Section Preview of the Teacher's Edition for

The Earth in Space, *Issues and Earth Science, 2nd Edition*

Activities 76-78

Suggested student responses and answer keys have been blocked out so that web-savvy students do not find this page and have access to answers.

To experience a complete activity please request a sample found in the footer at lab-aids.com

LAB-AIDS®

SEPUP®

Issue-Oriented Science

A Year Viewed From Space

76

2
40- to 50-minute sessions

ACTIVITY OVERVIEW

Students use a computer model to investigate the effects of the revolution of Earth around the Sun and Earth's tilt on seasonal changes in the Northern Hemisphere. Students use the simulation to observe Earth as it revolves around the Sun and to record data for different seasons. They use their observations to develop an explanation for the cause of Earth's year and seasons.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Revolution of a planet (in this case, Earth) around the Sun explains its year length and seasons. (EarthSci: 3)
2. Seasons result from variation as Earth revolves around the Sun in the length of the daylight and the intensity of the Sun's energy hitting the surface, due to the tilt of Earth's axis. (EarthSci: 3)
3. Models can help us describe and explain natural phenomena. (Inquiry: 2)

KEY VOCABULARY

axis

equator

hemisphere

orbit

plausible

revolution

revolve

rotate

MATERIALS AND ADVANCE PREPARATION

For the teacher

* 1 overhead projector

1 *globe on a stand, or an Earth beach ball

1 Scoring Guide: Analyzing Data (AD)

For each pair of students

* 1 computer with access to the SEPUP Seasons Interactive Simulation

For each student

1 Student Sheet 76.1, "Earth's Year Viewed from Space: Top View"

1 Student Sheet 76.2, "Earth's Year Viewed from Space: Side View"

1 completed Student Sheet 71.1a, "My Ideas about the Day, Year, Seasons, and Moon Phases: Before"

1 copy of Scoring Guide: Analyzing Data (AD) (optional)

**Not supplied in kit*

Arrange for a full period of computer time allowing two students per computer. (If three or four students must share a computer, monitor them to be sure each has a chance to control the simulation.) The simulation is available from the *Issues and Earth Science* student page of the SEPUP website, as well as on the CD provided with the course materials.

You may want to do the computer activities in advance to familiarize yourself with the simulation and the pitfalls that students might encounter while using the software.

Masters for Scoring Guides are in Teacher Resources III: Assessment.

TEACHING SUMMARY

Getting Started

1. Discuss students' ideas about what causes a year.

Doing the Activity

2. Model Earth's rotation, revolution, and tilt.
3. Introduce the computer simulation.
4. Students investigate the simulation.

Follow-Up

5. (AD Assessment) Discuss Earth's revolution around the Sun and its role in determining the length of Earth's year and the seasons.

BACKGROUND INFORMATION

Earth's Nearly Circular Orbit

Many students and adults think that Earth's seasons are caused by an elliptical orbit, with winter taking place when Earth is farthest from the Sun and summer when Earth is closest to the Sun. Side view diagrams of the solar system, which exaggerate the elliptical nature of Earth's orbit, often reinforce that misconception.

In fact, Earth's orbit is nearly a circle. The distance of Earth from the Sun does vary, but too slightly (<5%) to cause the degree of temperature variation from season to season. And, as students will see, Earth is 6 million km closer to the Sun during the Northern Hemisphere's winter, rather than in its summer.

Earth's Tilt and the Angle of Sunlight

As the tilted Earth revolves around the Sun, the orientation of the tilt toward the Sun changes. At one point in its orbit, the Northern Hemisphere leans toward the Sun (and the Southern Hemisphere leans away from it), while at the opposite point in Earth's orbit, the Northern Hemisphere is tilted away from the Sun (and the Southern Hemisphere toward it). The tilt causes daily changes in the number of hours of daylight and determines where on Earth's surface the most direct (vertical, or "straight-on") rays of the Sun fall.

If Earth's axis were not tilted, Earth's orientation to the Sun would remain the same throughout its revolution, and the direct rays of the Sun would fall only along Earth's equator throughout the year. North and south of the equator, the rays would hit at an angle—an angle that would be constant year-round. Because of the tilt, the angle of the Sun varies throughout the year everywhere on Earth.

For example, the Sun's rays hit the equator most directly (when the angle with the horizontal is 90°) only on the equinoxes, on about September 21 and March 21. Between about March 21 and September 21, the Sun's most direct rays hit Earth's surface north of the equator, reaching their northernmost latitude at the Tropic of Cancer (23.5°N) on about June 21 (the Northern Hemisphere's summer solstice and the Southern Hemisphere's winter solstice). At this time, the Sun's rays are the most direct (at the highest angle) as they will ever be in areas north of the Tropic of Cancer. From about September 21 to March 21, the direct rays of the Sun hit Earth's surface south of the equator, reaching their southernmost latitude at the Tropic of Capricorn (23.5°S) on about December 21 (the Northern Hemisphere's winter solstice and the Southern Hemisphere's summer solstice). That's when the Sun's rays are the least direct (at the lowest angle) they will ever be in the Northern Hemisphere.

Areas between the Tropic of Cancer and Tropic of Capricorn (the tropics) vary much less in temperature or lengths of daylight from season to season than other areas—so little that the terms spring, fall, winter, and summer have less meaning to people there. In general, the farther one goes from the equator, the greater the seasonal variation in temperature and the variation in daylight length. The extreme cases are regions within the Arctic and Antarctic circles (66.5°N and 66.5°S), which experience continuous daylight on the first day of summer and continuous dark on the first day of winter.

TEACHING SUGGESTIONS

GETTING STARTED

1. Discuss students' ideas about what causes a year.

Ask students to look over their completed copies of Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Moon Phases: Before." Have them discuss the responses they wrote down to the questions on what causes a year and what causes the seasons. Some of the likely answers appear in Activity 71 of this Teachers' Guide. Additional questions you might ask are: ***What is a year? What happens to Earth in a year's time? Even if we didn't have calendars, how would we know that a year has passed? What did you learn in the last activity about what happens to the angle of the Sun and length of daylight over a year?*** Give students a chance to voice their ideas for you to record on chart paper or a transparency.

