CHICAGO BOTANIC GARDEN

Activity 1.4: Albedo, Reflectivity, and Absorption

Grades 5 – 6

Description: In this activity, students will explore how color affects reflectivity and heat absorption. Using black and white construction paper, students will measure heat absorption and make connections between the reflectivity (albedo) of different materials, the amount of heat absorbed by these materials, and the temperature of Earth.

Total Time: One 45-minute class period

Prior Knowledge
Students should be familiar with energy transformation and the different forms energy can take (light, heat, kinetic, etc.).

Materials
Per Class
- Topographical map or globe

Per Student
- Copy of student handout
- Pencil

Per Group
- Desk lamp
- 1 piece black construction paper
- 1 piece of white construction paper
- 2 thermometers
- Stopwatch
- Graph paper
- Ruler
- Tape or stapler

AAAS Benchmarks
- 4E/M4 Energy appears in different forms and can be transformed within a system…Thermal energy is associated with the temperature of an object…Light energy is associated with the frequency of electromagnetic waves.
- 4E/M6 Light and other electromagnetic waves can warm objects. How much an object's temperature increases depends on how intense the light striking its surface is, how long the light shines on the object, and how much of the light is absorbed.

Vocabulary (introduced in Activity 1.2)
- **Reflectivity**: The percentage of sunlight reflected by Earth's surface features (water, ice, snow, plants). Ice, especially with snow on top of it, has a high reflectivity. This means that most sunlight hitting the surface bounces back toward space. Water is much more absorbent and less reflective. So, if there is a lot of water, more solar radiation is absorbed by the ocean than when ice dominates.
- **Albedo**: The percentage of solar energy reflected from Earth back into space. It is a measure of the reflectivity of Earth's surface.
- **Energy absorption**: In the case of Earth's energy balance, it is the amount of light energy from the Sun converted into heat energy absorbed by the surface features of Earth (plants, earth, water) and its atmosphere. The energy that is not absorbed is reflected back out into the atmosphere.
- **Solar energy**: Light and heat energy from the sun.
- **Surface features of Earth**: topography (landforms), bodies of water, and ground cover that cover Earth's surface.

Guiding Questions

- How does the color of a surface affect the amount of solar energy absorbed?
- How does the amount of energy absorbed or reflected by different Earth surfaces affect the temperature of Earth?

Assessment(s)

- Student data collection sheets
- Student answer sheets

Before you start

- Collect black and white construction paper (you may also choose to use other earth-toned paper–green, brown, or beige) and cut in half
- Make sure you have enough heat lamps for one lamp per group
- Copy student handouts

Procedure:

1. Begin with a discussion using student experiences with head absorption and reflection. Write student responses on the board. Discussion questions might include:
    a. What colors do you tend to wear in the summer? In the winter? Why?
    b. Would you rather walk on bare feet on black asphalt or white concrete? Would your answer be different in the summer or winter? Why?
    c. Based on your answers, what might you hypothesize about the difference between light and dark colors?
    d. If necessary, review light to heat energy transformation. How does the sun feel on your face? (warm) How about when you put your hand close to a light bulb? (also warm). This is an example of light energy transforming and being absorbed as heat energy when it hits the surface of your skin.

2. Tell students they are going to do an experiment to test their hypothesis and find out how color affects a surface's ability to reflect or absorb heat. Depending on how much time you have and how independent your students are, you can either model creating the experiment or have students use the instruction sheet to carry out the experiment.

3. Divide students into groups of two to four students. Give each group an instruction sheet, two thermometers, a lamp, two different colored pieces of construction paper, tape or stapler, stopwatch, graph paper, and a ruler.

4. Have students carry out the experiment using the student instruction sheets. Allow 20 minutes for the experiment.

5. Once students have finished the experiment, bring the class back together to discuss the results. Students should notice that the black construction paper heated up more quickly, and more overall, while the white paper heated more slowly, and ended at a lower temperature, though results may vary.

6. Look at a map or a globe. Ask students based on their results which areas of Earth would reflect more radiation? Which would absorb more? Why? Write student answers on the board. Also have students write down their answers on their worksheet.

7. Ask students what this has to do with the temperature of Earth. Earth is all different colors. What do they think would happen if Earth were entirely black? Entirely white? Would the overall temperature be different?

8. Review vocabulary introduce in Activity 1.2: reflectivity, albedo, absorption, and explain to students that in their next activity they are going to use a climate model to look at how reflectivity, or albedo, affects Earth's global average temperature. They will be able to explore how changing the amount of light energy Earth's surface reflects impacts the temperature.

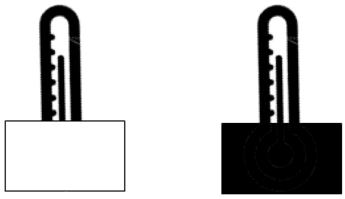
9. If there is time, you may have students watch this interactive visualization adapted from NASA and the United States Geological Survey. It illustrates the concept of albedo, which is the measure of how much solar radiation is reflected from the Earth's surface. http://www.pbslearningmedia.org/resource/ipy07.sci.ess.watcyc.albedo/

Investigating Reflectivity Instructions

1. You should have two paper rectangles, one white and one black. Fold each one in half and tape or staple the sides to make pockets that fit over the bulb of the thermometer.

2. Record the initial temperature of each thermometer on your worksheet, one in the black line and one in the white line.

3. Put one pocket over the bulb of each thermometer, making sure that you put the thermometer that you recorded on the black line in the black pocket and the thermometer you recorded on the white line in the white pocket.



4. Position the heat lamp 2 feet above the table.

5. Put both thermometers, with their different colored pockets, under the heat lamp.

6. Turn on the lamp, and start the stopwatch. You will collect temperature measures at 2-minute intervals for a total of 10 minutes. You will have six measurements at the end of the experiment. The initial temperature, and five measures of temperature during the experiment.

7. When you are done with the experiment, turn off the lamp.

8. Make a graph of your data, make sure you label each axis, and determine the appropriate intervals for your data.

9. Use your data to answer the questions on your worksheet.

CHICAGO BOTANIC GARDEN

Investigating Reflectivity Data Collection

Group Members:_____

_____

_____

1. Before starting the experiment, make a prediction. What do you think will happen to the temperatures of the two thermometers over time? Which will rise faster? Which will get hotter? Why?

2. Record starting temperatures for each of the two thermometers in the first column of the table below.

3. Start the experiment. Turn on the light and turn on your stopwatch. Record temperatures for both thermometers every two minutes during the experiment.

	Orig. Temp	2 min.	4 min.	6 min.	8 min.	10 min.
Black						
White						

4. Graph your data on the graph paper your teacher provided.

5. Looking at your data table and graph, which thermometer heated up more quickly? Which was slowest? Why do you think that was?

6. Was there a difference in the ending temperature after 10 minutes? Which was hotter? Explain why.

Class Discussion Notes

7. Look at a map or a globe. Which areas of Earth would reflect more radiation? Which would absorb more? Why?

8. What does the difference in heat absorption have to do with the temperature of Earth? What would happen if Earth were entirely black? Entirely white? Would the overall temperature be different?

9. Vocabulary Review
   Write the definitions of the following words:

   Reflectivity

   Albedo

   Absorption

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TEACHER ANSWER KEY

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_____

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