The Sun's Effect on Climate and Seasons
Lesson 3: Earth's Tilt and Its Orbit around the Sun

Grade: 5	**Length of lesson: 74 minutes**	**Placement of lesson: 3 of 6 lessons**
Anchoring Phenomenon: 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.		
Lesson Main Learning Goal: Earth's consistent tilt toward the North Star produces opposite seasons in the Northern and Southern Hemispheres. **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 Question:** Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?
Science content storyline: The Sun's light strikes Earth's curved surface at different angles in different locations, which causes areas with higher average temperatures (warmer areas) near the equator and areas with lower average temperature (cooler areas) as one moves toward the polar regions. Earth spins on its axis, which passes through the North and South Poles, as it orbits the Sun in a nearly circular path once a year. Earth is tilted on its axis at 23½ degrees from a line perpendicular to its orbital path. As Earth orbits the Sun, its axis always tilts in the same direction—toward the North Star. Earth's consistent tilt as it orbits the Sun causes the Northern Hemisphere to lean *toward* the Sun at certain times of year and *away* from the Sun at other times of the year. When the Northern Hemisphere is tilted toward the Sun, the Southern Hemisphere is tilted away from the Sun. Earth's Northern Hemisphere experiences summer when it leans toward the Sun while the Southern Hemisphere experiences winter. Conversely, Earth's Southern Hemisphere experiences summer when it leans toward the Sun while the Northern Hemisphere experiences winter. (Note that the seasonal variations that we call *summer* and *winter* do not occur at latitudes close to the equator.) When Earth's hemispheres lean neither toward nor away from the Sun along Earth's orbit, we experience spring and fall. As Earth orbits the Sun, the axis always tilts in the same direction, which results in different parts of Earth getting different amounts of sunlight at the same time of the year. Consequently, Earth's consistent tilt produces opposite seasons in the Northern and Southern Hemispheres.		
Ideal student response to the Lesson Focus Question: When we have summer in the United States, the North Pole of Earth is tilted toward the Sun and toward the North Star. When we have winter in the United States, the North Pole of Earth tilts away from the Sun but still toward the North Star. As Earth orbits the Sun, the tilt of Earth does not change directions—the North Pole always points toward the North Star. Earth's consistent tilt also means		

that when the Northern Hemisphere gets more-direct sunlight and it is summer, the Southern Hemisphere gets less-direct sunlight and it is winter there. So, the Northern and Southern Hemispheres have winter and summer at opposite times.

Preparation

MATERIALS NEEDED	AHEAD OF TIME
Sun's Effect on Climate and Seasons PowerPoint (by lesson) **Teacher Resource** • TE3.2 *North Star* **Student Handout** • HO3.1 *Earth's Orbit around the Sun* (1 per student) **Other Materials** • 1 globe for teacher use (if you have access to a globe on a stand, use it; otherwise, use an inflatable one) *For each group of 4–5 students* • 1 light setup (to represent Sun) (lightbulb, socket w/plug, extension cord, power strip) • 1 hula 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 pushpins (to locate the United States and Argentina on the Styrofoam ball) • 1 stand for Earth's axis (to keep it tilted at 23½ degrees)	• Review the background information found on pages 12-14 of the *Content Background* document. • Prepare the handout for students. • Put the rubber bands around the middle of the Styrofoam balls. • Place two pushpins in each Styrofoam ball, one to represent where the United States is located and the other to represent the location of Argentina. • Place the large star somewhere near the ceiling on a wall of the classroom to represent Polaris, the North Star. Leave this North Star up throughout the unit. • Arrange the materials at stations around the classroom, 1 setup per group of 4-5 students. • During the Setup for the Activity 1, divide students into groups of 4 to 5.

Lesson 3 General Outline

Time	Phase of lesson	How the science content storyline develops
5 min	**Link to the Last Lesson:** The teacher reviews the main learning goal from the last lesson.	The Sun's light strikes Earth's curved surface at different angles in different locations, which causes areas with higher average temperatures (warmer areas) near the equator and areas with lower average temperature (cooler areas) as one moves toward the polar regions.
5 min	**Lesson Focus Question:** The teacher introduces the Lesson Focus Question: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?*	
5 min	**Setup for Activity 1:** Students describe how a Styrofoam ball on a stick, a lightbulb, and a hoop can be used to model Earth's orbit around the Sun.	
10 min	**Activity 1:** Students create a model of Earth as it orbits the Sun and use it to express their thinking about seasons in the Northern and Southern Hemispheres during the course of one year.	Earth spins around its axis, which passes through the North and South Poles, as it orbits the Sun in a nearly circular path once a year.
10 min	**Follow-up to Activity 1:** Students examine the Earth-Sun model and then explain why they think the Northern and Southern Hemispheres experience different seasons at different times of the year.	
5 min	**Setup for Activity 2:** The teacher introduces the idea that Earth is tilted in its orbit and prepares students to display a consistent tilt as Earth revolves around the Sun.	Earth is tilted on its axis at 23½ degrees from a line perpendicular to its orbital path. As Earth orbits the Sun, its axis always tilts in the same direction—toward the North Star.

