Biology and Geology

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

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Do not write in this book. Do all the activities in your notebook.
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This book covers the curriculum in a clear, comprehensive and rigorous way.

Each unit deals with one of the United Nations' Sustainable Development Goals. This knowledge can be a tool to improve the world around us.

The images will help you to understand the contents more easily. You will be able to practice listening comprehension in some activities.

A series of final activities encourage and consolidate learning.

Specific activities are designed to work on 21st century competences:
- Competence in Mathematics, Science and Technology
- Linguistic competence
- Learning to learn
- Social and civic competence
- Digital competence
- Initiative and entrepreneurship

Critical thinking. You will be able to practise critical analysis of scientific texts, a valuable tool in today’s information society.
7 Know how to. You will apply your knowledge and improve your scientific competence.

8 Cooperative project. These activities and tasks are designed to be done in groups or in pairs.

Great scientists. You will learn about the lives of great scientists and their contributions to science, as well as other interesting facts about them.

9 At the end of the book you will find:
- Lab experiments
- Nature atlas
- Scientific glossary
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.

Help to protect the planet by improving climate change education and awareness among people and institutions.

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

**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.
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 called 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.

LEARNING OBJECTIVES

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

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 years 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?
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.

**LEARNING OBJECTIVES**
- Understand the differences between the models of the universe.
- 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 ...?

**ACTIVITIES**
3. Ask about earlier models of the universe: Who proposed / invented / proved ...?
4. What is the difference between the universe as we know it today and the previous models?

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.

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.

**Comets** are celestial bodies made of ice and rock. As comets get closer to the Sun, these materials heat up and form their characteristic tail of gas and dust.

Every object in the solar system, except the moons, 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 3 AU 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?

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The Sun is a star made primarily of hydrogen and helium. Nuclear reactions take place in its interior and produce huge amounts of energy. As a result, the surface temperature of the Sun is about 6 000 °C and it emits light and heat.

The rocky planets have orbits close to the Sun. Moving out from the Sun, they are [Mercury, Venus, Earth](#) and Mars.

The Oort cloud surrounds the solar system. Comets originate here.

The gas giants lie beyond the Asteroid belt. They are Jupiter, Saturn, Uranus and Neptune.

Dwarf planets, like Pluto
The **rocky planets** are located between the Sun and the Asteroid belt. Their surface is solid. Both the crust and the mantle 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 ºC 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.

### EARTH
- **Satellites:** the Moon
- **Distance from Sun:** 1 AU
- **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.

### 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 to the other planets.
  - Carbon dioxide in its atmosphere causes high surface temperatures.
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. The Great Red Spot is a giant storm. The diameter of this spot is 2.5 times the diameter of the Earth.

*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 the 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.

At a depth of 7,000 km, Neptune has a thick layer with methane.

The pressure and temperature on Neptune are suitable for diamond crystals to form from the methane. These crystals accumulate near the core.

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

**LEARNING OBJECTIVES**

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

**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 °C. 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 particles and 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.

**ACTIVITIES**

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

**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.
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?
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 ecliptic plane is tilted 23.5° 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.

**LEARNING OBJECTIVES**

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

**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. Autumn begins in the Northern Hemisphere. Spring begins in the Southern Hemisphere.

**March equinox**

Around 20th March, the Sun is over the equator. 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.
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.

- **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.
The Moon is the Earth’s only satellite. Its diameter is 3,476 km. It is approximately 380,000 km away.

**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. Both movements are completed in the same amount of time. 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 four phases that always occur in the same order.

- **New Moon.** The Moon is between the Sun and the Earth, so the Moon is not visible at night. The dark side faces the Earth.
- **Last quarter.** The Moon is halfway between full Moon and new Moon. The left half is lit by the Sun. Its outline looks like the letter C.
- **First quarter.** The Moon is halfway between new Moon and full Moon. The right half is lit by the Sun. Its outline looks like the letter D.
- **Full Moon.** The Earth is between the Sun and the Moon. The illuminated side of the Moon faces the Earth.
Eclipses

