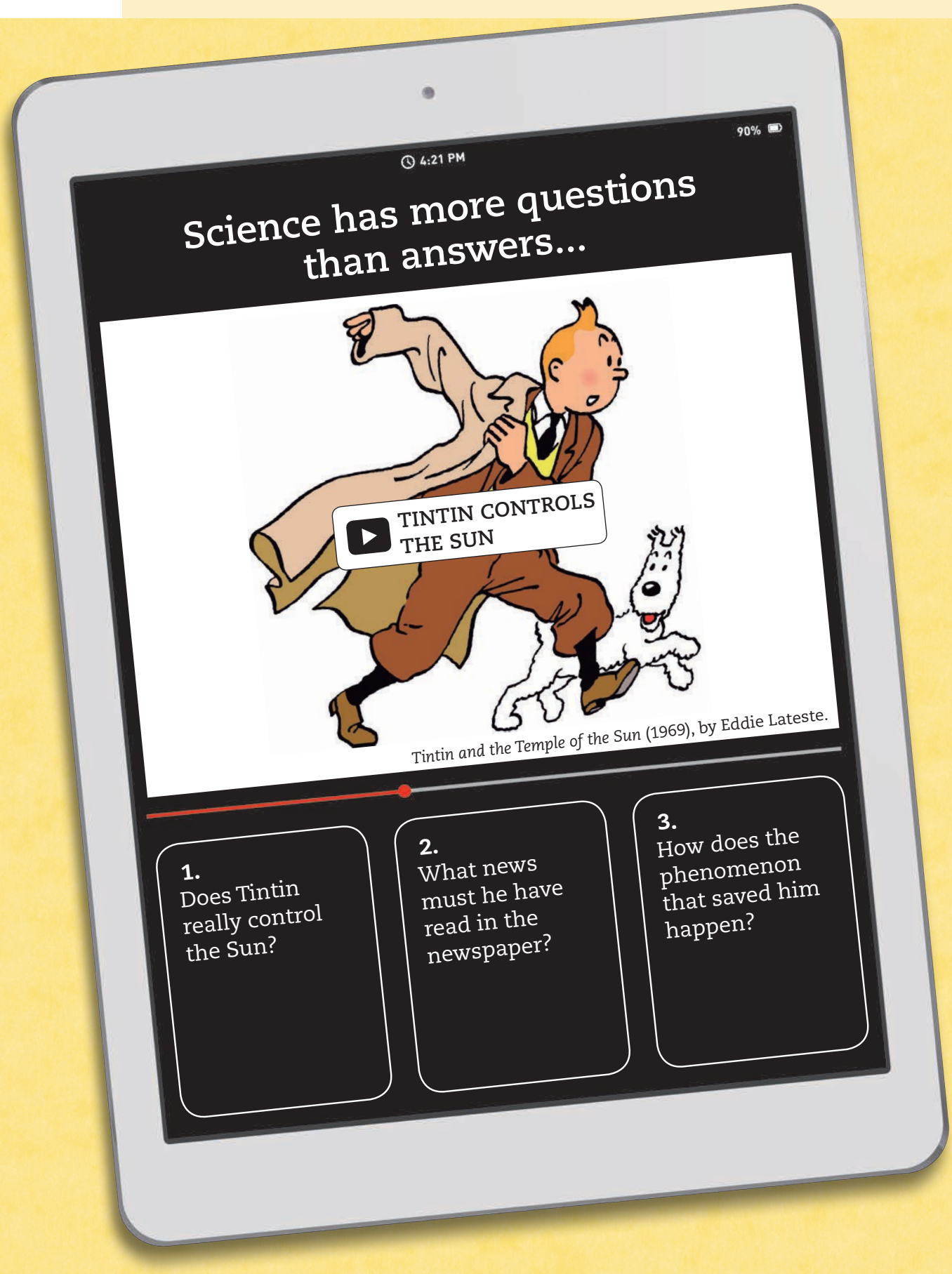
2 THE EARTH


4:21 PM
90%
Science has more questions than answers...
TINTIN CONTROLS THE SUN
Tintin and the Temple of the Sun (1969), by Eddie Lateste.
1. Does Tintin really control the Sun?
2. What news must he have read in the newspaper?
3. How does the phenomenon that saved him happen?

Can I remember?

THE LAMPLIGHTER'S PROBLEM

"I follow a terrible profession. In the old days it was more reasonable. I put the lamp out in the morning, and in the evening I lighted it again. I had the rest of the day for relaxation and the night for sleep."

"And the orders have been changed since that time?" the little prince asked.

"The orders have not been changed," said the lamplighter. "That is the tragedy! From year to year the planet has turned more rapidly and the orders have not changed!"

"Then what?" asked the little prince.

"The planet now makes a complete turn every minute, and I no longer have a single second to rest. Once every minute I have to light my lamp and put it out!"

"That is very funny! A day lasts only one minute, here where you live!"

"It is not funny at all!" said the lamplighter. "While we have been talking a month has passed."

"A month?"

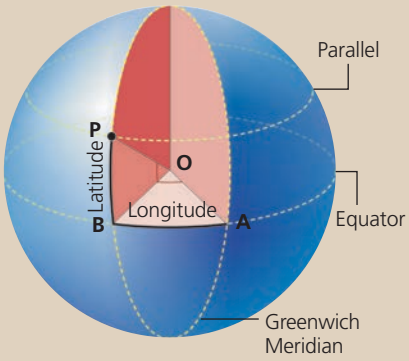
"Yes, a month. Thirty minutes. Thirty days. Good evening." And he lighted his lamp again. [...]

"I can tell you a way you can rest whenever you want to...," he said. Your planet is so small that three strides will take you all the way around it. To be always in the sunshine, you need only walk along rather slowly. When you want to rest, you will walk and the day will last as long as you like."

Antoine de SAINT-EXUPÉRY
The Little Prince (adaptation)

1. *What is a day?*
2. *Which movement of the planet is it associated with?*
3. *How long is a day on the Earth? Does it last the same on all planets?*
4. *Where does the Sun rise?*
5. *What is the direction of rotation of the Earth: from east to west or vice versa?*

1 The Earth



Any point *P* on the Earth's surface is determined by two angles: the angle *AOB*, called **longitude**, which takes the meridian on which the point meets the Greenwich Meridian, and the angle *POB*, called **latitude**, which forms the parallel on which the point meets the Equator.

The Earth is the third planet in the solar system and is approximately 150 million kilometres from the Sun. It is located between the planets Venus and Mars and its only satellite is the Moon.

It is a rocky planet with a spherical shape that is slightly flattened at the poles and its radius is approximately 6 378 km on the Equator and 6 357 at the poles.

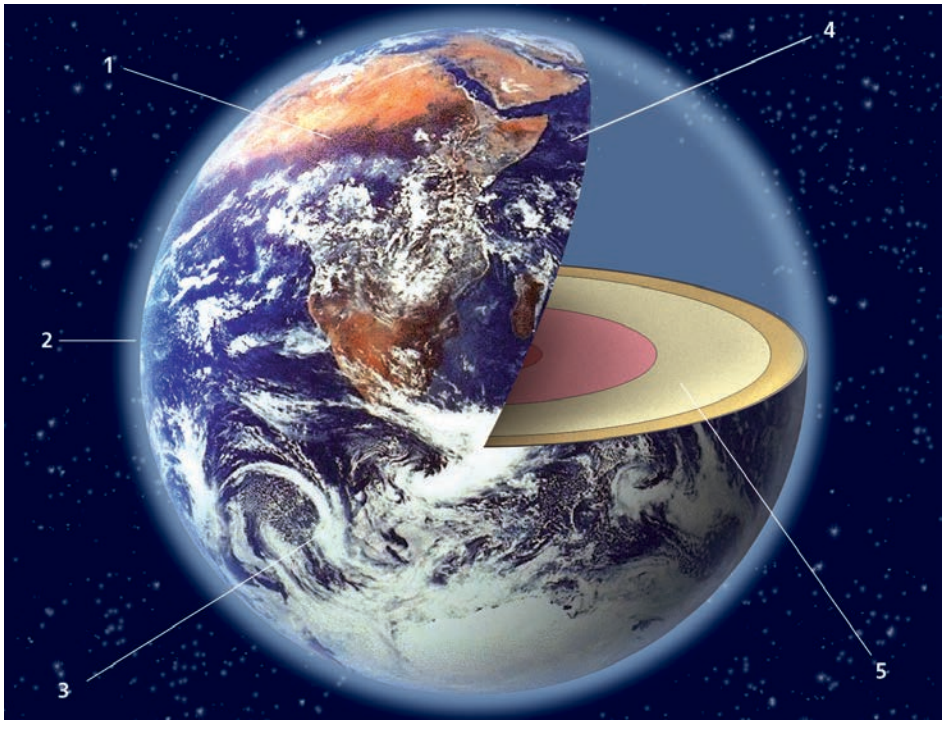
Its force of gravity allows it to maintain an atmosphere made up primarily of nitrogen and oxygen. The distance from the Sun and the composition of the atmosphere means that the average surface temperature is 20°C. This means that water can exist in liquid form. In fact, three-quarters of the planet's surface is covered by oceans.

Having a moderate temperature and liquid water means that the Earth is the only planet in our solar system that can support life.

On Earth there are three **concentric layers** from the outside to the inside:

- The **atmosphere**: this is the gaseous outer layer that surrounds the others.
- The **hydrosphere**: this is the layer of water that makes up the oceans, inland waters (lakes, rivers, groundwater) and glaciers. It also includes water in the atmosphere.
- The **geosphere**: this is the rocky body that constitutes the inner part of the Earth. It is formed by rocks that can be found in both a solid and liquid state.

There is also a fourth layer, the **biosphere**. It is formed by the combination of all living things and occupies part of the other three layers.



1. The **continents** are the large parts of the **geosphere** that emerge above sea level.
2. The **atmosphere** is the gaseous layer of our planet.
3. **Clouds** are large quantities of liquid water droplets that are suspended in the air of the atmosphere.
4. The **hydrosphere** is the layer of water that covers much of the Earth's surface.
5. The **geosphere** is the predominantly solid inner part of the planet.

REPRESENTING THE EARTH

To indicate the **position** of a place on the Earth, a series of imaginary lines called meridians and parallels is used.

- The **axis** is the imaginary line that passes through the two poles. The Earth rotates around this axis.
- The **meridians** are semi-circles that pass through the two poles. The meridian that passes through the town of Greenwich (United Kingdom) is called the **reference meridian**, or prime meridian. The position of a point relative to this meridian is called **longitude**.
- The **parallels** are circles drawn around the Earth perpendicular to the Earth's rotation axis. The **Equator** is the largest of the parallels and is located in the plane that divides the Earth into two equal parts, called **Northern Hemisphere** and **Southern Hemisphere**. The distance of a point from the Equator is called **latitude**.

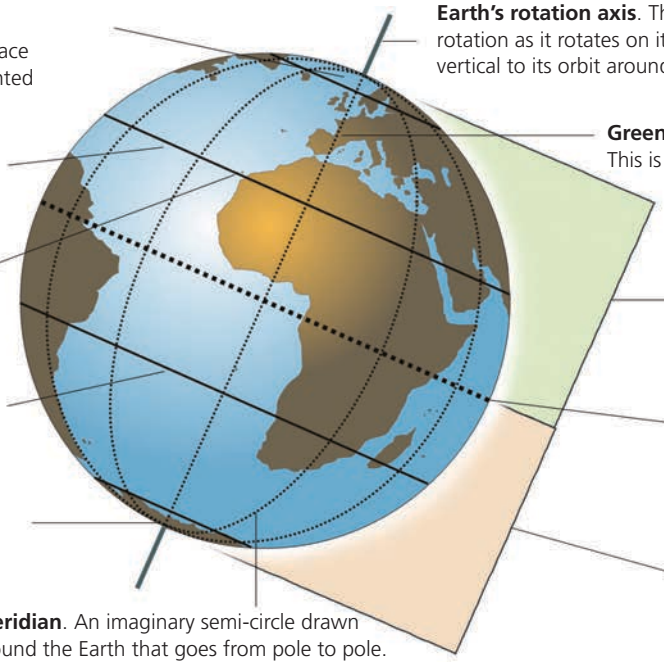
North Pole. The Earth's rotation axis intersects this point of the Earth's surface in the Northern Hemisphere. It is oriented toward the North Star.

Parallel. An imaginary circle drawn around the Earth perpendicular to the Earth's rotation axis.

Tropic of Cancer. Parallel of the Northern Hemisphere located at 23° 27′ north latitude.

Tropic of Capricorn. Parallel of the Southern Hemisphere located at 23° 27′ south latitude.

South Pole. The Earth's rotation axis intersects this point of the Earth's surface in the Southern Hemisphere. It lies on the opposite side of the Earth from the North Pole.



Earth's rotation axis. This is the axis of the Earth's rotation as it rotates on itself. It is tilted 23° 27′ from the vertical to its orbit around the Sun.

Greenwich Meridian or prime meridian. This is the longitude taken as a reference.

Northern hemisphere. An imaginary semi-circle drawn around the Earth between the North Pole and Equator.

Equator. This is the parallel that divides the Earth into two equal parts, called hemispheres.

Southern Hemisphere. An imaginary semi-circle drawn around the Earth between the Equator and the South Pole.

Meridian. An imaginary semi-circle drawn around the Earth that goes from pole to pole.

Activity bank: 33 and 34

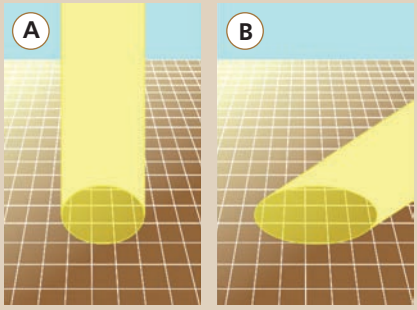
HAVE I UNDERSTOOD?

1. Copy and complete the following phrases:
   "The Earth is located between the planets ____ and ____ . It has a ____ shape that is slightly flattened at the ____ . There are ____ layers from the outside to the inside: the ____ , ____ and ____ ."
2. CA Read the first section and name the two characteristics of the Earth that make it suitable to support life.
3. Why it is said that the biosphere is a layer of the Earth that occupies part of the geosphere, atmosphere and hydrosphere? Name at least one organism that lives in each of them.

APPLYING MY KNOWLEDGE

4. CD Use the Google Earth program and answer the questions about these places on Earth: Mount Everest, Doñana National Park, the Hawaiian Islands, Kilimanjaro and Lake Chad.
   a) What hemisphere are they located on?
   b) Are they east or west of the Greenwich Meridian?

2 The movements of the Earth



A. The ray of light falls perpendicularly on the squared surface.

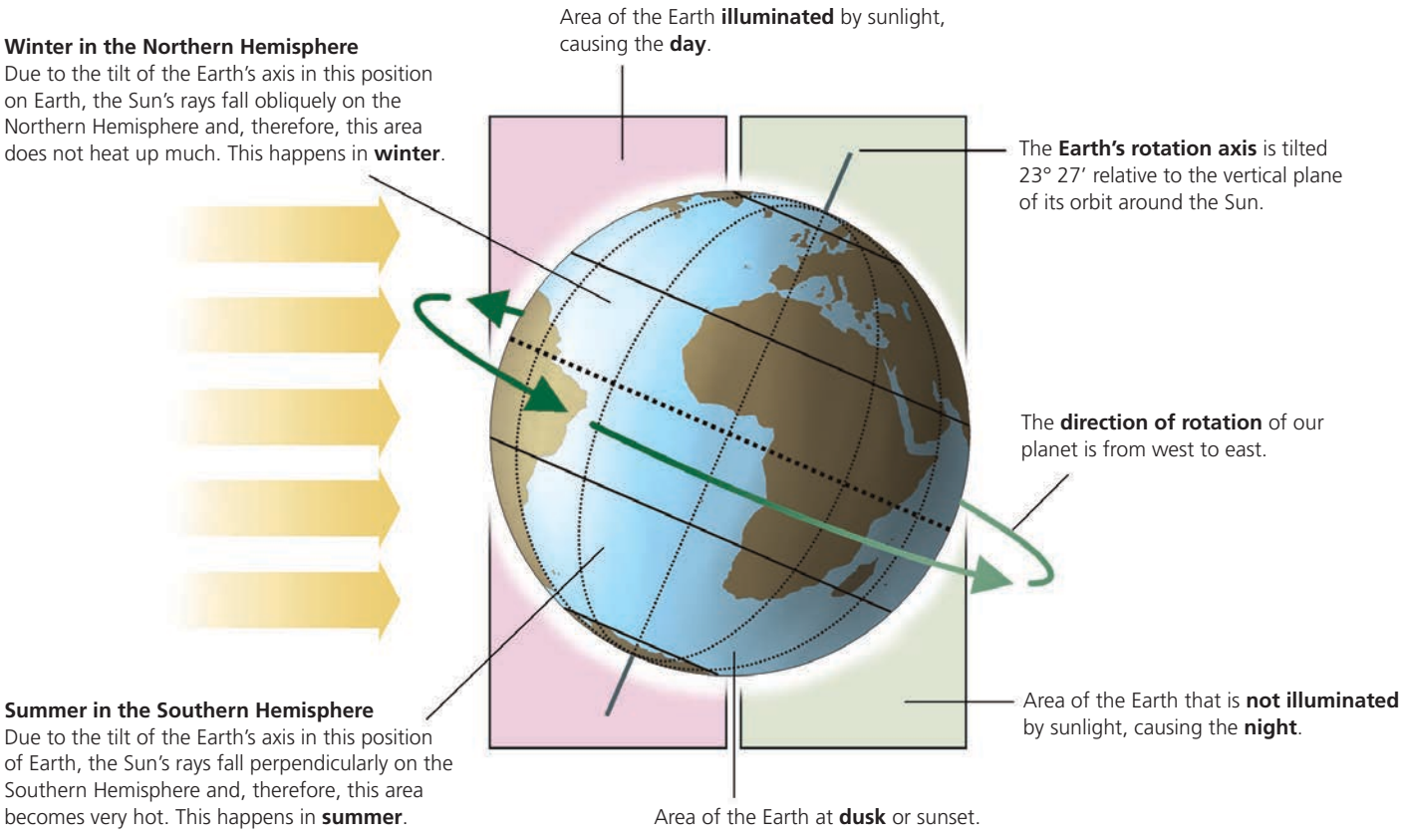
B. When the same ray of light, or in other words, the same amount of energy, falls obliquely on the squared surface, it is distributed across more squares. Therefore, each square receives less energy and, therefore, heats up less than when the rays fall perpendicularly.

