Neighbouring planets

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Justification

- This material is designed for teachers of children before starting primary school. Some content is presented to give the teacher more resources, although they may be too ambitious for such young children, but the questions that they may sometimes ask require broader knowledge to be able to rigorously explain the issues that may arise.

Goals

- Show in a simple way the meaning of the data on the planets of the Solar System that often appear in texts.
- Introduce, by playing, the set of movements of the Solar System
- Discover the Moons surface
- Consider the surfaces of some planets and moons

Solar System

- Models that are only manual work are not enough for us
- We want models with more content wich allow us to show some specific characteristics

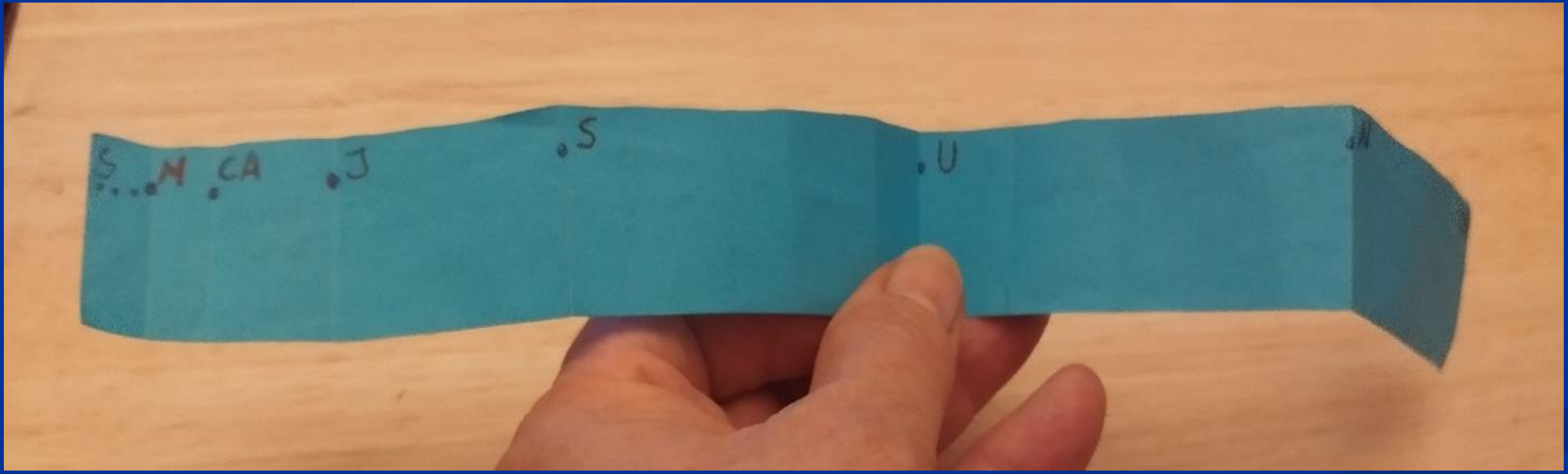
Actividy 1: Distances to the Sun

We prepared a model using the following approximation, the distance between a planet and the Sun is half the distance between of the next planet from the Sun. For example, Jupiter ‘s distance from the Sun is approximately half Saturn’s distance from the Sun.

Planet	Real Distance	Distance of the model
Mercury	57 900 000 km	67 500 000 km
Venus	108 300 000 km	125 000 000 km
Earth	149 700 000 km	187 500 000 km
Mars	228 100 000 km	250 000 000 km
Asteroid Belt (average)	410 000 000 km	500 000 000 km
Jupiter	778 700 000 km	750 000 000 km
Saturne	1 430 100 000 km	1 500 000 000 km
Uranus	2 876 500 000 km	3 000 000 000 km
Neptune	4 506 600 000 km	4 500 000 000 km
Kuiper Belt (average)	5 700 000 000 km	6 000 000 000 km

Activity 1: Distances to the Sun

- We cut a strip of DIN A4 card. We write an S (Sun) at one end and KB (Kuiper Belt) at the other end and fold it in half, placing the rest of the planets.



