Unit 2 - The Universe and The Solar System

Key concept - **Systems** - How do different systems interact on Earth, in the solar system and in the universe?

Related concepts - **Models and environment** - How can we use scientific models to explain events and predict future events?

Global concept - **Orientations in time and space** - Why is the position of Earth in the solar system essential for our survival?

Unit 1 KEYWORDS

- Big Bang
- Geocentric
- Heliocentric
- Universe
- AU
- Light-year
- Galaxy
- Nebulae
- Star
- The Solar Sytem
- Planets
- Asteroid belt
- Dwarf plant
- Revolution
- Rotation
- Axis
- Seasons
- Satellites
- Tides
- Eclipse
- Solar
- Lunar

Task guide

The tasks and questions on the Weebly will be coloured to represent the different style of questions that you will find in your exams. The different tasks will be done according to your teacher's instructions.

Green - Explaining scientific knowledge
Orange - Applying scientific knowledge and understanding
Red - Analysing and evaluating information

There will also be "**extension**" tasks for students who finish tasks quickly! Also look out for *links* to interactive resources and videos.

Where did it all start?

Since ancient times, humankind has been curious about the celestial bodies and the enormity of the universe.

The first astronomers could only study a small part of the universe, such as part of the solar system and nearby stars. Nowadays, although science and technology have allowed us to study the most distant galaxies, the more we discovered the more questions we have.
The universe is all the known or imagined objects, matter, and events throughout space. From Latin, *universum* means all together or integrated.

Task 1a: Write down in your notebook as many things as you can about how the universe was created.

What is the Big Bang theory?

Looking out into space, we can see that all stars and galaxies are actually moving away from each other. This suggests that the Universe must be expanding.

If we were to reverse time then we would see everything moving together until . . .

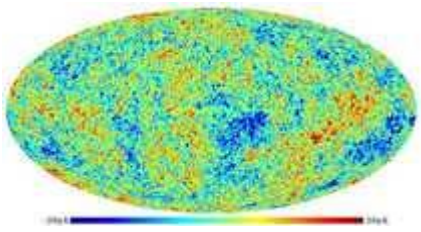
. . . at some point everything must have been found in a single point.

This suggests that there must have been some kind of explosion which created the universe from a single point. We call this **The Big Bang**.

Activitities

1. **Add 2 more things** you now know about the Big Bang.
2. **State** how old the universe is?
3. **Explain** why are the words "big" and "bang" strange to use for this theory?

Extension: Explain what cosmic background radiation is and how it supports the Big Bang theory?



(Hossenfelder, 2006)

How Big is the Universe?

The furthest that our telescopes allow us to see is about 13.8 billion light-years. We can this the observable universe because this is the maximum that we can see. However, because we know the universe is expanding, the actual universe must be bigger than this. So, what units of distance do we use in space? It would be ridiculous to use normal units of distance such as meters or kilometers, as the numbers would be so huge.

For example, the distance between Earth and Mars would be 4 700 000 000 000 m.

To avoid such large numbers we use **astronomical units** (AU) and **light-years** (ly)

1 AU = 150 000 000 km – approximately the distance between the Earth and the Sun

1 light-year is the distance that light can travel in 1 year. Approximately 9,460,800,000,000 km!!!

Example distances:
Sun --> Jupiter 5.19 AU
Diameter of The Milky Way 100,000 light-year
Distance to furthest known star 13,800,000,000 light-year

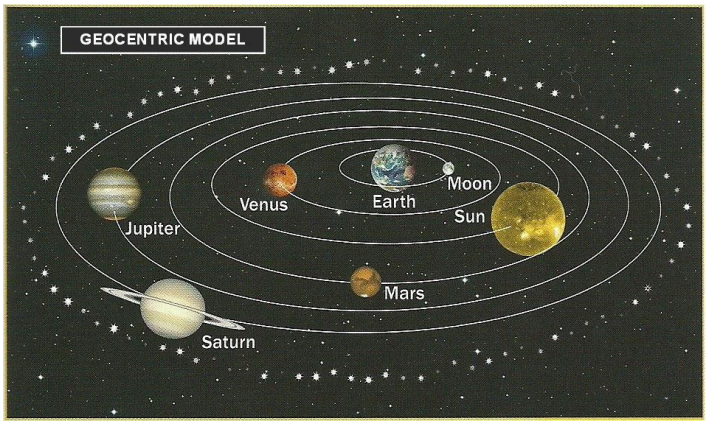
Activities -

4. **State** which units would be best for measuring the distances between galaxies?
5. **State** which units would be best for measuring distances in our solar system?

