Recipe for a Living World

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 *Recipe_for_a_Living_World.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Collect embedded assessment questions from Problem 1.

Activity Materials

- Compatible TI Technologies: TI- Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software

Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Recipe_for_a_Living_World_Student.doc
- Recipe_for_a_Living_World_Student.pdf

TI-Nspire document

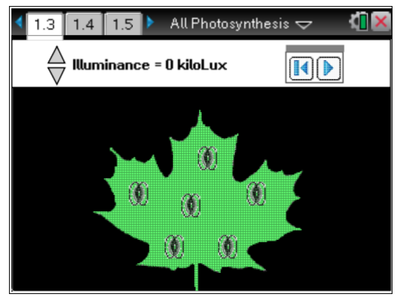
- Recipe_for_a_Living_World.tns

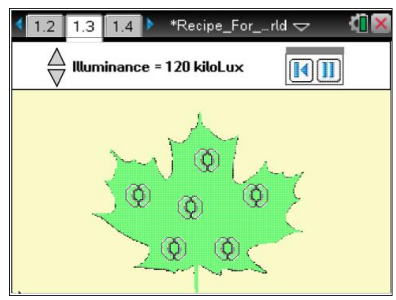
Discussion Points and Possible Answers

Move to page 1.2.

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, however, the entire process of photosynthesis would grind to a halt. Many components must be in place in order for photosynthesis to occur. Yet if there is no energy input at the outset, no food can be made. In the simulation found in Problem 1, students will observe the effects of light intensity (illuminance, measured in kiloLux) on the rate of photosynthesis.

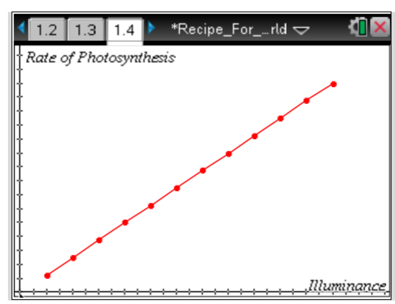
Move to page 1.3.





1. On page 1.3, students need to click on the start arrow and then repeatedly click on 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 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.
2. To run the simulation again, students may click on the reset arrow and start over. As they increase the light intensity, they generate a graph on page 1.4. Following the graph, the three questions below are found in the .tns document.

Move to pages 1.4-1.5.



Q1. Students sketch graph in the space to the right. To reset the simulation and run it again, click on the reset button.

Answer: See the graph to the right.

Move to pages 1.6–1.8.

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

Q2. As the 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

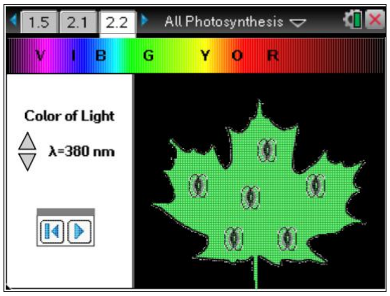
Q4. During which of the following months would you expect photosynthesis rates to be highest in the Southern Hemisphere?

Answer: A. January

Discussion Points and Possible Answers

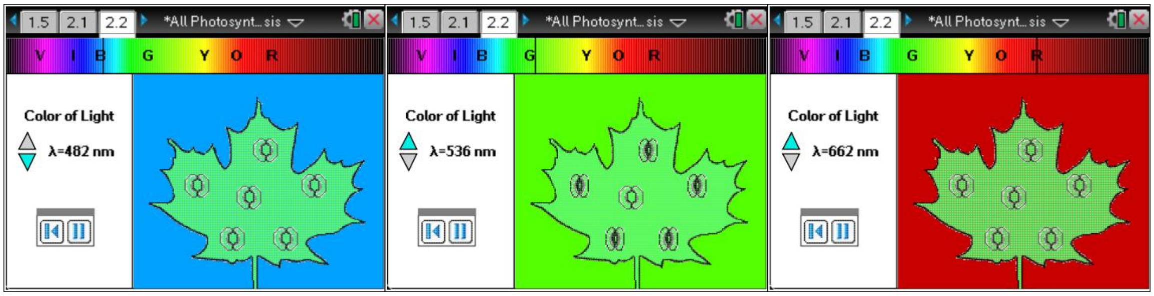
Move to pages 2.1–2.5.

Students will read the brief background information on page 2.1.



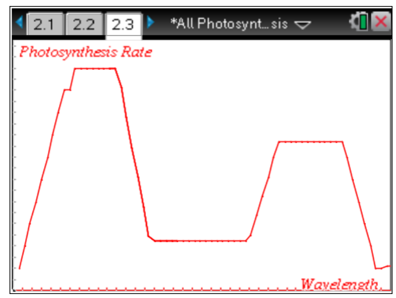
3. In this interactive simulation, students will observe the impact of the wavelength (color) of light on the rate of photosynthesis. To start the simulation on page 2.2, students click on the start arrow. They then click repeatedly on the "up arrow" to increase the ***wavelength*** of visible light 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 below. Sample graphs are on the right.

   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.



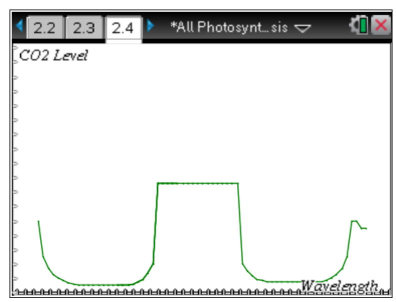
Students will answer the following questions on the student activity sheet.

Q5. Sketch both graphs in the spaces to the right.



Answer: See the sketches to the right.

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



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.

Q7. Why do you think ROYGBIV was displayed backward on page 2.2?

Answer: The spectrum is arranged by increasing wavelength, with the shorter wavelengths to the left (violet) and the longer wavelengths to the right (red).

Q8. Which wavelengths of light were best for photosynthesis? How can you tell?

Answer: About 440–460nm and 660–700nm. These regions of the spectrum showed the peaks in photosynthesis rate.

Q9. Which colors of light were best for photosynthesis?

Answer: Blue and red. These regions of the spectrum showed the peaks in photosynthesis rates.

Q10. Which wavelengths of light were least used for photosynthesis?

Answer: from about 530–620nm

Q11. Which colors of light were least used for photosynthesis?

Answer: mostly green and colors around green in the spectrum

Q12. How does your answer to Question 11 explain the color of most plants?

Answer: Plants are green because they have chlorophyll, which reflects green light, rather than absorbing it and using it for photosynthesis.

Q13. During the simulation, how could you tell which wavelengths were best for photosynthesis and which ones were not?

Answer: You could tell by looking and the “peaks” and “valleys” on the first graph.

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

Answer: Photosynthesis would occur very slowly, or not at all, and the plant would eventually die of starvation.

Q15. Describe a place on Earth where photosynthesis rates would tend to be consistently very high. Explain.

Answer: Best answer would be either a tropical rain forest or tropical oceans and seas. Light intensity is high and there is plenty of water available.

TI-Nspire Navigator Opportunities

Ask students to share their screens as they pause at various wavelengths in Problem 2. Discuss the results with the entire class. Question responses from Problem 1 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, pull back 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.
- Summative assessment will consist of questions/problems on the chapter test.