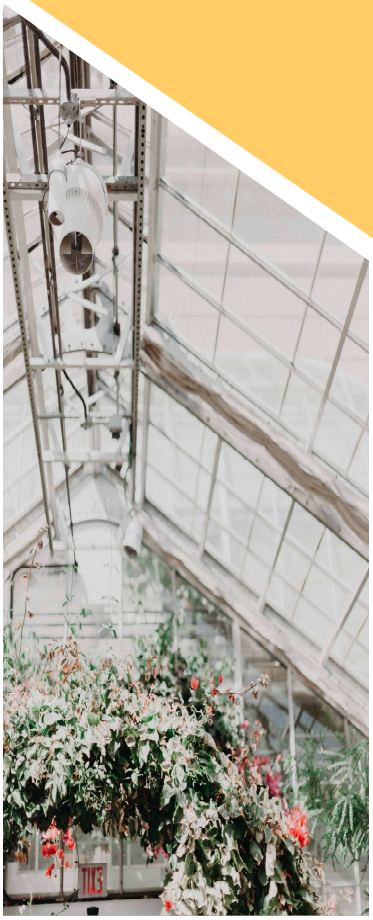
"THE GREENHOUSE"

LESSON PLANS

How A Greenhouse can teach us about STEM Education

STEM TEACHING

Four Lesson Plans inspired from Greenhouse Applications.



"NICOSIA VS NITRA, A BRIGHT CONTEST"

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"IT'S TOO HOT"

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"CAPTURING THE SUNLIGHT"

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"IT SMELLS LIKE A GREENHOUSE"

"NICOSIA VS NITRA A BRIGHT CONTEST"

In this activity, students will figure out the best angle to tilt a solar panel to make it work the best. They'll start by trying out different ideas and answering questions to learn the basics before deciding how the solar panels should face.

First, students will do hands-on experiments to understand how the tilt, or angle, of a solar panel affects how well it works. They'll ask specific questions and try different setups to gather the necessary information. This helps them build the basic knowledge needed to decide on the best way to position the solar panels.

In simpler terms, students will find the optimum gradient of a Solar Panel so for it to obtain its maximum efficiency. To do so, firstly the students will experiment with specific questions that lead to prerequisite knowledge for concluding as to the Solar Panels' orientation.

At the end of the activity, students will be able to calculate the Solar Panels' gradient in Nitra and compare their findings.

Expected outcome:

For maximum efficiency the Solar Panels should have an angle of elevation of 28-35^{o} for the majority of European Countries.

Questions to be investigated:

1. *What is light?*
2. *How is light transmitted in an empty space?*
3. *Relative Earth-Sun motion.*
4. *How are seasons created?*

Guidelines for Teachers:

1. *What is light.*

   This is a question that has been puzzling scientists for many years. Light behaves like a wave but at the same time it carries energy.

   Therefore, light has a dual nature:

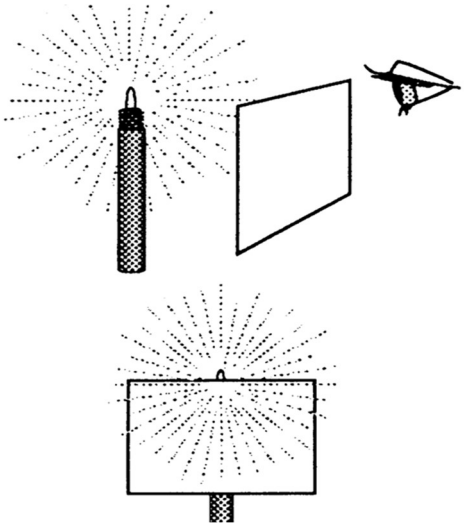
   a. Sometimes it behaves like a particle (called a photon), which explains how light travels in straight lines.
   b. Sometimes it behaves like a wave, which explains how light bends (or diffracts) around an object.
   c. Scientists accept the evidence that supports this dual nature of light (even though it intuitively doesn't make sense to us!)

   This dual nature of light is to be investigated, up to a point, by the students. Students of the age 10-14 years old do not have the knowledge to conclude as to the nature of light but they can make simple observations of the light being a wave and carrying energy. A simple experiment that they can contact, based on observation is the following:

   Students can expose themselves to Sun rays for a short period of time and then share their observations.

