The Sun's Effect on Climate and Seasons
Lesson 4: Earth's Tilt, the Angle of Sunlight, and Seasons

Grade: 5	Length of lesson: 75 minutes	Placement of lesson: 4 of 6 lessons

Anchoring Phenomena: Earth's Northern and Southern Hemispheres experience repeating, predictable seasonal changes in average temperatures.

Unit Learning Goal: Earth's curved surface and consistent tilt and its orbit around the Sun result in uneven heating across the planet. This difference in the sunlight's intensity causes different locations on Earth to experience different seasons at the same time of year as well as varying average yearly temperatures.

Main learning goal: Because of Earth's tilt, the angle at which sunlight strikes Earth at different times of year causes the Northern and Southern Hemispheres to experience more and less intense sunlight and thus opposite periods of higher and lower average temperatures (seasons).

Science and Engineering Practices: Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena; Developing and Using Models: Evaluate limitations of a model for a proposed object or tool.

Crosscutting Concepts: Patterns: Graphs, charts, and images can be used to identify patterns in data; Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Unit Central Question: Why are some places on Earth hotter than others at different times of the year?	**Lesson Focus Questions:** What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?

Science content storyline: Earth's curved surface causes differential heating from the Sun's light. Additionally, Earth's consistent tilt toward the North Star throughout its orbit causes the Northern and Southern Hemispheres to point toward or away from the Sun at different times of year, thus experiencing winter and summer in opposite times of year. Earth is tilted on its axis at an angle of 23.5 degrees. This tilt causes Earth's surface to experience variations in temperature partly due to the changing angle at which the Sun's light strikes Earth's surface in relation to latitude. Because of Earth's tilt, the change in the angle of the Sun's light striking Earth means that an entire hemisphere receives more-direct sunlight at certain times of the year, specifically during the summer months. When the North Pole tilts toward the Sun, the Sun's energy is more concentrated in the Northern Hemisphere, causing temperatures to be higher, thus it is summer. During this same time, the Southern Hemisphere is tilted away from the Sun, so the Sun's energy is less concentrated, and they experience winter. Earth's consistent tilt causes the Sun to not be directly overhead at the equator all year long. When the Northern Hemisphere points toward the Sun, the sunlight is more concentrated and temperatures increase (become warmer); conversely, when the Northern Hemisphere points away from the Sun, the sunlight is more spread out and temperatures decrease (become cooler). The same happens in the Southern Hemisphere when the South Pole points either toward or away from the Sun. Thus, the angle of sunlight related to Earth's tilt is one critical factor in determining temperatures around the globe. Because Earth's tilt remains consistent as it orbits, the angle at which sunlight strikes Earth at different times of year causes the Northern and Southern Hemispheres to experience more and less intense sunlight and thus opposite periods of higher average (warmer) and lower average (cooler) temperatures (seasons). In June–August, the Northern Hemisphere is tilted toward the

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Sun, thus it is summer there but winter in the Southern Hemisphere. In December–February, it is the opposite because the Southern Hemisphere is tilted toward the Sun.
Ideal student response to the Lesson Focus Questions: The Earth is always tilted at the same angle as it orbits the Sun. This causes the North Pole to be tilted toward the Sun sometimes during its orbit but away from the Sun during other times. When the North Pole (Northern Hemisphere) points toward the Sun, it is summer; at the same time, it is winter in the Southern Hemisphere. This happens in June–August. The opposite happens in December–February because the North Pole (Northern Hemisphere) points away from the Sun. So, it is summer in the Southern Hemisphere and winter in the Northern Hemisphere. Therefore, when it is winter in the United States in December–February, it is summer in Brazil. They are opposite.

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Preparation

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<th>MATERIALS NEEDED</th>
<th>AHEAD OF TIME</th>
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Sun's Effect on Climate and Seasons PowerPoint (by lesson)

Teacher Resources:

- HO4.1 *The Sun's Incoming Energy—Angle Related to Latitude at Position 1*
- HO4.2 *The Sun's Incoming Energy—Angle Related to Latitude at Position 3*
- HO1.5 *Bar Graph of January Temperatures (from Lesson 1-1 copy)*
- HO1.6 *Bar Graph of July Temperatures (from Lesson 1-1 copy)*
- HO 2.4 *Sun's Incoming Energy (from Lesson 2-1 copy)*

Student Handouts

- HO4.3 *Angle of Sunlight and Seasons on Earth* (1 per student)
- HO4.4 *Sun's Incoming Energy with Tilt—Position 1* (1 per student)
- HO4.5 *Sun's Incoming Energy with Tilt—Position 3* (1 per student)
- HO4.6 *Data Table: Number of Sun's Incoming Rays by Season at Different Latitudes* (1 per student)

Other Materials

- Earth-Sun model from Lesson 3 (1 per group of 4-5 students)
- Number of Lighted Squares data table with the graph paper cutouts from Lesson 2
- Number of Light Rays per Latitude data table from Lesson 2
- globe (on stand, if available; otherwise, inflatable)
- North Star image displayed in classroom

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- Review the background information found on pages 14-17 of the *Content Background* document.
- Prepare all handouts.
- Arrange the Earth-Sun model stations around the classroom, 1 setup per group of 4-5 students.

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Lesson 4 General Outline

Time	Phase of lesson	How the science content storyline develops
5 min	**Link to Previous Lessons:** Students connect the learning goals for Lessons 1–3.	Earth's curved surface causes differential heating from the Sun's light. Additionally, Earth's consistent tilt toward the North Star throughout its orbit causes the Northern and Southern Hemispheres to point toward or away from the Sun at different times of year, thus experiencing winter and summer in opposite times of year.
5 min	**Lesson Focus Questions:** The teacher introduces the Lesson Focus Questions: *What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?*	
10 min	**Setup for Activity:** The teacher connects the learning goals from Lessons 2 and 3 in setting up the activity for this lesson.	Earth is tilted on its axis at an angle of 23.5 degrees. This tilt causes Earth's surface to experience variations in temperature partly due to the changing angle at which the Sun's light strikes Earth's surface in relation to latitude.
20 min	**Activity:** Students use a model of a tilted Earth to explore the role of Earth's tilt on the angle of the Sun's incoming rays.	Because of Earth's tilt, the change in the angle of the Sun's light striking Earth means that an entire hemisphere receives more-direct sunlight at certain times of the year, specifically during the summer months. When the North Pole tilts toward the Sun, the Sun's energy is more concentrated in the Northern Hemisphere, causing temperatures to be higher, thus it is summer. During this same time, the Southern Hemisphere is tilted away from the Sun, so the Sun's energy is less concentrated, and they experience winter.
15 min	**Follow-up to Activity:** Students analyze the role of Earth's tilt on the angle of the Sun's incoming rays and how that affects temperatures on Earth's surface at different latitudes at different times of year.	Earth's consistent tilt causes the Sun to not be directly overhead at the equator all year long. When the Northern Hemisphere points toward the Sun, the sunlight is more concentrated and temperatures increase (become warmer); conversely, when the Northern Hemisphere points away from the Sun, the sunlight is more spread out and temperatures decrease (become cooler). The same happens in the Southern Hemisphere when the South Pole points either toward or away from the Sun. Thus,

