One Giant Leaf for Mankind — Teacher Notes

SCIENCE THROUGH ENGINEERING DESIGN WITH TI-INNOVATOR™ SYSTEM

Science, Technology, Engineering and Math Objectives

- Students will research **science** topics including:
    - o Energy and material flow in photosynthesis
    - o Cellular organelles in plants
    - o The effects light brightness and plant surface area have on plant energy production.
- Students will **engineer** and build a model space-based greenhouse.
- Students will use appropriate **technology** to evaluate their design, collaborate with colleagues and present their findings.
- Students will use **mathematical** processes of:
    - o Area of a rectangle
    - o Slope of a line
    - o Interpreting graphs
    - o Proportional reasoning

Tech Tips:

- This activity includes screen captures taken from the TI-Nspire™ CX. It could also be used with the TI-Nspire CX Software.
- This activity will use the TI-Innovator™ Hub with TI LaunchPad™ Board. .
- Watch for additional Tech Tips throughout the activity.

Suggested Grade Level: 6-8

Lesson Files:
Student Activity

- One_Giant_Leaf_For_Mankind _Student.doc
- One_Giant_Leaf_For_Mankind _Student.pdf
- One_Giant_Leaf_For_Mankind_Teacher.tns

Vocabulary

- chloroplast and mitochondria
- photosynthesis
- carbon dioxide
- oxygen
- water
- sugar
- energy
- light intensity (lux)

About the Lesson

- This is a project-based science activity that will engage your students in the engineering design process while using TI-Nspire technology.

Activity Materials

- Aluminum Foil
- 2 L soda bottles or water bottles
- Coffee cups or clear cups
- Plastic wrap (i.e. Saran wrap)
- Tape
- Scissors
- Meter Stick
- Small flashlight, or other light source

Technology Requirements

- TI-Nspire CX handheld
- TI-Innovator Hub with USB Cable
- Light Sensor from the TI-Innovator I/O Modules Pack

Teacher Tip: The above materials are listed as suggestions. The goal is to have a variety of materials available for the students to create the model greenhouse. Students should work in groups of two. Building time should be limited to one class period.

Prerequisite Content Knowledge and Skills

- Students will review the reaction for photosynthesis and plant cell structure and function.
- This activity incorporates many of the process skills and crosscutting principles of the Next Generation Science Standards (NGSS).
- Students will need some understanding of the unique conditions in space that will impact the effectiveness of their greenhouse design.
- Suggested additional Photosynthesis Activities from Science Nspired:
  - *Recipe for a Living World:* https://education.ti.com/en/tisciencenspired/us/detail?id=58521D6DDBE349EBA7D83EA82FDBC98E&t=0657D6BEA4D14F0C9288AFC29D1BCD2B
  - *When Water Leaves*: https://education.ti.com/en/tisciencenspired/us/detail?id=37B810C1821A4B128D8DA08AB53454AE&t=0657D6BEA4D14F0C9288AFC29D1BCD2B

Teacher Tip: The use of this activity is designed to be flexible. It can be used as part of a project-based classroom or a problem-based learning environment.

Teacher Tip: Additional activities or student research might be necessary to supplement this activity to ensure students have a base-line knowledge of the process of photosynthesis.

The Situation

Students are asked to play the role of a horticultural engineer on the International Space Station (ISS) who has been researching food production for extended space exploration missions.

They have been tasked with designing and building a space-based greenhouse model, conducting a simple experiment using the scientific method, and learning about photosynthesis and plant cell structure. They will use the model to investigate how the plant surface area and light brightness affect how fast energy (stored in yams) is produced. The goal is to grow at least 800 calories of yams in three months (from a single plant).

Background Science:

In outer space, there is no atmosphere to scatter the Sun's light rays. This means the light comes in straight from the distant Sun. Ask students to imagine an extremely bright flashlight far away on a dark night; that is what the Sun might look like out in the darkness of space on the way to Mars. Since the Sun's light rays would not surround a greenhouse, as they do on Earth, their design should account for this difference, and attempt to concentrate the Sun's direct and dim rays. You can also have students review the following website prior to the start of the activity to help set the stage for the exploration: http://science.ksc.nasa.gov/biomed/marsdome/index.html

Teacher Tip: It is important that students understand the unique conditions in space prior to starting their designs. Students can also research greenhouses in general to help inform their design. The following discussion questions could be used to generate a brainstorm and discussion around design parameters:

- What greenhouse specifications might be needed for outer space?
- Are some shapes better than others for collecting and focusing light?
- How can your design help keep the plants warm?
- Where should you mount a light sensor?

Related STEM Career – Horticulture Engineer

Horticultural engineering blends agricultural engineering, plant science, computer science, and control theory to produce effective and efficient plant growing systems, whether in high-tech greenhouses or low-tech row cover systems. Degrees in Horticultural Engineering are available at many colleges and universities.