Students are likely to propose that Earth is closer to the Sun in summer than in winter. The evidence they find in the first part of this activity should help them change this preconception. A few students may know something about the role of Earth's tilt in determining the seasons. Leave this question open—you will return to it after students complete the activity.

Discuss how the passage of the year has always been notable to humans in many areas of the world in view of the significant impact of the seasons on climate and on the availability of food and water. Early in history people in many cultures figured out when to plant crops by studying the changing time of the sunrise and sunset and the patterns of the stars.

DOING THE ACTIVITY

2. Model Earth's rotation, revolution, and tilt.

Use a globe or the Earth beach ball to introduce some of the terms used in this activity. Point out the **equator**, and explain that it is an imaginary line that people have designated to divide Earth into two halves called the **Northern Hemisphere** and **Southern Hemisphere**. Also point out the North Pole and the South Pole.

Explain that the term **latitude** refers to how far a city is north or south of the equator. Point out the locations and latitudes (rounded to the nearest degree) of the cities used in the simulation: Anchorage, Alaska (latitude 61°N) is an example of a very northern city; Chicago, Illinois (latitude 42°N) is a mid-latitude Northern Hemisphere city; Quito, Ecuador (latitude 0°) is near the equator; and Melbourne, Australia (latitude 38°S) is a mid-latitude Southern Hemisphere city.

As students learned in the last activity, Earth rotates around its axis once during each day–night cycle. Now introduce the concept that Earth also moves around, or **revolves** around, the Sun, and explain that one complete turn around the Sun is called a **revolution**. Earth's **orbit** is the path it follows as it revolves. Model this by moving the beach-ball globe (or another sphere) around a lightbulb or other object that represents the Sun. Then model both rotation and revolution at once. Throughout this activity, encourage students to use the terms rotate and revolve as much as possible to describe the motions of Earth.

Raise the point that Earth's axis is tilted. The best way is to use a standard tilted globe that shows the correct orientation of the axis of Earth relative to the plane of its orbit (23.5° from a vertical line perpendicular to Earth's orbit). You can also use the beach-ball globe to demonstrate Earth's tilt.

3. Introduce the computer simulation.

Let students know they will be using an interactive computer simulation to explore another planetary characteristic, the year length. Beforehand use the screen-shot of the Seasons Interactive Simulation in the Student Book to orient them to what they will see.

Step 1 of the Procedure directs them to an introductory page of the simulation. This page reiterates for them the position of the equator and shows the locations of the four cities that appear in the interactive. It also defines the optional terms *Tropic of*

Cancer and *Tropic of Capricorn*. These are considered optional because there are so many terms in this activity, and students can grasp the main ideas of the unit without them.

Be sure to tell students that the size of the Sun and Earth in this simulation are not to scale. The Sun is much larger (its diameter is more than 100 times that of Earth). Also point out that the top view shows the orbit as nearly circular, while the side view shows it stretched out into a more eccentric ellipse. The top view is much closer to the correct view. The side view stretches out the orbit to make it easier to see Earth. This kind of view contributes to the misconception that the distance from Earth to the Sun is the variable that determines the seasons. Make sure that students understand that the top view is more accurate. Note that students will explore size and distance of planets in the solar system further in Unit G, "Exploring the Solar System."

■ FOLLOW-UP

4. Students investigate the simulation.

Distribute Student Sheet 76.1, "Earth's Year Viewed from Space: Top View." Have students complete Procedure Steps 1–7 (Part A) of the activity.

As they watch the simulation, circulate among them, asking them what they are seeing. Refer them back to their initial ideas in the activity, and ask if they have seen any evidence for or against those ideas. Be sure they confront the observation that Earth is closer to the Sun during our (Northern Hemisphere) winter and that this refutes the idea that distance from the Sun determines the seasons. This may be difficult for students to grasp.

Distribute Student Sheet 76.2, "Earth's Year Viewed from Space: Side View," and explain to students how they will use sketches of Earth like those at the top of the page to show Earth at each season in the Northern Hemisphere. You may need to suggest that they look specifically at the tilt of Earth as they stop it in each of the four months designated. If any students have extra time, encourage them to explore additional months as well. Then have students continue to Part B of the activity. Sample results for Student Sheets 76.1 and 76.2 are on the next page.

To check their understanding of the effect of Earth's tilt, stop before Step 13 and have students vote on whether they think that changing the tilt to 0° will: a) have no effect, b) make the seasons less extreme, or c) make the seasons more extreme in Chicago.

For Step 13, students should find that at 0° tilt, there is little or no seasonal variation for Chicago.