Theories of the Universe

THEORY 1 - The first well known theory of the universe was described by Aristotle in 384 B.C. and then developed by Claudius Ptolemy in 100 A.D.

This theory states that The Earth was the centre of the universe and all the planets, The Sun and the stars rotate around it. This is called the **geocentric theory** because the prefix "geo" is to do with The Earth. This was the prevailing theory until the 16th century.



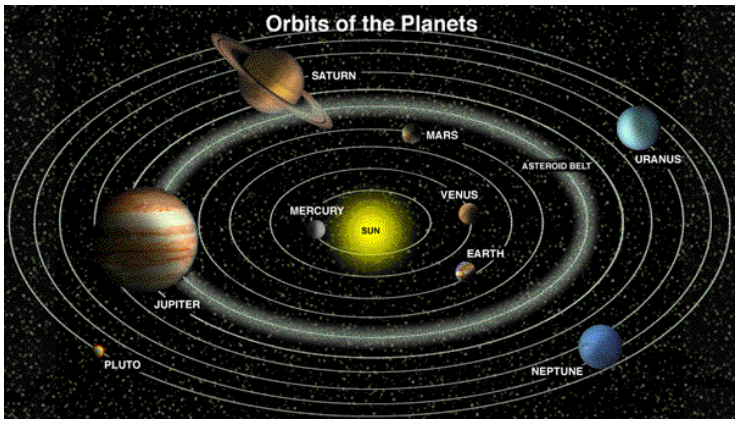
("1.1. Primeras ideas sobre el universo", 2020)

How many words can you think of beginning with “geo”?

THEORY 2 - Proposed by Copernicus in the 16th century.

Over 1000 years later, Nicolas Copernicus developed the **heliocentric theory**. This states that the Sun is at the centre of the universe with the planets moving around it. All the other stars are around the outside but not moving.

Galileo Galilei and Johannes Kepler verified it with other observations.



How could "helio" be related to the sun?

Does this match perfectly with what we know now?

(Sinha, 2020)

Activity

6. Draw both the geocentric can the heliocentric models in your notebook outlining the details of each model and who proposed them.

What can we find in our Universe?

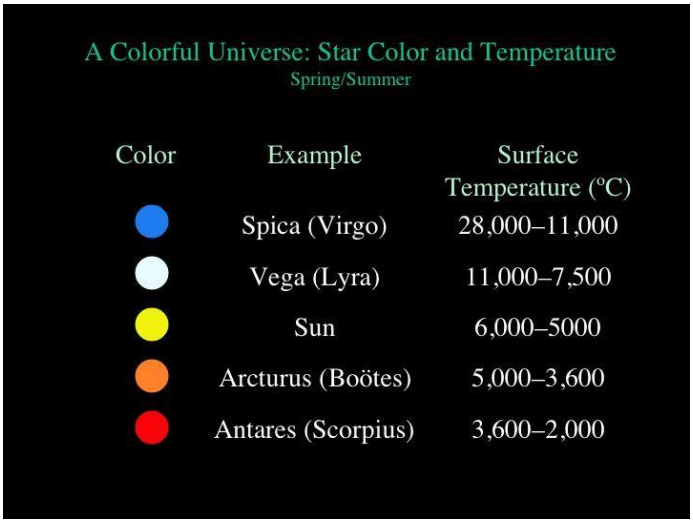
The universe is made up of many galaxies. Galaxies are made up of many stars. **Galaxies** are huge collections of stars and other celestial bodies, and cosmic dust, which are travelling in space.

Stars

Stars are powerful sources of light. They are large balls of gas – mainly hydrogen and helium that release lots of heat and light energy due to chemical processes. The star in our solar system is called the **Sun**. The temperature on the outside of the Sun is about 5 500 °C, but in the middle it is 15 000 000 °C !!

Stars come in different colours according to their temperature. The coolest ones are dull red. Others, like the Sun, are hotter and glow bright yellow. Others are even
hotter and give our a bluish-white light.

