

Understanding Albedo

Levels V-VI



Grades 9-12

Overview:

Students learn about albedo and the ice albedo feedback effect as it relates to snow, ice, and the likely results of reduced snow and ice cover on global temperatures.

Objectives:

The student will:

- formulate a hypothesis about global warming based on the ice albedo feedback effect;
- set up a simple model to test his or her hypothesis;
- draw conclusions from his or her model; and
- demonstrate an understanding of how reduced snow and ice cover in the Arctic may affect global temperatures.

GLEs Addressed:

Science

- [9-11] SA 1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.
- [9] SA 2.1 The student demonstrates an understanding of the attitudes and approaches to scientific inquiry by formulating conclusions that are logical and supported by evidence.
- [10] SB 2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by examining energy (i.e., nuclear, electromagnetic, chemical, mechanical, thermal) transfers, transformations, and efficiency by comparing useful energy to total energy.

Materials:

- Desk lamp with a 60-watt bulb
- Black construction paper
- White construction paper
- Thermometers (2 for each pair of students)
- Scissors
- Stapler
- STUDENT WORKSHEET: "Albedo Lab"

Activity Procedure:

1. It is common knowledge that wearing dark clothing could result in a person feeling warmer than if they wore the same clothing in a light color. This is because of a property of all materials called albedo. When the sun shines on a surface, solar radiation or solar energy is either absorbed into or reflected off of that surface. Albedo is the measurement of how much solar energy is reflected off a surface. Materials that are lighter in color have a higher albedo than the same materials with a darker color. Black jeans have a low albedo; they reflect very little solar energy. White jeans have a high albedo; they reflect a large amount of solar energy.

Soil, water, and snow also have albedo measurements. Fresh snow reflects 90% of the solar energy striking its surface, so its albedo measurement is 90. This means that only 10% (100-90) of the solar energy that reaches the snow is absorbed. The albedo of a water surface depends on the angle at which the sunlight strikes it and whether the surface is smooth or rough. The average albedo of Earth as a whole is 30%.

TEACHER NOTE: The albedo of snow changes as snow ages and becomes discolored.

2. Ask students what has a higher albedo – ice or open-ocean? (*Ice*) Ask students if the Arctic Ocean’s albedo will change over time if the ocean remains ice-free for a longer period of time each year? (Yes.) Will the albedo increase or decrease? (*Decrease*) What does this mean for the amount of solar energy absorbed into the Arctic Ocean? (*It will increase*)

Explain that this phenomena is called the ice albedo feedback effect. A feedback effect or feedback loop is a loop within a system that continually increases (“positive feedback”) or decreases (“negative feedback”) the effects of the system. On Earth surfaces, solar energy that is absorbed is later emitted toward its surroundings as heat. In the case of the ground or ocean, much of that energy is emitted into the atmosphere and surface ice, warming the atmosphere or melting the ice. As ice on the surface of the ground and ocean melt, the overall surface albedo (ground or ocean and ice combined) lowers, causing more energy to be absorbed, and continuing the feedback loop.

3. In the Arctic, where snow and ice are present for long periods each year, a change in the albedo measurement of the surface can cause rapid climate changes. A small increase in atmospheric temperature can cause snow cover and ice to form later in the year, resulting in a lower albedo as dark soils and ocean waters are exposed to the sun’s energy.
4. Explain that students will conduct a lab to better understand the ice albedo feedback effect. Hand out the STUDENT WORKSHEET: “Albedo Lab” and ask students to work in pairs to complete the assignment.

Critical Thinking Concept: Activity Response Method. Explain that students will write a paragraph describing their response to the information they have just learned. They can begin their response with “I was surprised to learn...” or “I learned that...” or “I wonder if...”

Answers:

1. b
2. Answers will vary.
3. Answers will vary.
4. Answers will vary, but should match the data collected in question 3.
5. Answers will vary, but should use the data from question 3 and be calculated correctly.
6. black thermometer
7. black thermometer
8. ice
9. The ocean’s albedo would decrease, driving up ocean temperatures.
10. The ocean’s temperature would increase, and ice would form later in the year.

Name: _____

Albedo Lab

Student Worksheet (page 1 of 3)

Levels V-VI



Materials:

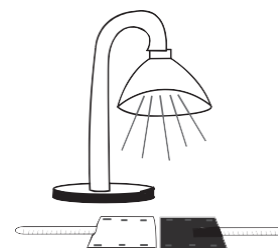
- stapler
- scissors
- desk lamp with a 60-watt bulb
- black construction paper
- thermometers (2 for each pair of students)
- white construction paper

Directions: Answer the question below and then work in pairs to complete the lab.

1. What is albedo?
 - a. Albedo is the percentage of radiant energy produced by the sun.
 - b. Albedo is the measure of how much radiant energy from the sun is reflected.
 - c. Albedo is the measure of how much radiant energy from the sun is absorbed.

Procedure: To study albedo, work in pairs to complete the following lab.

1. Cut two 4 ¼" by 5 ½" squares, one from black construction paper, one from white construction paper.
2. Fold each square in half twice.
3. Staple two edges of each square to form pockets.
4. Place the bulb end of each thermometer into the pocket.
5. Place the thermometers directly under the lamp so that they receive equal amounts of light. The lamp should be pointed straight down.



Hypothesis:

2. Make a prediction about the temperature of each thermometer. How will the temperature of each thermometer change over time? Which will get warmer? Which will rise fastest?

Data:

3. Allow two minutes for the thermometers to reach the temperature of the surrounding air. This will be the initial temperature for the lab. Record this initial temperature on the chart below. Turn on the lamp. Record the temperature of each thermometer every two minutes for the next 20 minutes. Be sure to use the same units (°F, °C) for both thermometers.

Thermometer	Starting	2 min.	4 min.	6 min.	8 min.	10 min.	12 min.	14 min.	16 min.	18 min.	20 min.
White											
Black											

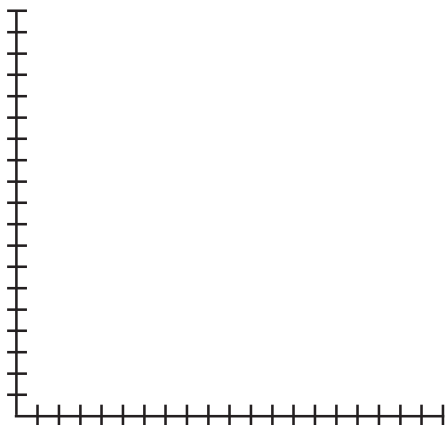
Name: _____

Albedo Lab

Student Worksheet (page 2 of 3)

4. Graph the data on the line graph below. Use a different color pen or pencil for each thermometer. Label the key and the axes of the graph.

KEY White Black



5. Subtract the starting temperature from the final temperature for each thermometer.

White: _____ - _____ = _____
(final temperature) (starting temperature) (increase in temperature)

Black: _____ - _____ = _____
(final temperature) (starting temperature) (increase in temperature)

Analysis of Data:

6. Which thermometer registered the warmest temperature?

7. Which thermometer registered the fastest rise in temperature?

Conclusion:

8. Based on your analysis of data, which surface has a higher albedo, ice or open-ocean?

Name: _____

Albedo Lab

Student Worksheet (page 3 of 3)

9. If an increase of 1 degree in global temperatures causes the Arctic Ocean to remain ice free for two additional weeks each year, how will it affect the ocean's albedo? Why?

10. If the ocean's albedo decreases, how will this affect ocean temperatures and ice formation in the winter? Explain.