Like all other planets in the solar system, the Earth makes two kinds of movement:

- **Rotation**. The Earth rotates on its own axis. It takes 23 hours and 56 minutes to make one complete rotation; this is known as a day.
- **Revolution**. The Earth revolves around the Sun in an elliptical orbit. The period of time that our planet takes to complete an orbit is called a year and it has 365.25 days. It actually takes 365 days plus a quarter of a day, or in other words, 6 hours more. So that the seasons always coincide with certain dates, it was agreed that after three years with 365 days there would be one year with 366 days, known as a leap year. The extra day is on the 29th of February.

The energy that each hemisphere receives from the Sun varies throughout the year. This is because the tilt of the Earth's axis of rotation is relative to the plane that its orbit makes around the Sun (ecliptic plane). This means we can distinguish four seasons during the year: spring, summer, autumn and winter.

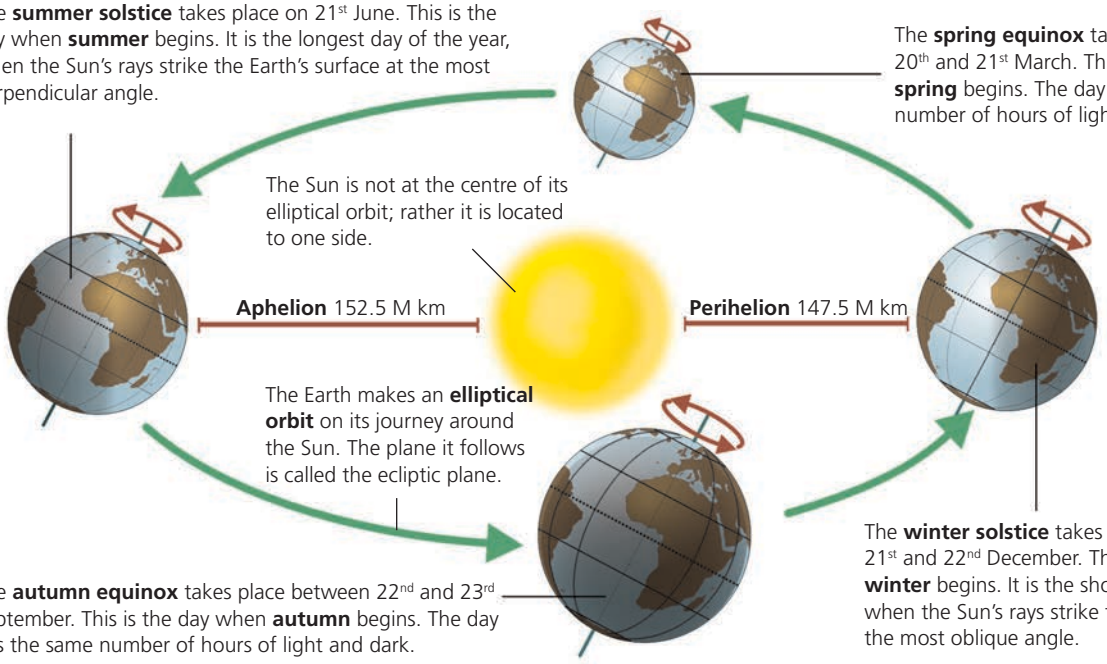
- In summer, the Sun's rays fall perpendicularly on the Earth's surface; therefore they are more concentrated and last more hours a day. As a result, the temperature is higher than the other seasons of the year.
- In winter, the Sun's rays reach the Earth's surface at a more oblique angle and for fewer hours a day. Therefore it is colder.



THE SEASONS IN THE NORTHERN HEMISPHERE

The **summer solstice** takes place on 21st June. This is the day when **summer** begins. It is the longest day of the year, when the Sun's rays strike the Earth's surface at the most perpendicular angle.

The **spring equinox** takes place between 20th and 21st March. This is the day when **spring** begins. The day has the same number of hours of light and dark.



The **autumn equinox** takes place between 22nd and 23rd September. This is the day when **autumn** begins. The day has the same number of hours of light and dark.

The **winter solstice** takes place between 21st and 22nd December. This is the day when **winter** begins. It is the shortest day of the year, when the Sun's rays strike the Earth's surface at the most oblique angle.

It starts on…	21st March	21st June	23rd September	21st December
Northern hemisphere	Spring	Summer	Autumn	Winter
Southern Hemisphere	Autumn	Winter	Spring	Summer

Watch the following excerpt from the BBC documentary series *The Universe*. What would happen if the Earth's axis were vertical?

Activity bank: 21, 22, 23, 24, 25, 35, 36, 37 and 38

HAVE I UNDERSTOOD?

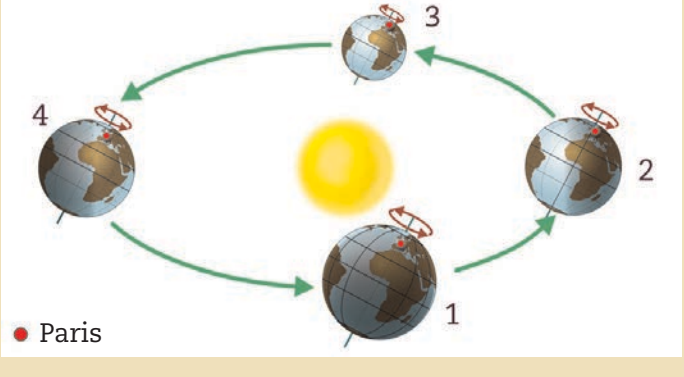
5. CA Make a schematic drawing of rotation and another of revolution, labelling them with the key terms.

6. Indicate which of these sentences are true (T) and which are false (F), and explain the error they contain.
   a) Leap years are repeated every four years.
   b) The summer is hot because the Earth is closest to the Sun during this season.
   c) During the summer it is the same temperature in the Northern Hemisphere as in the Southern Hemisphere.
   d) The Earth makes a circular orbit around the Sun, which is at the centre of this orbit.
   e) The day and night cycle is due to rotation.

APPLYING MY KNOWLEDGE

7. Two friends at a summer camp, Juan from Pontevedra and Luis from Valencia, had an argument. They both believed that the Sun rises earlier in their city than in the other. Explain which of the two friends is right.

8. For each of the positions indicated on the graph, explain which season it is in Paris.



3 The internal structure of the Earth

There are three layers inside the **geosphere** of the Earth: the **crust**, **mantle** and **core**.

- The **crust** is the outermost layer of the Earth. Compared to the others, it is a very thin layer; its thickness varies between 60 km in the landmass and just 7 km in the crust that makes up the ocean floors.
- The **mantle** is the Earth's middle layer. It extends from the crust to a depth of 2 900 km. There are two different layers depending on their chemical composition:
  - The **upper mantle**, located between the crust and a depth of 700 km. Currents of magma are produced inside this layer.
  - The **lower mantle**, which lies at a depth between 700 and 2 900 km.
- The **core** is the innermost part of the geosphere. It ranges from a depth of 2 900 m to the centre of the Earth, or in other words, up to 6 371 km in depth, where temperatures reach 4 600ºC. It is composed of iron and nickel, and is known as NIFE. It has two layers:
  - The **outer core**, which consists of materials in a semi-solid or sticky state and behaves like a liquid.
  - The **inner core**, found in the innermost part. It is solid.

JOURNEY TO THE CENTRE OF THE EARTH

In 1864, Jules Verne wrote the novel *Journey to the Center of the Earth*. At the time, this journey was impossible. And today?

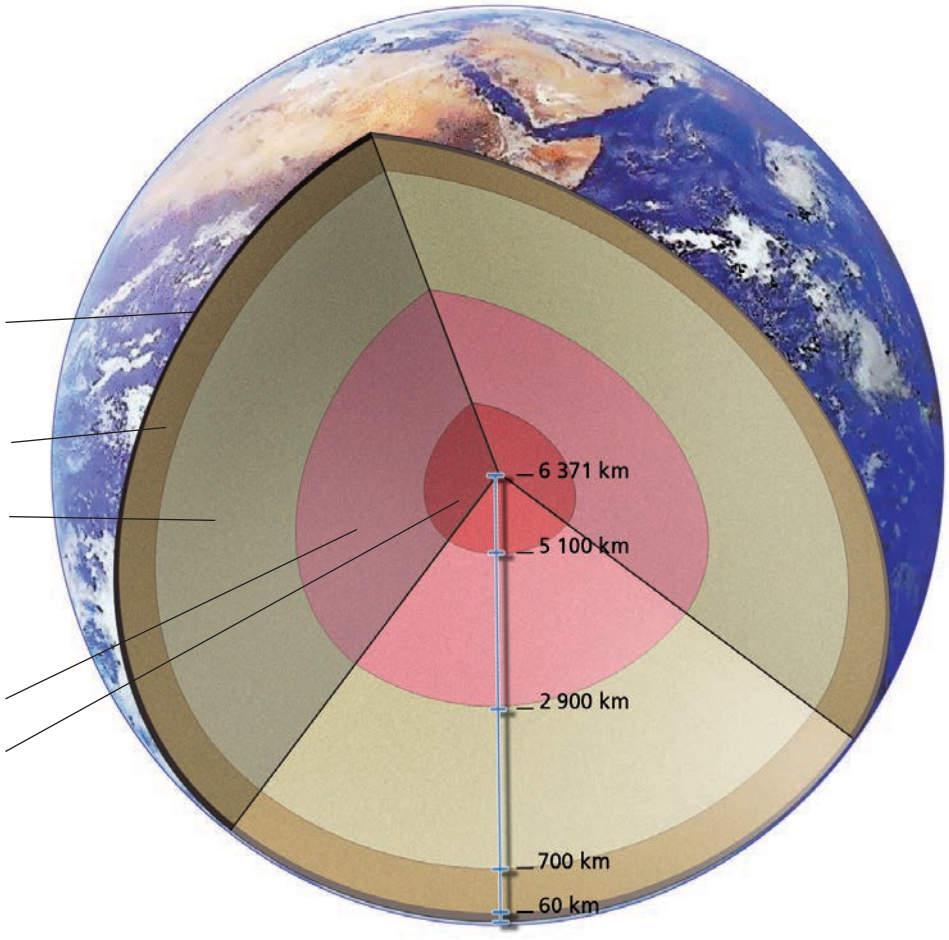
Watch the following clip from the documentary *Journey to the Center of the Earth* from Discovery Channel and answer the questions. Is it possible to travel to the centre of the Earth? What factors make this trip difficult?

Now watch the following clip from the film *Journey to the Center of the Earth* by George Miller, based on the book by Jules Verne, and answer the following questions.

a) What layer of the Earth are the characters in?
(Data: 1 mile = 1.6 km)

b) Could this layer be like this in reality? Why?

Now, why not read the book by Jules Verne and try to discover what the writer was right about and the things he was not.

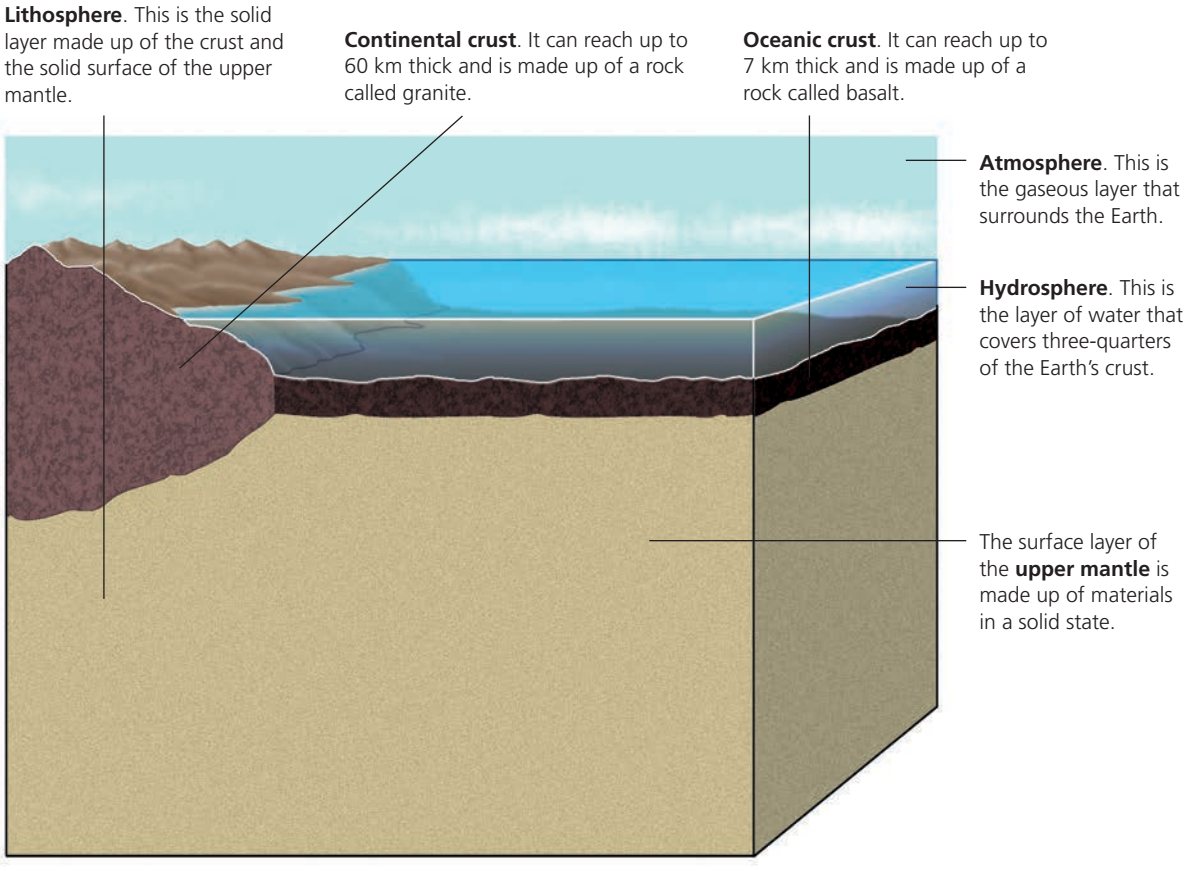


Crust
The solid surface layer.

Mantle
– **Upper mantle**. Between the crust and 700 km.
– **Lower mantle**. 700 - 2 900 km.

Core
– **Outer core**. 2 900 - 5 100 km.
– **Inner core**. 5 100 - 6 371 km (centre of the Earth).

Geologists give the name **lithosphere** to the solid surface layer that is fragmented into **tectonic plates** which float and move, pushed by the currents of magma from the mantle.



HAVE I UNDERSTOOD?

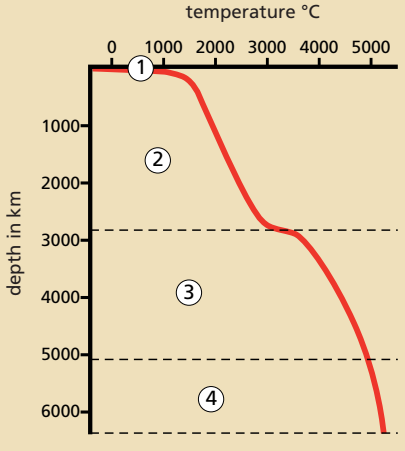
Activity bank: 26, 27, 28, 29, 30 and 39

9. Find the errors in the following text and correct them:
"The crust is the middle layer of the Earth. It is made up of materials in a solid state. There are two types of crust: the continental crust, which has a thickness of about 7 km and is made up of mainly basalt. The oceanic crust, which is under the oceans, can reach 60 km thick and is made up of mainly granite."