Some stars have planetary systems similar to our solar system.



The Solar System

Our solar system is located in the [Milky Way Galaxy.]

The Milky Way is part of a cluster called the Local Group of about 30/40 other galaxies (including Andromeda and M32).
It has a spiral shape and a diameter of about 100 000 light years. It has 5 arms around the central bulge. The Earth is located in one of the spiral arms. There are blue stars and red stars in our galaxy. Blue stars

are young and hot stars. Red stars are old and cool stars, as we have already seen.

The solar system is a planetary system made up of eight planets and other celestial bodies, such as dwarf planets, satellites, asteroids and comets, which move around the Sun.
It formed around 5 000 million years ago from a nebula (a cloud of gas and dust). Most of the matter in the centre of the nebula formed the Sun and the matter surrounding the Sun formed the other celestial bodies which still move around it.

Let's have a closer look at the different celestial bodies of our solar system!

Planets

Planets are spherical bodies which orbit the Sun. They do not produce light but reflect the light from the Sun.

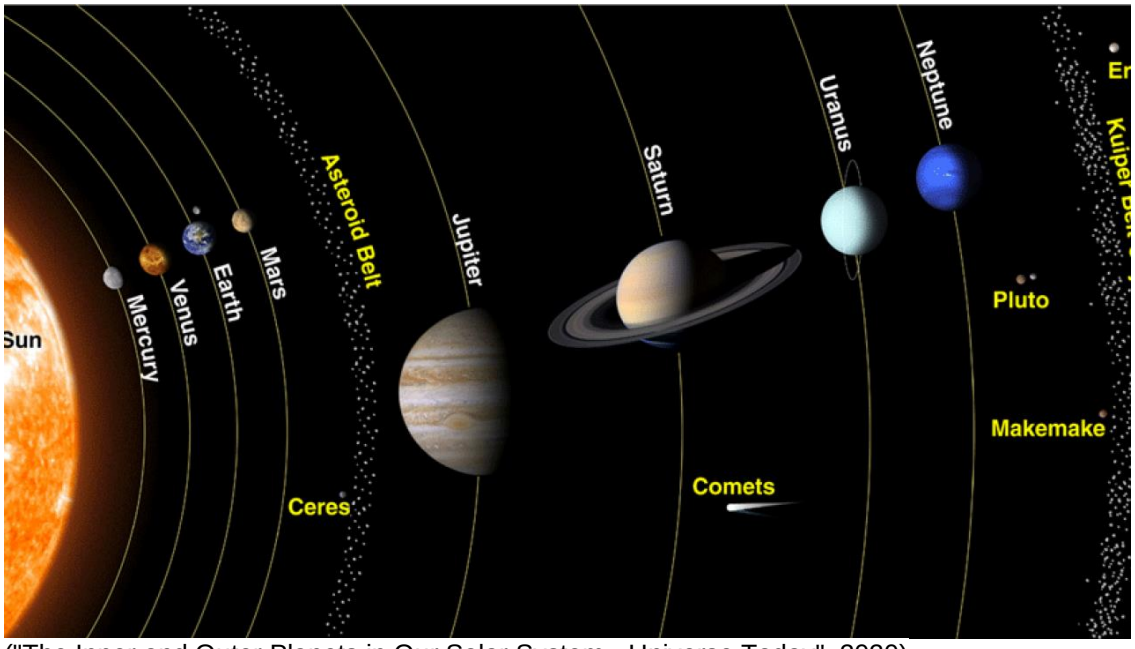
There are 8 planets in our solar system which move around the Sun in slightly elliptical orbits. The planets also rotate counterclockwise around their own axis, except Venus and Uranus which have a clockwise rotation.

The planets are divided in two groups:

- Inner planets: Mercury, Venus, the Earth and Mars
- Outer planets: Jupiter, Saturn, Uranus and Neptuno

Inner Planets – Mercury, Venus, the Earth and Mars

They are small, solid planets made mainly of rocks and are close to the Sun. They are inside the asteroid belt. They have few satellites, rotate slowly on their axis and do not have rings.



("The Inner and Outer Planets in Our Solar System - Universe Today", 2020)

Outer Planets – Jupiter, Saturn, Uranus and Neptune

These are the gaseous giant, large planets that are made mainly of gases and are far from the Sun, on the other side of the asteroid belt. They have many satellites, rotate quickly on their axes and have rings.