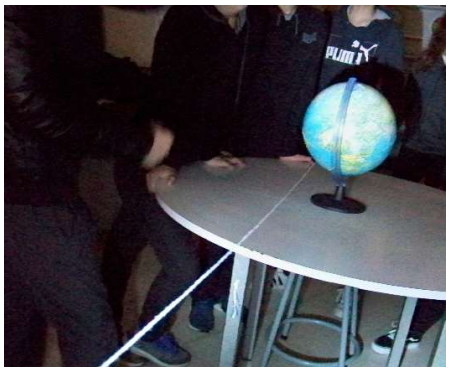
   - The first expected observation is that the sun made them feel hot. Students can discuss their observation and the fact that heat can only occur when energy is transferred from one body another. So, in their case this can only happen with the energy transferred from the Sun Rays to their bodies. Therefore, the Sun rays carry some form of energy that heats their bodies and generally anything that is exposed to the Sun rays.

- The fact that light diffracts can be shown using a piece of paper and a light source i.e. a lamp. When you place the paper in a place where it covers half of the lamp, you will notice that the light rays somehow "bend" and create the same "light circle" as before, overlapping the paper. This is an observation of light diffraction.



2. *How it is transmitted through vacuum space.*
   Only electromagnetic waves have the ability to travel through space since they don't require solid matter to travel through. Therefore, light behaves as an electromagnetic wave since it travels through space, reaching Earth.

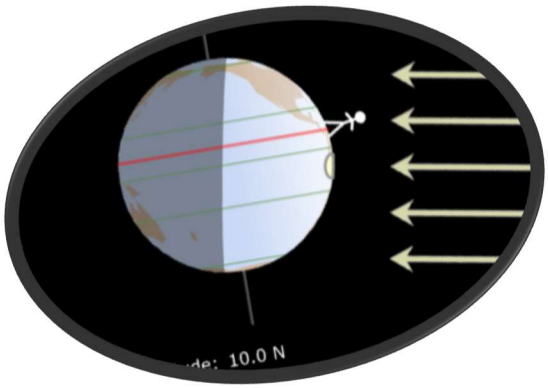
3. *Relative Earth-Sun motion.*
   Using a torch, a globe and a thread, students may construct a model to represent the sun rays and the relative Sun-Earth motion, as the pictures indicates. Earth rotates around its axis and therefore, day and night is created. It also orbits around the Sun, while Sun is stationery.



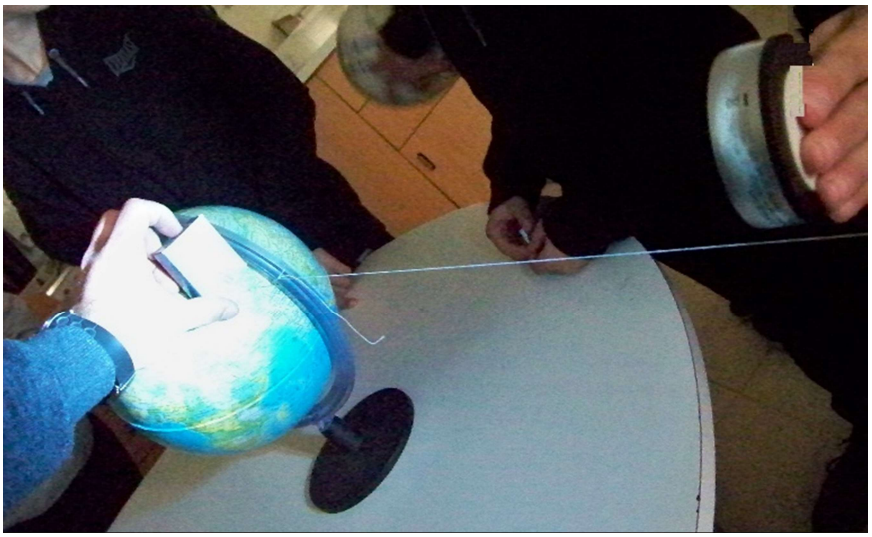
4. How seasons are created.
   Students can move the Globe circularly, around a table, keeping the torch stationary. At the same time, they can rotate the globe around its axis. Students can comment that as Earth (Globe) is in orbit around the Sun, different areas of the Globe have different exposure time to the Sun and this fact creates the seasons. The areas with longer exposure to Sun have summer periods and the areas with less exposure have winter periods.
   An accurate tool for seasons' formation can be found in this link:
   https://astro.unl.edu/classaction/animations/coordsmotion/eclipticsimulator.html

Main Investigation:

Using the previous model, the students may set the Earth in such a position against the torch, so that their country has the longest sun exposure. Special attention needs to be paid to placing the sun across the globe. It must not be placed parallel to the Earth's axis but it needs to be placed like the following shape indicates.

