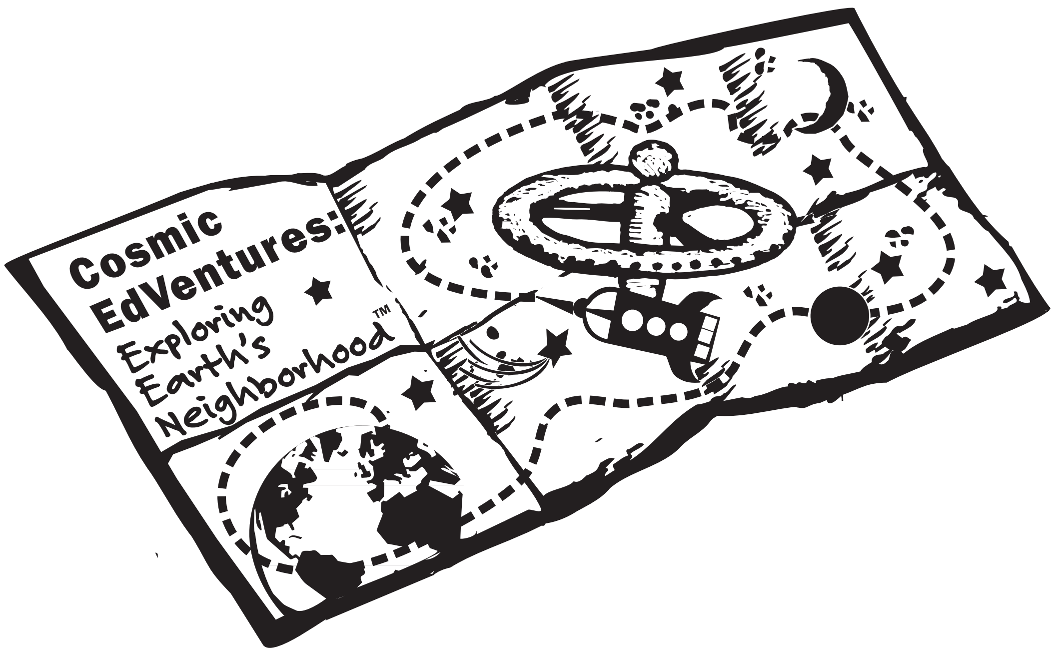
A New Slant on the Seasons



This lesson is from Cosmic EdVentures: Exploring Earth's Neighborhood™, an interdisciplinary Solar System unit in which 3rd - 6th grade students become futuristic travel agents and design excursions to places throughout the Solar System.

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Another in the series of Challenger Learning EdVentures™ from

Challenger Center®

Solar System Basics

Unit 1

A New Slant on the Seasons

Topic

How the tilt of the Earth's axis causes Earth's seasons.

Science Processes

- Observing
- Predicting
- Making models
- Interpreting data
- Making graphs
- Defining operationally
- Investigating

Mathematics

- Finding patterns and relationships
- Building spatial relationships
- Making graphs

Overview

This lesson examines the role of the Earth's tilted axis in causing the seasons we experience on Earth. Students explore this phenomenon by modeling the seasons using globes positioned in a circle around an overhead projector (the Sun). Students observe the areas of the Earth receiving the most sunlight at each season by studying the shape and size of a projected grid. After completing this activity, students will be able to explain the reasons for the seasons.

Key Question

How does the Earth's tilt cause the seasons?

Objectives

1. To model the positions and orientations of the Earth with respect to the Sun in the different seasons.
2. To observe how the Earth's tilt affects the amount of sunlight energy an area receives.
3. To draw conclusions about the relationship between the tilt of the Earth and the seasons.
4. To dispel a common misconception that Earth's distance from the Sun causes seasons.

Key Concepts

- Many people think that the Earth is farther away from the Sun in the winter and closer in the summer. This is not the case. Earth's distance from the Sun does not change enough over the year to be the cause of the seasons.
- The Earth's axis tilts with respect to its orbit around the Sun.
- The slant of the Earth's axis combined with its orbit around the Sun means the Northern and Southern Hemispheres alternately tilt toward the Sun over the course of a year.
- The tilt of the Earth's axis is fixed with respect to the star Polaris and other stars.

