ScienceNews

EDUCATOR GUIDE

September 23, 2023

AI Technology and Photosynthesis

SOCIETY FOR SCIENCE

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About this Guide

Dive into recent news articles from the September 23 issue of *Science News* to have students learn how applying AI to existing technology in self-driving cars might solve safety problems and to explore the chemical processes of photosynthesis and how changes in environment can impact plants' ability to photosynthesize.

This Guide includes:

Article-based Comprehension Q&A — Artificial intelligence, or AI, provides a new way to focus a camera's lens! Researchers have now used AI to overcome limitations in thermal-imaging technology — and they didn't stop there. Learn how applying this AI to existing technology, such as self-driving cars, might solve safety problems and help transform what had been science fiction into reality. Apply knowledge to new applications and answer questions that confront the nuance sometimes lost by dichotomies as literary devices.

> **Related standards include NGSS-DCI:** HS-ETS1; MS-ETS1.
>
> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.
>
> **Paired Articles:**
> *Science News:* "How artificial intelligence sharpens blurry thermal vision images"
> Readability Score: 10.5
>
> *Science News Explores:* "AI can now turn blurry thermal vision into crisp images"
> Readability Score: 7.8

Activity — Ever wonder how soil and seeds transform into bushes and trees? And why do these plants have specific requirements for light and water? Are there conditions that push plants to the brink? Explore such questions by taking a deep dive into the chemical processes of photosynthesis. Create a series of comics to illustrate how green plants convert light energy into stored chemical energy. Then, investigate how changes to light, water and temperature can impact plants' ability to photosynthesize and how plants can adapt when conditions aren't ideal.

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>
> **Paired Articles:**
> *Science News:* "Some leaves in tropical forests may be getting too hot for photosynthesis"

Readability Score: 11.0

Science News Explores: "Explainer: How photosynthesis works"
Readability Score: 7.0

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Article-based Comprehension, Q&A: Paint a Clearer Picture with AI

Directions for teachers: To engage students before reading the article, have them answer the "Before Reading" questions as a warmup in class or for homework. If you'd like to address AI technology in depth, consider combining this assessment with a lesson plan about ChatGPT. Then, ask students to read the online *Science News* article "How artificial intelligence sharpens blurry thermal vision images" and have them answer the "During Reading" questions. As an optional extension, have students apply what they've learned and discuss the "After Reading" questions. A version of the article, "How artificial intelligence sharpens blurry thermal vision images," appears in the September 23, 2023, print issue of *Science News*. *Science News Explores* offers another version of the same article written at a middle school reading level.

Before Reading

1. If given the opportunity, how likely is it that you'd choose to ride in a self-driving car? Would you feel more safe, less safe or equally safe riding such a car at night vs. at day? Briefly explain your reasoning.

Answers will vary. Some might say they are unlikely to ride such a car, and that riding at night would feel less safe due to limited daylight. However, others might reason that the roads might be less busy at night, therefore they'd feel safer.

2. What is a piece of equipment or technology that a self-driving car would require, but that would be optional or absent in a normal car?

Answers will vary. An example would be sensors, especially cameras or other devices, that monitor the road. Some regular cars do have cameras, but they are not as crucial as they would be in a self-driving car.

During Reading

1. Thermal cameras work by detecting heat sources. To do that, they must sense particular wavelengths of light that our eyes cannot see. What kind of light do thermal cameras detect?

Thermal cameras detect infrared light.

2. Regarding thermal imaging, what is "ghosting?" What problem does ghosting cause?

Ghosting occurs when heat from an object overwhelms image details, such as textures. The problem with ghosting is that it can cause images to appear blurry.

3. When scientists paired artificial intelligence (AI) with thermal-imaging technology, the technique produced more detailed images than produced by the thermal camera alone. What information did the AI reveal that the thermal camera on its own did not?

Artificial intelligence helped untangle details in a thermal image about the textures and types of materials that the viewed objects were made from.

4. What extra or higher quality data might be available to self-driving cars using the type of AI described in the story?

Self-driving cars might better be able to measure distances and more accurately navigate driving at night.

5. Using current self-driving car technology, how might having many self-driving cars on the same road "confuse one another?" Why do researchers say AI technology could make self-driving car technology safer to scale up?

Currently, self-driving cars judge distance by bouncing signals off of nearby objects. However, problems may occur if many self-driving cars are on the same road because they may confuse another vehicle's signals for their own. The new technology could reduce this problem because it does not need to emit signals to judge distances.

6. Researchers point out that despite the new camera's potential, it's unlikely to appear in vehicles in the near future. Give three reasons why.

Firstly, this new camera is too big for practical use in a vehicle. Secondly, the camera is too expensive. Thirdly, the image processing time needs to be faster in a self-driving car that must respond to situations rapidly.

