

# Solar Energy and Tray Color

## BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

### Grade 5—Quarter 2

#### Activity 15

**SC.B.1.2.2**

*The student recognizes various forms of energy (e.g., heat, light, and electricity).*

**SC.B.1.2.3**

*The student knows that most things that emit light also emit heat.*

**SC.B.1.2.4**

*The student knows the many ways in which energy can be transformed from one type to another.*

**SC.B.1.2.5**

*The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.*

**SC.B.1.2.6**

*The student knows ways that heat can move from one object to another.*

**SC.H.1.2.1**

*The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.*

**SC.H.1.2.2**

*The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.*

**SC.H.1.2.3**

*The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.*

**SC.H.1.2.4**

*The student knows that to compare and contrast observations and results is an essential skill in science.*

**SC.H.1.2.5**

*The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.*

**SC.H.2.2.1**

*The student knows that natural events are often predictable and logical.*

SC.H.3.2.2

*The student knows that data are collected and interpreted in order to explain an event or concept.*

## **ACTIVITY ASSESSMENT OPPORTUNITIES**

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. Remind the students that they are using a series of experiments to test factors that affect the transfer of solar energy. Ask them to identify the factor tested in the last activity, and the factor tested in this activity. (In the last activity, we tested covering the container. In this activity, we tested tray color.) Ask the students to use their data or the bar graph to estimate how many times hotter the water got in the darker container. (The water was about two times hotter in the black solar energy collector.)
2. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

# Solar Energy and Tray Color

## OBJECTIVES

Students investigate the importance of color in the absorption and reflection of solar energy.

### The students

- ▶ measure the change in water temperature in black and white solar collectors
- ▶ conclude that the darker the collector, the more energy it absorbs; the lighter the collector, the more energy it reflects
- ▶ graph their results

## SCHEDULE

About 1 hour

## VOCABULARY

absorb  
reflect

## MATERIALS

### For each student

- 1 Activity Sheet 15
- 1 pr safety goggles\*

### For each team of four

- 1 solar tray, black
- 1 solar tray, white
- 2 solar tray covers
- 2 thermometers, Celsius
- 2 tumblers, large



### For the class

- 2 containers, 6-L
- 12 L water, tap\*
- DSR *Earth, Moon, and Sun*

\*provided by the teacher

## PREPARATION

- 1 Make a copy of Activity Sheet 15 for each student.
- 2 Select an area outdoors where 16 solar collectors can be left undisturbed for 40 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 four will need one black solar tray, one white solar tray, two solar tray covers, two tumblers, and two thermometers.

## BACKGROUND INFORMATION

An object may have the ability, because of some physical property, to **reflect** the energy that strikes it. Energy that is not reflected is **absorbed** by the object.

Most of the solar energy that reaches Earth is absorbed by the atmosphere, land masses, and oceans. The amount of energy absorbed depends on many factors, one of which is the color of the substance or object absorbing the energy. The darker the color, the more energy that is absorbed. The lighter the color, the more energy that is reflected (see Figure 15-1).

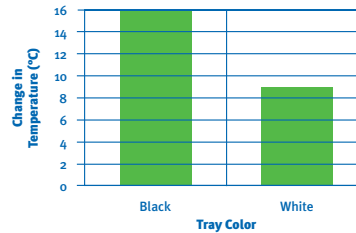
When a water-filled solar collector absorbs solar energy, the water in the collector heats up. In this activity, the black solar trays will absorb much of the energy that hits them while the white solar trays will reflect much of the energy that hits them. As a result, the water in the black trays will become warmer than the water in the white trays.

▼ **Activity Sheet 15**

**Solar Energy and Tray Color**

	Starting Time _____		Ending Time _____	
	Starting Temperature (°C)	Final Temperature (°C)	Change in Temperature (°C)	
Black Solar Tray	20°C	36°C	+ 16°C	
White Solar Tray	20°C	29°C	+ 9°C	

- Record the starting temperature of the water and the starting time.
- 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 \_\_\_\_\_  
\_\_\_\_\_
- After 40 minutes, record the final temperatures of the water and the ending time. Calculate and record the change in temperature for each tray.
- Make a bar graph to show the change in temperature in each solar tray.