APPLYING MY KNOWLEDGE

10. Read the text and look at the picture of the inner layers of the Earth. How thick are the following layers of the Earth?
a) The lower mantle
b) The core
c) The outer core
d) The inner core

11. This diagram shows the internal structure of the geosphere with a graph that indicates the variation in the internal temperature.
a) What layers are indicated with the numbers 1, 2, 3 and 4?
b) Which layer has the greatest thickness?
c) What depths is this layer at?
d) What is the temperature at a depth of 2 900 km? And at a depth of 5 150 km?

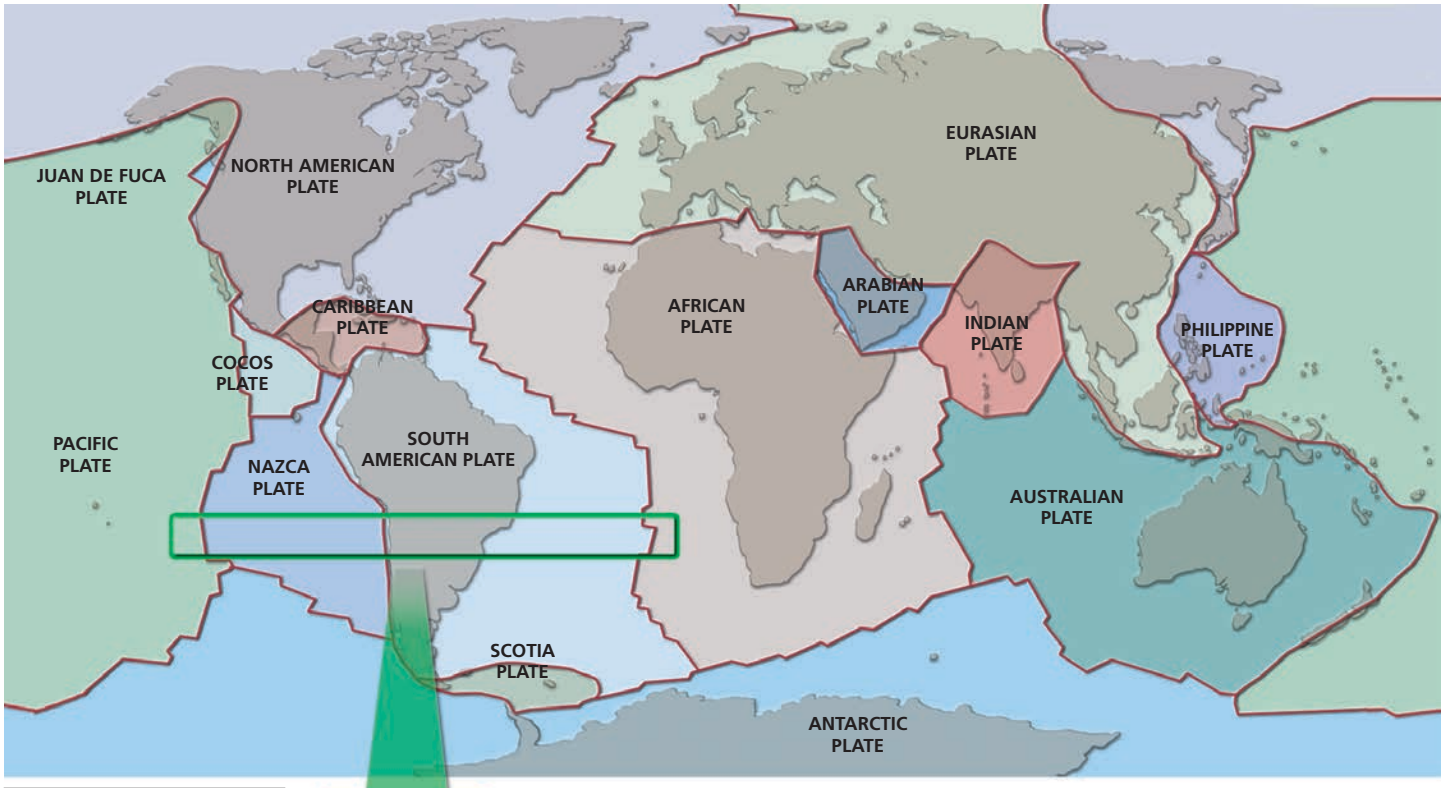


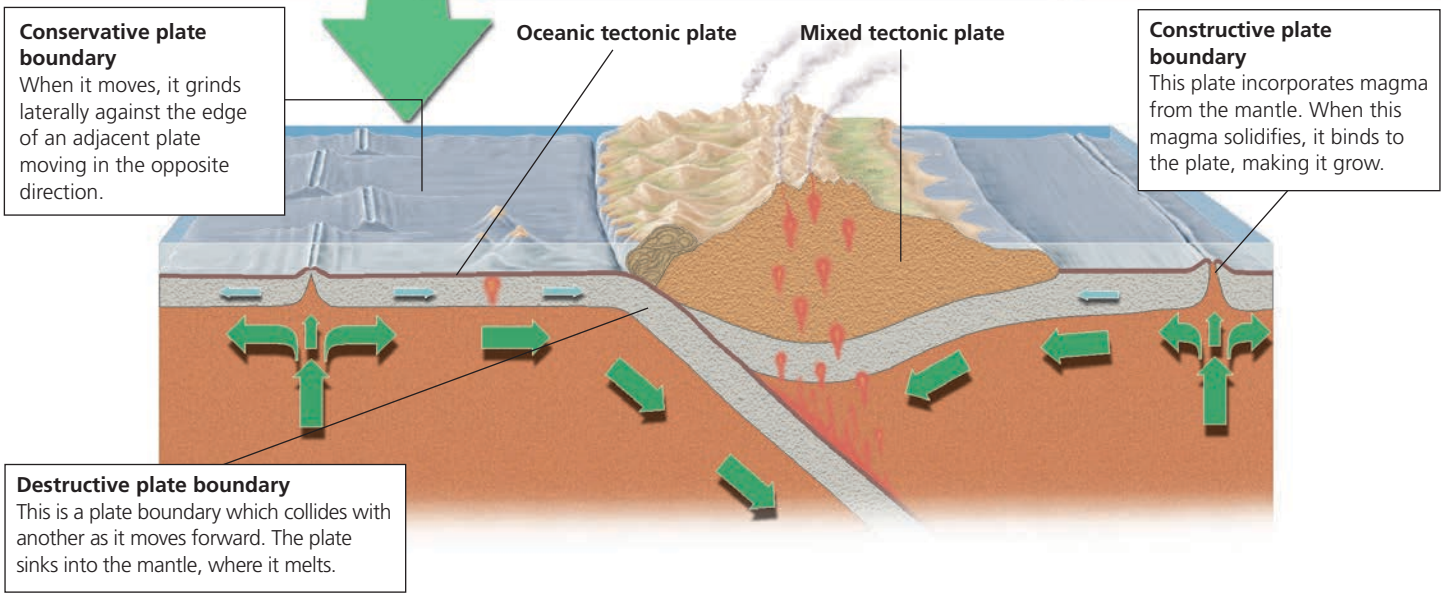
4 Tectonic plates

The **lithosphere** is not a continuous layer. It is fragmented into **tectonic plates**.

Depending on its structure, two types of plates can be distinguished:

- **Oceanic plates**. They are formed by a thin oceanic crust. Underneath this crust is the solid layer of the upper mantle, called **residual mantle**. For example, the Pacific Plate and the Nazca Plate.
- **Mixed plates**. These plates have one part of oceanic crust and another of continental crust on the upper mantle. For example, the South American Plate and the African Plate.



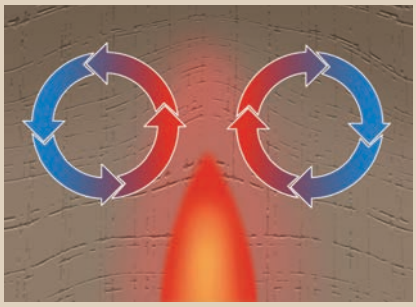


4.1 The effects of tectonic plates

The theory of **plate tectonics** or **global tectonics** says that the **lithosphere** is divided into tectonic plates that float and move over the mantle, driven by convection currents. These currents cause the plates to grow, move, rub and collide with each other, sinking into the mantle, where they melt and disappear.

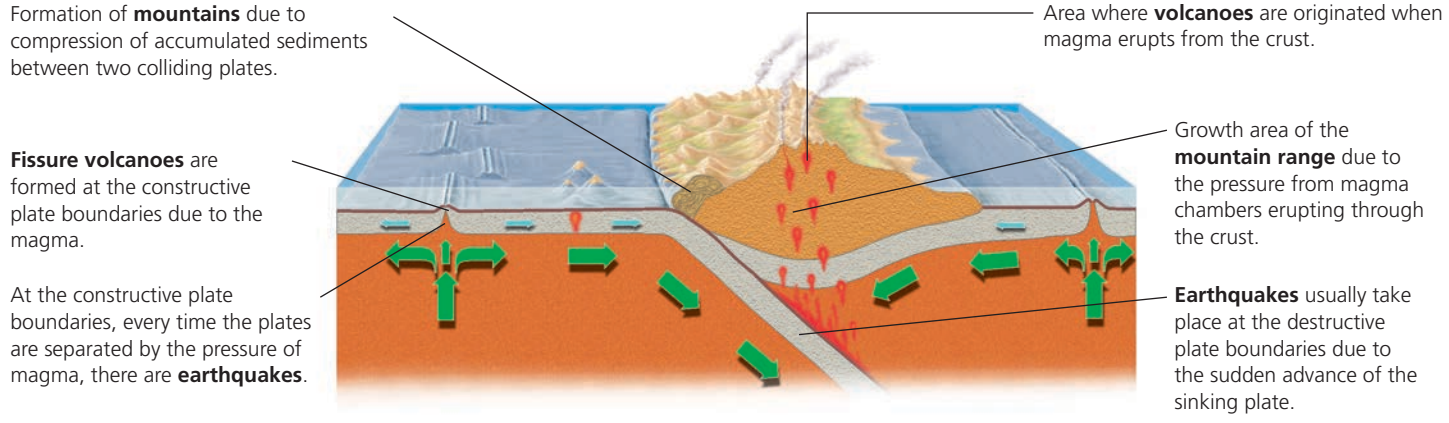
The main effects of this activity are:

- **Volcanism**. This is when magma erupts onto the Earth's surface through cracks in the lithosphere. Most volcanoes occur in places where the plates move apart or collide.
- **Earthquakes**. These are vibrations of the lithosphere caused by the sudden movement of an area of the lithosphere with respect to another. They are common in places where two plates collide and one is submerged beneath the other.
- **Orogeny**. This is the formation of mountain ranges caused by the compression and crumpling of sediments that have accumulated in areas of collision between two plates or by rising magma, which can be trapped inside the crust or erupt onto the outside through volcanic eruptions.



Convection is the movement that takes place in fluids when the heat is transported from areas with a higher temperature to those with a lower temperature, due to changes in the density of the materials. Hot materials expand, decreasing their density and, therefore, they rise.

EFFECTS OF THE MOVEMENT OF TECTONIC PLATES



HAVE I UNDERSTOOD?

12. Copy and complete the following phrases: "The ____ or solid layer that forms the Earth's surface is divided into fragments that are called ____ . These structures can be classified as follows:

- Oceanic plates. They are made up of the residual mantle and a thin ____ crust.
- ____ plates. They are formed by the ____ on which appear sectors of thin oceanic crust and sectors of a thick ____ crust."

13. CA CL Draw a conceptual diagram showing the types of boundaries, summarising what they consist of.

14. Answer the following questions.

a) When does a destructive plate boundary occur? What geological effects are produced in it?

b) When does a constructive plate boundary occur? What geological effects are produced in it?

APPLYING MY KNOWLEDGE

15. Look at the picture of the *effects of the movement of tectonic plates*. Where do earthquakes originate?

5 The Moon

The **surface of the Moon** is covered with a fine powder.

A. The **Copernicus crater**. These craters are caused by the impact of meteorites on the surface of the Moon. Some of them may also be due to ancient volcanoes.

B. The **Sea of Tranquillity**. The Moon's seas are vast plains of basalt.

C. The **Montes Apenninus**. Some of the Moon's mountains can reach heights of thousands of metres.

The Moon is the Earth's only natural satellite. It is located 384 000 km from it and its diameter is more than a quarter of the Earth's diameter. It does not have water and, because of its low force of gravity, it cannot retain gases to form an atmosphere.

When viewed from Earth, we can see light and dark areas on the surface of the Moon. The light areas are mountainous and contain many craters caused by impact from meteorites or belonging to ancient volcanoes. The dark areas or seas are plains of solidified lava.

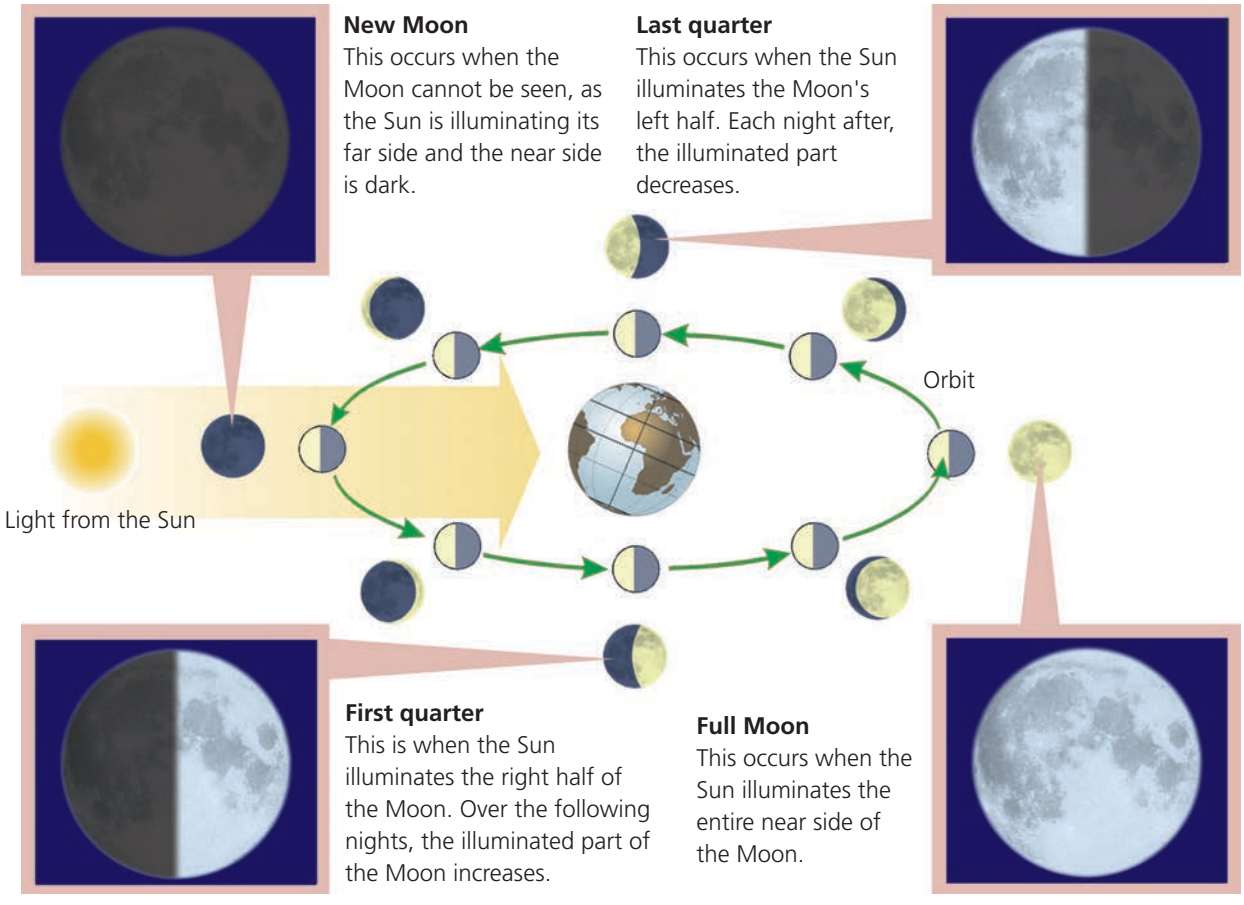
The Moon makes two types of movements:
- **Rotational movement** on itself.
- **Revolution** around the Earth.

The Moon takes the same time to make both movements: 27 days and 7 hours. This is why we always see the same side of the Moon, called the near side, and never the other side, known as the far side.

Due to the revolution of the Moon, there are **phases of the Moon** and **eclipses**.

THE PHASES OF THE MOON

From the Earth we see how the illuminated part of the Moon changes as its position varies. This produces the phases of the Moon.

