ACTIVITY 2

As the Earth Turns

OBJECTIVES

Students explain the sky motions they observed in Activity 1 by studying Earth's daily rotation on its axis.

The students

- build a model of the Earth and sky
- explain how the rotation of Earth causes the sky motions they have described
- explain how the rotation of Earth causes sunrise and sunset each day

SCHEDULE

About 45 minutes

VOCABULARY

axis
rotation

MATERIALS

For each student

1	Activity Sheet 2, Parts A and B
1	astronomy journal*
1	safety goggles*
1	Sun Map (from Activity 1)*

For each team of four

1	Earth globe
1	grease pencil, black
1	grease pencil, yellow
1 pr	scissors*
1	SkyCaps, laminated, set/12
1	sphere, plastic, with holes
1 pc	wire

For the class

1 stk	clay
1	Earth globe
1	marker, black, permanent (optional)*
1	sphere, plastic, with holes
1	Star Patterns, Northern and Southern Hemispheres
1 roll	tape, transparent
8	wet-erase markers (optional)
1 pc	wire

*provided by the teacher

PREPARATION

1. Make a copy of Activity Sheet 2, Parts A and B, and the Star Patterns sheet for the Northern and Southern Hemispheres for each student. Reproducible pattern sheets are in the kit; they are also included in the Copymasters section of this guide. Students will also need their copies of the Sun Map used in Activity 1 from their Astronomy Portfolios.

2. Students will use clear plastic spheres with constellation markings to simulate the starfield around Earth. You can mark the constellations on the spheres yourself before class, or you can have the students draw them on during the activity. Although marking the constellations is time-consuming, it does have the advantage of reinforcing students' memories of the pattern shapes. If you decide to mark the patterns on the spheres yourself, use a permanent marker so you can reuse them year after year. If students are going to do the marking, they should use grease pencils or wet-erase markers. You can then remove the markings for each new class.

3 Make a demonstration Sky Sphere model for students, as follows: Thread a 30-cm (12-in) length of coated wire through the Earth globe and secure it at the North and South Poles with small amounts of clay. (The globe should rotate when you turn the wire.) Then position the globe inside the plastic sphere (using the line-up arrows) so that the wire exits through the bottom and top holes. The globe should rotate freely inside the Sky Sphere when you turn the wire (see Figure 2-1). Always rotate the globe west to east, or left to right (or when looking from above the North Pole, counterclockwise).

BACKGROUND INFORMATION

The Earth rotates on its ***axis*** at a rate of one full turn per day. This motion is what causes day and night. The daily ***rotation*** also causes observers on Earth to see a changing starfield as they gaze at the night sky. It's not that the sky moves, but that Earth moves relative to the sky.

In a moving car, an observer looking out the window sees the scenes moving backward as he or she moves forward. In the same manner, an observer on Earth sees the stars moving westward as he or she moves eastward with the rotating Earth.

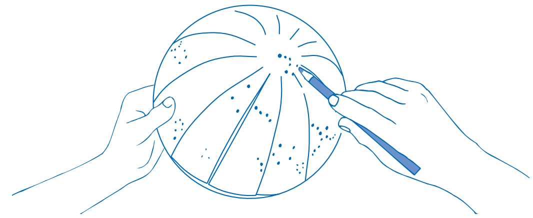
In this activity, students must translate Earth's rotation under the fixed sky to the apparent sky motions they observed in the last activity. Students who have trouble changing reference frames tend to memorize a description of what is happening instead of figuring out the actual relationships. In guiding this activity, be certain that students recognize that they are supposed to see the sky from the perspective of someone standing on the globe inside the Sky Sphere.

▼ Activity Sheet 2, Part A

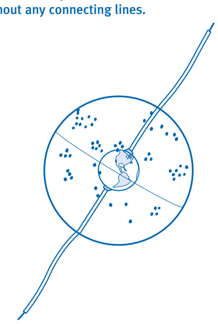
As the Earth Turns

In this activity, you will discover what causes the Sun and stars to appear to move westward across the sky.