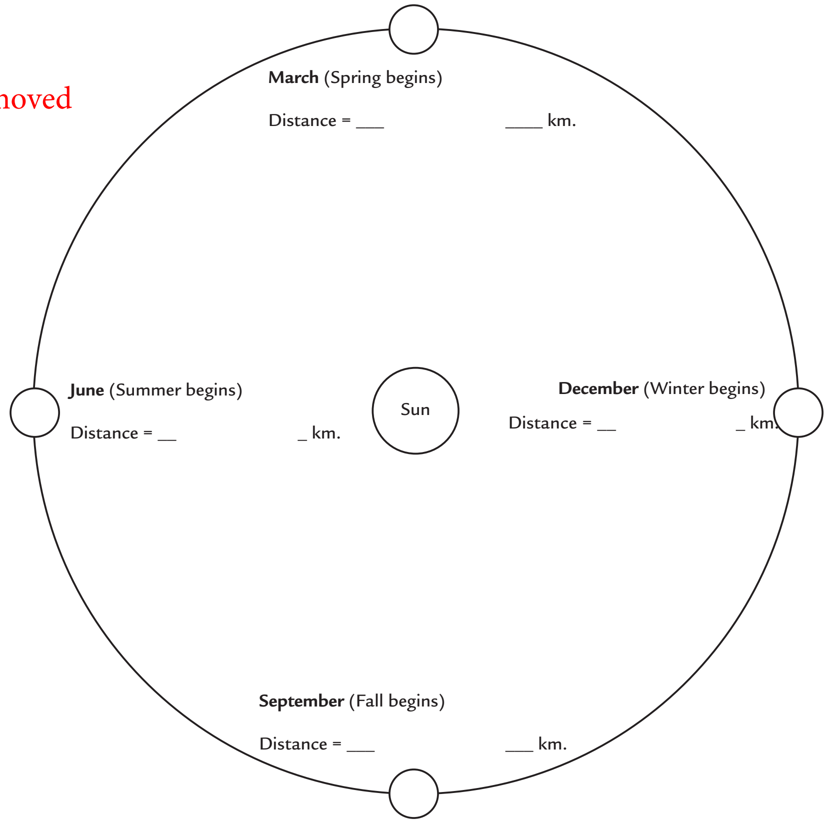
For Step 14, they should observe that the daylight period in Melbourne in December is 14 hours and 46 minutes, while in June it is 9 hours and 33 minutes. They should find that there the average temperature in December is 63°F, 17°C, while in June it is 50°F, 10°C. *From this they should describe these seasons as reversed from those in Chicago. This is the important point for them to notice now.* They may also notice that winter and summer are milder in Melbourne. (Although there are other variables that affect weather, they may be able to reason that one factor is the greater distance of Chicago from the equator. Another is Chicago's distance from an ocean, while the ocean has a moderating effect on temperatures in coastal Melbourne.) You may wish to ask them to review their diagrams and speculate why Melbourne would have winter in June and summer in December. That will help you see if they can reason that the orientation of Earth's axis causes the Southern Hemisphere to tilt away from the Sun in June and toward the Sun in December.

5. (AD Assessment) Discuss Earth's revolution around the Sun and its role in determining the length of Earth's year and the seasons.

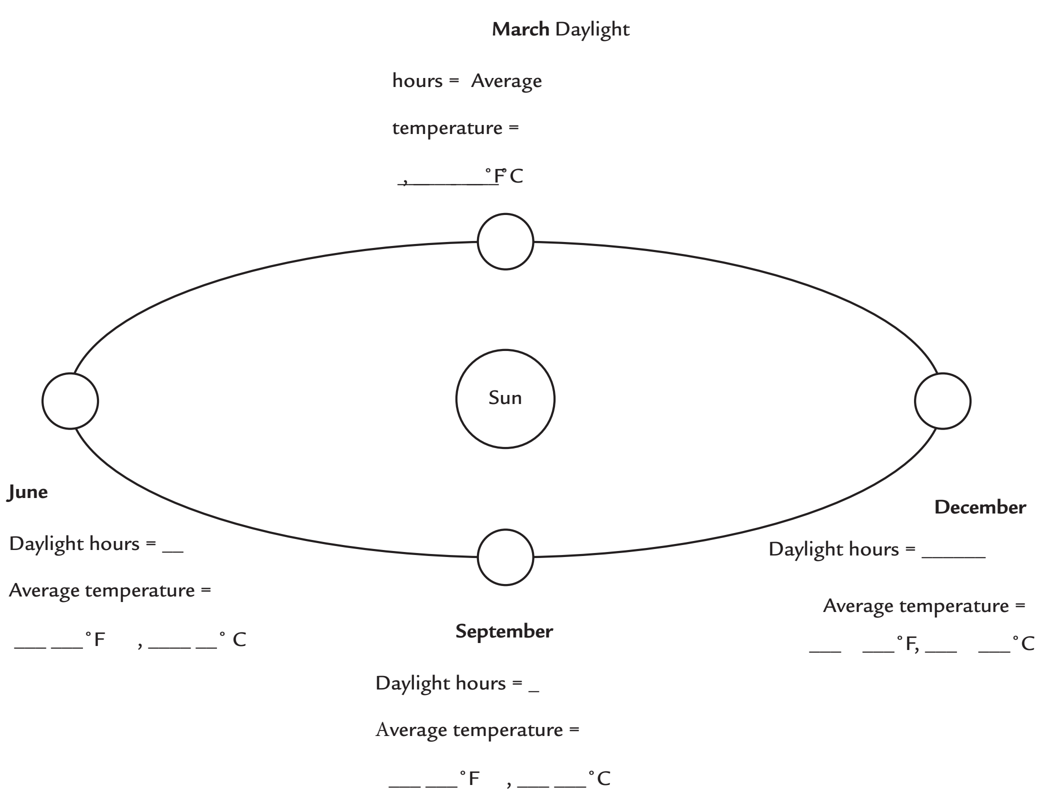
Allow students time to discuss Questions 1–3. Circulate around the room and provide hints as needed. Be sure they have observed the Northern Hemisphere's tilt toward the Sun at the beginning of its summer in June, and away from the Sun in the beginning of its winter in December.

When they have had a chance to think about the ideas on their own, hold a class discussion on the seasons before asking them to complete the individual questions. Have students discuss how the tilt of the Earth leads to warm summers and cold winters in many places. Review the idea that the seasons in the Southern Hemisphere are reversed from those

Sample Results for Student Sheet 76.1, “Earth’s Year Viewed From Space: Top View”



Sample Results for Student Sheet 76.2, “Earth’s Year Viewed From Space: Side View”



in the Northern Hemisphere. Explain that when one of these hemispheres of Earth is tilted toward the Sun, that half of Earth receives more direct sunlight (closer to vertical) and is in the Sun for a longer period of time, both of which lead to warmer temperatures. Students will explore these concepts further in Activities 77 and 78.

Tell students that their individual answers to Question 4 will be used to assess how well they have learned to analyze data. Use the ANALYZING DATA Scoring Guide to score their responses.

Remind students of the explanations for the seasons that they offered before doing the activity, and ask them to describe how their ideas have changed. The idea that seasons are determined by distance from the Sun is still logical based on our experience on Earth—the closer you get to a hot object, the warmer you get. But the actual evidence shows that distance from the Sun as an explanation for the seasons is just not correct. The distance factor also does not explain why it is summer in the Southern Hemisphere when it is winter in the Northern Hemisphere. For these reasons, distance from the Sun as an explanation for the seasons is no longer plausible. A good explanation for any natural phenomenon, such as the changes of the seasons, must make sense, and it must explain most, if not all, aspects of the phenomenon.