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Time	Phase of lesson	How the science content storyline develops
		the angle of sunlight related to Earth’s tilt is one critical factor in determining temperatures around the globe.
18 min	**Synthesize and Summarize Today’s Lesson:** Students write their answers to the Lesson Focus Questions in their notebook. The teacher provides a lesson summary.	Because Earth’s tilt remains consistent as it orbits, the angle at which sunlight strikes Earth at different times of year causes the Northern and Southern Hemispheres to experience more and less intense sunlight and thus opposite periods of higher average (warmer) and lower average (cooler) temperatures (seasons). In June–August, the Northern Hemisphere is tilted toward the Sun, thus it is summer there but winter in the Southern Hemisphere. In December–February, it is the opposite because the Southern Hemisphere is tilted toward the Sun.
2 min	**Link to the Next Lesson:** Next time, we will examine another factor that influences how the Sun’s light heats Earth and influences temperatures.	

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
5 min	**Link to Previous Lessons** Synopsis: Students connect the learning goals for Lessons 1–3. Main Science Ideas: Earth's curved surface causes differential heating from the Sun's light. Additionally, Earth's consistent tilt toward the North Star throughout its orbit causes the Northern and Southern Hemispheres to point toward or away from the Sun at different times of year, thus experiencing winter and summer in opposite times of year.	Link science ideas to other science ideas.	Before we begin today's lesson, let's review what we have learned about the Sun's effect on climate and uneven heating on Earth. ***NOTE TO TEACHER:*** *Hold up or point to the temperature bar graphs from Lesson 1. Next, point to the Number of Lighted Squares data table with the graph paper cutouts. Also, have a Sun-Earth model available for reference.*	
			Remember the temperature bar graphs from Lesson 1. What have we learned about temperatures around the world?	We learned that they are different around the world. It's warmer closer to the equator and colder farther away. **Can you show us what you mean using the globe?**
			How did our model of how Earth orbits the Sun help us understand seasons?	We learned that the seasons are opposite in the Southern Hemisphere. **What do you mean by "opposite"?** The tilt means we have seasons. **Tell me more about the tilt. Do you agree with [student]?**
			What can you tell me about the angle of sunlight when it strikes Earth and how that affects temperatures? What data did we use to help us investigate the angle of the Sun's light when it strikes Earth?	We shined the flashlight straight on and at an angle. It's hotter when the light is more direct. **Show me what you mean by "at an angle." Is the light at an**

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
				angle or is something else at an angle? We used the globe and the paper with all the Sun's rays and counted them. **What did we learn by counting the rays?**
5 min	**Lesson Focus Questions** Synopsis: The teacher introduces the Lesson Focus Questions: *What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?*	Set the purpose with a focus question.	In today's lesson, we will continue our investigation of the angle of sunlight striking Earth as it orbits the Sun. Our Lesson Focus Questions are *What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?* ***NOTE TO TEACHER:*** *Add these focus questions to your list of Lesson Focus Questions, which are posted so you and the students can easily refer to them throughout the lesson.* Take two minutes and record the questions and your current thinking in your science notebook. Use what we have learned so far in our lessons to explain your thinking.	
10 min	**Setup for Activity** Synopsis: The teacher connects the learning goals from Lessons 2 and		Last time, we used a model to observe Earth's tilt on its axis and to explore what happens as Earth orbits the Sun. We looked at the planet in four different positions in its orbit.	

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	3 in setting up the activity for this lesson. <u>Main Science Ideas</u>: Earth is tilted on its axis at an angle of 23.5 degrees. This tilt causes Earth's surface to experience variations in temperature partly due to the changing angle at which the Sun's light strikes Earth's surface in relation to latitude.	Make explicit links between science ideas and activities (before the activity).	Who can remind us what those four positions looked like? ***NOTE TO TEACHER:*** *Ask a team of students that worked together in Lesson 3 to use the Earth-Sun model materials to show Earth in the four positions in its orbit. If necessary, remind them of the North Star position in the room.* Do you agree with this team's modeling? Does anyone have anything to add? Now, let's take a quick look back at our *Sun's Incoming Energy* handout from Lesson 2 from when we looked at the incoming solar radiation. Locate it in your notebook. Look at what I am holding up to help you find it. Notice the position of Earth in our handout. What is different about the position of Earth in this handout and in our model of Earth's orbit? Great observation! Yes, in our model, Earth is tilted, which is the actual position of Earth when it orbits the Sun. In today's activity, we are going to build on what we learned in Lesson 2 and find out if the tilt makes a difference in the angle of the Sun's light striking Earth. ***NOTE TO TEACHER:*** *Project* The Sun's Incoming Energy—Angle Related to Latitude at Position 1 *and* The Sun's Incoming Energy—Angle Related to Latitude at Position 3. *Ask students to make predictions using questions such as the following.*	Earth is not tilted in the picture from Lesson 2, but it is tilted in our model.

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Ask questions to elicit student ideas and predictions.	Do you think the tilt will make a difference in where the Sun's light strikes Earth directly or at an angle?	No, the Sun always shines directly at the equator. **Tell me why you think so.** Well, I don't agree, I think the light will be more sideways. **What do you mean by "sideways"?** **Do you agree with [student]?** The light is always at an angle at the North Pole because it's so cold. **What do you mean by "at an angle"?** **How are "cold" and "angle of light" related?** The light will be more concentrated in the summer and more spread out in the winter. **Say more about the light in the summer and winter.** **Only in the Northern Hemisphere?**
20 min	**Activity** <u>Synopsis</u>: Students use a model of a tilted Earth to explore the role of Earth's tilt on the angle	Engage students in using and applying new science ideas in a variety of	OK, let's get started on your group activity. ***NOTE TO TEACHER:*** *Distribute the handouts* Angle of Sunlight and Seasons on Earth *and* Data Table: Number of Sun's Incoming Rays by Season at Different Latitudes. *Also distribute to each student the* Sun's Incoming Energy with Tilt *handouts for*	

