

You Are My Sunshine

Photosynthesis

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Grade Level	10th – 12th Grade	**Time Frame**	100 minutes
Subject	Science	**Duration**	2-3 class periods
Course	Biology, Environmental Science		

Essential Question

How does energy guide function?

Summary

In this lesson, students explore energy conservation based on how energy from the sun is captured and used to make chemical energy. Students also review how solar energy and the concept of photosynthesis have been used to engineer technology that could be beneficial to humans. This lesson can be used to introduce or conclude a photosynthesis unit.

Snapshot

Engage

Students watch solar dancing toys and record their observations.

Explore

Students conduct a lab with spinach and light.

Explain

Students answer questions about the lab.

Extend

Students read about photosynthesis and renewable energy.

Evaluate

Students create two-minute documentaries about the articles they read.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD403: Translate information into a table, graph, or diagram
IOD505: Analyze presented information when given new, simple information
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS3: Energy
HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Oklahoma Academic Standards (Physical Science)

B.LS1.1.2: All cells contain genetic information in the form of DNA molecules.

Oklahoma Academic Standards (Physical Science)

CH.PS3: In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

Oklahoma Academic Standards (Physical Science)

PS.PS3: Use mathematical representations to support the explanation that the total momentum of a system of objects is conserved when there is no net force on the system.

Oklahoma Academic Standards (Physical Science)

PH.PS3: If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by change in the momentum of objects outside the system.

Attachments

- Carbon-Is-Not-the-Enemy-You-Are-My-Sunshine - Spanish.docx
- Carbon-Is-Not-the-Enemy-You-Are-My-Sunshine - Spanish.pdf
- Carbon-Is-Not-the-Enemy-You-Are-My-Sunshine.docx
- Carbon-Is-Not-the-Enemy-You-Are-My-Sunshine.pdf
- Lesson-Slides-You-Are-My-Sunshine.pptx
- Photosynthesis-Lab-You-Are-My-Sunshine - Spanish.docx
- Photosynthesis-Lab-You-Are-My-Sunshine - Spanish.pdf
- Photosynthesis-Lab-You-Are-My-Sunshine.docx
- Photosynthesis-Lab-You-Are-My-Sunshine.pdf
- Reverse-Photosynthesis-Uses-Sunlight-to-Convert-Plant-Biomass-Into-Fuel-You-Are-My-Sunshine - Spanish.docx
- Reverse-Photosynthesis-Uses-Sunlight-to-Convert-Plant-Biomass-Into-Fuel-You-Are-My-Sunshine - Spanish.pdf
- Reverse-Photosynthesis-Uses-Sunlight-to-Convert-Plant-Biomass-Into-Fuel-You-Are-My-Sunshine.docx
- Reverse-Photosynthesis-Uses-Sunlight-to-Convert-Plant-Biomass-Into-Fuel-You-Are-My-Sunshine.pdf
- The-Difference-Between-Photosynthesis-and-Solar-Cells-You-Are-My-Sunshine - Spanish.docx
- The-Difference-Between-Photosynthesis-and-Solar-Cells-You-Are-My-Sunshine - Spanish.pdf
- The-Difference-Between-Photosynthesis-and-Solar-Cells-You-Are-My-Sunshine.docx
- The-Difference-Between-Photosynthesis-and-Solar-Cells-You-Are-My-Sunshine.pdf
- Why-the-Secret-of-Blue-Begonias-Can-Improve-Energy-Efficiency-You-Are-My-Sunshine - Spanish.docx
- Why-the-Secret-of-Blue-Begonias-Can-Improve-Energy-Efficiency-You-Are-My-Sunshine - Spanish.pdf
- Why-the-Secret-of-Blue-Begonias-Can-Improve-Energy-Efficiency-You-Are-My-Sunshine.docx
- Why-the-Secret-of-Blue-Begonias-Can-Improve-Energy-Efficiency-You-Are-My-Sunshine.pdf

Materials

Entire Lesson

- Lesson Slides (attached)
- Carbon Is Not the Enemy (attached)
- Reverse Photosynthesis Uses Sunlight to Convert Plant Biomass Into Fuel (attached)
- The Difference Between Photosynthesis and Solar Cells (attached)
- Why the Secret of Blue Begonias Can Improve Energy Efficiency (attached)
- Solar dancing toys (3)