Time	Phase of lesson	How the science content storyline develops
10 min	**Activity 2:** In their groups, students model Earth with a consistent tilt as it orbits the Sun. They record their ideas about seasons in each of four positions on a diagram of the Sun-Earth model.	Earth's consistent tilt as it orbits the Sun causes the Northern Hemisphere to lean *toward* the Sun at certain times of year (summer in North America) and *away* from the Sun at other times of the year (winter in North America). When the Northern Hemisphere is tilted toward the Sun, the Southern Hemisphere is tilted away from the Sun.
10 min	**Follow-up to Activity 2:** Students analyze the results of a tilted Earth on seasons in the Northern and Southern Hemispheres.	Earth's Northern Hemisphere experiences summer when it leans toward the Sun while the Southern Hemisphere experiences winter. Conversely, Earth's Southern Hemisphere experiences summer when it leans toward the Sun while the Northern Hemisphere experiences winter. (Note that the seasonal variations that we call *summer* and *winter* do not occur at latitudes close to the equator.) When Earth's hemispheres lean neither toward nor away from the Sun along Earth's orbit, we experience spring and fall.
12 min	**Summarize and Synthesize Today's Lesson:** The teacher summarizes today's main learning goal. Students compare their earlier ideas and write a summary in their notebooks.	Earth orbits the Sun, the axis always tilts in the same direction, which results in different parts of Earth getting different amounts of sunlight at different times of the year. Consequently, Earth's consistent tilt produces opposite seasons in the Northern and Southern Hemispheres.
2 min	**Link to Next Lesson:** The teacher links to the next lesson about angle of sunlight according to latitude and the tilt of Earth.	