Other celestial bodies

Satellites, such as the Moon, are celestial bodies which rotate around planets. Except for Venus and Mercury, the other planets in the solar system have satellites.

Asteroids are rocky celestial bodies which orbit the Sun. Most of them are found in the so-called asteroid belt located between the orbits of Mars and Jupiter. Sometimes the path of an asteroid's orbit changes and it becomes a meteorite which can collide with other celestial bodies.
Comets are small celestial bodies made of rock and ice. They rotate around the Sun and have elliptical orbits. When they get nearer to the Sun their ice evaporates and is pushed by the solar wind into a tail. The tail always points away from the Sun.

Watch the video in the web → The Solar System- our home in space, and answer the following questions.

7. There used to be 9 planets in our Solar System, now there are only. **Explain** what happened to the 9th planet.
8. **Explain** why the inner planets have higher average temperatures than the outer planets.
9. **Explain** which planet would take the longest to revolve around the Sun.
10. **Explain** why do the bigger planets usually have more moons that the smaller ones?
11. **Explain** why is Jupiter useful for the safety of the Earth?
12. Which other planet would be most suitable for humans to live on? **Explain** your answer.
13. Venus has an atmosphere made of 97 % carbon dioxide compared to 0.1 % on Earth. **Explain** why this makes Venus a much hotter planet.
14. If we look at the stars and galaxies around us, we notice that they are all moving away from each other. **Explain** how this helps us to work out that the Universe started at a single point.

The Earth, our home

The Earth is the 3rd planet from the Sun (about 150 million km from the Sun), with a diameter of 12 756 km and a mass of around 6 x 10^{21} tonnes.

Our Earth is a sphere slightly flatten at the poles. It is a rocky planet surrounded by an atmosphere made of gas and ¾ of its surface is covered by a layer of water known as the hydrosphere. It is divided into two hemispheres by an imaginary line called the equator. It has a natural satellite -the Moon, which rotates around the Earth because of gravitational attraction.

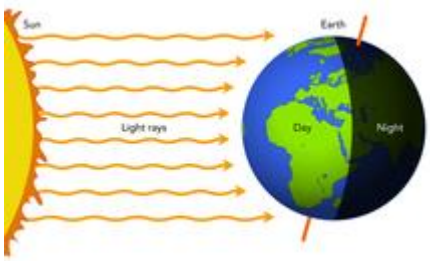
It is the only planet in our solar with the right conditions to support life.

The movements of the Earth

The Earth makes tow continuous movements: rotation and orbit or revolution. Day and night are caused by the rotation of the Earth on its own axis and the seasons are the result of the orbit of the Earth around the Sun and its tilted axis.

- The Earth's axis is an imaginary line that runs through the center of the Earth from the north pole to the south pole.
- The Earth is "tilted" with relation to this imaginary line 23.5^{o}

Rotation: This is the movement of the Earth around its own axis. The Earth makes a complete rotation once every 24 hours, and this is responsible for day and night. The Earth's tilted axis affects the length of days and nights, depending on location. When our side of the Earth faces the Sun it is daytime, and the temperature rises. When the Earth turns so that we are facing away from the Sun, it is night-time, and heat radiates out into space dropping the temperatures.

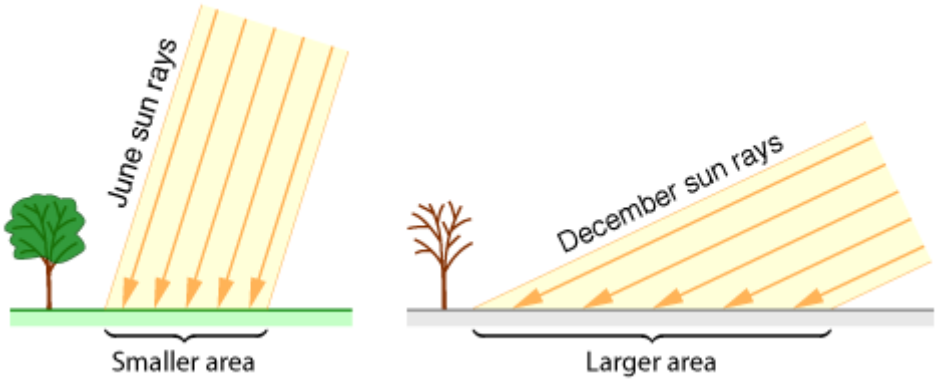


Orbit or revolution - The Earth also moves in an elliptical orbit around the Sun. This movement, with the tilted axis of Earth, is responsible for the **seasons** we experience.