Explore (Option 1)

- Photosynthesis Lab (attached; 1 copy per student)
- Timer (1 per group)
- Light lamps (4–5)
- Spinach leaves (3–5 per group)
- Hole punch (1–2 per group)
- Clear cups or beakers (2 per group)
- Large syringe without needle (2 per group)
- Baking soda (1.5 g per group)
- Liquid dish soap (1 bottle)
- Water (600 mL per group)

Explore (Option 2)

- P51™ Chlorophyll Lab: Green Glows Red! (linked here and in the narrative; 1 copy per student)
- Spinach leaves (3–5 per group)
- Acetone or 90%+ isopropyl alcohol (about 2 ml per group; volume depends on the extraction method)
- 70% isopropyl alcohol (~0.5 cm-deep covering of chromatography chamber per group)
- Filter paper for chromatography (1 per group)
- Mortar and pestle (1 per group)
- Paper chromatography setup: beaker and glass stirring rod, or similar (1 per group)
- Pipettes (micropipettes or plastic transfer pipettes can be used) (1 P20 or P200 with tips, or several plastic transfer pipettes, per group)
- Funnel and filter paper, or microcentrifuge (1 per group)
- 200 µl tubes (about 5 per group)
- 1.7 ml microcentrifuge tubes (if using a centrifuge) (1–3 per group)
- P51™ Molecular Fluorescence Viewer or other blue light illumination system (1 per group)
- Gyro™ microcentrifuge, fixed speed
- 10 µl micropipette tips (2 racks of 96)
- 10 µl minipette (fixed volume micropipette; set of 10)
- 200 micropipette tips (2 racks of 96)
- 20–200 µl adjustable volume micropipette (H-style)
- 4 µl minipette (fixed volume micropipette; set of 10)
- Set of 4 adjustable-volume micropipettes with rack: 0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl (H-style)
- Disposable lab pack: 50 slides, 50 plastic cover slips, and lens paper booklet

Objectives

- Determine how organisms capture and store free energy from physical sources (the sun) for use in biological processes (photosynthesis).
- Evaluate the contributions of photosynthesis and the capturing of light in the creation of man-made technology.
- Construct explanations based on scientific evidence as to how the interaction of subcellular structures provides essential function.
- Investigate the best pigment for light absorption and its level of efficiency for photosynthesis.

5 minutes

Engage

Teacher's Note: Lesson Preparation

For this activity, you need three solar dancing toys and two lamps of different strengths. Place one toy under a strong light source so it "dances" a lot, place one under a moderate light source so it "dances" a little, and place the third toy under no light or in the shade so it doesn't move at all.

As students enter the classroom, allow them the freedom and time to watch the solar dancing toys or whatever students want to do. After a minute, introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to read aloud the essential question. Display **slide 4** to go over the lesson objectives. Review these slides with students to the extent you feel necessary.

Bring students' attention back to the solar dancing toys. Display **slide 5** and ask students: "Why is this happening?"

In response to that question, have students write a statement of speculation as to what is happening with the toys. Then, have each student share their explanation with a partner.

Students are going to revisit both the question and their original statements at the end of the lesson, so have students store their responses for later.

Optional Video

Solar dancing toys are cheap and can be found at most dollar stores. However, if you're too busy to shop or can't find the toys, you may instead show students this video, titled "Young Sunflowers Follow the Sun's Rays."

Embedded video
https://youtube.com/watch?v=lwl0tGzr4S8

After the video, have students complete the rest of the Engage section as directed above: Ask the same question, have students share their explanations with partners, and have them hang on to their responses until the end of the lesson.

40 minutes

Explore (Option 1)

The Explore section of this lesson has two lab options for you to choose from. Option 1 focuses on the reactants necessary for photosynthesis and the products of this process.

Teacher's Note: Lab Setup

Before beginning the lab, make sure all groups have the appropriate materials at their tables. It is recommended that students wear goggles during this lab.