Teacher Tip: Students might find it valuable to explore this STEM career after completing the activity.

Overview of the Activity

Your students will be tasked with: designing and building a space-based greenhouse model, conducting a simple experiment using the scientific method, and learning about photosynthesis and plant cell structure.

Move to pages 1.2 - 1.5 in TI-Nspire Document.

In Problem 1, students are asked to read the storyline that sets the context of the tasks they are about to complete. Give students time to read this section, and you can follow reading with a discussion with topics such as ISS, food production, and the unique conditions in space.

On the student activity sheet question #2 "Identify", students should write two hypothesis statements that predict the relationships between the *independent* variables (light brightness and place surface area) and the *dependent* variable (yam growth).

Teacher Tip: If students have completed the cellular respiration activity ("*One Small Bite for Man*") already, they should begin at Problem 2. It is recommended that students do both this activity and the "*One Small Bite for Man*" activity, as the storylines are connected. The reactions of photosynthesis and cellular respiration are complimentary processes because they are each other's products and reactants.

Move to pages 2.1 - 2.11 in TI-Nspire Document.

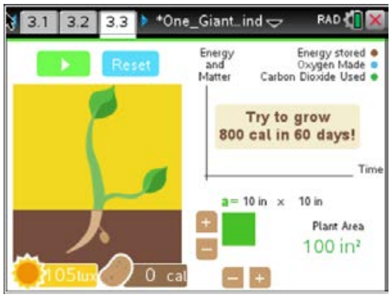
In Problem 2, students are asked to learn or review concepts of photosynthesis including energy and material flow, plant cell structure, and the photosynthesis reaction. In Problem 2.2, a plant cell simulation allows students to explore the structure of a plant cell.

After reviewing this problem and information, students will answer question #3 "Research" on their student activity sheets and the questions in this problem of their TNS file.

Teacher Tip: Students might want to look for additional resources online to learn further about plant cells and the process of photosynthesis.

Teacher Tip: You can choose to have students compare and contrast a plant cell versus an animal cell.

Move to pages 3.1 - 3.13 in TI-Nspire Document



In Problem 3, students will first establish a control, taking an initial Lux reading using the Hub and light sensor.

Students will then design and build a space-based greenhouse model for collecting light onto the light sensor. Then, students will use their model to investigate how the plant surface area and light brightness affect how fast energy (yams) is produced. The goal is to grow at least 800 calories of yams in three months (from a single plant).

Students will observe the graph(s) of the energy (stored in yams) produced from photosynthesis, as they manipulate the different variables. Students will record their data from various trials on their student activity sheets.

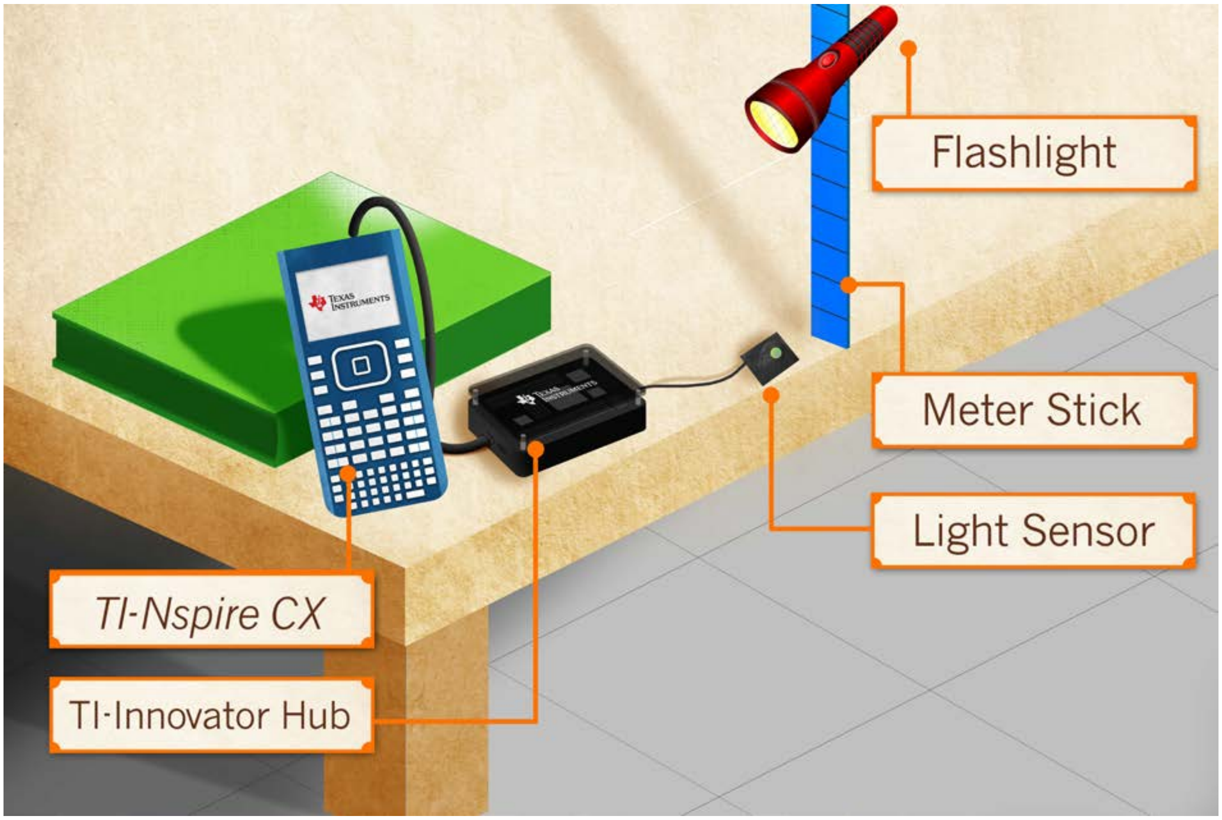
Finally, students will be asked to draw conclusions based on the graphs and answer questions on their student activity sheets.

