The Sun's Effect on Climate
Lesson 3a: Earth's Orbit around the Sun

Grade 6	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 3a of 7 two-part lessons on the Sun's effect on climate
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 (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?
Main learning goal: Earth tilts on its axis as it orbits the Sun. This tilt produces opposite seasons in the Northern and Southern Hemispheres during the same time of year.		
Science content storyline: By 6th grade, many students already know that (1) Earth orbits the Sun once a year, and (2) Earth is tilted on its axis at 23.5 degrees from a line perpendicular to its orbital plane around the Sun. However, most students don't realize that Earth's tilt causes opposite seasons in the Northern and Southern Hemispheres. When the Northern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and locations in the Southern Hemisphere experience winter. Conversely, when the Southern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and locations in the Northern Hemisphere experience winter. (Note that the seasonal variations we call *summer* and *winter* don't occur at latitudes closest to the equator.) Spring and fall occur when the hemispheres lean neither toward nor away from the Sun along Earth's orbit.		
Ideal student response to the focus question: Earth tilts on its axis as it orbits the Sun once a year. This causes opposite seasons in the Northern and Southern Hemispheres at the same time. So when the Northern Hemisphere is tilting toward the Sun, places like the United States experience summer, and places like Argentina experience winter because the Southern Hemisphere is tilting away from the Sun. When the Southern Hemisphere is tilting toward the Sun, Argentina experiences summer, and the United States experiences winter because the Northern Hemisphere is tilting away from the Sun.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- 1 globe with stand (for teacher)
- For each group of 4–5 students:
  - 1 light setup (lightbulb, socket, plug) (representing the Sun)
  - 1 Hula Hoop (representing Earth's orbit)
  - 1 globe:
    - 1 Styrofoam ball on a stick (The stick represents Earth on its axis.)
    - 1 rubber band (representing Earth's equator)
    - 2 pushpins (to show where the United States and Argentina are located on the globe)

Student Handouts
- 2.3 The Sun's Incoming Energy (from lesson 2b)

Ahead of Time
- Review section 6 (Earth's Tilt) in the SEC content background document.
- To prepare for the activity:
  - Student globes: Position a rubber band around the middle of each Styrofoam ball to represent Earth's equator and insert 2 pushpins into each ball to show where the United States and Argentina are located.
  - Arrange the materials at stations around the classroom (1 setup per group of students).
- *ELL support:* To enhance ELL students' understanding of the Earth-Sun model and help them identify the various parts, create and label a diagram of the model to post in the classroom for students to refer to throughout the lesson. Also identify vocabulary words from Tiers 2 and 3 to review with students. Examples: *orbit*, *Earth's tilt*, *axis*, *Northern/Southern Hemisphere*, *perpendicular*, *angle*, *more* or *less direct*, *more concentrated/intense*, *more spread out*, *hits* or *strikes*, *light energy/solar radiation, North/South Pole*.

Lesson 3a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
4 min	**Link to previous lesson:** The teacher reviews the unit central question and key science ideas from the previous lesson.	• Because Earth is a sphere, sunlight hits the curved surface more directly closer to the equator and less directly closer to the poles. Variations in the angle at which sunlight strikes Earth's surface at different angles create uneven heating. • The angle at which the Sun's incoming energy, or radiation, strikes Earth's curved surface results in warmer temperatures closer to the equator and cooler temperatures moving toward the poles.
10 min	**Lesson focus question:** The teacher introduces the focus question, *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?*	
10 min	**Setup for activity:** Students consider how a lightbulb, a Hula Hoop, and a Styrofoam ball on a stick can model what Earth's orbit around the Sun looks like.	• Earth is tilted on its axis at 23.5 degrees and orbits, or revolves around, the Sun once a year.
10 min	**Activity:** Students create a model simulating Earth's orbit around the Sun during the course of a year and demonstrate how Earth's tilt affects seasons in the Northern and Southern Hemispheres at different times of the year.	• The tilt of Earth on its axis causes opposite seasons in the Northern and Southern Hemispheres. When the Northern Hemisphere (and the North Pole) leans toward the Sun, locations in that hemisphere experience summer, and locations in the Southern Hemisphere experience winter. When Earth is on the opposite side of the Sun, halfway around its orbit, the Southern Hemisphere (and the South Pole) leans toward the Sun. In that position, the Southern Hemisphere experiences summer, and the Northern Hemisphere experiences winter.
10 min	**Follow-up to activity:** Students discuss the Earth-Sun model and share their ideas about Earth's orbit and what causes the Northern and Southern Hemispheres to experience opposite seasons at the same time of year.	
5 min	**Synthesize/summarize today's lesson:** Students write a preliminary answer to the focus question, synthesizing what they've discovered so far about the cause of seasons on Earth.	• The Northern and Southern Hemispheres experience opposite seasons at the same time of year. When the Northern Hemisphere tilts toward the Sun, that hemisphere experiences summer, and the Southern Hemisphere experiences winter. When the Southern Hemisphere tilts toward the Sun, that hemisphere experiences summer, and the Northern Hemisphere experiences winter.
1 min	**Link to next lesson:** The teacher links science ideas about Earth's tilt and opposite seasons in the Northern and Southern Hemispheres to the next lesson.	