1. Locate the two Star Patterns sheets and the two clear sphere halves. Cut out the pattern sheets and follow the printed directions to make two pattern domes—one for each hemisphere. Place one dome inside each sphere half (the dome with Ursa Minor at the top goes in the Northern Hemisphere). With a black grease pencil, make dots on the outsides of both spheres for each star on the pattern sheets. Try to make bigger dots for the brighter stars. Do not connect the stars with lines. Be sure to transfer the line-up arrows.



2. Remove the pattern domes and look at the star dots on each sphere half. List the constellations you can recognize easily without any connecting lines. Use the names on the pattern sheet for reference.
Answers will vary.



3. Locate the Earth globe and piece of wire. The wire represents Earth's axis. Push the wire through the holes in the globe and secure it with small dabs of clay at the North Pole and South Pole. Using the line-up arrows, place the two sphere halves around the globe so that the globe is in the center of the complete sphere. The wire will stick out through the spheres at the north and south poles of the sky. Line up the sphere halves so the star patterns match.

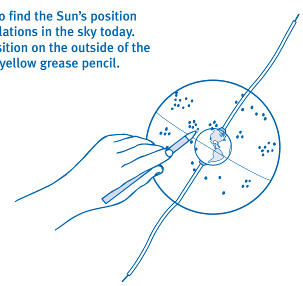
▼ Activity Sheet 2, Part B

As the Earth Turns

4. Turn the wire so that the Earth turns eastward but the Sky Sphere does not move. Find your home on the globe. If you were looking up at the Sky Sphere from your home, what would you see as the Earth spins eastward on its axis?
All the stars and constellations in the sky would be moving from east to west.

5. How does this motion of the sky compare with the motion you observed when you compared SkyCaps in Activity 1?
It is the same. The star patterns in the SkyCap moved westward, from the eastern horizon to the western horizon over the course of the night.

6. Use the Sun Map to find the Sun's position among the constellations in the sky today. Mark the Sun's position on the outside of the Sky Sphere with a yellow grease pencil.



7. Turn the Earth eastward underneath the Sky Sphere. Watch how the Sun moves over your location on the globe. In your own words, describe what causes sunrise and sunset each day.
The rotation of the Earth eastward causes the Sun to appear to rise in the east and set in the west. Actually the Earth is moving eastward below the Sun, not the Sun moving westward above the Earth.

Guiding the Activity

Additional Information

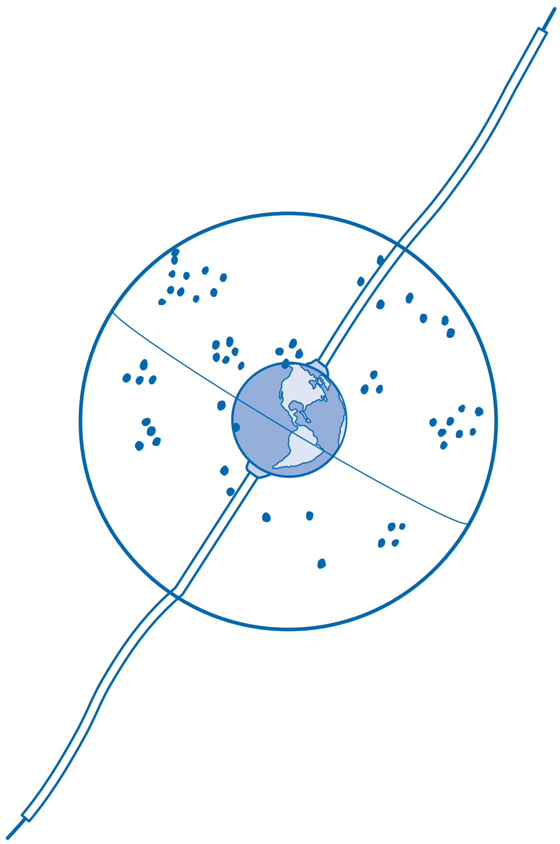
1 Begin this activity by reviewing student hypotheses, recorded in their journals, from the end of Activity 1. Ask, **Why do you think the stars and Sun appear to move westward across the sky?**

Student answers will vary. Accept all responses for now.