Teacher Preparation: Setting up for the Experiment

The light sensor that will be used in the experiment has a max reading of ~200 lux. Depending on the lighting in your classroom, you might need to tweak the control set-up shown here.

It is important that the baseline reading (control) students take should not exceed 100 lux. This will allow adequate room for students to experiment with, and increase the light intensity, by moving the light source further away, or closer to the greenhouse model. This recommended set-up uses small flashlights to increase/decrease light intensity.

The control reading is taken at 1 meter away from the light sensor on the desk. Students can hold the flashlight or connect it to a ring stand, if available.



Control Set-Up Diagram

Teacher Tip: It is important to test out the control set-up prior to students starting the activity. You might have to play around with different lighting (turn off the overhead lights, close shades, etc) to make sure your initial control reading is below 100 lux. If the flashlight is too bright, you could put a coffee filter over the light to decrease the intensity.

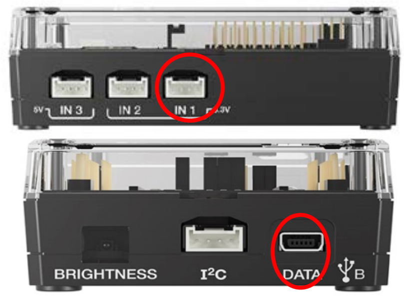
Student Task 1: Establish a Control.

In Problem 3, students are asked to complete three tasks, as they research, design, and build a model of a space-based greenhouse. This problem is the essential part of the activity.

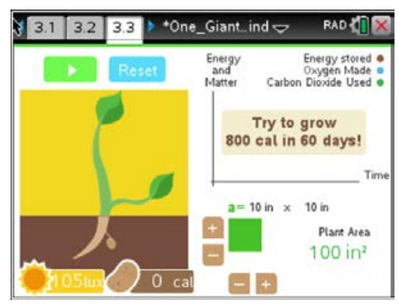
On Pages 3.1 and 3.2, students will establish a control. Students will first use the light sensor and the TI-Innovator Hub to establish a control reading, using the control setup from above. Once they have their control reading, they will build a model greenhouse and use that model to conduct several simple experiments using the scientific method.

Connecting the Hub to the TI-Nspire CX:

Students will plug in Light Sensor into port *IN1* of the TI-Innovator Hub and connect the TI-Innovator Hub to the TI-Nspire CX handheld. Be sure they insert the "B" end of the unit-to-unit cable into the DATA port on the TI-Innovator™ Hub.



Note: They should see a green line at the top of screen to show you are connected.



Students will need to select the 'play' button. The brightness of light will be detected and will display that value in units of Lux. Students should record this on their student activity sheet Question #4.

Design and Build the Greenhouse:

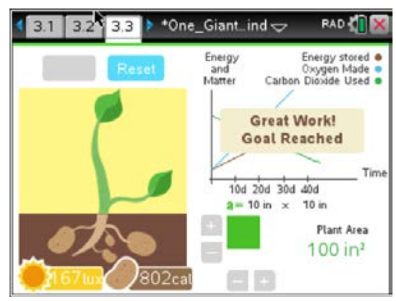
Students should now understand how the sensor will collect light in their experiment. Students should make a detailed sketch of their model on their student activity sheet with appropriate labels and material lists before they begin construction. This is a good checkpoint to ensure students are on task and have thoughtfully considered their designs based on the unique conditions of space.

