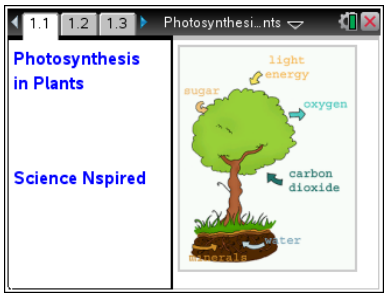
Science Objectives

- Students will develop a deeper understanding of the variables affecting the rate of photosynthesis in plants.
- Students will manipulate variables, such as light intensity and wavelength of light, to observe the effects on photosynthesis rates.



Vocabulary

- illuminance
- photosynthesis
- stomata
- visible spectrum
- wavelength

About the Lesson

- In this lesson students will observe the effects of certain variables on the rate of photosynthesis in a plant.
- As a result, students will:
  - Better understand the importance of the visible portion of the electromagnetic spectrum.
  - Develop an understanding of reflection and absorption of light energy by a pigment.

TI-Nspire™ Navigator™

- Send out the *Photosynthesis_in_Plants.tns* file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to spotlight student answers.
- Collect embedded assessment questions from Part 1.

Activity Materials

- *Photosynthesis_in_Plants.tns* document
- TI-Nspire™ Technology

TI-Nspire™ Technology Skills:

- Open a new TI-Nspire document
- Manipulate the variables in a TI-Nspire simulation
- Answer embedded questions in a TI-Nspire document

Tech Tips:

Make sure students understand how to start, stop, and reset an animation.

Lesson Materials:

Student Activity

- Photosynthesis_in_Plants_Student.doc
- Photosynthesis_in_Plants_Student.pdf

TI-Nspire document

- Photosynthesis_in_Plants.tns

Discussion Points and Possible Answers

Allow students to read the background information on the student activity sheet.

Part 1:

Move to page 1.2.

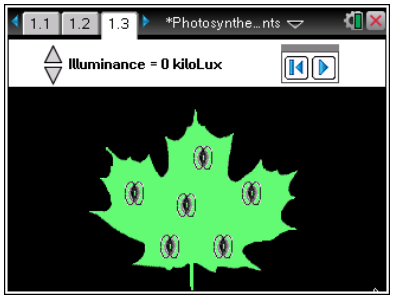
Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

Have students read the brief background information on page 1.2. Because light is typically not included as a substance in the generalized equation for photosynthesis, it is often overlooked. Without light to provide the energy for the reaction, however, the entire process of photosynthesis would grind to a halt. Many components must be in place in order for photosynthesis to occur. If there is no energy input at the outset, no food (glucose) can be made.

In simulation 1, students will observe the effects of light intensity (illuminance, measured in kilo Lux) on the rate of photosynthesis.

In the second simulation, students will change the color (**wavelength**) of visible light and see how it affects photosynthesis rates.

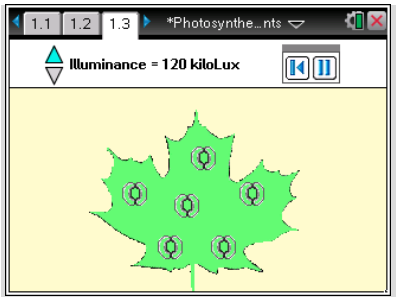
Move to page 1.3.



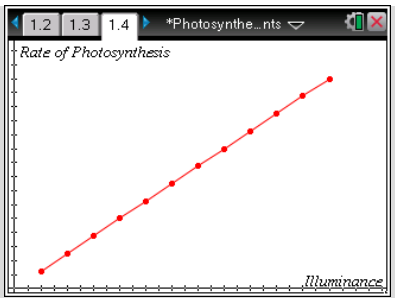
1. On page 1.3, students need to click on the Play button, and then repeatedly click the up arrow ▲ to increase the light intensity from 0 to the maximum to 120 kiloLux. They will see the screen background go from black to bright as the **illuminance** (light intensity) is increased. The number of stomata that are open can be used as a guideline for the rate of photosynthesis as the light intensity is increased.

Teacher Tip: ***Make sure students pay attention to the stomata as they make their adjustments.***

2. To run the simulation again, students may click the Reset button and start over. As they increase the light intensity, they generate a graph on page 1.4.



Move to page 1.4.



Q1. Have students sketch the graph they generated in the space to the right.

Answer: See the graph to the right.

Move to pages 1.5 – 1.7.

Have students answer questions 2-4 on either the handheld, on the activity sheet, or both.

Q2. As the illuminance, or light intensity, increases, the rate of photosynthesis _____.

Answer: A. increases

Q3. As the rate of photosynthesis increases, which of the following substances would you expect to decrease?

Answer: B. carbon dioxide

Q4. During which of the following months would you expect photosynthesis rates to be highest in the Southern Hemisphere?

Answer: A. January

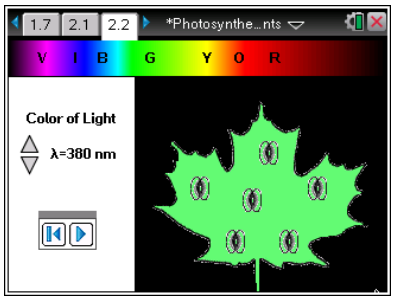
Part 2:

Move to page 2.1.

