PLOTTING THE APPARENT DAILY MOTION OF THE SUN

ACTIVITY B-8

GRADE LEVEL: 9+

What's This Activity About?

This activity is excellent for later grades, incorporating experimentation about the location and height of the Sun and their relation to the seasons. Like other Project STAR activities, this includes some challenging questions for students, along with thorough answers and guidelines for the teacher. The activity complements "The Reasons for the Seasons" from the Lawrence Hall of Science.

What Will Students Do?

Students start by investigating their preconceptions about the position of the Sun in the sky over the day and year. They use a transparent plastic hemisphere to create a model of the sky, and mark the position of the Sun in the sky on the hemisphere. The Sun's position is recorded many times in one day, creating a visible path across the hemisphere that can be studied later. From the path, students can determine the location of sunrise, sunset, and the Sun's height at noon. Alternatively, students record the position of the Sun at the same time over many days.

Tips and Suggestions

- "Plotting the Apparent Daily Motion of the Sun" builds on the concepts of horizon astronomy developed in previous activities. It does not discuss the amount of sunlight received on Earth as the Sun's position changes, nor does it describe how the Sun's position will change with the observer's latitude. These concepts are developed in the two activities that follow.
- This activity includes four extensions, enabling students to explore sunrise and sunset positions, solar motions over an entire day, and different solar paths over the year.
- As an alternative to the clear plastic hemisphere, you can use a celestial globe, such as the "Starship Earth" globe from Spherical Concepts (available through the ASP catalog).
- The plastic hemisphere may be obtained from Project STAR, Hands-On Science Materials (800) 537-8703. Order the PS-03, Sun Tracking Plastic Hemisphere, $6.00.

What Will Students Learn?

Concepts
- The Sun's motion during one day
- The Sun's height in the sky

Inquiry Skills
- Observing
- Recording
- Predicting

Big Ideas
- Patterns of Change
- Models

PLOTTING THE APPARENT DAILY MOTION OF THE SUN

PURPOSE

To plot and discuss the Sun's apparent daily movement across the sky.

WHAT DO YOU THINK?

Your teacher will give you a plastic hemisphere. Place the square rim of the hemisphere flat on your desk.

Imagine that the sky is the inside surface of the hemisphere. As an observer, you would be standing at the center of the circle at the base of the hemisphere. This is the spot marked X in Figure 1.4. You will draw the path of the Sun as it would appear from inside the hemisphere.

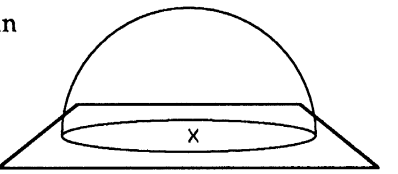

Figure 1.4

With the plastic hemisphere in front of you, choose a point on the base at one of the ridges and use a transparency pen to tag it as North and label it "N." Looking down on the dome and going clockwise from north, mark the other three ridges as East (E), South (S), and West (W).

P1. *a) Predict the following positions for the Sun for today by writing a letter on the dome. Use the letter* **r** *to show the position of the Sun at sunrise; the letter* **n** *to indicate its position at noon; and the letter* **s** *to indicate its position at sunset.*

b) Connect these points on the hemisphere with a curved line that represents how you think the Sun will move across the sky on this day.

P2. *From what direction did the Sun rise this morning?*

P3. *In what direction will the Sun set this evening?*

P4. *Where in the sky is the Sun at noon?*

P5. *How many hours of daylight will there be today?*

You will repeat this activity another day. Meanwhile, store your hemisphere in a safe place to prevent loss, damage, or smudging.

MATERIALS

Figure 1.5: Hemisphere Base Diagram
cardboard sheet, 20 cm x 20 cm (8 in x 8 in)
plastic hemisphere from the **WHAT DO YOU THINK?** section of this activity
marking pencil (Use a grease pencil if possible; sunlight may fade felt-tip inks.)
magnetic compass
transparent tape or stapler

PROCEDURE

A. Tape or staple Figure 1.5 (the "base sheet") to the cardboard sheet. Then tape or staple the base of the hemisphere to the base sheet-cardboard combination so that the ridge marked "N" lines up with North on the base sheet and so that the + mark is directly under the center of the hemisphere. See Figure 1.6.

