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# K-12 Partnership Lesson Plan

# Emily Grman

# *Albedo:*

# *How much of the sun’s energy gets absorbed?*

## Overview

Students will explore how different substances (air, water) and different colors absorb energy from the sun and warm up. We will discuss what we already know about light energy and absorption, make predictions about what color of background paper will cause air and water to heat up faster, test our predictions by constructing boxes and collecting temperature data, analyze our data, and make conclusions about the implications for climate change.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Graph data and interpret graphs
* Draw conclusions from data collected during an experiment
* Understand that the energy that powers almost everything on the planet comes from the sun, and that different substances can absorb more or less of that energy

**Length of Lesson**

Four 60-minute classperiods

**Grade Levels**

Middle school

**Standards covered (NGSS)**

Disciplinary Core Ideas:

* **MS-PS3-3**: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
* **MS-ESS3-5:** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century

Cross Cutting Concepts:

* Patterns
* Energy and matter
* Stability and change

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence
* Obtaining, evaluating, and communicating information

***Previous Michigan Standards Met:***

* **S.IP.07.12:** Design and conduct scientific investigations
* **S.IP.07.13:** Use tools and equipment appropriate to scientific investigations
* **S.IP.07.14:** Use metric measurement devices in an investigation
* **S.IP.07.15:** Construct charts and graphs from data and observations
* **S.IP.07.16:** Identify patterns in data
**S.IA.07.11**: Analyze information from data tables and graphs to answer scientific questions.
* **S.IA.07.13:** Communicate and defend findings of observations and investigations
* **S.RS.07.11:** Evaluate the strengths and weaknesses of claims, arguments, and data
* **S.RS.07.15:** Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities
* **S.RS.07.17:** Describe the effect humans and other organisms have on the balance of the natural world
* **P.EN.07.62:** Explain how only a tiny fraction of light energy from the sun is transformed to heat energy on Earth
* **E.ES.07.73:** Explain how the temperature of the oceans affects the different climates on Earth because water in the oceans holds a large amount of heat

**Materials**

* Cardboard boxes (1 per student group)
* Colored construction paper (white, black, green, other interesting colors)
* Thermometers
* Beakers of water
* Saran wrap
* Tape
* Towels to cover boxes for cooldown

**Background**

The energy that powers everything on the planet comes from the sun, about half as visible light, about half near-infrared, and a little bit of ultraviolet. **Albedo**=percentage of sun’s energy that is reflected without being changed. White=high albedo, black=low albedo. Because sea ice has a much higher albedo than open ocean or vegetation, melting sea ice will cause the earth to absorb more of the sun’s energy and heat up faster. This is a positive feedback cycle: increasing global temperatures melts sea ice, which causes global temperatures to increase even more. Water has a higher specific heat capacity than air, meaning that it takes more energy to heat one g of water than one g of air.

### Activities of the session

**Day 1:**

1. Begin by connecting to what students already know about solar power. All energy comes from the sun. Our question: how do different things absorb the energy from the sun?
2. Find out what the students know about light—why does black paper look black (absorbs all wavelengths)? Why does white paper look white (reflects all wavelengths)? If a black car and a white car were sitting in a hot sunny parking lot, which one would feel hotter? Have students begin filling in their worksheets.
3. Put up slide of visible light spectrum (in introductory powerpoint). Why are plants green?
4. From all this, we think that the color of something might affect how much light energy it absorbs. **Albedo**=percentage of sun’s energy that is reflected without being changed. White=high albedo, black=low albedo.
5. Does everything heat up at the same rate, if it’s absorbing the same amount of light energy? Do air and water heat up at the same rate? Do they cool down at the same rate, or does one cool down faster? Have you noticed that a swimming pool is about the same temperature in day and at night, even though the air temperature can change a lot?
6. Both of these basic properties, the color and speed at which something heats/cools, affect climate and weather.
7. Move to next slide on powerpoint: photographs of sea ice in 1979 and 2003. The amount of sea ice has changed a lot—now the surface of the earth has a lot less white and a lot more black. Knowing what we know about how black and white absorb light (review this again), can we make a prediction about how melting sea ice will change the temperature? How will melting sea ice affect temperature (increase it)?
8. Let’s test it—show materials and thermometer. How would we want to test whether the color of something affects the rate at which it heats up or cools down? What treatments should we have? What should we measure?
9. We also want to know whether air and water heat up at the same rate. How would we test this?
10. Should we all build the boxes the same? Why? (discuss experimental controls, only changing one variable) Guide the students in making a very specific plan or set of instructions for constructing the boxes.

**Day 2:**

1. Begin by reviewing what we’re doing: testing how different colors and materials affect the rate of temperature increase. Review predictions: water will heat up more slowly than air, black paper will heat the air faster than white or green paper.
2. Review how to construct boxes, stress the importance of everybody doing it the same.
3. Get into groups and make boxes.

**Day 3:**

1. Head outside to test the effect of color on how fast air and water heat up and cool down from the sun.
2. Class should get 20 minutes of heating (measuring temp every 5 min), then cover boxes and measure cooldown for 10 min (measuring temp every 5 min).

**Day 4:**

1. Compile class data, averaging as appropriate. How you do this will depend on how the class collected data. If each group had one box/cup of each treatment, you will average everybody’s white cup and record that number (and so on, for the other colors/treatments). If each group had a different color/treatment but took replicate measurements, average the group’s data to get treatment means.
2. Make a figure of the class’s average data. Time (x axis) and temperature (y axis), using different colored lines for air and water, colors of paper. The Excel file provided (figs.xls) has room to enter six columns of data (for 6 groups). Change the column headers (Temp. 1, Temp. 2, etc) to treatment names. Enter each treatment, one in each column, and the results should graph themselves just below your data table. Display this figure with a projector for the class to see.
3. Discuss your results: Which treatment heated up the fastest? Is that what we expected? Why (relate to wavelengths of light absorbed)?
4. Did air or water heat up fastest? Which cooled down fastest? Is that what we expected?
5. If you did not get the results you expected, why? Was our hypothesis wrong, or was it not a fair test? (Could something else have affected our results?)
6. Relate to climate/weather: living near the ocean moderates temperatures—not so hot in summer and not so cold in winter. Next powerpoint slide has a map and data taken from<http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_4.html>, listing mean January and mean July temperatures for two pairs of cities at the same latitude (Los Angeles and Little Rock at 34\*N, Seattle and Bismarck at 47\*N). In general, coastal cities have cooler July and warmer January temperatures than inland cities. Discuss how Lake Michigan might affect Lawton’s weather.
7. Relate to albedo/climate change: melting glaciers and snow ice should make global warming happen faster because it decreases albedo.