Greenhouse Technology

Brief Description:

Students will use a greenhouse to germinate seeds and grow plants to better understand the science and dynamics of a greenhouse. For schools without greenhouses students will research, design and create a cost analysis of building a greenhouse at school.

Objective:

Students will be able to:

1. Prepare seeds to germinate and grow in a greenhouse.
2. Document the atmospheric and greenhouse temperatures and observe the growth of their plants in order to understand the science of how a greenhouse operates.

Time:

Activity 1: The preparation of the potting mix and seeds will take approximately one class. The monitoring, recording, and observation of plant growth and greenhouse temperatures will be done the first 15 to 20 minutes of each class for up to a month, depending on the type of seeds planted. The final greenhouse evaluation will also take one class.
Extension Activity: One to two weeks depending on how much in-class work is done.

Materials:

- A greenhouse (if possible)
- Thermometer that measures both the **high and low** atmospheric/outside temperatures, as well as the **high and low** of the greenhouse temperatures
- Potting mix or sand, compost, peat moss, perlite
- 500mL (cm^3) beakers
- Calculator
- Metric ruler centimeters (cm)
- Plastic tub for mixing potting mix
- Mixing shovel
- Potting tray
- Newspaper
- Masking tape
- Markers
- Microgreen seeds or seeds of your choice
- Clip boards for recording information

Vocabulary:

UV spectrum, solar wavelengths, shorter wavelengths, longer wavelengths, infrared, thermal energy, convection, conduction, radiation, converted, quantitative, qualitative, range, mean, ratio and inundated

Background:

How Does a Greenhouse Work?

Greenhouses are designed to germinate seeds and grow plants when the conditions for germination and the growth of plants is not possible in the natural environment. Fruits and vegetables, such as blueberries and tomatoes, are not naturally available at all times of the year, in all climates, and in all geographical locations. Greenhouses create a controlled environment in which seeds can germinate and grow even when the outside environment is inhospitable to plant growth.

In order to grow, plants need sunlight, water and nutrients. Greenhouses are built to provide all of those needs at all times. At its most basic, greenhouses collect the sunlight and convert it to heat. The heat is stored by preventing it from escaping back into the outside, colder air. Thus, the temperature and humidity are stable by keeping the cold air outside, preventing too much rainwater from inundating plants, and protecting plants from pests and diseases.

Short and Long Wavelengths

Glass (as well as other transparent materials such as plastic) allows most of solar (sun) shorter wavelengths to pass through, with the exception of the long (thermal infrared) wavelengths. So, solar radiation can come into the greenhouse, where the plants convert it into thermal, long wavelengths (heat). Since the glass is not transparent to the thermal wavelengths, they get trapped in the greenhouse, heating the air, plants, soil and the greenhouse structure itself.

When heated by the sun, soil warms up, whether it is in the greenhouse or outside of it. The air around the soil warms up as well and, as it is less dense than the cool air, starts expanding and raising. Outside of the greenhouse, the warm air goes into

Florida Standards:

SC.6.N.1.5, SC.6.N.1.3, SC.7.N.1.5, SC.7.L.17.2, SC.7.L.17.3, SC.8.N.1.5, LAFS.6.SL.1.2, LAFS.6.SL.1.3, LAFS.6.SL.2.4, LAFS.68.RST.1.1, LAFS.68.RST.1.2, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, MAFS.7.SP.2.4, VA.68.C.2.1, VA.68.C.2.2, VA.68.C.2.3, SS.7.C.2.12, SS.7.C.2.13, and SS.7.C.2.14

the atmosphere, where it eventually cools off. In the greenhouse, hot air is trapped, so the temperature in the greenhouse keeps rising throughout the day. The heat causes water to evaporate, creating high humidity making the greenhouse atmosphere better for plants' growth.

Heating and Cooling

Of course, we cannot stop the sun from shining and heating the greenhouse, so the temperature can become too high for plants. It is up to us to design a system to control the amount of heat that remains in the greenhouse. Well-designed greenhouses have vents that automatically open when the air temperature reaches a certain point, and close when the temperature drops below the one desired. Fans help to keep the temperature within the entire greenhouse even by circulating the air – moving the hot air higher up and mixing it with the cooler air at the lower parts of the greenhouse. Automatic misting systems can also help with keeping the temperature and humidity stable. During the night, the temperature can drop too low and the greenhouse sometimes has to be heated in order to keep the temperature optimal for plants' growth.