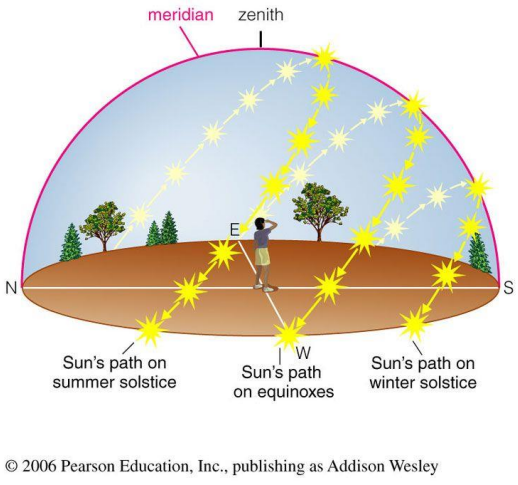
The Earth takes 356 ¼ days to complete an orbit of the Sun (1 year). Since the Earth is a sphere, the Sun's radiation impacts differently across its surface. At the Equator it is perpendicular and becomes gradually more inclined as we get closer to the Poles. The amount of solar radiation that impacts each of the two hemispheres varies throughout the year due to the angle of the rotation, the tilted axis and the Earth's orbit.

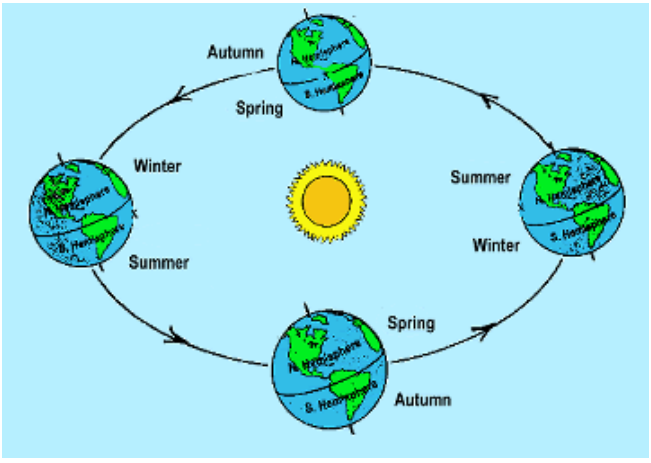
During summer in Spain, the **northern hemisphere** is lilted towards the Sun (as in the diagrams below). The Sun's path is high in the sky, the same number of Sun´s rays are falling on a smaller area of the Earth´s surface, and the days are longer, So that hemisphere receives more solar radiation.

During winter our hemisphere is now tilted away from the Sun. The Sun stays low in the sky, the Sun´s rays are more spread out, and days are short. Our hemisphere now receives less solar radiation.



("Seasons", 2020)





("02-17.jpg (767×712) | Eco friendly house, Color theory, Sun path", 2020)

As the Earth orbits the Sun, the northern hemisphere will gradually end up pointing away from the Sun. This reverses the seasons.

So, you have seen that the seasons are not caused by the distance from the Sun!