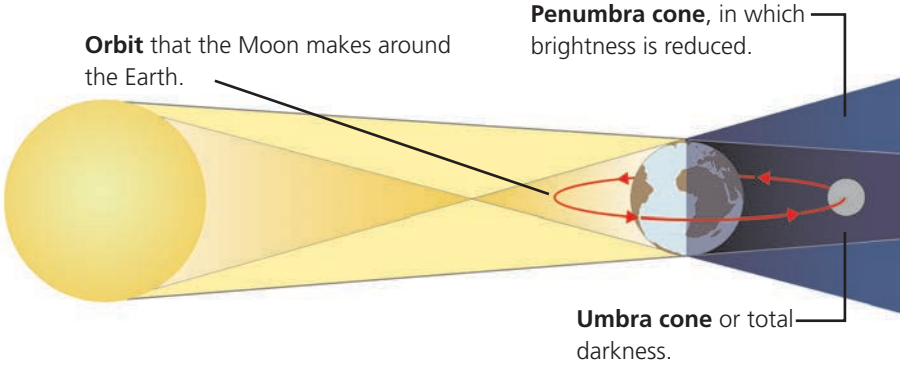


ECLIPSES

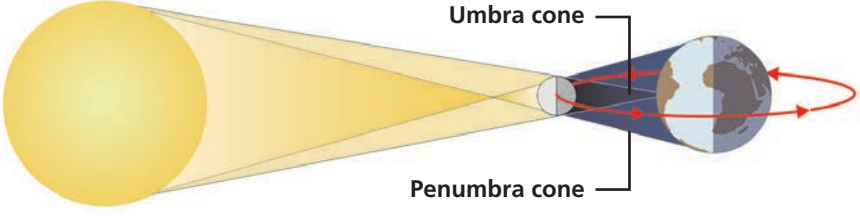
An eclipse is the **obscuring** or **concealment** of an astral body when it moves in front of another, preventing the light from a star from illuminating it.

In the Earth-Moon system, there are two types of eclipses. The Earth, Moon and Sun have to be aligned.

- **Eclipse of the Moon**. The Moon darkens when the Earth moves between it and the Sun. In this case, the Earth's shadow covers the Moon completely or partially.



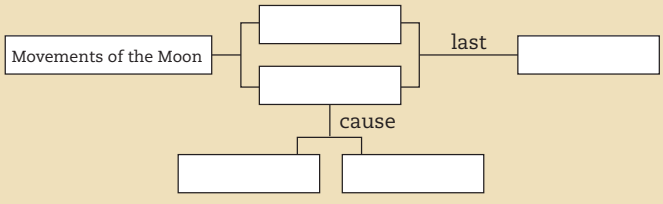
- **Solar eclipse**. This occurs when the Moon passes between the Sun and the Earth. In areas located in the umbra cone we see a total eclipse of the Sun, while in those in the penumbra cone there is a reduction in brightness.



Activity bank: 31, 32, 40 and 41

HAVE I UNDERSTOOD?

16. CA Copy and complete this concept map.



APPLYING MY KNOWLEDGE

17. Look at this photo taken during an eclipse (figure 1).
a) Explain what type of eclipse was taking place.
b) What order were the celestial bodies in during this eclipse?

18. Explain what phase of the Moon appears in figure 2.

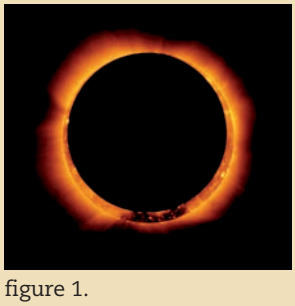
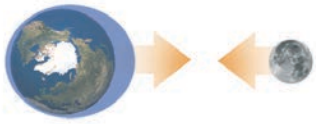
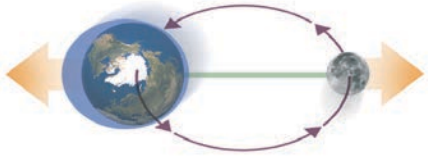


figure 1.


figure 2.



High tide caused by the attraction of the Moon.



High tide caused by the centrifugal force created by the rotation of the Earth.

TIDES

The **tides** are cyclical changes in the height of the sea level caused by the gravitational attraction of the Moon. The Sun also attracts water from the oceans, but as it is farther away, it has less force. Centrifugal force created by the Earth's rotation is also involved.

As it is so close to the Earth, the Moon attracts water from the oceans towards it, causing a rise in sea level, resulting in a **high tide**. On the opposite side, the position of the Moon also causes a higher sea level occurs due to the centrifugal force of the Earth, which causes another high tide.

Between the two rises in sea level there are two areas in which the water level is lower, causing two **low tides**.

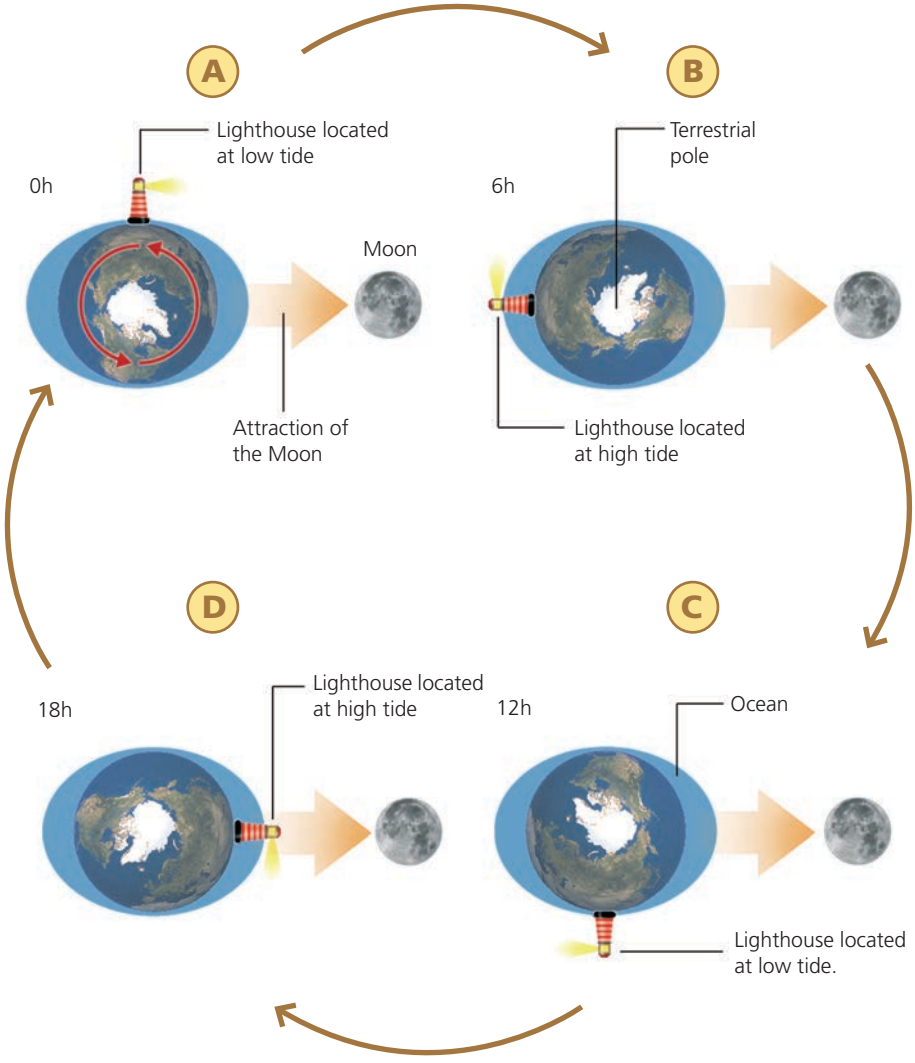
As the Earth turns on its own axis every 24 hours, every point on the coast has two high and two low tides each day.

LOW TIDE

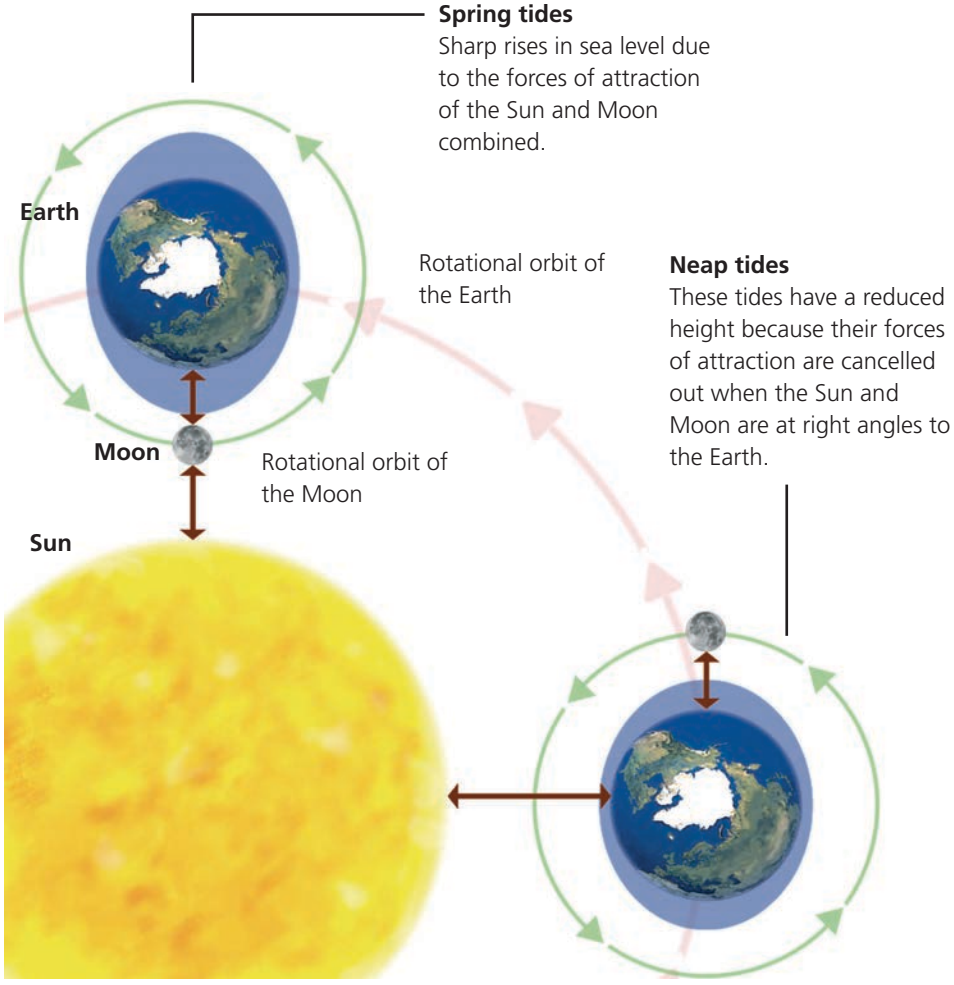
Beach at low tide, situations A and C.

HIGH TIDE

Beach at high tide, situations B and D.



The tides are not always the same height; therefore, when the Moon and the Sun are aligned they combine their forces of attraction and generate sharp rises in sea level or **spring tides**. By contrast, when the Moon and Sun are at right angles, their forces of attraction are cancelled out, reducing the height of the sea level, producing a **neap tide**.



APPLYING MY KNOWLEDGE

19. This graph represents the oscillation in sea level due to tides in Ferrol between the 17th and 21st June.

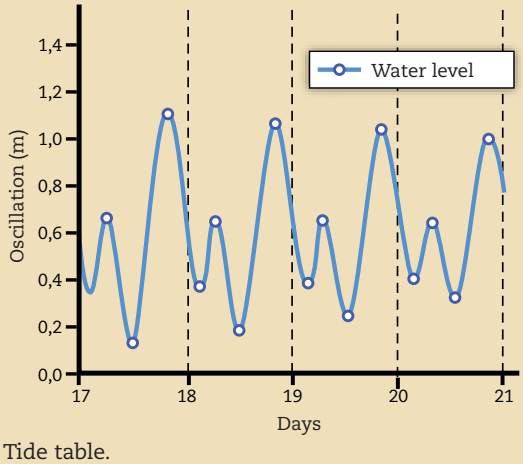
a) On what day was the highest tide?

b) How many changes in sea level take place in one day due to tides?

c) How many hours pass between a low tide and the next high tide?

▲ **20.** CI CS In groups, imagine that you work for Ferrol City Hall and you have to make alterations in the city's coastal area. Explain the advantages and disadvantages of the following projects: hotel, green area with playground, hospital, car park and residential area.

Activity bank: 42, 43 and 44



Tide table.

ACTIVITY BANK

HAVE I UNDERSTOOD?

21. Why is it warmer in July and August in the Northern Hemisphere if the Earth is furthest from the Sun during these months?

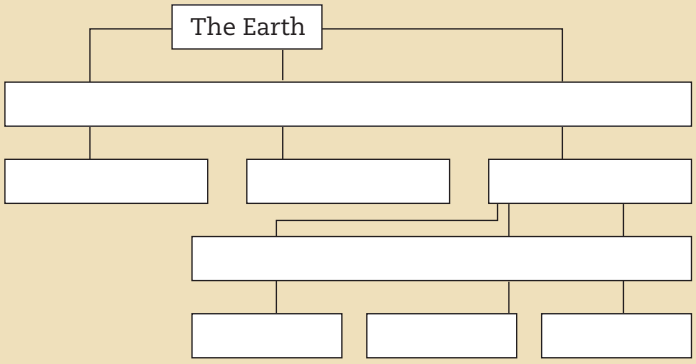
22. During winter at the North Pole, is there a succession of days and nights or are there only nights? For how long?

23. Explain why temperatures in both hemispheres are similar in spring and autumn.

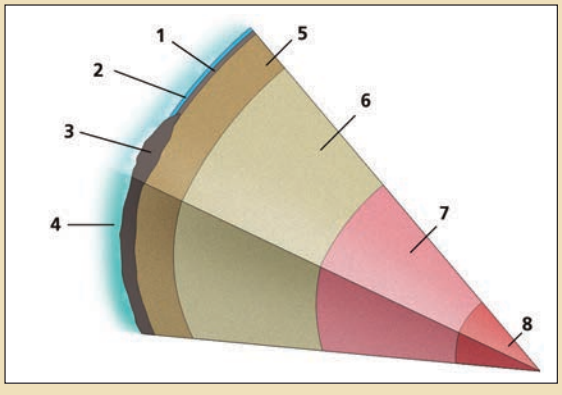
24. If the speed of rotation of the Earth increased, what effect would this have on the length of day and night? Why?

25. CL Find and make a note of the meaning of the words *equinox*, *solstice*, *ecliptic* and *precession*.

26. CA Copy and complete the following diagram with these words and expressions: *geosphere*, *is divided into...*, *crust*, *atmosphere*, *has the following layers*, *core*, *hydrosphere* and *mantle*.



27. Label the illustration with the following words: *atmosphere*, *internal core*, *upper mantle*, *hydrosphere*, *external core*, *lower mantle*, *oceanic crust* and *continental crust*.



28. What is a tectonic plate? Explain the mechanism that moves the tectonic plates over the mantle.

29. Why is the Earth's core known as NIFE?

30. Complete the following table indicating the inner layers in the Earth's structure according to their depth.

Depth	Layer of the Earth
0-60 km	
60-700 km	
700-2 900 km	
2 900-6 371 km	

31. The Moon has dark areas that are called seas. What is the difference between these seas and the Earth's seas?

32. Why can the far side of the Moon never be seen?

APPLYING MY KNOWLEDGE

33. CD Search for the location of your city hall on Google Earth and record the latitude and longitude at which it is located.

34. Calculate the longitude and latitude of the opposite point on the planet to the city where you live. Use an atlas to find out what place it corresponds to.

35. The Earth's axis of rotation is tilted 23° 27›, with its far north end pointing to the North Star. However this has not always been the case, since both the angle of the axis and the star that indicates the North Pole have varied over 4.6 billion years since our planet was formed.
a) Would there be differences in the length of day and night if the axis were vertical?
b) Would the seasons remain the same throughout the year with this position of the rotational axis?

APPLYING MY KNOWLEDGE

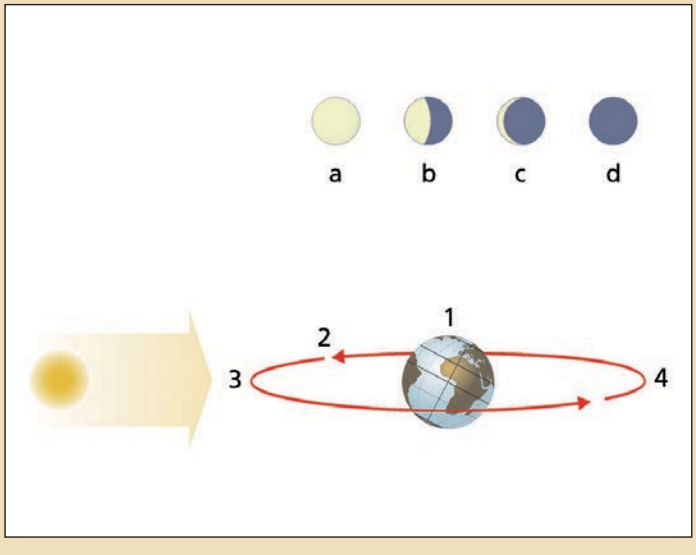
36. Alberto is going to Argentina during his summer holidays, but when watching the news, he noticed that there were people dressed in winter clothes in Buenos Aires. He has to pack his suitcase but he does not know what clothes to take.
a) What clothes would you advise him to take?
b) What argument would convince him?

