

# Temperature Changes

## OBJECTIVES

Students observe changes in air temperature and discover the role of the Sun in heating Earth.

### The students

- ▶ measure and record outdoor air temperature at three different times of day for a period of 5 days
- ▶ discuss the role of the Sun in heating Earth
- ▶ conclude that changes in air temperature are caused by changes in the amount of sunlight that reaches Earth

## SCHEDULE

**Session I** About 40 minutes, followed by temperature readings taken 3 times a day for 5 days

**Session II** About 40 minutes

## MATERIALS

### For each student

- 1 Activity Sheet 3, Parts A and B
- 1 pencil, red\*
- 1 ruler
- 1 thermometer, dual-scale

### For each team of two

- 1 cup, foam

### For the class

- 1 chart, Temperature Graph
- 1 container, 2-L\*
- 1 desk lamp, adjustable (optional)\*

- 1 marker, black\*
- 1 ruler
- 1 roll tape, masking
- water, tap\*

\*provided by the teacher

## PREPARATION

### Session I

- 1 Make a copy of Activity Sheet 3, Part A, for each student.
- 2 Start this activity early in the morning, so that students can take their first temperature reading as close to 9:00 A.M. as possible.
- 3 Each student will need a thermometer.

### Session II

- 1 Make a copy of Activity Sheet 3, Part B, for each student.
- 2 This session should be done on a sunny day. Find a place indoors—preferably in the classroom—where students will be able to leave cups of water in direct sunlight for about 20 minutes. In the absence of sunlight, a strong desk lamp will also work.
- 3 Fill a 2-L container with tap water and let it sit out (away from sunlight) until it has achieved room temperature.
- 4 Each student will need a thermometer, a ruler, a red pencil, and his or her completed activity sheet from Session I. Each team of two will need a foam cup filled with room-temperature tap water. You will need the Temperature Graph chart, a black marker, a ruler, and some tape.