  NOTE: Actually, the Earth does wobble a little with respect to the stars. However, one wobble takes 26,000 years so its effects are negligible on a year-to-year basis.

- The slant of Earth's axis means the hemisphere tilted toward the Sun gets direct, intense sunlight (summer), while the hemisphere tilted away from the sun gets less intense sunlight (winter).
- In summer, long days mean that the Sun can heat the ground for a long time. In winter, short days leave less time for the Sun to heat the ground.

Materials

- 2 globes (not included in kit)
- Four stickers or adhesive circles (not included in kit)
- Copies of the Slant on the Season Worksheet (1 per student)
- Copies of the What Causes the Seasons Fact Sheet (1 per student)
- 2 overhead projectors
- Extension cords
- 2 transparent grids (See step 3 of the Teacher Preparation for instructions)
- Masking tape labels marked December, March, June and September
- Square of aluminum foil
- 40-foot length of rope or twine
- One 12 cm (approx. 5-inch) diameter circle cut out of yellow construction paper labeled "Sun"

Procedure

1. Before doing the lesson with the class, read through the Student Worksheet and review the What Causes the Seasons Fact Sheet.
2. To better understand what students know and want to learn about the seasons, do a KWL. There is a sample KWL chart and instructions in the Appendix on page TG 143.
3. Confirm that all of the materials have been collected.

Causes of the Seasons Mission

4. As a class, review the Causes of the Seasons Fact Sheet. Depending on grade level, this may be done by having students read portions aloud or silently to themselves.
5. Explain to the students their mission as royal advisors to King Caeson as described on the Student Worksheet.

Set up the Classroom

6. Clear the floor and make a space approximately 3 meters (about 15 feet) across. Have the students sit in a circle around the outer edge of this clearing.
7. Have a student tie the ends of the rope together to make a loop. Pick a leader to lay the loop in a circle. The class should be sitting a foot or two beyond the perimeter of the rope circle.
8. Choose helpers to place the overhead projectors back to back on the floor in the center of the circle. Plug the projectors in, but do not turn them on.
9. Tape the yellow circle to the neck of one of the projectors and place the transparency grids on them. Explain to the class that the yellow circle represents the Sun.
10. Ask a volunteer to roll up the sheet of aluminum foil to make a small ball. Pick a spot on the wall farthest from the center of the circle, and have the volunteer tape the foil ball high on the wall. Explain to the class that this is Polaris, the North Star.
11. Choose a royal globe bearer. Have him or her hold the un-stickered globe in the middle of the circle.

Hemispheres and Earth's Axis

12. Have the students look at the globe. Remind them that the equator divides the Earth into the Northern and Southern Hemispheres. Put a sticker on the United States. In which hemisphere is the United States? *The United States is in the Northern Hemisphere.*
13. Put a sticker on Australia. In which hemisphere is Australia? *Australia is in the Southern Hemisphere.*
14. Have the globe bearer move the globe until the North Pole points towards the model Polaris. You may need to tip the globe slightly. Emphasize that the pole will always point in this direction.

Earth's Orbit

15. Ask the students to dictate how the Earth orbits around the Sun. Have the globe bearer demonstrate this by walking around the perimeter of the circle, keeping the pole pointed toward Polaris. *If observing from above the North Pole, Earth orbits counterclockwise around the Sun. Therefore, the student should also walk counterclockwise.*

December (Winter)

16. Ask students where the globe should be positioned so that
    - the North Pole of Earth points towards Polaris AND
    - the Southern Hemisphere of Earth tilts toward the Sun.

    With masking tape, label that spot on the floor "December." *December is the place in the orbit where the Earth is between the Sun and Polaris.*

June (Summer)

17. Have students identify where the globe should be positioned so that
    - the north pole of Earth points towards Polaris, AND
    - the Northern Hemisphere of Earth tilts towards the Sun.

    Label that spot "June" with a piece of masking tape. *June is the place in orbit where the Sun is between Earth and Polaris.*

March (Spring) and September (Fall)

18. Ask the students to dictate where the March and September labels should go. Label these positions accordingly. *If looking toward Polaris, March should be placed on the left side of the circle, halfway between December and June. September will be on the right side.*
19. Have the students label the seasons on question 1 of the Student Worksheet.