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	of the Sun's incoming rays. Main Science Ideas: Because of Earth's tilt, the change in the angle of the Sun's light striking Earth means that an entire hemisphere receives more-direct sunlight at certain times of the year, specifically during the summer months. When the North Pole tilts toward the Sun, the Sun's energy is more concentrated in the Northern Hemisphere, causing temperatures to be higher, thus it is summer. During this same time, the Southern Hemisphere is tilted away from the Sun, so the Sun's energy is less concentrated, and they experience winter.	ways and contexts.	*positions 1 and 3. Ask students to assemble in their team from Lesson 3 and to set up their Sun-Earth model as before. Then, review the Lesson Focus Questions, the directions for the activity, and the data table. Emphasize that students will be collecting data about the angle of sunlight and whether Earth's tilt changes the angle.* *them complete their data tables, as necessary.* *Before moving to the Follow-up to Activity, allow time for teams to use the data in their data tables to talk about the discussion questions.* *Also, to make the follow-up discussion more productive, ask each team to record the data from their data tables on an overhead transparency or chart paper so all students can see the collective results. (Because students are counting lines from the handouts, there should not be wide variations in the data.)*	
15 min	**Follow-up to Activity** Synopsis: Students analyze the role of	Engage students in analyzing and	Let's look at the data we collected. What is the variation in the number of "lines" of solar radiation we counted?	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	Earth's tilt on the angle of the Sun's incoming rays and how that affects temperatures on Earth's surface at different latitudes at different times of year. Main Science Ideas: Earth's consistent tilt causes the Sun to not be directly overhead at the equator all year long. When the Northern Hemisphere points toward the Sun, the sunlight is more concentrated and temperatures increase (become warmer); conversely, when the Northern Hemisphere points away from the Sun, the sunlight is more spread out and temperatures decrease (become cooler). The same happens in the Southern Hemisphere when the South Pole points either toward or away from the Sun.	interpreting data and observations. Engage students in communicating in scientific ways.	***NOTE TO TEACHER:*** *Because the difference in the numbers is roughly 10 lines at or near the equator and 2–4 lines near the poles, the students might not think there would be a lot of difference in temperatures. However, they need to relate the relative differences to their square counts from the graph paper cutouts from Lesson 2. Where would the light be more concentrated or more spread out?* As we share our data and ideas about what it means, please refer to our CSW chart to select appropriate sentence stems to use. Take a minute to look up at the chart, especially the stems for numbers 2, 3, and 4. Where was the Sun's light more concentrated, or more direct, in position 1? What about position 3, where was the Sun's light more direct?	The Northern Hemisphere was getting more sun, the Southern Hemisphere was getting less sun. **Can you use a CSW stem and your data to help us understand your thinking?** In the Southern Hemisphere. The Sun's light was not straight on at the equator in either position. It went up and down from summer to winter. **Up and down? Tell me more about that.**

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	Thus, the angle of sunlight related to Earth’s tilt is one critical factor in determining temperatures around the globe.		Did the distance between the Sun and Earth ever change? ***NOTE TO TEACHER:*** *If students mention that the tilt caused a little bit of difference in the distance between Earth and the Sun, let them know that in our model, it may seem like this little difference is significant, but in real life, the Sun is so far from Earth that it would be like standing three to four feet from the open oven door and moving your hand just ¼ of an inch away. You wouldn’t feel any difference in the heat with that small amount of change. See the* Content Background *document for more information.*	No, the distance between them stayed the same.
			If it’s not the distance between Earth and the Sun that’s making a difference in the average temperatures being higher or lower in the different seasons, so, what is making average temperatures higher or lower at different times of the year?  *Listen to students’ ideas. What’s visible about student thinking?*	The tilt caused just a little bit of change in the distance between Earth and the Sun. **Say more about “a little bit of change.”** I think it’s the tilt. Earth tilts closer in summer and away in winter—both in the Northern Hemisphere and in the Southern Hemisphere. **Does where the light is straight on or at an angle change with our tilted Earth?** **Do you think that matters?**

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Let's think more about the effect tilt might have. First, look at our Number of Light Rays per Latitude data table from lesson 2. Remember that we were not looking at a tilted Earth in Lesson 2.	
			Let's compare our Lesson 2 data to the data we just collected for a tilted Earth. How do the number of the Sun's rays compare with and without a tilted Earth at ● 0°–15° N latitude, ● 30°–45° S latitude, and ● 60°–75° N latitude?	In Lesson 2, the light was straight on at the equator. There were 10 lines of light near the equator when Earth had no tilt, but today there were only 8 when Earth was tilted. **So, what are you saying about the difference in the light intensity due to Earth's tilt? Can you use data from today and from Lesson 2 in your answer?** Well, since our Earth is tilted, the intensity is less than it would be if it weren't tilted.
		Make explicit links between science ideas and activities (after the lesson).	Is the Sun's energy at the same concentration or intensity at the same latitudes in Lesson 2 as compared to today when Earth is tilted? ***NOTE TO TEACHER:*** *Redisplay* The Sun's Incoming Energy—Angle Related to Latitude at Position 1 *and* The Sun's Incoming Energy—Angle Related to Latitude at Position 3 *slide 20 to help students visualize how Earth's tilt affects the angle at which the Sun's light energy strikes Earth's surface during different seasons. Relate these content representations to* The Sun's Incoming Energy	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			handout from Lesson 2 that showed Earth with no tilt. *It is also important that students understand that in real life we don't actually count individual rays of the Sun. This is just a model we can use to understand how solar radiation is more concentrated in some areas and less concentrated in other areas.* Now let's take a few minutes to think about all the representations and models we've used so far in Lessons 2 through 4. Which ones helped you the most, and why? Which ones helped you the least, and why?	 The hula hoop and Styrofoam ball. **What about it made it helpful?** Because I could move it around and see it. **You said "see it". What did you see that helped you?** I could see on the ball where the light was more bright and less bright. **Did anyone else have a similar idea? Can you build on this idea of more bright and less bright?** I thought it was helpful when we counted the rays. **Can you hold up that handout and tell us what made that helpful?**