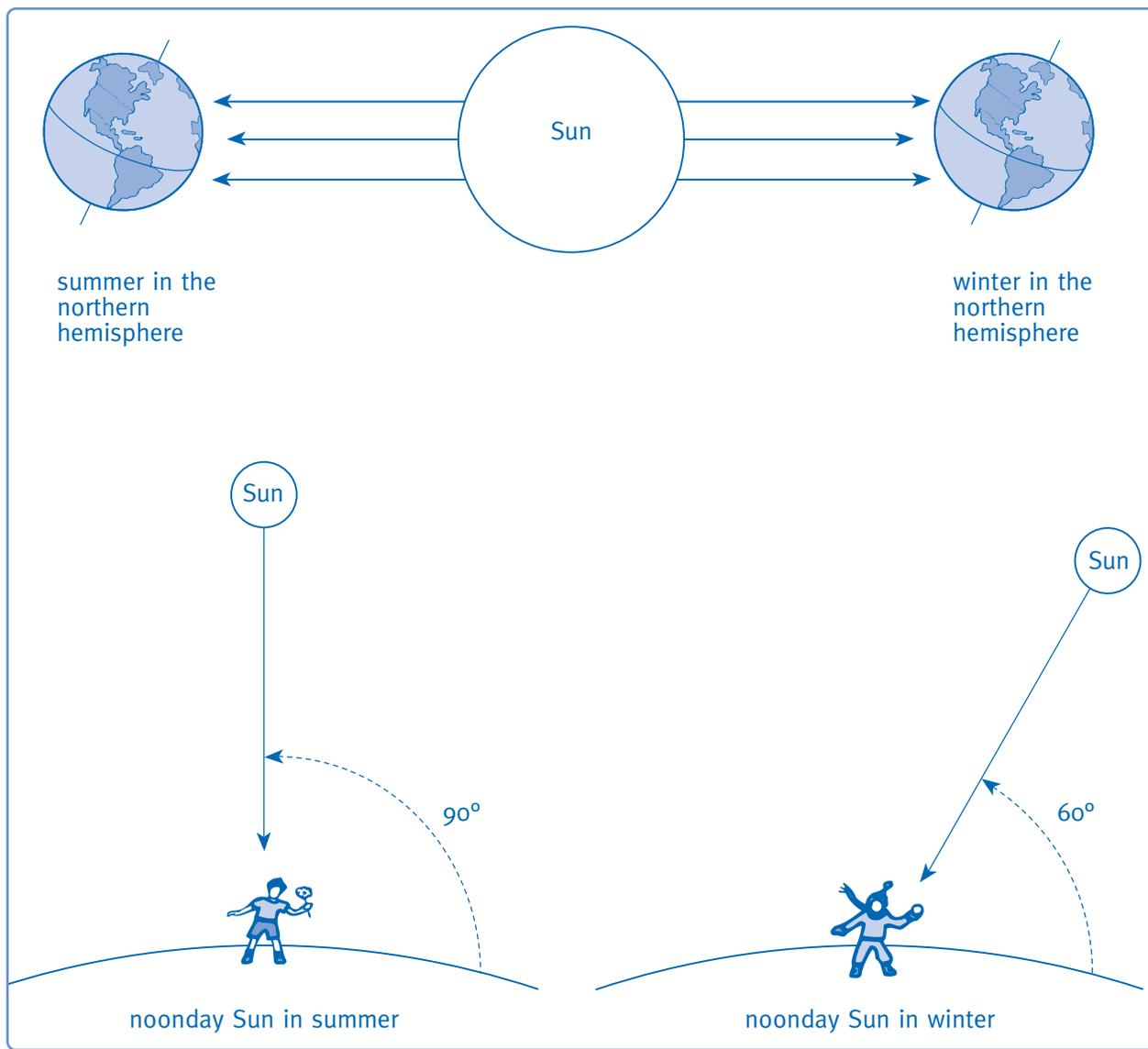
## BACKGROUND INFORMATION

The Sun is a star—a glowing ball of gases—and is the source of heat and light for Earth. Given the composition of Earth’s atmosphere, the distance between Sun and Earth—about 93 million miles—is just right for sustaining life: If the Sun were any closer, Earth would overheat; if the Sun were farther away, the water on Earth would turn to ice. In either case, all living things would die.

Despite the tremendous amount of energy produced by the Sun, only a very tiny fraction

of the Sun’s energy—about one-tenth of one billionth—reaches Earth. Of that, about 30 percent is reflected back into space, 20 percent is absorbed by clouds and the atmosphere, and about 50 percent is absorbed by Earth’s crust. The heat absorbed by Earth’s crust, in turn, transfers heat back to the air around us.

In general, changes in air temperature are caused by changes in the intensity and duration of sunlight that reaches Earth and by the rate at which sunlight is absorbed by Earth’s crust.



▲ **Figure 3-1.** The Northern Hemisphere is warmer during the summer months because the Sun’s rays strike it at a more perpendicular angle.

The intensity and duration of sunlight depend on the time of day and the time of year (season). In general, temperatures are highest at midday, when the Sun is at its highest point in the sky, and lowest at night, when it is dark.

Likewise, temperatures are highest in summer, when that part of Earth is tilted toward the Sun and the number of daylight hours and the angle at which the Sun's rays strike Earth are the greatest; temperatures are lowest in winter, when that part of Earth is tilted away from the Sun and the number of daylight hours and the angle at which the Sun's rays strike Earth are the least (see Figure 3-1).

The rate at which sunlight is absorbed by Earth's crust depends on the color and composition of the surface struck by sunlight. For example, dark, dense forests absorb more sunlight than snow-covered regions; grassy fields absorb more sunlight than sandy deserts. In addition, land heats up and cools down faster than water, which is why deserts experience extremes in temperature between night and day while coastal regions experience more moderate fluctuations in temperature.