Sunlight Intensity

20. Have the globe bearer set the globe on the floor in the position marked June. Again, make sure that the North Pole is pointing toward Polaris. Have the globe bearer join the rest of the class at the perimeter of the circle.
21. Place the second, pre-stickered globe on the position marked December.
22. Point the projectors in the direction of the globes and turn the overheads on. Focus the projectors so that the grids show up clearly on the globes. It may help to turn off the overhead lights. Make sure that the projectors are still in the middle of the circle!
23. Explain the purpose of the grids and what the squares represent:
    - Imagine that each grid square represents 1 unit of energy: rays of sunlight hitting the Earth.
      Grid on projector: ❑ = one unit of energy
    - If the squares are small, the energy is concentrated and intense. These represent the intense, direct rays of summer.
    - If the squares spread out or get bigger, the same amount of energy has to be spread over a larger area. It is less concentrated. These represent the less intense rays of winter.
24. Divide the class in half and encourage them to investigate the globes more closely. Half of the class should look at June, the other half at December. Help students carefully observe the differences in grid box shape and size by pointing out what happens to the shape of the squares near the poles.
25. Have students write their observations on question 2 of the Student Worksheet. Set an

observation time limit and have the groups switch places at the end of this period.

Wrap Up

26. After the students have observed both seasons, disassemble the model and return the classroom to its normal state.
27. Have the students complete the remaining questions at their desks.
28. Ask Reflection & Discussion questions. Wrap up the activity by asking the students what they learned about seasons, doing the "L" of the KWL.

Preparation

1. Read through the lesson and review the Fact Sheet.
2. Gather the materials needed for the lesson.
3. To create a transparency grid, copy the sheet of graph paper on page ARG 38 onto a copier-safe transparency.
4. With a marker and masking tape, make four labels marked "September," "December," "March" and "June."
5. On only one of the globes, place a sticker on Australia and another on the United States.
6. Make arrangements to have two overhead projectors during the lesson period.
7. To gauge the best globe positions and where to put Polaris, do the demonstration before trying it with students.

Management

This lesson can be completed in three class periods. For younger students, it may be beneficial to divide this lesson into three parts: one period spent reviewing the Fact Sheets with the students, one period for the demonstration and the last period spent doing the worksheet and discussing the lesson. This lesson has many procedures. Follow the steps closely. The concepts behind the seasons are complicated. Grasping the concept of light intensity and length of daylight in connection with the slant of the Earth is a difficult one. Strong teacher facilitation and questioning techniques will help students to internalize by making them share their thinking out loud.

Reflection & Discussion

1. How does the Earth's tilt lead to warmer, summer weather? *The hemisphere tilted towards the Sun gets more direct, intense sunlight, and longer days mean more time the sunlight can heat the Earth.*
2. Why is careful observation important to scientists? *Careful observing can allow scientists to discover facts about the Solar System.*
3. What are some of the advantages and limits of using models? *Models allow us to study things that are very big or very small. However, models are never perfect copies so you have to be careful!*
4. Why is the changing distance between the Earth and Sun NOT the reason for the seasons? *The Earth's orbit does not bring the planet close enough to the Sun to drastically affect the seasons.*
5. Imagine you were a scientist who looked for meteorites in Antarctica. For what time of year would you plan your expedition? *Antarctica's summer occurs in December and January, when it will be warmer and you will have 24 hours of sunlight a day!*
6. Imagine the Earth's axis was not tilted. Would the Earth have seasons? *No. Without the Earth's tilt, the Sun's intensity would not change very much. All of the days would have almost exactly 12 hours of daylight and 12 hours of night. It would be slightly warmer when the Earth was closer to the Sun, but the seasons would not be as drastic as those we observe today.*

TRANSFER/EXTENSION

1. Research the star Polaris. How did it get its name? How can people use it to figure out which way they are facing on Earth?
2. Keep a bi-weekly log on the wall, recording sunrise time and sunset time over a few months. These times are usually posted in the weather section of a local newspaper. Graph your results.
3. Research the distance between the Earth and Sun each month. Chart what you find. When is the Earth closest to the Sun?
4. Around June 22 is the Summer Solstice. Around December 22 is the Winter Solstice. Listen to newscasts on these days or read the paper. What is special about these days?
5. Discuss how the seasons affect humans. Think about the food we eat, clothing, indoor and outdoor activities, health and holidays.
6. Compare the seasons on Mars with the seasons on Earth.
7. Repeat the lesson, using an untilted globe. How does this affect the intensity of sunlight in the different hemispheres?