Activity 1: Distances to the Sun

Planets	Initial serie	+4	Titus-Bode Distances	Real Dist. (AU)	Paper model Distances
Mercury	0	4	0.4	0.38	0.33
Venus	3	7	0.7	0.72	0.65
Earth	6	10	1.0	1.00	0.98
Mars	12	16	1.6	1.52	1.25
Asteroids Belt	24	28	2.8	2.73	2.50
Jupiter	48	52	5.2	5.20	5
Saturn	96	100	10.0	9.54	10
Uranus	192	196	19.6	19.20	20
Neptune	384	388	38.8	30.06	30
Kuiper Belt	768	772	77.2	38.00	40

The Titius-Bode method begins in the first column with the series 0, 3, 6, 12, 24, 48, 96… in which each value is doubled. The second column shows the same numbers plus 4. In the third column, we divide all of them by 10, and the resulting values are quite similar to the distances (in astronomical units, AU) shown in the fourth column. The fifth column is the simplified model created by folding the paper.

Activity 1: Distances to the Sun

The basis of the model (half and half) is a simplified version of the Titius-Bode mnemonic.

This empirical rule was used in the 18th century to figure out the distances between the Sun and the planets known at the time (instead of deduce the distances of the then-known planets). This law is roughly true for the moons of Jupiter and Uranus, as well as Saturn's, but with some exceptions. Right now, they're thinking about using it for exoplanets.

Activity 2: Diameters

Sun	1 392 000 km		139.0 cm
Mercury	4 878 km		0.5 cm
Venus	12 180 km		1.2 cm
Earth	12 756 km		1.3 cm
Mars	6 760 km		0.7 cm
Jupiter	142 800 km		14.3 cm
Saturn	120 000 km		12.0 cm
Uranus	50 000 km		5.0 cm
Neptune	45 000 km		4.5 cm

Activity 2: Diameters

General scaled diameter model with the planets glued on the Sun.

Activity 3: Comparison of volumes

The volume of a sphere is 4/3 pi times the radius cubed. Therefore, if the radius of one planet is twice that of another, its volume is not just double, it's much larger.

As an example, let's compare Earth and Jupiter. Jupiter's radius is 11 times greater than Earth's, so Jupiter's volume is more than 1300 times greater (11 x 11 x 11 = 1331). To visualize this, we can use a kilogram of chickpeas.

Activity 3: Comparison of volumes

A chickpea is approximately 1 cm in diameter. We took a sufficiently large plastic bag and filled it with 1331 chickpeas. We sealed the bag into a spherical shape using transparent tape and compared it to a single chickpea.

To count them, we'll use a measuring cup or small cup that allows us to count the chickpeas quickly. For example, if 100 chickpeas fit in the cup, we'll put 13 cups in the bag and then add 31 more chickpeas.

Activity 4: Model of distances with movement

- We painted a circle on the floor of the patio with chalk to represent the orbit of each planet centered on the Sun.

Activity 4: Model of distances with movement

Mercury	57 900 000 km	⇒	6 cm	0.4 AU
Venus	108 300 000 km	⇒	11 cm	0.7 AU
Earth	149 700 000 km	⇒	15 cm	1.0 AU
Mars	228 100 000 km	⇒	23 cm	1.5 AU
Jupiter	778 700 000 km	⇒	78 cm	5.2 AU
Saturn	1 430 100 000 km	⇒	143 cm	9.6 AU
Uranus	2 876 500 000 km	⇒	288 cm	19.2 AU
Neptune	4 506 600 000 km	⇒	450 cm	30.1 AU

Activity 4: Model of distances with movement

- One volunteer plays the role of a planet and will move along the chalk line until it completely circles the Sun. This is the revolution or annual motion.
- Another volunteer does the same thing, but with a simultaneous rotational movement around his axis. He also simulate the daily rotational movement.
- A third volunteer is circling around the second: it is a moon around the planet.

It is necessary to mention that with these movements some bodies can pass in front of others, and so transits and eclipses occur.

Activity 5: Orbital period model

- The translational movement is faster for the inner planets and slower for the outer ones.
- We will simulate this situation with a simple model. We hold a rope at the opposite end to which we have fixed a nut and we make it rotate like a sling above our head

Activity 5: Orbital period model

- As we release the rope we will see that it takes more time to make a complete circle (an orbit).