Finally, Earth's atmosphere acts like a giant thermostat, protecting it from too much solar energy during the day and helping to keep excessive amounts of heat from escaping at night. Without the moderating effect of the atmosphere, the temperature changes that occur on Earth would be much more extreme—and life-threatening.

In this activity, students measure the changes that occur in air temperature over the course of 5 days, and discover the role of the Sun in heating Earth.

### ▼ Activity Sheet 3, Part A

#### Temperature Changes

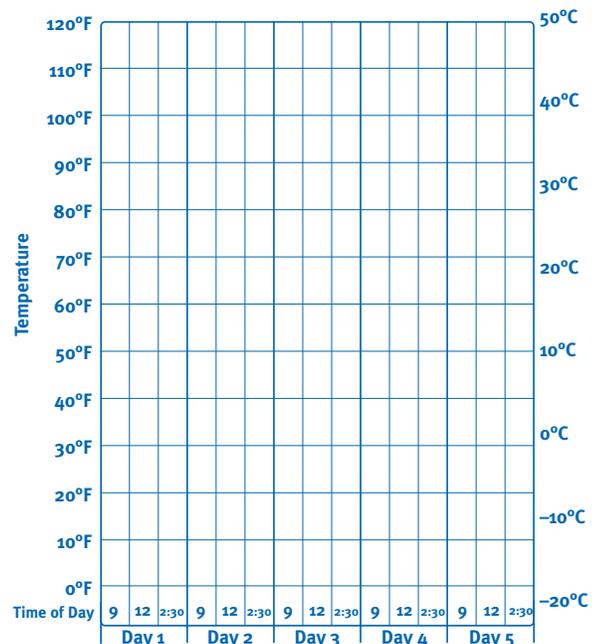
Measure the temperature outside three times a day for the next 5 days. Record your temperature readings in both °F and °C.

Day	Time	Temp °F	Temp °C
1  (name of day)	9:00 A.M.		
	12:00 (noon)	Answers will vary.	
	2:30 P.M.		
2  (name of day)	9:00 A.M.		
	12:00 (noon)		
	2:30 P.M.		
3  (name of day)	9:00 A.M.		
	12:00 (noon)		
	2:30 P.M.		
4  (name of day)	9:00 A.M.		
	12:00 (noon)		
	2:30 P.M.		
5  (name of day)	9:00 A.M.		
	12:00 (noon)		
	2:30 P.M.		

### ▼ Activity Sheet 3, Part B

#### Temperature Changes

Show the temperature changes you recorded over the past 5 days. Color the bar graph.



## Guiding the Activity

### Additional Information

#### Session I

- 1 Review the definition of *temperature* from Activity 2.

Ask, **What causes the temperature of a substance to increase or decrease?**

Tell students that in this activity they are going to measure the changes in outdoor air temperature that occur over the next 5 days.

*Temperature is a measure of how hot or cold something is.*

*Temperature changes are caused by an increase or decrease in the amount of heat in that substance.*

- 2 Distribute a copy of **Activity Sheet 3, Part A**, and a thermometer to each student. Review how to use a thermometer. Then bring the students outdoors and have them measure the temperature of the air.

Have students record their temperature readings—in both Fahrenheit and Celsius—in the chart on the activity sheet.

Have students take temperature readings three times a day—9:00 A.M., 12:00 P.M. (noon), and 2:30 P.M. (or as late in the school day as possible)—for the next 5 days.

At the end of each day, collect the thermometers and return them to the kit.

*Their readings should be taken in the shade, out of the wind. Thermometers should be in place for 3 minutes before taking a reading.*

*After the initial reading, you may want to assign pairs of students to go outdoors and take readings that they can then share with the class. Make sure all students have an opportunity to take additional readings.*

#### Session II

- 3 At the end of the fifth day, discuss the students' findings. Record the average temperature readings for the class in a chart on the board. Ask students, **What do you notice about the temperature on the past 5 days?**

*The temperature did not stay the same. It changed over the course of 5 days.*

## Guiding the Activity

Tape the Temperature Graph chart to the board. Distribute a copy of **Activity Sheet 3, Part B**, a ruler, and a red pencil to each student. Using a marker and a ruler, demonstrate how to make a bar graph.

