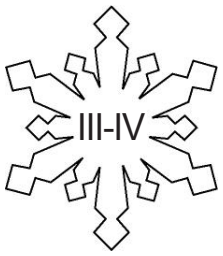
Melting the Ice: Energy Transfer

Levels



Grades 5-8

Overview:

Students observe a discrepant event, explore thermal energy and energy transfer, and apply their knowledge of energy transfer to sea ice processes.

Objectives:

The student will:

- follow step-by-step directions to make ice cream;
- observe a demonstration of thermal energy transfer;
- make a prediction;
- recognize that there are many different forms of energy; and
- illustrate the types of energy transfer that occur in sea ice processes.

GLEs Addressed:

Science

- [5-8] 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.
- [6] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by recognizing that energy can exist in many forms (i.e., heat, light, chemical, electrical, mechanical).
- [6] SB3.1 The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by recognizing that most substances can exist as a solid, liquid, or gas depending on temperature.
- [8] SD3.2 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by recognizing types of energy transfer (convection, conduction, and radiation) and how they affect weather.

Materials:

- 2 400-milliliter beakers
- Tablespoon and teaspoon for measuring
- Kosher salt (4 tablespoons per student + 1 tablespoon)
- Water
- Food coloring
- Ice cube trays
- Milk, canned evaporated or fresh (4-6 ounces per student)
- Vanilla (1/2 teaspoon per student)
- Can opener, if using canned milk
- Sugar (1 tablespoon per student)
- 4 cups crushed ice (per student)
- Sandwich-size re-sealable plastic bags (2 per student)
- Gallon-size re-sealable plastic freezer bag (1 per student)
- Towel or gloves (1 per student)
- Spoon (1 per student)
- OVERHEAD: "Radiation"
- OVERHEAD: "Conduction and Convection"
- STUDENT INFORMATION SHEET: "Plastic Bag Ice Cream"
- STUDENT WORKSHEET: "Melting the Ice"

Activity Preparation:

1. The day before the lesson or sooner, mix together plain water and food coloring and pour into ice cube trays. Freeze.
2. The day of the lesson, fill 2 400 milliliter beakers with water. Stir 1 tablespoon of kosher salt into one of the beakers.
3. Ensure that colored ice cubes are at an easy to reach location.

Teacher's Note: Regular salt can be used in this lesson. However, because it contains impurities, it will cause a cloudy appearance in the water. Kosher salt is pure NaCl and will darken, but not cloud the water.

Activity Procedure:

1. Ask the class if anyone knows how ice cream is made. Explain that in this lesson students will make ice cream in a plastic bag. Distribute the STUDENT INFORMATION SHEET: "Plastic Bag Ice Cream" and materials. Assist students, as needed, in making their ice cream.

Teacher's Note: Be aware of students who may have allergies to milk and milk products. If making and eating ice cream in the classroom is not possible or practical, the activity can be done as a demonstration. Alternatively, set an ice cube on a plate where all students can see. Then, sprinkle salt over the ice. Explain that the salt lowers the freezing point of the ice, causing it to revert to a liquid state.

2. As students are eating their ice cream, discuss how the salt and ice work together to freeze the cream mixture. Explain that when salt comes in contact with water, it lowers the freezing point, allowing the melted ice and salt mixture to reach a lower temperature than would otherwise have been possible. When making ice cream, the ice draws heat away from the milk, cooling it. Mixing the salt and ice together, and surrounding the cream in the mixture creates an environment in which the cream can become cold enough to freeze, allowing it to form ice cream.
3. The process that allowed the ice cream to form is called energy transfer. Energy is the ability to do work; it's what causes things to happen. Food contains energy that allows us to work and play. Lamps use electrical energy to run. There are many different forms of energy including thermal (heat), chemical, electrical, magnetic, and mechanical. Thermal energy is what drives weather and sea ice formation, as well as the formation of ice cream.
4. Thermal energy moves around the universe in three different ways: conduction, convection, and radiation.
5. Show OVERHEAD: "Radiation." Explain that radiation is the method by which the sun transfers energy to Earth's surface. When solar radiation hits Earth's surface, land or water, it is either absorbed or reflected. The ice reflects most of the sun's radiation, but the ocean absorbs most of it. This warms the surface of the ocean.
6. The heat or thermal energy that has been transferred to the ocean from the sun is then transferred to the ice or atmosphere around it by a process called conduction. Show OVERHEAD: "Conduction and Convection." Explain conduction occurs when energy is passed directly from one item to another, like heat from a stove is transferred to a pot. The heat from the ocean will transfer to the ice that is on the surface of the water.
7. If students completed the "Convection and Wind" lesson, remind them of the investigation and how convection was related to wind. Explain that convection works the same way in the ocean. As the water loses heat from conduction to the ice, it cools and sinks, driving warmer water to the top in a circular motion, just like soup is heated in a pot on the stove.