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 the Last Lesson** Synopsis: The teacher reviews the main learning goal from the last lesson. Main Science Ideas: The Sun's light strikes Earth's curved surface at different angles in different locations, which causes areas with higher average temperatures (warmer areas) near the equator and areas with lower average temperatures (cooler areas) as one moves toward the polar regions.	Highlight key science ideas and focus question throughout.	What did we learn last time that might help us answer part of our Unit Central Question, *Why are some places on Earth hotter than others at different times of the year?* ***NOTE TO TEACHER:*** *Ask this question as a think-pair-share so that each student has a chance to use their own language with a peer before a few students answer in the whole group. Ask students to revisit their graphs and charts in their science notebook. Ask them to share their cutout models from last time, as well as their ideas.*  Listen to students' ideas and observe the models that are shared. What's *visible* about student thinking? Did they understand the main idea that the angle of the Sun's incoming light changes the amount of warming of Earth in different places?	The temperature that you get depends on the angle that the Sun's rays are hitting where you are. **Say more about the angle that causes some places to be hotter or colder.** When the light shined on the surface at an angle, the light was more spread out. This means that there isn't as much of the Sun's energy at each place on the graph paper and it won't be as warm there. **What do you mean that there isn't as much solar energy? Can you show us what you mean?** The Sun shines straight on at the equator, so it's warmer there. **What does "straight on" and "more spread out" have to do with temperature?** It's like we saw in our investigation. The farther you are from the equator, the more you get light at an angle, so the energy gets more and more spread out.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Good. Because Earth is round like a ball, the Sun's light hits some places straight on and other places at an angle. This means that the sunlight is more intense, or more concentrated, near the equator and causes average temperatures to be higher in those locations. Where the sunlight is less intense, or more spread out, as we move closer to the poles, this causes average temperatures to be lower in those locations.	**Can you say more about "the energy gets spread out"?** **Where is it spread out, and why does that matter?**
5 min	**Lesson Focus Question** Synopsis: The teacher introduces the Lesson Focus Question: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?*	Set the purpose with a focus question. Link science ideas to other science ideas.	In today's lesson, we will add to our ideas about how the Sun heats Earth differently in different places. If the angle of sunlight hitting Earth was the only thing that mattered in heating the surface, then we might think that the temperatures north and south of the equator should be the same all the time. But we know that temperatures do not stay the same all year long. Where we live, sometimes it's hot and sometimes it's cold. Let's look at today's Lesson Focus Question, *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			NOTE TO TEACHER: *Add the focus question to your list of Lesson Focus Questions, which are posted so you and the students can refer to them throughout the lesson. Point out the United States and Argentina on the globe to orient students for today's task.* Think about what you know about the angle of sunlight and the temperature patterns you saw in Lesson 1. Take two minutes to talk with a partner about why you think it is summer in the Northern Hemisphere at the same time it is winter in the Southern Hemisphere. Then, write the Lesson Focus Question in your science notebook. Under the question, record your ideas—what you think now. Your thinking might change as we continue with today's lesson, but let's keep track of our current ideas.	
5 min	**Setup for Activity 1** Synopsis: Students describe how a Styrofoam ball on a stick, a lightbulb, and a hoop can be used to model Earth's orbit around the Sun.	Select content representations and models matched to the learning goal.	***NOTE TO TEACHER:*** *Divide students into groups of 4 to 5. Display the Styrofoam ball on a stick, the hula hoop, and the lightbulb setup. Point out that the stand at their station will NOT be used in Activity 1. Provide students a few minutes to think about what part of the real world is represented by each of the materials.*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			Today we're going to use some familiar materials to represent the relationship of the Sun and Earth in space. What do you think each of these materials will represent in today's model?	
			Yes, the light represents the Sun and the ball represents Earth.	I think the lightbulb will represent the Sun. I think the Styrofoam ball will be either Earth or the Moon. **Say more about how the ball might represent either Earth or the Moon.**
			Why do we have a rubber band around the middle of the Earth model? What locations do the pushpins represent?	The rubber band is the equator. One pin is north of the equator and the other one is south.
			The pushpins relate to our focus question and show us the locations of the United States and Argentina.	**What are we trying to model with these materials?** **How are these materials similar to or different from the real world?**
			What about the stick—what do you think it represents?	The stick is the line through Earth that goes through the North and South Poles.
			Yes, the stick represents Earth's axis, which is an imaginary line that passes through the North and South Poles	**What do you mean by "line through the poles"?** **Is this a real line?**
			NOTE TO TEACHER: *If students are confused about what the stick represents, show students a globe on a stand and note its tilt within its stand. Point out the part of the stand that represents the axis,*	No, there's no real stick in Earth, but we spin around as if we had a stick.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			which is similar to the stick through the Styrofoam ball.	**When you say we spin around, what does that mean? Why is that spinning important?**
				When Earth spins it makes day and night. We face the Sun or we face away from the Sun.
			What do you think the hula hoop represents?	The hula hoop must be the path Earth travels around the Sun—our orbit.
			 Listen to students' ideas. What's visible about student thinking?	**Describe what you mean by "orbit."**
				There's no real hoop or road for Earth, like a highway, but there is a path that we go around year after year.
				How is the hula hoop the same or different from how you think about Earth's orbit?
				The hoop is a circle, but Earth's orbit isn't in a circle. It's more of an oval.
				Say more about the orbit as an oval not a circle.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Engage students in using content representations and models. Highlight key science ideas and <u>focus question</u> throughout.	***NOTE TO TEACHER:*** *Because of how illustrations are drawn in books, many students will picture Earth's orbit as an ellipse and not as a circle. These drawings perpetuate the misconception that Earth is closer to the Sun at different times of the year. We will address this misconception in the Follow-up to Activity 2.* First in today's activity, I want you to show how you think Earth orbits the Sun during one year. Keep in mind our focus question: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?* Be prepared to show one another what the position of Earth would be when it's summer in the United States and winter in Argentina. Also, as you work in your groups today, I want you to make sure that everyone has a chance to work with the materials and that everyone is contributing ideas in the conversation. If you find that you're the only one moving the Earth model around or you're the only one talking, please make sure that you let someone else get their hands on the Earth model or have a chance to share their ideas.	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Engaging students in communicating in scientific ways.	You will be making observations, looking for patterns, asking clarifying questions, and agreeing or disagreeing as you work, so let's look up at our CSW chart and revisit numbers 2, 3, 6, and 7. Let's remind each other to use the sentence stems on our chart. ***NOTE TO TEACHER:*** *Assign one group of students to each station. Have the students place the materials in their positions with the light in the center of the hula hoop and the Styrofoam ball with a stick somewhere along the rim of the hula hoop. Again, remind them that they will NOT be using the stand at this time.* OK, you may begin your exploration of Earth's orbit around the Sun!	
10 min	**Activity 1** Synopsis: Students create a model of Earth as it orbits the Sun and use it to express their thinking about seasons in the Northern and Southern Hemispheres during the course of one year.	Select content representations and models matched to the learning goal.	***NOTE TO TEACHER:*** *Circulate among groups of students as they work on the task of completing Earth's orbit. Note whether they already know to tilt Earth. Also note how and why they are determining which hemisphere is in summer and which is in winter. Take time to listen to the things students are saying before you interrupt or ask questions.*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	Main Science Idea: Earth spins around its axis, which passes through the North and South Poles, as it orbits the Sun in a nearly circular path once a year.			