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4 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews the unit central question and key science ideas from the previous lesson. **Main science idea(s):** • Because Earth is a sphere, sunlight hits the curved surface more directly closer to the equator and less directly closer to the poles. Variations in the angle at which sunlight strikes Earth's surface at different angles create uneven heating. • The angle at which the Sun's incoming energy, or radiation, strikes Earth's curved surface results in warmer temperatures closer to the equator and cooler temperatures moving toward the poles.		**Show slides 1 and 2.** What did we learn in our last lesson 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?* **Think-Pair-Share:** Look at the map showing the Sun's incoming energy and review the ideas in your science notebooks from yesterday's lesson. Then pair up and share your ideas for answering this question with a partner. **NOTE TO TEACHER:** *Give students time to review the ideas in their science notebooks and examine the Sun's Incoming Energy map (handout 2.3) from the previous lesson before sharing their ideas with a partner.* **ELL support:** *Have ELL students discuss their ideas in same-language groups before sharing them with the whole class.* **Whole-class discussion:** So what ideas from yesterday's lesson might help us answer our unit central question? STOP *Listen to students' ideas. What's visible about their thinking? Did they get the main idea that the angle of the Sun's incoming light (solar radiation) changes the amount of sunlight hitting different places on Earth, resulting in temperature variations?*	The temperature you get depends on the angle that the Sun's rays are hitting where you are. When the light shines on a surface at an angle, it's more spread	Tell me more about the angle that makes some places hotter or colder.

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				out, so the temperatures wouldn't be as warm there. The Sun shines straight on at the equator, so it's warmer there. The farther you are from the equator, the more you get light at an angle, so the energy gets more and more spread out.	What does "straight on" have to do with temperature? Can you say more about "the energy gets more and more spread out"? Where is it spread out, and why does that matter?
		Highlight key science ideas and focus question throughout.	**Show slide 3.** You've brought up some important science ideas. Here's what we know so far that might help us answer our unit central question: • Because Earth is a sphere (like a round ball), the Sun's light hits some places more directly (or more straight on) and other places less directly (or at a less direct angle) along the curved surface. • This means that the light energy, or solar radiation, is more intense and concentrated near the equator, so temperatures are warmer there.		

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			• Light energy is less intense, or more spread out, moving toward the poles, so temperatures are cooler in these locations.		
10 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?*	Link science ideas to other science ideas. Set the purpose with a <u>focus question</u> or goal statement.	Today we'll add to our ideas about how the Sun heats Earth differently in different places. If the angle of sunlight were the only factor affecting temperatures on Earth, we might expect temperatures north and south of the equator to be the same all the time. But from our investigations so far, we know that temperatures in these locations don't stay the same all year long. Sometimes it's hot where we live, and sometimes it's cold. **Show slide 4.** Our focus question for this lesson is *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* Take a moment to write this question in your science notebooks and draw a box around it. **NOTE TO TEACHER:** *Write the focus question on the board or chart paper so students can refer to it throughout the lesson. Point out the United States and Argentina on a globe to orient students for today's activity.* **Show slide 5.** **Think-Pair-Share-Write:** Reflect on what you know about angles of sunlight and		

