4. Life on Mars

Experiment: ***Compare habitability on different planets*** ***(from science@nasa: https://science.nasa.gov/science-news/science-at-nasa/msad16mar99_1a)***

Earth in a bottle

Equipment:

- 1 cup lukewarm water
- 3 cubes sugar
- 7g of baker's yeast
- 1 empty half-liter plastic water bottle
- 1 party balloon
- 1 cloth measuring tape
- 1 small funnel (optional)

Instructions:

- Mix water and sugar in water bottle until the cubes are dissolved.
- Using the funnel add yeast, gently swirl the mixture.
- Cap the bottle with a balloon.
- Use the cloth measuring tape to measure the circumference of the balloon every 15 minutes.

Speech:

This basic recipe can be considered an "Earth in a Bottle." It is a warm, healthy environment for yeast with plenty of nutrients. The objective is to measure the viability of yeast samples and to explore environmental conditions which affect the health of yeast microbes.

The total amount of CO_2 in the balloon when it reaches its greatest volume is proportional to the number of healthy yeast microbes present in the initial sample. For the Earth bottle, the balloon will achieve its maximum volume less than two hours after the yeast are added to the nutrient mix.

The rate at which the balloon inflates is proportional to the growth rate of the yeast colony. After the yeast are added to the nutrient broth they begin to divide and increase in number. As the colony size increases so does the rate of CO_2production, so long as there is an ample supply of nutrients. If the environment inside the bottle is conducive to yeast growth, the maximum rate of CO_2 production will be high. Conversely, if the environment is hostile to yeast, the maximum rate of CO_2 production will be low.

With simple variations to the basic recipe, one can explore conditions on other planets. Although we cannot create truly accurate extraterrestrial conditions in a classroom, there are many simple variations that are representative of conditions on other planets.

Mercury in a bottle

Equipment:

- Same as Earth bottle but the water must be boiled

Instructions:

Mercury's surface is very hot:

- Boil the water before adding sugar and yeast.

Mars in a bottle

Equipment:

- Same as Earth bottle
- Freezer
- UV light

Instructions:

Mars is cold and has a thin atmosphere which allows much solar UV radiation to penetrate to its surface:

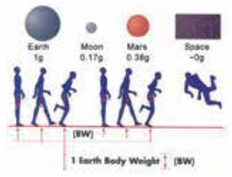
- freeze the yeast
- then expose the microbes to ultraviolet radiation from a UV lamp before adding yeast to the nutrient mix.

5. Martian Gravity

Experiment: ***Tricked bottles to simulate the effect of gravity on Earth and Mars***

Equipment:

- 3 identical non transparent bottles (milk bottles for example)
- Paper
- Stones
- Weighing scale



Instructions:

- Fill the bottles with paper and stones to simulate the feeling one would have carrying a 1kg bottle on Earth, Mars and the Moon. The mass must be equally distributed throughout all the bottle.
- On the weighing scale, the Earth bottle should weigh: 1000 g, the Mars bottle: 380 g , the Moon bottle: 170 g.

Speech:

Mass is not the same as weight. The mass is a measurement of the quantity of matter in an object and the unity is the kilogram (kg). The mass is the same everywhere in the Universe. The weight is different. The weight is a measurement of how much a celestial body attracts an object. The weight of an object is the force on the object due to gravity (the unity is in Newton, N). An object on Mars would weigh less than it does on Earth because of the lower gravity, but it would still have the same mass. The experiment with the bottles is just a trick to get a feeling of what the gravity would be on another planet.

STORIES OF TOMORROW

Classroom experiments for learning about Mars

Mini-workshops

- Travel to Mars
- Landing on Mars
- Martian Atmosphere
- Life on Mars
- Martian Gravity

The mini-workshops are supported by the Stories of Tomorrow project which is financed by the European Commission within the Horizon 2020 Programme.