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
18 min	**Synthesize and Summarize Today's Lesson** Synopsis: Students write their answers to the Lesson Focus Questions in their notebook. The teacher provides a lesson summary. Main Science Ideas: Because Earth's tilt remains consistent as it orbits, the angle at which sunlight strikes Earth at different times of year causes the Northern and Southern Hemispheres to experience more and less intense sunlight and thus opposite periods of higher average (warmer) and lower average (cooler) temperatures (seasons). In June–August, the Northern Hemisphere is tilted toward the Sun, thus it is summer there but winter in the Southern Hemisphere. In	Engage students in making connections by synthesizing and summarizing key science ideas.	At the end of Lesson 2, we talked about this science idea: When the angle of sunlight is more direct, the sunlight is more intense and Earth's surface will get warmer. When sunlight striking Earth's surface is less direct—when we move from the equator to the poles—then the Sun's light is less concentrated and the surface does not warm as much.	
			What did we change about our model from Lesson 2 to Lessons 3 and 4?	We tilted Earth on its axis to make it more accurate.
			From today's activity, do you still agree with the idea that the more direct, or intense, the sunlight is the more it causes the surface to warm?	Yes, our data showed that was still true. **Who can share data that support this statement?** **Were the data in any one location the same for tilted versus direct?**
		Summarize key science ideas.	OK, so we agree that because Earth is curved, the intensity of sunlight still changes even when we made our model more accurate by tilting Earth. So, what does that help us understand?	That summer and winter times receive different intensities of light, which warms or cools Earth.
		Highlight key science ideas and focus	But today's focus questions—*What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?*—take us beyond that idea. We are now	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	December–February, it is the opposite because the Southern Hemisphere is tilted toward the Sun.	question throughout.	considering the season and time of year in a particular location. The data you have collected today will help you think about and relate all of these. Look back at your original thinking about the focus questions. Take two to three minutes to add your new ideas in your science notebook. Add your new ideas under your original response. Include in your response a labeled Earth-Sun model of positions 1 and 3, as well as data from today, to support your answers to the questions. ***NOTE TO TEACHER:*** *After students have responded, guide them in a self-assessment of their understanding as described below. Stop after each key idea to allow them to look for those points in their own response and make edits as needed.*	
		Summarize key science ideas.	Now that you have completed your response, please use another color to self-assess and make edits to your response as I share some key ideas that should be in your response: • We experience summer in June, July, and August here in the Northern Hemisphere because that is the point in Earth's orbit when this hemisphere is tilted toward the Sun. This causes more intense light at northern latitudes than during the other	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			months of the year. In our model, this is represented by position 1. • People in the Southern Hemisphere experience summer in December, January, and February because that is the point in Earth's orbit when it is tilted toward the Sun. This causes more intense light at the southern latitudes than at other times in the year. In our model, this is represented by position 2. • Summer and winter in the two hemispheres occur at opposite times of the year because *Earth stays consistently tilted as it orbits the Sun.* This consistent tilt causes the Northern and Southern Hemispheres to receive the most intense sunlight during opposite times of Earth's orbit around the Sun. Now let's revisit our Driving Question Board. • What questions have we answered? • What part of the lesson helped you answer the question? What is your answer? • What questions would you add? *Ask a question related to CSW 11: Let your ideas change and grow.* • Who changed their mind about something we talked about so far today?	 **What idea changed? What helped you change your mind?**

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Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
2 min	**Link to the Next Lesson** Synopsis: Teacher shares with students that they will examine another factor that influences how the Sun's light heats Earth and influences temperatures.	Link science ideas to other science ideas.	Today we learned that as Earth orbits the Sun, the consistent tilt of Earth's axis causes different places to receive Sun either more directly or more spread out, which results in higher and lower average temperatures, and therefore, seasons, during different times of the year. Next time we will explore another factor that influences varying temperatures on Earth. ***NOTE TO TEACHER:*** *Keep the models of the Earth-Sun system handy. Students will use them in the next lesson.*	

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Lesson 4
The Sun's Effect on Climate and Seasons

1

Unit Central Question

Why are some places on Earth hotter than others at different times of the year?

2

Link to Previous Lessons: The Sun's Effect on Climate and Seasons

What patterns did we observe on the temperature bar graphs from Lesson 1?

What important science ideas have we learned from our lessons so far?

(State the science ideas in complete sentences.)

3

Link to previous lessons: The Sun's effect on climate and Seasons

How did our model in Lesson 3 of Earth's orbit around the Sun help us understand seasons?

What can you tell me about the angle of sunlight when it strikes Earth and how it affects temperatures?

What data did we use to help us investigate the angle of the Sun's light when it strikes Earth?

4

Lesson 4 Focus Questions

What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?

5

Investigation: Why is it warmer in the summer than in the winter?

Let's use our model to remind ourselves of Earth's orbit around the Sun.

- What is important about the four positions in the orbit?
- Do you agree/disagree with this team's model of Earth's orbit?
- What would you like to add or change to make the model more scientifically accurate?

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Investigation: Why is it warmer in the summer than in the winter?

Observe the position of Earth in our *Sun's Incoming Energy* handout from Lesson 2.

- What is different about the position of Earth in this handout and in our model of Earth's orbit?

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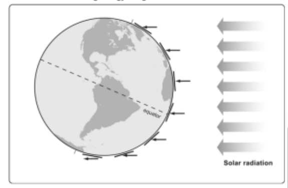
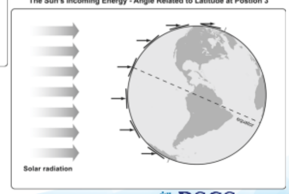
Investigation: Why is it warmer in the summer than in the winter?

The Sun's Incoming Energy - Angle Related to Latitude at Postion 1



The Sun's Incoming Energy - Angle Related to Latitude at Postion 3



Do you think the tilt will make a difference in where the Sun's light strikes Earth directly or at an angle?

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Investigation: Why is it warmer in the summer than in the winter?

Something to think about …

- I think adding Earth's tilt [will change/will not change] where the Sun's light strikes Earth more directly or at an angle.
- My evidence is ______________________.

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Investigation: Why is it warmer in the summer than in the winter?

Let's review today's investigation.

Angle of Sunlight and Seasons on Earth

Purpose: This activity will help us collect evidence to answer our focus questions: What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?

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Investigation: Why is it warmer in the summer than in the winter?

Team Task: As Earth orbits the Sun, describe what happens to the ***angle of sunlight*** hitting Earth at different times of the year.

- Focus your attention on the effect of Earth's ***orbit*** and ***tilt of the axis***. Be prepared to share your ideas.

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Investigation: Why is it warmer in the summer than in the winter?

Record your data.

Number of Sun's Incoming Rays by Season at Different Latitudes

	Position 1 Season:____________ (Northern Hemisphere) Season:____________ (Southern Hemisphere)	Position 3 Season:____________ (Northern Hemisphere) Season:____________ (Southern Hemisphere)
Latitude 60°–75°N (near Alaska)		
Latitude 30°–45°N (near Denver)		
Latitude 0°–15°N (north of the equator)		
Latitude 0°–15°S (south of the equator)		
Latitude 30°S–45°S (near the bottom of South America)		
Latitude 60°S–75°S (near northern Antarctica)		

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Investigation: Why is it warmer in the summer than in the winter?

Set up your model of Earth's orbit and start collecting your data to answer our Lesson Focus Question.

- I will provide additional handouts as each team is ready.
- As you complete your data table, record your data on chart paper so we can easily compare our class data. (Write in **large** numbers!)

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Investigation: Why is it warmer in the summer than in the winter?

Let's look at the data we collected:

- What is the variation in the number of lines of solar radiation we counted?