- Timer
- Light source
- Spinach leaves (3–5 per group)
- Hole punch (1–2 per group)
- Clear cups or beakers (2 per group)
- Large syringe without needle (2 per group)
- Baking soda (1.5 g per group)
- Liquid dish soap (1 bottle)
- Water (600 mL per group)

Display **slide 6** and pass out a copy of the attached **Photosynthesis Lab** handout to each student. Allow students to form groups and ask them to answer the three pre-lab questions on the handout.

Once students have answered the pre-lab questions, have them read through the lab procedure and instructions before beginning. Be sure to answer any questions that arise as students work, and remind them to record the data they collect on their lab handouts.

After students have completed the lab, have them answer the post-lab questions on the handout.

Optional Video

If students struggle to get their disks to sink, consider playing the following video, titled "Photosynthesis Lab Walkthrough," starting at 1:30. The video shows students how to load their leaf disks and make them sink before they attempt to do so themselves.

Embedded video
https://youtube.com/watch?v=ZnY9_wMZZWI?t=90

Teacher's Note: Differentiation for AP Biology

This is a lab recommended by the College Board—but the way this lab is written and the pre- and post-lab questions are NOT challenging enough for AP. If you would like to use this lesson for AP, you can still follow all the steps, but use the College Board's version of the lab (linked here) instead.

45 minutes

Explore (Option 2)

The Explore section of this lesson has two lab options for you to choose from. Option 2 focuses on how light is captured, identifies the structural components that capture light, and reviews the effects of light wavelength on the rate of photosynthesis.

Teacher's Note: Lab Setup

Before beginning the lab, make sure all groups have the appropriate materials at their tables. It is recommended that students wear goggles during this lab.

- P51™ Chlorophyll Lab: Green Glows Red! (linked here; print 1 copy per student ahead of time)
- Spinach leaves (3–5 per group)
- Acetone or 90%+ isopropyl alcohol (about 2 ml per group; volume depends on the extraction method)
- 70% isopropyl alcohol (~0.5 cm-deep covering of chromatography chamber per group)
- Filter paper for chromatography (1 per group)
- Mortar and pestle (1 per group)
- Paper chromatography setup: beaker and glass stirring rod, or similar (1 per group)
- Pipettes (micropipettes or plastic transfer pipettes can be used) (1 P20 or P200 with tips, or several plastic transfer pipettes, per group)
- Funnel and filter paper, or microcentrifuge (1 per group)
- 200 µl tubes (about 5 per group)
- 1.7 ml microcentrifuge tubes (if using a centrifuge) (1–3 per group)
- P51™ Molecular Fluorescence Viewer or other blue light illumination system (1 per group)
- Gyro™ microcentrifuge, fixed speed
- 10 µl micropipette tips (2 racks of 96)
- 10 µl minipette (fixed volume micropipette; set of 10)
- 200 micropipette tips (2 racks of 96)
- 20–200 µl adjustable volume micropipette (H-style)
- 4 µl minipette (fixed volume micropipette; set of 10)
- Set of 4 adjustable-volume micropipettes with rack: 0.5–10 µl, 2–20 µl, 20–200 µl, and 100–1,000 µl (H-style)
- Disposable lab pack: 50 slides, 50 plastic cover slips, and lens paper booklet

Display **slide 6** and pass out a copy of the **P51™ Chlorophyll Lab: Green Glows Red!** to each student. Read the instructions aloud to review expectations as a class.

Organize students into groups of 3–4 and have them work through the lab together. Be sure to answer any questions that arise as students work, and remind them to record the data they collect on their lab printouts.

After students have completed the lab, have them use the Claim, Evidence, Reasoning (CER) strategy to record their observations of chromatography during the lab and answer the analysis questions.

Optional Lab Report

Consider asking students to write a lab report using the R.E.R.U.N. strategy. This strategy helps students reflect on their lab experiences with more organized analysis and evaluation of their findings. Be sure to go over the instructions and provide a rubric so students know what is expected of them.

Additional Support

You may also consider having students observe where photosynthesis takes place by viewing a plant cell under a microscope. Invite students to take a small piece of onion skin (no chunks), place it on a microscope slide, and add a drop of food coloring or iodine to stain the slide. Then, have students add the cover slip at a 45-degree angle over the onion and view it on scanning, low, and high power under a microscope.

