SNOW PENNIES

Overview:

Students apply knowledge about albedo by making observations in the environment, working through energy ratio data, and designing an experiment to prove or disprove a hypothesis about snow melt.

Objectives:

The student will:
- identify the initial source and resulting change in forms of energy;
- describe an experiment and make inferences to explain the results; and
- organize and display data into a histogram.

Targeted Alaska Grade Level Expectations:

Science

[7-8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating.

[7] SA1.2 The student demonstrates an understanding of the processes of science by collaborating to design and conduct simple repeatable investigations, in order to record, analyze (i.e., range, mean, median, mode), interpret data, and present findings.

[7]SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by explaining that energy (i.e., heat, light, chemical, electrical, mechanical) can change form.

[8] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by identifying the initial source and resulting change in forms of energy in common phenomena (e.g., sun to tree to wood to stove to cabin heat).

Math

[8] S&P-1 The student demonstrates an ability to classify and organize data by [designing, collecting (L)], organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers or community), using histograms, scatter plots, or box and whisker plots with appropriate scale [or with technology (L)].

Vocabulary:

absorption – the taking up and storing of energy (such as radiation, light or sound) without it being reflected or transmitted

albedo – the proportion of the incident light or radiation that is reflected by a surface

heat – thermal energy that flows from an object or substance at a higher temperature toward an object or substance at a lower temperature

radiation – the emission or movement of electromagnetic energy through space or a medium, such as air

reflection – the turning back of a wave (such as a light or sound wave) when it encounters a boundary; reflected waves return immediately to their original medium instead of entering the medium they encounter

Whole Picture:

The light that reflects off snow can be blinding. Before Western-style sunglasses were introduced, the Athabascan people used the technology of the snow goggle to limit the amount of light that reached the eyes. Cutting and shaping a piece of cottonwood bark to fit over the nose and across the eyes, then placing narrow slits over the eyes, reduced the amount of reflected light and prevented snow blindness for subsistence hunters. Elder Robert Charlie remembers using snow goggles. "I had to use it when I used to be out doing my subsistence way of life. Let's say, March, when it snows, it's much brighter than other times and you are out walking, taking

care of your trapping activity and the sun is shining very bright on the fresh snow—that's when you have a good chance of having snow blindness."

In Western science, the amount of energy that snow is reflecting is a topic of study. The reflectivity is called Albedo. It is common knowledge dark-colored clothing is warmer than light-colored clothing. The scientific property behind this difference is called albedo. When the sun shines on a surface, solar radiation, or solar energy, is either absorbed into or reflected off that 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.

Albedo affects Earth's environment. Soil, water, and snow also have albedo measurements. Fresh snow reflects 90 percent of the solar energy striking its surface, so its albedo measurement is 0.90. This means that only 10 percent (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 percent. As snow ages and becomes discolored, its albedo changes.

The climate system is characterized by strong positive and negative feedback loops between processes that affect the state of the atmosphere, ocean, and land. A simple example is the ice-albedo positive feedback loop whereby melting snow exposes more dark ground (of lower albedo), which in turn absorbs heat and causes more snow to melt.

A feedback effect, also known as a feedback loop, is a cycle within a system that continually increases ("positive feedback") or decreases ("negative feedback") the effects of the system. The climate system is characterized by strong positive and negative feedback loops between processes that affect the state of the atmosphere, ocean, and land. A simple example is the ice-albedo positive feedback loop whereby melting snow exposes more dark ground (of lower albedo), which in turn absorbs heat and causes more snow to melt. In the northern oceans melting sea ice exposes more dark water (of lower albedo), which in turn absorbs heat and causes more ice to melt.