References

The Astronomical Almanac for the Year 1997 (1996). U.S. Naval Observatory. Washington, D.C.: U.S. Government Printing Office.

Celestial Mechanics II (1993). University of Colorado. Boulder, CO: Fiske Planetarium.

"A Private Universe" videotape (1989). Produced by Harvard University and the Smithsonian Institution. Directed by M.H. Schneps. Santa Monica, CA: Pyramid Film and Video.

The Reasons for the Seasons (1995). In *Project ASTRO Resource Notebook* (p. 32). San Francisco, CA: Astronomical Society of the Pacific.

Websites

Bill Nye Episode Guide: Earth Seasons
http://nyelabs.kcts.org/nyeverse/episode/e15.html

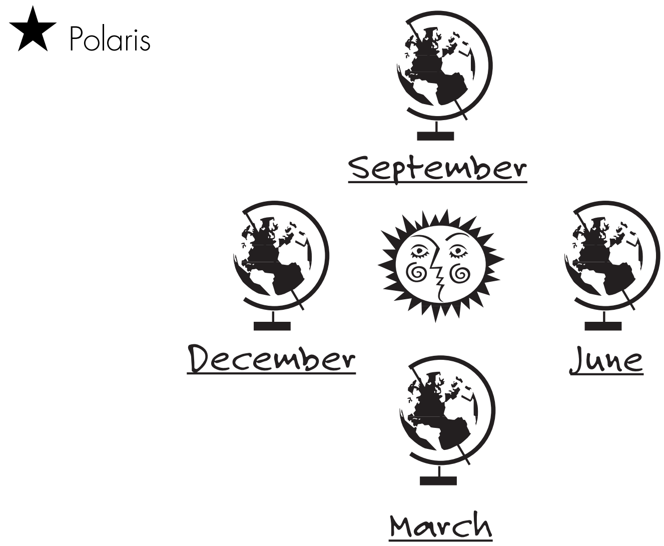
The Earth and Moon Viewer
http://www.fourmilab.ch/earth/vplanet.html

Eye on the Sky, Feet on the Ground
http://heawww.harvard.edu/ECT/the_book/toc.html

The Four Seasons
http://www.bouldernews.com/BoulderNews/KRT/equin/equin.html

Worksheet Answer Key

1. The diagram should be labeled as follows:



2. Answers will vary but may include:

	June	December
Northern Hemisphere	1. Smaller, brighter boxes close together. 2. Grid boxes are squares.	1. Larger, dimmer, spread-out boxes. 2. Grid boxes are more rectangular.
Southern Hemisphere	1. Larger, dimmer, spread-out boxes. 2. Grid boxes are more rectangular.	1. Smaller, brighter boxes close together. 2. Grid boxes are squares.