Thermal Mass

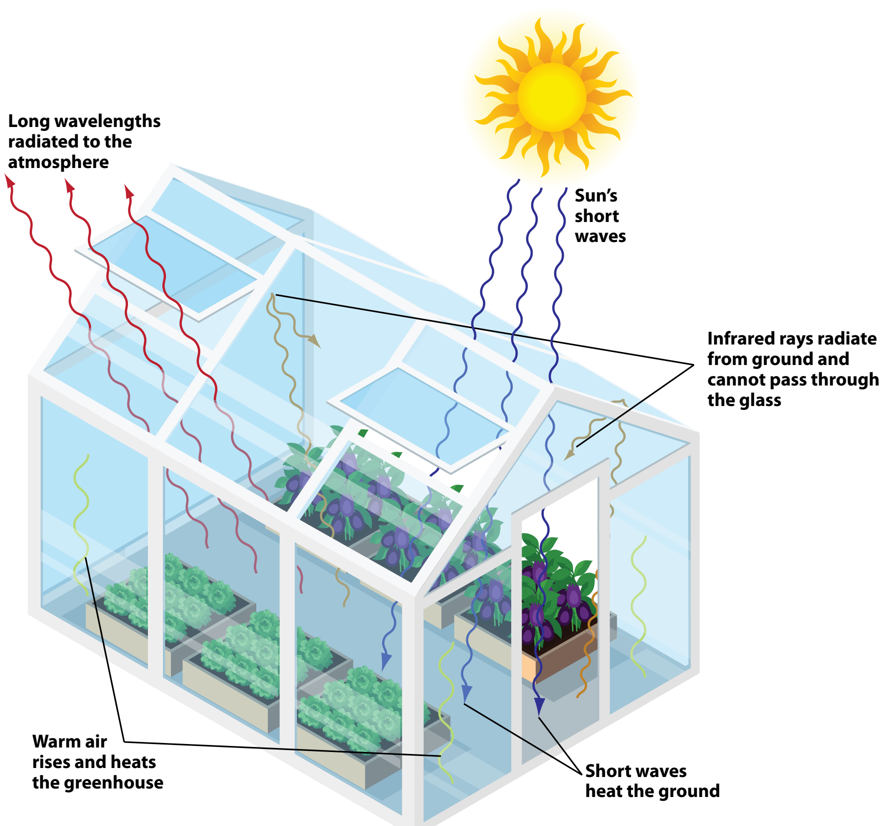
Of course, the air is not the only thing that gets heated by the sun. Everything else in the greenhouse gets heated to a different extent. Wood, water, soil and bricks get heated slowly and release heat slowly. Iron and aluminum warm up fast, and release heat fast. This is particularly important at night when the stored heat or 'thermal mass' slowly releases the heat, keeping the temperature in the greenhouse warm even when the sun is not there to heat it up. That is why it is so important to design the greenhouses carefully, using materials that have the ability to store and release a large quantity of heat slowly. Wooden frame, brick greenhouse floor, open plant trays full of soil, all store and release heat slowly, and are more useful to keeping the greenhouse temperature optimal at night than iron or aluminum, which heat fast, but lose the heat fast as well.

Water

Plants in the greenhouse get a fair amount of needed water through water vapor, but it is not enough for a fast growing process. An automatic watering system provides water to plants when it is needed, and the greenhouse structure prevents too much water, such as excess rain, from inundating plants. A well-designed greenhouse will have a system or gutters and drainage for managing the excess water inside and out.

Protection

A greenhouse also acts as a 'house' for plants – it keeps them protected from insects, pests, domestic pets, hail, strong wind, falling debris, flying baseballs and anything else that can damage your precious buds and seedlings. Keep in mind that pollinators, like bees, are also kept outside, so choose self-pollinating plants or introduce a few bees inside.



Introduction:

1. Begin by having students answer a starter/challenge question that relates to outside temperatures and plant growth, such as:
"The record low temperature ever recorded in Florida was -2°F which occurred on February 13, 1899, in Tallahassee. The record high for Florida in February was 90°F which occurred in Orlando in 1962. What is the range in temperatures for the record high and low in Florida?"
Answer: 90°F-(-2°F)= 92°F
2. Discuss the extreme weather fluctuations that occur in parts of Florida (especially in the north) from late December until early March and how these fluctuations make it very difficult and risky to plant many types of fruits and vegetables, such as tomatoes, lettuces, sweet basil and oranges. Prompt with questions such as "How can people grow fruits or vegetables if the climate is not supportive?"
3. Distribute the background materials on "How Does a Greenhouse Work" and read aloud with the class. Discuss the advantages and disadvantages of growing in a greenhouse. Discuss the type of greenhouse that you will be using at your school.

Procedure:

1. Students will engineer their own potting mix, referring to the *Seed and Potting Mix Preparation* sheet on creating a potting mix for microgreens. The preparation of the potting mix takes one class. Generally, four students per tray of mix and seeds works best.
2. Once the tray of seeds is placed in the greenhouse, distribute the *Greenhouse Observation Lab* and review the key components of the chart on an overhead projector. Remind students that they can work with the people at their table, but each person is responsible for recording temperatures and plant growth. Ten to fifteen minutes should be spent during each class recording and observing the plants in the greenhouse.
3. When the plants have reached full growth, complete the *Greenhouse Evaluation* sheet. Encourage students to write complete sentences when creating the captions for the science of a greenhouse.

Extensions:

1. Students can design experiments to see if changing the ratio of perlite or fertilizer impacts plant growth.
2. If your school does not have a greenhouse have students (in groups) design an ideal greenhouse for the space available at your school. Make sure to include building materials, irrigation, heating, cooling and possible tables or shelves.
3. After the greenhouse is designed, students will research the cost to create their "ideal" greenhouse.
4. You can set a budget and space availability for students before groups begin their designs or let students decide.