In the Arctic, where snow and ice are present for long periods each year, a change in the albedo of the surface can cause rapid climate changes. Climate models predict far more warming in the polar regions than in the tropics. In the past few decades, temperatures have risen about twice as fast in the Arctic as in the rest of the world. This is largely because of the high albedo of snow and ice. As snow and ice melt, the exposed darker surfaces absorb more heat. This sensitivity to climate makes it more difficult to model climate responses at the poles.i

Materials:

- Pennies, preferably 1982 or later to ensure all have the same metallic composition (nine per group)
- Snow or blocks of ice
- Containers that are at least 4 inches x 4 inches x 4 inches to hold snow or blocks of ice (one per group)
- Heat lamps (one per group)
- Timer (one per group)
- Ruler
- Black permanent marker
- White correction fluid or non-water-soluble paint
- VIDEO: "Albedo: Reflections from the Surface"
- STUDENT WORKSHEET: "Albedo"
- STUDENT LAB SHEET: "Snow Pennies"

Activity Preparation:

(NOTE: This activity may take a substantial amount of time. Once students design their experiment you may want to have them make observations at regular intervals throughout the day, rather than continuously observing the snow.)

1. Blacken one third of the pennies with black magic marker, cover one third of the pennies with white correction fluid, and leave one third as they are. Make enough so that each group of three students will have a least three of each type.

2. Scout for an area to conduct Activity Procedure steps one and two. Look for items that have landed and melted small holes into the snow or ice.
3. Write the vocabulary words with definitions on the board or on chart paper.

Activity Procedure:

1. Take students outside to observe how small objects that are on snow or ice, like spruce cones, small branches, gravel, sand, dog feces, pieces of bark, etc., eventually end up below the surface of the snow where they first landed (or were placed). (NOTE: This observation will be easiest to make when there has not been a fresh snowfall for at least a few days, the temperature has been fluctuating between the 10°F and 30°F, and there is plenty of daylight.)
2. Ask students to explain why they think objects on the snow seem to tunnel into the snow. If they think the objects melted their way into the snow/ice ask them how this could be when the temperature has been below freezing. If they say the sun heated up the objects ask why the sun did not heat up the snow around the tunnel too. Some students may state or imply that no melting has occurred, but the objects weight compacted the snow. Ask the class how they might test this idea. Return to the classroom.
3. Review the vocabulary words written on the board or chart paper. Use examples from around the classroom to illustrate. The overhead lights are radiating light, objects in the room reflect and absorb that light, etc. Explain the word albedo is used by scientists to talk about reflectivity in the environment. For example, fresh snow has the highest reflectivity of all Earth's natural surfaces. It reflects up to 90 percent of sunlight. Dirt reflects only about 5 percent of sunlight. The rest is absorbed. Albedo is an important factor when studying climate and climate change. As Earth warms, snow cover decreases. Less snow means less energy is reflected and more energy is absorbed. When Earth's surface absorbs more energy, temperature increases. Warmer temperatures mean less snow and the cycle is set in motion.
4. Show students the video component, "Albedo: Reflections from the Surface." Start with Global Energy Balance, then move on
   to Snow Reflects Energy and Snow-Albedo Feedback. Pass out STUDENT WORKSHEET: "Albedo," and ask students to complete.
5. Divide students into small groups. Hand out STUDENT LAB SHEET: "Snow Pennies." Explain each group will design an experiment, with a testable question and a hypothesis, about albedo using a block of ice or container of snow, a set of nine pennies, a timer, a ruler and a heat lamp. Each experiment must have:
   - a testable question
   - a hypothesis
   - one variable (experimental group), and a control group
   - a way to measure and keep track of results

   Possible testable questions include:
   a. How does the color of the penny affect how much ice/snow it can melt?
   b. How does the distance between the objects affect how fast the ice/snow melts?
6. Draw an example of a bar graph on the board. Instruct groups to use the data collected from their group's experiment to graph their results, and then determine if the data does or does not support their hypothesis. Students should have their hypothesis and plan/procedure approved before collecting materials to begin.