3. June: Northern Hemisphere. December: Southern Hemisphere

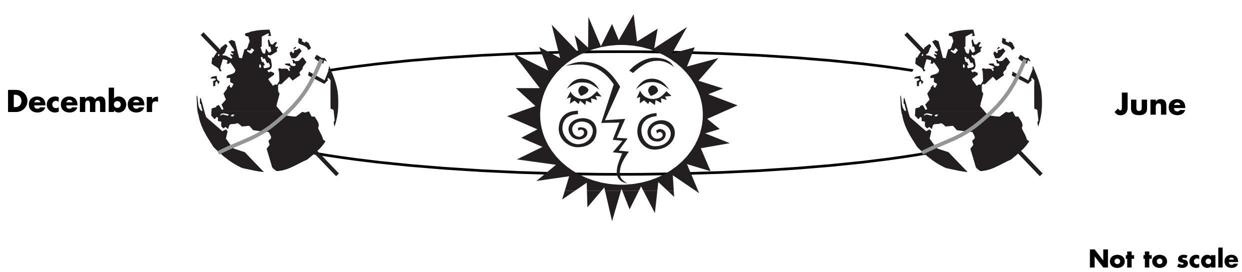
4. Australia

5. Northern Hemisphere: June. Southern Hemisphere: December

6. The royal family should expect summer weather in December in Australia and pack accordingly.

What Causes the Seasons? Fact Sheet

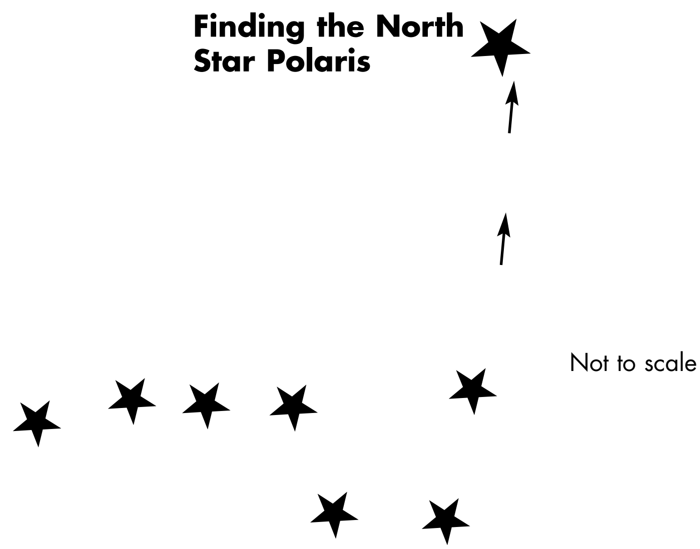
The equator divides the Earth into the Northern Hemisphere and the Southern Hemisphere. When the Northern Hemisphere has summer, the Southern Hemisphere has winter. When continents like Europe and North America have winter, southern continents like Australia have summer. Why does this happen? To understand why we have seasons, imagine yourself looking at Earth from far away.



Each year, the Earth makes one trip, or orbit, around the Sun. When looking down on the north pole, the Earth orbits counterclockwise around the Sun. The Earth's axis is the imaginary line that runs through the Earth from the north pole to the south pole. The Earth's axis is tilted 23.5°. This means that as the Earth travels around the Sun, different parts of the Earth will end up being tilted toward the Sun. In December, the Southern Hemisphere tilts toward the Sun. In June, the Northern Hemisphere tilts toward the Sun.

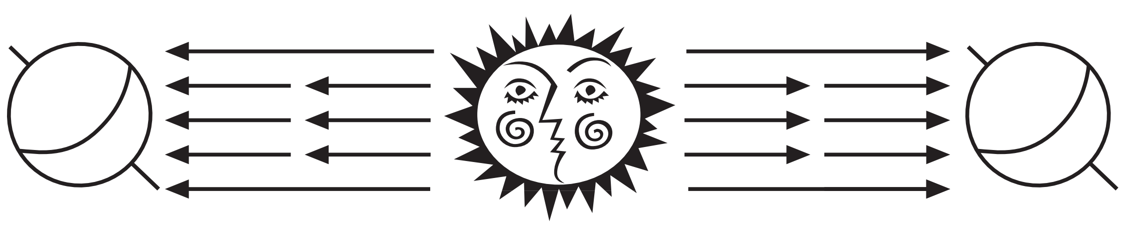
Our Pole Star

If you could extend the Earth's axis into space, the northern end would point toward a star called Polaris (poh-LARE-iss). Polaris means "the pole star." People sometimes call Polaris "The North Star." You can find Polaris at night in the Northern Hemisphere by using the Big Dipper.



Summer Sunlight: Direct & Intense

Being tilted toward the Sun does not make you much closer to the Sun. The reason a tilt toward the Sun causes warmer weather is due to more intense sunlight. When your hemisphere tilts toward the Sun, the rays of sunlight hit the hemisphere more directly. The energy from the sunlight is intense, warming the ground more. In winter, the Sun's rays hit the ground at a greater angle, spreading the sunlight's energy over a larger area.



