### Albedo Laboratory Teacher Guide

Driving Question: What effect does albedo have on surface temperature?

In this activity your students will:

- 1. Understand how light reflection and absorption are related to albedo.
- 2. Understand that lightly colored surfaces (snow and ice, for example) have a higher albedo than darker colored surfaces (trees, blacktop roads, etc.).



#### **Background Information**

The **albedo** of an object is a measure of how strongly it reflects light from light sources such as the Sun. Albedo is the percentage of incoming light that is reflected rather than absorbed. It is thought that the Earth's average albedo is around 30%. Energy in the form of visible radiation (light) from the Sun warms the earth. Some of the energy from the Sun is reflected back into space while some of the energy is absorbed. Clouds, snow, ice, land, and particles or pollutants in the atmosphere can all reflect energy back into space. The part that is absorbed by the Earth warms the surface, which then re-radiates energy (infrared) back out into space. The hotter the Earth's surface, the more energy is radiated out.

The diagrams below help to explain what happens to the energy from the Sun.

In general lighter colored objects tend to have a higher albedo, while darker colored objects absorb the Sun's energy. If the Earth receives more energy from the Sun than it sends back to space, the Earth gets warmer. If the Earth reflects more of the Sun's energy than it absorbs, the Earth gets colder.





Some of the radiation that is emitted by the Earth is absorbed by greenhouse gases in the atmosphere that re-emit the energy as heat back to the Earth's surface.



The classic example of albedo effect is the snow-temperature feedback. If a snow-covered area warms and the snow melts, the albedo decreases, more sunlight is absorbed, and the temperature tends to increase. The converse is true: if snow forms, a cooling cycle occurs. Below are some examples of objects and their albedo ratings. Numbers closer to 1 are considered to have a higher albedo, while numbers closer to 0 have a lower albedo. A high albedo means that material has a more reflective surface and can reradiate much of the Sun's energy away.

Surface	Typical Albedo
Fresh Asphalt	0.04
Conifer Forest (summer)	0.09-0.15
Worn Asphalt	0.12
Deciduous Trees	0.15-0.18
Bare Soil	0.17
Green grass	0.25
Desert Sand	0.40
New Concrete	0.55
Ocean Ice	0.5-0.7
Fresh Snow	0.80-0.90

If the Earth receives more energy from the sun than it sends back to space, the Earth gets warmer. If the Earth reflects more of the Sun's energy than it absorbs, the Earth gets colder. In general, lighter colored objects tend to have a higher albedo, while darker colored objects absorb the Sun's energy and have a lower albedo.

# Contractory Description

This experiment investigates how the color of a surface influences its ability to reflect or absorb heat. Students place temperature probes (or thermometers) within envelopes of black paper and white paper. Students measure and compare changes in temperature as the temperature probes (or thermometers) are heated with a high intensity lamp (or outdoors in sunlight).



#### Equipment List

For each laboratory team – Students should work in teams of 4.

- 1. 2 thermometers or temperature probes
- 2. 1 piece of **Black** colored paper
- 3. 1 piece of White colored paper
- 4. 1 high intensity lamp
- 5. Albedo Laboratory Student Guide
- 6. Albedo Laboratory Investigation Sheet



#### <sup>4</sup> Classroom Management Notes:

- 1. Students work in groups of 4.
- 2. Assign students in each group the following tasks:
  - a. **Temperature monitors (2 students).** The temperature monitors read the temperature for each apparatus when the timekeeper indicates.
  - b. **Timekeeper.** The timekeeper keeps track of the measurement intervals and tells the other group members when to take measurements.

c. **Recorder.** The recorder writes the observations and temperature measurements provided by the group.



## Guide the students through the following steps. A modified version of these instructions will be on the Albedo Laboratory Student Guide.

- 1. Instruct students to wrap the thermometers or temperature probes in paper.
  - a. Wrap one thermometer or temperature probe in a black paper envelope.
  - b. Wrap one thermometer or temperature probe in a white paper envelope.
  - c. How to make an envelope:
    - i. Take 4 1/4" by 5 1/2" square of paper.
    - ii. Fold each square in half twice.
    - iii. Staple or tape the edges of each square to form a pocket.
    - iv. Place the bulb end of the thermometer or probe into the pocket.



2. Instruct the students to place the wrapped thermometers directly underneath the lamp (or out in the sun). The light should be about 24 centimeters over the thermometers/envelopes. Each item should be arranged an equal distance from the light source. (Note: The lamp is not turned on yet.)



- 3. Instruct students to complete the *prediction section* on their investigation sheet. They should predict which envelope they think will heat the fastest and which envelope will reach the highest temperature, thus having lower albedo.
- 4. Measurement Overview: The temperature readings for both thermometers (or probes) should be checked and recorded every 2 minutes for a total of 10 minutes. After the 6-minute measurement, students should discuss and note which color paper (white or black) has the highest temperature. After the 8-minute measurement has been taken, students are to turn off the light. One more temperature reading is gathered at the 10-minute mark.

#### 5. Step-by-Step Procedure

- a. **BEFORE:** Instruct students to measure temperature prior to turning on the light bulb. Prompt students to record the temperature in the **BEFORE** column.
  - i. Emphasize to your students that it is important to know the temperature both before and after the light is turned on. This provides a starting point so changes in temperature can be discussed accurately.

#### b. TURNING THE BULB ON

- i. Begin timing immediately after turning the light on.
- ii. Measure and record temperature in the **0-minute** column on the worksheet.
- c. 2-MINUTE INTERVALS: Students will take and record temperature measurement on their Albedo Data Collection Table every 2 minutes for the first 8 minutes of the experiment with the light on. Remind students that the time labels at the top of the data chart are elapsed time. Teachers will:
  - i. Prompt students to record the temperature in the correct time column as needed.
- d. **6-MINUTE INTERVAL**: After students have collected data for **6 minutes**, instruct them to discuss and note which color paper (white or black) has the lowest albedo (which envelope appears to have absorbed the most heat) and which color paper has the highest albedo (which envelope appears to have absorbed the least heat). Prompt students to record this information as "**high**" or "**low**" in the **Albedo Ranking** row on their data table.
- e. 8-MINUTE INTERVAL: Instruct students to turn off the light bulb immediately after the temperatures are recorded for the 8-minute interval. Remind students to not turn off their temperature data recorder if they are using a temperature probe.
- f. At the 10-minute interval instruct students to measure the temperature for each color.
- g. **Instruct** students to calculate the **Heat Increase** the difference between the **start measurement** and **the 8-minute** interval temperature – and record the difference on their Albedo Data Collection Table.
- Instruct students to calculate the Heat Retention the difference between the 8-minute and the 10-minute intervals - and record the difference on their Albedo Data Collection Table.
- i. Instruct students to complete the **Albedo Lab Analysis** questions #1-6 on their investigation sheet.



## Step 3: Group Discussions

Review and discuss student question responses from the students' investigation sheet. See **Albedo Lab** - **Assessment** for sample answers.