Tell students that in this activity they will conduct an experiment to determine if their hypotheses are correct.

2 Ask students to imagine that Earth is surrounded by a sphere of stars. Show students your demonstration Sky Sphere (Figure 2-1).

Explain that stars are really at different distances from Earth and spread out in all directions. The sky is not shaped like a huge ball around Earth. This model shows a simplified starfield on a sphere surrounding the Earth globe. In a later activity, students will explore the three-dimensional starfield.



▲ ***Figure 2-1.*** *A completed Sky Sphere model.*

Guiding the Activity

Additional Information

3 Divide the class into teams of four. Distribute a copy of **Activity Sheet 2, Parts A and B,** to each student, and the following materials to each team: one Earth globe, one 30-cm (12-in) length of coated wire, a small amount of clay, one clear sphere, and a yellow and a black grease pencil. Each team also needs one copy of the Star Patterns for the Northern and Southern Hemispheres, as well as scissors and tape for assembling and transferring the patterns.

Explain to students that first they will draw the constellations on their spheres to represent what they see in the sky when they look up.

4 Read Step 1 on the activity sheet together. Show students how to use the Star Patterns to draw the constellations on the outside of their spheres.

If students are going to use spheres on which the stars are already drawn, have them skip to Step 2 on their activity sheets and answer the questions.

The Star Patterns are printed in an arrangement that can be cut out and assembled to form two hemispheres that fit inside the sphere halves. Refer students to the illustration on the activity sheet. Help students as needed with the construction. Once they have transferred the star patterns onto the sphere halves, ask students to answer the questions in Step 2 of their activity sheets.

The Star Pattern with Ursa Minor in the center goes in the Northern Hemisphere sphere half.

Now tell teams to finish constructing their Sky Spheres, following the directions in Step 3 on the activity sheets.

Students should thread the wire through the North and South Poles of the Earth globe and hold it in place with small amounts of clay. Then they can position the globe inside the sphere. Be certain that the wire runs through the North and South Poles of Earth and the north and south holes in the sphere.

Show students your demonstration model again and point out how the globe turns inside the sphere when you turn the wire. Once assembled, student models should feature a rotatable globe surrounded by a starry sky.

Note: *Have students thread the wire carefully so it does not get jammed or bent.*

Safety Note: *Safety goggles are recommended when students are using sharp objects such as the wires in this activity.*

Guiding the Activity

Guiding the Activity	Additional Information
5 Ask, **What would you see if you were standing on the globe looking up into the night sky?**	*the stars, or constellations*
Write *rotation* and *axis* on the board. Explain to students that the Earth is constantly **rotating,** or turning, on its **axis,** the imaginary center line around which Earth spins. It makes one full turn every day.	*In their models, the wire represents Earth's axis.*
Have students model this motion by turning the wires in their models and watching the globes rotate. Remind students that Earth rotates in one direction only. Ask, **In what direction should we rotate our Earth globes?**	*Rotate from left to right, or from west to east. When viewed from the North Pole end of the axis/wire, the Earth globe should rotate counterclockwise.*
Ask, **As the globe rotates, does the sky move?**	*No, it stays fixed in one position.*
Ask, **Then why do you think we see the sky change during the night?**	*Students may realize that because they are moving, the fixed sky appears to be moving.*
6 Direct students' attention to Part B of Activity Sheet 2. Ask students to complete Steps 4 through 7 in their groups. Then discuss student findings.	
Ask, **Based on what you've just learned, is the hypothesis you recorded in your journal at the end of Activity 1 correct?**	*Student answers will vary.*
Have students verify or correct the hypotheses written in their journals about why the stars move westward. Then ask them to use their own words to describe what makes the stars move during the night and to record their observations in their journals. Also, encourage students to describe what causes sunrise and sunset and to make a drawing that illustrates what is happening. See Figure 2-2 for a sample entry.	