   Tell students:
   - The heat lamp must be at least 12 inches away from the surface of the ice or snow.
   - The heat lamp and its bulb will be hot and should not be touched.
   - They can use the ruler and timer in any way they need in their experiment.
   - They will have _____ (determined by teacher) amount of time to design and implement their experiment.
   - They will have _____ (determined by teacher) amount of time to complete their graph and worksheet. They can put the graph on the back of their lab packet or use a fresh piece of paper.
   - Time permitting, students can share results with the rest of the class at the end.

Critical Thinking Questions:

1. What type of energy did the heat lamp emit, and what type of energy was this turned into when it hit a penny or the ice/snow? How did the color of the penny affect this process?
2. How could you use what you learned during this activity to help you pick a color of house paint if you lived in a cold area that did not get hot in the summer? How about if you lived in a desert that was sunny and hot the whole year?

Extension Idea:

Allow students to design a similar experiment using materials other than pennies.

Answers:

STUDENT WORKSHEET: "Albedo"

1. a. Vegetation; b. White Concrete; c. Black Asphalt; d. Bare Soil
2. Highest reflectivity: snow
   Highest absorption: black asphalt
3. (50% + 78% + 30% + 3%)/4 = 40.25%
4. The reflectivity = 100%, so 300 watts/ 1000 watt) x 100% = 30%. According to the table the surface is likely bare soil.
5. Answers will vary.
6. The crossword puzzle answers are: 1: reflection; 2: albedo; 3: absorption; 4: radiation; 5: heat

STUDENT LAB SHEET: "Snow Pennies"

Answers will vary.

NAME: _____

ALBEDO

What you need to know

absorption – the taking up and storing of energy (such as radiation, light, or sound) without it being reflected or transmitted

albedo – the proportion of the incident light or radiation that is reflected by a surface; reflectivity

heat – thermal energy that flows from an object or substance at a higher temperature toward an object or substance at a lower temperature

radiation – the emission or movement of electromagnetic energy through space or a medium, such as air

reflection – the turning back of a wave (such as a light or sound wave) when it encounters a boundary; reflected waves return immediately to their original medium instead of entering the medium they encounter

When sunlight reaches Earth's surface, some of the light energy is absorbed and some is reflected. The energy that is absorbed contributes to heating things on the surface. The reflected light is what we use to actually see what is around us. Scientists measure the reflectivity and absorption in terms of percentage of energy that falls on the body. The combination must add up to 100 percent. For example, if 100 watts of light energy falls on a snowy surface, 80 watts will be reflected and 20 watts will be absorbed.

The term "albedo" is a scientific term used to talk about how energy is reflected by an object. Albedo is given a range from 0 to 1. An object that reflects no light whatsoever would have an albedo of 0. Most land areas are in the albedo range of 0.1 to 0.4.

Figure A - Reflectivity Map

A. **50%**	B. **78%**
C. **3%**	D. **30%**

Table 1 - Reflectivity Chart

Material	Reflectivity
Snow	80%
White Concrete	78%
Bare Aluminum	74%
Vegetation	50%
Wood Shingle	17%
Water	5%
Black Asphalt	3%
Bare Soil	30%

1. Look at the Reflectivity Map (Figure A) and the Reflectivity Chart (Table 1). What are the likely compositions of the areas in the map?

   A. _____ C. _____

   B. _____ D. _____

2. What material (on the chart) has the highest reflectivity? _____

   What material (on the chart) has the highest absorption? _____

NAME: _____

ALBEDO

3. Using Figure A, what is the average area of these four equal-area regions combined? Use the back of this page to work out the math, then write your answer below.

_____

4. You are doing some measurements near the school. You note that 1000 watts of light energy hit the surface; 300 watts are reflected and the rest are absorbed. What is the reflectivity of the surface? Looking at Table 1, what is the surface likely to be?

_____

Critical Thinking

5. There is a thermometer near the community center in your town/village. That temperature is recorded each day at noon and at midnight and the temperature readings are put into the town records. The parking lot is currently bare soil. Next summer there is a plan to pave the parking lot with black asphalt. Do you think the change will affect the temperature readings? Why or why not?

