ScienceNewsLearning

EDUCATOR GUIDE

December 16 & 30, 2023

Evaporation by Light and Scaling Telescopes

SOCIETY FOR SCIENCE

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About this Guide

Use articles from the December 16 & 30, 2023 issue of *Science News* to have students investigate a recent study about how light, and not just heat, may aid in the evaporation of water and how describing aspects of The Great Magellan Telescope can provide many examples of scale and relative values.

This Guide includes:

Lesson Plan: Green light means "go"

> **Learning Overview:** Just when we all thought we had evaporation all figured out, clever experiments shine a new light on old assumptions. A new study points to light having the ability to help sever bonds (a type of intermolecular force) between water molecules to boost evaporation. Learn how these findings support new scientific claims and challenge the old notion that light affects evaporation only indirectly, through heat generation.
>
> **NGSS-DCI:** HS-PS2; HS-PS3; MS-PS3; MS-PS4.
>
> **Paired Articles:**
> *Science News:* "Light, not just heat, might spur water to evaporate"
> Readability Score: 10.4
>
> *Science News Explores:* "Heat makes water evaporate. Now it appears light can, too"
> Readability Score: 7.5
>
> **Student Worksheet**: These questions are formatted so it's easy to choose the ones that will work for your students, post them to your LMS or print them off as a worksheet.

Lesson Plan: Scaling the world's largest telescope

> **Learning Overview:** The Giant Magellan Telescope could reveal signs of life on faraway planets — mainly because of the telescope's massive mirrors. But just how big are they? Use this article to investigate the benefits of using scale and relative values in writing. Then solve a related word problem and devise your own useful examples of scale.
>
> **NGSS-DCI:** HS-ESS1; MS-ESS1.
>
> **Paired Article:**
> *Science News:* "How giant mirrors are made for what will be the world's largest telescope"
> Readability Score: 12.6
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Lesson Plan: Green light means "go"

Learning Overview: Just when we all thought we had evaporation all figured out, clever experiments shine a new light on old assumptions. A new study points to light having the ability to help sever bonds (a type of intermolecular force) between water molecules to boost evaporation. Learn how these findings support new scientific claims and challenge the old notion that light affects evaporation only indirectly, through heat generation.

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Science News: "Light, not just heat, might spur water to evaporate"
Readability Score: 10.4

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Readability Score: 7.5

Directions: To engage students before reading the article, share with them this PHET simulation demo (selecting water and adding enough "heat" to make some molecules break away from other, or evaporate). Then have students answer the "Before Reading" questions as a warmup in class or for homework. Now ask students to read the online *Science News* article "Light, not just heat, might spur water to evaporate." Afterward, have them answer the "During Reading" questions. As an optional extension for deeper analysis on proportions and relative values, have students discuss the "After Reading" questions. This article also appears in the December 16 & 30 double issue of *Science News*. *Science News Explores* offers another version of the same article written at a middle-school reading level.

Before Reading
1. Before viewing the simulation, think about a glass of water sitting on your counter for five days. What changes can you observe?

The water evaporates, and some of it appears to vanish.

2. During evaporation, what happens to the states of matter? Do you think this is a physical or chemical change? Explain why.

During evaporation, water changes from a liquid phase to a gas. This is a physical change, because the molecular structure of water stays the same, but the spacing or density of the molecules changes.

3. Watch the simulation. Explain what happens to a water molecule as it evaporates.

When water evaporates, the individual water molecules separate from one another, but the molecules themselves remain intact.

4. What action might you take if you wanted to speed up the evaporation of water? What does the simulation allow you to control to change the speed of evaporation?

Answers will vary. Increasing the water's temperature would increase the evaporation rate, as would increasing the exposed surface area and exposing the water to windy conditions. The simulation allows you to control heat.

During Reading
1. What are photons?

Photons are individual particles of light.

2. What do the study's new findings suggest about the impact of photons on the bonds between water molecules?

Photons might sever bonds, or intermolecular attraction forces, between water molecules.

3. How does added heat affect the rate of evaporation?

Added heat increases the rate of evaporation.