■ EXTENSION

Students can use data provided in the computer simulation to graph daylight length (and/or average temperature) versus month for one of the cities. (Note that the daylight length in the simulation is in hours and minutes. For convenience in graphing daylight length, they should convert minutes to tenths of hours by dividing the minutes by 60.) For Anchorage or Chicago, they will find a greater fluctuation in daylight length than they saw in Activity 75 for a middle U.S. latitude, as both of these cities are farther from the equator. Differences in daylight lengths will be especially noticeable for Anchorage, while Quito will show little fluctuation. They may notice that the temperatures in Quito are cooler than they would expect of a city near the equator. This is because Quito is at a high elevation, and thus has a cooler climate than low-lying areas nearby. For Melbourne, they will find its graph is opposite to those they made in Activity 75 for the mid-latitude United States and for Chicago or Anchorage, reflecting the Southern Hemisphere's decrease in daylight hours as June approaches, and gradual increase again after June 21 to its longest day on December 21. For students to graph their own city, they can obtain the data they will need from the following website (they will need to know their city's latitude and longitude—easy to find on the Internet—beforehand):

National Research Council Canada. Sunrise/Sunset/Sun Angle Calculator, http://www.hia-iha.nrc-cnrc.gc.ca/sunriseadve.html.

If this link becomes un-available, an updated link will be provided on the *Issues and Earth Science* page of the SEPUP website.

SUGGESTED ANSWERS TO QUESTIONS

1. *What motion of the Earth causes the yearly cycle of the seasons?*

Sample responses removed for preview

2. *Why does a year on Earth have 365 $\frac{1}{4}$ days?*

   Earth rotates slightly more than 365 times during one revolution around the Sun (or year).

3. *In which months is Earth:*

   a. *closest to the Sun?*

b. farthest from the Sun?

4. (AD ASSESSMENT) *Based on what you have observed about the distance from Earth to the Sun, does the distance from Earth to the Sun determine the seasons? Explain the evidence for your answer.*

Level 3 Response:

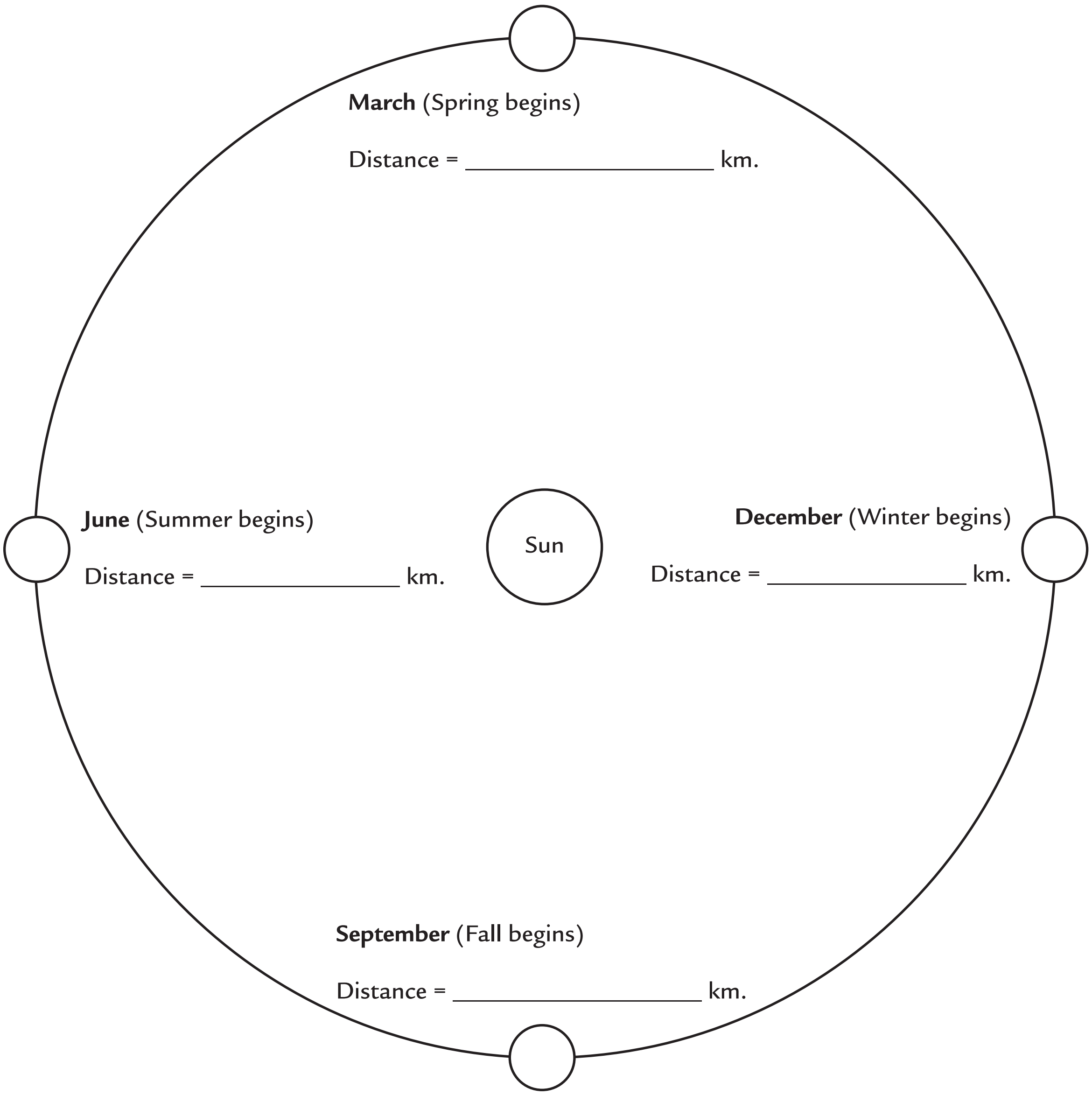
5. *In what month is the Northern Hemisphere most tilted toward the Sun?*

6. *In what month is the Northern Hemisphere most tilted away from the Sun?*

7. *Explain how the tilt of Earth affects the seasons and daylight hours.*

Name ________________________________ **Date** _____________

Earth's Year Viewed from Space: Top View



Name ______________________________ Date ____________

Earth's Year Viewed from Space: Side View

Earth's orbit is not really stretched out as in the drawing below. It is shown this way because when you look at a circle from the side and slightly above, this is what it looks like.