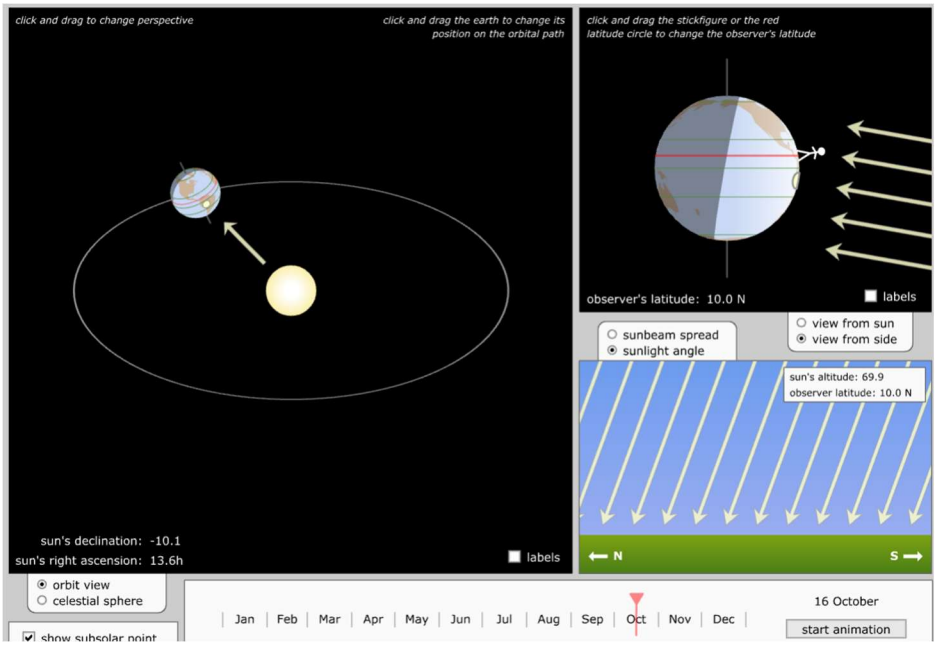


Then a thread from the torch to their country will represent the Sun rays. Using a rectangle that represents the Solar Panels, the students can place it at the proper angle for the thread to be perpendicular. Now they are able to measure the angle of elevation for the Solar Panels, using a protractor.



To verify the accuracy of their calculations, they can use online simulations, such as:

https://astro.unl.edu/classaction/animations/coordsmotion/eclipticsimulator.html



Conclusion

Through this simulation, students have investigated the optimum slope for the Solar Panels. In the prosses, they learned about the dual nature of light and its electromagnetic abilities. They had the chance to create a model for investigating the Relative Earth-Sun motion and study the seasons formation. At the end they were able to use their model and conclude as to the optimum Solar Panel Gradient.

"IT IS TOO HOT"

In this activity, students have the chance to explore and understand the Greenhouse Effect. To start, they will conduct experiments aimed at answering specific questions. These experiments are designed to provide the necessary background knowledge required to effectively use a Greenhouse Effect Simulation Model later on in the activity.

In simpler terms, students will first try out hands-on activities to learn some important things. Once they have that basic knowledge, they can then construct a hands-on model to explore the Greenhouse Effect in more detail.

Expected outcome:

A laboratorial experiment that proofs that sun rays in an enclosed environment, increase the area's

The scientist who first “proved” the greenhouse effect.

In 1856, decades before the term "Greenhouse Effect" was created, Eunice Newton Foote demonstrated the greenhouse effect in her home laboratory. She placed a glass cylinder filled with carbon dioxide in sunlight and found that it was heated much more than a cylinder of ordinary air. Her conclusion: more carbon dioxide in the atmosphere could result in a warmer planet.