4. Before these findings, what did scientists believe about the impact of light on evaporation rates?

Before these findings, scientists believed that light only impacted evaporation rates indirectly, by contributing heat.

5. In the new study, researchers shone light on various hydrogel samples. How did their measured rates of evaporation compare with what they expected?

Their measured rates exceeded the hypothetical rates of evaporation.

6. The study's findings suggested that different wavelengths of light impacted the water differently. Which wavelength — or color of light — stood out in the study?

Green light produced the highest rate of evaporation.

7. What evidence did Janet A.W. Elliott point to that supported the claim that added heat alone could not account for the differences seen between samples exposed to different colors of light?

Janet A.W. Elliott pointed to study results showing that when just a heater was used — and therefore, heat alone was applied — there was no accelerated evaporation.

After Reading
1. Your best friend attempts to explain evaporation, but you notice that their explanation contains an error. Your friend says, "When water evaporates, the hydrogen and oxygen atoms in the water molecules all break apart, and that is how the water turns from a liquid to a gas. Find the error in your friend's explanation and write out a response that would address and correct that error.

When water evaporates, the individual water molecules remain intact. However, the forces that connect water molecules to one another break, and that's how water turns from a liquid to a gas.

2. Before this study, scientists believed that light "indirectly" affected water's evaporation rates. However, after this study, scientists realized that light might also have a "direct" effect. After reading this story, consider the difference between an indirect effect and a direct one. If an action — such as shining a light on water — directly impacts a result, what does that mean? How does that direct impact differ from an

indirect impact? Point to evidence from this story that supported the scientists changing their position regarding light's direct vs. indirect impact on water evaporation.

To say that an action directly impacts something is to say that the act caused the result. However, to say that an action indirectly impacts something is to say that the action set in motion a series of changes that led to the observed result. Answers will vary regarding supporting evidence, but students may refer to the discrepancy between the observed evaporation rates and the expected ones based on calculations with heat input.

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Student Worksheet: Green light means "go"

Directions: Watch this simulation and answer the "Before Reading" questions. Then read the online *Science News* article "Light, not just heat, might spur water to evaporate" and answer the following questions as directed by your teacher.

Before Reading

1. Before viewing the simulation, think about a glass of water sitting on your counter for five days. What changes can you observe?

2. During evaporation, what happens to the states of matter? Do you think this is a physical or chemical change? Explain why.

3. Watch the simulation. Explain what happens to a water molecule as it evaporates.

4. What action might you take if you wanted to speed up the evaporation of water? What does the simulation allow you to control to change the speed of evaporation?

During Reading

1. What are photons?

2. What do the study's new findings suggest about the impact of photons on the bonds between water molecules?

3. How does added heat affect the rate of evaporation?

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After Reading

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Lesson Plan: Scaling the world's largest telescope

Learning Overview: The Giant Magellan Telescope could reveal signs of life on faraway planets — mainly because of the telescope's massive mirrors. But just how big are they? Use this article to investigate the benefits of using scale and relative values in writing. Then solve a related word problem and devise your own useful examples of scale.

NGSS-DCI: HS-ESS1; MS-ESS1.

Paired Article:
Science News: "How giant mirrors are made for what will be the world's largest telescope"
Readability Score: 12.6

Directions: Use the questions in the first section as a class discussion, then have students read the *Science News* article "How giant mirrors are made for what will be the world's largest telescope" and answer the remaining questions. You may choose to use questions in the third section as a group activity or an assessment.

Defining scale

1. Define scale and give an example. How can you use it to make sense of objects you haven't seen?

Scale is a mathematical relationship used to illustrate the size of objects by comparing them to something else. Scale is useful for objects or quantities that are very large or very small. For example, maps typically have a scale bar because they cover distances that are very large relative to the size of the paper they are drawn on. Scale is helpful to depict objects you haven't seen, to provide a sense of their size compared with something you're more familiar with. Students may mention that scales often refer to ratios between two quantities or give a measure of something as a proportion of something else.