- If we remove the rope, it takes less time to turn around (it is good to pass the rope through the inside of a small tube so as not to erode the hand if the rope is removed quickly)

Activity 6: Terrestrial and gaseous planets

	Density	Diameter
Mercury	5.41 g/cm3	4 878 km
Venus	5.25 g/cm3	12 180 km
Earth	5.52 g/cm3	12 756 km
Mars	3.90 g/cm3	6 760 km
Jupiter	1.33 g/cm3	142 800 km
Saturn	0.71 g/cm3	120 000 km
Uranus	1.30 g/cm3	50 000 km
Neptune	1.70 g/cm3	45 000 km

Activity 6: Terrestrial and gaseous planets

Terrestrial planets

- Mercury, Venus, Earth and Mars.
- Smaller and closer to the Sun
- Without or with few satellites (0, 0, 1 and 2 respectively)

Gaseous planets

- Jupiter, Saturn, Uranus and Neptune.
- Bigger and farther from the Sun
- With many satellites
- With rings of ice and dust

Activity 6: Terrestrial and gaseous planets

Terrestrial planet

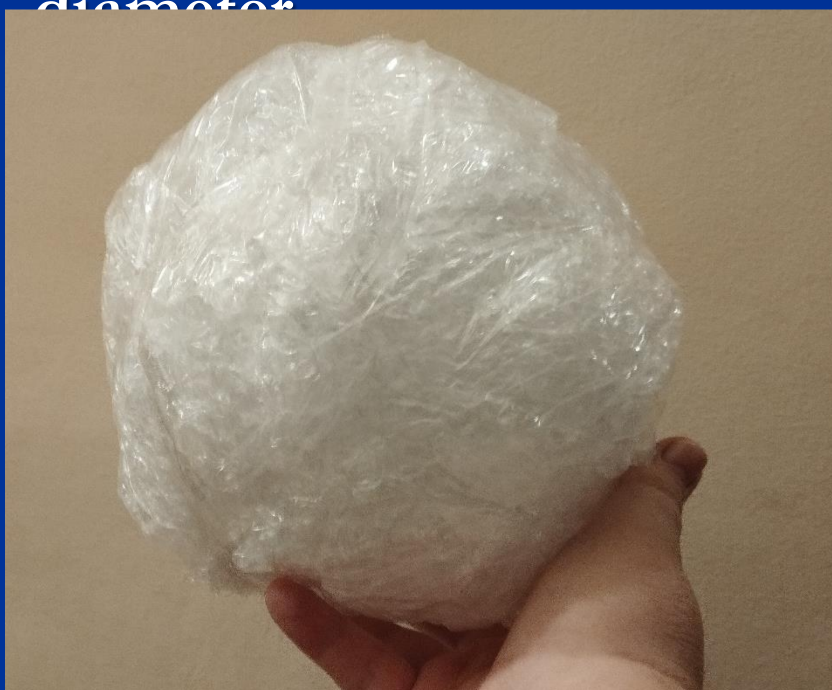
- Model of the Earth with modeling clay, a sphere of 2.6 cm in diameter

Credit: NASA

Activity 6: Terrestrial and gaseous planets

Gaseous planets

- Jupiter model with bubble paper, a sphere of 28.5 cm in diameter

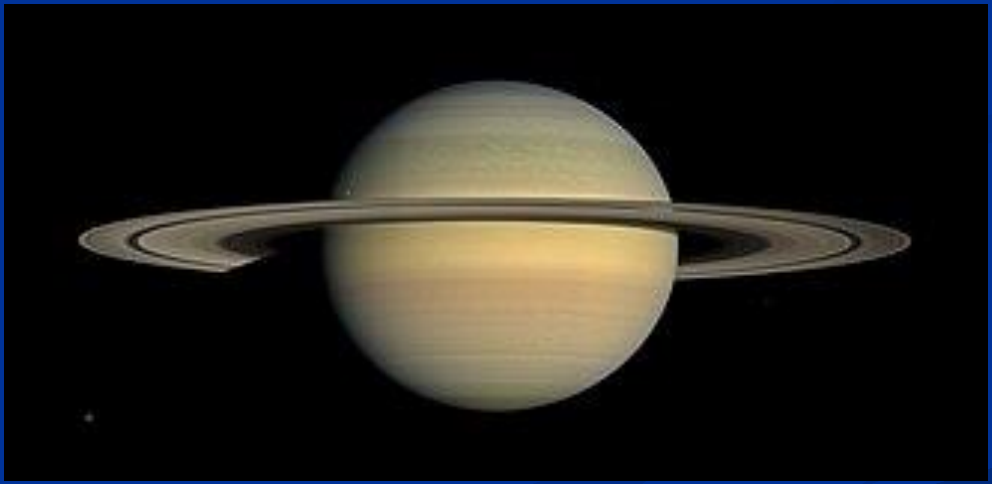


Credit: NASA

Activity 7: Planetary rings

Saturn is famous for its ring system visible from Earth. Jupiter, Uranus, and Neptune also have rings, though less spectacular. The rings, composed of dust, rocks, and ice, rotate in the planets' equatorial plane.