The ability to heat carbon dioxide is fundamental to climate science and explains why our planet's temperature is rising as we burn fossil fuels like oil and gas at a rapid rate, sending more carbon dioxide into the atmosphere. Foote herself even hypothesized that global warming was possible: "An atmosphere of this gas [carbon dioxide] would give our earth a high temperature," she wrote, "and if, as some suppose, at a time in its history air had mixed with it in greater proportion than it does today, an elevated temperature . . . It would necessarily happen."

https://www.bbvaopenmind.com/en/science/environment/eunice-newton-foote-pioneer-greenhouse-effect

Questions to be investigated:

1. What is light?
2. How is it transmitted in vacuum space?
3. What is the Greenhouse effect?

Guidelines for Teachers:

1. What is light.

   This is a question that has been puzzling scientists for many years. Light behaves like a wave but at the same time it carries energy.

   Therefore, light has a dual nature:

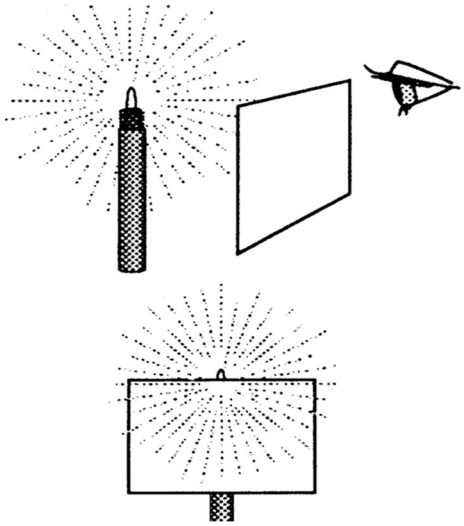
   d. Sometimes it behaves like a particle (called a photon), which explains how light travels in straight lines.
   e. Sometimes it behaves like a wave, which explains how light bends (or diffracts) around an object.
   f. Scientists accept the evidence that supports this dual nature of light.

   This dual nature of light is to be investigated, up to a point, from the students. Students of the age 10-14 years old do not have the knowledge to conclude as to the nature of light but they can make simple observations of the light being a wave and carrying energy. A simple experiment that they can contact, based on observation is the following:

   Students can expose themselves to Sun rays for a short period of time and then share their observations.

   - The first expected observation is that the sun made them feel hot. Students can discuss their observation and the fact that heat can only occur when energy is transferred from one body another. So, in their case this can only happen with the energy transferred from the Sun Rays to their bodies. Therefore, the Sun rays carry some form of energy that heats their bodies and generally anything that is exposed to the Sun rays.

- The fact that light diffracts can be shown using a piece of paper and a source of light, i.e. a lamp. When you place the paper in a place where it covers half of the lamp, you will notice that the light rays somehow "bend" and create the same "light circle" as before, overlapping the paper. This is an observation of light diffraction.



2. *How it is transmitted through vacuum space.*

   Only electromagnetic waves have the ability to travel through space since they don't require solid matter to travel through. Therefore, light behaves as an electromagnetic wave since it travels through space, reaching Earth.