Eclipses happen when three celestial bodies are aligned and one, totally or partially, obscures another. From the Earth, two types of eclipses can be seen: a **solar** 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, but with less intensity. 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?
1. Copy and complete the key concepts.
   - According to the **model**, the Earth was at the centre of the universe. According to the **model**, the Sun was at the centre of the universe.
   - Today, we believe that the universe came into existence as the result of an **called the Big Bang**.
   - The distance from the Earth to the Sun is approximately 150 **kilometres**, which is equivalent to one **light year**. A light year is equivalent to **kilometres**.
   - The universe is made up of **groups** of **. Our galaxy is called the **galaxy**.
   - The solar system contains the rocky planets **, **, and **; the **belt and the gas giants **, **, **, **, and **.
   - The four systems of the Earth are the **, the **, and the **.
   - Like the other planets, the Earth moves in two different ways: it **on its axis**, which takes **hours**, and it **around the Sun**, which takes **days**.
   - The Moon takes **days** to rotate once on its axis, and **days** to orbit the Earth.
   - The Moon looks like the letter D when it is in the **phase**.
   - In a solar eclipse, the **passes directly between the Sun and the Earth**.
   - During the **, day and night are equal in length. During the **, the difference in length between day and night is at its greatest.

2. Copy the table and complete it.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Description and examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky planets</td>
<td>Made of rock and a metallic core.</td>
</tr>
<tr>
<td>Giant planets</td>
<td></td>
</tr>
<tr>
<td>Asteroids</td>
<td></td>
</tr>
<tr>
<td>Comets</td>
<td></td>
</tr>
</tbody>
</table>

3. Write definitions for these words:
   - **eclipse**
   - **tide**
   - **solstice**
   - **equinox**
   - **ecliptic plane**

4. Copy and complete the diagram:

   ![Solar system diagram]

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

6. Make a drawing of the Sun and the Earth. Label the part of the Earth where it is day and the part where it is night.
   Add the axis of rotation, the equator and the ecliptic plane. Label the North Pole and the South Pole, and draw an arrow to show the direction of the Earth's rotation.

7. 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.

8. Copy the drawing and label: **the Earth, the Oort cloud, Jupiter and the Kuiper belt.**
9. The largest known star is NML Cygni. It has a radius of 1,155 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. In what part of the world can we find these paths of the Sun?

11. 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?

12. 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) Is the place that it corresponds to in the Northern or the Southern Hemisphere?

CRITICAL THINKING. Science and technology collaboration

Nebulae and telescopes

Nebulae are clouds of gas and dust that float inside galaxies. They are created from dying stars. The stars explode when they have burnt through all their fuel, throwing out the dust and gas that form the nebula. At first, nebulae are more or less spherical, but they soon disperse in space and mix with other clouds of gas.

Some of the most beautiful images captured by the Hubble Space Telescope are of these glowing nebulae.

13. The Orion Nebula is the only nebula visible with the naked eye. It can be seen clearly with a pair of binoculars. It is found in the centre of the sword in the constellation Orion. Search for information on how to find this constellation and try to observe the nebula in the sky.

14. Write a brief description of what the nebula in the photo, or another nebula you know, reminds you of. Remember that, as beautiful as they are, nebulae are created through an incredibly violent process: the enormous explosion of a dying star.

15. Form groups of three or four and design a mural showing how nebulae are formed and how they change over time. Search the Internet for drawings or photos to illustrate the process.

16. Do you think it is important that research organizations and technological companies work together? Why? Prepare a report about technological inventions that have helped discover and understand the universe throughout history.
Observe and describe the constellations

Constellations are groups of stars that, when seen from the Earth, appear to form a shape or image. Babylonian, Greek, Chinese, Egyptian and Mayan astronomers all described different constellations. Throughout history, most cultures have associated the constellations with their own mythologies.

We are going to hold a class exhibition about the constellations and their astronomical and mythological significance.

The exhibition will have several panels. Each panel will be about a different constellation and will have three parts:

- A sheet of black poster board with holes in it to represent the stars. Some stars are brighter than others, so the holes will be different sizes. You will draw lines connecting the stars to show the shape of the constellation.
- An astronomy fact sheet about the science behind the stars in the constellation.
- A mythology fact sheet about the mythology associated with the constellation.

In the library, you will be able to find books with information on the constellations and how to identify them, such as star atlases. You can also find a lot of information on the Internet, as well as beautiful images you can use as a model to prepare your constellation.

Model of a constellation

Choose a large sheet of black poster board suitable for your constellation. The bigger it is, the more detail you will be able to include. But remember that if it’s too big it will be harder to make.

- Punch holes in the poster board to represent the stars in the constellation. Some stars are brighter than others, so punch larger holes for the brighter stars and smaller holes for the less bright ones.
- Draw lines to connect the stars and make the 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 a light-coloured poster board to make an astronomy fact sheet about the stars in the constellation. Include the following information:

- The name of the brightest star in the constellation, its size compared to the Sun and the distance of the constellation’s stars 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.
- An interesting fact about the constellation’s discovery or one of its stars.
- A picture of the constellation taken using a telescope, from the Internet.