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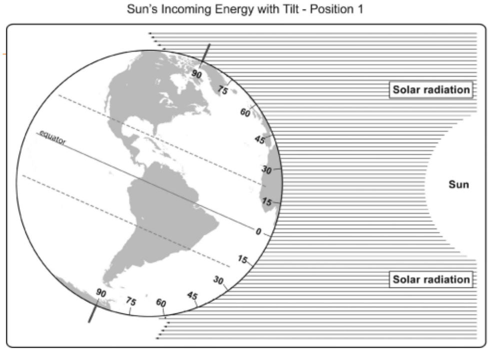
Sun's Incoming Energy with Tilt - Position 1



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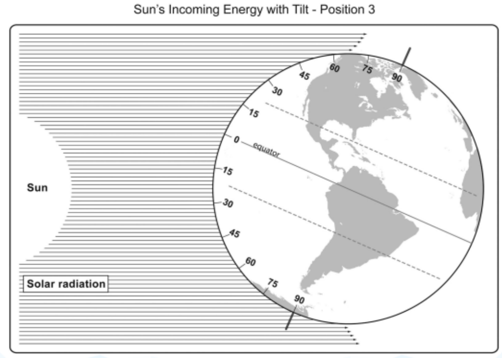
Sun's Incoming Energy with Tilt - Position 3



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Investigation: Why is it warmer in the summer than in the winter?

Where was the Sun's light more concentrated (more direct)?

- In position 1?
- In position 3?

Think about your graph paper cut outs from Lesson 2. Where on Earth's surface would the light be

- more concentrated?
- more spread out?

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Investigation: Why is it warmer in the summer than in the winter?

- As Earth orbits the Sun, does the distance between the Sun and Earth ever change?
- If it's not the *distance* between Earth and the Sun that changes the average temperatures to be higher or lower in different seasons, then what *does* make the difference?

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Investigation: Why is it warmer in the summer than in the winter?

Let's compare our current data with our data from Lesson 2.

- How do the numbers of the Sun's rays compare with and without a tilted Earth at
  - 0°–15° N latitude?
  - 30°–45° S latitude?
  - 60°–75° N latitude?

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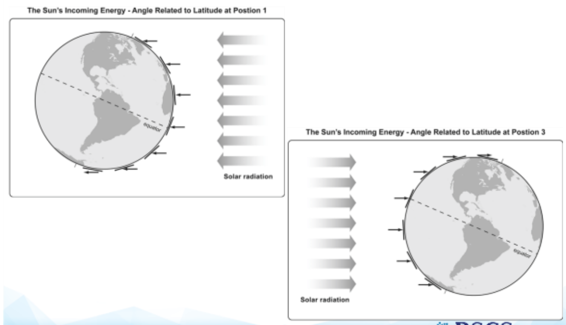
Investigation: Why is it warmer in the summer than in the winter?



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Lesson Summary: Key Science Ideas and Today's Focus Question

- When the angle of sunlight is more direct, the sunlight is more intense and Earth's surface will get warmer.
- When sunlight striking Earth's surface is less direct, then the Sun's light is less concentrated and the surface does not warm as much.

Based on today's investigation, use these key science ideas to answer today's focus questions.

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Lesson Summary: Key Science Ideas

- We experience summer in June, July, and August in the Northern Hemisphere because Earth's tilt gives us more-direct light at northern latitudes than during the other months of the year.
- People in the Southern Hemisphere experience summer in December, January, and February because the Sun's light is more direct in the southern latitudes when the South Pole points toward the Sun.

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Lesson Summary: Key Science Ideas

- Summer and winter in the two hemispheres occur at opposite times of the year because ***Earth stays consistently tilted as it orbits the Sun***.
- This consistent tilt causes the Northern and Southern Hemispheres to receive the most intense sunlight during opposite times of Earth's orbit around the Sun.

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Driving Question Board (DQB)

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In the next lesson, you will think about …

Is there another factor, beyond latitude, that influences varying temperatures on Earth?

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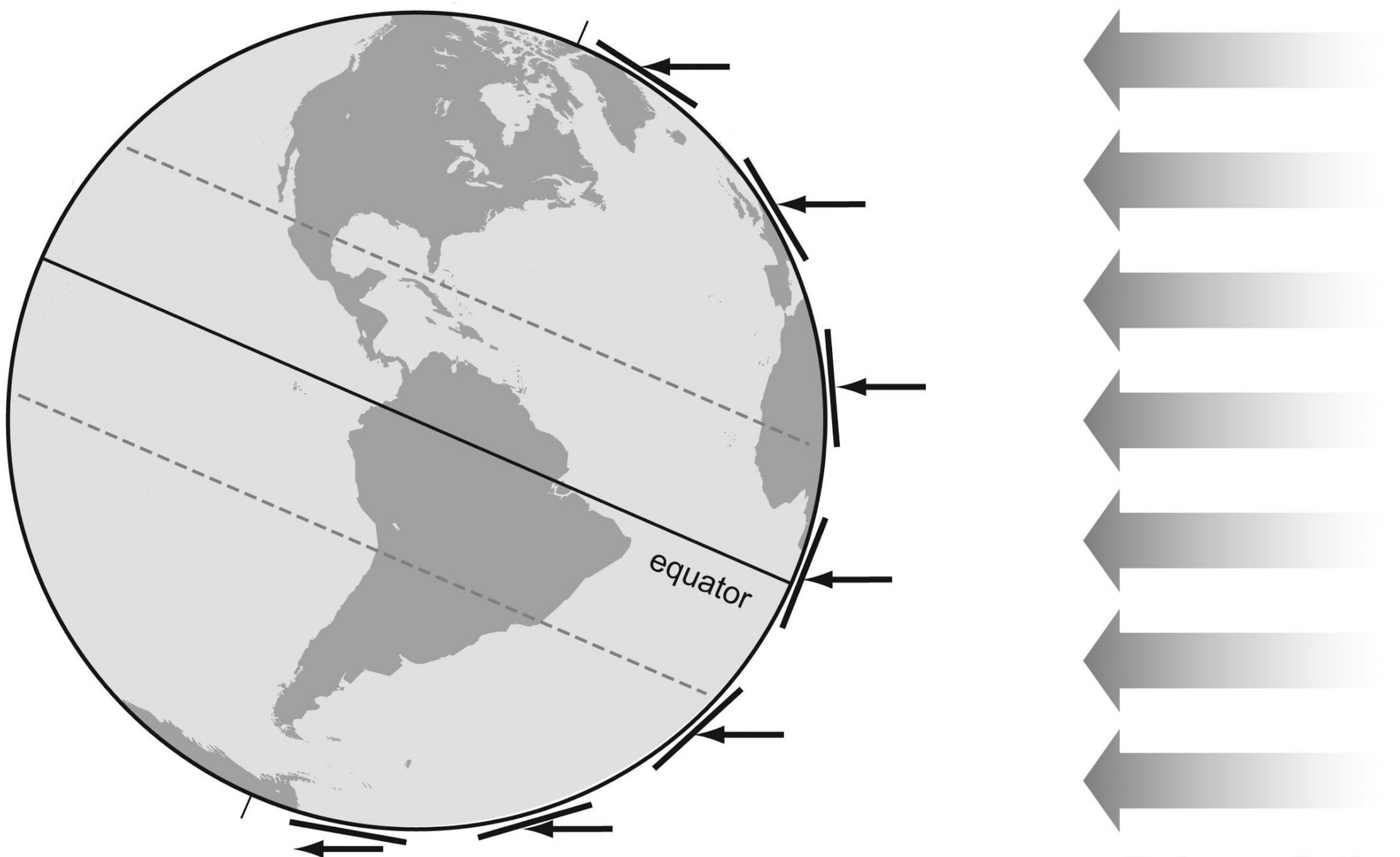
The Sun's Incoming Energy - Angle Related to Latitude at Position 1



