Lesson Plan

Reflecting on Reflectivity

In a Nutshell:

Students plan and construct a "mini-lab" to measure the reflectivity of different earth surfaces. They measure reflectivity of materials, including ice, soil, rocks, etc., and then extrapolate from what they have learned to consider the impacts of melting ice on the Arctic.

Goal:

To have students evaluate the reflectivity of natural surfaces and then relate the significance of albedo and changing albedo to northern climate change.

Background Learning:

Before starting this activity, students should be familiar with the basic science of climate change as reviewed in:

- High School Backgrounder #1:
  Climate Change: What's the Big Deal?
- High School Backgrounder #2:
  The Greenhouse Effect

Towards the end of the lesson, students will read:

- High School Backgrounder #7:
  The Changing World of Water and Ice

Grade Level: 9–12

Subjects: Sciences, Social Studies, Geography, Northern Studies

Enrichment: Science, Social Studies, English Language Arts

Time: Two to four hours

Setting: Classroom

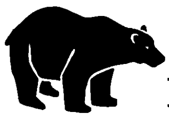
Materials: Copies of the backgrounders, copies of student handout (if you decide to use it), cardboard box, black paper, data-logger (e.g., PASCO 500), with light-sensor fitting, flashlight, various construction materials (glue, tape, scissors, Exacto knife), earth surface materials to measure, e.g., soil, rocks, leaves, snow, clear ice (freshwater), sea ice

Skills: Problem-solving, invention, research, measuring, observation, inference

Key Vocabulary: Greenhouse effect, albedo, reflectivity, feedback loops (positive and negative)

Learning Outcomes:

Visit the website and click on the icon for your territory to review the learning outcomes that are addressed by this lesson.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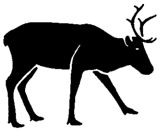
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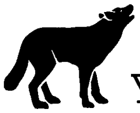
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Introduction to Lesson Plan:

This lesson combines the excitement of planning and constructing a reflectivity "mini-lab," the skills of scientific observation and measurement, and a broader reflection on what these scientific measurements will mean for the north. The one piece of sophisticated equipment you need is a data-logger with a light-sensor attachment. (PASCO 500 is one model; there are others.) If you don't have one in your school, see if you can borrow one.

Grade 11 students at Tusarvik School, Repulse Bay, in Nunavut constructed their "reflectivity lab" in the form of a cardboard box lined with black paper (to stop incidental reflection). A hole was cut into the upper side of a box, and an internal hood constructed over it, so that the beam of the flashlight was directed entirely to the surface at the bottom of the box. The light meter was mounted on the top of the box so that it picked up only the light reflected from the surface below. The class developed a system to allow them to slide trays of various earth surface materials into the bottom of the box. This mini-lab allowed them to measure the reflectivity of different surfaces.

This experiment served as a jumping-off point for reflection on the impacts of northern climate change.

Activity:

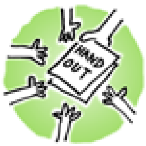
1. Introduce the students to the basics of climate change. For ideas on how to interact with the backgrounders, see the lesson entitled *Getting Into the Backgrounders*. As well, explain the concepts of albedo, reflectivity, and feedback loops (positive and negative) – see the Glossary, and More Information, below. Decide whether you want to distribute copies of *Student Handout: Albedo*, describing the basics of the albedo effect.

2. Pose the problem: to design a mini reflectivity lab that will accurately measure the reflectivity of different surface materials. Present the available materials and explain their uses. Challenge students to plan a design for the mini-lab that will ensure that the variables are controlled – the reflectivity of materials will be measured accurately. You may want to divide the class into groups for part of this process, having each group plan and present a design. Then build the mini-lab.

3. With the students, decide how you will record the measurements you are collecting. Make sure the students each keep accurate records as you measure the reflectivity of layers of different textures: e.g., soil, rocks, leaves, snow, clear ice (freshwater), sea ice.

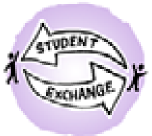
4. Establish that ice reflects a greater amount of light than other substances such as dirt. (Note: Ice and snow are both very reflective: Fresh snow reflects up to 95% of incoming radiation.) Discuss what this means for the north – if there was less ice, how much energy wouldn't be reflected? What would happen to this energy? (Answer: The concern with the melting ice is what lies beneath it… the incredible heat capacity of water (something that students may need to be familiar with) makes it able to absorb and disperse a large amount of heat energy.) What effect would this have on land around? (Answer: Increased energy absorption would lead to increased temperatures, which would lead to increased melting – a positive feedback loop.) If there are questions that you and the students don't know the answers to, write them on a section of the board or on chart paper.

5. Give the students copies of *Backgrounder #7: The Changing World of Water and Ice*. Invite them, using the results of their experiment, to write up a report on the experiment and what the results might mean for the north. Challenge them to use some of their new vocabulary – greenhouse effect, reflectivity, albedo, feedback – in their reports.



Handouts:

Visit the website and click on the icon for the handout that supports this lesson – *Student Handout: Albedo.*



Student Web-Exchange:

Post student reports, along with pictures of your mini-lab, on the Student Exchange. Visit the website and click on the icon for information on how to post material.