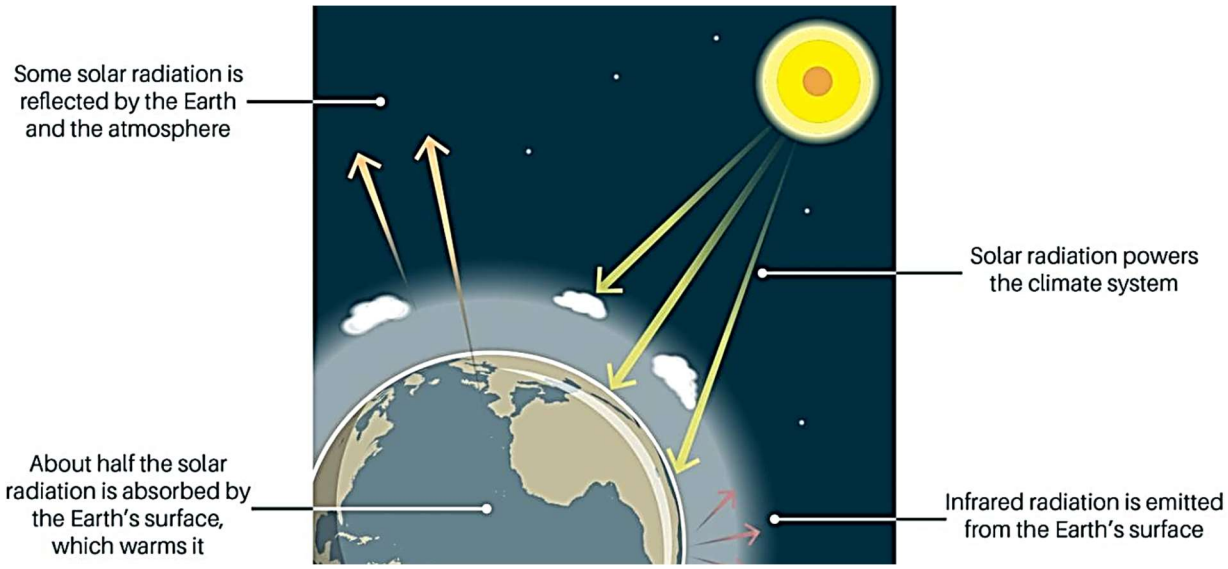
3. *What is the Greenhouse effect.*

   The greenhouse effect is a process that occurs when gases in Earth's atmosphere trap the Sun's heat, not allowing it to escape out of the atmosphere. These gases have increased in the recent years and therefore this process is more intense, making Earth much warmer than it would be without this effect.

   During the day, the Sun shines through the atmosphere. Earth's surface warms up in the sunlight. At night, Earth's surface cools, releasing heat back into the air. But some of the heat is trapped by the greenhouse gases in the atmosphere. That's what keeps our Earth a warm and cozy 58 degrees Fahrenheit (14 degrees Celsius), on average.

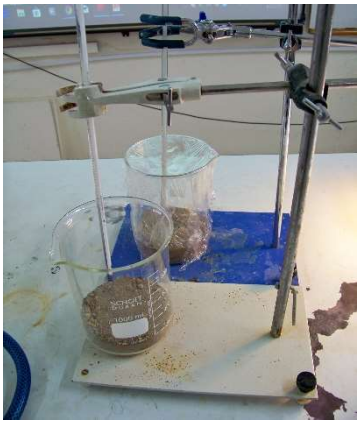
   The recent years, mainly due to air pollution with certain gases, the amount of trapped heat increases, leading to global temperature increase.

One can imagine these gases as a cozy blanket enveloping our planet, helping to maintain a warmer temperature than it would have otherwise.



Main Investigation:

Students may use two beakers to create a model of the atmosphere and the earth. They can use soil, small plants, rocks and anything else they want to resemble the earth's environment. The two beakers need to be identical. One beaker is covered with cling film membrane and the other one is left open. A thermometer is hanging in the pot, and it measures the temperature in the center of each beaker. Both beakers simultaneously are exposed to the same light heating source and the temperature is measured every one minute.



Students can compare both results, create charts, calculate the mean temperature, and conclude as to the outcome of the experiment. It is expected that students will notice a significant temperature increase in the beaker with the cling film.

After the temperature is stable, they can try to make some holes in the cling film. They will notice that the more holes the cling film has, the bigger is the drop in the beaker's temperature. This leads to the conclusion that less greenhouse gases, lead to bigger drop in the atmospheric temperature.

Conclusion

Through this simulation, students have investigated the Greenhouse Effect and constructed a model that simulates it. In the prosses, they learned about the dual nature of light and its electromagnetic abilities. At the end they were able to construct the model and study its variables.

"CAPTURING THE SUNLIGHT"

In this project, students will learn about what makes a solar panel work well. They're going to look at different things that can affect how efficient a solar panel is. Efficiency here means how good the solar panel is at turning sunlight into energy.

To figure this out, they'll test different materials and see how well they make the solar panel work. After doing these tests, they'll come to conclusions about what things make a solar panel more or less effective.

Expected outcome:
Color, material, and insulation are the main factors that affect the efficiency of a Solar Panel

Questions to be investigated:

1. What is light?
2. How is it transmitted in vacuum space?
3. Does color affect the ability of a material to absorb light?
4. Different materials of the same color have different abilities to adsorb light?
5. What kind of insulations allow light to heat up a material and insulate it at the same time? (Connection can be made with the Greenhouse effect)

Guidelines for Teachers:

1. What is light.

   This is a question that has been puzzling scientists for many years. Light behaves like a wave but at the same time it carries energy.