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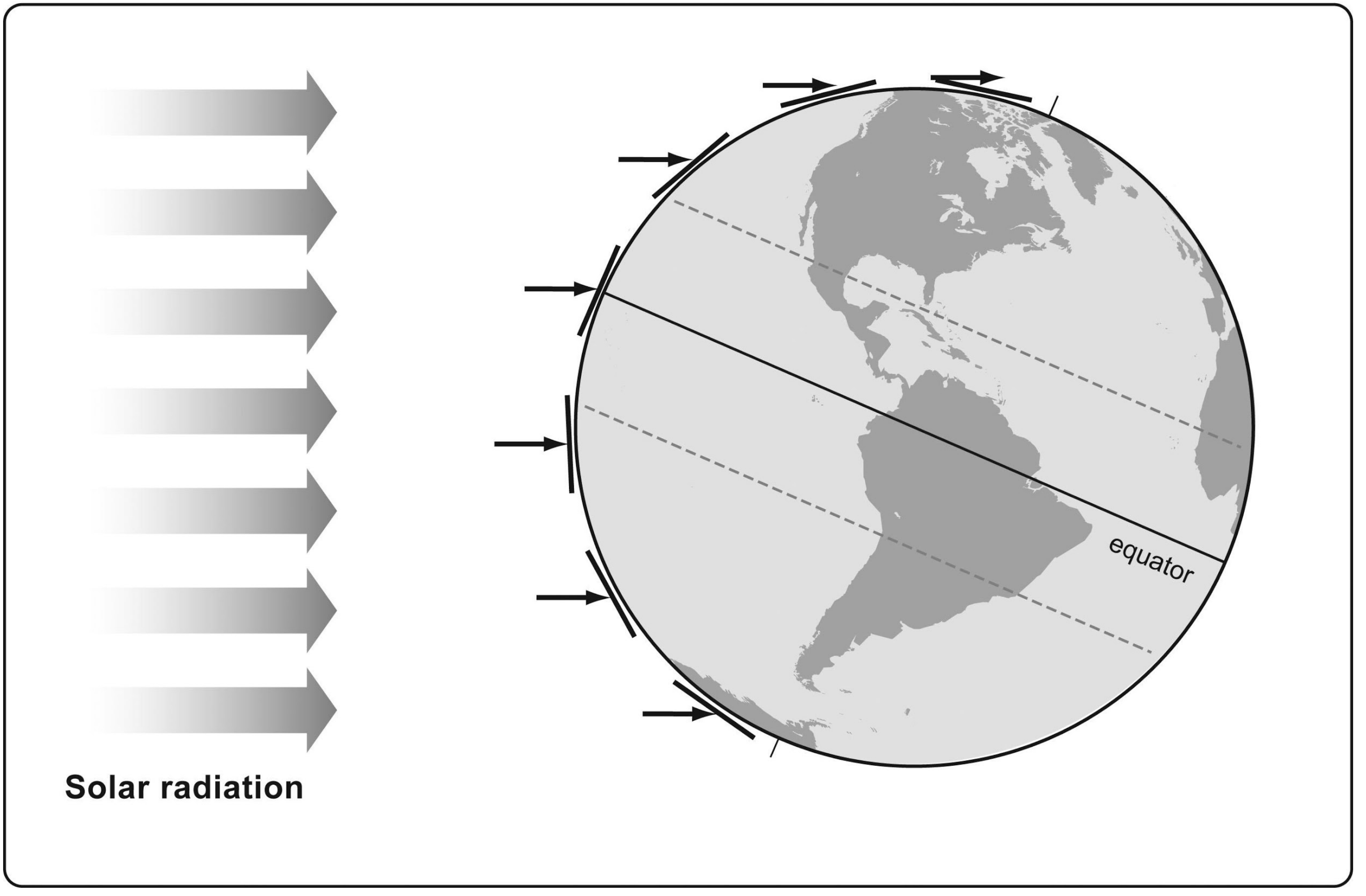
The Sun’s Incoming Energy - Angle Related to Latitude at Position 3



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Angle of Sunlight and Seasons on Earth

Purpose
This activity will help us collect evidence to answer our Lesson Focus Questions:

What causes winter in the United States to occur in December–February and summer to occur in the United States in June–August? What is happening in Brazil, and why?

Team Task
As Earth orbits the Sun, describe what happens to the *angle of sunlight* hitting Earth at different times of the year. Focus your attention on the effect of Earth's *orbit* and *axis tilt*. Be prepared to share your ideas.

Materials
Your team will need these items:

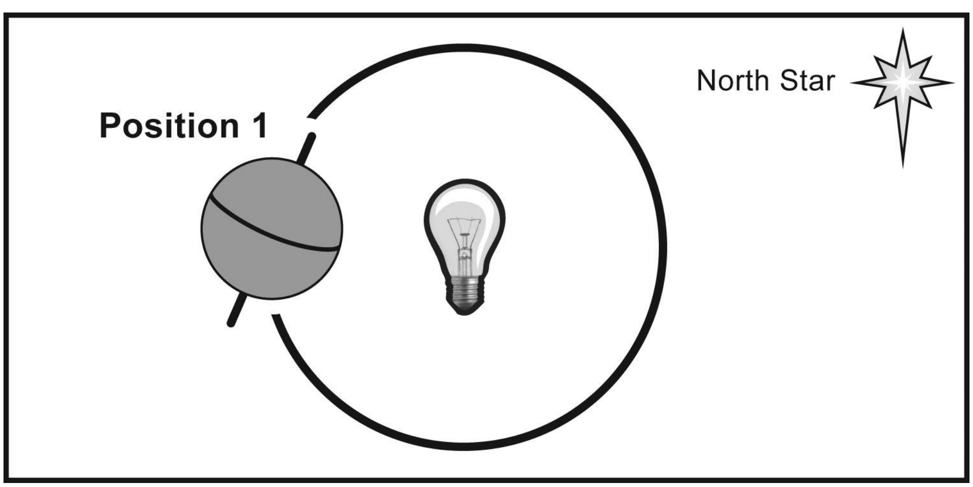
- 1 light setup (lightbulb, socket, plug)
- 1 hoop (to represent Earth's orbit)
- 1 Styrofoam ball on a stick (to represent Earth on its axis)
- 1 rubber band (representing the equator)
- 2 push pins (locating where we are on the globe and where Brazil is on globe)