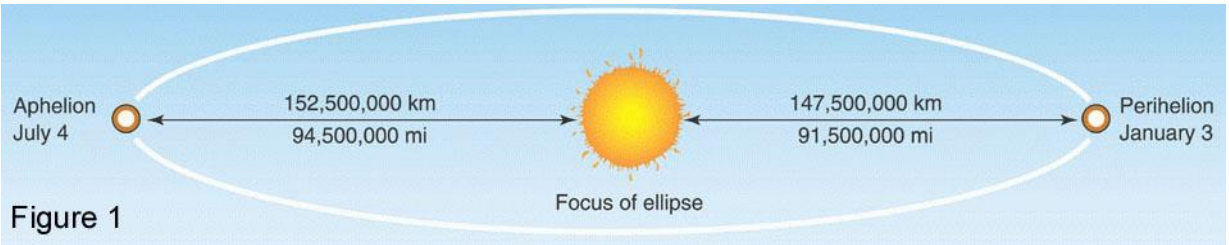


Figure 1

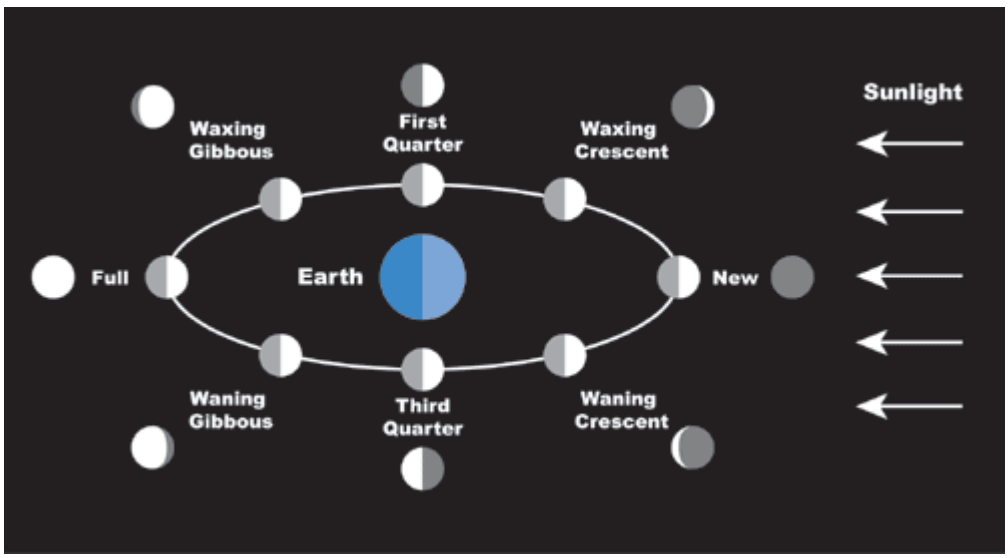
(2020)

The Moon, our satellite

The Moon is the Earth's satellite.

The Moon is a non-luminous celestial body, but we see it because it reflects sunlight. It moves steadily along its orbit, at a distance of about 400 000 km from the Earth, as well as it rotates around its own axis.
The Moon has the same period of rotation as of revolution. That is it takes the Moon the same time, 28 days, to orbit and Earth as it does to rotate on its axis. It is for this reason that we always see the same side of the Moon, known as the near side. The other side of the Moon, the one that we don't see is the far side or the dark side of the Moon.

The shape of the Moon changes during a month. Sometimes we see a full Moon, sometimes a half Moon. These are some of the phases of the Moon. As the Moon orbits the Earth how much of the Moon we see changes.



(Schimmrich & profile, 2011)

Video on the phases of the Moon.