Organized by

Cité de l'espace TOULOUSE

ELLINOGERMANIKI AGOGI

1. Travel to Mars

Experiment A: *Travelling through the solar system – VR*

Equipment:

- 1 Google cardboard (https://vr.google.com/cardboard/ available pretty cheap on amazon)
- 1 smartphone compatible with the app Titans of space (I guess easy to find among the participants of the summer school) (https://play.google.com/store/apps/details?id=com.drashvr.titansofspacecb&hl=fr)

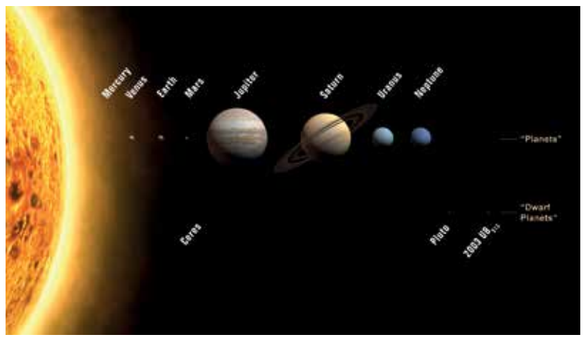
Instructions:

- start titans of space on smartphone (landscape view)
- place the smartphone in the google cardboard
- place google cardboard on your face and enjoy

Speech:

You will go through all solar system, starting from our planet the Earth. Everything you see is toy-sized, shrunk down to 1 millionth of their actual size, which means you will see Earth as a 12.7-meter-wide holographic ball, rather than the giant 12756km-wide ball of rock that it is. As the travel begins we go toward Mercury, and then go away from the sun to have a look to all the planets.

The solar system is composed of 4 rocky planets (telluric), and 4 giant gaseous ones. Today the Earth is the only habitable planet of the solar system, thus we need to take care of it.



Experiment B: *From Earth to Mars - software*

Equipment:

- 1 Computer
- software

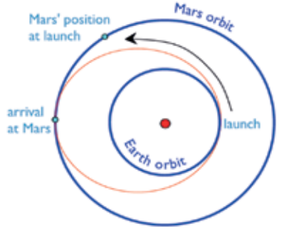
Instructions:

- Start the software
- Press spacebar to launch rocket
- Observe if the rocket lands on Mars or not

Speech:

Because the Earth and Mars are always moving, the rocket launch to go to Mars has to take place at a very specific time, called a launch window. To minimize the quantity of energy used to go to Mars, we use a special trajectory called the Hohmann transfer orbit. Playing with this software, try to launch the rocket at the good time to land on Mars, observe the trajectory and time needed to arrive safely on the red planet.

If you miss the launch window, you have to wait for about two years.



Hohmann transfer trajectory

Experiment C: *Leaving Earth – Vinegar rockets*

Equipment:

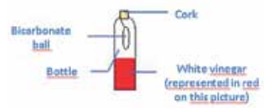
- string
- 20cl of white vinegar (8°)
- 1 tea spoon of sodium bicarbonate
- 1 sheet of toilet paper
- 1 plastic bottles (preferably form sparkling water)
- 1 corks
- 1 bucket (launch pad)

Instructions:

- *To be prepared in advance:*

  Take a sheet of toilet paper, place the sodium bicarbonate (quantity equivalent to a teaspoon) in the middle of the sheet. Roll it up and close each extremity with the string. Leave 5 cm of string form one of the extremities. The bicarbonate ball is now ready to use.

  Try the cork with the bottles, some may be too big or too thin.



- *With the children:*

  Each child takes a bottle (decorated or not), a cork, and a bicarbonate ball. Pour 20cl of white vinegar in the bottle. Place the bicarbonate ball in the bottle, but there must be no contact between the bicarbonate ball and the vinegar, here the 5cm of string becomes useful. The string must be caught by the cork so the bicarbonate ball will hang in the bottle above the vinegar.

  Return the bottle on the launch pad (typically a bucket or a reversed cone) and get away.

Speech:

We will launch vinegar rockets. What is going on in the bottle? The sodium bicarbonate reacts with the vinegar (acid-base reaction). It creates gas (CO_2). The gas will increase the pressure inside the bottle and push against the cork. When the pressure is high enough, the cork will be propelled and the vinegar will be released at high velocity, as a result, the rocket will take off. It is the principle of action-reaction.