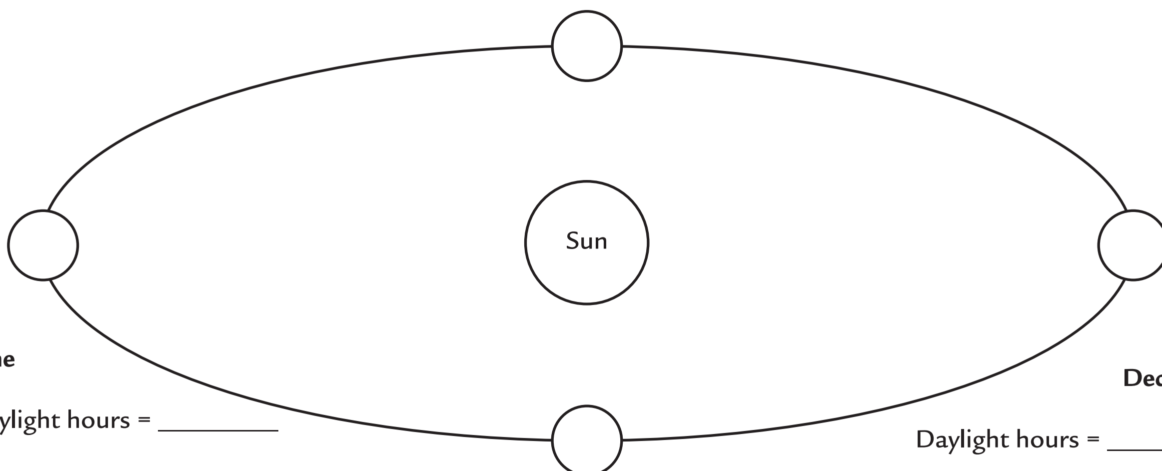
The Sun is much larger than Earth, but is small in the diagram so that you will have room to draw Earth's position in each of the four seasons.

March

Daylight hours = ________

Average temperature =

________ °F, ________ °C



June

Daylight hours = ________

Average temperature =

________ °F, ________ °C

September

Daylight hours = ________

Average temperature =

________ °F, ________ °C

December

Daylight hours = ________

Average temperature =

________ °F, ________ °C

Name ______________________________ Date ____________

My Ideas About the Day, Year, Seasons, and Moon Phases: Before

Day	Year
What changes happen in the sky every 24 hours? What causes these changes?	What is a year? What changes happen in the Sun's position in the sky over a year? What causes these changes?
Seasons	**Moon Phases**
What changes happen in the seasons every year? What causes these changes?	What changes take place in the visible shape of the Moon from day to day? How long does it take for these changes to take place? What causes these changes?

3. ANALYZING DATA (AD) ASSESSMENT COMPONENTS

What to look for:

- *Student's response accurately summarizes data, detects patterns and trends, and draws valid conclusions based on the data.*

Assessment Components

COMPONENT	INDICATOR
1. Characteristics of data	a. Source of data is objective and reliable.
	b. Data are free of inconsistencies or inconsistencies are identified.
	c. Student identifies potential sources of error and, where appropriate, estimates the relative importance of such errors.
2. Trends and relationships	a. Interpretation of data is accurate.
	b. Identification and description of trends and relationships between variables are correct.
3. Inferences and conclusions	a. Conclusion is compatible with analysis of data.
	b. Student recognizes the need for additional data where appropriate.
	c. Analysis is mathematically correct.

Scoring Guide

LEVEL	DESCRIPTION
Level 4 Above and beyond	Student accomplishes Level 3 AND goes beyond in some significant way, such as: • explaining unexpected results. • judging the value of the investigation. • suggesting additional relevant investigation.
Level 3 Complete and correct	Student analyzes and interprets data correctly and completely, AND draws a conclusion compatible with the analysis of the data.
Level 2 Almost there	Student notes patterns or trends, BUT does so incompletely.
Level 1 On your way	Student attempts an interpretation, BUT ideas are illogical, OR ideas show a lack of understanding.
Level 0	Student's analysis or interpretation of data is missing, illegible, or irrelevant.
X	Student had no opportunity to respond.

Explaining the Seasons 77

1-2
40- to 50-minute sessions

MODELING

ACTIVITY OVERVIEW

Students continue to explore the effect of Earth's tilt in determining the seasons. Two teacher demonstrations show that light is more concentrated, or less spread out, when it strikes a surface at a 90° angle than at any other angle. Using a photovoltaic cell, students explore how the angle of the sunlight striking it affects the amount of solar energy the cell absorbs.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Revolution of a planet (in this case, Earth) around the Sun explains its year length and seasons. (EarthSci: 3)
2. Seasons result from variation as Earth revolves around the Sun in the length of the daylight and the intensity of the Sun's energy hitting the surface, due to the tilt of Earth's axis. (EarthSci: 3)
3. Models can help accurately describe and explain natural phenomena. (Inquiry: 2)
4. People from many cultures have studied the skies to predict seasonal changes. (History: 1)

KEY VOCABULARY

axis

revolve

MATERIALS AND ADVANCE PREPARATION

For the teacher

	1	Earth beach ball (or *other globe)
*		tape or adhesive page tags
*	1	flashlight
*	1	meter stick

For each group of four students

1	solar cell
1	electric motor with flag on axle
2	wire leads with alligator clips (one red and one black)

**Not supplied in kit*

This activity should be done in a sunny location away from any reflective surfaces that might reflect light onto the solar cells. An open grassy or roughly paved area is ideal. Check the weather forecast in advance. You need some sunlight for this activity, but a few minutes of it will be enough for students to collect the data they need. Hazy sunshine is probably adequate. Shining an overhead projector lamp on a tilted and untilted solar cell shows the effect of tilting. **Do not use the projector lamp, however, to investigate distance.** The distance from the overhead lamp changes the energy absorption by the cells significantly even if students just move the cell a few feet, giving the incorrect idea that seasonal changes in light striking the surface of Earth is related to distance from the Sun.

