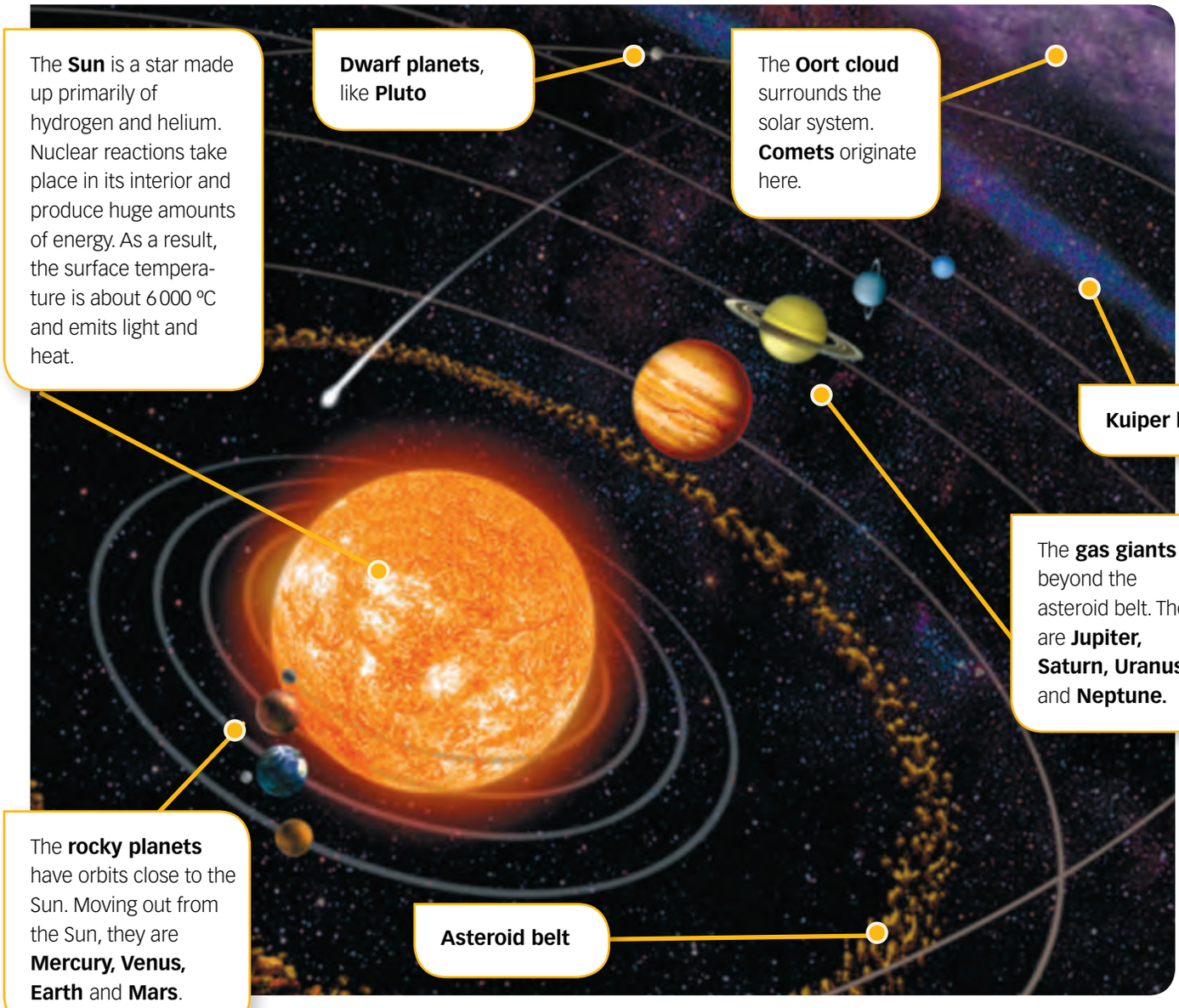
ACTIVITIES

5 Describe the structure of the solar system. Make a mind map.

6 Find out about three comets. When can you see each one?

7 The asteroid belt is 3AU from the Earth. Asteroids travel at 20 000 km/h. How long would it take one to reach Earth?

8 What parts of the solar system are described?



LEARNING OBJECTIVES

- List the main characteristics of the planets.

3 The planets

The **rocky planets** are located between the Sun and the asteroid belt. Their surface is solid. Both the crust, the outer layer, and the mantle, the layer under it, are made of rock. The core, however, is metallic.

MERCURY

Satellites: 0

Distance from Sun: 0.39 AU

Diameter: 4 878 km

Atmosphere: none

Surface temperature: between 420 and –180 ºC

Interesting facts: Its huge, metallic core makes up 47% of its volume (compared to 16% for Earth).

Its surface is covered with impact craters.

The *Caloris Basin* is the largest crater in the solar system, with a diameter of 1 550 km.

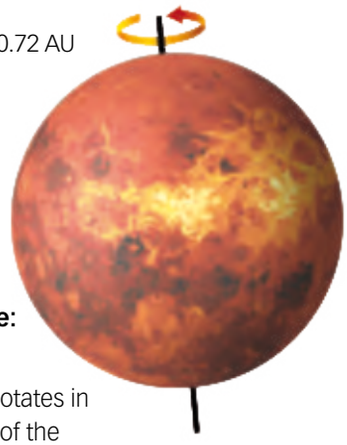
VENUS

Satellites: 0

Distance from Sun: 0.72 AU

Diameter: 12 100 km

Atmosphere: very dense; mainly carbon dioxide with clouds of sulphuric acid



Surface temperature: 465 ºC

Interesting facts: It rotates in the opposite direction of the other planets.

Carbon dioxide in its atmosphere causes high surface temperatures.