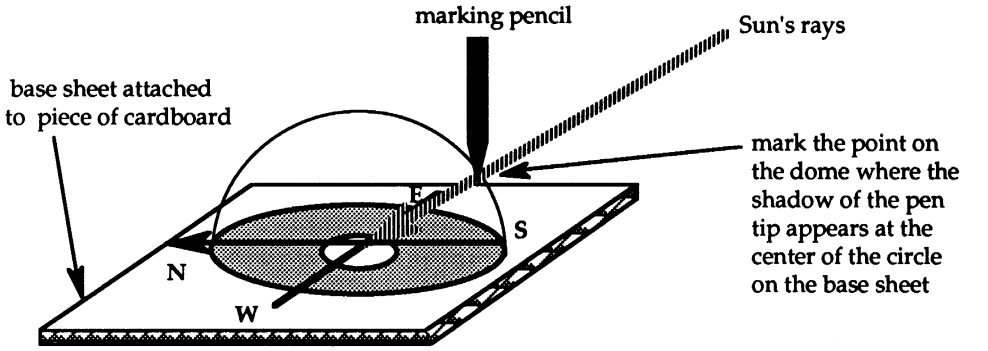

Figure 1.6

B. Place the hemisphere on a flat, horizontal surface in direct sunlight. With the aid of a magnetic compass, turn the hemisphere so the ridge marked "N" points north. NOTE: Be careful not to place your hemisphere near iron or steel objects since these metals will attract your compass needle and produce an inaccurate reading. Once the dome is set in place, DO NOT MOVE IT! (Draw an outline around the cardboard with a piece of chalk just in case the hemisphere is accidentally moved.)

DO NOT STARE AT THE SUN. IT CAN DAMAGE YOUR EYES.

C. Plot the Sun's position in the following way (see Figure 1.6):

1) Carefully move the tip of the grease pencil close to the plastic hemisphere, but do not let the pencil touch the sphere.

2) Move the pencil around until the shadow cast by its tip falls directly on the + mark that is at the center of the base sheet.

3) Touch the pencil tip to the dome and at that point make a dot. The dot's shadow should fall directly on the + mark on the base sheet.

4) Repeat steps C1–C3 every 10 minutes for at least 30 minutes and longer if possible.

5) Connect the plotted points with a line. Draw this line on the *inside* of the hemisphere. Label the line with the date and time range of C4. DO NOT ERASE THIS LINE.

DISCUSSION QUESTIONS

1. Discuss how the points and line you drew for question P1 compare with the points and line plotted in this activity.

2. From what direction did the Sun rise?

3. Where was the Sun at noon? What was the approximate angular height of the Sun at noon?

4. In what direction did the Sun set?

When you have answered these questions, erase the line you drew for question P1. Keep the line you plotted in step C.

EXTENSION

1. Bring the hemisphere and a magnetic compass home on the same day you did this activity. Follow the set-up and plotting procedures described in steps B and C. Plot the Sun's apparent motion across the sky for half an hour before sunset and for half an hour after sunrise the next morning. (You may have to wait a day or more if the sky is overcast at sunset or sunrise.) Label the lines with the dates and time ranges.

2. On a clear weekend day follow steps B and C for the entire day. Plot the points at ONE HOUR intervals only.

3. Repeat this plotting of the Sun's apparent daily motion on a clear day one month after the date of your original plot. Repeat this plotting for as many months as possible. Use a different color pen for each month.

4. Refer to an almanac or a calendar to determine the first day of each season. Plot the apparent daily motion of the Sun on the hemisphere for these days. Use a different color pen for each day.