37. Calculate the average radius of the Earth and use it to find the length of the Equator in kilometres (you will need the formula to find this distance: find out yourself or ask your teacher).

38. How many times does the Earth turn on itself during one complete revolution around the Sun? How many times does the Moon turn on itself while making a revolution around the Earth?

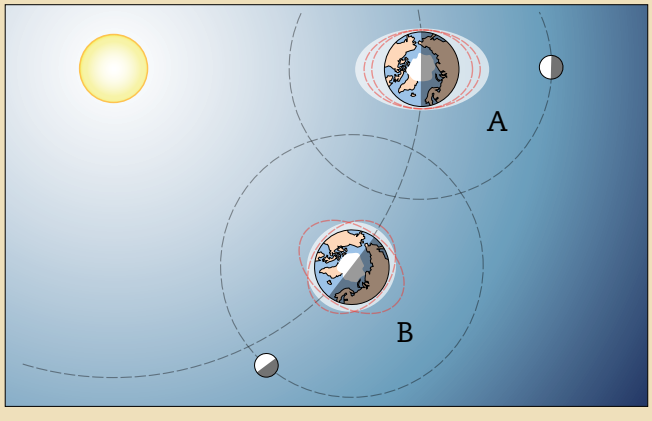
39. As we go deeper into the Earth's crust, the temperature rises one degree every 33 metres.
a) If this increase were constant, what temperature would it be at the centre of the Earth? (Take the radius of the Earth to be 6 371 km.) Would this temperature be possible? Why?
b) As you know, the temperature at the centre of the Earth is 4 600°C. If the temperature were to increase steadily, in how many metres would it increase by 1°C?
c) Evidently, the temperature increase is not constant. Why?

40. Locate each of the Moon's phases below. Say whether this sequence corresponds to the first quarter or last quarter Moon.



41. CL The following comment has appeared on the Internet: "Today there will be a solar eclipse as the full Moon will be between the Earth and our star." Is this sentence correct? If not, explain why.

42. This drawing shows the location of the Sun, the Moon and the Earth during a spring tide and neap tide.



a) Indicate which corresponds to a spring tide and explain what is happening.
b) Do the same with the part of the drawing that corresponds to a neap tide.
c) How much time has elapsed between the spring tide and neap tide?

43. CL Watch the clip of *The Moon and its influence*.
a) Make a summary of the content.
b) How does the Moon influence the cycles of some living things?
c) Is the side of the Moon that is seen in the Northern Hemisphere the same in the Southern Hemisphere? Is there a difference?

44. Look for inventions that have helped man reach the Moon and that have been useful for mankind.

...perhaps you already have answers

Reread the questions related to the initial video.
a) What are the answers to the questions?
b) Are they the same you gave before studying the unit?
c) After completing the unit, do you have any further questions?

The first man on the Moon, a dream come true

CS CL

"That's one small step for a man, one giant leap for mankind," said Armstrong.

The Soviets started the space age in 1957 by launching the tiny *Sputnik* satellite, and proclaimed that they were ahead of the rest of the world in missile technology. The first attempts by the United States to send an unmanned spacecraft to the Moon either failed or sent back limited data. This was the start of a decade of intense space warfare between the United States and the former Soviet Union (USSR). In the early years, the Soviets had the most powerful rockets and the best organised space programme. Their superiority was proved to the world in 1961, when Russian cosmonaut Yuri Gagarin became the first human to go into space and complete an orbit around the Earth.

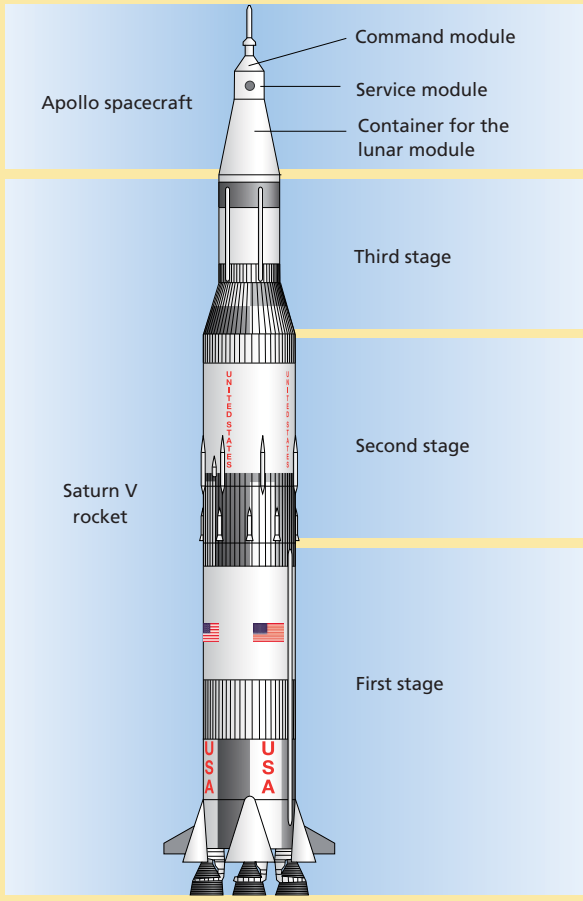
On 21st July 1969, man reached the Moon for the first time in Apollo 11. American astronaut Neil Armstrong, who was 39 years old, first set foot on the surface of the Moon at 3.56 am Spanish time on 21st July 1969, and said these words: "That's one small step for [a] man, one giant leap for mankind." At that very moment, 528 million people on Earth were watching the events on their televisions.

After Apollo 11, there were five more Moon landings, but all projects were cancelled due to the very high costs and the Moon has not been visited by humans again since 1972.

The spacecraft that intended to put two astronauts on the surface of the Moon consisted of a Saturn V rocket carrying the Apollo spacecraft. When it was launched, it weighed 3 200 tons and had a total height of 110 metres. The Saturn V rocket consisted of three phases and its function was to propel the Apollo spacecraft away from Earth's gravity. To do this, it consumed 15 tons of fuel per second.

The Apollo spacecraft was made up of three elements:

1. A conical-shaped **command module** which holds the control panels. The astronauts sit in the module, both for the launch and for the return to Earth. It has a fireproof shield that protects the module from the high temperatures generated by crossing the atmosphere during the return to Earth.
2. The **service module** holds the electrical equipment, oxygen, hydrogen and helium tanks, and the manoeuvring engines.
3. The **lunar module** has room for two people and is the only part of the spacecraft that can descend to the surface of the Moon.



Getting ready for an expedition to Mars in 2023

There are 39 Spaniards among the 1 058 short-listed from around the world to create the first human colony on Mars in 2023 with a one-way ticket for a trip to the red planet. The next step is a medical examination to confirm the physical condition of those short-listed.

The trip to Mars will take seven months in a shuttle with four people. However, those selected will first be trained for seven years as astronauts and for three months they will be isolated at a location in Antarctica or the desert.

The project plans to send up a communications satellite in 2018, and in 2020 a robot that will set up houses of about 50 square metres, where the people who eventually make up the human colony will live.

The homes will have solar panels to provide energy from solar radiation and greenhouses shall be built so they can grow their own food.

Antena3.com, 3/3/2014 (adaptation)

The full Moon at perigee gives us another supermoon on 9th September

A supermoon is seen when there is a full Moon at perigee, or in other words, at the point when the Moon is closest to the Earth as it rotates around it. This happened at 3.38 am on 9th September in mainland Spain.

This is not an uncommon event. In fact, there are usually three to five supermoons a year. The increase in size cannot be seen with the naked eye, but they are much brighter, between 25 and 30%.

In the image on the left we see the Moon at perigee, or in other words, at its closest point to the Earth. On the right we see the Moon at apogee, or the furthest point. www.rtve.es, 9/9/14 (adaptation)

1. C1 What was Saturn V's mission?
   a) To place the Apollo spacecraft in the Moon's orbit.
   b) To allow the Apollo to escape the Earth's gravity.
   c) To transport astronauts to the Moon and back.
   d) To place the Apollo in the Earth's orbit.
2. C2 Explain the meaning of Neil Armstrong's words when he set foot on the Moon.
3. C3 During Moon landings, the lunar module used rockets to slow its fall. Why couldn't they use parachutes during their descent?
4. C2 Watch the video and answer the questions.
   a) Where did Apollo 11 land?
   b) Why do you think they chose this location?
5. C1 Imagine you are selected to go to Mars and are asked to design an experiment to carry out there.
   a) What experiment would you suggest?
   b) What hypothesis would you suggest?
   c) What materials would you take to carry it out?
6. C3 Answer the following questions with reasoned arguments:
   a) Why do you think it would be useful to be able to send people to Mars?
   b) What problems could these people experience on Mars?
7. C1 Answer the following questions:
   a) What is the perigee?
   b) What is a supermoon?
   c) Is it a rare phenomenon?

Where do most volcanoes and earthquakes originate?

CA CI

Tectonic plates move over the Earth's mantle pushed by currents of magma. These currents make the plates grow, grind together and sink into the mantle when they collide. These movements take place abruptly, causing earthquakes which crack the plates and allow magma to erupt onto the Earth's surface. Therefore, volcanoes and earthquakes are not evenly distributed across the Earth; rather, they are related to the activity of tectonic plates.

Materials
– World map with the distribution of volcanoes and epicentres where earthquakes originate

Hypothesis. Are volcanoes and earthquakes found in any point on the Earth's surface or are they concentrated in certain places? Are they related to tectonic plates? Are they concentrated in the centre of the plates or at their boundaries? Can you determine if it is a constructive or destructive boundary depending on its seismic and volcanic activity? We could choose one of these questions and generate a hypothesis. For example, can we determine the destructive boundary of a plate by analysing the type of volcanism and seismic activity? Carry out the following activity and determine whether this hypothesis is correct.

EXPERIMENT

We will use the Nazca plate for this activity.

Download and print the map for the activity. Look at it carefully and answer the questions.

1. What type of tectonic plate is the Nazca Plate?

2. Look at the location of the volcanoes. Are there alignments?

3. What colour is used to show the earth tremors that originate on the surface? Where do they occur most?

4. Which colour represents the earthquakes that take place at intermediate-depth? Where are they located? Do they have alignments?

5. What is used to indicate deep-focus earthquakes? Where are they found? Are there alignments?

6. Is there an alignment of superficial, intermediate-focus and deep-focus earthquakes?

7. At the constructive boundaries, plates are formed with magma from the mantle. They are no thicker than 100 kilometres. What kind of earthquakes will be produced: superficial or deep?

8. At the destructive boundaries, the tectonic plates sink into the mantle and melt until they disappear. What types of earthquakes will originate in this plate boundary?

ANALYSIS

1. Check if there are areas where volcanic activity coincides with a strong seismic risk.
2. Does the tectonic plate that sinks into the mantle only produce superficial earthquakes or also deep-focus ones?
3. Indicate where the destructive boundary is located on the Nazca Plate.

CONCLUSION

After analysing the data, write out the conclusions you have reached. Have you proved the hypothesis that you wanted to check?

Now, write another hypothesis that enables you do to more research with geological events related to tectonic plates.

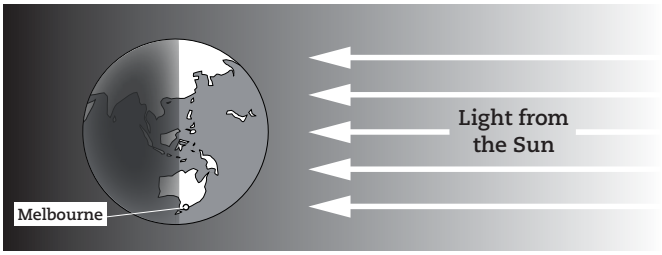
CC CS

The longest day

On 21st June, when the Northern Hemisphere is celebrating its longest day, Australians will have their shortest day. In Melbourne, Australia, the Sun will rise at 7.36 am and will set at 5.08 pm, providing 9 hours and 32 minutes of light. Compare this day with the longest day of the year in the Southern Hemisphere, which will be 22nd December, when the Sun will rise at 5.55 am and will set at 8.42 pm, providing 14 hours and 47 minutes of light. The president of the Astronomical Society, Mr Perry Vlahos, said the existence of changing seasons in the Northern and Southern Hemispheres was related to the 23 degree tilt of the Earth's axis.

Adaptation from a past PISA test

1. C1 What sentence explains why there is day and night on the Earth?
   a) The Earth rotates around its axis.
   b) The Sun rotates around its axis.
   c) The axis of the Earth is tilted.
   d) The Earth revolves around the Sun.
2. C1 What movement of the Earth is related to the seasons?
3. C1 What title would you give the text?
4. C2 The drawing represents the Sun's rays illuminating the Earth. Redraw the globe to make it the shortest day in Melbourne. Then find the Earth's axis, the Northern Hemisphere, the Southern Hemisphere, the Equator and the city of Melbourne. Label the globe with your answers.



5. C3 Imagine you want to travel to Melbourne. To do so, you have to leave from Barajas airport in Madrid. The distance between Madrid and Melbourne is 17 310 km and the time difference is eight hours. Say whether the following statements are true or false.

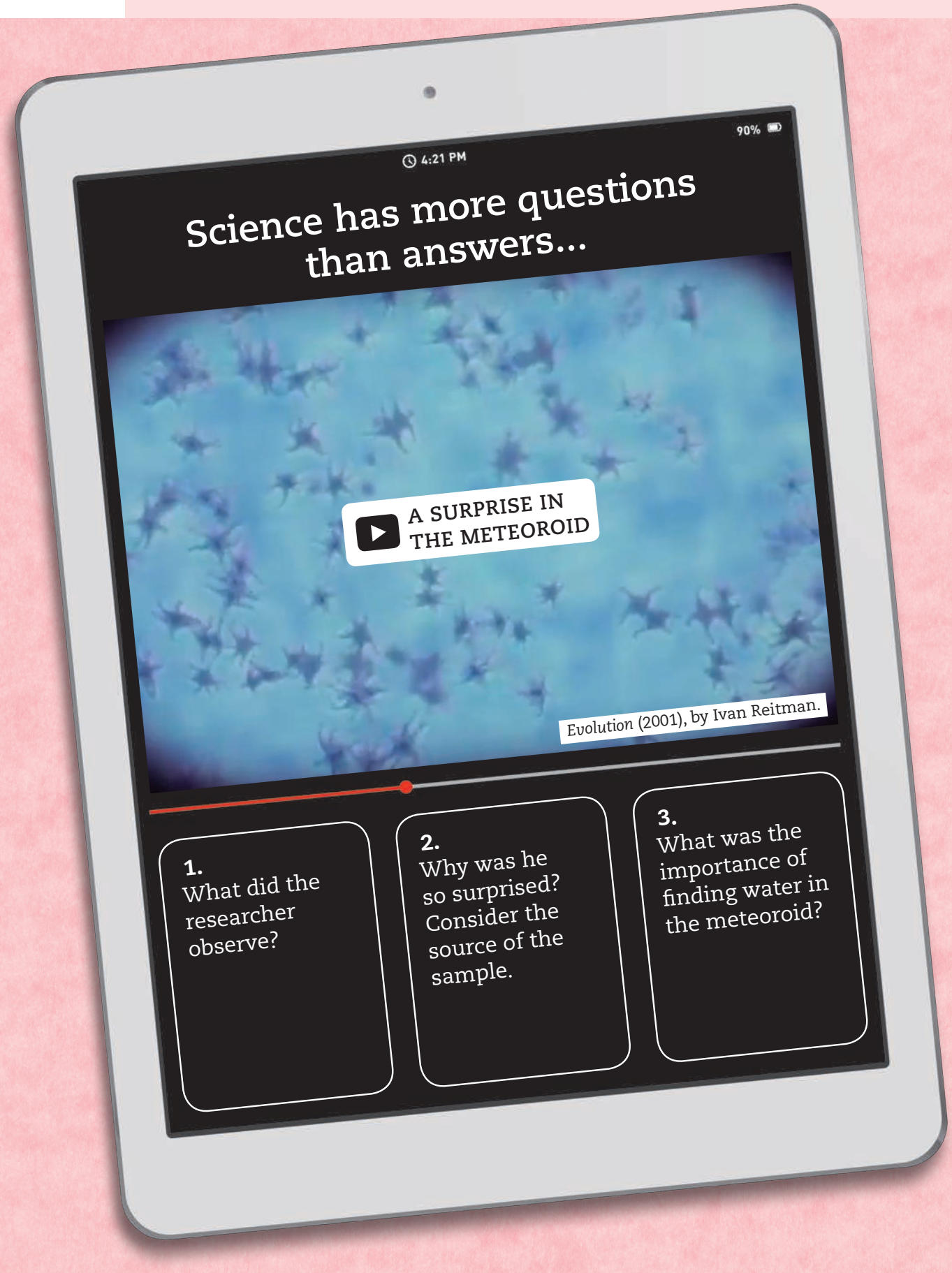
   (Note: the average speed of a commercial airliner is 850 km/h)

   a) The flight takes 15 hours.
   b) If the plane arrives in Melbourne at 5.00 pm, in Spain it will be 9.00 am.
   c) If you leave Madrid on the 20th at 7.00 am (time in Spain), you will arrive in Melbourne on the 21st at 11.00 am (time in Australia).
   d) If you leave Madrid on the 20th at 1.00 am (time in Spain), you will arrive in Melbourne on the same day at 9.00 pm (time in Australia).
6. C2 If you travel to Melbourne in July, what clothes would you need to pack? Explain your answer.