8. Sea ice growth and melt is a direct result of thermal energy. When cold air cools the ocean by drawing heat from the water through conduction, ice begins to form. As the ocean temperature nears the freezing point, the water density increases and the water sinks. Warmer water that replaces it must also be cooled. In this way, more than just the surface of the ocean must reach the freezing point before ice can form.
9. Once the ice begins to grow, it acts as an insulator between the ocean and atmosphere, slowing down conduction, and also as a barrier from solar radiation, preventing thermal energy transfer by radiation. A layer of snow on the ice reduces the energy transfer from radiation even further.

Critical Thinking Question: ***What If? Method.*** Before performing the following demonstration, ask students what will happen to ice as it melts in a beaker of regular water and a beaker of saltwater. List student predictions on the board.

---

10. Inform students they will be watching the same demonstration they did in the "Saltwater Science" lesson, in which an ice cube was placed in a beaker of freshwater and another was placed in a beaker of saltwater.
11. Place the two beakers of water and saltwater, which are room temperature, in a location where students can see. Explain one beaker contains water and one beaker contains saltwater.
12. Place one colored ice cube in each beaker and watch as the ice cubes melt.
13. Divide students into small groups and ask each group to use the information they just learned to explain why the ice in the two beakers behaved differently. When ready, ask students to share their explanations with the class. (NOTE: Students will likely use density in their explanation. Encourage this explanation and guide students to include energy transfer in their explanation.)
14. If necessary, explain that the heat from the water caused the ice to melt. As the ice in the regular water melted, the cool water sank to the bottom of the beaker. Warmer water from the bottom of the beaker rose to the top, creating convection. The convection assured that the warmer water was always at the top of the beaker.
15. In the beaker with saltwater, the ice cube also melted. However, in this case, the denser saltwater resulted in the cold water staying at the top of the beaker. This meant that the ice in the saltwater beaker was always in colder water due to lack of heat transfer. The ice in the regular water was always in warmer water. As a result, the ice in the saltwater melted at a slower rate that the ice in the regular water.
16. The difference could be seen in the coloring from the ice cube. In the regular water, color was mixed throughout, in the saltwater it was all at the top.
17. Distribute the STUDENT WORKSHEET: "Melting the Ice" and divide the class into groups. Explain that students should illustrate convection, conduction, and radiation as they apply to ice melt. Instruct students to draw individual illustrations on their worksheet, and then share their illustrations within their group. Invite individual students to share their illustrations with the class as a whole.

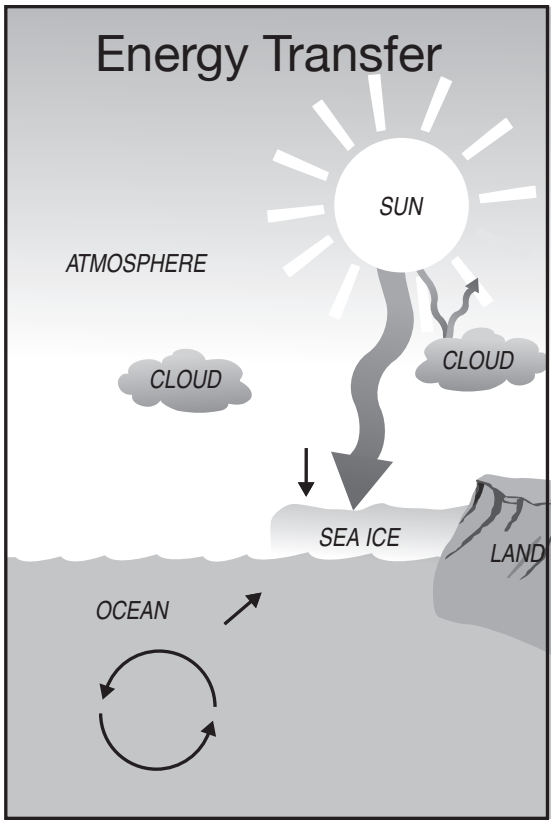
Extension Idea: If students are mathematically inclined, they may desire to estimate ice thickness using the following formula and data from the Science Observation Network at http://www.arcticclimatemodeling.org/son/index.html.