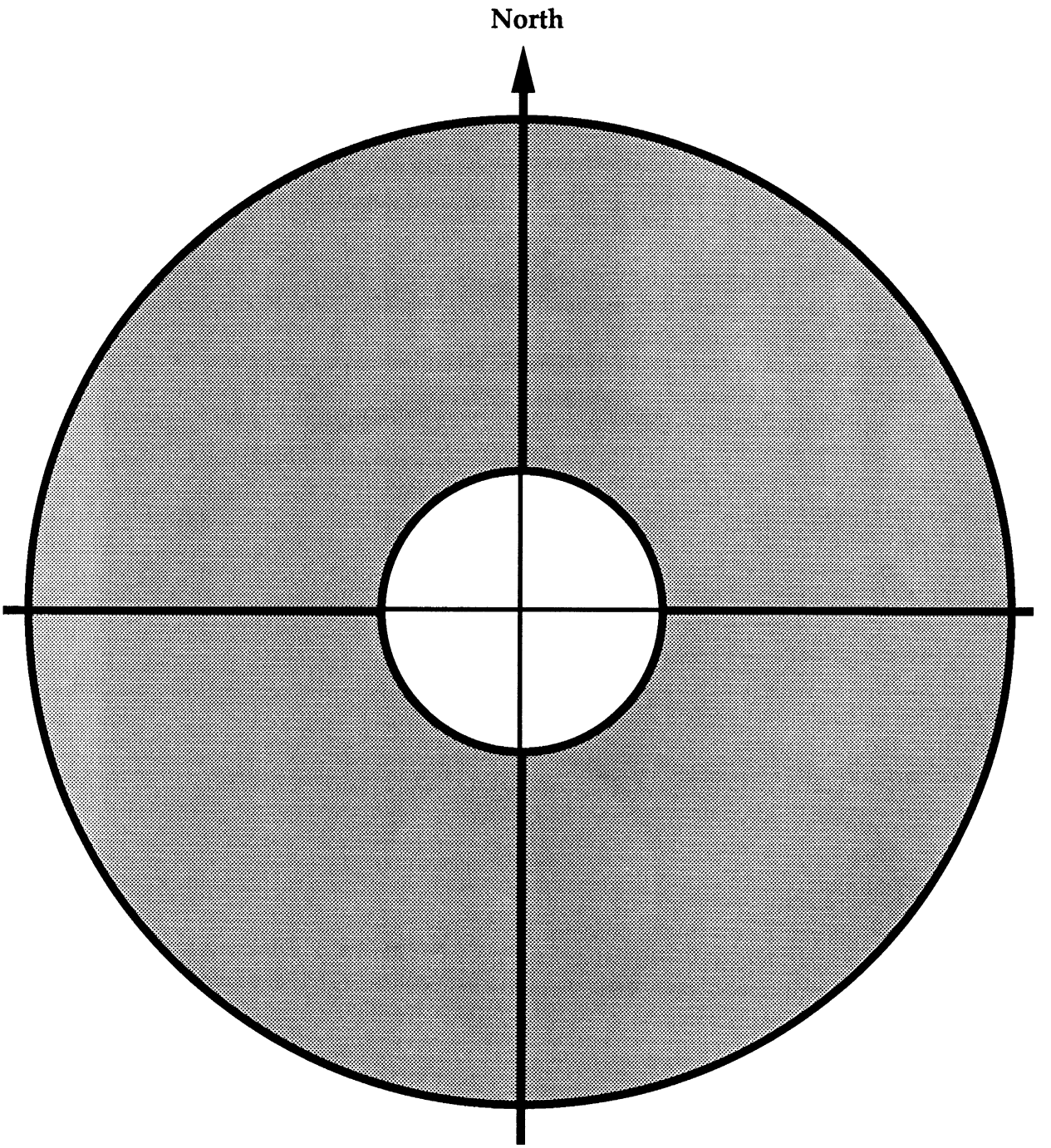

Figure 1.5 Hemisphere Base Diagram

Teaching Notes

Class time: 45-55 minutes

1. Preconceptions

Questions P1-P5 constitute the "What Do You Think?" section for Activity 1.2. These questions ask what the student believes about the path of the Sun across the sky on a given day, including directions of sunrise and sunset and the number of hours of daylight. Many students think that the Sun rises due east, passes directly overhead at noon, and sets due west. The path plotted by the student in answer to P1 is therefore often a simple arc starting from east, passing over the top of the hemisphere, and down to the west. The idea that the Sun is overhead at noon, regardless of the time of year, is strongly held by many people of all ages and backgrounds. Expect a number of students to state 12 hours for P5; others may be more aware that the days have been getting longer or shorter and respond with values more or less than 12 hours. This activity will directly test these ideas for the date the activity is done. In combination with Activities 1.3 and 3.2, additional insight into the patterns of the Sun's apparent motions (daily and seasonal) and their causes will be gained.

2. Activity Tips

Although the plastic hemisphere is quite durable, it will dimple if too much pressure is applied with the marking pen. However, the dome can usually be popped back into shape, even if someone accidentally steps on it.

Depending on the size of your class, your schedule, and your access to an area where the hemispheres can be safely set out on the ground, you may wish to vary step C. As written, the plotting portion of the activity is designed to be completed in one class period. However, if you can leave the hemispheres in place for the day, you could have different classes plot positions over the day, or arrange to have students from one class come back during study periods, lunch, or after school to continue the plotting. This procedure would be similar to doing Extension 2 in school.

If you are going to plot paths for selected days over a period of time (such as in Extension 3), you may want to use a grease pencil instead of a felt-tip marker; many felt-tip inks fade on the plastic over a period of days or weeks. If you have time, you should experiment with your felt-tips to see how fade-resistant they are.

In step B, the alignment of the hemispheres by magnetic compass should take into account the magnetic declination at your location. Magnetic declination is the angular difference between the direction to which the needle points, which is towards the North Magnetic Pole, and the North Pole ("true north"). In the eastern United States, a compass needle points west of true north. Thus, if the declination for your region is 10° west, true north is 10° to the east (or to the right if you are facing north) of the direction the needle points. In the western U.S., a compass needle points east of true north, so true north lies to the west (or left) of the indicated direction.

3. Answers to Discussion Questions.

The answers will vary with the time of year and your location.

1. The answer will vary among your students. See the Preconceptions section for the sources of possible discrepancies between student predictions and results.

2. The answer depends upon your latitude and the time of year. During fall and winter in the continental U.S., the Sun rises somewhere to the south of due east (on the first day of fall, the