10 min	**Follow-up to Activity 1** Synopsis: Students examine the Earth-Sun model and then explain why they think the Northern and Southern Hemispheres experience different seasons at different times of the year.	Select content representations and models matched to the learning goal.	Before we talk about your ideas about how Earth orbits the Sun, let's talk about our Earth-Sun model. How do you think this representation of Earth and the Sun are like the real thing? How might this representation be different from the real Earth and Sun?  *Listen to students' ideas. What's visible about student thinking?* *Do students understand that creating and manipulating this scale model of the Sun and Earth in the classroom can help them to understand the interaction between the real Sun and Earth but that the classroom model might have some limitations?*	The distances and the sizes of Earth and the Sun are not like the real Earth and Sun. Earth is really much smaller than the Sun. Earth is also much farther away from the Sun. The lightbulb gives off light, but it doesn't give off as much heat as the Sun. If we're trying to understand something about how hot it is on the planet, the lightbulb won't heat things up in the same way. **What does the hula hoop represent in our model?** **Does the distance between Earth and the Sun ever change as Earth travels in its orbit?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Engage students in communicating in scientific ways.	Now, let's share ideas about how Earth orbits the Sun. Will the group at Station 1 please go first and show us how Earth orbits the Sun? Please tell us about where different places on Earth would have summer and winter in your orbit. Everyone else, please observe the Earth-Sun model closely and decide whether you agree or disagree with their ideas about how Earth orbits the Sun. ***NOTE TO TEACHER:*** *Ask one group to show how they moved Earth around the Sun.* ***Pay particular attention to how students display Earth's tilt as the planet revolves and how they describe the seasons.*** *Ask other students to comment on whether they moved their Earth model in the same way. As time allows, have multiple groups demonstrate their orbits and discuss similarities and differences. Suggest to students to communicate in scientific ways by saying, "I/We (agree/disagree) with ____ because (state evidence)."*	When Earth is on this side of the Sun, then we have summer. When we moved Earth over here, on the other side of the Sun, it still seems like it's summer. **Tell me more about how you know it's summer where we live.** We know Earth is tilted, but we're not sure which way. We think it's winter in South America when the South Pole points away from the Sun, but we're not sure. **Does anyone agree or disagree with how this group has displayed summer in the Northern Hemisphere**? **Can anyone add to their ideas?** **Use the model to demonstrate your ideas.** **Show me what you mean by "tilted."** **Which groups had similar ideas? Who agrees or disagrees?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
				Can you show us why you agree or disagree?
5 min	**Setup for Activity 2** Synopsis: The teacher introduces the idea that Earth is tilted in its orbit and prepares students to display a consistent tilt as Earth revolves around the Sun. Main Science Idea: Earth is tilted on its axis at 23½ degrees from a line perpendicular to its orbital path. As Earth orbits the Sun, its axis always tilts in the same direction—toward the North Star.	Make explicit links between science ideas and activities (before activity).	***NOTE TO TEACHER:*** *Display the image of Earth in the four positions as it orbits the Sun. Point out the consistent tilt toward the North Star as you discuss this idea with students.* We need to add one more idea to our Earth-Sun model to make it more accurate. Look back in your science notebook at the diagrams from last class. How is Earth's axis oriented? Yes, our diagrams and models from last time are not quite accurate. Most of you know that Earth doesn't rotate around the Sun in a straight up and down position—rather, it tilts. However, we saw that in the last activity groups had Earth tilting, but not in the same direction. The accuracy of the tilt is really important. Notice that on this diagram (*point to slide 11*), Earth's axis always tilts in the same direction. It does not move back and forth as some of you demonstrated. So, to keep our Earth model tilting in the proper direction, we're now going to put the end of the	Earth's axis was straight up and down. **One of our group's just mentioned they thought the axis was tilted. What do others think about that idea?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			stick in the stand at your station. The stand keeps the Earth ball tilted at 23½ degrees. Earth's tilt always points in the same direction. It happens to point toward the North Star, which is in line with Earth's tilt. Notice that I've put an image of the North Star on the wall over here. In the next activity, you need to make sure that Earth's axis always points toward that star on the wall, just like in the diagram.	
		Highlight key science ideas and <u>focus question</u> throughout.	Now, in your groups, you will move Earth again in its orbit around the Sun. This time, on the diagram I will hand out in a minute, you will record which *season* the Northern Hemisphere experiences and which *season* occurs in the Southern Hemisphere in each of the four positions of Earth's orbit. Before you begin, talk within your group about how the change in our model--the consistent tilt of Earth--will or will not change what you observed from the first time. Be prepared to share your ideas about our Lesson Focus Question: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere?* ***NOTE TO TEACHER:*** *Distribute one copy of the diagram,* Earth's Orbit around the Sun*, to each student before they begin the next activity. They are to record on this diagram the seasons each hemisphere experiences as Earth orbits the Sun.*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
10 min	**Activity 2** Synopsis: In their groups, students model Earth with a consistent tilt as it orbits the Sun. They record their ideas about seasons in each of four positions on a diagram of the Sun-Earth model. Main Science Idea: Earth's consistent tilt as it orbits the Sun causes the Northern Hemisphere to lean *toward* the Sun at certain times of year (summer in North America) and *away* from the Sun at other times of the year (winter in North America). When the Northern Hemisphere is tilted toward the	Make explicit links between science ideas and activities (during activity).	***NOTE TO TEACHER:*** *Circulate among the groups of students as they work on the task.* *Ask questions about Earth's tilt and why we experience particular seasons on Earth when Earth is in each of the four positions shown on the handout. Help students orient Earth's axis toward the North Star so that the direction of the tilt never varies. Ask them to describe which hemisphere is tilted toward or away from the Sun and why that makes a difference in the seasons experienced in different places on Earth.* *Students might have difficulty with positions 2 and 4 because Earth is not tilted toward the Sun at those times. Take time to listen to students' ideas about why those positions might mean spring and fall rather than summer or winter.*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	Sun, the Southern Hemisphere is tilted away from the Sun.			
10 min	**Follow-up to Activity 2** Synopsis: Students analyze the results of a tilted Earth on seasons in the Northern and Southern Hemispheres. Main Science Ideas: Earth's Northern Hemisphere experiences summer when it leans toward the Sun while the Southern Hemisphere experiences winter. Conversely, Earth's Southern Hemisphere experiences summer when it	Engage students in analyzing and interpreting data and observations. Engage students in using content representations and models. Make explicit links between science ideas and activities (after activity).	What did you observe with our tilted Earth model? How did your group's prediction compare to what you actually observed at the four positions? ***NOTE TO TEACHER:*** *As time permits have groups use their model to show and describe what they observed and how it compared to their prediction. You will move next to a two-dimensional model, so ensure that students can use the three-dimensional model to explain their observations.* Now let's look at the diagram of the orbit of Earth around the Sun and talk about the tilt of Earth in the four positions you explored. What part of Earth received more sunlight in position 1? What season would it be in the Northern Hemisphere when Earth is in that position? What about in the Southern Hemisphere? During what months of the year would Earth be moving between positions 1 and 2?	I see that the Northern Hemisphere got more sunlight in position 1, so it would be summer in the Northern Hemisphere. The Southern Hemisphere got less sunlight in position 1, so it would be winter there. It would be June or July, I think.