EARTH

Satellites: the Moon

Distance from Sun: 1 UA

Diameter: 12 740 km

Atmosphere: mainly nitrogen and oxygen

Average surface temperature: 15 ºC

Interesting facts: It is the only planet with liquid water and life.

It is the only rocky planet with internal geological activity and with continents that move over its surface.

MARS

Satellites: 2

Distance from Sun: 1.52 AU

Diameter: 6 787 km

Atmosphere: very thin; mainly carbon dioxide

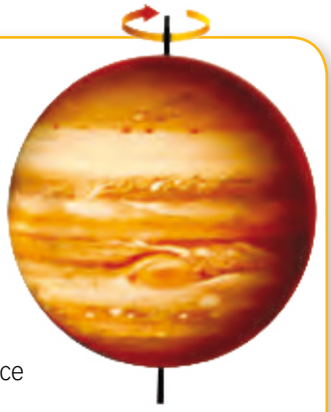
Average surface temperature: –55 ºC

Interesting facts: It had oceans in the distant past.

Mount Olympus is the largest volcano in the solar system, more than 21 km high.

The **gas giants** are located beyond the asteroid belt. Their surface and composition are gases, mainly hydrogen and helium. They have a solid core.

JUPITER



Satellites: 63

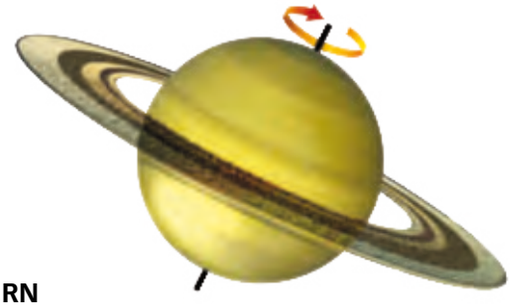
Distance from Sun: 5.20 AU

Diameter: 142 984 km

Interesting facts: It gives off more energy than it receives from the Sun. This indicates a strong source of internal heat.

It is the largest planet in the solar system. Its diameter is 2.5 times the diameter of the Earth. The Great Red Spot is a giant storm.

Europa, one of its moons, may have an ocean of liquid water under its icy surface. This makes it the best candidate for having extraterrestrial life in our solar system.



SATURN

Satellites: 61

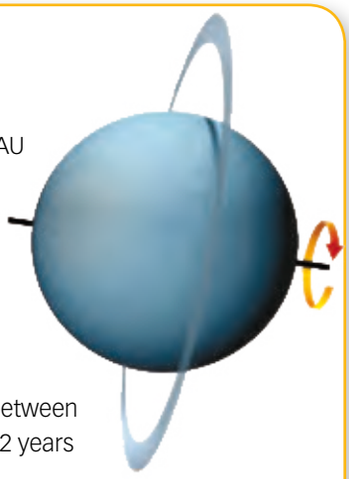
Distance from Sun: 9.54 AU

Diameter: 120 536 km

Interesting facts: The bands on its surface are caused by high winds that can reach more than 1 600 km/h.

Its rings are huge but very thin. They are made of ice, dust and rock fragments.

URANUS



Satellites: 27

Distance from Sun: 20 AU

Diameter: 51 108 km

Interesting facts: Its rotational axis is almost horizontal to its orbit. The planet takes 84 years to orbit the Sun. So, each pole alternates between 42 years of daylight and 42 years of darkness.

It has a thin ring system, which is almost vertical because of the planet's rotational axis.

NEPTUNE

Satellites: 14

Distance from Sun: 30.06 AU

Diameter: 49 538 km

Interesting facts: It is the most distant planet from the Sun. It has the strongest winds of any planet, at speeds of more than 2 000 km/h.

It orbits the Sun every 164.8 Earth years. During this orbit, one or the other of its poles points at the Sun, and receives around 42 years of direct sunlight. The rest of the time they are in darkness. The methane gas in its atmosphere makes Neptune look blue.

ACTIVITIES

1. Ask questions about the planets: *Which planet is ... AU from the Sun? What's the diameter of ...?*
2. Find out about the atmosphere and surface temperature of the gas giants. Make a table.
3. What characteristics make each planet a poor candidate for human life?

LEARNING OBJECTIVES

- List the main characteristics of the Earth.
- Identify and describe the components of the Earth.

4 The Earth – a unique planet

The Earth has a series of characteristics that make it unique among the planets in the solar system.

What characteristics make life on the Earth possible?

Surface temperature. Due to its distance from the Sun, the Earth maintains an average surface temperature of about 15 ºC. This makes it possible for water to exist in three states: ice, liquid water and water vapour. It also makes a **complete water cycle** possible.

Atmosphere. The Earth is the largest of the rocky planets. It retains its atmosphere due to gravitational force. Among other gases, the atmosphere contains **oxygen**, used by many living things for respiration.

Geological activity. Activity in forms such as erosion, volcanoes, earthquakes and the formation of mountains is very common.

Satellite. The Earth has a relatively large satellite, the **Moon**, which is responsible for important events like ocean tides.

Magnetic field. The field that surrounds the Earth protects living things from dangerous solar particle radiation.

The four major systems of the Earth

The Earth consists of four separate systems that interact very closely with each other:

- **Geosphere.** The Earth's surface, its crust and mantle. This is where the other systems are located. It provides living things with mineral salts dissolved in water.
- **Hydrosphere.** All the water on the Earth. It can be liquid, gaseous or solid, like ice and snow. The hydrosphere erodes the Earth's surface and in the process distributes materials. It also provides moisture to the soil and air. Water is home to many living beings and also a fundamental part of living organisms.
- **Atmosphere.** The layer of gases surrounding the Earth. The atmosphere provides oxygen to living things.
- **Biosphere.** All living things on the Earth. Through their actions, living things can change the landscape and the composition of the air. They can also create rocky deposits, like coral reefs.