Make a mythology fact sheet about the constellation using another light-coloured poster board. Include the following information:

- The Greek or Roman myths associated with the constellation. These often involve mythological characters who represent different human qualities, such as bravery, beauty, love, etc.
- References to the constellation found in other cultures.
- Drawings or photos of paintings and sculptures that represent the characters from the mythology associated with the constellation.
Observe and describe the constellations

17 Do you know a star or constellation that is easy to spot in the sky? What is it called and how can you find it?

18 During your research, have you found out any interesting or surprising facts, such as the size of a star, its brightness, etc.? Explain.

19 Do the constellations really have the shapes we describe, or do we just imagine they are arranged this way because of how they look from Earth? Explain your answer.

20 Search for information on the constellation Orion. What does it look like, where is it and what myth is associated with it?

Astronomy fact sheet: Ursa Major

Ursa Major is a constellation located in the sky near to the geographic North Pole. It never sinks beyond the horizon.

It is made up of seven main stars that form the shape of a plough. They are between 60 and 110 light years from the Earth.

Ursa Major is one of the most easily visible and recognisable constellations in the sky. It is also one of the most characteristic constellations in the Northern Hemisphere. It is visible throughout the year.

The handle of the plough is made up of three stars. The middle star, Mizar, is binary (it is actually two stars) and can be seen clearly with a pair of binoculars.

Because Ursa Major is so easy to identify, it has been used since ancient times as a reference point for locating other constellations.

Mythology fact sheet: Ursa Major

According to Ancient Greek mythology, a beautiful nymph called Callisto was seduced by Zeus. His wife, who was jealous, then turned Callisto into a bear.

One day, Callisto’s son Arcas went hunting and came across a bear. Not knowing it was really his mother, he tried to kill it, but Zeus intervened. He told Arcas that the bear was really his mother.

To keep her safe, Zeus transformed Callisto into Ursa Major (which is Latin for Great Bear) and sent her up into the sky. He then turned Arcas into a bear as well, and sent him to keep his mother company, forming the constellation Ursa Minor.

The Greek word for bear is *arktos*, and this is where we get the word Arctic from. This is because the Arctic is in the Northern Hemisphere, near to Ursa Major and Ursa Minor.

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.
Annex:

• *Lab experiments*
• *Nature atlas*
Contents

Lab experiments

Laboratory equipment

Safety rules

1. Formation of a crater from a meteorite impact
2. Analysis of a sandy sediment
3. Relationship between atmospheric currents and air pollution
4. Modelling the water cycle
5. Build your own optical microscope
6. Dissection of a bony fish
7. Create a butterfly collection
8. Create a vertical garden or a vegetable garden
9. Confirm the existence of bacteria
10. Analysis of a terrestrial ecosystem
Laboratory equipment

glass slides

glass coverslips
test tubes

beaker

filter paper
dropper
tweezers
crystallizer

digital scale
graduated cylinder

scalpel
spatula

watch glasses

beaker

dropper
 graduated cylinder

crystallizer

stereoscopic microscope

Bunsen burner

optical microscope
It is important to follow some basic safety rules when you do experiments in the laboratory:

- Before you start an experiment, read the instructions carefully and check you have everything you are going to need. Don’t start working until you understand exactly what you have to do.
- Work carefully. Don’t play with the equipment or chemical products. Don’t run or push anyone.
- Keep your workspace clean and tidy. Clear away any books, clothes or bags.
- Stereoscopic and optical microscopes are fragile, so handle them with care and don’t force any parts. If something doesn’t work correctly, ask for help.
- Hold glass coverslips and glass slides at the edges or use tweezers to avoid getting grease on them and contaminating them.
- Solid waste such as used containers, paper filters or broken glass should be put in the appropriate bins.
- Never heat a completely sealed container. To heat a test tube, hold it with tweezers, never with your hands. Always point the mouth of a test tube away from yourself and other students.
- Chemical products can be dangerous. Before using them, read the safety labels carefully to understand the risks and precautions you need to take.
- Never pour a liquid quickly into a test tube. Pour it slowly down the wall of the tube. Put test tube stoppers you aren’t using on the table facing upwards. Replace them as soon as you finish using the test tubes.
- Carry bottles containing reagents by holding the base, never the lid.
- Never transfer products to other bottles that are not labelled correctly.
- Handle corrosive products with care to avoid contact with your skin or clothes.
- Never use the same dropper for different reagents as this can cause contamination or provoke dangerous reactions.
- Never tip leftover liquids down the sink without checking with your teacher first. Some products can be harmful to the environment and must be processed in a special way.
- At the end of an experiment, each group is responsible for clearing up, cleaning and tidying their desks. Always wash your hands after using chemical products and before leaving the laboratory.
- Always clean the equipment thoroughly after use and wipe up any spillages immediately. Turn off taps and switch off Bunsen burners.
Formation of a crater from a meteorite impact

On the surface of the Moon, we can see almost circular areas surrounded by irregular ridges. These are lunar craters. They are large basins made up of basaltic rocks formed by the impact of huge asteroids. The Moon’s surface also has thousands of smaller impact craters.