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	leans toward the Sun while the Northern Hemisphere experiences winter. (Note that the seasonal variations that we call *summer* and *winter* do not occur at latitudes close to the equator.) When Earth's hemispheres lean neither toward nor away from the Sun along Earth's orbit, we experience spring and fall.		What about position 3? What part of Earth receives more sunlight? What season is it in the Northern Hemisphere when Earth is in that position? What season is it in the Southern Hemisphere? During which months of the year is Earth moving between positions 3 and 4? What seasons do positions 2 and 4 represent for the Northern Hemisphere? Does it make sense to you that, in positions 2 and 4, both hemispheres receive the same amount of the Sun's energy? How would you describe the tilt of Earth in positions 2 and 4 relative to the Sun? ***NOTE TO TEACHER:*** *Continue the discussion in this way for all four positions as Earth orbits the Sun. Discuss which season might be represented in each hemisphere and why. Also, talk about the months of the year represented in and between the positions of Earth along its orbit. Refer to their three-dimensional model when appropriate so students are connecting the two.*	Oh, it is opposite position 1! The southern hemisphere gets more sun in this position. That means it is winter in position 3. It is opposite, so summer. Well, we go through spring from winter to summer. They must be spring and fall, but I don't understand why. Not really. Isn't it warmer in the spring than in the fall? Earth is not tilted toward or away from the Sun, but beside it somehow. **Tell me more about what the tilt has to do with summer and winter.**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
		Highlight key science ideas and <u>focus question</u> throughout.	According to both of our models, is Earth actually closer to the Sun when we have summer in the United States? Is Earth closer to the Sun when it is summer in Argentina?	No, the distance between Earth and the Sun stays the same in all the positions. In the drawing, the orbit is a little bit oval, but mostly a circle. **What evidence do you have from your models?** **And what about our three-dimensional model, what is your evidence?** The hula hoop is round like a circle.
			Even though many pictures in books make it look like the orbit of Earth around the Sun is shaped like an oval, Earth's orbit is really closer to being circular—it is only slightly oval. That is why we used a hula hoop to represent the orbital path. This means that Earth is really not closer to the Sun when we experience summer, and it is not farther away from the Sun when we experience winter. We will talk more about these ideas in the next two lessons.	
		Engage students in using content representations and models.	We've considered two models to help us gather evidence related to our Lesson Focus Question for today: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?*	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			How would you answer this question now? Record your ideas in your science notebook by completing the following: It is summer in the United States when it is winter in Argentina because _____. My evidence from our Earth-Sun model is _____. Now please turn back to your initial thinking about our focus question and add your current thinking under your initial response. Include the following: a. Make a labeled diagram (model). b. Identify any patterns that you observed from our models. c. Use evidence from our models to explain your reasoning. ***NOTE TO TEACHER:*** *Remind students that their labeled diagram should only respond to the focus question (position 1). Although this requires time, it is important for students to record their current thinking to self-assess and begin to link ideas.*	
12 min	**Synthesize and Summarize Today's Lesson** Synopsis: The teacher	Summarize key science ideas.	***NOTE TO TEACHER:*** *Display the image of Earth in the four positions as it orbits the Sun and use it as you summarize today's science ideas.* As we summarize our learning, self-assess your own response for understanding.	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
	summarizes today's main learning goal. Students compare their earlier ideas and write a summary in their notebooks. Main Science Idea: As Earth orbits the Sun, the axis always tilts in the same direction, which results in different parts of Earth getting different amounts of sunlight at different times of the year. Consequently, Earth's consistent tilt produces opposite seasons in the Northern and Southern Hemispheres.	Engage students in making connections by synthesizing and summarizing key science ideas.	Using our model of the Sun-Earth system and the four positions of Earth's orbit around the Sun, we can see these patterns: a. Earth's tilt never changes directions. It always points in one direction—toward the North Star. *(Point this out at positions 1–4.)* b. Earth's North Pole does not always point toward the Sun. Sometimes, it points away from the Sun (*position 3*). c. When the North Pole points toward the Sun, the South Pole points away from the Sun (*position 1*). d. When Earth is in position 1, the Northern Hemisphere experiences summer and the Southern Hemisphere experiences winter. Review your response. Did you identify these same patterns? What questions do you have? Who can summarize a few other patterns you noticed? What is your evidence? Look back in your notebook at your response to our Lesson Focus Question and self-assess. Do you still agree with your ideas using the questions on the slide.	In positions 2 and 4, it isn't summer or winter in the north or south. It's fall or spring. **Tell me more about why it isn't summer or winter in those positions.** The seasons are opposite in positions 1 and 3. **What do you mean by "opposite"?**