Guide students as they make a bar graph of their results based on the information they gathered in Part A of the activity sheet. When they have finished, ask, **What happened to the air temperature over the course of each day?**

Ask, **At what time of day was the outdoor air temperature highest?**

Ask, **What do you think caused the temperature to change over the course of the day?**

4

Ask students to look at their thermometers to see the temperature of the room. Write the room temperature on the board.

Distribute a cup of water (at room temperature) to each team of two. Have students measure the temperature of the water.

Have students put their cups on a sunny windowsill in the classroom and leave them there for about 20 minutes.

After 20 minutes, have students retrieve their cups and measure the water temperature again.

Ask, **What do you notice about the temperature of the water now?**

Ask, **What made the water temperature increase?**

## Additional Information

*Show students how to use a ruler to guide them across the graph. Tell them to look at each day and time. They can then draw a line at the correct number and color in the bar up to the line.*

*In general, it increased over the course of the morning and decreased over the course of the afternoon.*

*In general, the temperature each day is highest in the early afternoon.*

*Students may guess that the Sun had something to do with it. Accept all reasonable answers.*

*The temperature of the water should be the same as the temperature of the air in the room: about 65°F to 75°F.*

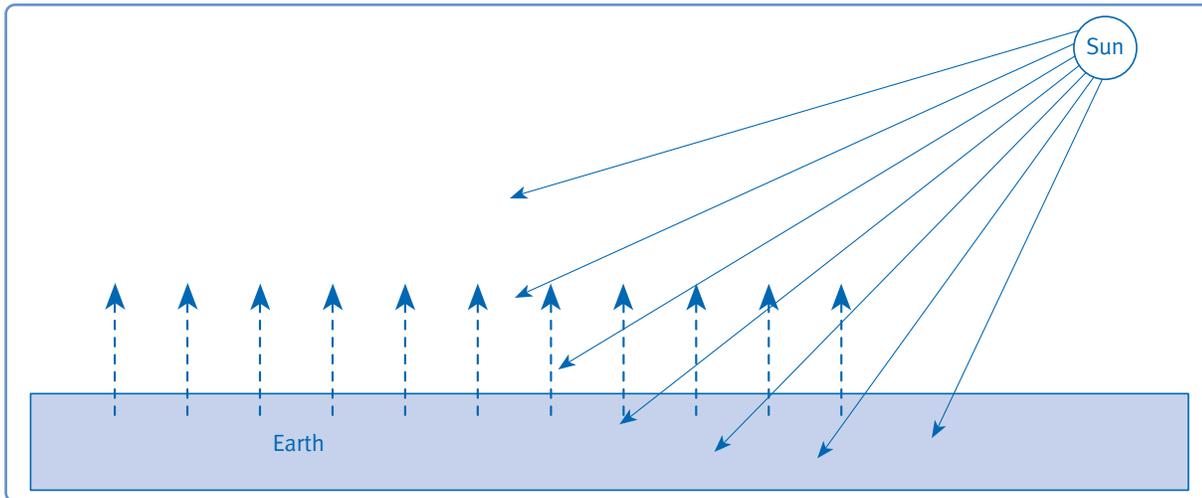
*The thermometers should not be in the cups while the cups are in the Sun.*

*It increased.*

*Students should conclude that the water was warmed by the Sun.*

## Guiding the Activity

## Additional Information



▲ *Figure 3-2. The Sun warms Earth's surface; Earth's surface warms the air around it.*

Explain that the Sun is the source of heat for Earth. The Sun warms the land and water, which, in turn, warm the air above it (see Figure 3-2).