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			temperature patterns on Earth from previous lessons. Look briefly at the charts, bar graphs, and maps from those lessons and the ideas in your science notebooks. Then pair up and share your initial ideas for answering our focus question. Why do you think it's summer in places like the United States in the Northern Hemisphere when it's winter in places like Argentina in the Southern Hemisphere? Make sure to include evidence. After you've shared your ideas, write them down in your science notebooks, using this sentence starter: I think it's summer in the Northern Hemisphere when it's winter in the Southern Hemisphere because _____. My evidence is _____. Your thinking might change as we gather more information, but let's keep track of our current ideas.		
10 min	**Setup for Activity** **Synopsis:** Students consider how a lightbulb, a Hula Hoop, and a Styrofoam ball on a stick can model what Earth's orbit around the Sun looks like. **Main science idea(s):** • Earth is tilted on its axis at 23.5 degrees and	Select content representations and models matched to the learning goal and engage	**Show slide 6.** **NOTE TO TEACHER:** *Divide the class into groups of four or five students. Display the Styrofoam ball on a stick, the hula hoop, and the lightbulb setup.* Today you're going to work in small groups using some familiar materials to model Earth's orbit around the Sun. What do you think each of these materials will represents in our model?	I think the lightbulb	

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	orbits, or revolves around, the Sun once a year.	students in their use. Make explicit links between science ideas and activities **before** the activity.	• Lightbulb • Styrofoam ball • Rubber band around ball • Pushpins • Stick in ball • Hula Hoop **ELL support:** Drawing a diagram of the model and labeling the materials as well as what they represent can help ELL students understand the model and identify its parts. That's right! We'll use a lightbulb to represent the Sun, and a Styrofoam ball to represent Earth. Why do you think there's a rubber band around the middle of the ball? What does it represent? What locations do you think the pushpins represent? The pushpins relate to our focus question and show us where the United States and Argentina are located on Earth. What about the stick? What do you think it represents?	will represent the Sun. I think the Styrofoam ball will be either Earth or the Moon. The rubber band is the equator. One pushpin is north of the equator, and the other is south. The stick is the line that goes through the North and South Poles.	Say more about how the ball represents either Earth or the Moon. What are we trying to model with these materials? What do you mean by "the line that goes through the North and South Poles"?

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					Do the North and South Poles really have a line going through them?
				No, there's no real line or stick going through Earth, but we spin around as if there was a stick through it.	When you say "we spin around," what does that mean? Why is spinning important?
				When Earth spins, it makes day and night. We face the Sun, or we face away from the Sun.	When you say "we face the Sun," who are you talking about?
			The stick represents Earth's *axis*, which is an imaginary line that runs through the North and South Poles. **NOTE TO TEACHER:** *If students are confused about Earth's axis, hold up a globe and note the way it tilts on its stand. Point out that the stand represents Earth's axis, which is similar to the stick through the Styrofoam ball.* What about the Hula Hoop? What does it represent? STOP *Listen to students' ideas. What's visible*	The Hula Hoop must be the path or orbit Earth travels around the Sun.	Describe what you

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			about student thinking? **NOTE TO TEACHER:** *Many students will visualize Earth's orbit as oval or elliptical, not circular, because some textbooks illustrate it this way. These drawings perpetuate the misconception that Earth is closer to the Sun at different times of the year, which causes the seasons. This misconception will be addressed in the follow-up to the activity.* **Show slide 7.** For today's activity, I want you to show how you think Earth orbits the Sun in a year. Keep our focus question in mind during this investigation: *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* Be prepared to demonstrate what Earth's position would be along its orbital path around the Sun when it's summer in the United States and winter in Argentina. Make sure everyone in your group has a chance to work with the materials and	There's no real hoop that Earth follows around the Sun, but there's a path it goes around year after year. The hoop is a circle, but Earth's orbit isn't in a circle. It's more of an oval.	mean by "orbit." How is the Hula Hoop similar to or different from how you think about Earth's orbit? Say more about Earth's orbit as an oval, not a circle.

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			contribute ideas to the conversation. If you find that you're the only one talking and moving the model around, please let someone else have a chance to share ideas and handle the model. Now let's set up our model of Earth. Your group should have a light setup to plug in, a Hula Hoop, a Styrofoam ball on a stick with a rubber band around the middle, and two pushpins in the ball showing the locations of the United States and Argentina. **NOTE TO TEACHER:** *Have each group of four or five students set up the activity materials, positioning the light in the center of the Hula Hoop, and the Styrofoam ball somewhere along the rim of the hoop.* OK, now that our models are set up, let's begin our exploration of Earth's orbit around the Sun!		
10 min	**Activity** **Synopsis:** Students create a model simulating Earth's orbit around the Sun during the course of a year and demonstrate how Earth's tilt affects seasons in the Northern and Southern Hemispheres at different times of the year. **Main science idea(s):** • The tilt of Earth on its	Select content representations and models matched to the learning goal and engage students in their use. Make explicit links between science ideas and activities	**NOTE TO TEACHER:** *Continue displaying slide 7 during this phase. Circulate among the groups as students simulate Earth's orbit around the Sun and determine which hemisphere is tilted toward or away from the Sun in different positions. Listen carefully to students' conversations and ideas before interrupting or asking questions. You may also want to jot down notes as you notice misconceptions or other issues to address later.* *Groups might have to place their light setup on a stack of books or raise it some other way*		