Evaluation:

Evaluate students on:

- participation in the experiment
- records of experiment
- reports on the experiment and impacts on the north

More Information:

Feedback loops (positive and negative) – http://nsidc.org/arcticmet/patterns/feedback_loops.html

Information on melting ice, the Arctic, and more – www.solcomhouse.com

Enrichment Ideas:

Science/Social Studies/ English Language Arts

Researching Reflectivity: Invite students to decide on a research question arising from the experiment and discussion. (Check the unanswered questions collected by the class – there might be some good questions there.) Direct them to the web links under Resources, and suggest search words to help them find the information they need to create an essay, an informational poster or a future news report.

About the Author:

Brent Urie has taught at Tusarvik School for four years. Tusarvik School is a K–12 school with 220 students. It's located in Repulse Bay, a coastal community of 650 people, right where the Arctic Circle meets the west coast of the Hudson Bay. As well as teaching phys-ed, math and science, Brent coaches the men's volleyball team, which won the Territorial competition and is headed for the 2004 Arctic Winter Games.

There are many things Brent likes about teaching in Repulse Bay: great fishing, lots of hunting, and a great variety of wildlife, from polar bears to narwhal and beluga whales. People are very friendly. "People in the community are teaching me how to hunt," explains Brent, who came to Repulse Bay after teaching in South Korea, Colombia, and Mexico.

Student Handout

Albedo

Planetary albedo is the ratio between incoming and reflected radiation at the top of the atmosphere. This includes effects of reflection from the atmosphere, mainly clouds, and surface albedo. On average 24% of incoming radiation is reflected by low altitude clouds and water vapor, and ozone in the stratosphere. Low clouds reflect most sunlight and have little effect on the energy reflected by the earth, helping to cool the current climate. In other words, low clouds do not trap energy that is headed for space. While higher temperatures are the result of high clouds that reflect less radiation and trap more emitted energy. **Changes in the atmosphere can alter climate by changing the amount of solar radiation that reaches the Earth's surface.**

Cloud Overcast	% of incoming radiation reflected
Cumuliform	70–90 %
Stratus (500–1,000' thick)	59–84%
Altostratus	39–59 %
Cirrostratus	44–50 %

Surface albedo is the ratio of incoming radiation to reflected radiation where the atmosphere comes in contact with Earth's surfaces (the boundary between earth surface and the atmosphere). Reflectivity is the capacity of an object to reflect solar radiation. It depends on radiation wavelength and the physical composition of the object. Soil reflectivity varies because of variations of moisture content, particle size, organic matter content, surface roughness, and mineral composition. Vegetation reflectivity varies with how much of the ground it covers, leaf size and area and plant growth stage. Snow reflectivity varies with crystal size, compaction, age, and liquid water content. Water reflectivity is affected by turbidity, depth, and concentrations of small aquatic plants called phytoplankton. Water albedo is lowest when the sun is near zenith and increases to near 100% when the sun is near the horizon. Here are samples of some of Earth's surface albedos in percentages.

Water Surfaces

Winter:	
0° latitude	6
30° latitude	9
60° latitude	21
Summer:	
0° latitude	6
30° latitude	6
60° latitude	7

Bare Areas & Soils

Snow, fresh-fallen	75–95
Snow, several days old	40–70
Ice, sea	30–40
Sand dune, dry	35–45
Sand dune, wet	20–30
Soil, dark	5–15
Soil, moist gray	10–20
Soil, dry clay or gray	20–35
Soil, dry light sand	25–45
Concrete, dry	17 –27
Road, black top	5–10

Natural Surfaces

Desert	25–30
Savanna, dry season	25–30
Savanna, wet season	15–20
Meadows, green	10–20
Forest, deciduous	10–20
Forest, coniferous	5–15
Tundra	15–20
Crops	15–25

Albedo varies with geographic region and time of year since snow and ice are generally highly reflective. The temperature difference between the Tropics and the Poles is the driving force behind the circulation of the Earth's atmosphere and oceans, thus creating winds and ocean currents that carry excess heat and moisture. When the moisture encounters cooler temperatures as it moves to the poles, clouds form and reduce the emission of energy to space. Any change in surface albedo will alter climate by drastically changing the amount of solar energy absorbed by the planet.

When the angle of the sun to the surface is low (closer to the horizon), solar energy is less intense since it is spread out over a larger area. Changes in this angle are one of the controlling factors that that make latitude one of the strongest influences on climate. The other controlling factor is the length of day. For latitudes of 66.5* and above, the length ranges from zero during winter solstice to 24 hours during summer solstice. The Equator has a constant 12-hour day all year long. The seasonal range of temperature therefore decreases from high latitudes to the tropics.

Human Effects On Earth's Albedo

Suggestions have been made that human modifications of the Earth's surface may be altering the planet's albedo. It has been said that overgrazing in desert regions can increase surface albedo as much as 20%. It has also been estimated that such changes may suppress rainfall, which can enhance the process of desertification. And again it's possible for extensive deforestation in tropical rain forests to increase surface albedo and result in a major climatic change.