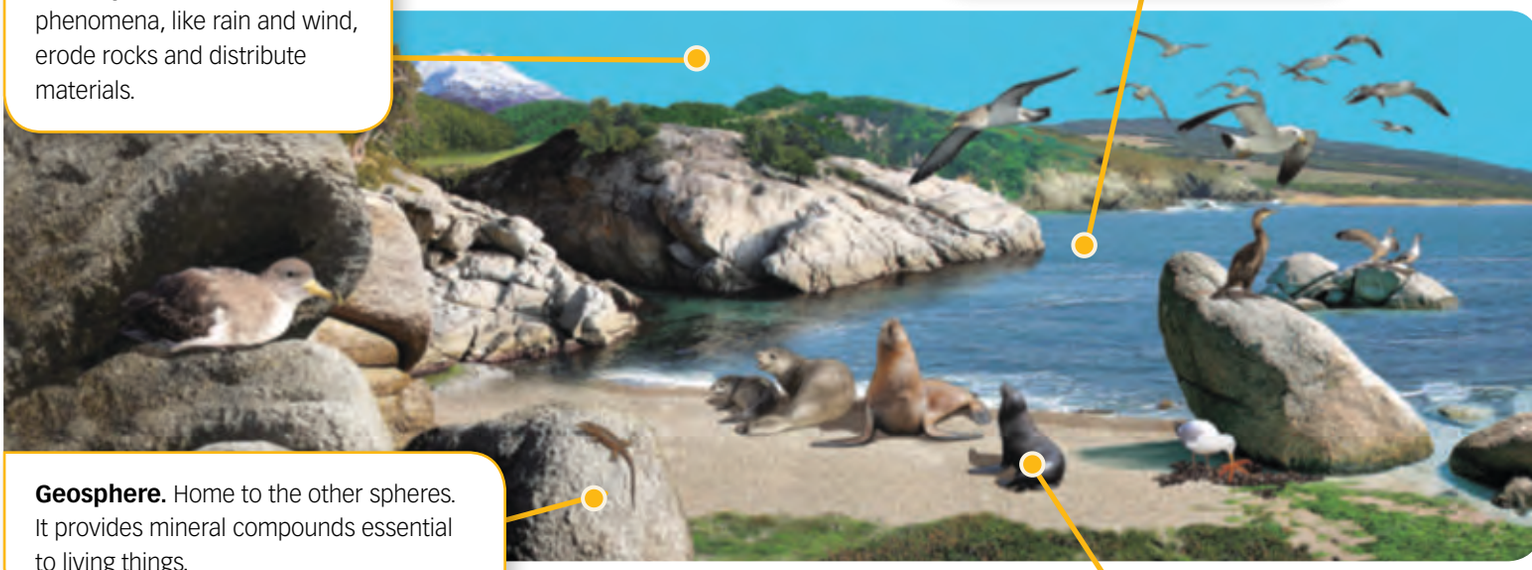
Some examples of interaction are shown below.

WORK WITH THE IMAGE

1. What living and non-living things can you see? Which system does each belong to?
2. Give two specific examples of interaction between each of the four systems.

Hydrosphere. All living organisms are made up mainly of water.

Atmosphere. Weather phenomena, like rain and wind, erode rocks and distribute materials.



Geosphere. Home to the other spheres. It provides mineral compounds essential to living things.

Biosphere. Living things interact with each other and produce physical and chemical changes in the environment.

ACTIVITIES

3. Describe five characteristics that make life possible on the Earth.
4. Explain these terms and give an example of each:
   • *geosphere* • *hydrosphere* • *atmosphere* • *biosphere*
5. Can water exist in three states on Mars or Venus? Why? / Why not?

LEARNING OBJECTIVES

- Explain the relationship between the movements of the Earth and its daily and annual cycles.
- Explain the change of seasons.

5 The movements of the Earth

Like the other planets in the solar system, the Earth moves in two different ways: rotation on its axis, and revolution around the Sun. Both movements have important consequences.

The following terms help to understand these movements:

- **Axis of rotation.** An imaginary line that passes through the geographic North Pole and the geographic South Pole. These two poles do not coincide exactly with the magnetic poles on a compass.
- **Equatorial plane.** An imaginary plane that is perpendicular to the axis of rotation. It passes through the **equator**, the imaginary line that divides the Earth into the Northern and Southern Hemispheres.
- **Ecliptic plane.** An imaginary plane that contains the orbits of most objects orbiting the Sun, including the Earth. It passes through the centre of the Sun.

WORK WITH THE IMAGE

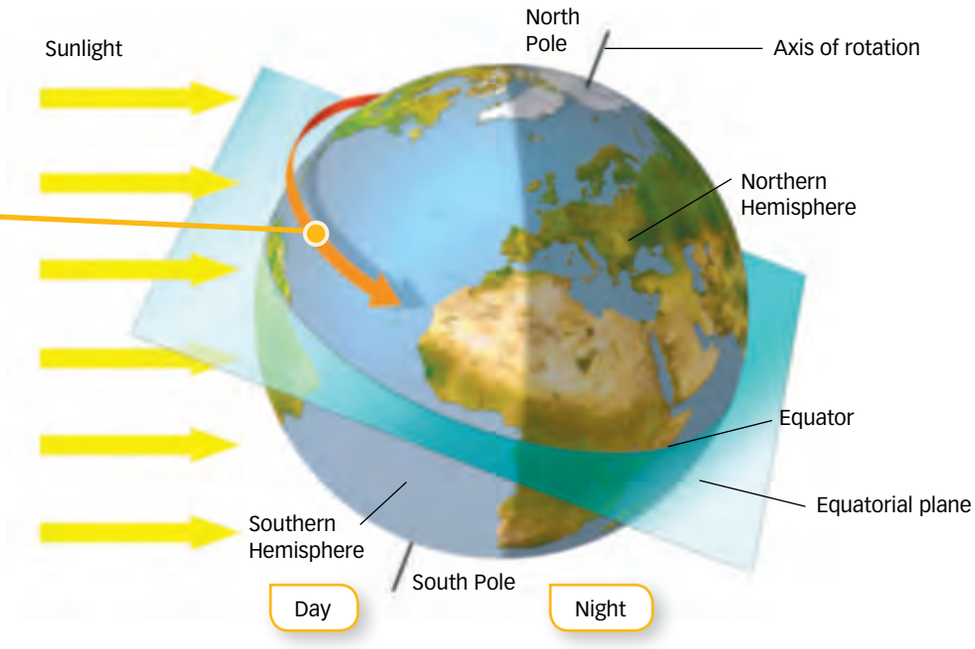
1. Is it dusk or dawn in Spain? Explain your answer.
2. In which direction is the Earth rotating?