15 minutes

Explain

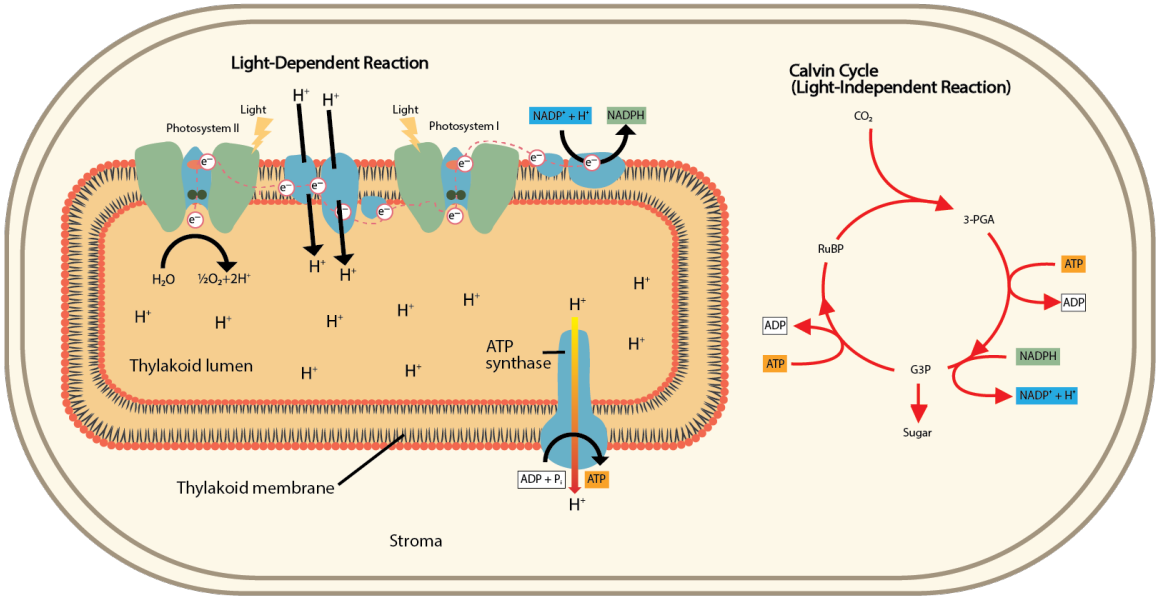
Once students have finished the lab, help them come up with the equation of photosynthesis based on what they discovered in the lab. As students share out, write what they say on the board and guide them to this equation:

6 CO2 + 6 H2O –> C6H12O6 + 6 O2

Teacher's Note: Equation Explanation

Consider informing students of the purpose of the coefficient in front of the compounds. Explain how, when we balance a chemical equation, the amount of each element on the left side of the equation should be equivalent to the products on the right side.

Display **slide 7** to reveal a diagram of photosynthesis within the chloroplast. Have students closely examine the diagram so they can understand the full complexity of light-dependent and light-independent (Calvin Cycle) reactions.



Go to **slide 8** and ask students to consider the reaction for photosynthesis and how it relates to their lab data. As the first part of a Think-Pair-Share activity, have students write their answers to the following questions:

- In the lab, where did the carbon dioxide come from?
- What role did the light play? What did the light do?
- What did you observe that let you know photosynthesis was occurring? How does that fit into the equation?
- In the water solution, do you think the leaf disks were still making sugar? Why or why not?

After students have written their answers, have them pair up and share what they wrote with their partners.

Once students have confidence in their answers, call on several pairs to share their speculations with the whole class.

Teacher's Note: Clarifying Time

Take this opportunity to gauge students' levels of understanding at this point. Clear up any misconceptions students may have.

15 minutes

Extend

Teacher's Note: Activity Preparation

Before beginning this activity, preview the attached articles listed below and decide whether to print them front/back, based on what works best for your class.

To save paper, you could place copies of the articles in a sheet protector for each page and provide erasable markers for students to annotate their assigned article as described below. This way, students can wipe off their markings and allow the next class to complete the activity with the same copies.

Organize students into five groups. Give each group copies of one of the following attached articles:

- **Carbon Is Not the Enemy**
- **Reverse Photosynthesis Uses Sunlight to Convert Plant Biomass Into Fuel**
- **The Difference Between Photosynthesis and Solar Cells**
- **Why the Secret of Blue Begonias Can Improve Energy Efficiency**

Teacher's Note: But There Are Only Four Articles!