Sample Greenhouse Design. Note that the sensor is placed in the bottom of the cup, and is not "hidden" from the light source.

Teacher Tip: Students should be made aware of any time restrictions for building their models, as it can impact their designs. It is recommended that building time be limited to one class period.

Task 2: Students test the effectiveness of their greenhouse model designs.

Once students have their model built with the light sensor installed IN the greenhouse, and accessible to the TI-Innovator Hub, Students will take a lux reading (under the same lighting conditions as the control) with the light sensor IN the greenhouse model.



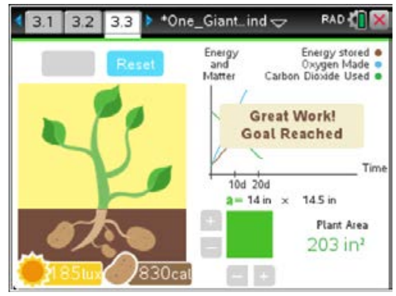
Was the lux reading greater than the control? If not, encourage students to tweak their designs, and try again.

Students should answer this and other parts of question #7 on their student activity sheet. Their Lux reading WITH the greenhouse should be at least as much as the "control" reading. If it is not, have students consider what changes to make to their design.

They should tweak their designs, retest, and record any additional Lux readings on the student activity sheet.

Task 3: Investigate relationships using the model.

The final task will involve students investigating the following two scenarios to help further determine the relationships between the independent variables of surface area and brightness, and the dependent variable of energy (stored in yams) production of the plant.



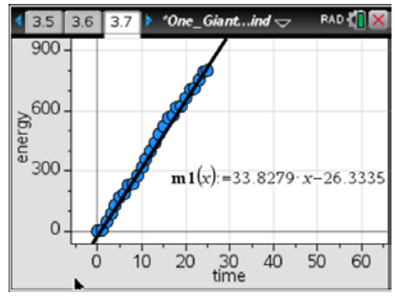
- **Scenario 1:** Students should keep the surface area constant while the brightness is varied by moving the greenhouse progressively further away from the light source. The brightness (intensity) of light falling on the sensor will inform the slope of the energy graph. As they move the light source closer to/further away, go to Page 3.4 to add the moveable line (**menu> Analyze> Moveable Line**). Record the lux setting and energy slopes on the student activity sheet. Students should complete **at least 2-3 different trials of varying distances from the light source, recording the lux and slope values after each change.**
- **Scenario 2:** Students should keep the distance to the light held constant and vary the surface area of the plant. The area of the rectangle is a representation of the surface area of the plant. This area will inform the graph on the same page. After each adjustment to the surface area, students go to Page 3.4 and add the moveable line. They will record the surface area and energy slopes on the student activity sheet. Students should **complete at least 2-3 different trials of varying surface areas (SA), recording the surface area and slope values after each change.**

> **Tech Tip:** Be sure the light sensor is plugged into the IN1 port on the TI Innovator Hub.

Analyzing Growth Rate Data from Space-based Greenhouse

The key takeaways for students should be:

1) Students will find that the brightness (intensity) of light falling on the sensor will inform the slope of the energy graph. Brightness is proportional with growth rate (slope of energy graph).
2) Students will find that when the surface area is great, the rate of growth (slope of energy graph) will increase in proportion. Note the relationship between the geometry of the rectangle and the number of leaves on the yam plant.



As students adjust the variables in Task 3, they will use the graph(s) on Page 3.7 showing a graph of the energy produced from photosynthesis.

On Pages 3.8 – 3.13, there are questions to help students analyze their graph and draw conclusions. Questions and answers are included on the Student Activity Sheet Answer Key.

Teacher Tip: Discussion questions to help guide student conclusions:

- What does the slope of your graph tell you about the plant in your model greenhouse?

Answer: The rate of energy production (growth)

- Why are the slopes of the energy graphs positive?

Answer: Energy is being produced not consumed.

- What are the units of the slope of the graph?

Answer: Calories/hour

- What effect does brightness have on the energy production rate (growth)?

Answer: The brighter the light the greater the energy production rate.

- What effect does plant surface area have on the energy production rate (growth)?

Answer: The greater the surface area, the greater the energy production rate.

Assessment

Students will complete the Student Activity sheet which will contain design sketches, data analysis, answers to the questions included in the TNS file, and finally their conclusions.

You can also have students prepare a brief presentation explaining their design and findings using a dry erase board, poster board, or multimedia. They should include pictures of their design, and findings from their experiment.

- Formative assessment consists of questions posed to students throughout the design process to determine if they understand the concepts presented in the lesson.
- Summative assessment will consist of the overall quality of the design and student explanation of their model and findings.