   Therefore, light has a dual nature:

   - Sometimes it behaves like a particle (called a photon), which explains how light travels in straight lines.
   - Sometimes it behaves like a wave, which explains how light bends (or diffracts) around an object.
   - Scientists accept the evidence that supports this dual nature of light

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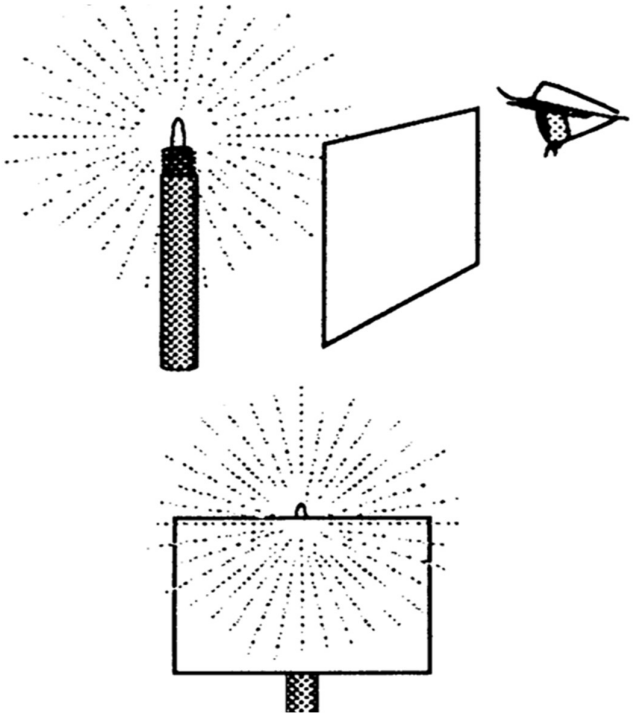
   - The first expected observation is that the sun made them feel hot. Students can discuss their observation and the fact that heat can only occur when energy is transferred from one body another. So, in their case this can only happen with the energy transferred from the Sun Rays to their bodies. Therefore, the Sun rays carry some form of energy that heats their bodies and generally anything that is exposed to the Sun rays.

- The fact that light diffracts can be shown using a piece of paper and the Sun. When you place the paper in a place where it covers half of the Sun, you will notice that the Sun rays somehow "bend" and create the same "light circle" as before, overlapping the paper. This is an observation of light diffraction. For a simpler experiment, the students can use a candle instead of the Sun.



2. *How it is transmitted through vacuum space.*
   Only electromagnetic waves have the ability to travel through space since they don't require solid matter to travel through. Therefore, light behaves as an electromagnetic wave since it travels through space, reaching Earth.

3. *Does color affect the ability of a material to absorb light.*
   Black color is considered to include all other colors., Therefore when it is exposed to the sun rays, it absorbs all the light and reflects little to none, thus absorbing more heat than other colors. The darker the color of an object, the more heat it absorbs, while the lighter the color, the less heat it absorbs.

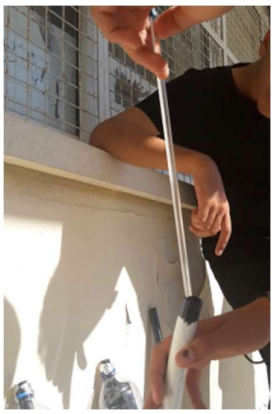
4. *Different materials of the same color have different ability to adsorb light.*
   The range of results will vary. Generally, metallic materials absorb energy better than plastic but they also loose energy to the environment easily.

5. *What kind of insulations allow light to heat up a material and insulate it at the same time.*
   The expected outcome is for students to conclude that plastic is the best material since it allows light to penetrate and is more insulating than glass for example.

Main Investigation:

Color:

Students can experiment by keeping constant a specific material and changing its color. For example, they can use several plastic pipes of identical dimensions, filled with water and painted in different colors. After ten minutes of sun exposure, they will measure the water's temperature and conclude that the black colored pipe absorbs more light energy than the other colors.