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			If not, do not erase your ideas, rather, use a different-color writing utensil to make necessary additions or changes. It is summer in the United States when it is winter in Argentina because _____. My evidence from our Earth-Sun model is _____. Record your ideas in your science notebook. 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?**
2 min	**Link to Next Lesson** Synopsis: The teacher links to the next lesson about angle of sunlight according to latitude and the tilt of Earth.	Link science ideas to other science ideas.	Today, you examined the position of Earth as it orbits the Sun to figure out why seasons in the Northern and Southern Hemispheres are not the same at the same time. Next time, you will add to your understanding of what causes the seasons by thinking again about the angle of sunlight—as we investigated in Lesson 2—and whether the tilt of Earth changes	

Time	Phase of lesson and how the science content storyline develops	STeLLA strategy	Teacher talk and questions	Possible student and teacher dialogue
			the angle of sunlight that different places on Earth receive. ***NOTE TO TEACHER:*** *Keep the models of the Earth-Sun system handy. Also keep the North Star displayed. Students will use the models and North Star in the remaining lessons of the unit.*	

BSCS SCIENCE LEARNING
Transforming Science Education Through Research-Driven Innovation

Lesson 3
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 Lesson

Think-Pair-Share

What did you learn last time that might help you answer our Unit Central Question?

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

Use your science notebook and graphs and charts for evidence.

3

Link to Previous Lesson

Here's what we know so far …

- Earth is round like a ball, so the Sun's light hits some places more directly and other places less directly.
- The sunlight is more intense (more concentrated) near the equator, so average temperatures are higher.
- The sunlight is less intense (more spread out) as we move closer to the poles, so average temperatures are lower in those places.

4

Lesson 3 Focus Question

Why is it summer in the United States (North America) when it is winter in Argentina (South America)?

5

What do you think *now* about the focus question?

I think it is summer in the Northern Hemisphere at the same time it is winter in the Southern Hemisphere because _____.

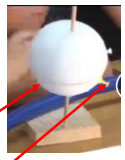
6

Investigation 1: What does Earth's orbit around the Sun look like?

What does each of these materials represent in our model of Earth's relationship to the Sun?

lightbulb and base

hula hoop



Styrofoam ball and stick

rubber band

pushpins

BSCS

7

Investigation 1: What does Earth's orbit around the Sun look like?

Use these materials to show how you think Earth orbits the Sun during one year.