- https://www.youtube.com/watch?v=-KrwETayL6A&feature=emb_logo

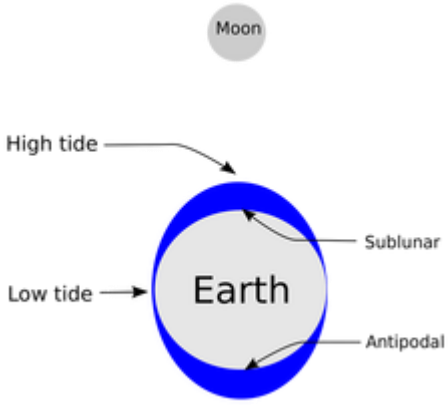
Activities

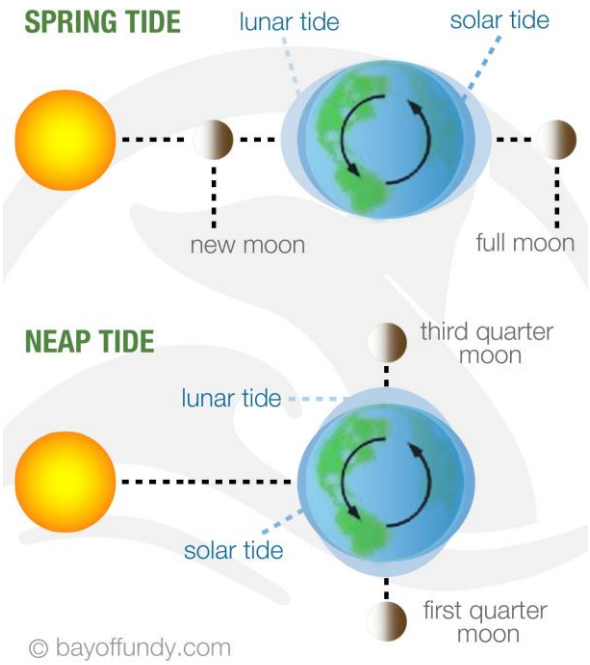
15. Draw in your notebook the phases of the Moon (new Moon, First quarter, full Moon and third quarter) and briefly explain each one.
16. Explain what is the far side of the Moon, also known as the dark side of the Moon.

Tides

The gravity of the Earth keeps the Moon in a permanent orbit. However, the gravity of the Moon also has an effect on Earth's water masses deforming and causing variations in their levels. These are known as tides.

As it revolves around the Earth, its gravitational pull causes the seas and oceans to bulge towards itself. This causes a high tide, and the places that are at the side of the Earth will have a low tide.





The gravity from the Sun can also make tides bigger or smaller. It the Moon and Sun are aligned then we get even higher tides, called **spring tides**. And if they are not aligned then the tides are smaller, called **neap tides**.

There are 4 tides in a day, one roughly every six hours, alternating between high and low tide.

Extension Activity

Why does the water "bulge" the opposite side of the Earth as well?

Activities

17. Define what are tides in your notebook.
18. Briefly explain what causes high and low tides.

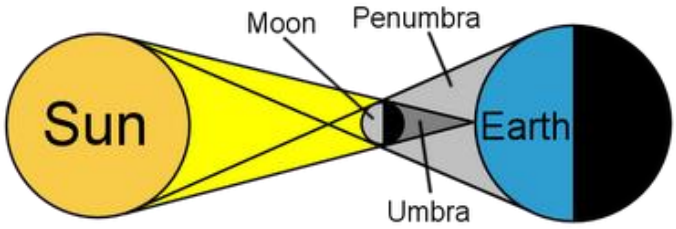
19. Explain what are: spring tides, neap tides and tidel bore. There is a video on the web on tidel bore.

Eclipses

As the Moon orbits the Earth, it sometimes blocks our view of the Sun, producing an eclipse of the Sun or solar eclipse. Other times the Moon is hidden by the Earth's shadow, producing an eclipse of the Moon, or lunar eclipse.

Solar Eclipse

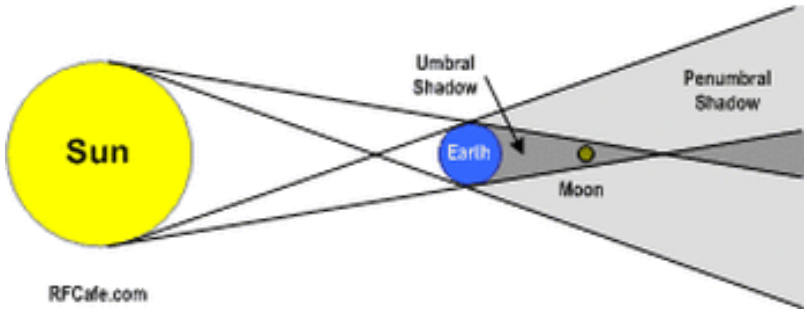
- In a solar eclipse the Moon passes directly between the Sun and the Earth. The Moon's shadow falls on the Earth, and the Sun's light is blocked off for a few minutes.
- In a solar eclipse the shadows of the Moon and the Earth are in two parts:
  - The full shadow, the **umbra,** where there are no rays from the Sun,
  - The partial shadow, the **penumbra**, where some of the Sun's rays are blocked off.



(Gallery4share.com, 2015)

Lunar Eclipse

- Eclipse of the Moon or lunar eclipse: The full Moon gradually darkens until it becomes very dim; then it gradually lightens up again
  - This happens when the Moon's orbit takes it into the Earth's shadow, so it can not refletc any light and it looks as it is disappearing.



(Gallery4share.com, 2015)

Activity

20. Define what an eclipse is and draw in your notebook a solar and a lunar eclipse. Include a brief explanation of each.

References

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