TEACHING SUMMARY

Getting Started

1. Review what students learned from the computer simulation, and introduce the Challenge.

Doing the Activity

2. Use a globe to demonstrate the effect of changing the angle of light from a flashlight.
3. Students use photovoltaic cells to investigate the effect of the angle of a surface on the intensity of the solar energy hitting the surface.

Follow-Up

4. Discuss the role of Earth's tilt in determining the length of Earth's year and the seasons.

TEACHING SUGGESTIONS

■ GETTING STARTED

1. **Review what students learned from the computer simulation, and introduce the Challenge.**

Elicit students' understanding of the computer simulation by reviewing the following ideas:

The seasons are not determined by Earth's distance from the Sun. Although this is a reasonable hypothesis (and may in fact be true for other planets), Earth's orbit is fairly close to a circle. The slight variation in distance cannot be a major factor in seasonal changes. If it were, both the Northern and Southern hemispheres would have summer from December through February when Earth is closest to the Sun.

The seasons on Earth are instead determined by the tilt of Earth. As it revolves around the Sun, the Northern Hemisphere tilts toward the Sun in the months around June, when summer begins in the Northern Hemisphere. The Southern Hemisphere is most tilted toward the Sun during the months around December, which is the beginning of its summer. Note that although the Northern Hemisphere tilts the most toward the Sun in June, June is not typically the warmest month. It takes time for the oceans and land to warm up.

Ask students for responses to the Challenge: "Why does the tilt of Earth lead to different surface temperature?"

They may suggest that the tilt brings the Northern Hemisphere closer to the Sun. This activity will address this concept and provide evidence *that it is not the distance, but the directness (angle) of the Sun's rays that determines the seasons.*

■ DOING THE ACTIVITY

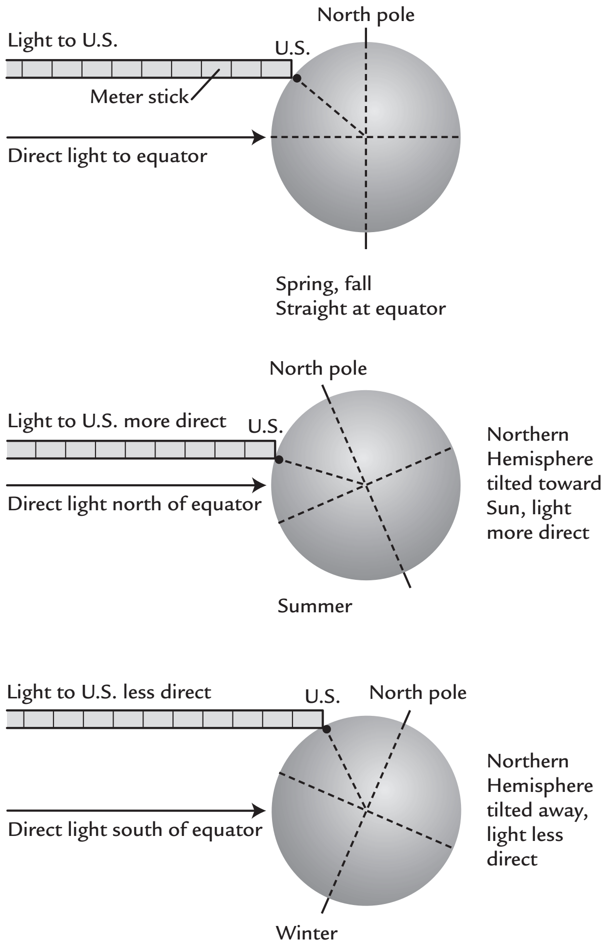
2. **Use a globe to demonstrate the effect of changing the angle of light from a flashlight.**

Begin by darkening the room and showing students that the light from a flashlight is concentrated into a smaller area if you direct it straight at the wall or the floor (at an angle perpendicular to the surface) than if you direct it at a lower angle. Then use the globe and a flashlight to model what happens if you direct the beam of light straight onto (at a 90° angle to) the United States. In this case, the light covers a fairly small circle. But if you then tilt the globe so that the United States tilts less directly toward the light beam, creating a different angle between the U.S. and the light beam, the beam will spread out over a larger area and may even look slightly less intense. Make the point that the same amount of light energy is now spread out over more of Earth's surface, and therefore the light energy hitting any particular place is decreased. The more the Northern Hemisphere tilts away from the beam (as in winter), the less directly the Sun's light will hit any given part of the United States. Be sure to point out that the Sun is very far away from Earth, and the slight change in distance (several thousand km out of 150 million km) due to the tilt is not enough to make any change in Earth's temperature.

Be sure students don't think that the term "less direct rays" means reflected rays. Make the point that the term "direct rays" from the Sun means that the rays strike Earth at a 90° angle, or perpendicular to the horizontal. Less direct rays are at a lower angle.

To more clearly demonstrate the effect of Earth's tilt on the angle of the Sun's rays, use a globe and a meter stick to illustrate the angle. Show that in spring and fall the rays from the Sun come in straight toward the equator and perpendicular to Earth's axis. Then in summer, the Northern Hemisphere tilts toward the Sun, while in winter it tilts away. This is shown on the next page.

Earth's Tilt and Angle of Sunlight



3. **Students use photovoltaic cells to investigate the effect of the angle of a surface on the intensity of the solar energy hitting the surface.**

Tell students they will now collect some direct evidence about the amount of energy absorbed by a part of Earth's surface when the sun's rays hit the surface at a 90° angle as opposed to when it hits the surface at another angle.