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

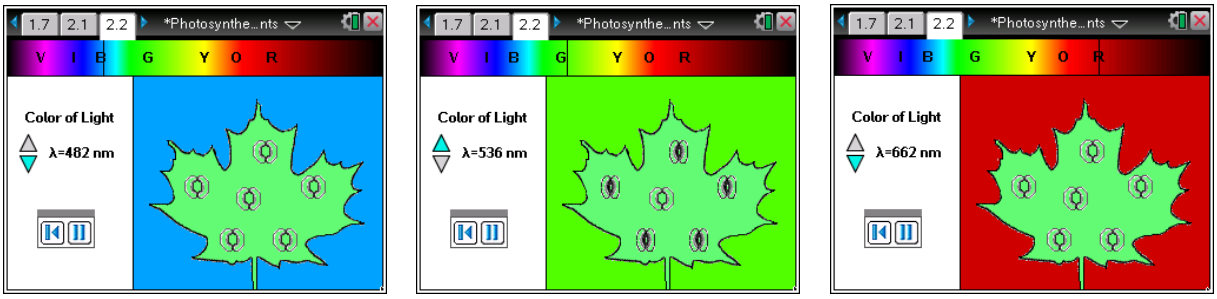
Have students read the brief background information on page 2.1.

Move to pages 2.2 – 2.4.



3. In this interactive simulation, students will observe the impact of the wavelength (color) of light on the rate of photosynthesis. To start the simulation on page 2.2, students need to click the Play button, and then repeatedly click the up arrow to increase the ***wavelength***, (or color), of visible light to which the leaf is exposed. They should continue to increase the wavelength until they reach the upper limit of 780 nm.

   As they increase the wavelength, an indicator moves across the ***visible spectrum*** (ROYGBIV) at the top of the screen. The background of the screen also changes as the wavelength increases, as do the number of stomata that are open and closed. Remind students to pay attention to the opening and closing of the stomata at various wavelengths. This is an indication of the rate of photosynthesis. Sample screens are shown on the next page.



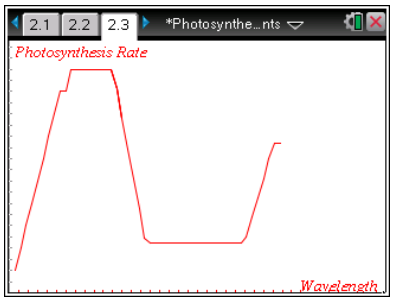
Light certainly plays a huge role in the efficiency and rate of photosynthesis. However, other variables not addressed in this activity, are involved.

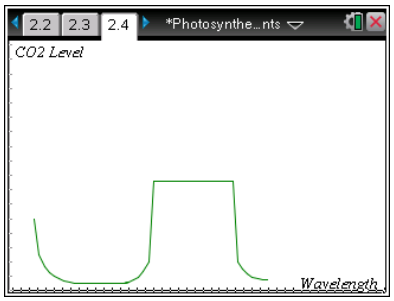
You may wish to discuss the importance of water to the photosynthetic process. And the most critical limiting factor to the rate of photosynthesis is often carbon dioxide, since the atmospheric concentration is only 0.04%. If environmental conditions are really good for photosynthesis, the plant can actually deplete the level of carbon dioxide around the leaf. This can lead to an undesirable result called "photorespiration."

If desired, discuss this problem with your students, and introduce the idea of C4 and CAM plants to them. These plants manage to avoid photorespiration because of an alternative pathway to glucose production.

Q5. Sketch both graphs in the spaces below.

Sample Answers:





Q6. Explain why the graphs look the way they do.

Sample Answers:

Photosynthesis Rate: The plant can absorb and use light energy with wavelengths in the blue and red ranges, but not with wavelengths in the green range. This is why there are peaks of activity in the blue and red ranges and a valley in the green range.

CO_2 Level: The CO_2 level in the air around a leaf will be inversely proportional to the rate of photosynthesis. Therefore the levels of CO_2 will be lower when the rate of photosynthesis is higher, and vice versa.

Move to pages 2.5 – 2.13.

Have students answer questions 7-15 on either the handheld, on the activity sheet, or both.

Q7. Which colors of light are best for photosynthesis?

Answer: A. Blue

Q8. Which wavelengths of light are best for photosynthesis?

Answer: A. 440-480 nm

Q9. Which colors of light are used the least used for photosynthesis?

Answer: C. Green

Q10. Think about this: How does your answer to Question 9 explain the color of most?

Answer: Most colors of light are absorbed, but the green color is reflected.

Note: Remind your students that the light that they see is the light that is reflected into their eyes.

Q11. What does photosynthesis do to environmental CO_2 levels?

Answer: B. Decrease CO_2

Q12. What happens to oxygen (O2) levels?

Answer: A. Increase in O_2

Q13. Based on what you know about CO_2 and photosynthesis, how do plants change the air we breathe?

Answer: By turning CO_2 into oxygen, plants provide us with the air we breathe.

Q14. What would happen if a plant were exposed ONLY to green light? Why?

Answer: Because plants reflect green light, they would have a difficult time collecting enough light to perform photosynthesis.

Q15. Describe a place on Earth where photosynthesis rates are normally very high. Explain why you chose this place.

Answer: Any place that students can describe as very sunny and with a lot of plant life should be accepted (a grassy field, the Amazon, etc.)

TI-Nspire Navigator Opportunities

Ask students to share their screens as they pause at various wavelengths in Simulation 2. Discuss the results with the entire class. Question responses may be collected and assessed using TI-Nspire Navigator.

Use TI-Nspire Navigator to capture screen shots of student progress and to retrieve the file from each student at the end of the class period. The student questions can be electronically graded and added to the student portfolio.

Wrap Up

When students are finished with the activity, retrieve the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.