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Overview

Even though the sun is our most abundant source of energy, only a small fraction of the solar energy that hits the earth is absorbed by it, and an even smaller fraction of that amount is able to be converted to usable forms of energy, such as heat and electricity. The activities in this Delta Science Module provide students with the opportunity to understand what is involved in making use of this very valuable natural resource.

In the first activity, students are introduced to photosynthesis and the role that the sun plays in plant growth. As a class, they construct two terrariums and place one in a sunny location and the other in a dark place. After 7-10 days, students compare the rate of growth in the two terrariums and conclude that solar energy is necessary for the growth and health of plants.

In Activity 2, students build solar collectors to investigate the transfer of solar energy from energy source (the sun) to energy receiver (the collector—a solar tray filled with water). In doing so, students also discover the effect that a cover has on the retention of heat absorbed by a solar collector.

Activity 3 teaches students about the importance of color in the absorption and reflection of solar energy. By comparing the water temperature of a black tray with that of a white tray, students conclude that the black tray absorbs much of the solar energy that hits it while the white tray reflects much of the solar energy that hits it.

In Activity 4, students set out four trays, each containing a different amount of water, and conclude that the smaller the volume of water, the more quickly it heats up.

Is exposure time a determining factor in the amount of solar energy absorbed? In Activity 5, students measure the change in water temperature in their collectors over the course of 90 minutes. They conclude that the longer the collector is exposed to the sun, the more energy it will absorb, up to a point.

Activities 6, 7, and 8 introduce students to the concept of a controlled experiment. Each team of students establishes a control solar collector which acts as the standard to which the experimental collectors are compared. Among the variables tested are the angle at which the sun's rays strike the solar collector (Activity 6), the use of a reflector (Activity 7), and the type of solution in the collector (Activity 8).

In Activity 9, students apply what they have learned in previous activities regarding the factors which allow the maximum absorption of solar energy to design and construct the most efficient solar collector.

The students discover in Activity 10 that partially obscuring a solar collector reduces the amount of solar energy absorbed by the collector. Then the students observe the conversion of solar energy to electrical energy in an electric motor powered by a solar cell. Finally, they observe how partially covering a solar cell reduces the amount of energy the cell collects. The results of this can be seen in the reduced speed of the motor.

In Activities 11 and 12, students investigate heat exchange. They learn that heat travels from warmer to cooler objects, and they experiment with different insulating materials to see which is most effective at minimizing the transfer of heat.

Finally, in Activity 13, students construct solar stills and observe how contaminated water can be distilled (purified) using solar energy.

Materials List

Qty		Description
1	c	aluminum foil
8		bottles, plastic, 2-L
16		cardboard squares
2		containers, 6-L
2		containers, fluted
32		containers, round
8		cups, calibrated, 1-oz
1	c	food coloring, blue, 1 pt
32		lids, for small tumblers
1		motor, electric
2	c	salt, 26 oz
2	c	seeds, grass, p/1000
1	c	soil, 4 qt
1		solar cell
32		solar tray covers
32		solar trays, black
8		solar trays, white
2		spoons, measuring
32	c	sticks, wooden
1	c	tape, masking
16		thermometers, Celsius
32		tumblers, large
32		tumblers, small
1		video, *Solar Energy*
2		wire leads, with clips
1		teacher's guide

Teacher provided items

Qty		Description
1		eraser, board
-		foam packing pieces
-	c	ice cubes, small
1	c	milk, 0.5 gallon
6		newspaper, sheets
1		pencil
1		pencil sharpener (manual)
1		pitcher (insulated)
16		rulers
-		sand or soil
1		scissors
-	c	tap water
1		VCR

c = consumable item

Activity 2
Transferring Solar Energy

Objectives

Students investigate the transfer of solar energy and the effect that a cover has on the retention of heat absorbed by a solar collector.