Rotation

Rotation is the movement that the Earth makes on its axis. It takes 24 hours, one **day**, to complete one rotation.

The rotation of the Earth is responsible for the cycle of day and night. Any point on the surface passes part of the 24 hours in sunlight (day) and the other part in darkness (night). The length of day and night vary throughout the year due to the tilt of the axis.

The Earth rotates towards the east. As a result, we see the Sun and the Moon rise in the east, and set in the west.



Revolution

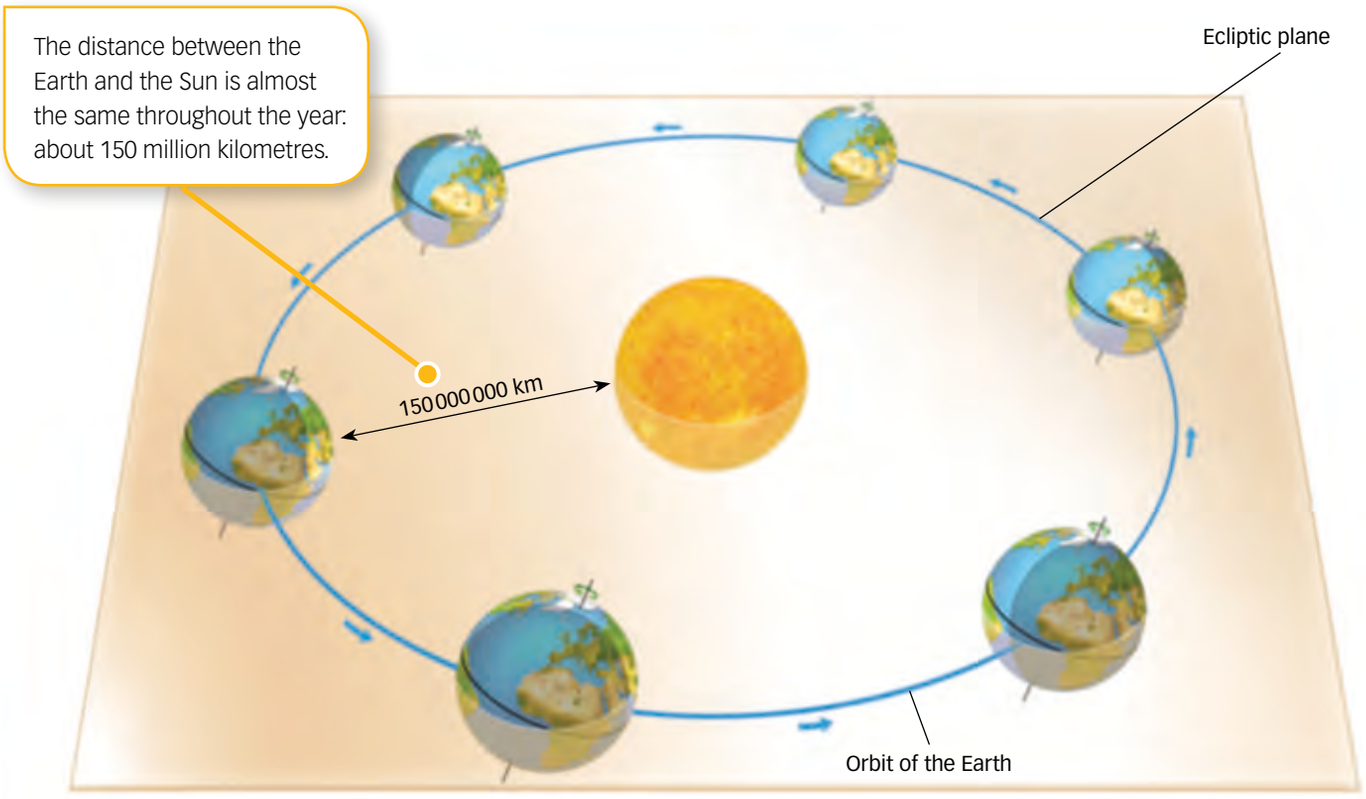
Revolution is the movement the Earth makes in an orbit around the Sun. The orbit of the Earth is an ellipse, almost a circle. It takes 365 days, **one year,** to complete one revolution. The orbit of the Earth is contained within the ecliptic plane that passes through the Sun's centre.

Revolution has two important consequences. First, due to the tilt of the axis of rotation, revolution causes the annual cycle of seasons. Second, for part of the year, one pole faces toward the Sun, so there is no night there. At the same time, the other pole faces away from the Sun, so there is no day there. For the next part of the year, the situation is reversed.

WORK WITH THE IMAGE

3 What shape is the Earth's orbit? Is the distance between the Earth and the Sun always the same?

4 In which of the six drawings of the Earth would there be daylight for 24 hours at the North Pole? And at the South Pole?