The inner edge of the rings is 74,000 km from the center of Saturn and the outer edge is 140,000 km away (while the radius of Saturn is only 58,000 km).



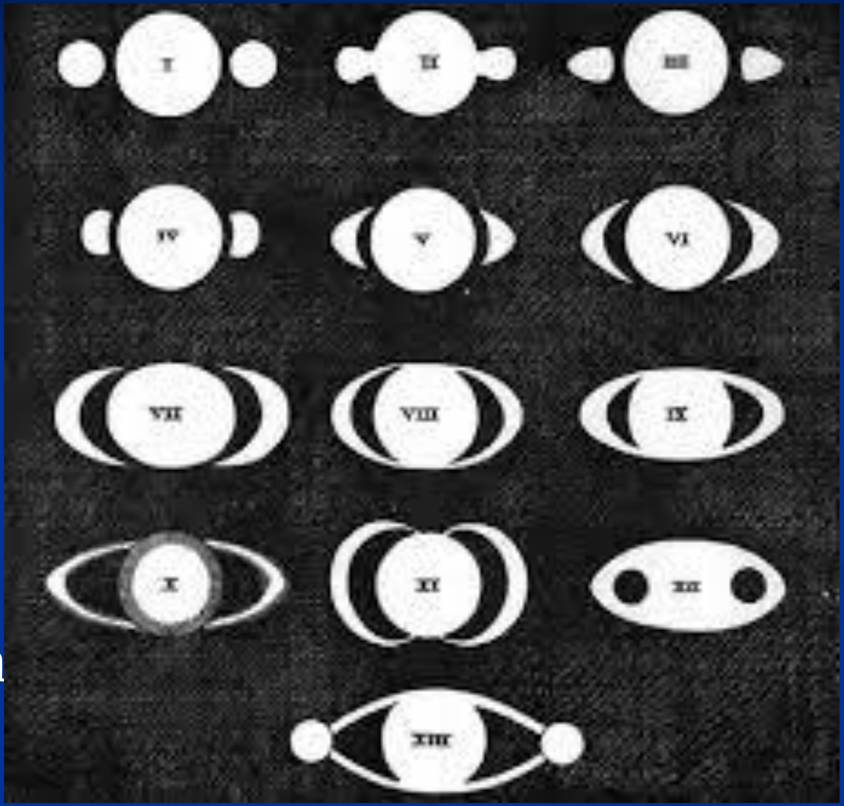
Activity 7: Planetary rings

We used a DVD or CD and a polystyrene ball to simulate Saturn and its rings. We cut the ball in half and glued the two halves to either side of the CD or DVD.

To make the model to scale, keep in mind that the diameter of a CD or DVD is 12 cm, so, based on a simple proportion, we should use a polystyrene ball slightly less than 5 cm in diameter.