- Make sure everyone has a chance to work with the materials and is adding ideas.
- Think about the focus question as you work.

BSCS

8

Investigation 1: What does Earth's orbit around the Sun look like?

First, let's think about our model.

- How do you think this representation of Earth and the Sun are like the real thing?
- In what ways is our representation different from the real Earth and Sun?

BSCS

9

Investigation 1: What does Earth's orbit around the Sun look like?

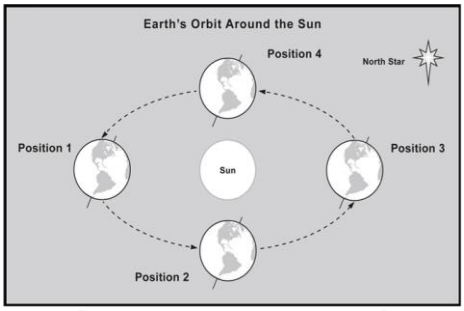
Now, let's have a group demonstrate how Earth orbits the Sun each year.

- Where would different places on Earth have summer and winter in your orbit?
- Observe and listen carefully as each team shares.
- I/We (agree/disagree) because _____.
- Our evidence is _____.

BSCS

10

Investigation 2: Why does Earth's tilt matter?



BSCS

11

Investigation 2: Why does Earth's tilt matter?

What do you notice about Earth's tilt on its axis in this diagram?

How can we make sure our Earth model's axis always tilts in the proper direction?

- Pay attention to the North Star!

BSCS

12

Investigation 2: Why does Earth's tilt matter?

Let's move Earth for another year in its orbit around the Sun.

- In each of the four positions on the diagram,
  - record which *season* the Northern Hemisphere experiences.
  - record which *season* the Southern Hemisphere experiences.

Be prepared to share your ideas about the Lesson Focus Question: *Why is it summer in the United States (Northern Hemisphere) when it is winter in Argentina (Southern Hemisphere)?*

13

Investigation 2: Why does Earth's tilt matter?

Let's first look at Earth in position 1.

- What part of Earth receives more sunlight?
- What season is it in the Northern Hemisphere when Earth is in that position?
- What season is it in the Southern Hemisphere?
- During which months of the year is Earth moving between positions 1 and 2?

14

Investigation 2: Why does Earth's tilt matter?

What about Earth in position 3?

- What part of Earth receives more sunlight?
- What season is it in the Northern Hemisphere when Earth is in that position?
- What season is it in the Southern Hemisphere?
- During which months of the year is Earth moving between positions 3 and 4?

15

Investigation 2: Why does Earth's tilt matter?

- What seasons do we experience in positions 2 and 4?
- Describe Earth's tilt in positions 2 and 4 relative to the Sun.
- What does that say about the amount of sunlight each hemisphere receives in those positions?

16

Investigation 2: Why is it summer in the United States when it is winter in Argentina?

Use the Earth-Sun model to explain your answers to these questions:

- Is Earth closer to the Sun when it is summer in the United States?
- Is Earth closer to the Sun when it is summer in Argentina?
- If Earth is not closer to the Sun in the summer, how can you explain why we have higher average temperatures in the summer?

17

Investigation 2: Why is it summer in the United States when it is winter in Argentina?

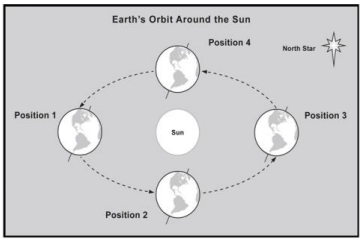
- It is summer in the United States when it is winter in Argentina because _____.
- My evidence from our Earth-Sun model is _____.
- Record your ideas in your science notebook.

18

Lesson Summary: Key Science Ideas

Earth's tilt never changes directions. It always points in one direction—toward the North Star.

Earth's North Pole does not always point toward the Sun. Sometimes, it points away from the Sun.

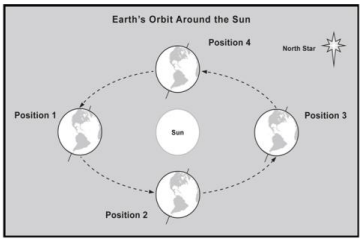


19

Lesson Summary: Key Science Ideas

When the North Pole points toward the Sun, the South Pole points away from the Sun.

When Earth is in position 1, the Northern Hemisphere experiences summer and the Southern Hemisphere experiences winter.