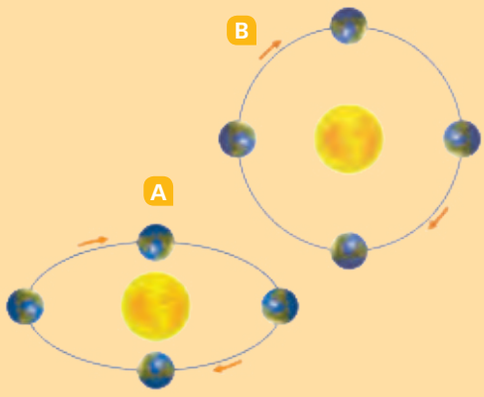
ACTIVITIES

5 Write definitions for these terms:
• *axis of rotation* • *ecliptic plane* • *equatorial plane* • *rotation*

6 What consequences do these movements of the Earth have?
• *rotation* • *revolution*

7 Look at the two drawings on the right. Which one looks like the orbit of the Earth? What mistake is there in the drawing? Copy it correctly.

8 Where would the difference between the length of day and night be greater throughout the year, at the South Pole or the North Pole? Download photos and make a collage.



LEARNING OBJECTIVES

- Explain what causes the seasons.
- Explain the apparent movement of the Sun in the sky throughout the year.

6 The seasons

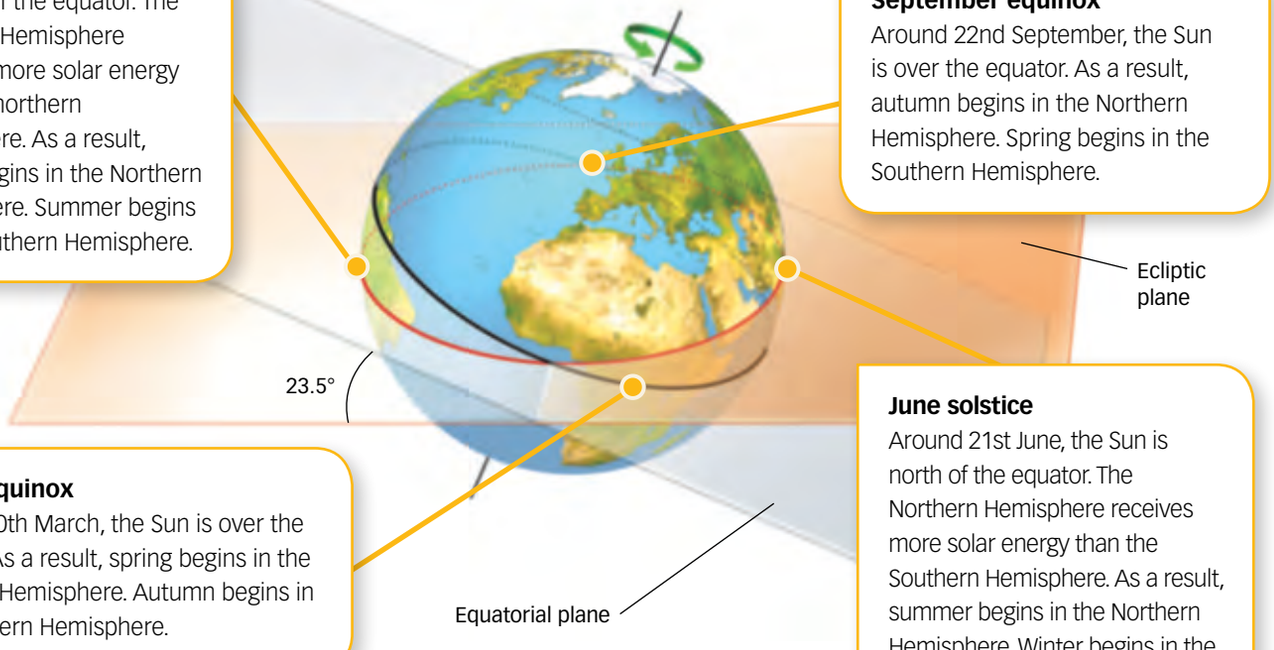
The ecliptic plane is tilted 23.5º with respect to the equatorial plane because of the tilt of the Earth's axis. As the Earth orbits the Sun, this tilt causes different parts of the Earth to receive different amounts of sunlight during the year. The different amounts of sunlight create the seasons: spring, summer, autumn and winter.

In short, the seasons are caused by the tilt of the axis of rotation as the Earth orbits the Sun.

- The **equinoxes** are the days when day and night are equal length: 12 hours.
- The **solstices** are the days when the difference in length between day and night is the greatest.

December solstice
Until 21st December, the Sun is south of the equator. The Southern Hemisphere receives more solar energy than the northern hemisphere. As a result, winter begins in the Northern Hemisphere. Summer begins in the Southern Hemisphere.

September equinox
Around 22nd September, the Sun is over the equator. As a result, autumn begins in the Northern Hemisphere. Spring begins in the Southern Hemisphere.



March equinox
Around 20th March, the Sun is over the equator. As a result, spring begins in the Northern Hemisphere. Autumn begins in the Southern Hemisphere.

June solstice
Around 21st June, the Sun is north of the equator. The Northern Hemisphere receives more solar energy than the Southern Hemisphere. As a result, summer begins in the Northern Hemisphere. Winter begins in the Southern Hemisphere.

