Name _____ Class _____ Date _____

Exploration Lab

OBSERVATION

Calculating Calories in Sunlight

All objects in the universe have energy, which is the ability to produce a change in the object itself or a change in the object's surroundings. Like matter, energy cannot be created or destroyed. Rather, it merely changes form. The stored chemical energy in foods, for example, is converted into energy of motion that enables you to carry out many activities your body does every day. Radiant energy from the sun is converted to heat that warms Earth, making it possible for life to exist.

Heat is the transfer of energy and can be measured in a unit called calories. A calorie can be defined as the amount of heat required to raise the temperature of one gram of water one degree Celsius (given one atmosphere of pressure). The amount of solar energy that reaches Earth's atmosphere has been determined to be 1.94 calories per square centimeter per minute (cal/cm2/min). This value, which is called the solar constant, differs widely for the solar energy which reaches Earth's surface, depending on various factors including location, elevation above sea level, cloud cover and other general weather conditions, and obviously, the time of year. In this laboratory activity, you will contrast how three different solar collectors absorb the sun's energy and compare the results with the solar constant.

OBJECTIVES

Construct three different solar collectors.

Contrast the number of calories of energy from sunlight absorbed by the water in each collector.

Compare your results to the solar constant and **explain** any discrepancies.

MATERIALS

- baby food jars, clean, small, labels removed (3)
- calculator (optional)
- Celsius thermometer
- construction paper, black (or black matte paint)
- glue or tape
- graduated cylinder
- lab apron
- magnifying glass
- metric ruler
- paper towels
- scissors
- watch or clock
- water, distilled

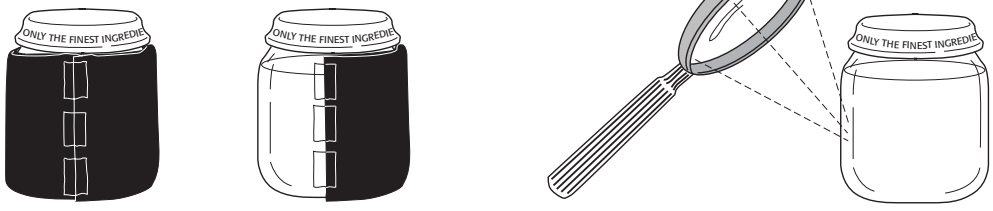
Procedure

Part I—Constructing the Solar Collectors

1. Put on your lab apron. Use the paper towels to immediately wipe up any spills onto your work area or the floor.
2. Measure and cut a piece of black construction paper that is half as long as the circumference of the baby food jars and just as wide as the jars are high.
3. Glue or tape the construction paper onto one of the jars so that it completely covers one half of the jar as shown in the figure below.
4. Measure and cut another piece of black construction paper that will completely cover the outside of one of the jars as shown in the figure below. Glue or tape this piece of paper onto the jar.
5. Use the graduated cylinder to measure and pour 50 mL of distilled water at room temperature into each jar.

Part II—Collecting Data

6. Use the thermometer to measure and record the temperature of the water in each jar. Remember to let the thermometer reach room temperature before making all new measurements.
7. Put the jars on the window sill or in a sunny spot on your work area.
8. Use the magnifying glass to focus the sun's rays onto the jar with no paper. Hold the lens about 2.54 cm from the jar and at an angle as shown in the figure below. Looking directly at the sun or looking at the sun through the magnifying lens can cause instant and permanent eye damage including blindness.
9. After 5 minutes, measure and record the temperature in the jar.
10. While keeping sunlight focused on the jar, repeat step 9 two more times. Average your data for this collector and record it in the data table.
11. Repeat steps 8–10 for the other two jars.



CALORIES OF ENERGY RECEIVED BY THREE SOLAR COLLECTORS

	Jar without paper				Jar half covered				Jar completely covered			
Trial	1	2	3	Avg	1	2	3	Avg	1	2	3	Avg
Initial temperature (°C)												
Final temperature (°C)												
Temperature change												
Calories absorbed												
Calories/cm^2/minute												

PART III—COMPUTING CALORIES FROM SUNLIGHT

12. Compute the area of your magnifying glass by using the formula $A = \pi r^2$, where A is the area, π is 3.14, and r is the radius of the lens. Record this value here.

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13. One milliliter of water has a mass of one gram. Use this fact to compute the number of calories absorbed by the water in each collector by multiplying the mass of the water by the average number of degrees the temperature changed. Record your calculations in the data table.

14. Now compute the number of calories of sunlight received per square centimeter of lens surface per minute for each collector. Record your values in the data table.

Analysis

1. Examining Data In which collector were the largest number of calories of solar energy absorbed?

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2. Examining Data In which collector were the least number of calories of solar energy absorbed?

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3. **Recognizing Patterns** In general, how do your values of the number of calories absorbed per square centimeter per minute compare with the solar constant?

4. **Analyzing Data** Compute the efficiency of each of your solar collectors.

Conclusions

5. **Evaluating Results** Give at least three reasons why the number of calories absorbed per square centimeter per minute in this activity differs from the solar constant.

6. **Interpreting Information** Based on your data, which collector is the most efficient at absorbing solar energy?

7. **Making Predictions** At what time of day would you get optimal results from this activity? Why?