Another Cause of Seasons

The tilt of the Earth also has an effect on the length of daylight. When you are tilted toward the Sun in the summer, the Sun rises higher overhead at noon. Days are longer with shorter nights. Longer days mean more hours the sunlight can heat the ground. In the winter, the Sun is not as high in the sky at noon. It rises later and sets earlier. Shorter days mean less time that the Sun's energy can warm the ground, leading to cooler temperatures.

The Land of the Midnight Sun

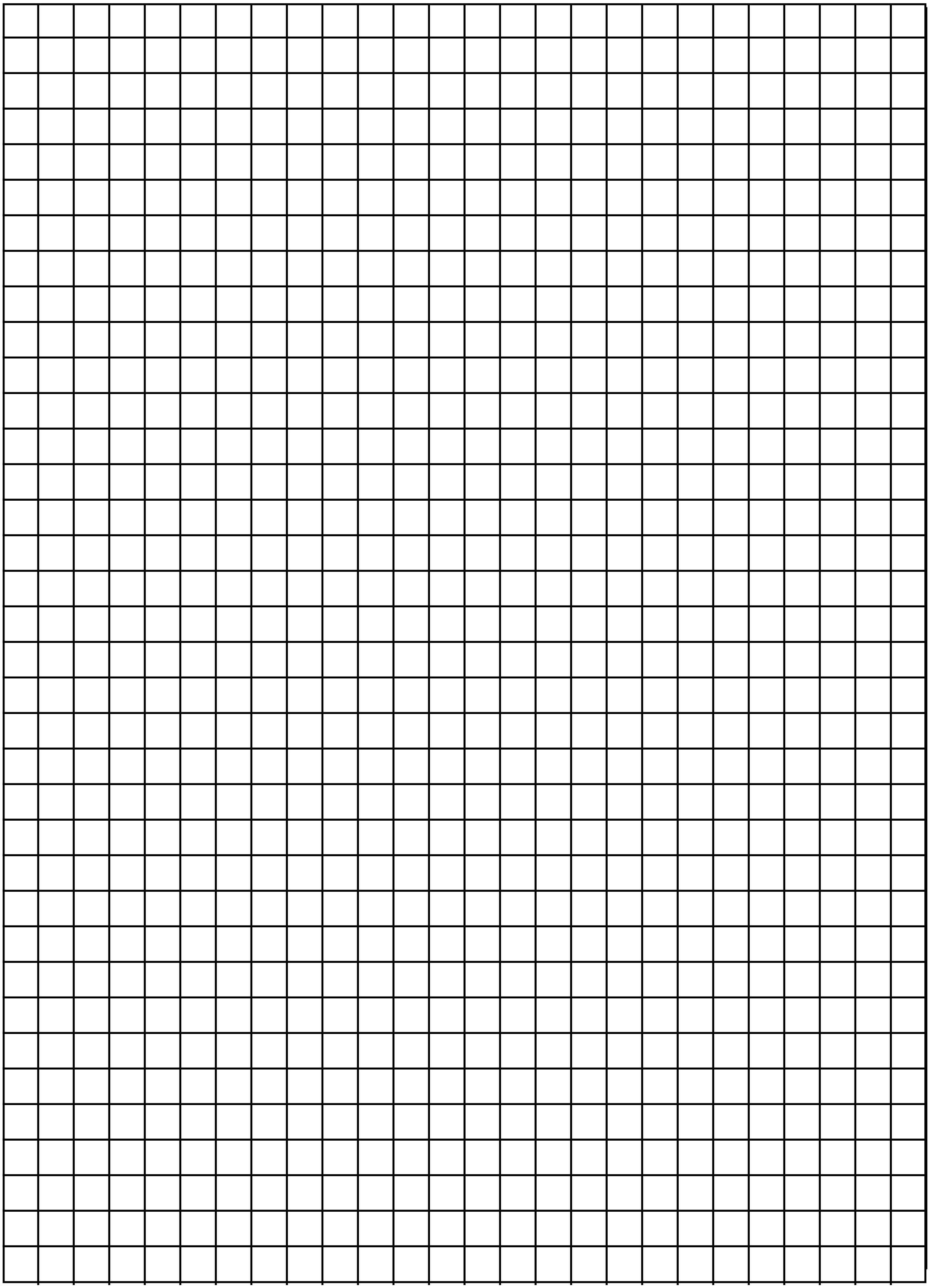
The changing amount of daylight is extreme in the most northern and southern latitudes. In June, the Northern Hemisphere tilts enough toward the Sun that sunlight can reach all the land north of the Arctic Circle at the same time. As the Earth rotates, the Sun circles the dome of the sky, but never sets. Sometimes the lands far to the north are called “the Land of the Midnight Sun” because during the summer, the Sun will be shining even at midnight.