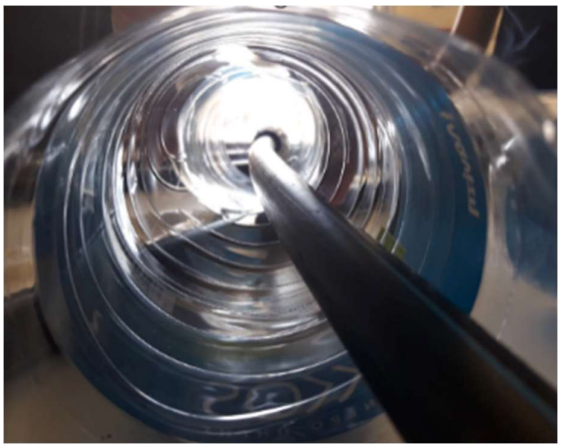


Material:

Students can experiment by keeping constant a specific color of an object and change its material. For example, they can use several black pipes (metallic, plastic, bronze etc.) of identical dimensions, that are filled with water. After ten minutes of sun exposure, they will measure the water's temperature and conclude as to the best light absorbing material.

Insulation:

The expected outcome is for students to conclude that clear plastic is the best material since it allows light to penetrate and is more insulating than glass for example. To conclude to this, students heat up water (not boiling water) and put it in a plastic bottle and a glass bottle of the same dimensions. Measurements of the water temperature can be taken every one minute and at the end the students will notice that glass bottle's temperature will drop faster than the plastic one, even though the plastic bottle is much thinner than the glass one.



Conclusion

Through this activity students studied the factors that affect the efficiency of a Solar Panel. They concluded that dark colors and metallic materials are heated up easier than other and plastic is good choice for insulation from Sun Rays.

"IT SMELLS LIKE A GREENHOUSE"

It smells like a Greenhouse.

In the early 2000's Italian archaeologists found the oldest perfume bottle yet on the Mediterranean island of Cyprus. The bottle contained remnants of many botanical extracts including Pine, Coriander, Almond, Bergamot, Anise, and Parsley. Terracotta distilling equipment was also found scattered throughout the same site.

In this activity students will construct perfumes from plants they have grown or gathered themselves. For the purpose of this lesson plan we will examine how the students will create rosewater from wild roses. The same lesson plan may be adjusted for any plant, not only roses.

Expected outcome:

Rosewater using distillation will be produced.

Questions to be investigated:

5. All about Cyprus's wild Roses.
6. What is distillation.
7. Distillation in ancient Slovakia and Cyprus.
8. Molecules, bonds and vapors

Guidelines for Teachers:

1. **All about Cyprus's wild Roses.**

In Cyprus, one can come across a rose variety that Cypriots call "fragrant" and sometimes "wild Rose" is nothing more than the Damask Rose or "Rosa Damascena" as is the name of the plant. About a century ago, the teacher of the area Agros, Nearchos Clerides, saw in the bushes of the rose that grew in the region a new opportunity and on his initiative, he created a nursery and has given students the necessary knowledge for the cultivation of the plant.

Greek Mythology and Cypriot Roses

It is said that these roses come from a rose blossomed on the coasts of Syria from the blood of the beautiful Adonis killed by a wild boar in which the God Mars was transformed to eliminate him as mad with jealousy because Aphrodite madly loved by God, was madly in love with Adonis. The rose was then brought to Cyprus by Aphrodite in memory of her lost love.

2. **What is distillation.**

Distillation is a widely used method for separating mixtures based on differences in the conditions required to change the phase of components of the mixture. To separate a mixture of liquids, the liquid can be heated to force components, which have different boiling points, into the gas phase. The gas is then condensed back into liquid form and collected. Repeating the process on the collected liquid to improve the purity of the product is called double distillation. Although the term is most commonly applied to liquids, the reverse process can be used to separate gases by liquefying components using changes in temperature and/or pressure.

A plant that performs distillation is called a distillery. The apparatus used to perform distillation is called a still.

3. **Distillation in ancient Slovakia and Cyprus.**

Archeologists in Turkey, Cyprus, Sardinia and Slovakia (Belgiorno 2018, pp. 79-101) discovered similar kind of pots used for distillation at Bronze Age, called apparatus. The pot is figure 1, is a replica of what is believed to be used in ancient times in these areas in order to distill plants.