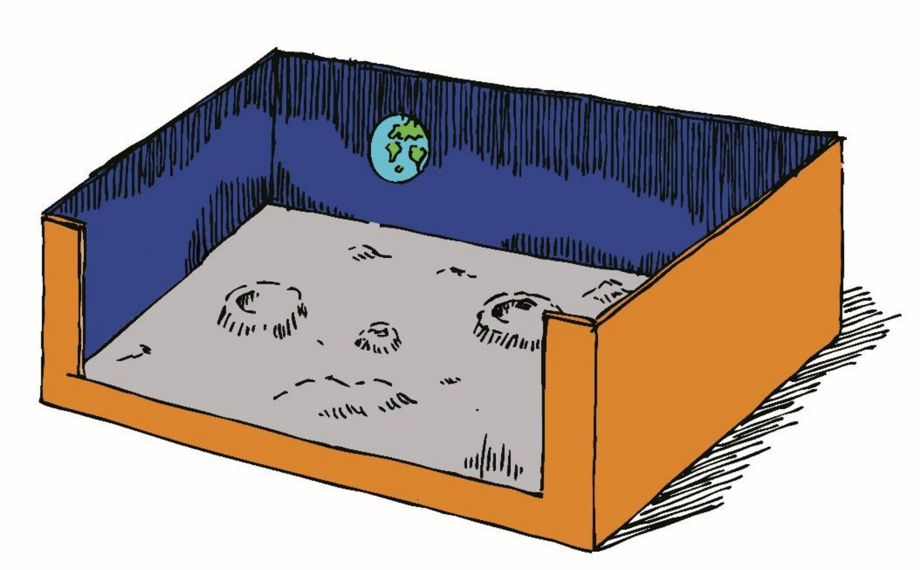
Activity 7: Planetary rings

If we hold the model with two fingers fixed on the poles, varying the position of the sphere will show the ring tilted at different angles. These positions will be similar to what Galileo Galilei observed in 1610 with his small telescope.



Activity 8: Dioramas

- **We know what the surface of the Earth, the Moon and Mars look like.**
- **We make dioramas of each of these places.**
- **We simulate the surface with craters or not, and we paint the sky.**



- The light of the Sun is colorful. In the atmosphere of the Earth, due to its composition, the blues have "won", in that of Mars the pinks "won" and on the Moon there is no atmosphere and the sky looks black

Activity 8: Diorama of Mars

Credit: NASA

The surface of Mars is reddish due to iron oxides.

Credit: NASA

The atmosphere of Mars is very weak and there is a lot of dust in suspension, so the sky looks pink-orange. You have to paint the sky pink or orange. You can put a “rover” whose design does not need to be aerodynamic!

Activity 8: Diorama of Mars

Example of the reddish surface of Mars, the pink atmosphere and the non-aerodynamic “rover”

Activity 8: Diorama of the Moon

We simulate the surface of the Moon with powdered cement, ash or with flour and cocoa. It must have craters.

Credit: NASA

On the Moon, since there is no atmosphere, you have to paint the sky black and maybe... put an astronaut in a diving suit, there is no air to breathe.

Credit: NASA

Activity 8: Diorama of the Moon

Example of the surface of the Moon with craters, black sky and an astronaut in a diving suit, because there is no air to breathe.

Activity 8: Diorama of the Earth

The Earth's surface usually has vegetation and you can put a few animals. It is the planet of life. You can add an aerodynamic car