The students

- discuss the sun as an energy source
- observe evidence of the transfer of solar energy
- measure the change in water temperature in covered and uncovered solar collectors
- conclude that a covered solar collector retains more heat than an uncovered solar collector
- graph their results

Schedule

Session I – About 50 minutes
Session II – About 40 minutes, 45 minutes after setting up the experiment in Session I

Vocabulary

energy
energy receiver
energy source
energy transfer
solar collector
solar energy

Materials

For each student

1	Activity Sheet 2

For each team of two

1	solar tray cover
2	solar trays, black
1	thermometer, Celsius
2	tumblers, large

For the class

2	containers, 6-L
1	*eraser, board
1	*pencil
1	*pencil sharpener, manual
12 L	*water, tap

*provided by the teacher

Preparation

1. Make a copy of Activity Sheet 2 for each student.
2. Select an area outdoors where 32 solar collectors can be left undisturbed for 45 minutes in direct sunlight.
3. At least two hours before the start of the activity, fill two 6-L containers with tap water and place them in the shade near where the students will conduct their experiments.
4. Each team of two will need two black solar trays, one solar tray cover, two large tumblers, and a thermometer.

Background Information

The sun is an immense sphere of glowing, hot gas located about 150 million km (93 million miles) from the earth. The sun radiates energy called *solar energy.* Only one two-millionth of all the solar energy that the sun emits actually reaches the earth. Of this, about one-third is reflected by snow, deserts, and clouds; the other two-thirds is absorbed by water in the atmosphere, by the surface of the earth, and by plants.

A *solar collector* is a device that absorbs solar energy and converts it to energy that can be used for heating water, heating and cooling buildings, or for generating electricity. If the technology existed that would enable us to collect and store the solar energy falling just on Lake Erie, we could fulfill all of the energy needs of the entire United States.

In this activity, each team of students makes two solar collectors, one with a cover and one without. Students discover that while the same amount of solar energy is transferred to both collectors, the temperature of the water in the covered tray gets higher than that in the uncovered tray. This is because the cover traps a layer of air which acts as an insulator to retain the heat in the water. Air circulating over the surface of the water in the uncovered tray, on the other hand, causes heat to escape from the water into the air.

Name _____ Activity Sheet 2

Transferring Solar Energy

Starting Time _____		**Ending Time** _____	
	Starting Temperature (°C)	**Final Temperature (°C)**	**Change in Temperature (°C)**
Uncovered Solar Tray	20°C	24°C	+ 4°C
Covered Solar Tray	20°C	34°C	+ 14°C

1. Record the starting temperature of the water and the starting time.

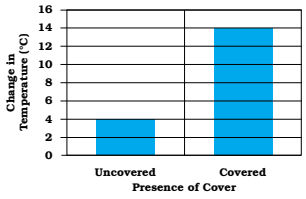
2. I predict that the water will be warmer in the _____ solar tray.
I predict that the water temperature in that tray will be _____ °C.

I predict that the water will not be as warm in the _____ solar tray.
I predict that the water temperature in that tray will be _____ °C.

I predict this will happen because _____

3. After 45 minutes, record the final temperatures of the water and the ending time. Calculate and record the change in temperature for each tray.

4. Make a bar graph to show the change in temperature in each solar tray.



5. What can you conclude about the importance of a cover on a solar collector?
Water retains more of the heat that it has absorbed if a cover is used.

Teaching Suggestions

Additional Information

Session 1

Write the word *energy* on the board. Ask, **What is energy?**

1

Students will probably say that energy is force or power.

Tell students that energy is defined as the ability to do work.

Write *energy source*, *energy receiver*, and *energy transfer* on the board. Ask a student volunteer to stand a few feet away from you. Tell the student that you will toss an eraser and that he or she should catch it.

Toss the eraser. After the eraser has been caught, ask, **What do you think is the energy source in this demonstration? the energy receiver? the evidence of energy transfer?**

Students may respond that the muscles in your throwing arm are the energy source, the hands catching the eraser are the energy receiver, and the eraser moving from teacher to student is evidence that energy is being transferred.

Show them another example by sharpening a pencil in a manual pencil sharpener. Ask, **What do you think is the energy source? the energy receiver? the evidence of energy transfer?**

2

Your arm muscles are the energy source, the pencil is the energy receiver, and the sharpened tip of the pencil and the pencil shavings are evidence of an energy transfer.

Copy Figure 2-1 on the board.