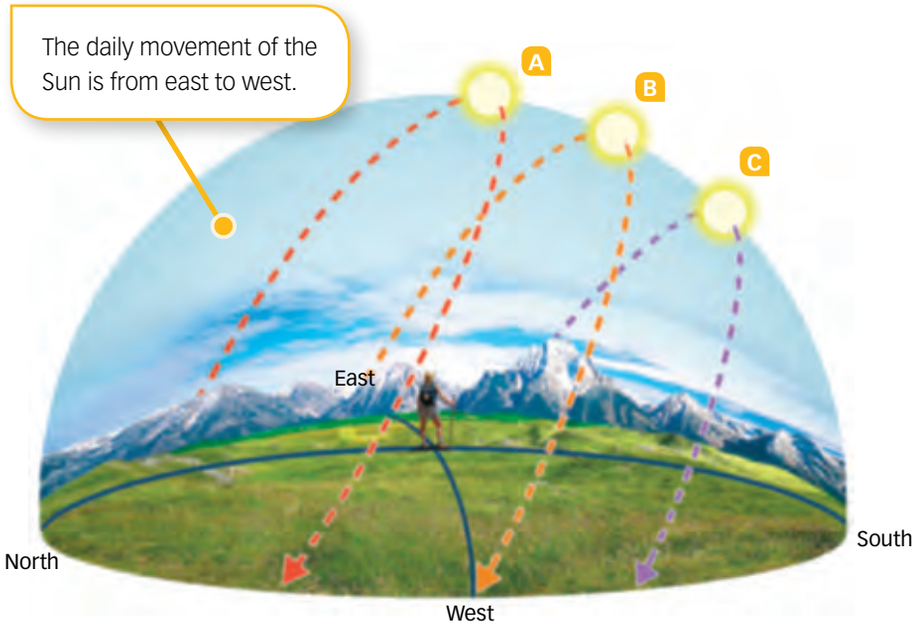
During the summer solstice, the Sun's rays strike the Iberian Peninsula perpendicular to the ground. As a result, they deliver more heat, and the period of daylight is longer.

During the winter solstice, the Sun's rays strike the Iberian Peninsula at an angle. As a result they deliver less heat, and the period of daylight is shorter.

The apparent movement of the Sun

From the ground it seems that the Sun orbits the Earth in an arc in the sky that begins at dawn and ends at dusk.

Within areas located at mid-latitudes, like Spain, the Sun traces a path in the sky that varies with the seasons and takes longer in summer than in winter.



WORK WITH THE IMAGE

1. Ask questions: *In this season, the Sun rises in the ... and sets in the ... What season is it?*
2. In which season would the hiker's shadow be the longest? And the shortest? Explain.

A During the June solstice, the Sun stays in the sky for more than 15 hours.

B At the equinoxes, the Sun stays in the sky for about 12 hours.

C During the December solstice, the days are shorter, and there is only about 9 hours of daylight.

- In **summer**, the Sun rises in the northeast and moves high across the sky. At noon, it is in the south. Later, it sets in the northwest.
- In **winter**, the Sun rises in the southeast and moves low across the sky. At noon, it is in the south. Later, it sets in the southwest.
- In **spring**, the Sun rises and sets every day a little farther north. At noon every day, it is a little higher in the sky.
- In **autumn**, the Sun rises and sets every day a little farther south. At noon every day it is a little lower in the sky.

ACTIVITIES

3. Summarize the position of the Earth with reference to the Sun at each equinox and solstice. Make a table. Use headings like these:
   - *position of the Sun*
   - *amount of sunlight in each hemisphere*
   - *the season that begins in each hemisphere*
4. Imagine you wanted to take a winter holiday. Name four cities: two with the longest days and two with the shortest.

DID YOU KNOW?

DAY AND NIGHT AT THE POLES

Midnight Sun in Lapland. In latitudes about 77° towards the poles, the Sun never sets for several weeks during summer. During winter, the Sun never rises at all for several weeks.

LEARNING OBJECTIVES

- Explain how the phases of the Moon occur.
- Explain the various types of eclipses.
- Understand the relationship between ocean tides and the Moon.

7 The Moon

The Moon is the Earth's only satellite. It is the largest satellite in the Solar System. Its radius is 1 738 km.

Movements of the Moon

Like the Earth, the Moon moves in two different ways:

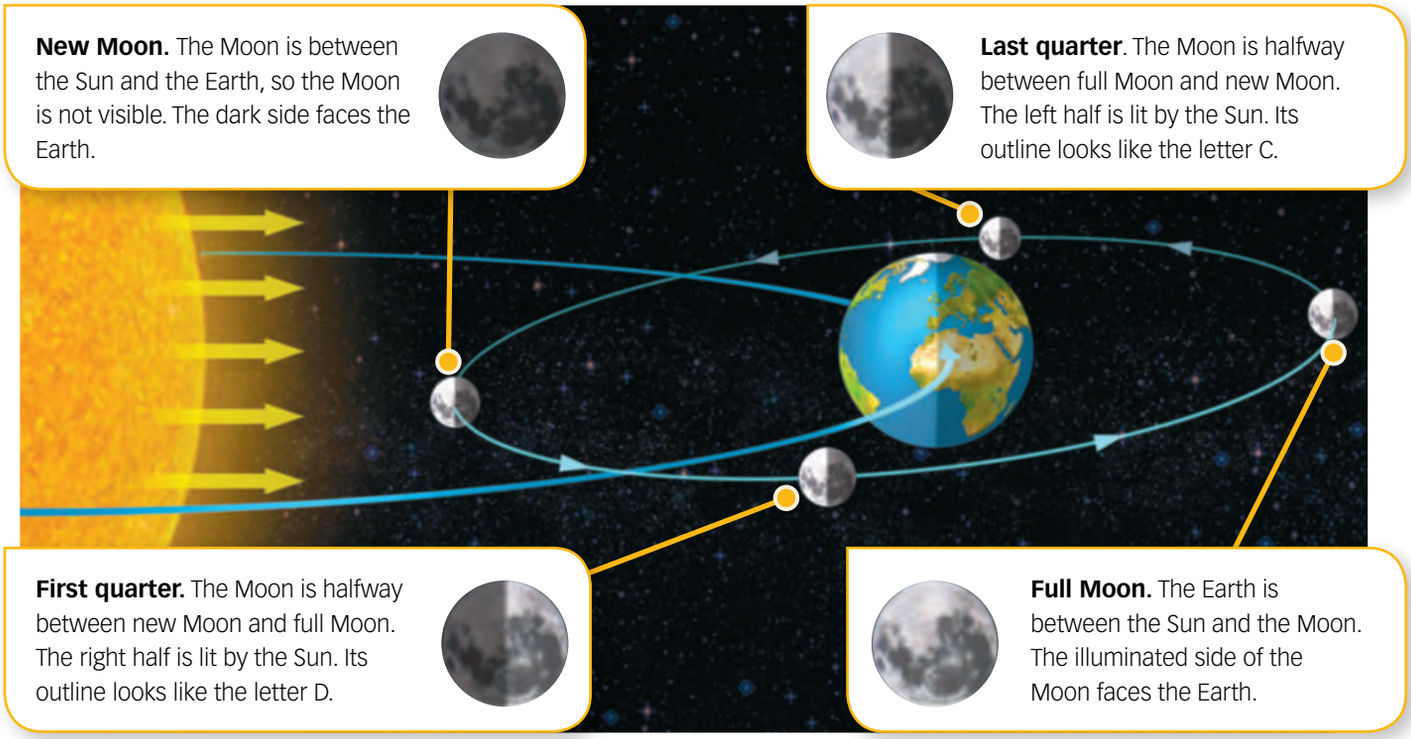
- **Rotation**. The Moon takes about 28 days to rotate once on its axis.
- **Revolution**. The Moon takes about 28 days to orbit the Earth once. Its path is almost circular. A 'lunar month' is the period of time between two new moons.