PISA ASSESSMENT FRAMEWORK

CATEGORY: The Earth in space
CONTEXT: **Situation:** Global
Content area: Frontiers of science and technology

6 LIFE ON EARTH: LIVING THINGS AND CELLS



Can I remember?

WHICH CAME FIRST, LIFE OR OXYGEN?

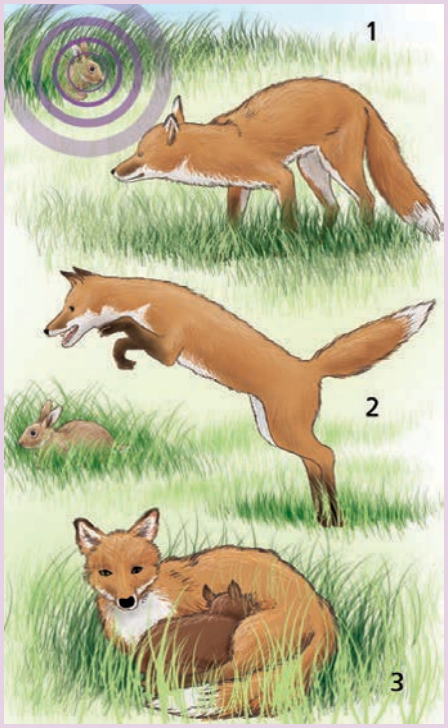
The only life we know is cellular. Therefore, the first living beings were cells, little packets of chemical substances capable of absorbing certain nutrients, dividing and producing heirs. These were, and still are, bacteria. They are microscopic organisms, of course.

[...]

The fossil record tells us that the oldest living things lived 3.5 billion years ago in shallow seabeds, in an atmosphere low in oxygen and rich in carbon dioxide, with hydrochloric and sulphuric acid vapour that today would burn our clothes, skin and lungs. These were **bacteria**, known as **cyanobacteria** because of their **blue-green colour**, and they invented something as incredible as photosynthesis: they absorbed water molecules, used the hydrogen and released the oxygen, oxygenating the primitive atmosphere until it became breathable.

JOSÉ R. AYLLÓN AND OCTAVIO RICO,
La película de la vida (The Film of Life) (adaptation)

1. What is a cell?
2. What are the three functions of living things?
3. What do we have to use to see a cell?
4. What is photosynthesis?
5. What terrestrial organisms perform photosynthesis?



1. A small noise (stimulus) perceived by a fox can cause a movement (response).

2. When the fox eats a rabbit, it obtains matter to build its body and to give it energy to be active.

3. Thanks to reproduction, a species continues and does not become extinct.

1 Living things

1.1 Living things and their functions

Living things can perform three vital functions: nutrition, interaction and reproduction.

- **Nutrition.** This is the ability of living things to obtain matter and energy from the environment to grow, develop and perform all vital functions.
- **Interaction.** This is the ability to perceive a change in the environment, known as a **stimulus,** and make appropriate **responses**. Some ways of responding to these stimuli are running away, attacking, moving towards the light and changing their coat in winter.
- **Reproduction.** This is the ability to generate new individuals. Organisms have a limited lifespan, so they need to multiply so that their species continues to exist.

Often, when living things are born they are not the same size as an adult or they do not look the same; instead they experience a stage of growth and development until they can reproduce.

Living things are made up of **organic matter** and **inorganic matter.**

Organic matter is made up of mainly **carbon and hydrogen atoms.** For example, proteins and carbohydrates are organic substances that are found in living things.

Inorganic matter, however, is **not made up of** mainly **carbon and hydrogen atoms,** for example water and sodium chloride.

Thanks to the energy they get from the Sun, these trees transform inorganic matter into organic matter that allows them to grow and develop.

1.2 Living things and their environment

All living things need the following environmental conditions:

- **A source of energy to perform vital functions**. This energy can be **light energy** or **chemical energy** found in **food** molecules.
  - **Plants** capture **light energy** from the Sun to produce the organic matter they need to grow and **perform their vital functions**.
  - **Animals** are able to obtain the chemical energy they need from food by eating plants or other animals.
- **A suitable temperature that allows the existence of liquid water**. This is because most chemical reactions that happen inside organisms take place in an aqueous medium.

1.3 What factors mean that a planet in the solar system can support life?

The Earth's atmosphere has been enriched with oxygen from photosynthetic organisms. Ozone is formed from oxygen, and does not allow the harmful radiation of the Sun to pass; this has allowed some types of living things to live outside water and colonise continents.

For a planet to support life, it must have a stable temperature that permits the existence of liquid water. For this, it has to meet the following conditions:

- **A suitable distance from the Sun.**
  If the Earth's orbit were closer to the Sun, the planet would have such a high average temperature that all liquid water would evaporate. On the other hand, if the Earth were further in distance from the Sun, all the water on the planet would be immobilised in the form of ice.
- **A suitable size of the planet.**
  A planet should not be too small in size so that the force of gravity can attract gases from the atmosphere surrounding it, this includes water vapour.

In the case of the Earth, its atmosphere contains oxygen and carbon dioxide; these two gases are very favourable for the development of different forms of life.

- **Carbon dioxide** is one of the main **nutrients of plants** and, in addition, **it traps heat that reaches the Earth's surface, known as the greenhouse effect**. This prevents sudden changes in temperature between day and night, which would be very dangerous for many living things.
- **Oxygen** allows **large amounts of energy to be obtained** when it combines with organic matter from food. This reaction is called **cellular respiration** and generates carbon dioxide. Oxygen is transformed into **ozone** by ultraviolet radiation from the Sun. Ozone is a gas that **prevents the passage of ultraviolet radiation**, which is very harmful to living things.

Activity bank: 21, 22, 23, 24 and 42

HAVE I UNDERSTOOD?

1. CL In your own words, write a definition of a living thing.
2. What is organic matter basically made up of?
3. What roles does carbon dioxide play in the atmosphere?
4. What type of energy do plants use to perform their vital functions?
5. Has there always been oxygen in the atmosphere? Explain your answer.

APPLYING MY KNOWLEDGE

6. Scientists are searching for life in other places in the universe, but not all are suitable for supporting life. What are the requirements for these places? Explain each one.
7. You have probably heard of the greenhouse effect. What is it? Is it positive or negative? Argue your answers.

2 The cell

The cell is the simplest living structure capable of acting by itself, performing the three vital functions, which are nutrition, interaction and reproduction.

All living things are made up of one or more cells, most of which are so small they can only be seen under the microscope. Each cell is made up of the **plasma membrane**, **cytoplasm** and **genetic material**.

- **Plasma membrane**. This is the layer which delimits the cell and controls the passage of substances between the inside and the outside.
- **Cytoplasm**. This is the content of the cell. It is made up of a liquid, **cytosol**, which contains a series of structures called **organelles**, which perform the various functions of the cell.
- **Genetic material**. It consists of a substance called **deoxyribonucleic acid** (DNA), which contains information on what the cell is like and how it functions. In many cells this DNA is surrounded by a membrane that forms the **cell nucleus**.

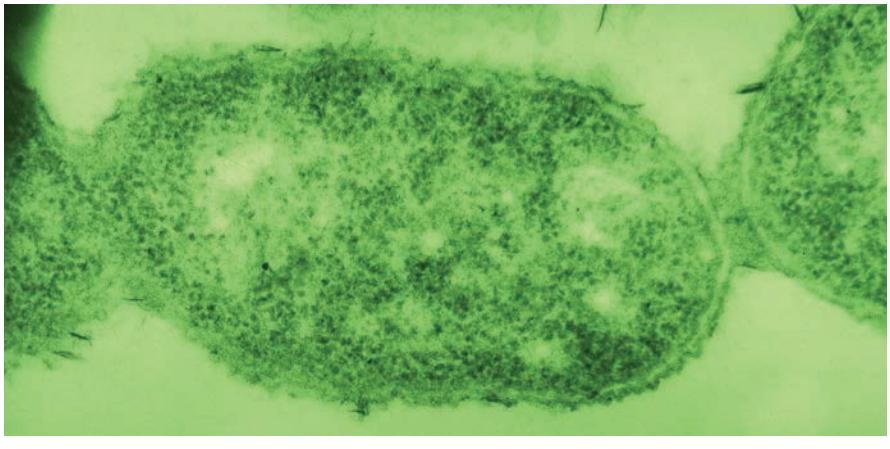
ORGANELLE	FUNCTION
Ribosome	They make proteins.
Lysosome	They digest organic substances.
Mitochondria	Cellular respiration.
Golgi apparatus	They store substances manufactured by the cell, especially carbohydrates.
Endoplasmic reticulum	They transport and store substances manufactured by the cell, especially proteins.

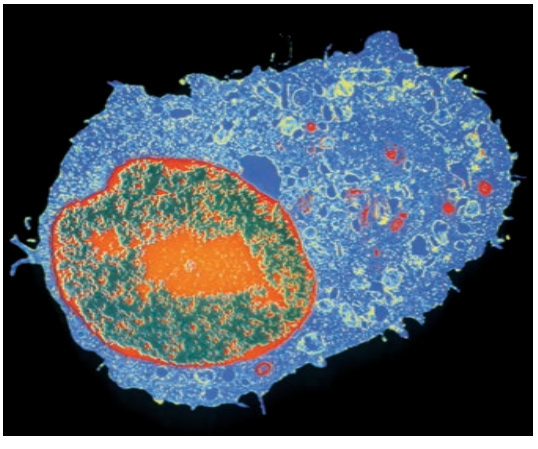
TYPES OF CELLS

Two types of cells are distinguished depending on whether the genetic material is dispersed in the cytoplasm or delimited by a membrane forming the **nucleus**: **prokaryotic** and **eukaryotic**.

- **Prokaryotic cells**. These cells do not have a nucleus; in other words, the genetic material is free in the cytoplasm and is not surrounded by a membrane. These cells are about ten times smaller than eukaryotes and most of them only have ribosomes in their cytoplasm. They are known as bacteria.
- **Eukaryotic cells**. These cells have a nucleus; in other words, they have a double membrane that surrounds and isolates their genetic material from the cytoplasm. They contain various types of cell organelles (such as ribosomes, endoplasmic reticulum and mitochondria). The cells of animals, plants, fungi, algae and protozoa are eukaryotic, or in other words, all cells other than bacteria.

Living things that are made up of a single cell are called **unicellular organisms** and those that are made up of more than one cell are called **multicellular organisms**

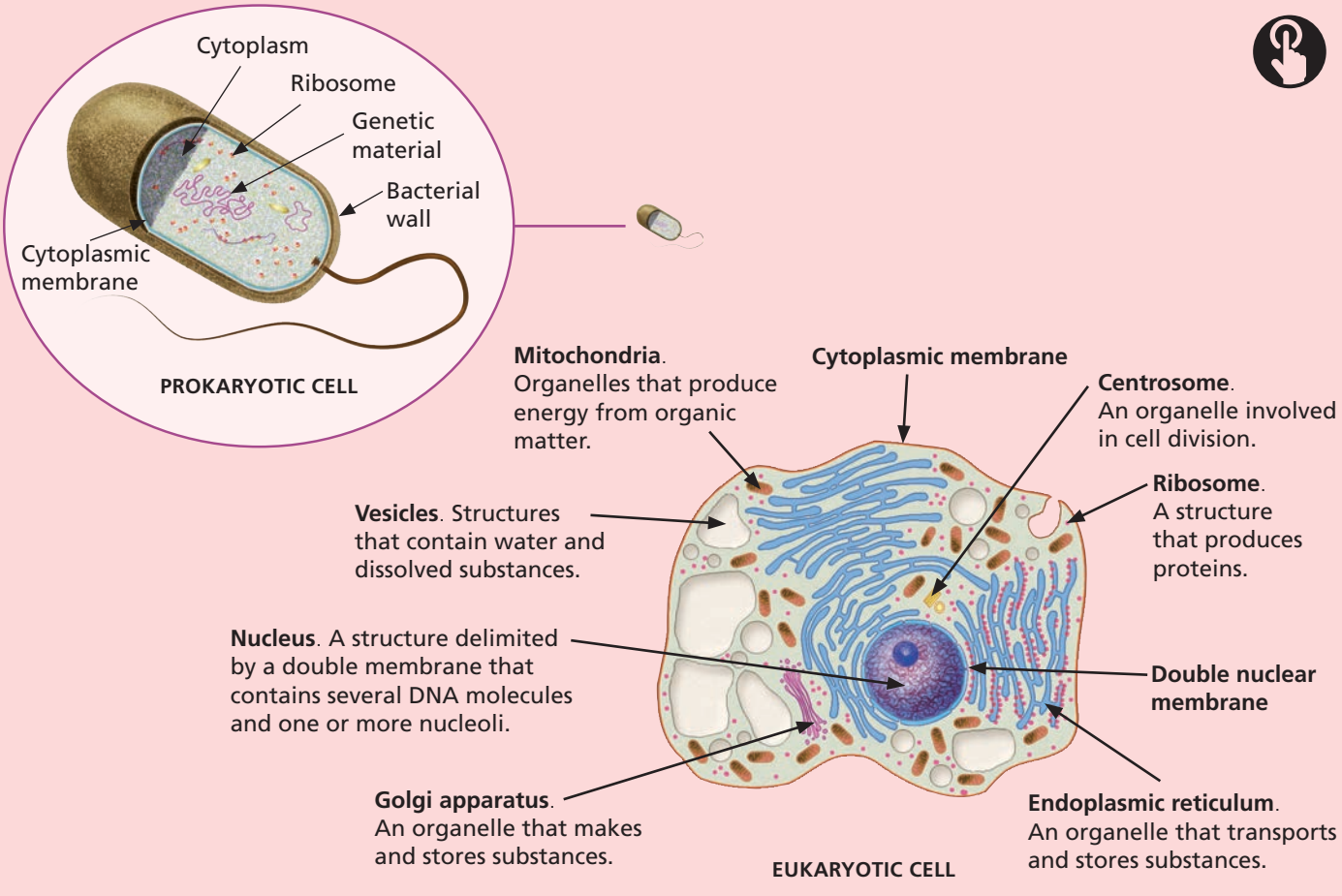




LEFT: prokaryotic cell. Bacteria viewed with transmission electron microscopy (TEM).

RIGHT: eukaryotic cell viewed with transmission electron microscope (TEM). The colours have been added, because electron microscopy only produces black and white images.

PROKARYOTIC AND EUKARYOTIC CELLS



Activity bank: 25, 26, 27, 28, 29 and 40

HAVE I UNDERSTOOD?