Seed and Potting Mix Preparation

Name: ____________________ Date: ____________ Per. ________

Background Information: Seeds remain dormant or inactive until conditions are right for **germination**, the sprouting of a seed into a plant. All seeds need are water, oxygen and proper temperature for germination to occur. Some seeds need specific amounts of sunlight, too. In this lab you will prepare the medium (materials in which a seed is placed), and monitor the temperature and the amount of time it takes your seeds to sprout. When growing **microgreens** in a container, you need to ensure that the container has a depth of at least five centimeters (two inches). It needs to be filled with excellent quality potting mix, as well as compost for root growth. The soil needs to be smoothened. Scatter the seeds at least one centimeter (¼ inch) apart and cover them with at least .5 cm (1/8 inch) of soil. Place the container in a place where it gets at least three to four hours of sunlight each day. It is best to place it in a south-facing window.

Materials: 500mL (cm^3) beakers, calculator, metric ruler centimeters (cm), plastic tub, mixing shovel, potting tray, newspaper, sand, store-bought compost, peat moss, perlite and microgreen seeds

Directions: Follow each step in order to place the correct amounts of potting mix in your potting tray.

1. Find the **volume** of your potting tray. Do not measure higher than **five centimeters for the height** of your tray. Show the formula for the volume of your tray, show your work, and be sure your answer is written in **cm^3**.

Answer ____________________

2. Your tray will need equal amounts of sand, compost and peat moss. How will you divide the volume of your potting tray into three equal parts? Explain how you complete this step mathematically and list the appropriate amount of sand, compost and peat moss in **cm^3 or mL**.

Sand____________ Compost____________ Peat Moss ____________

3. Once your work is **approved** by your teacher, you may prepare your potting mix in a plastic tub using a shovel or spoon.

4. All groups need to add perlite to the potting mix to help aerate the potting mix and trap in needed moisture. The ratio of perlite to potting mix is 1:25 or 1/25. In other words, for every one part of perlite, 25 parts of potting mix is needed. With that ratio in mind, show how much perlite will be needed if you have 6,500mL or cm^3 of potting mix.

5. Some of the groups will receive fertilizer for their potting mix. The ratio of fertilizer to potting mix is 1:50 or 1/50. In other words, for every one part of fertilizer, 50 parts of potting mix is needed. With that ratio in mind, show your work to solve how much fertilizer in mL or cm^3 will be needed if you have 6,500mL or cm^3 of potting mix.

6. Describe how your group decided to spread the seeds most evenly throughout the tray in order to achieve at least one seed per cm^2? What method worked the best?

Greenhouse Observation Lab

Name: ______________________________ Date: ________________ Per. __________

Directions: Over the next few weeks, you will observe your tray of microgreens that are growing in the greenhouse. Additionally, you will observe other trays, the high/low temperature of the greenhouse, and the high/low of the outside temperature.

Materials: Pencil, clipboard, calculator, thermometer and metric ruler

1. Use the table below and the temperature monitor in the greenhouse (GH) to record quantitative data about the greenhouse temperatures, the outside temperatures and the height of your tray of microgreens.

Date	GH-High Temp. ˚F	GH-Low Temp. ˚F	**Range** in GH Temp. ˚F	Outside High Temp. ˚F	Outside Low Temp. ˚F	**Range** in Outside Temp. ˚F	Microgreen Height in cm
Mean (average)							

2. **Qualitative data:** On the lines below and on the back side of this paper, record qualitative data about your tray of microgreens and other trays of microgreens, both in your class and in the other classes.

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Date ____________________

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Greenhouse Evaluation

Name: ____ Date: ____________________ Per. ____________

Directions: Using your data and observations from the *Greenhouse Observation Lab*, complete the following questions.

1. Which had a higher mean (average) temperature **range**, the greenhouse or the outside temperature?

2. How might you explain why the greenhouse or the outside temperature had a greater range?

3. What was the difference between the mean greenhouse **high** temperature and the mean outside **high** temperature? Show your work.

4. What was the difference between the mean greenhouse **low** temperature and the mean outside **low** temperature? Show your work.

5. Use your data to support the advantages of using a greenhouse in the winter months in North Florida. Cite your data as evidence while explaining the reasons for using a greenhouse in the winter.

6. Using handouts and online sources, create a simple sketch with **captions** that explains how a greenhouse is heated and how it traps heat. Your sketch should illustrate the flow of the sun's energy into the greenhouse and the movement of energy in the greenhouse. Your captions, (at least two) should explain how the sun's energy enters the greenhouse and how the sun's energy is trapped and converted into heat in the greenhouse.

Greenhouse

Sample Pre-Post Test Assessment

Directions: Answer each questions as thoroughly as possible.

1. What type of solar (sun) wavelengths are able to pass through the glass or plastic of a greenhouse?

2. What type of solar (sun) wavelengths become trapped in the glass or plastic of a greenhouse?

3. Name two advantages of using a greenhouse.

4. What is a possible disadvantage of a greenhouse?

5. What objects in a greenhouse will conduct the heat from the sun?