While orbiting the Earth, the Moon rotates on its axis. For this reason, the same side of the Moon always faces the Earth.

The Moon also accompanies the Earth in its orbit around the Sun.

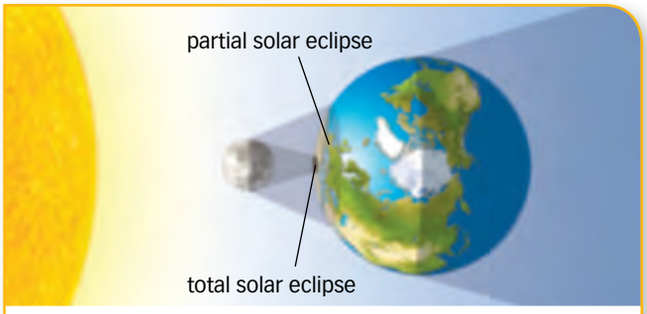
The phases of the Moon

As the Moon orbits the Earth, its shape seems to change. This is because we see it illuminated by the Sun from different angles. There are eight phases that always occur in the same order. The four phases below are the most well-known.



Eclipses

When one celestial body totally or partially obscures another, an eclipse takes place. From the Earth, two types of eclipses can be seen: a **solar eclipse** and a **lunar eclipse**.



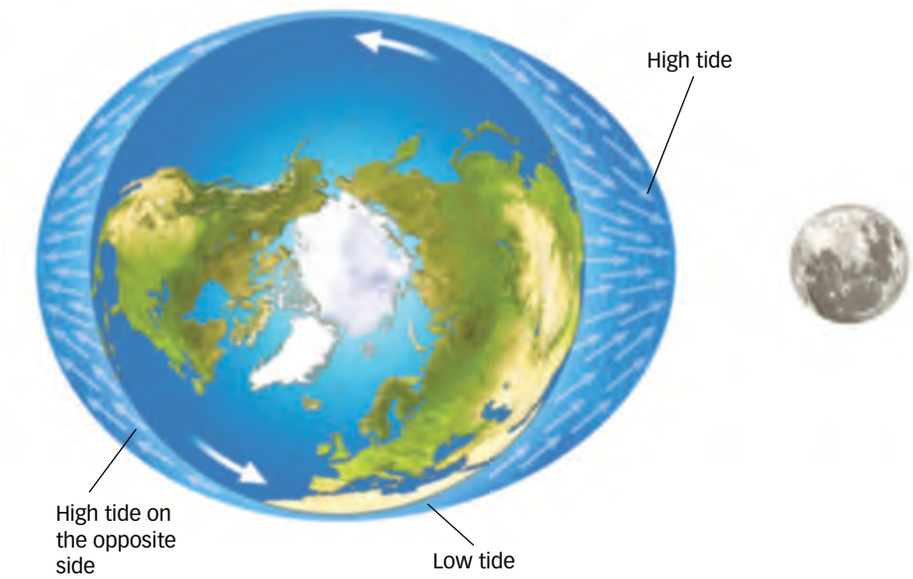
A **solar eclipse** occurs when the Moon passes directly between the Earth and the Sun. Its shadow hides the Sun. In an area where the Moon completely covers the solar disk, there is a **total solar eclipse**. Where the Moon covers the Earth only partially, there is a **partial solar eclipse**.

A **lunar eclipse** occurs when the Moon passes through the shadow produced by the Earth. If the Moon is completely hidden by the Earth's shadow, there is a **total lunar eclipse**. If only part of the Moon enters the shadow and the Moon is partially hidden and partially visible, there is a **partial lunar eclipse.**

The tides

The Earth and the Moon attract each other due to the force of gravity. The effect of this force can be seen in the oceans. Their waters are pulled due to the gravitational attraction of the Moon. In this way, tides are caused.

The water level rises on the side of the Earth closest to the Moon and also on the opposite side. In those places where the water level rises, high tide occurs. In areas where the water level becomes lower, low tide occurs.



ACTIVITIES

1 The Earth makes one complete rotation on its axis every 24 hours. How many high tides and low tides will take place at a coastal city during that time?

WORK WITH THE IMAGE

2 Describe one phase of the Moon: *It looks ... The ... side is lit.* Your partner names it and says which one comes next.