- What can you conclude about the importance of a color of a solar collector?  
A darker solar collector will absorb more solar energy and heat the water inside to a higher temperature.

**Guiding the Activity**

- Ask, **What are some ways in which you can change the temperature of the water in a solar tray?**

Tell students that in this activity they will experiment to find out how the color of a solar tray affects the temperature of the water in the tray.

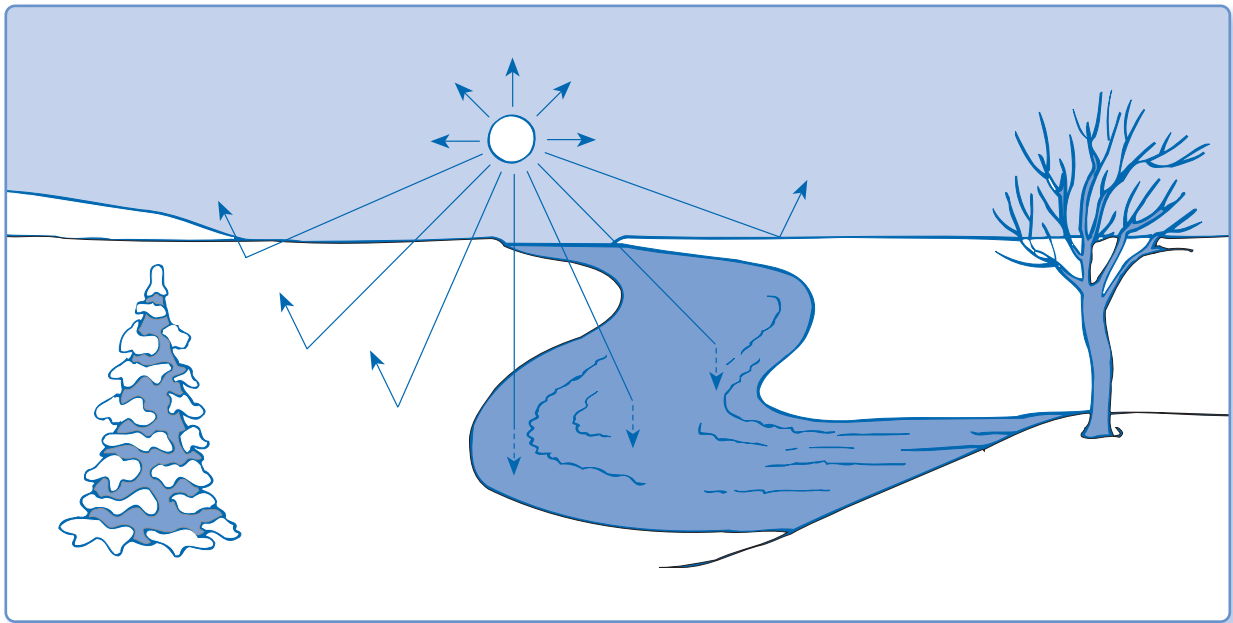
- Distribute a copy of **Activity Sheet 15** to each student. Divide the class into teams of four and distribute one black solar tray, one white solar tray, two solar tray covers, two tumblers, and two thermometers to each team. Tell the students that they will set up their experiments outdoors and to bring all of their materials, including Activity Sheet 15 and a pencil, with them.

**Additional Information**

*Record all suggestions on the board, and encourage students to keep thinking of more ideas during the next several activities.*

## Guiding the Activity

## Additional Information



▲ *Figure 15-1. The color of an object affects the amount of solar energy absorbed and reflected by the object.*

- 3 Once outside, have each team pour water from the 6-L containers into two tumblers, filling them to the bottom of the frosted rim. Tell them to measure the starting temperature of the water and record it in the chart on Activity Sheet 15.

Tell the teams to pour one tumbler of water into each tray and to cover both trays. Have them position the trays as in Activity 14. Tell them to record on their activity sheets the time at which they completed setting up the experiments (starting time).

Return to the classroom. Tell the students to bring their tumblers, thermometers, activity sheets, and the two 6-L containers with them.

- 4 Once back in the classroom, have students predict what will happen to the water in each tray. Ask, **After 40 minutes in the sun, which tray do you think will contain the warmer water: the black tray or the white tray?** Have the students write their predictions on their activity sheets.