Earth is warmed as the Sun rises. It is hottest when the Sun is highest in the sky—around midday. Earth then begins to cool as the Sun sets. It is usually coldest at night. In general, changes in air temperature are caused by changes in the amount of sunlight that reaches Earth.

**Ask, If you were to continue taking temperature readings every day for a year, what do you think your graphs would tell you?**

Tell students that changes in air temperature bring changes in the weather. In Activity 4 they will learn how temperature changes cause wind.

*The highest temperatures of the day often occur a few hours after noon due to the cumulative effect of the warmed air. The amount of heat received directly from the Sun, however, is greatest around noon, when the Sun is most perpendicular to the ground.*

*The temperature readings could increase or decrease dramatically, depending on the season and location. Answers should reflect the fact that temperatures are generally warmest in summer and coldest in winter.*

*On a day-to-day basis, however, they should follow the same general pattern: the temperature increases in the morning, is highest around midday or early afternoon, decreases in the afternoon, and is lowest at night. This is true no matter what the season.*

## REINFORCEMENT

Have students repeat the water-warming portion of the activity, this time positioning a desk lamp to simulate the different locations of the Sun relative to the ground during the course of the day. Have them note which lamp position produces the largest temperature gain in the water.

## SCIENCE JOURNALS

Have students place their completed activity sheets in their science journals.

## CLEANUP

Discard the water in the cups. Dry the cups and return them, along with the thermometers and rulers, to the kit.

## Connections

### Science Challenge

Students might like to find out about so-called “warm-blooded” and “cold-blooded” animals and the major difference between them. Provide resources so students can find out which types of animals are warm-blooded and cold-blooded and what “warm-bloodedness” or “cold-bloodedness” means in terms of the animals’ behavior and way of life. (Warm-blooded, or endothermic, animals—birds and mammals—are capable of maintaining a fairly constant body temperature, whereas the body temperature of cold-blooded, or exothermic, animals—fish, amphibians, and reptiles—fluctuates in response to the animals’ surroundings.)

### Science Extension

- ▶ Show students why their thermometers should be placed in the shade, not sunlight, when they are measuring air temperature. Have each team put one thermometer in the shade and another in the sunlight outdoors. After 15 minutes or so, have students compare the thermometer readings. (The one in the sunlight will show a much higher temperature.) Explain that sunlight does not heat air directly but passes through it and heats materials on Earth’s surface. The materials then transfer heat to the air. The thermometer in the sunlight shows a higher temperature because it was heated by sunlight striking it. The thermometer in the shade was heated by the air surrounding it.
- ▶ Have each team use a flashlight to model the Sun’s rays striking Earth at different angles. First tell students to shine the light directly down on a sheet of white paper. Guide them to notice that the light is brightly concentrated in a circle on the paper. Then tell them to hold the flashlight at an angle. They will see that the light

spreads over a wider area on the paper and is not as bright. Explain that the same thing happens with the Sun’s rays at different times during the day.

### Science and the Arts

Students might enjoy using sunlight to create artwork. Give each student a sheet of light-sensitive paper, and tell students to arrange a variety of objects on the paper to make a picture or a design that they like. Have students expose their setups to direct sunlight for 2–5 minutes until the paper turns pale blue. Have them remove the objects from the paper and, while protecting it from strong light, soak it in a container of water for about 1 minute, then let it dry flat. The image should sharpen as the paper dries.

### Science and Math

You may want to have students continue recording and graphing temperature data for an extended period of time—at least two months, preferably longer—so they can observe general temperature trends as seasons change. Make sure students understand that short-term changes, such as a brief cold spell in May or a one-week warming trend in December, are not related to seasonal patterns.

### Science and Social Studies

Provide students with copies of the weather report from a daily paper that includes the previous day’s high and low temperatures for several cities across the country. Help students locate each city on a United States map and then calculate the difference between its two temperatures. Ask students to identify the cities that had the biggest difference between high and low temperatures the previous day.