3

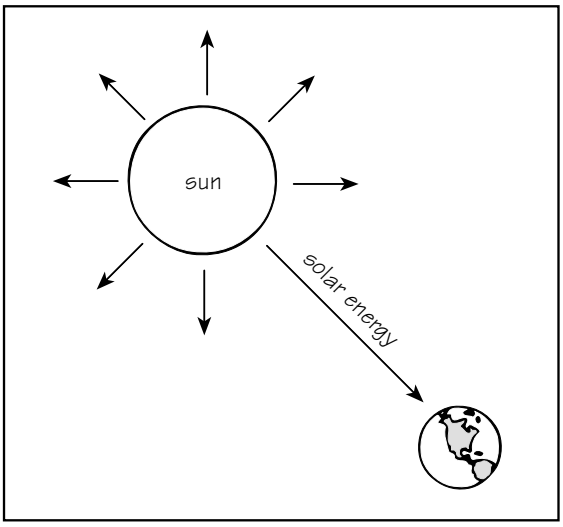


Figure 2-1. The sun emits solar energy, some of which strikes the earth.

Ask, **What do you think is the energy source in this diagram? the energy receiver? the evidence of energy transfer?**

The students will probably answer that the sun is the energy source and the earth is the energy receiver, but they may be confused as to what is the evidence of energy transfer.

Write the term *solar energy* on the board. Explain that energy from the sun is called solar energy and that something that has been heated up by the sun is evidence of energy transfer.

Ask, **How do you think you could collect energy from the sun?**

Students may have many different answers. They may mention solar-powered calculators, solar panels on the roofs of houses, or other examples they have seen.

Write the term *solar collector* on the board. Explain that a solar collector is a device that absorbs energy from the sun. Tell students that they will construct their own solar collectors using trays of water.

4

Distribute a copy of Activity Sheet 2 to each student. Divide the class into teams of two and distribute two black solar trays, one solar tray cover, two tumblers, and a thermometer to each team.

Tell students that in this activity they will observe evidence of energy transfer as well as experiment to find out what effect a cover has on the heating of water in a solar collector. Tell them that they will conduct the experiment outdoors and will need to bring all of their materials, including Activity Sheet 2 and a pencil, with them.

5

Take the students to the predetermined location outdoors. Show them the two 6-L containers of water, and have one member from each team fill two tumblers to the bottom of the frosted rim. Have the other team member measure the starting temperature of the water in each tumbler. This information should be entered in the chart on Activity Sheet 2.

If necessary, review with students how to use a thermometer.

Tell the teams to pour one tumbler of water into each of their two trays. Have them position the trays so that the wide, angled side of the troughs in each tray are facing the sun.

Have the students tilt each tray so that the liquid is evenly distributed among the troughs in the tray. The position of the trays is very important and will be discussed in more detail in a later activity.

Tell the teams to place a cover on one of their two solar trays and to note on the activity sheet the time at which the cover was added (starting time).

Tell the students that they will return to the site in about 45 minutes to measure the temperature of the water in each solar tray. Return to the classroom. Have the students bring their tumblers, thermometers, activity sheets, and the two 6-L containers with them.

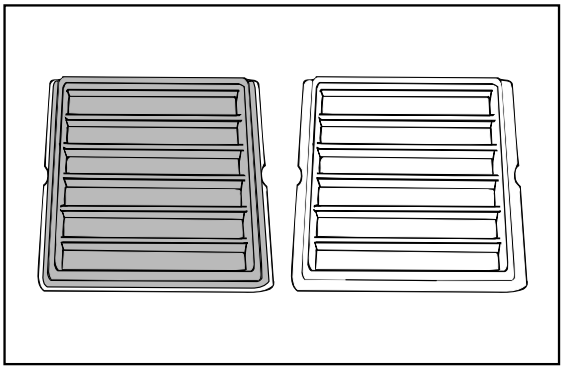


Figure 2-2. Two solar trays, one with a cover and one without.

Once back in the classroom, ask, **What do you predict will happen to the temperature of the water in your solar collectors?** Have the students write their predictions on their activity sheets.

6

Many students will realize that the temperature of the water in both collectors will increase because the collectors are sitting in the sun. Students may or may not know how the cover will affect the temperature of the water in the tray it was placed on.

Session II

Return to the site about 45 minutes after setting up the experiments. Have the students bring their tumblers, thermometers, and activity sheets with them.