3 Explain the difference between solar and lunar eclipses.

4 Look at the diagram. Where will the tide be highest, near the poles or near the equator. Why?

ACTIVITY ROUND-UP

1 Copy the table and complete it.

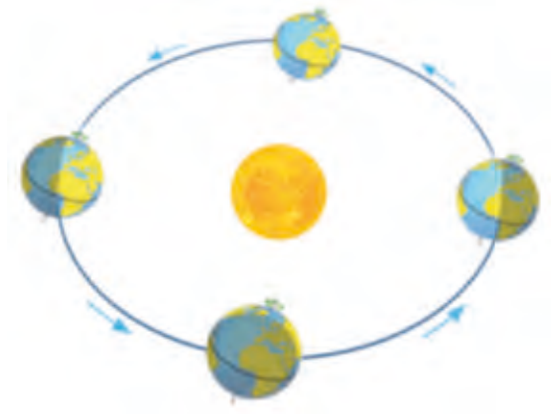
Objects	Description and examples
Rocky planets	Made of rock and a metallic core.
Giant planets	
Asteroids	
Dwarf planets	
Comets	

2 KEY CONCEPTS. Write definitions for these words:
• *ellipse* • *tide* • *solstice* • *equinox*

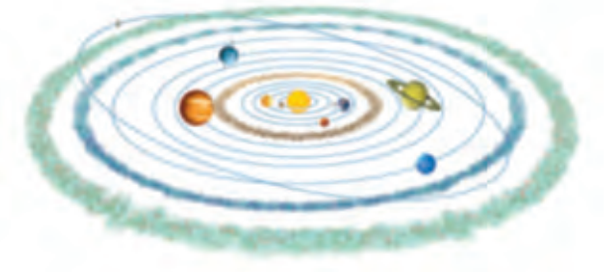
3 Draw the eight planets in order from smallest to largest (not to scale). Write their names and some characteristics in the same order.

4 Make a drawing of the Sun and the Earth. Label the axis of rotation, the equator and the ecliptic plane. The drawing should show that it is the winter solstice in the Northern Hemisphere. Label the North Pole and South Pole. Draw an arrow to show the direction of the Earth's rotation.

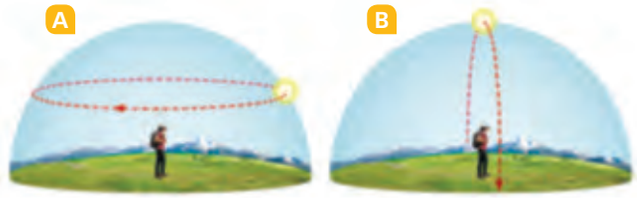
5 Copy the drawing in your notebook and label the winter and summer solstices, and the spring and autumn equinoxes in the Northern Hemisphere. Label the sections of the orbit where the days are longer and shorter in that hemisphere.



6 Copy the drawing and label: *the Earth*, *the Oort cloud*, *Jupiter* and *the Kuiper Belt*.



7 In what part of the world can we find these paths of the Sun?



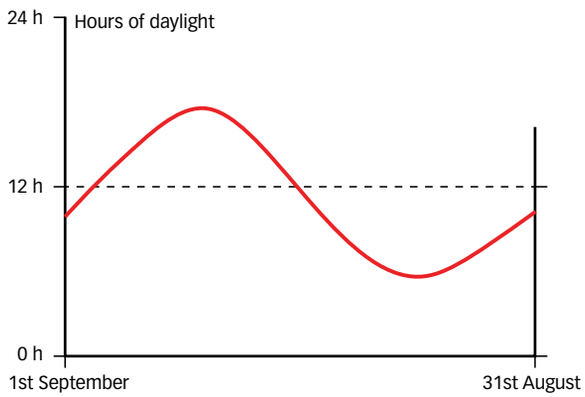
8 Imagine a square house in the Northern Hemisphere. Each of its four sides face one of the four cardinal points. Which side faces the Sun all day in winter? Which side receives no Sun all day?

9 The largest known star is NML Cygni. It has a radius of 1 255 million km.

a) Express this radius in astronomical units.
b) If NML Cygni was placed where the Sun is, which planets would be inside this star?

10 The graph represents hours of light from sunrise to sunset for one year (1st September – 31st August) at a specific place. Copy the graph and do the activities.

a) Mark the points that correspond to the summer and winter solstices and the spring and autumn equinoxes on the graph.
b) Analyse your graph. Is the place that it corresponds to in the Northern or the Southern Hemisphere?



KNOW HOW TO **Scientific competence**

Observe and describe the constellations

Prepare a presentation about the constellations and their astronomical and mythological significance.

The presentation should have several panels. Each panel will be about a different constellation. For each constellation make a model and prepare a fact sheet.

Model of a constellation

- Choose a large sheet of black poster board.
- Punch holes in the poster board to represent the stars. Some stars are brighter than others, so punch larger holes for the brighter stars.
- Draw lines to connect the stars and make an outline of the constellation. Use a silver marker or a white pencil.
- Use another colour marker to draw the mythological creature or figure that is associated with that constellation.

Fact sheet

Use light-coloured poster board to make a fact sheet about the stars in the constellation. Include the following information about the constellation:

- The name of its brightest star. Indicate its size compared to the Sun and its distance from the Sun in light years.
- The time of year that it is easiest to see.
- Its position in the sky and its location relative to nearby constellations.

Use light-coloured poster board to make a mythology fact sheet about the constellation. Include the following information:

- Greek or Roman myths that are associated with it.
- References to it found in other cultures.
- Drawings, photos of paintings or sculptures that represent the mythological creatures or figures associated with it.

COOPERATIVE PROJECT

An astronomy exhibit

Form groups of four to make the poster and fact sheets. Each group should choose a different constellation.

Present your work:

- Describe the constellation and where to find it in the sky.
- Explain your fact sheets.
- Explain any mythological or cultural connections and describe the illustrations on your fact sheet.

- Place the black poster board on your classroom window to light up the constellation.