20

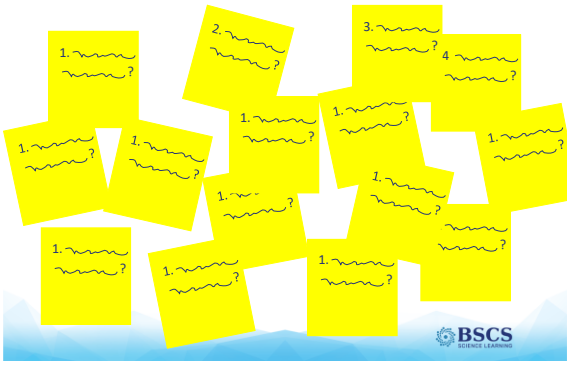
Summary: Why is it summer in the United States when it is winter in Argentina?

Find your earlier answer to the Lesson Focus Question in your science notebook.

- Do you still agree with your earlier ideas?
- What would you like to add? Change?
- Write a new summary to explain why people in the United States do not experience the same seasons as people in Argentina.
  - Use evidence from the Earth-Sun model.

21

Driving Question Board (DQB)

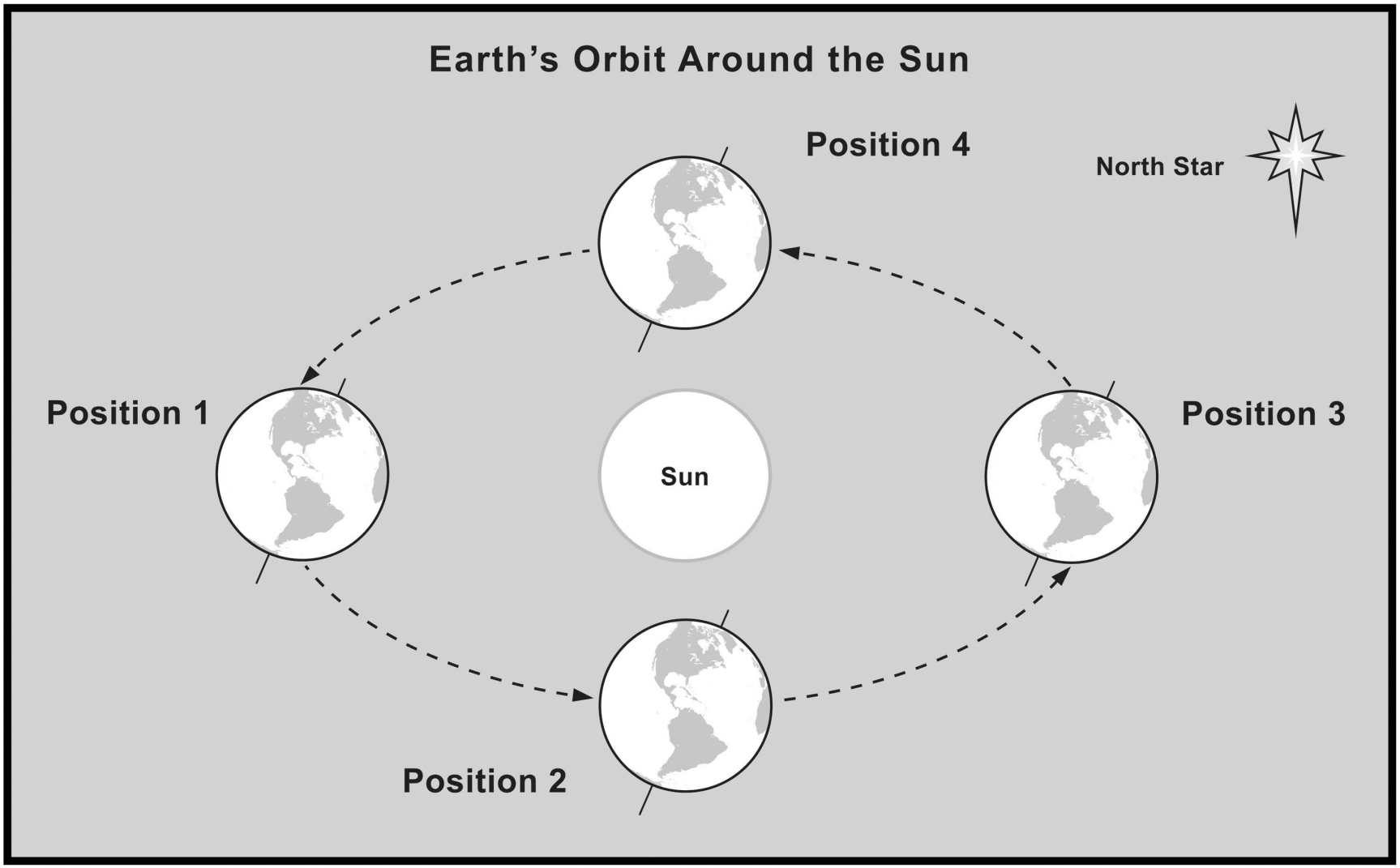


22

In the next lesson, you will think about …

Does the angle of sunlight and the tilt of Earth changes the angle of sunlight that different places on Earth receive?

23



North Star