While the Sun is shining at midnight in northern Alaska, Antarctica has a long, dark winter. With the Southern Hemisphere tilted away from the Sun, most of Antarctica does not get any sunlight in June. Instead, Antarctica has 24 hours of darkness.

Bet Your Family an Ice Cream Sundae!

Bet your family a chocolate sundae with all the trimmings that they do not know the reasons for the seasons and see what happens!

Many people believe the whole planet is closer to the Sun in the summer than in the winter. If that were true, every place on Earth would have winter during the same months! We know the Southern Hemisphere has winter while the Northern Hemisphere has summer. The distance between the Earth and the Sun does change because the Earth’s orbit is not perfectly round, but it cannot cause the seasons we observe. Research shows us that the Earth is actually closest to the Sun around January 3 each year—almost the coldest time of year for most of the Northern Hemisphere.



Name____Date______________

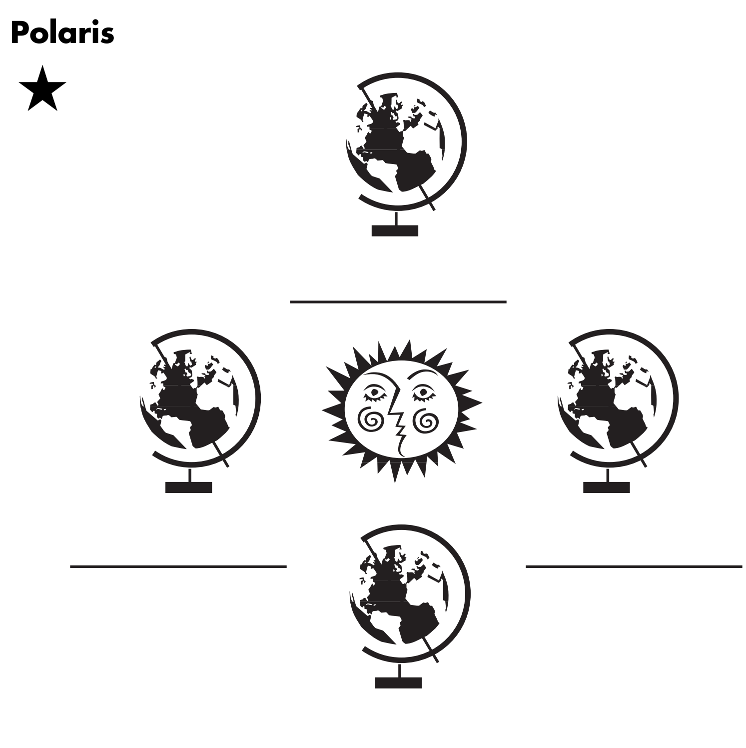
A New Slant on the Seasons Worksheet

YOUR MISSION

King Caeson and his family have some questions. Is December a good time of year to vacation in Australia? What clothes should they pack?

As Royal Court advisors, study models of the Sun and Earth to figure out the reasons for the seasons and give King Caeson advice about his vacation plans.

1. Label each month, based on the Earth's position:



WARMING THE EARTH

2. Observe the shape and size of the grid boxes for June and December in the Northern Hemisphere and the Southern Hemisphere. Write two observations comparing the grid's boxes.

	June	December
Northern Hemisphere	1. 2.	1. 2.
Southern Hemisphere	1. 2.	1. 2.

3. Which hemisphere gets the most energy from sunlight in

June?____

December? ____

4. Based on your answers for question 3, where do you think it is usually warmer in December? (circle one)

Continental United States	Australia	It is not warm in either place in December.

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