In this experiment you are going to simulate the impact of a meteorite on a surface to observe its appearance and compare it with lunar craters.

Objectives

▶ Simulate the impact of a meteorite on the Moon’s surface.
▶ Observe an impact crater and compare it with the ones on the Moon’s surface.

Equipment

– a large plastic tray
– a small plastic scoop
– fine, dry sand
– white plaster powder
– dry clay soil
– a sieve
– a marble
– a catapult (optional)

Steps

1 Prepare the Moon’s surface

Put a layer of sand approximately 1 cm thick in the tray. Smooth it out with the scoop (A).

Add a layer of white plaster of the same thickness and smooth it out (B). Try not to press it down.

Use the sieve to sprinkle the clay soil over the white layer until it is completely covered (C).
Simulate the meteorite impact

Throw or launch the marble vertically above the surface to create an impact crater. You can use a catapult for this (D). To avoid altering the results, do not pick up the marble. First, observe the structure of the impact crater. If you have a camera, take some photos of the whole structure and some close-ups of the crater. If you do not have a camera, describe or draw it. Then launch the marble again to create a second crater a few centimetres away from the first.

Results and conclusions

1. Observe the size of the crater. How big is it compared to the marble?
2. The material that is thrown out during the formation of a crater is called ejecta. Draw a picture of the tray that shows what the ejecta looks like.
3. Around the crater, you might see some larger fragments of white plaster. Can you explain the relationship between the size of the fragments and the distance they have fallen from the crater?
4. Launch the marble again to create a second crater a few centimetres away from the first. The ejecta from the second crater will partially cover the first one. Draw a picture that shows how the distribution of the ejecta helps us to find out which of the two impacts happened before and which happened after.
5. Look at the image of the Moon. The Mare Nubium is an area of basalt formed by an impact. Tycho is another impact crater with clearly visible ejecta situated near the lunar south pole. Which one happened first? Draw a picture to explain your answer.
Contents

Nature atlas

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• Trees and bushes and Spain ........................ 262
• Ecosystems in Spain ................................. 264
Spain is a country with a long history of mining. Some of its mines, like Riotinto, have been used to extract rocks and minerals for thousands of years.

Today, the mining of ornamental rocks like marble and granite, is very important. Spain is the world’s third largest producer of these types of rocks. It is also a producer of red clays, which are used in the manufacturing of bricks, tiles, etc.

The extraction of minerals in Spain is also important, specially fluorite, gypsum, feldspar and sepiolite. Most of Spain’s production of rocks and minerals is focused on obtaining materials for construction.

Marble
- Marble is a crystalline, metamorphic rock that can be different colours.
- The most well-known marble quarries in Spain are in Macael in the province of Almería. The high-quality white marble extracted there makes up more than 90% of Spain’s total production.
- The marble from these quarries was used to construct buildings like the Alhambra and the Generalife in Granada, and the Mezquita-Catedral de Córdoba.

Cinnabar
- Cinnabar is a bright red mineral. We can extract mercury from it.
- The mines of Almadén in the province of Ciudad Real contained the largest deposit of mercury in the world. The mines closed in 2002 and have been turned into a mining park.
- Mercury is used in some thermometers, thermostats and lamps.

Gypsum
- Gypsum is a sedimentary, evaporite rock. It forms when water with mineral salts evaporates.
- Spain is Europe’s leading exporter of gypsum. This rock is mined in twelve autonomous communities. Europe’s largest gypsum quarry is in Sorbas in the province of Almería.
- Most of the gypsum that is mined is used to manufacture cement, plaster for construction, etc.