8. Say whether the following things are living or non-living, unicellular or multicellular and natural or artificial.

a) Mosquito b) Bacteria c) Marble
d) Amoeba e) Plastic f) Pine tree

9. What is the cell nucleus? Are there cells without a nucleus? And without DNA?

10. Match the phrases in the two columns.

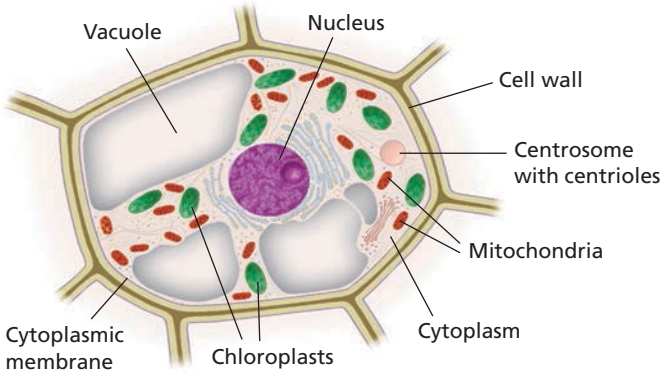
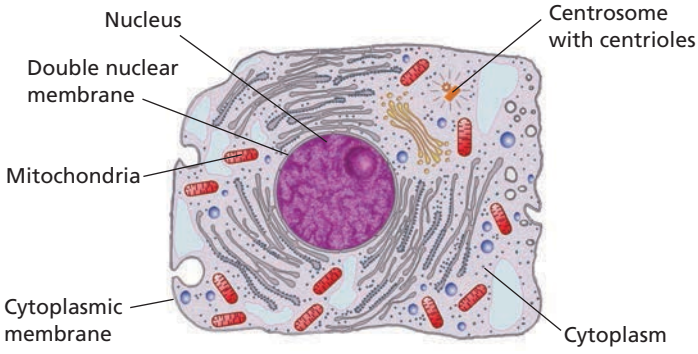
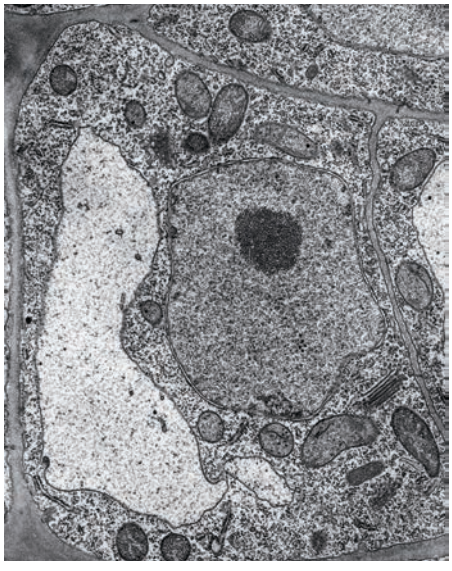
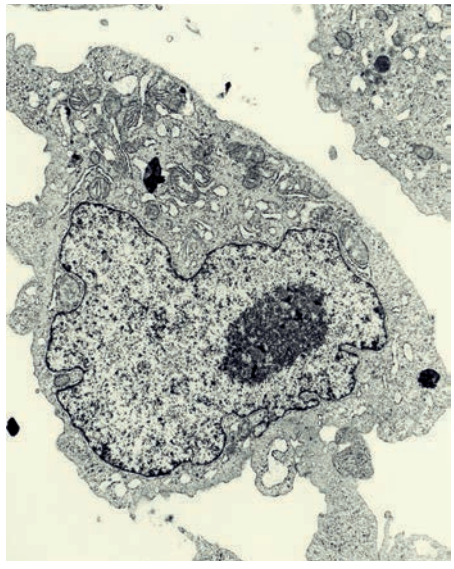
1. Mitochondria	A. Produces proteins.
2. Golgi apparatus	B. Contains water and dissolved substances.
3. Vacuole	C. Is involved in cell division.
4. Ribosome	D. Synthesises and stores substances, especially carbohydrates.
5. Centrosome	E. Produces energy from organic matter.

APPLYING MY KNOWLEDGE

11. The size of cells is expressed in micrometres (μm),), also called "microns" (μ). A micrometre is 1 000 times smaller than a millimetre. Express in microns the length of a eukaryotic cell which measures 0.04 mm and a prokaryotic cell which measures 0.003 mm. Indicate how many times larger one is than the other.

3 Eukaryotic cells

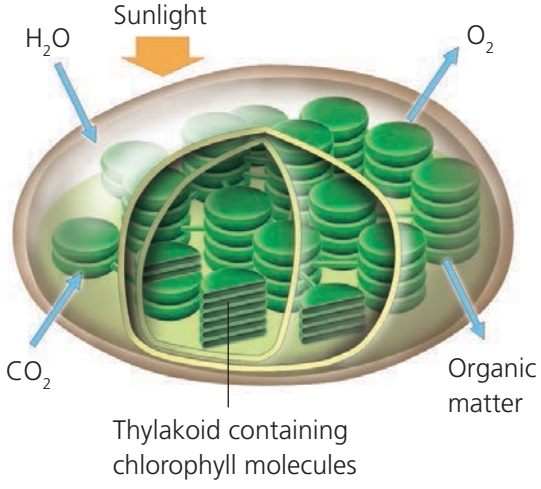
We can distinguish two types of eukaryotic cells: **plant cells** and **animal cells**.

PLANT CELLS	ANIMAL CELLS
• They are surrounded by a layer of cellulose called the **cell wall**, which gives consistency to the cell. It is located on the plasma membrane.	• They do not have a **cellulose cell wall**. In contrast, they secrete an intercellular substance, called **extracellular matrix**, which holds the cells together.
• They have special organelles called **plastids**, which have different functions. Those that contain chlorophyll and perform photosynthesis are called **chloroplasts** and are only found in cells in the green parts of the plant.	• **They do not contain plastids.**
• They have large **vacuoles**.	• They have **very small vacuoles.**
• Their **centrosome**, which is the organelle responsible for cell division, does not have **centrioles**.	• Their **centrosome** contains two **centrioles**, which are two cylindrical structures.
	
 Root cell.	 Mammalian cell.

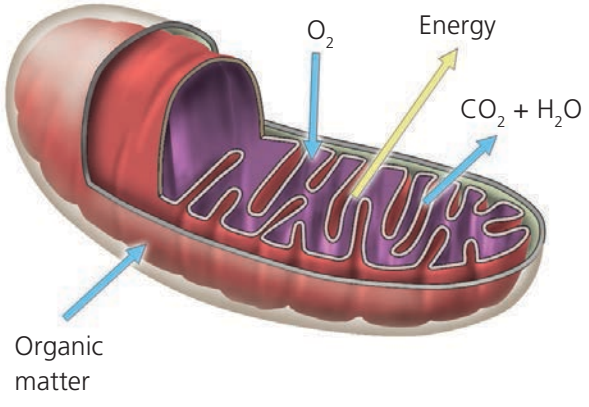
Chloroplasts are organelles that are only found in plant cells in the green parts of the plant. They are green in colour as they contain a pigment called chlorophyll, which is involved in photosynthesis.

Mitochondria are organelles found in both animal and plant cells. They are responsible for cellular respiration and the cell obtains its energy from them.

CHLOROPLAST



MITOCHONDRIA



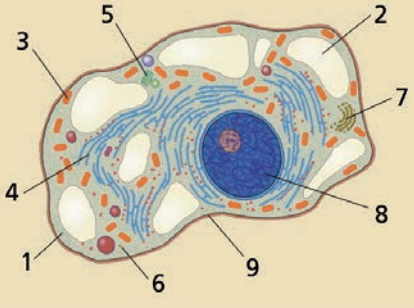
Activity bank: 30, 31, 38, 39 and 40

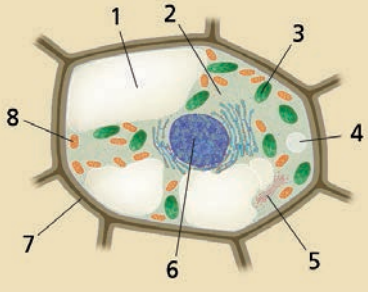
HAVE I UNDERSTOOD?

12. What function of the components of plant cells do animal cells not have?

13. Indicate which number corresponds to each of the following terms:

a) Cytoplasm
b) Small vacuoles
c) Mitochondria
d) Endoplasmic reticulum
e) Centrosome
f) Ribosome
g) Golgi apparatus
h) Nucleus
i) Plasma membrane





14. Write the name of each of the parts of the plant cell marked with a number.

15. Two of the following elements from cells are found in plant cells but not in animal cells. Which ones?

a) Plastid
b) Golgi apparatus
c) Vacuoles
d) Cellulose cell wall

APPLYING MY KNOWLEDGE

16. CD You can find various cell simulators on the Internet. For example, *SEPUP Cell Simulation*. Find the site and build an animal cell and a plant. Then save an image of each.

4 The functions of the cell

4.1 The function of nutrition

This is the function that cells use to capture matter and energy from the outside to grow or simply to stay alive. There are two types of nutrition: autotrophic or heterotrophic.

- **Autotrophic nutrition.** This form of nutrition takes place when cells capture inorganic material, namely carbon dioxide, water and mineral salts, to manufacture organic matter. They need energy to perform this transformation. If they use light energy, the process is called **photosynthesis**. Photosynthetic cells are green cells found in algae, plants and some bacteria. The chemical reaction of photosynthesis is:

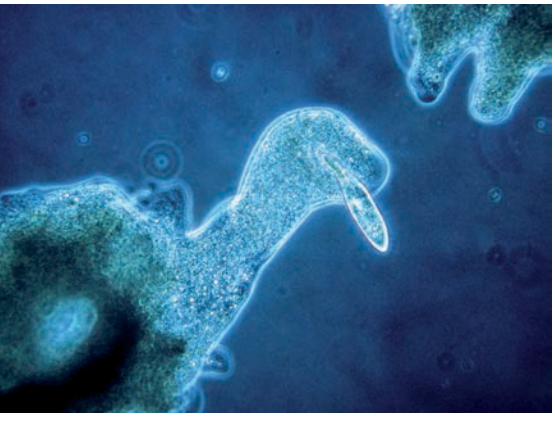
Inorganic matter (carbon dioxide + water) + Light → Organic matter + Oxygen

- **Heterotrophic nutrition**. This is a type of nutrition in which cells capture organic matter as a source of matter and energy. As the organic matter is produced by living organisms, heterotrophic nutrition means feeding on organisms or their remains. Organic matter is **digested** until it becomes small molecules, called nutrients, which can penetrate into cells, where they can be used for energy or growth or be stored as energy reserves. Heterotrophic cells are found in animals, fungi and protozoa, and also in many species of bacteria.

  To obtain energy, the small molecules of organic material from the digestion of food, which in autotrophic nutrition comes from photosynthesis, react with oxygen in cellular respiration. Its chemical reaction is:

Organic matter + Oxygen → Inorganic matter (carbon dioxide + water) + Energy

Therefore, cellular respiration takes place in organisms that use autotrophic nutrition and organisms that use heterotrophic nutrition.



In this photo you can see how an amoeba, a unicellular organism that uses heterotrophic nutrition, has detected chemical substances released by a paramecium (stimulus). It has moved towards it to ingest it (phagocytosis) in order to feed (response).

4.2 The function of interaction

This is the cell function in which a living thing perceives stimuli and then makes the appropriate responses.

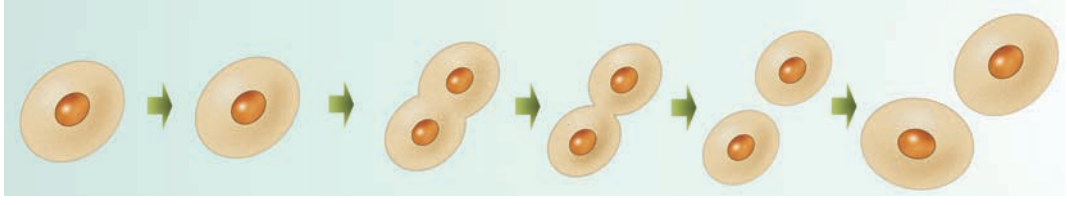
- The **stimuli** perceived by the cells can be **chemical**, such as a change in the salinity of the water; **tactile**, such as vibrations of the water, or **light**, such as higher or lower levels of light.
- The **responses** made by the cells can be **movements** towards or away from the stimulus or the **secretion** of certain substances.

4.3 The function of reproduction

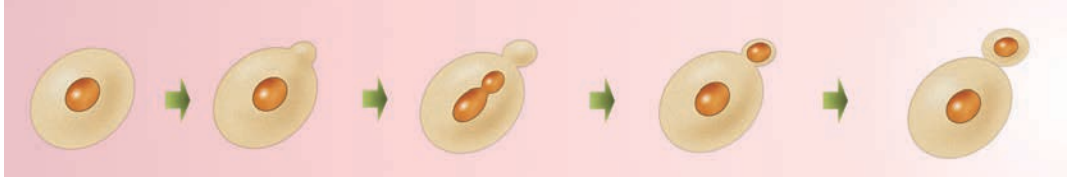
Cell reproduction is the function by which a cell generates new cells.

There are three types of cell reproduction depending on how they divide: **binary fission**, **budding** and **multiple fission**.

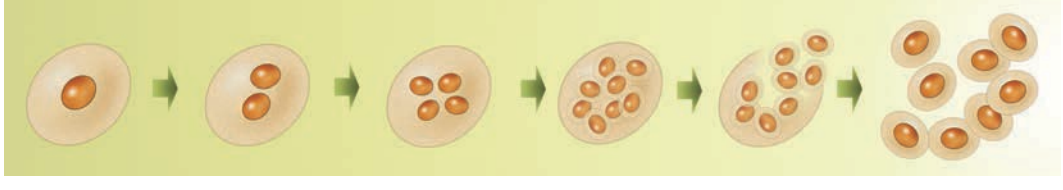
- **Binary fission**. In this form of cell reproduction, the parent cell divides into two daughter cells of approximately the same size.



- **Budding**. In this form of cell reproduction, a protuberance containing a nucleus appears on the parent cell. It then separates from the initial cell but continues to adhere to it.



- **Multiple fission**. In this form of cell reproduction, the nucleus of the parent cell is duplicated several times. Its cytoplasm then divides and each nucleus is enveloped in cytoplasm and membrane. If the small daughter cells are also coated with a waterproof coating, they are known as **spores** and the process is called **sporulation**.



HAVE I UNDERSTOOD?

Activity bank: 32, 33, 34, 35, 36, 37 and 41

17. Indicate what aspects autotrophic nutrition and heterotrophic nutrition have in common and how they differ.

18. Explain why it is necessary to digest food.

19. CL Is it correct to say that cells with autotrophic nutrition make their own food?

APPLYING MY KNOWLEDGE

20. What type of nutrition does a cell need to be able to survive on an uninhabited planet? Explain your answer.

ACTIVITY BANK

HAVE I UNDERSTOOD?

21. Explain the functions of a living thing that differentiate it from an inert object.

22. What is the difference between organic matter and inorganic matter? Give an example of each type.

23. What conditions are found on Earth that mean it is possible for life to exist?

24. Answer the following questions.
a) What is ozone?
b) What role does it play in the atmosphere?

25. CL Write a definition of a cell.

26. CC Draw the structure of a prokaryotic cell, labelling its main parts.

27. Make a list of the main differences between a prokaryotic cell and a eukaryotic cell?

28. Only one of these living things is prokaryotic. Which one? Explain your answer.
a) Paramecium
b) Bacterium
c) Moss
d) Fly

29. Indicate the two types of cells, define each type and give examples.

30. CC Do a drawing of a plant cell and an animal cell and underneath, write out the main differences which characterise each of them.

31. Indicate which is the only correct answer.
a) Which of the following characteristics is unique to animal cells?
A. Presence of mitochondria
B. Golgi apparatus
C. Presence of endoplasmic reticulum
D. Heterotrophic nutrition
E. Presence of ribosomes

b) Which of the following structures is unique to plant cells?
A. Ribosomes
B. Golgi apparatus
C.Endoplasmic reticulum
D. Vacuoles
E. Cellulose wall

c) What is the name of the fluid that fills the cell?
A. Cytoplasm
B. Cytosol
C. Water
D. Solution
E. Aqueous medium

d) Which of the following organelles do bacteria have?
A. Vacuoles
B. Ribosomes
C. Nucleus
D. Golgi apparatus
E. Centrosomes

32. Is food the same as nutrients? If not, explain the difference.

33. Indicate which of the following reactions correspond to photosynthesis and which correspond to cellular respiration.
a) water + energy ⟶ organic matter + oxygen + carbon dioxide
b) carbon dioxide + water + energy ⟶ organic matter + oxygen
c) organic matter + oxygen + energy ⟶ carbon dioxide + water
d) organic matter + oxygen ⟶ carbon dioxide + water + energy

34. Make a list of organisms that use autotrophic nutrition and another with organisms that use heterotrophic nutrition. Explain the difference between the two types of nutrition.

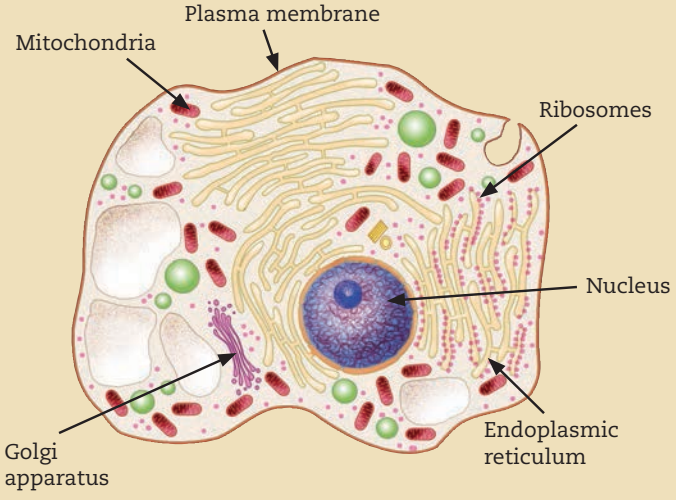
35. CI You want to know whether a unicellular organism is autotrophic or heterotrophic. What experiment can you do to find out what type it is?