Showing them a solar cell connected by two wires to a motor, explain that the solar cell can absorb light energy from the Sun and convert it to electrical energy. The electricity can in turn be converted to mechanical energy to run a small motor. Review the Procedure, and explain to the students that they will compare how fast the motor runs when the Sun's light hits the solar cell at a 90° angle with how fast it runs when the Sun's light hits the solar cell at other angles.

Have students read the introduction and Challenge, and then take them outside to complete the Procedure.

■ FOLLOW-UP

4. **Discuss the role of Earth's tilt in determining the length of Earth's year and the seasons.**

Discuss the students' observations. Use their responses to Questions 1–3 to elicit the following concepts:

- The angle of the light hitting a surface affects the intensity of energy hitting the surface. (If you don't want to use the term intensity, you can refer to how spread out or how concentrated into a smaller area the energy is.) The more directly (closer to 90° from the horizontal) the light hits the surface of the solar cell, the more energy per area the cell receives and the faster the motor turns. Gradually changing the solar cell's tilt makes the Sun's rays gradually hit less directly, thus reducing the amount of energy the cell will absorb and convert to electricity. Eventually the amount of the Sun's energy being absorbed and converted to electricity becomes so low that the motor stops.
- Moving the solar cell closer to the Sun does not make a difference in the speed of the motor. This is because the Sun is so far away that moving the solar cell a few feet closer makes no measurable difference in the energy of the sunlight hitting the solar cell and no observable difference in the motor's speed.
- Similarly, the tilt of the Earth has a very small effect on the distance of the Northern Hemisphere from the Sun. The distance variation caused by Earth's tilt is far smaller than the variation caused by Earth's noncircular orbit investigated in Activity 76. However, the tilt of the Earth does have a very significant effect on the angle of the Sun's rays and therefore the amount of energy hitting the surface in a particular area.

Use the globe beach ball or a regular globe and a bright light to demonstrate the effect of Earth's tilt on length of daylight. If you show the Northern Hemisphere tilted toward the light, students will see that the area near the North Pole will be in daylight most of the time, while the area near the South Pole will be in darkness most of the time. They will also be able to see that the United States has a longer daylight period than nighttime when the Northern Hemisphere is tilted toward the Sun, and vice versa when it is tilted away.

✓ Question 4 can be used as a quick check of students' understanding of how Earth's tilt results in warmer temperatures. Because this activity does not address daylight length, students are likely to focus on the angle from the Sun and the surface and not mention the longer days of summer. Remind them that Earth's tilt also causes an increase in daylight hours in summer, making it warmer in summer.

Questions 5 and 6 can be done as a class discussion. Question 5 asks students to apply their understanding to the Southern Hemisphere. Question 6 encourages students to think about how using a variety of models can help them understand a complex concept, such as the seasons.

SUGGESTED ANSWERS TO QUESTIONS

1. *When your teacher tilted a portion of the globe directly into light from a flashlight, what happened to the light striking the globe?*

2. *When you tilted the solar cell from Position A to Position B, what effect did it have on the speed of the motor attached to the solar cell?*

3. *What does this tell you about the amount of the Sun's energy transferred to the solar cell in the two different positions? Be sure to give a complete explanation.*

4. ✓ *Why is the Northern Hemisphere warmer when it is tilted toward the Sun?*

5. *In Australia, it is summer in December and winter in July. Why is this?*

6. ***Reflection:*** *How did each of the following models help you understand how Earth's tilt causes the seasons?*
   - *the computer model*
   - *the globe and a flashlight*
   - *the solar cell and motor*

   The goal of this question is for students to reflect on how each model helped them understand the seasons. They are likely to say that the com-

The Earth on the Move 78

1-2
40- to 50-minute sessions

READING

ACTIVITY OVERVIEW

Students read a summary of the reason for Earth's seasons. The reading emphasizes the role of Earth's tilt in determining the angle of the Sun's rays and the length of the day, both of which contribute to seasonal variations in temperature. Students complete a three-level reading guide to help them process the information in the reading.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Revolution of a planet (in this case, Earth) around the Sun explains its year length and seasons. (EarthSci: 3)
2. Motions of a planet (in this case, Earth) explain its day length, year length, and seasons. (EarthSci: 3)
3. Seasons result from variation as Earth revolves around the Sun in the length of the daylight and the intensity of the Sun's energy hitting the surface, due to the tilt of Earth's axis. (EarthSci: 3)
4. Models can help accurately describe and explain natural phenomena. (Inquiry: 2)

KEY VOCABULARY

axis

revolve

revolution

rotate

MATERIALS AND ADVANCE PREPARATION

For the teacher

1 Scoring Guide: UNDERSTANDING CONCEPTS (UC)

For each student

1 Student Sheet 78.1, "Three-Level Reading Guide: The Earth on the Move"

1 copy of Scoring Guide: UNDERSTANDING CONCEPTS (UC) (optional)

1 completed Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Moon Phases: Before"

1 Student Sheet 71.1b, "My Ideas About the Day, Year, Seasons, and Moon Phases: After"

**Not supplied in kit*

Masters for Scoring Guides are in Teacher Resources III: Assessment.

TEACHING SUMMARY

Getting Started

1. Introduce the reading.

Doing the Activity

2. (LITERACY) Students read the text.

Follow-Up

3. (UC ASSESSMENT) Students prepare diagrams to process and communicate what they have learned.

TEACHING SUGGESTIONS

GETTING STARTED

1. Introduce the reading.

Explain that the reading in this activity summarizes the concepts students investigated in the two previous activities. Ask students to recap what they have learned so far, and discuss what they still find difficult to understand.

Review the scenario in the introduction, and point out the location of Australia in the Southern Hemisphere. Ask students to suggest why seasons in Australia and other countries in the Southern Hemisphere are reversed from seasons in the United States. Distribute Student Sheet 78.1, "Three-Level Reading Guide: The Earth on the Move," and have students preview the statements on the sheet.

DOING THE ACTIVITY

2. (LITERACY) Students read the text.