7. Besides self-driving cars, in what other technology does Fanglin Bao hope to see this AI technology used?

Fanglin Bao hopes to see this technology used in robots.

After Reading

1. Besides image analysis, what is another existing technology or technique that AI might improve? Explain your answer. In your example, does AI serve more to overcome limitations of the technology? Or does it elevate this technology, offering it new capabilities?

Answers will vary. An example is genealogy, both family tree-related and forensic genealogy. In these cases, AI might help dive through loads of information. The machine-learning capabilities might help make sense of mixed data types, such as maps of family trees, DNA analysis sites, public records and more. And this could help identify potential criminals or find family. In the example in the story, AI serves more to address limitations of genealogy techniques by detecting patterns among mixed data from varying sources.

2. A dichotomy is when we think of two things as having a rigid division between them (good vs. evil, for instance.) Dichotomies are sometimes used as literary devices or models to explain contrasted concepts. For example, in the article, Bao suggests a dichotomy that exists between day and night. Dichotomies sometimes oversimplify the contrasted ideas, however, making the concepts seem more distinct than they really are. Besides those already mentioned (day vs. night & good vs. evil), give an example of a dichotomy you've seen used either in science or in other aspects of life. How might such a dichotomy, if given only passing thought, oversimplify an otherwise complex pair of concepts?

Answers will vary. Examples might include positive vs. negative, such as in regard to electrical charges. In this example, it's crucial to understand that there are degrees of positive and degrees of negative. Furthermore, the dynamics between elementary particles derive from degrees of difference between interacting particles. Other possible examples: acid/base, male/female, nice/mean, etc.

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Student Comprehension Worksheet: Paint a Clearer Picture with AI

Directions: Read the online *Science News* article "How artificial intelligence sharpens blurry thermal vision images" and answer the following questions as directed by your teacher.

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Science Bite Activity: Shining Light on Photosynthesis

Directions for teachers: For homework, or if you have time in class, have students read the *Science News Explores* article "Explainer: How photosynthesis works." Suggest that students perform a close reading exercise, such as highlighting or notetaking, to gather details from the articles.

Ask students to work with a partner to answer the first five questions in the "Breaking down photosynthesis" section. Divide the class into groups that will each create a comic or graphic tale depicting one of the chemical reactions in the process. Group topics can include: the overall chemical reaction of photosynthesis, the light reactions, and the steps of the Calvin cycle. Use this lesson plan to download the storyboard template. Have students present their comics in the order in which the chemical reactions generally occur. Make sure each group points out how their reaction or step is dependent on the reactants or energy produced by preceding reactions (or the incident sunlight). Display the comics in your classroom in a way that depicts the correct order.

To explore how changes in certain conditions can impact plants' ability to photosynthesize and how plants can adapt to such changes, ask students to read the *Science News* article "Some leaves in tropical forests may be getting too hot for photosynthesis" and discuss the second set of questions.

Breaking down photosynthesis

1. Based on what you read, write an overall chemical reaction for photosynthesis. If you have learned how to balance chemical reactions, balance it.

$$6CO_{2(g)} + 6H_2O_{(l)} + \text{sunlight} \rightarrow C_6H_{12}O_6 + 6O_{2(g)}$$

2. As the article indicates, photosynthesis is the result of multiple chemical reactions that are often described as two separate processes. What reactions do the "photo" in "photosynthesis" refer to? What reactions are classified by the "synthesis" in "photosynthesis"? Where do each of the processes occur?

"Photo" refers to the reactions that are triggered by light, as they require photons' energy to be absorbed by chlorophyll. This occurs in the thylakoid membranes, which are located inside the chloroplast, an organelle in plant cells. The "synthesis" reactions also take place inside the chloroplast, but they take place outside the thylakoid, in the stroma. This series of reactions makes up the process called the Calvin cycle, which produces glucose, a sugar that plants use to produce other carbohydrates such as cellulose, starch or fructose.

3. Working with a partner, use the article to diagram all the major chemical reactions in the "photo" and "synthesis" processes. Discuss the purpose or function of a single reaction in terms of how it fits into the overall cycle. Where are the reactions taking place? Are they consuming or producing energy? How is the energy used in subsequent steps?

Chlorophyll absorbs light and uses the light's energy to initiate the process of splitting oxygen off water molecules. Free oxygen atoms immediately pair up to create oxygen gas (a biproduct of the overall photosynthesis reaction). The reaction also produces NADPH and ATP, molecules that store energy and that are consumed during the Calvin cycle. The four major steps of the Calvin cycle are carbon fixation, reduction, carbohydrate formation and regeneration. Plants bring in CO_2 from the air for carbon fixation. Rubisco, a plant enzyme, attaches the carbon atom in CO_2 to ribulose 1,5-bisphosphase (RuBP) to form a six-member ring. That ring immediately breaks into two molecules that each contain three carbons. In reduction, the ATP and NADPH produced from the light reactions are used to change the three-carbon molecules into a small sugar, glyceraldehyde 3-phosphate (G3P). In carbohydrate formation, some G3P leaves the cycle to be converted into larger sugar molecules, such as glucose. During regeneration, the remaining G3P gains two more carbons to produce RuBP, and the Calvin cycle can continue. Each of the reactions helps to create products that are used in a subsequent step.