2. Landing on Mars

Experiment: *Simulation of the landing of Pathfinder and Sojourner, first rover on Mars*

Equipment:

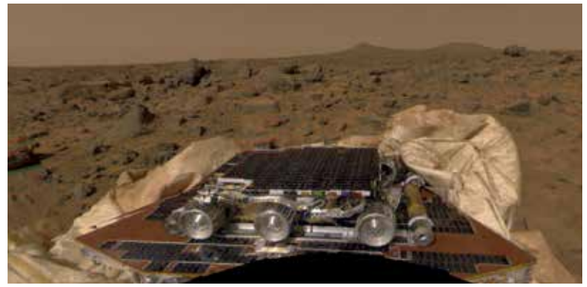
- cardboard
- foam (30-45 kg/m3)
- glue
- 1 Stanley knife
- adhesive tape
- blister warp (the one with big bubbles)
- 1 egg

Instructions:

- Cut 4 identical triangles in the cardboard using the Stanley knife
- Stick foam on the triangles using the glue
- Attached them together using adhesive tape
- Place an egg in the middle and close the pyramid using the tape
- Roll the pyramid up in the blister warp, put many layers, it has to be compressed
- Release it form human height, open, the egg is not broken

Speech:

We will simulate the landing of the first rover on Mars. It landed on the red planet on 4th of july 1997. The rover weight was 11.5 kg. The mission objectives were both technological and scientific: 1) to show that it was possible to send a load of scientific instruments to another planet; 2) to study/characterize Martian atmosphere and geology.



3. Martian atmosphere

Experiment A: *Creation of Martian air*

Equipment:

- 3 spoons of sodium bicarbonate
- 200 mL cleaning vinegar (14°)
- 1 transparent salad bowl

Instructions:

- Put the sodium bicarbonate in the transparent salad bowl.
- Level out the sodium bicarbonate in the bowl, remove the lump
- Pour the vinegar in the bowl, in a regular and continuous way making circles
- Allow few minutes for product to work, look and listen
- Do not touch the bowl, do not blow in it, do not pass your hand above it, do not move the air around the bowl, or the gas produced by the chemical reaction might disperse

Speech:

Let's make CO2. Let's look at the chemical reaction. What's going on? Foam appears, there is an effervescence ... gas bubbles are produced. Which gas is it? It is CO2 called carbon dioxide. We will study its properties.

Mars' atmosphere is mainly composed of CO_2 (95%). The Earth's atmosphere is mainly composed of nitrogen molecules, 78% (N^2) and oxygen molecules, at 21% (02). This mixture is called: air. The atmosphere of Mars was not created by mixing vinegar and sodium bicarbonate. It was created by the degassing of the molten rocks when the planet was formed, and then by the gaseous discharges of the volcanoes and the impacts of meteorites.

Experiment B: *Martian air VS Earth air*

Equipment:

- 1 Transparent salad bowl filled with Martian air (CO_2)
- something to make soap bubbles

Instructions:

- Place over the bowl, at 50cm.
- Blow gently a few bubbles, they should fall into the bowl.
- *Caution:* 3 trials maximum ! Do not touch the salad bowl, bubbles. Avoid moving too much around the bowl. Do not put your hands above.

Speech:

What is going on? Why do soap bubbles float above the bowl? What do they contain? Air. Since air is lighter than CO_2, soap bubbles filled with (essentially) air float on the CO_2.

On Mars, balloons filled with air would fly away ... like on Earth, balloons filled with helium fly away.

Experiment C: *Martian air breathable?*

Equipment:

- 1 Transparent salad bowl filled with CO_2
- 1 candle
- 1 inox ashtray
- 1 lighter
- 1 beaker (glassware)
- 1 Salad bowl cover

Instructions:

- Place the candle in the center of the ashtray.
- Position the ashtray on the side of the salad bowl
- Light the candle.
- Use the beaker to take CO_2 from bowl: without sudden gesture, position the beaker at the bottom of the bowl (horizontally with the opening slightly inclined upwards for about 15 seconds). If necessary, move the beaker forwards, from one side of the bowl to the other, without touching the liquid.
- At the same time, with the other hand, bring the ashtray to the edge of the bowl.
- Smoothly lift the beaker from the bottom of the bowl towards the candle, and pour the contents of the beaker onto the flame. Keep at few centimeters above the flame when pouring CO_2. Observe.
- *Caution:* 2 trials maximum! In case of failure: lower the ashtray to the bottom of the salad bowl (avoiding touching the liquid).
- The flame must extinguish.

Speech:

Why does the candle's flame extinguish when CO_2 is poured in? The combustion of the candle needs oxygen molecuwles (O_2) contained in the air. The CO_2 poured replaces the air (thus the oxygen) and prevents the combustion, the flame extinguishes. Just like the candle needs oxygen to burn, humans need oxygen to breathe. Conclusion: the atmosphere of Mars contains almost no oxygen, so it is unbreathable and deadly to human beings. If some day one goes on Mars, he/she will have to put on a spacesuit to breathe outside the Martian base.