Each of you will need these things:

- handout: *Sun's Incoming Energy with Tilt—Position 1*
- handout: *Sun's Incoming Energy with Tilt—Position 3*
- handout: *Data Table: Number of Sun's Incoming Rays by Season at Different Latitudes*
- your science journal

Directions

1. Position your Styrofoam ball "Earth" in position 1 in its orbit around the Sun so that the North Pole points *toward* both the Sun and the North Star with a 23.5° tilt.



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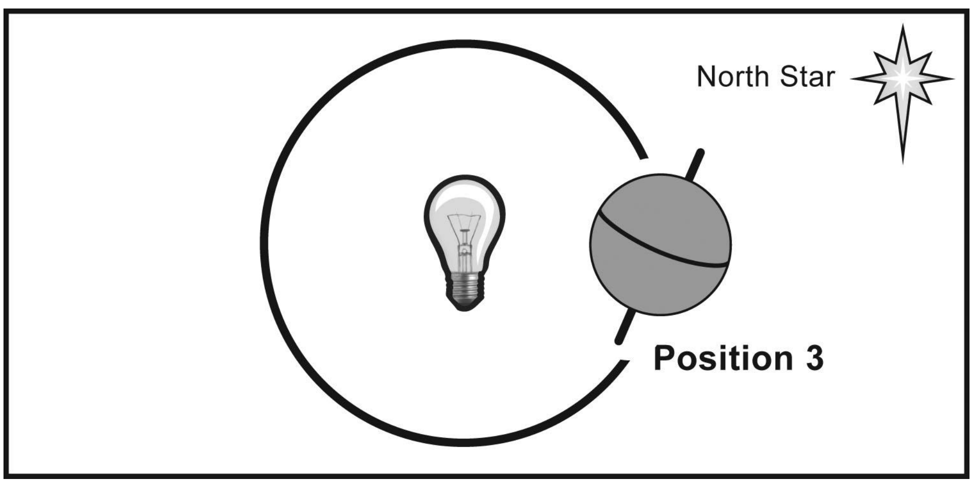
a. Place the handout *Sun's Incoming Energy with Tilt—Position 1* on the table next to your Styrofoam "Earth." Notice that the Earth image on your handout is tilted at 23.5°, just like the Styrofoam "Earth," so that the North Pole points *toward* the Sun and the North Star.
b. Count the number of lines of solar radiation hitting Earth in the following locations on Earth's surface and record the numbers in your data table:

Latitude 60° N–75° N
Latitude 30° N–45° N
Latitude 0°–15° N
Latitude 0°–15° S
Latitude 30° S–45° S
Latitude 60° S–75° S

2. Now, place your Styrofoam "Earth" at position 3 in its orbit. The North Pole is still pointing toward the North Star, but now it's pointing at a 23.5° angle *away* from the Sun and the South Pole is pointing *toward* the Sun.



a. Place the handout *Sun's Incoming Energy with Tilt—Position 3* on the table next to your Styrofoam "Earth." Notice that the Earth image on your handout is tilted at 23.5°, just like the Styrofoam "Earth," so that the North Pole points *away* from the Sun but still toward the North Star. (Where is the South Pole pointing?)

b. Count the number of lines of solar radiation hitting Earth in the following segments on Earth's surface and record the numbers in your data table:

Latitude 60° N–75° N
Latitude 30° N–45° N
Latitude 0°–15° N
Latitude 0°–15° S
Latitude 30° S–45° S
Latitude 60° S–75° S

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<u>Discuss with your team.</u>

1. Where is the Sun's light "straight on" when Earth is in position 1? (Think: Is it at the equator?)
    a. Which hemisphere experiences summer in position 1?
    b. Which hemisphere experiences winter in position 1?
    c. Use your data to explain why it is summer in one hemisphere and not the other.

2. Where is the Sun's light "straight on" when Earth is in position 3?
    a. Which hemisphere experiences summer in position 3?
    b. Which hemisphere experiences winter in position 3?
    c. Use your data to explain why it is summer in one hemisphere and not the other.

3. Compare the data in your data table to the data you collected in Lesson 2 on your *Sun's Incoming Energy* handout in your notebook. Is the Sun's energy the same intensity at the same latitudes now as in Lesson 2? Where do you find differences?

4. What is the reason for the differences in your data? (Think about what is different in the diagram from Lesson 2 and these diagrams.)

5. Summarize your learning from this activity *using specific data from your table* and the following sentence stems.

    Winter and summer occur in each hemisphere during ...
    When comparing the hemispheres, I notice …
    The data that support this are …
    This happens because ...