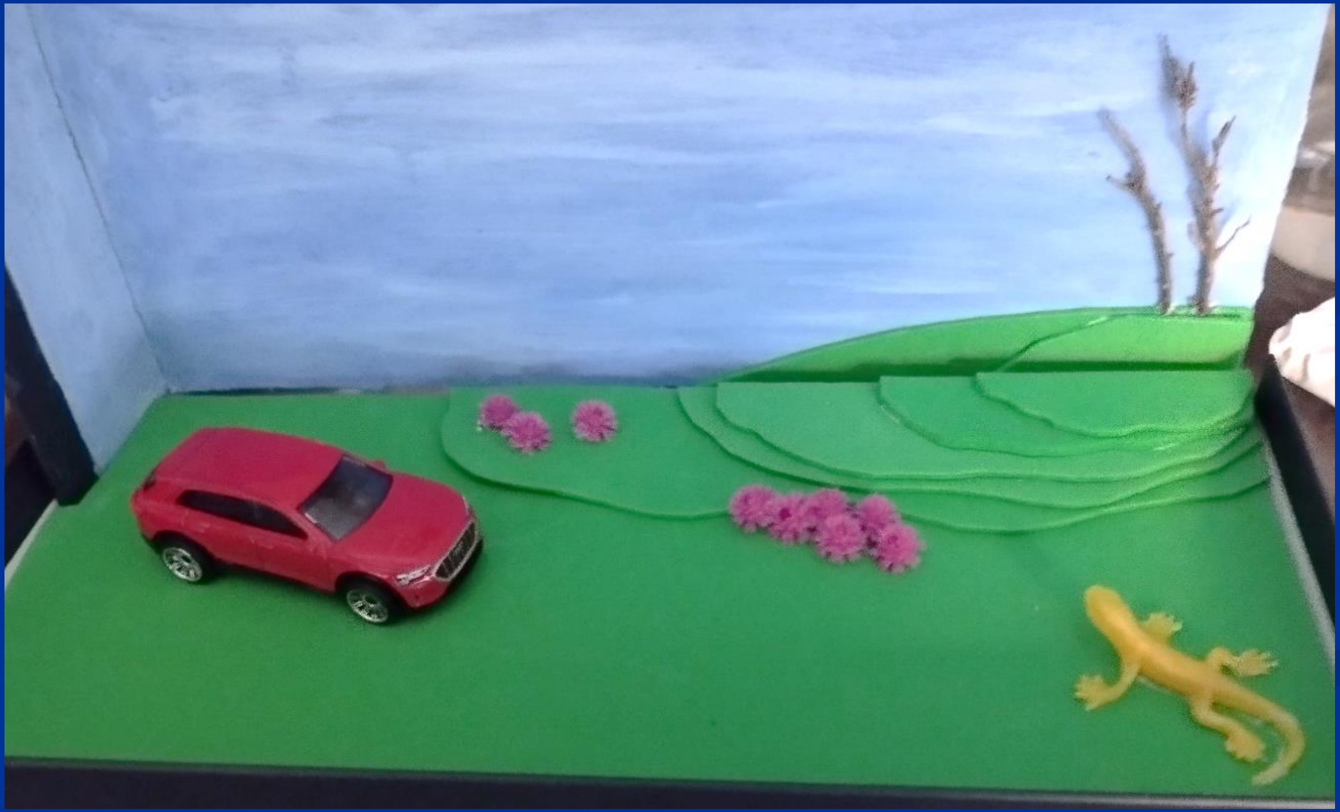
Credit: Martingraf

Credit: Pixabay

The Earth's atmosphere is much denser than that of Mars. You have to paint the sky blue.

Activity 8: Diorama of the Earth

Example of the Earth's surface with the blue sky, vegetation and some small animals and an aerodynamic car



Smell on some planets

The Earth's atmosphere diffuses the molecules responsible for smells. When these molecules reach our noses, they are detected by specialized sensors, then interpreted by the brain. An atmosphere is necessary for the propagation of smells.

Let's consider what smells would be like on the Moon (where a spacecraft has Moon landed) and on Mars or Venus (where several spacecraft have landed).

Smell of the Moon

- There is no atmosphere on the Moon, so you cannot smell anything.
- The astronauts who walked on the Moon returned to the module with small amounts of lunar dust in their suits and most of them agree that it's the smell is reminiscent of a mixture between ashes and "burnt gunpowder", like "chimney ashes".

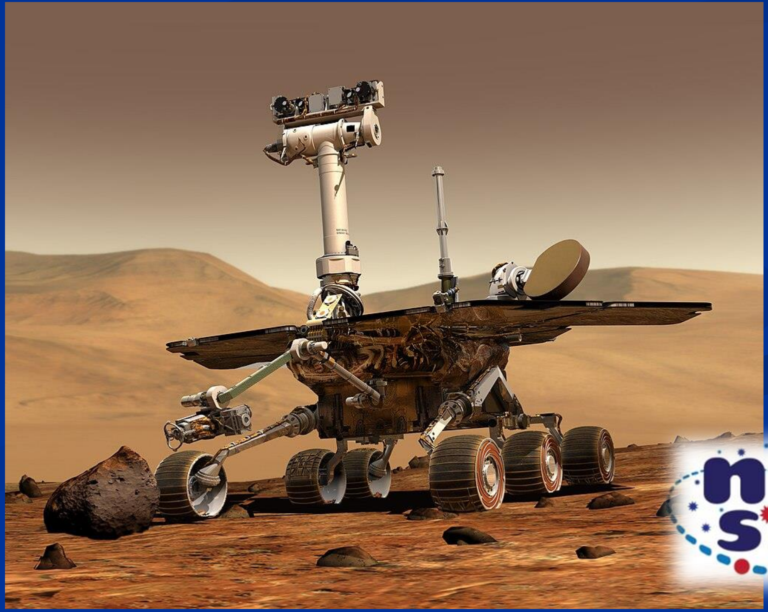
Smell of Venus

Venus's atmosphere is very dense, composed mainly of CO_2 (odorless) and sulfuric acid (odorless). We know that sulfuric acid rain occurs there, and rivers and lakes of this acid form. Various sulfur compounds are found on the surface of Venus, some of which smell like rotten eggs.

Smell of Mars

The “rovers” have revealed that the Martian atmosphere is rich in CO_2 (96%), which does not contribute any aroma to the environment, but is also composed mainly of iron, magnesium, sulphur and acids. It may have a certain ferrous odor due to the abundant iron oxides in the dust.