Metallic minerals
- Gold and silver are native elements. They are found in nature in a pure state as minerals and they are composed of a single element. Other metals are obtained from specific minerals. For example, iron is extracted from hematite and magnetite, and zinc is obtained from sphalerite.
- Spain’s most important mining basin for the extraction of metallic minerals is Riotinto in the province of Huelva. These mines have been in use for 5000 years.
- Gold and silver are used in jewellery and medicines.
### Slate
- Slate is a metamorphic rock that easily splits into thin sheets. It is usually black and lightly shiny.
- Slate is mined in big opencast quarries. The main slate quarries in Spain are in Bierzo in the province of León and in Valdeorras in Ourense.
- Thin layers of slate, called slabs, are mainly used to make roofs. Spain is the world’s biggest producer of roofing slate.

### Granite
- Granite is an igneous rock composed of quartz, feldspar and mica. It is the most abundant rock in the continental crust. It can be grey or pink depending on the colour of the feldspar.
- Spain is the biggest producer of granite in Europe. The main quarries are in Galicia, central Spain, Extremadura, Andalucia and Cataluña.
- It is mainly used in construction and for flooring because it is hard, resistant, easy to polish and decorative.

### Halite
- Halite or rock salt is a sedimentary evaporative rock. It forms when water with mineral salts evaporates.
- The extraction and trading of common table salt on the Iberian Peninsula has a long history. Today, rock salt is mainly produced in Cantabria, Comunitat Valenciana and Cataluña.
- Halite is used in the chemical industry to produce chlorine and caustic soda, and in the processing of hydrochloric acid and sodium bicarbonate. It is also used to season and preserve food.

### Pumice
- Pumice is an igneous rock that can be different colours. It is very light and porous.
- Spain is the third largest producer of pumice after Italy and Greece. The main quarries are in Tenerife and Las Palmas de Gran Canaria. In other parts of the Peninsula, like in Campo de Calatrava, pyroclastic rocks are mined. These are solid fragments of volcanic material.
- Pumice is used as a thermal insulator and to make cement and concrete. It is also used in toothpaste, soap and as an ornamental garden rock.
1 The universe and our planet

**astronomical unit** the distance from the Earth to the Sun: approx. 150 million km.

**axis of rotation** imaginary line that passes through the geographic North Pole and the geographic South Pole.

**eclipse** when three celestial bodies are aligned and one blocks the view of another. Eclipses can be solar or lunar.

**ecliptic plane** an imaginary plane that passes through the centre of the Sun. It contains the orbits of most objects orbiting the Sun, including the Earth.

**equatorial plane** an imaginary plane that passes through the equator and divides the planet into the North and South Hemisphere. It is perpendicular to the axis of rotation.

**equinox** moment of the year when day and night are equal in length.

**geocentric model** a theory that put the Earth at the centre of the universe.

**heliocentric model** a theory that put the Sun at the centre of the universe.

**light year** the distance light travels in one year: about 9.5 trillion km.

**Milky Way** the galaxy where our solar system is located.

**revolution** the circular movement of one celestial body around another.

**rotation** the turning of the Earth on its axis that causes day and night.

**solstice** day when the difference in length between day and night is the greatest.

**tide** the rise and fall of ocean water due to the gravitational pull of the Moon. High tide occurs when the water level rises. Low tide occurs when the water level becomes lower.

2 The geosphere, minerals and rocks

**core** the inner layer of the Earth. Its temperature is over 4 000 °C.

**crust** the outer layer of the Earth. It consists of continental crust and oceanic crust.

**igneous rock** rock formed from cooled magma.

**impurities** small amounts of other substances found in minerals. They can change some mineral properties.

**lustre** the way minerals reflect light. It can be metallic or non-metallic.

**mantle** the middle layer of the Earth, below the crust, which is made up of rock. The temperature is from 1 000-4 000 °C, so some areas are molten.

**metamorphic rocks** rocks formed from the effects of heat or pressure, for example, slate.

**Mohs scale of hardness** a classification of minerals by hardness from 1, soft, to 10, very hard.

**non-silicates** minerals which do not contain silicon, such as oxides, native elements, sulphides, carbonates and halides.

**quarry** a type of above-ground surface mine where blocks of rock, such as marble or granite, are mined.

**sedimentary rocks** rocks formed by the accumulation and compaction of sediment, such as fragments of clay, sand or rock.

**silicates** the most abundant minerals on the Earth. They are made up of silicon, oxygen and other elements, for example, mica.

**streak** the colour of a mineral in powder form.

3 The atmosphere

**global warming** a gradual increase, 0.5-0.9 °C, in world temperatures over the last century.

**greenhouse effect** a physical process in which thermal radiation is absorbed by atmospheric gases. This process increases the temperature of the atmosphere.

**ionosphere** the highest and thickest layer of the atmosphere.

**mesosphere** a layer of the atmosphere with a thickness of about 40 km that contains ice clouds and dust.