_____

_____

_____

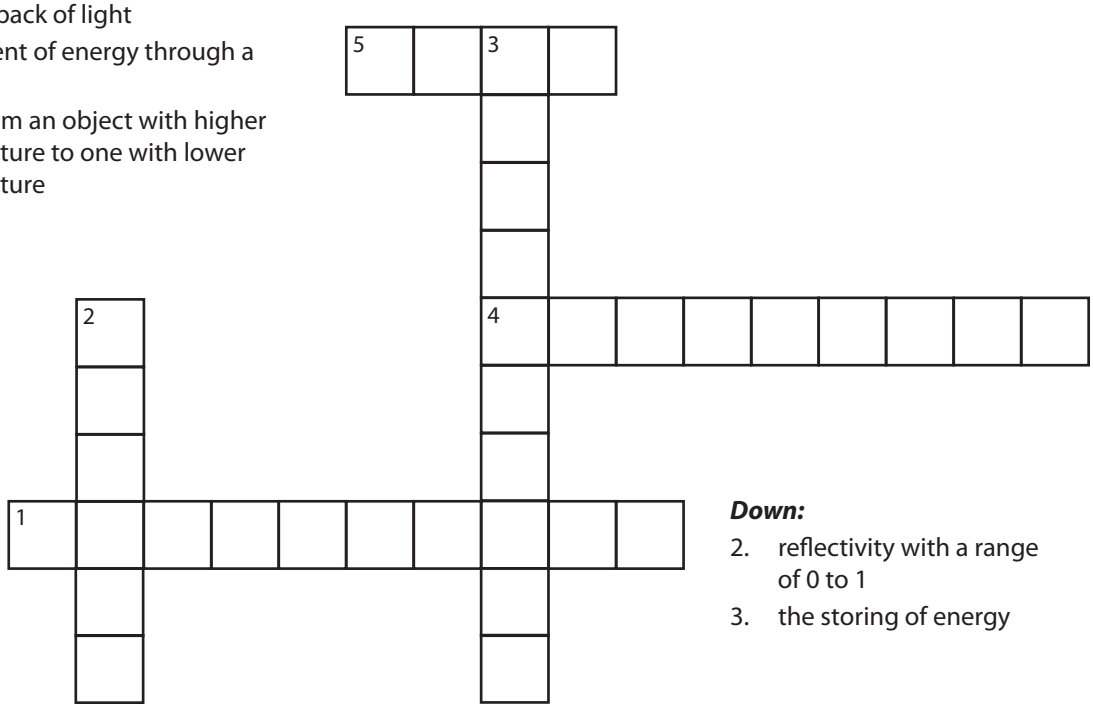
_____

Vocabulary Review

Using the vocabulary words on page one, please complete the crossword puzzle below.

Across:

1. turning back of light
4. movement of energy through a medium
5. flows from an object with higher temperature to one with lower temperature



Down:

2. reflectivity with a range of 0 to 1
3. the storing of energy

NAME: _____

SNOW PENNIES

Testable Question:

_____

_____

Hypothesis:

_____

_____

_____

Materials:

- Container with ice or snow
- Set of nine pennies: three plain, three painted black, three painted white
- Timer
- Heat lamp

Directions: Design an experiment that has one variable (experimental group), and a control group. Include a way to measure and keep track of your results. Your teacher must approve your hypothesis and plan before you begin.

NOTE: ***Your heat lamp must stay 12 inches from your ice or snow.***

Variable:

_____

Control:

_____

Method of data collection:

_____

_____

Plan:

(Use this area to make notes, write your plan and draw a diagram.)

NAME: _____

SNOW PENNIES

Data Collection:

(Use this area to record your data as you collect it. Refer to your plan. Remember that you will be using your data to make a graph.)

Variable

Control

Conclusion:

Was your hypothesis proved or disproved? Use complete sentences to explain.

_____

_____

_____

_____