Presumably the surface must give a certain ferrous smell due to iron oxides



Smell of space

Helen Sharman, the first British astronaut on Mir, explains that there is very little smell because in microgravity, warm air doesn't rise, and so "the smell of hot food" doesn't escape from the plate.

Many astronauts have said that after a spacewalk, they perceive "a smell of welding, of metal in the air, of burnt electrical wiring." The cause of this smell is a mystery, but it is noticeable.

Activity 9: Smells on the Moon, Venus and Mars

MOON

We can recreate the smell of spacesuits by:

- smelling the ashes of a bonfire or burning paper.
- for the smell of gunpowder, we can use sparklers or firecrackers from festivals or birthday parties.

Activity 9: Smells on the Moon, Venus and Mars

VENUS

Sulfuric acid doesn't smell, but sulfur compounds that smell like rotten eggs can be simulated with a "smel bomb" like the ones used for parties and magic tricks.

Activity 9: Smells on the Moon, Venus and Mars

MARS

To simulate the smell on Mars, we suggest using arid and very dry soil mixed with a collection of rusty nails or screws that will simulate the smell of the dust formed by iron oxides that give the typical reddish color to the Martian surface.

Life in the Solar System

For life to exist:

- The planet must be in a habitable zone for liquid water to exist, and an atmosphere is needed to maintain humidity.
- Sunlight must interact with the atmosphere to generate, for example, ozone, which protects against ultraviolet radiation responsible for the destruction of living cells.
- The planet must have a surface like the Earth, which heats up and then heats the atmosphere.

Many things are needed for life to progress:
a star that isn't too large, a rocky planet at the right distance from its star, water, an atmosphere, and a suitable temperature and humidity...

Activity 10: Sprouted Chickpeas

Life requires a certain temperature, light, and humidity. Let's take as an example four chickpeas wrapped in cotton wool and placed in separate glasses.

- We will put a chickpea in a cotton ball soaked with water (which we will keep always moist) inside a small glass. We repeat this four times and place them in:
  - a sunny spot
  - a spot with almost no light
  - inside a refrigerator.
  - finally, we'll place the fourth chickpea, covered with cotton but without being moistened with water.

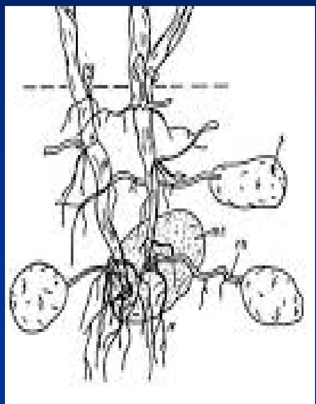
Activity 10: Sprouted Chickpeas

After about 7 or 10 days, we observe that the chickpeas placed:

- without water have not germinated
- inside the refrigerator have not germinated despite humidity, but the temperature was too low and it lacked light
- in the shadows with moistened cotton and very little light have germinated but have a weak and long stem
- in the sun with moistened cotton and good temperature have developed vigorously and strongly, although they are shorter than the previous ones

It can be done with different seeds

Activity: Sprouted Potatoes



We cut the potatoes laterally (to activate them).

We need to find the potato's "navel" (the point where the potato was attached to the plant's root). We place the potato with the navel facing down and cut vertically.

We place a potato (with small sprouts) in a glass of water, but without letting it touch the surface of the water so it doesn't rot. After about 3 or 4 weeks, a strong, long stem will sprout.

Life on exoplanets

The first exoplanet discovered in 1995 is called Dimidio (before 2015 was known as 51 Pegasi b). It orbits the star Helvetios, also called 51 Pegasi, a star similar to the Sun, in the constellation Pegasus. It was discovered by Michel Mayor and Didier Queloz.

The conditions for locating Earth-like exoplanets are:

- temperatures that are not too extreme;
- a radius at most two Earth radii; and
- a mass less than about 10 Earth masses

(These are criteria used by the Kepler mission to search exoplanets. This missions was active between 2009 and 2018 and discovered thousands of exoplanetary systems).

We hope that the James Webb Space Telescope or others will provide new data on possible inhabited exoplanets and that we will have some exciting news in the coming years.

Conclusions

- Know experimentally the dimensions of the planets.
- Establish relationships for a better understanding of the dimensions of the Solar System and the size of the main bodies in it: the Solar System "is empty."
- Know the translation and rotation movements of the planets.
- Know some characteristics of the surfaces of some planets and the Moon

Thank you very much
for your attention!