▲ ***Figure 2-2.*** *A sample student journal entry.*

Guiding the Activity

	Additional Information
Finally, ask students to examine the Earth globes in the Sky Spheres and to think about how the sky above would change as they moved toward the North Pole. Have them record their predictions in their astronomy journals.	*They will examine this question in the next activity.*

REINFORCEMENT

If students are having difficulty imagining themselves as observers on their Earth globes, have them attach a small piece of clay to the globe surface approximately where they live. Then ask them to imagine that they are the clay. Have them note how the sky above that point changes as Earth rotates.

SCIENCE NOTEBOOKS

Have students place their completed activity sheets, journals, and Sun Maps in their science notebooks or Astronomy Portfolios.

CLEANUP

Teams will need their Sky Spheres in the next activity. Return the SkyCaps, grease pencils, tape, and Star Patterns masters to the kit. Put away the scissors.

SCIENCE AT HOME

Encourage students to imagine themselves standing on their model Earth globes tonight as they observe the stars. Rather than imagining the stars moving past them, have students imagine themselves moving past the stars. If students stand facing east as they observe, they will see the stars rise in front of them.

Connections

Science Extension

Different places around the world face the Sun at different times; this created the need for a standard system of time measurement. The result was the 24 time zones established around the world, beginning at Greenwich, England. Invite interested students to research the history of Greenwich mean time and report their findings to the class. As part of their presentation, students might mark up a copy of a world map to show the different time zones. Students who are aware of the 1-hour time difference between zones may be surprised to discover that a few places have only ½- or ¾-hour time differences from their neighboring time zones (India and central Australia are two examples).

Science and Math

- Greenwich mean time came about through the efforts of King Charles II to make navigation safer. The method decided on was to compare a ship's time at sea with the time at the Royal Observatory in Greenwich, England (ships carried on board clocks that were set to Greenwich time). In effect, this gave the ship's longitude, which when combined with its latitude gave the ship's position. Students can confirm this concept by using a time zone map of the world to determine the difference in longitude between two places. This can be accomplished by multiplying the difference in hours by 15 (1 hour is equal to 15° in longitude). Given the known longitude of one place, they can determine the longitude of the other by adding or subtracting the difference, depending on whether the second location is west or east of the known location.
- All the planets in the solar system rotate on their axes, but the length of the "day" on each planet varies. Have students look at the times given for rotation period on the Planet Cards to determine the length of each planet's day in Earth units. Point out that an Earth day is divided into twenty-four 60-minute hours. Encourage students to determine how long an "hour" would be on another planet, such as Mercury with its 59-day rotation period (2.45 days).

Science and Social Studies

Invite students to imagine that they lived long ago, before the science of astronomy revealed the true nature of the solar system and the universe. What view of the universe might they develop by watching the Sun, Moon, and stars wheel around Earth? Explain that in the second century, the Alexandrian (Egypt) astronomer Ptolemy advanced the theory that Earth is stationary and at the center of the universe. In the Ptolemaic system, all of the heavenly bodies revolve around Earth. Encourage students to research details of the Ptolemaic system and of the Copernican system that replaced it in the sixteenth century. Ask why it took 1,500 years for people to accept the notion that Earth is not the center of the universe.

Science, Technology, and Society

Encourage interested students to research the device known as Foucault's pendulum, which demonstrates the rotation of Earth on its axis. An extremely heavy weight filled with sand that trickles out is suspended from a very long chain or cable and set in motion over a large compass rose drawn on the floor. As the pendulum swings repeatedly in the same direction, Earth actually rotates underneath it, as can be seen from the sand tracks on the compass rose. Students who have visited a large science museum may have seen a Foucault pendulum in action. Ask them to describe it to the rest of the class.