*Have the students tilt each tray so that the liquid is evenly distributed among the troughs in the tray. It is also important that students position their trays with the wide, angled side of the troughs facing the sun.*

*If time allows, write their predictions on the board and discuss them.*

## Guiding the Activity

### Additional Information

- 5** Return to the site about 40 minutes after setting up the experiments. Have the students bring their tumblers, thermometers, and activity sheets.

Tell the teams to pour the contents of each solar tray into separate tumblers. They should measure the final temperature of the water in each tumbler, note the time at which it was taken (ending time), and record this information on Activity Sheet 15.

- 6** Once back in the classroom, ask, **Why do you think you got these results?**

Write the words *absorb* and *reflect* on the board. If necessary, explain that **absorb** means “to take in” and **reflect** means “to throw or bend back from a surface.”

Tell the students that both trays were exposed to the same amount of solar energy but that the light color of the white solar tray reflected much of the solar energy while the dark color of the black solar tray absorbed much of the solar energy. As a result, the water in the black tray became warmer than the water in the white tray.

Tell students to complete the activity sheet. As appropriate, read or review page 6 from the Delta Science Reader *Earth, Moon, and Sun*.

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

*Students should have observed that while the temperature of the water in both trays increased, the water in the black solar tray got warmer than the water in the white solar tray, but they might not know why.*

## REINFORCEMENT

Ask the students which color long-sleeve shirt they would rather wear on a hot, sunny day: black or white. Most students will realize that a black shirt would absorb, not reflect, solar energy, making them feel hotter.

## CLEANUP

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

## SCIENCE AT HOME

Invite students to use thermometers to investigate how the color of a car affects how hot it gets inside when parked in the sun. Tell them to test their theories and keep track of their results.

**Note:** This activity should be done only under parental supervision.

## Connections

### Science Challenge

Ask interested students to research what happens to the solar energy that reaches Earth's atmosphere. (About 30% is reflected back into space by clouds and particles in the air; about 47% is absorbed by Earth and converted to heat; about 23% is used in powering the water cycle; and less than 1% produces winds and ocean currents. Only a very tiny amount—0.02%—is captured by plants and used in photosynthesis.) Ask volunteers to create a bulletin board display or mural showing these distributions of solar energy.

### Science Extension

Use the following activity to show students that solar energy also heats solid materials. Each group of students will need a sheet of black construction paper, a sheet of white construction paper, and two thermometers. Students should lay the paper on the ground in a sunny location and put a thermometer under each sheet. Ask students to predict which thermometer will show the highest temperature and to record their prediction. Have students read and record both temperatures after 15 minutes and again after 30 minutes. How do the actual readings compare with their prediction? What accounts for the difference in temperature? (The black paper absorbed more energy; its thermometer will show a higher reading. The white paper reflected energy; its thermometer will show a lower reading.)

Another way for students to observe the effect of color on the absorption of solar energy is to place an ice cube sealed in a small plastic bag on each sheet of paper. After 10 to 20 minutes—before both cubes melt entirely—students should pour off the meltwater from each bag and measure it with a graduated cylinder. The cube in the bag on the black paper will have melted more than

the other cube. Students might like to try this activity with various colors of paper in addition to black and white.

### Science and the Arts

Students can use sunlight to create their own silhouettes. This activity is best done outdoors close to noon on a clear day. With students working in pairs, one student lies down with one side of his or her head resting on a stiff sheet of light-colored paper, and the partner traces around the shadow created by the first student's profile. When the first profile is drawn, students should change places and repeat. Each student can then hold a sheet of black construction paper firmly under the stiff paper and cut around the profile to make his or her silhouette. Students can mount their black silhouettes on white or colored construction paper or on patterned paper.

### Science and Math

Using the percentages given in the Science Challenge above, students can make a circle graph showing the distribution of the solar energy that reaches Earth's atmosphere. Encourage students to try to indicate the "less than 1%" amount that produces winds and ocean currents, but tell them to simply label the tiny amount used by plants.

### Science, Technology, and Society

Students might enjoy researching the solar phenomena known as *solar flares* and *sunspots*. Encourage students to investigate the causes and characteristics of these phenomena and find out how solar flares affect electrical activity on Earth.