Fig.1 Yiannoula Lazarou tending a traditional terracotta still in Cyprus at the Perfumery Theme Park in Korakou, 2019. (AP Photo/Petros Karadjias)

With Fire we heat the still containing our Plants & Water from the Earth. The heat breaks the bonds of the Plants' cells & these particles bestow themselves to the steam which travels through the swan neck and into the condenser, transmuting back into a liquid, the distill.

4. **Molecules Bonds and Vapor.**

During the distillation process, students will notice vapors that are created. How is water vapor created? Students can watch the following simulation that simulates the creation of water vapor.
https://contrib.pbslearningmedia.org/WGBH/arct15/SimBucket/Simulations/meltingandboilingsimulation/content/index.html

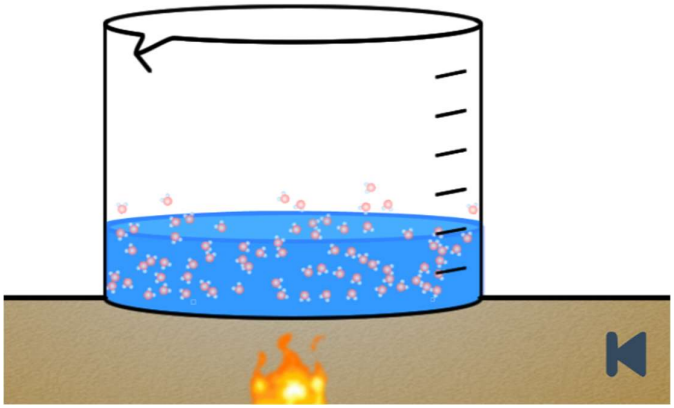


Fig.2 Water vaporized at 100°C

The simplest explanation for this phenomenon is that the water molecules gain enough energy that they can “escape” the water forces and vaporize.
Depending on the age group and the classroom knowledge, the teacher can explain that when the heat is raised (as water is boiled), the higher kinetic energy of the water molecules causes the hydrogen bonds to break completely and allows water molecules to escape into the air as gas.

Main Investigation:

Students can gather wild roses of Cyprus to distill the petals into rosewater (If wild roses are not found in the area, they can order some from a flower shop).
Students will now separate the petals from the rest of the flower and then they will place a small number of petals, with some water in the pot, in ratio 1:3 approximately. The water with the petals must be less than half the volume of the pot so that it will not overflow when heated. (Fig.3)

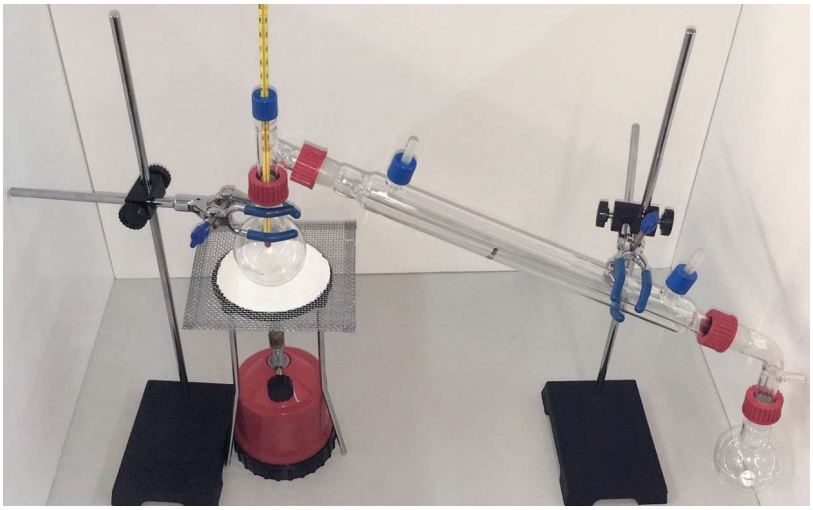


Fig.3

As soon as the fire is on, students will notice some vapor in the pot. It is the essential oil of flowers that is being vaporized first. During the distillation process, students must know that the essential oils vaporize at a heating temperature of 65-70 ^{o}C. If the temperature is higher then the distillation of oils stops and only water is then vaporized.
The essential oil vapors will be guided in the tube, to cool down and end up in the container as rose-oil.

Conclusion

Distillation of the roses is a simple procedure that releases oils from the petals, through vaporization and when it cools them down, the oil is taken from the petals. The same process can be followed for any other plant distillation.