4. After reviewing all the steps of the photosynthesis, does the overall reaction capture everything that occurs during photosynthesis? What does the overall reaction tell you? What does it leave out?

The overall reaction does not indicate the pathway or chain of reactions that ultimately create the plant's glucose and the oxygen byproduct. It only gives an overview of what the reactants and products are.

5. Why might it be important to understand all the steps and details of photosynthesis and not just memorize the overall reaction?

Answers will vary. Photosynthesis is a complex series of reactions that isn't fully described by the overall reaction. Understanding the steps can help us appreciate how plants have adapted to use carbon dioxide, water and sunlight to grow. This also reveals the process by which plants get the materials and energy to produce carbohydrates that are key parts of the foods that we eat.

6. Create a comic or graphic tale that explains one of the chemical reactions in the process of photosynthesis. Make sure you highlight the reactants and products and point out how your reaction plays an important role in the overall process of photosynthesis. What preceding reaction is your reaction dependent on, and why is your reaction critical to the overall process? Is your reaction producing or consuming energy? Use additional resources to look up more information about the reaction or part of the process that is assigned to you.

Can plants adapt?
To investigate how certain conditions can impact plants' ability to photosynthesize and how plants can adapt to such conditions, read the *Science News* article "Some leaves in tropical forests may be getting too hot for photosynthesis" and discuss the second set of questions with a partner.

1. Almost all plants undergo photosynthesis. What are some environmental factors that can affect the process of photosynthesis and therefore the health of plants? Explain using an example from the *Science News* article.

Temperature, amount of sunlight, precipitation, soil nutrient level. In the article, scientists determined that some plant leaves in tropical forests were getting too hot for photosynthesis to occur. High temperatures can break down the proteins that are needed to convert light energy into sugar.

2. In the study referenced in the *Science News* article, what data did scientists collect to learn that leaf temperatures may be getting too hot for photosynthesis?

The researchers used data from ECOSTRESS, a thermal sensor on board the International Space Station, combined with temperature data from sensors taped to leaves and in a tower in the Amazon.

3. Describe your neighborhood's environmental conditions. What conditions are your local plants exposed to throughout the year?

Students should describe the environmental conditions, such as precipitation, sun, temperature and humidity, that their region experiences during the seasons of the year. Students can also describe attributes of the seasons, such as mild winters, stormy summers, rainy autumns, etc.

4. Given your area's environmental conditions, what adaptations do your local plants need to survive? Think beyond photosynthesis. For example, if you live in an area with high levels of erosion, plants need strong roots.

Answers will vary. For example, if students reported that their area receives a lot of rain, plants should have strong roots. If they mentioned that their area is very dry, plants should have high water-retention abilities.

The care and keeping of plants
Choose a native plant that grows in your local area. Do some research and fill in the information below to create a "care card" for your plant. Include a description of the adaptations your plant needs to survive in your local area in the "Additional notes" portion. What makes the plant grow well in your local area?

Plant's Common Name:
Plant's Scientific Name:
Average size:
Water requirements:
Sun tolerance:
Cold hardiness:
Common pests:
Additional notes:

A sample answer is given below.

Plant's Common Name: Goldenrod
Plant's Scientific Name: Solidago
Average size: 1.5–5 ft. tall, 1-3 ft. wide
Water requirements: Mature plants are drought tolerant, so they don't typically need watering. Newly planted goldenrod needs damp but not soggy soil.
Sun tolerance: Full sun
Temperature: Thrives in temperatures 65-80 degrees Fahrenheit
Common pests: Beetles, aphids
Additional notes: Goldenrod grows well in my local area because the temperatures in summer are mild and we don't get a lot of rain.

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Breaking down photosynthesis

1. Based on what you read, write an overall chemical reaction for photosynthesis. If you have learned how to balance chemical reactions, balance it.

2. As the article indicates, photosynthesis is the result of multiple chemical reactions that are often described as two separate processes. What reactions do the "photo" in "photosynthesis" refer to? What reactions are classified by the "synthesis" in "photosynthesis"? Where do each of the processes occur?

3. Working with a partner, use the article to diagram all the major chemical reactions in the "photo" and "synthesis" processes. Discuss the purpose or function of a single reaction in terms of how it fits into the overall cycle. Where are the reactions taking place? Are they consuming or producing energy? How is the energy used in subsequent steps?

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