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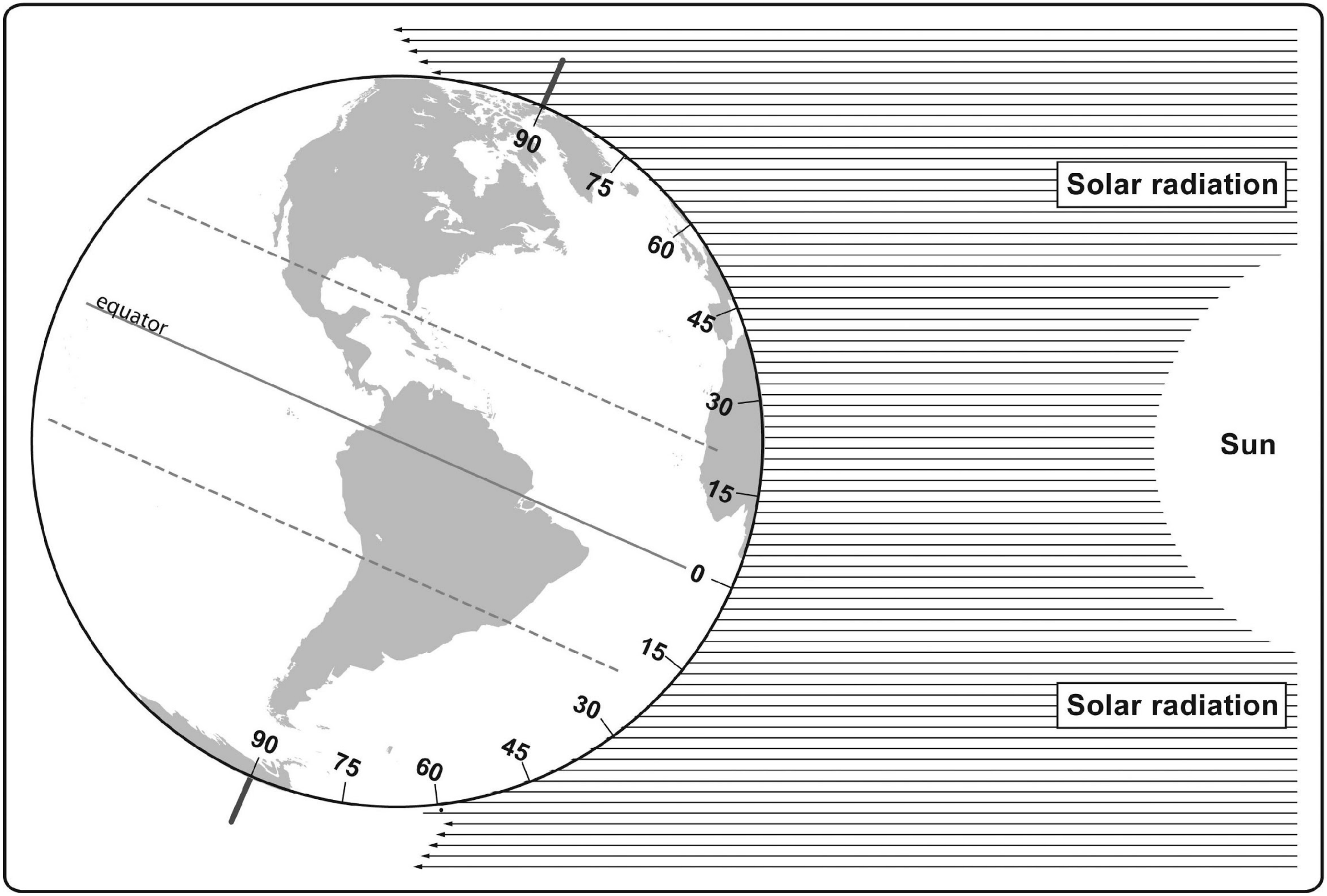
Sun's Incoming Energy with Tilt - Position 1



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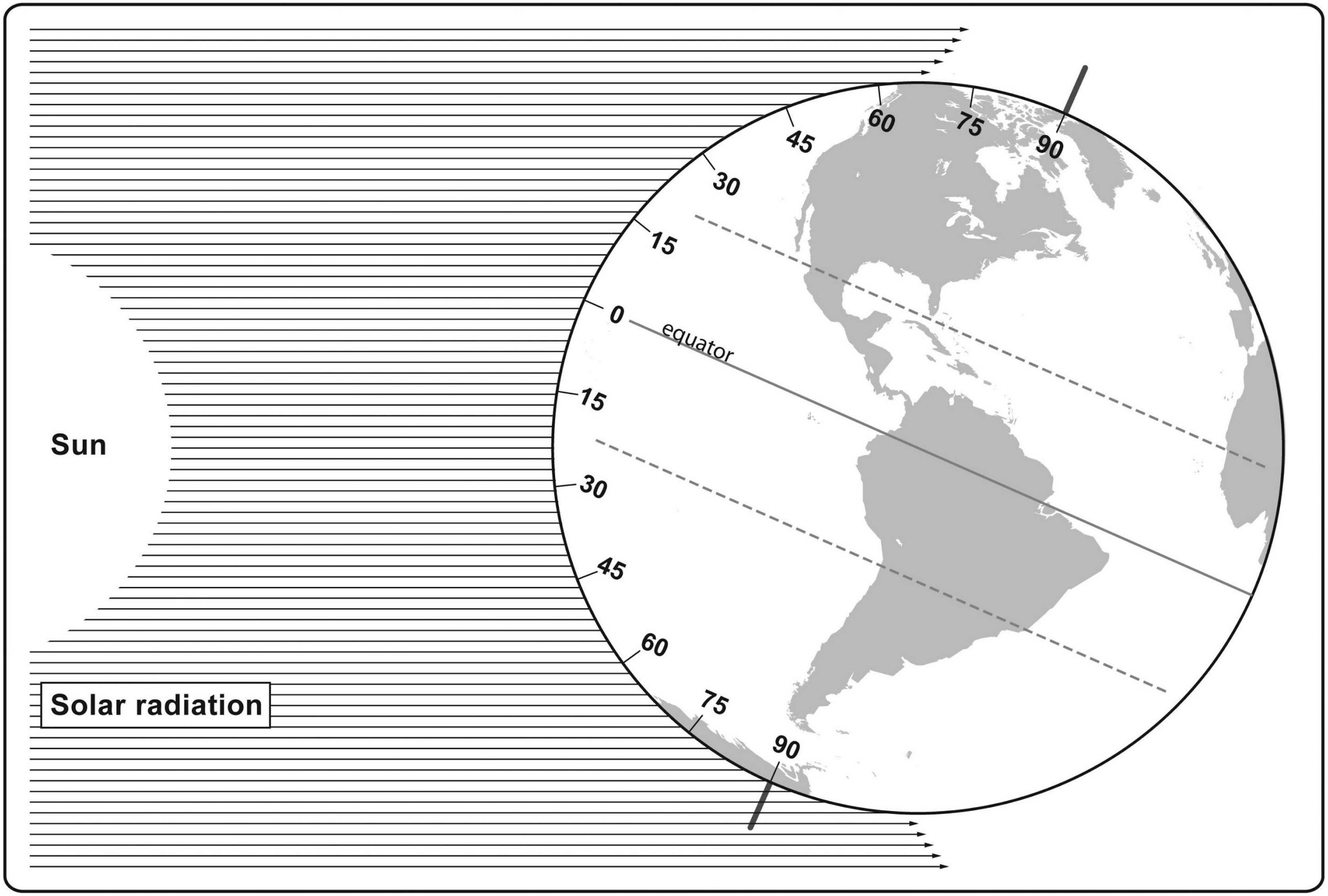
Sun’s Incoming Energy with Tilt - Position 3



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Data Table

Number of Sun's Incoming Rays by Season at Different Latitudes		
	Position 1 Season:____________ (Northern Hemisphere) Season:____________ (Southern Hemisphere)	**Position 3** Season:____________ (Northern Hemisphere) Season:____________ (Southern Hemisphere)
Latitude 60˚–75˚N (near Alaska)		
Latitude 30˚–45˚N (near Denver)		
Latitude 0˚–15˚N (north of the equator)		
Latitude 0˚–15˚S (south of the equator)		
Latitude 30˚S–45˚S (near the bottom of South America)		
Latitude 60˚S–75˚S (near northern Antarctica)		

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