The article titled “Carbon Is Not the Enemy” is much longer than the others and can be broken into two parts. With this in mind, assign this article to two groups. Have one group read the first two pages of the article, and have the other group read the last three pages.

The activity works well this way, as the first two pages focus on the hazards of the language of current environmental legislation, and the last three pages contain suggestions for using the carbon cycle and photosynthesis as the basis of sustainable construction.

Display **slide 9** and explain the CUS and Discuss strategy to students. Ask them to do the following as they read their group’s assigned article:

- Circle words or concepts they don't understand.
- Underline details that support the main idea.
- Star the main idea.

After students have finished, have them discuss what they marked and why with their group members.

Teacher's Note: Guiding Students Toward the Main Ideas

Each article focuses on something different and has valuable information for students to learn and understand. As they work through the CUS and Discuss activity, guide them toward these main ideas if they miss them.

1. "Carbon Is Not the Enemy" is about how carbon is not inherently bad, even though we tend to frame it negatively when we talk about it. The second half of the article explains how we can use the properties of photosynthetic plants to create buildings/cities that function more like trees/forests.
2. "Reverse Photosynthesis Uses Sunlight to Convert Plant Biomass Into Fuel" is about how scientists have used their understanding of photosynthesis to develop a process called reverse photosynthesis, which could potentially be used to produce fuel and chemicals more quickly and efficiently, thus reducing pollution.
3. "The Difference Between Photosynthesis and Solar Cells" compares and contrasts plants' natural photosynthetic processes with the functions of a solar cell, which is man-made and is used to convert solar energy into electricity.
4. "Why the Secret of Blue Begonias Can Improve Energy Efficiency" is an overview of a recent scientific study that found some begonias produce blue chloroplasts ("iridoplasts") in low light. This occurs because, in near-dark conditions, green light is more available for plants to absorb than blue light (which reinforces light absorption properties). These findings could be used to develop more efficient technology.

50 minutes

Evaluate

Once students have discussed their articles with their groups, go to **slide 10**. Inform students they are going to create Two-Minute Documentaries to present the information from their articles to the entire class.

Optional Technology Integration

You may consider having groups use Padlet to record and share their documentaries.

Teacher's Note: Have Fun, but Stay on Task

As students prepare their documentaries, walk around and make sure they're including the main ideas and important details outlined in the Extend section.

Resources

- Bozeman Science. (2011, October 30). Photosynthesis Lab Walkthrough [Video]. YouTube. https://www.youtube.com/watch?v=ZnY9_wMZZWI
- College Board. (n.d.). Cellular Processes: Energy and Communication. Big Idea 2. https://secure-media.collegeboard.org/digitalServices/pdf/ap/bio-manual/Bio_Lab5-Photosynthesis.pdf
- K20 Center. (n.d.). Claim, Evidence, Reasoning (CER). Strategies. https://learn.k20center.ou.edu/strategy/156
- K20 Center. (n.d.). CUS and Discuss. Strategies. https://learn.k20center.ou.edu/strategy/162
- K20 center. (n.d.). Padlet. Tech Tools. https://learn.k20center.ou.edu/tech-tool/1077
- K20 Center. (n.d.). R.E.R.U.N. Strategies. https://learn.k20center.ou.edu/strategy/819
- K20 Center. (n.d.). Think-Pair-Share. Strategies. https://learn.k20center.ou.edu/strategy/139
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- McDonough, W. (2016). Carbon is not the enemy. Nature 539, 349–351. https://doi.org/10.1038/539349a
- MiniPCR. (2019, March). P51™ Chlorophyll Lab: Green Glows Red! Amplyus. https://www.minipcr.com/wp-content/uploads/miniPCR-Chlorophyll-Glow_Lab_student_guide_v1.0_vF.pdf
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- WallpapersWide. (n.d.). Sunlight [Image]. WallpapersWide. http://hd.wallpaperswide.com/thumbs/sunlight-t1.jpg
- Williamson, B. (2017, April 21). The Floating Leaf Disk Assay for Investigating Photosynthesis. Biology Junction. https://biologyjunction.com/floating-leaf-disk-assay/