7

Tell the teams to pour the contents of each solar tray into a tumbler and to measure the temperature of the water in each tumbler. Tell them to record on Activity Sheet 2 the final temperatures and the time at which they were taken (ending time).

When the students are finished, tell them to dump out the water, collect all of their materials, and return to the classroom.

Once back in the classroom, begin a discussion by asking, **Why do you think you got these results?**

8

There should be general agreement that the temperature of the water in each tray increased because the water was heated by the sun. Students will probably have various opinions as to why the water in the covered solar tray got warmer than the water in the uncovered solar tray.

Explain to students that the water inside the covered tray retained more of the heat it absorbed from the sun because the cover trapped a layer of air inside the collector, preventing the heat from escaping into the atmosphere. The water in the uncovered tray lost some of the heat it absorbed from the sun because the air circulating over the surface of the water removed heat from the water.

Ask, **What do you think is the energy source in this experiment? the energy receiver? the evidence of energy transfer?**

The sun is the energy source, the water is the energy receiver, and the change (increase) in water temperature is evidence of an energy transfer.

Have students complete Activity Sheet 2. Tell them that in the activities that follow, they will experiment to find out what other factors affect the heating of water in the solar trays. Explain that from now on they will use covers on all of their solar trays.

Reinforcement

Students who think that the air heated the water should be encouraged to experiment further by placing one tray in the shade and one tray in the sun and covering both trays.

R Ask them to explain the difference in water temperature now that the cover is no longer a variable in the experiment.

Cleanup

Have students return the 6-L containers, solar trays, covers, tumblers, and thermometers to the kit.

C

Science at Home

Have students investigate why their parents cover pots and pans while cooking food.

How do the covers help speed up the cooking process?

Connections

Science Extension

Students may have seen "solar tea" being made in a television commercial for iced tea. Let groups of students do this themselves, as follows. Put three or four tea bags in a quart jar, fill the jar with water, screw on the lid, and let the jar stand in direct sunlight for an hour or two. (The length of time needed to steep the tea will depend on the time of year and the angle of the sun's rays.) If different groups use different flavors of herb tea, students can taste each other's varieties. *Note:* You may want to combine this activity with the first Science Extension in Activity 5 (making sun-dried fruit) and the second Science Extension in Activity 7 (cooking hot dogs in solar cookers) so that students can make a "solar lunch."

Help students relate what they learned about the covered and uncovered trays to the types of clothing worn in hot and cold weather. For example, on a hot summer day, would they feel cooler wearing a hat with ventilation holes in it or a hat that allows no air movement through it? Which hat would be warmer in cold weather? How does thermal clothing help keep people warm? (Tiny spaces trap and hold warmer air next to the body.) Why does wearing several lighter-weight layers of clothing keep you warmer than one heavy sweater? (Layers trap warm air between them.)

Science and Health

Tell students that our bodies make vitamin D when our skin is exposed to the ultraviolet rays in sunlight. Encourage students to research and report on the functions of vitamin D in the human body and the diseases caused by a vitamin D deficiency. Also ask students to find out what foods are good sources of dietary vitamin D.

Science and Language Arts

Ask students to research the derivation of the word *solar.* (from the Latin *solaris,* from *sol,* meaning "sun") Also ask students to suggest definitions for the words *solarium* and *solarize.* Let students use a dictionary to verify or correct their definitions.

Science and Math

Have interested students research the distance between the earth and the sun (93,000,000 miles) and the speed of light (186,000 miles per second). Ask students to use these numbers to calculate the length of time it takes for energy produced by the sun to reach the earth. (500 seconds, or 8 minutes and 20 seconds)

Encourage students to research the origin of and differences between the Fahrenheit and Celsius thermometer scales. What are the freezing and boiling points of water on each scale? (freezing: 32°F, 0°C; boiling: 212°F, 100°C) Ask students to suggest reasons why scientists use the Celsius scale. Have volunteers show the rest of the class how to convert readings between the two scales.

$$°C = \frac{°F - 32}{9} \times 5 \qquad °F = \frac{9}{5}°C + 32$$

Science and Social Studies

As a follow-up to the second Science Extension above or as an independent activity, suggest that students research the types of clothing that are traditionally worn in extremely hot and extremely cold areas of the world. If students' families originally came from such areas, encourage them to bring in items of clothing to show and explain to the rest of the class.