$$1.33 \times \frac{\text{-1.8 ˚C - avg. daily temperature}}{\text{total days below freezing}}$$, where 1.8 ˚C is the freezing temperature of ocean water. ([7] E&C-4)

Answers:

Answers will vary, but should resemble the following:

1.



2. The ocean warms the ice through conduction. The atmosphere warms the ocean through conduction. The sun warms the ocean and the ice through radiation. The ocean redistributes energy within itself by convection.

3. D

Rubric:

Scientific Drawing. Use this rubric to assess students' performance, as best fits the class, and/or allow students to assess their own performance.

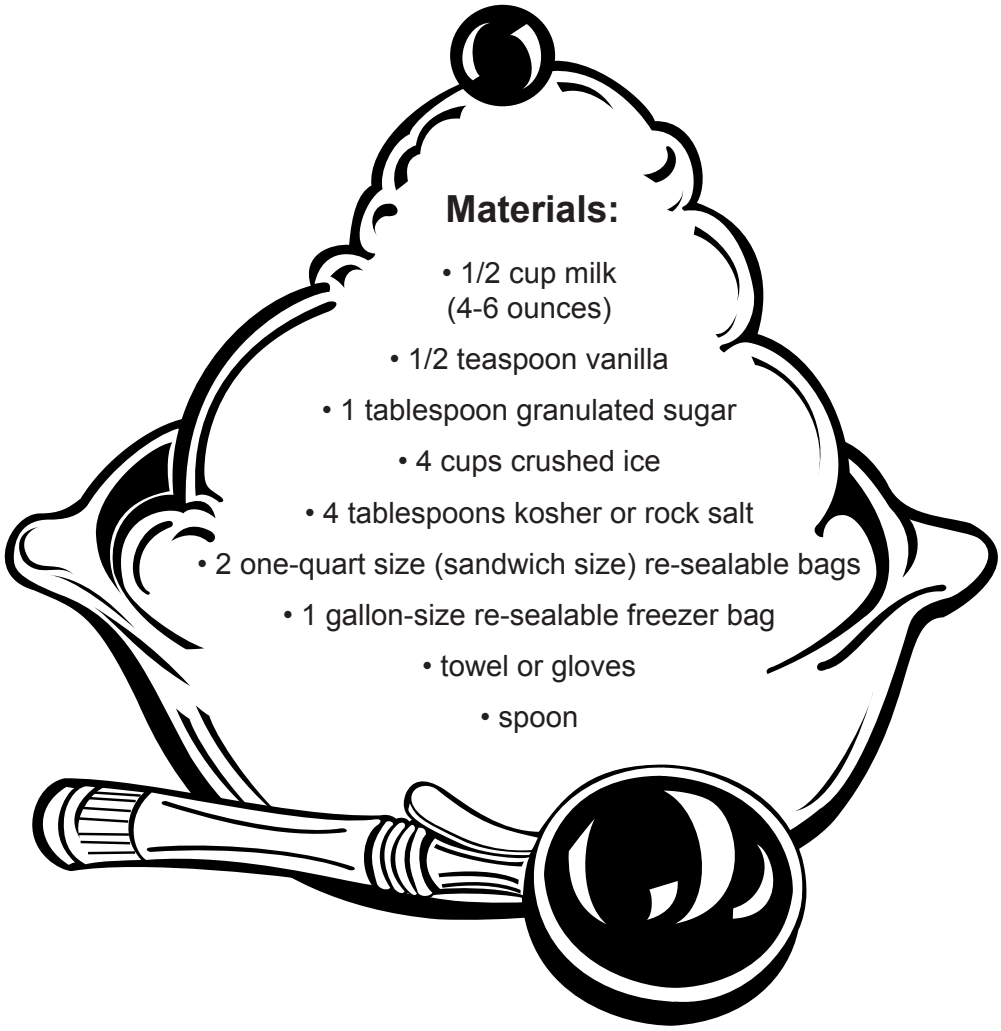
Performance Measure	Self	Teacher
1. My drawing looks very similar to what I learned.		
2. My drawing only includes what I actually learned, not what I think should be included.		
3. I labeled all the parts of my drawing.		
4. I provided a written explanation of my drawing.		
5. My drawing is of appropriate size for details to be easily recognized.		