You may want students to stop reading after each section and review the three-level reading guide. After each section they can put a check next to those statements that are supported by the section. The statements in each level of the reading guide help students understand the text. The Level 1 statements require students to find literal meaning in the reading, Level 2 asks them to interpret it, and Level 3 has them apply their understanding to new situations.

After students complete the reading, review the statements with them. Suggested responses are shown on the next page.

FOLLOW-UP

3. (UC ASSESSMENT) Students prepare diagrams to process and communicate what they have learned.

Have students respond to the Analysis Questions. Question 1 allows them to compare and contrast rotation and revolution and their effects. Emphasize that each has an impact on our experience on Earth and how we measure time.

Question 2 can be used to assess students' understanding of the relationship of the angle of sunlight to the seasons. Use the UNDERSTANDING CONCEPTS Scoring Guide to score students' responses. As you discuss Question 2, elicit students' experiences that relate to changes in the intensity of the Sun in summer as opposed to winter. These would include the increased warmth of the Sun and increased likelihood of a sunburn in the summer.

Have students review their responses to Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Moon Phases: Before" in preparation for answering Question 3. After the class discusses Question 3, have them record the scientifically correct explanation for the year length and seasons in the second and third boxes on Student Sheet 71.1b, "My Ideas About the Day, Year, Seasons, and Moon Phases: After."

SUGGESTED ANSWERS TO QUESTIONS

1. *Rotation and revolution are both motions of the Earth.*

   a. *How do each of these motions help us mark time?*

   b. *In your science notebook, create a larger version of the Venn diagram shown on the next page. Compare and contrast the rotation and the revolution of the Earth by recording the unique features of each phenomenon on the far side of each circle. Record common features of Earth's rotation and revolution in the space where the*

Sample responses removed from preview

Sample Responses to Student Sheet 78.1, "Three-Level Reading Guide: The Earth on the Move"

1. Check the statements below that you think say what the reading says. Sometimes the exact words found in the reading are used. At other times, other words may be used to communicate the same meaning.

_ **a.** Earth is closer to the Sun in December than it is in June.

_ **b.** In the United States, the Sun's rays are least direct in December.

_ **c.** Only the Northern Hemisphere has seasons.

2. Check the statements below that you think represent the intended meaning of the reading.

_ **a.** Rays from the Sun that hit Earth more directly heat Earth's surface more than less direct rays do.

_ **b.** The effects of Earth's tilt are far more significant than the effects of changes in distance from the Sun in determining the seasons.

_ **c.** If Earth were tilted even more, it would always be winter.

_ **d.** The orbit of Earth around the Sun is almost circular.

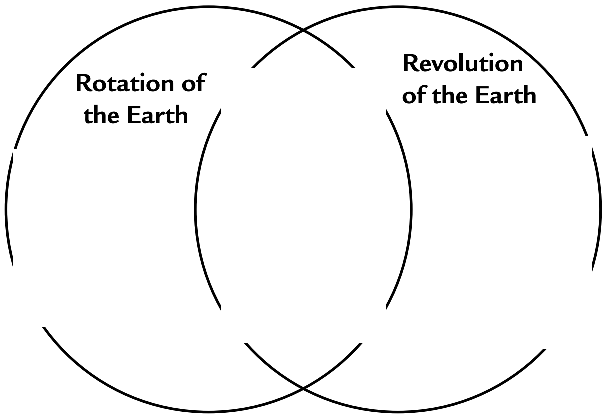
_ **e.** When the Northern Hemisphere has spring, the Southern Hemisphere has fall.

3. Check the statements below that you agree with, and be ready to support your choices with ideas from the reading and from your own knowledge.

_ **a.** If Earth were not tilted, the northern United States would usually be just as warm as the southern United States.

__ **b.** Seasons become more extreme as you move toward either the North or South Pole.

Response to Venn Diagram



circles overlap. Hint: Think about what you have learned about these motions in the last few activities.

2. (UC ASSESSMENT) *Prepare a labeled diagram that includes a caption that explains to Emily's cousin Charlotte how Earth's tilt and its revolution around the Sun cause each of the following:*

   a. *changes in the angle of sunlight hitting Earth*

   Level 3 Response:

3. ***Reflection:*** *Review your ideas about the seasons that you recorded on Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Phases of the Moon: Before." How have your ideas about the reasons for the seasons changed since you began this unit?*

Name ______________________________ Date ____________

Three-Level Reading Guide: The Earth on the Move

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4. UNDERSTANDING CONCEPTS (UC)

What to look for:

- *Student's response identifies and describes scientific concepts relevant to a particular problem or issue.*

Scoring Guide

LEVEL	DESCRIPTION
Level 4 Above and beyond	Student accomplishes Level 3 AND goes beyond in some significant way, such as: • providing relevant information not provided in class that enhances the response. • using a diagram to clarify scientific concepts. • relating the response to other scientific concepts.
Level 3 Complete and correct	Student accurately and completely explains or applies relevant scientific concept(s).
Level 2 Almost there	Student explains or applies scientific concept(s) BUT omits some information OR includes some errors.
Level 1 On your way	Student incorrectly explains or applies scientific concept(s) OR shows a lack of understanding of the concept(s).
Level 0	Student's response is missing, illegible, or irrelevant.
X	Student had no opportunity to respond.

Name ______________________________ **Date** ____________

My Ideas About the Day, Year, Seasons, and Moon Phases: Before

Day	**Year**
What changes happen in the sky every 24 hours? What causes these changes?	What is a year? What changes happen in the Sun's position in the sky over a year? What causes these changes?
Seasons	**Moon Phases**
What changes happen in the seasons every year? What causes these changes?	What changes take place in the visible shape of the Moon from day to day? How long does it take for these changes to take place? What causes these changes?

Name ______________________________ Date ____________

My Ideas About the Day, Year, Seasons, and Moon Phases: After

Day	Year
What changes happen in the sky every 24 hours? What causes these changes?	What is a year? What changes happen in the Sun's position in the sky over a year? What causes these changes?
Seasons	**Moon Phases**
What changes happen in the seasons every year? What causes these changes?	What changes take place in the visible shape of the Moon from day to day? How long does it take for these changes to take place? What causes these changes?