2. Choose two objects in your classroom and create a scale that relates them to each other.

Student answers will vary. One example: the whiteboard is roughly the width of five chairs in a row.

3. Come up with a scale for an object. Choose a celestial object, a part of the body that is invisible to the naked eye, an unfamiliar county's size (or anything else that is unfamiliar to you) and compare it to a more familiar object.

Student answers will vary.

The Magellan telescope and scale

1. Write down some examples of scale that the article's author used to explain the size of the Magellan telescope's mirror.

An enormous mirror — one as tall as a two-story house, if stood on edge
Together, the mirrors will function as a single unit, about as wide as an adult blue whale is long.

The mirror then undergoes two years of polishing, yielding a surface so smooth that if it were expanded to the size of North America, the tallest imperfection would be half as tall as a golf tee.

2. How are literary devices used to describe the scale? Name at least one literary device used and highlight the sentence that uses it.

Analogies and similes are used in the article to describe the scale. For example, a simile is used in the sentence "If all goes to plan, the molten material will anneal to form the body of an enormous mirror — one as tall as a two-story house, if stood on edge."

3. What is another way you could help a reader better understand the size of the mirror for the Magellan telescope? Come up with your own way of representing the scale of the mirror.

Student answers will vary. Instead of describing the scale of the mirror in language, they could create a diagram that shows the scale. They could also think of another analogy that relates the size of the mirror to an object they're familiar with.

Solving for scales

1. The article states that the mirror has a "surface so smooth that if it were expanded to the size of North America, the tallest imperfection would be half as tall as a golf tee." Given an average golf tee height of 3 inches (2.54 centimeters = 1 inch) and an area of North America of approximately 24.23 million square kilometers (km^2), estimate the height of the tallest imperfection of the polished mirror at its current size. Give your answer in meters, then convert it to nanometers. Show your work.

Half as tall as a golf tee would be 1.5 inches, or 0.038 meters. The diameter of the mirror is 8.5 meters wide. Using the diameter, you can calculate the area of the mirror using the following formula:
Area of mirror = $\pi(D/2)^2$, which equals 56.7 m^2
Area of North America (1 km^2 = 1 x 10^6 m^2) = 24.23 x 10^6 km^2 = 24.23 x 10^{12} m^2
Create a proportion of the areas to the golf tee length and solve for the unknown length. The imperfection would be about 8.90 x 10^{-14} m, or 8.90 x 10^{-5} nm.

2. Why do you think the author of the article explained the size of the imperfection using an analogy instead of stating the exact size? Explain.

The comparison helps me understand how tiny the imperfections are. I can grasp the size of a golf tee. The half-golf tee-sized imperfection is very small compared with the size of North America Similarly, the actual size of the imperfection must be tiny compared with the size of the mirror. The size of the imperfection that I found in my calculation was so small that it was difficult to understand. That's probably why the author used the comparison instead of the absolute value.

3. Read through the article again and write down all examples of scales not related to the size of the Magellan telescope that you can find (there are many!).

Student answers will vary. They may mention the furnace's description in the first paragraph — carousel-sized, fire truck red, shaped like a flying saucer. The amount of borosilicate glass is nearly 17,500 kilograms,

roughly four semitruck loads. The new telescope's resolution is 4 times better than today's most advanced telescopes. The mirror size of the new telescope is compared to the James Webb Space Telescope mirror size.

4. What's another quantity or value given in the article that is difficult to grasp in terms of its magnitude? Devise your own way of helping a reader understand the quantity or value given by writing a literary device that scales the amount or size to something more familiar or by providing a diagram.

The article states that the furnace's temperature reaches 1,165 degrees Celsius and states that a 100-nanometer thick coat of aluminum is applied to the clear glass surface. It would be helpful to use a comparison to better understand both quantities. For example, 100 nanometers is a thousand times smaller than the thickness of a typical sheet of paper.

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Student Worksheet: Scaling the world's largest telescope

Directions: Read the *Science News* article "How giant mirrors are made for what will be the world's largest telescope" and answer the questions according to your teacher's instructions.

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