Plastic Bag Ice Cream

Student Information Sheet

Levels

III-IV



Procedure:

STEP 1. Carefully pour the milk, vanilla and sugar into one of the smaller re-sealable bags. Seal tightly, squeezing out as much air as possible.

STEP 2. Place the bag with the mixture inside the other small bag and seal it, leaving as little air as possible.

STEP 3. Place the ice inside the one-gallon re-sealable bag.

STEP 4. Place the two small bags containing the mixture inside the larger bag with the ice. Make sure the ice surrounds the bags with the cream mixture.

STEP 5. Sprinkle the salt over the ice in the larger bag.

STEP 6. Seal the larger bag, letting as much air escape as possible.

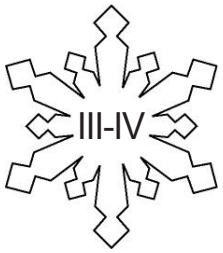
STEP 7. Wear gloves or wrap bag in a towel.

STEP 8. Shake and massage the bag for approximately eight minutes.

STEP 9. Remove small bags from large bag, open, and eat!

Name:_____

Levels



Melting the Ice

Student Worksheet

1. Draw the local environment including the ocean, sea ice, atmosphere, and sun. Use arrows to indicate processes of energy transfer. Label the drawing.

2. Explain your drawing.

_____

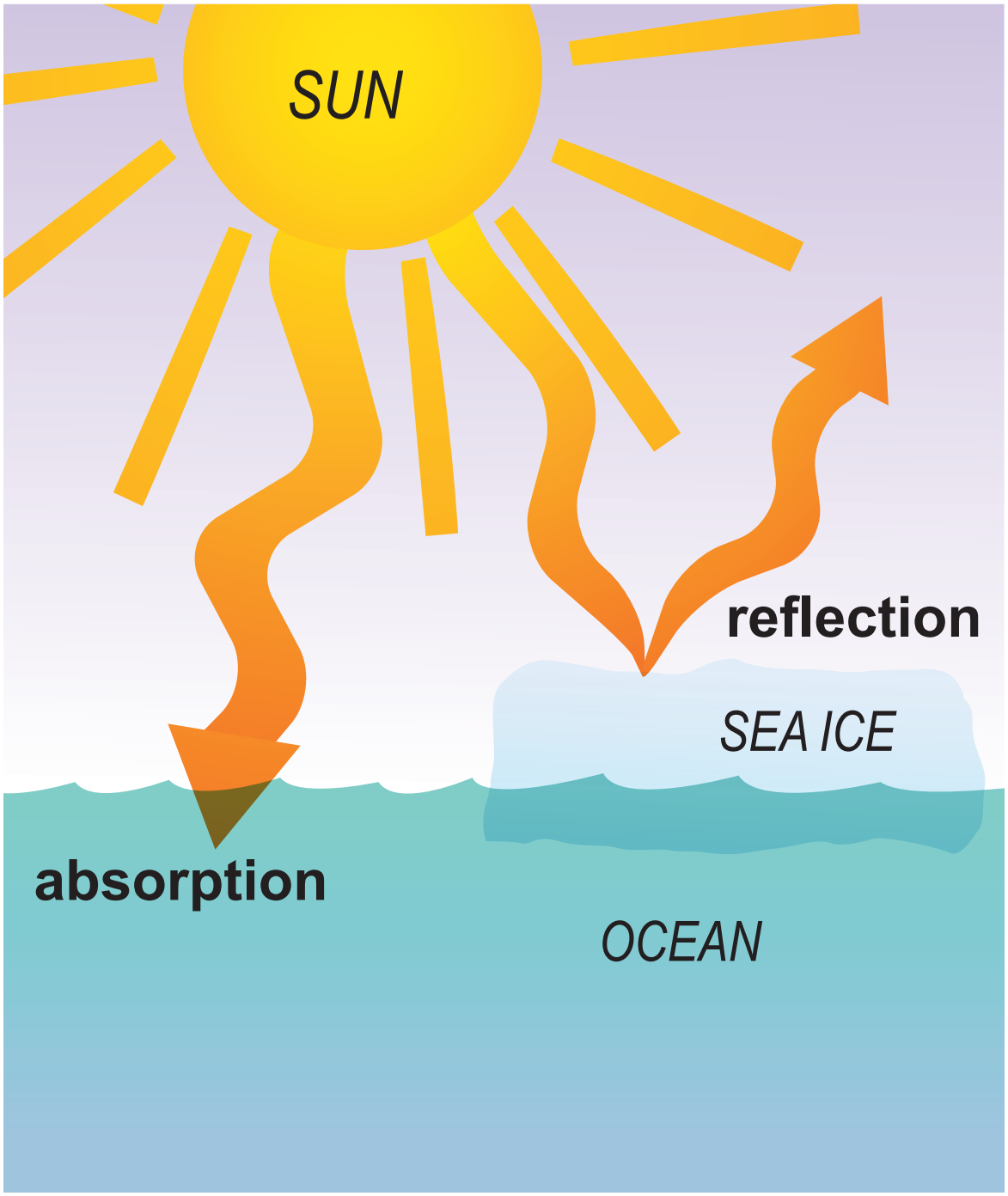
_____

_____

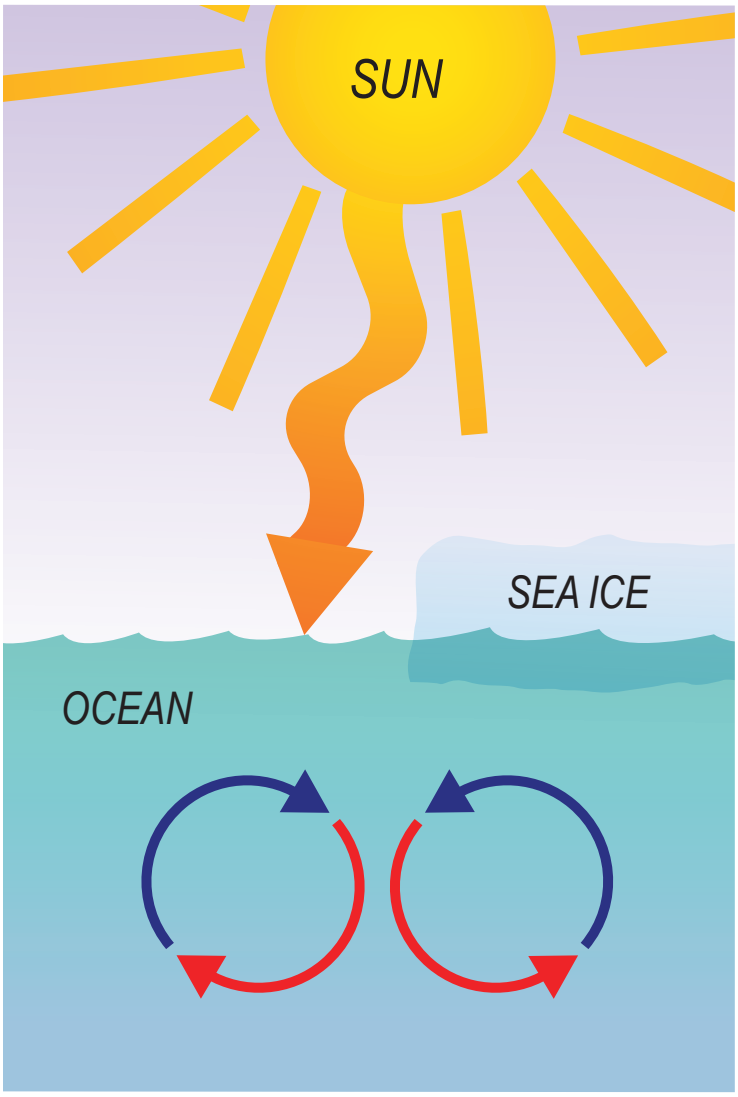
_____

3. What forms of energy exist?
   A. mechanical
   B. electrical
   C. thermal
   D. all of the above

Radiation
Overhead



Conduction and Convection
Overhead



Thermal energy from the sun is transferred to the ocean by **conduction**.

Ocean is heated by **convection**. The warmer water rises. Cool water falls to take the warmer water's place.