36. CI What types of stimuli can a cell perceive? What experiment can you do to find out?

▲ **37.** The paramecium is a unicellular organism which has a membrane covered in cilia that allows it to move in all directions. If a microscope slide containing paramecia is lit with a light that is not too bright, they move towards the light. What kind of behaviour is shown by paramecia from the point of view of the function of interaction?

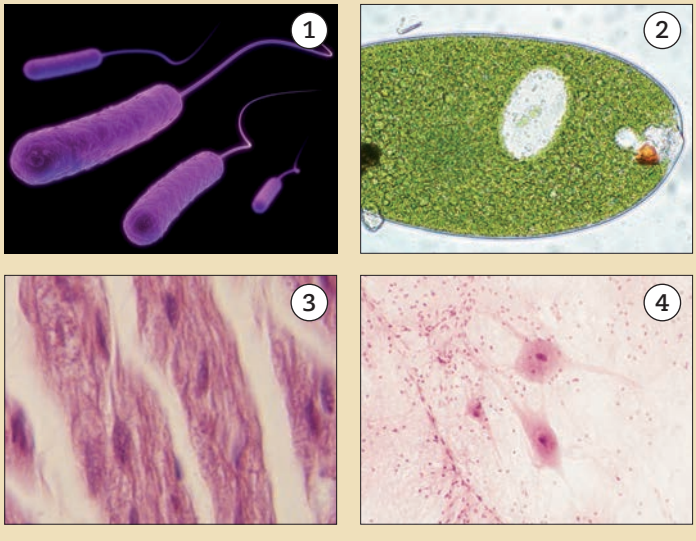
APPLYING MY KNOWLEDGE

38. Indicate which cellular structure from those shown in the drawing below correspond to each of the following comments:



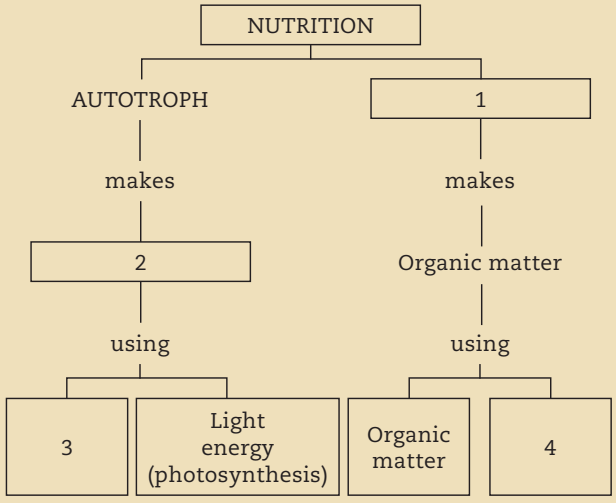
a) This layer delimits the cell.
b) This is the cell's control centre, containing DNA, the molecule that contains information about the cell and how it works.
c) A series of small sacs and tubes used to transport and store substances.

39. Look at the cells and indicate:
a) Which are prokaryotic and which are eukaryotic? Why?
b) Which ones perform photosynthesis and which do not? Why?



40. CL Watch the excerpt from the BBC documentary *The Cell* and summarise its contents.

41. CA Copy and complete the following concept map, writing the following terms in the boxes: *organic matter, heterotroph, inorganic matter* and *chemical energy (cellular respiration)*.



42. A scientific team is commissioned to send a form of terrestrial life to one of the eight planets in the solar system. It will need to be able to survive on the planet and, eventually, create better habitability conditions, so that other less resistant life forms can be sent there and will be able to survive. Using the data on the planets that appear on page 13, answer the following questions.
a) Which planet would you send the living thing to?
b) What are your reasons for ruling out the other planets?
c) What living thing would you send?

...perhaps you already have the answers.

Reread the questions related to the initial video.
a) What are the answers to the questions?
b) Are they the same that you gave before studying the unit?
c) Now you have completed the unit, do you have any new questions?

Microscopes

CL CA

A little history

Between 1590 and 1610, Hans and Zacharias Janssen built the first compound microscopes, with two lenses that enlarged the image up to 20 times.

In 1665, Robert Hooke, using a compound microscope, was the first to observe cells and use the word *cell*. In about 1820, Lister, an English optician, designed an achromatic microscope that made great advances towards creating the modern optical microscope. In 1931 the first type of electron microscope appeared, thanks to Max Knoll and Ernst Ruska, Physic Nobel Prize winner in 1986.

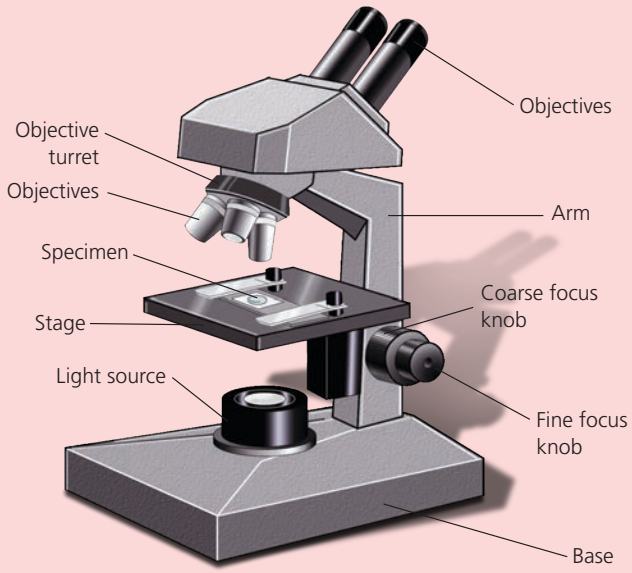
Over time, scientific technology has developed two types of microscopes: optical microscopes and electron microscopes.

The optical microscope

An optical microscope uses a visible light source and a system of glass lenses that can increase the size at which we see an object. Some optical microscopes can enlarge the image over 2 000 times. This type of instrument can be used to view living tissues, prokaryotic cells and eukaryotic cells.

PARTS OF AN OPTICAL MICROSCOPE

- **Objective**: this is the lens of the microscope that is located near the object being observed. Several different magnifications * are used. The most common magnifications are x5, x10, x40 and x100.
- **Eyepiece**: this is the lens that is close to the eye. It captures and enlarges the image formed by the objectives. Several different magnifications are used. The most common magnifications are x10, x15 and x20. There may be one objective (monocular microscopes) or two (binocular microscopes).
- **Objective turret** or revolver: this is the part of a microscope that holds several objectives. The user rotates the objective turret to change the objective.
- **Base**: this is the part at the bottom of the microscope.
- **Arm**: this is the vertical part of the microscope which is located between the base and the objective turret.
- **Stage**: the sample to be observed is placed on this platform.
- **Coarse and fine focus knobs**: these knobs are used to focus on the specimen; they move the stage up and down.
- **Light source**: this is usually a light bulb, although it can also be a mirror that reflects light toward the stage. Before reaching it, the light passes through an adjustable opening called a **diaphragm**, which allows the amount of light to be controlled, and then a **condenser** lens, which allows all the light to be concentrated on the specimen we are going to look at.



***Number of magnifications**. To calculate the number of magnifications used, the magnifications of the eyepiece should be multiplied by the magnifications of the objective. For example, if we are using a x10 eyepiece and a x40 objective, the specimen is observed at 400 magnification.

The electron microscope

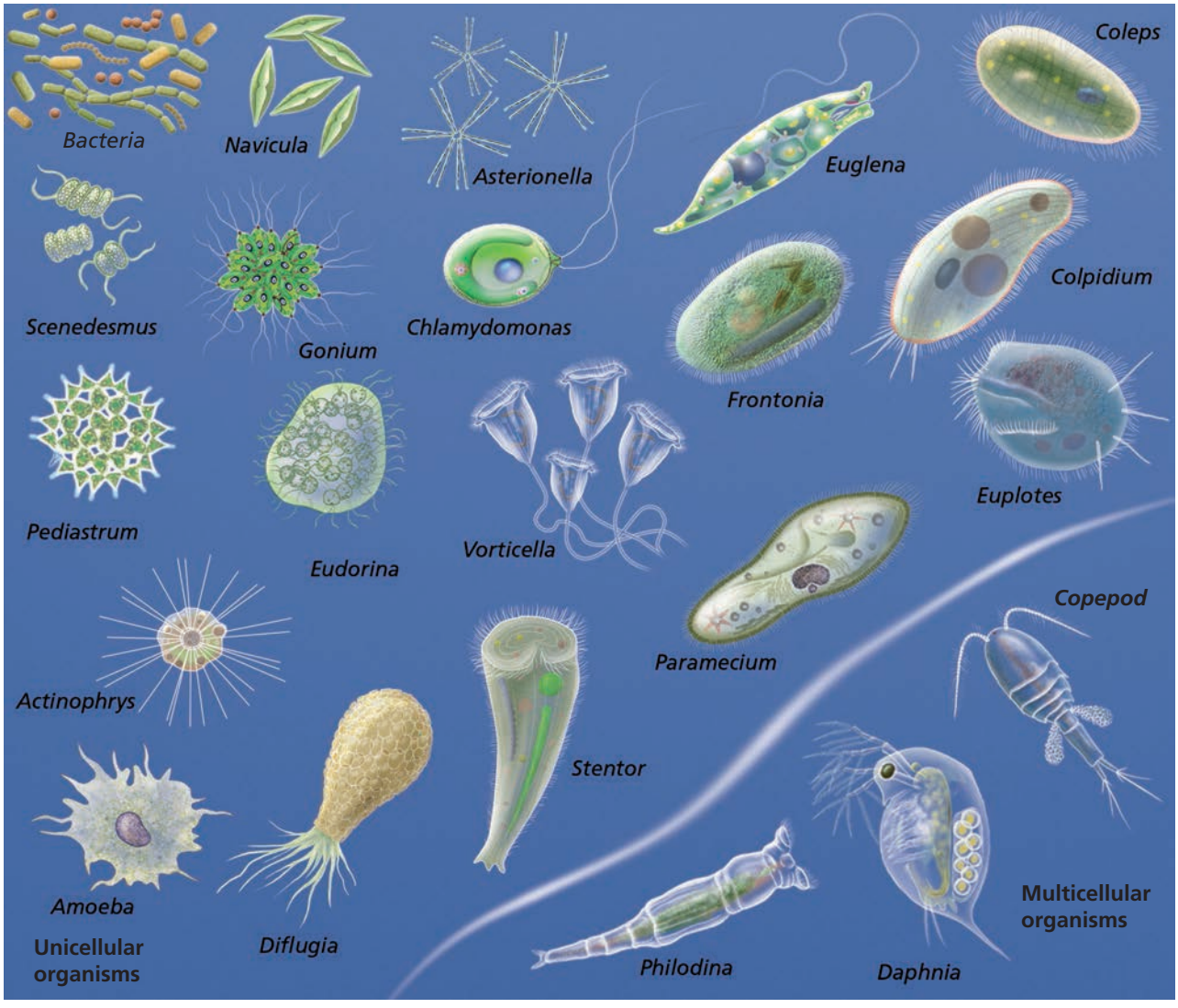
This type of microscope uses electrons instead of visible light, and electromagnets instead of lenses.

This microscope allows us to obtain very large images of the sample, projected on a screen. Some microscopes can magnify the image of an object up to 1 000 000 times.

Electron microscopes can only "see" in black and white, since they do not use light, but artificial colours can be added to the image on the computer to highlight certain details.

A researcher is observing organisms in a sample of water that he collected from a natural source. The first thing he does is draw them. Use these drawings to answer the following questions.

1. C1 Which parts of an optical microscope contain the lenses?
2. C2 What should be done with the microscope to see this organism twice the size? And to see it half the size so you can see more individuals at once?
3. C3 What is the actual size, without the spines, of *Actinophrys* if the drawing is exactly the size of the image he saw, using an eyepiece of 10 magnifications (x10) and an objective of 40 magnifications (x40)?
4. C1 Why does the researcher first observe and draw the organisms?
5. C3 Before they reproduce by binary fission, unicellular organisms increase greatly in size so that the two daughter cells have a similar volume to that of the parent cell. Assuming that the individual *Actinophrys* that was drawn is completely spherical, what volume should it reach before it divides? The volume of a sphere is 4/3 of πr^3 ($V = 4/3$ of πr^3).



Note: The organisms are not drawn to the same scale.

Can microorganisms resist drought?

CI CA

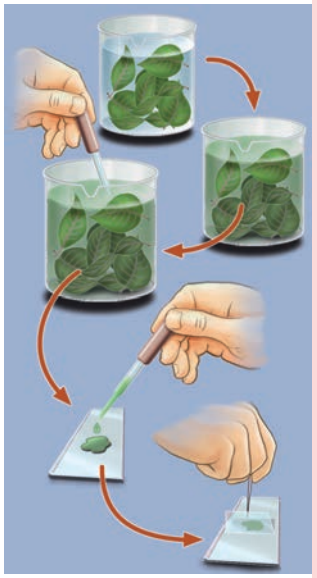
Shortly after it rains, it is possible that microscopic living things (protozoa and algae) can be observed in the water in a puddle. As rainwater does not contain microorganisms, they may be present because they were already there and, although they are aquatic organisms, they can resist periods of drought.

Hypothesis: do microorganisms resist drought conditions? Formulate a hypothesis and test it with an experiment.

Materials
- Six equal-sized wide mouth jars
- Fabric and rubber bands
- Dried leaves
- A bottle of still mineral water
- Dropper
- Slides and cover slips
- Microscope

EXPERIMENT

To rule out that the microorganisms were not already in the water, use three jars with water only, and to rule out that they do not arrive in the air, put lids on all the jars.



1. Place a handful of dried leaves in jars 1, 2 and 3, add mineral water to the edge and cover them with a piece of fabric and a rubber band.
2. In jars 4, 5 and 6, just add water and cover them.
3. Leave the jars in a warm and well-lit place for 10 or 15 days without putting them in direct sunlight.
4. Using an eyedropper, remove a small amount of water from near the plant remains in jars 1, 2 and 3. Place a drop on a slide and cover carefully with a cover slip to prevent the occurrence of air bubbles. If the microorganisms move very quickly, make another preparation, adding a few cotton fibres to hinder their movement.
5. Try to identify all the microorganisms with the help of the images on page 109.
6. Take a drop from jars 4, 5 and 6 and observe them using the microscope.
7. Take the leaves out of the jars and put them out in the sun to dry. Once dry, carry out the same experiment and see if the microorganisms reappear.

ANALYZE

Copy and complete a table like this with your results.

	Contains microorganisms	Number of species observed	Name of the species identified
Jars 1, 2 and 3			
Jars 4, 5 and 6			
After drying the leaves			

CONCLUSION

Answer the following questions. Have any of the microorganisms resisted drought? All of them? Which species have resisted drought?

CI CL

Extraterrestrial life?

For decades, scientists have speculated about the possibility of life on any of the planets or moons in the solar system. One candidate is Europa, a satellite of Jupiter that has a frozen crust of between 20 and 60 km thick, beneath which there appears to be a liquid ocean.

Imagine that an unmanned spacecraft has landed on the satellite Europa and has managed to perforate the thick layer of ice in order to take water samples from its ocean. You are part of the team of scientists who will analyse the sample once the spacecraft returns to Earth.

When you look at the sample under the electron microscope, you see that there are some particles that seem to be microscopic living things, although they may very well be small fragments of rocks.

1. C1 Describe what actions the team of scientists has carried out so far. If you were one of them, what would you do next?
2. C1 What aspects should you take into account to find out whether they are living things or fragments of rocks? What should you look at to help you decide? Mark the correct answer.
   a) Find out if they have a cell nucleus.
   b) Check if they perform the functions of nutrition, interaction and reproduction.
   c) See whether they move.
   d) Pour acid on them and see if they disintegrate.
3. C1 If you determine that they are living organisms, what type of cells might they be, prokaryotic or eukaryotic?
4. C2 If the organisms in the sample are living things, what kind of nutrition might they have?
   a) They would be heterotrophic organisms that feed on organic matter in the water.
   b) They would be autotrophic organisms that produce their own food from CO_2, water and minerals through photosynthesis.
   c) They would be autotrophic organisms that produce their own food from CO_2, water and mineral salts by chemosynthesis; in other words, through energy released when inorganic compounds oxidise.
   d) They would be organisms that do not feed themselves, but instead just look to reproduce like viruses are known to do.
5. C2 Although it may have microorganisms, Europa is a satellite that would have very little life, and this would only be in the water beneath the surface ice. What features does our planet have that allow it to host so many living organisms?
6. C3 While you are watching the organisms you notice that one of them has divided in half, creating two individuals equal to it but smaller. What type of reproduction do they use? After 30 minutes, you notice that the two daughter organisms divide again. If division continues at this rate, how many organisms equal to the first would there be after five hours? Mark the correct answers.
   a) Sporulation.
   b) Binary fission.
   c) There will be 2 048 microorganisms.
   d) There will be 20 microorganisms.

PISA ASSESSMENT FRAMEWORK

CATEGORY: Living systems
CONTEXT: **Situation:** Global
Content area: Frontiers of science and technology