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	axis causes opposite seasons in the Northern and Southern Hemispheres. When the Northern Hemisphere (and the North Pole) leans toward the Sun, locations in that hemisphere experience summer, and locations in the Southern Hemisphere experience winter. When Earth is on the opposite side of the Sun, halfway around its orbit, the Southern Hemisphere (and the South Pole) leans toward the Sun. In that position, the Southern Hemisphere experiences summer, and the Northern Hemisphere experiences winter.	**during** the activity.	*so the lightbulb will shine more or less directly on the middle of the Styrofoam ball as students move the model of Earth along its orbit.* *It isn't necessary for students to spin the Styrofoam model on its axis to represent day and night during Earth's orbit around the Sun. By 6th grade, students should already know that day and night are caused when Earth spins on its axis. During this investigation, students should focus on Earth's orbit around the Sun and how this relates to seasons rather than becoming distracted with Earth's daily rotation.* **ELL support:** ELL students may find it helpful to refer to a labeled diagram of the model (see overview page). Draw their attention to it as needed throughout the activity and follow-up to enhance their understanding and help them identify the parts of the model.		
10 min	**Follow-Up to Activity** **Synopsis:** Students discuss the Earth-Sun model and share their ideas about Earth's orbit and what causes the Northern and Southern Hemispheres to experience opposite seasons at the same time of year.	Select content representations and models matched to the learning goal and engage students in their use. Make explicit links between science	**Show slide 8.** Let's talk about our Earth-Sun model briefly before we share ideas to explain Earth's orbit around the Sun and what causes seasons. In what ways is our model *like* the real Earth and Sun? In what ways is our model *not like* the real Earth and Sun?	The distances and the sizes of the Earth and	

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	Main science idea(s): • The tilt of Earth on its axis causes opposite seasons in the Northern and Southern Hemispheres. When the Northern Hemisphere (and the North Pole) leans toward the Sun, locations in that hemisphere experience summer, and locations in the Southern Hemisphere experience winter. When Earth is on the opposite side of the Sun, halfway around its orbit, the Southern Hemisphere (and the South Pole) leans toward the Sun. In that position, the Southern Hemisphere experiences summer, and the Northern Hemisphere experiences winter.	ideas and activities **after** the activity.	Even though this model has limitations, how can it help us understand the relationship between the real Earth and Sun?  *Listen to students' ideas. What's visible about student thinking? Do students realize that even though this scale model of the Sun and Earth has limitations, it can help them understand the relationship between the real Sun and Earth?* **Show slide 9.**	the Sun aren't like the real Earth and Sun. The real Earth is 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.	Did the distance between Earth and the Sun ever change as Earth traveled in its orbit?

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		Engage students in analyzing and interpreting data and observations. Engage students in communicating in scientific ways.	Now let's hear your ideas about how Earth orbits the Sun and what causes seasons. Group 1, I'd like you to go first. Please show us how Earth orbits the Sun and which locations would have summer and winter during Earth's orbit. Everyone else listen carefully to this group's explanation. Observe Earth's orbit closely and decide whether you agree or disagree with the ideas being expressed. Remember our guidelines for communicating in scientific ways. **NOTE TO TEACHER:** *As the first group demonstrates Earth's orbit around the Sun, pay close attention to how students describe the seasons at different points in the orbit, and how they tilt the model during its revolution.* *Students often change the tilt of Earth's axis during its orbit so that the North Pole always points or leans toward the Sun (rather than the North Star). Since the North Star will be introduced in lesson 3b, don't correct discrepancies at this time. Allow students to discuss them and puzzle over what causes opposite seasons in the Northern and Southern Hemispheres. This will begin to make sense in the next lesson.* *As time allows, have other groups demonstrate their orbits and discuss similarities and differences in how they showed Earth's movement around the Sun.*	*Examples of group ideas:* When Earth is on this side of the Sun, then we have summer. When we moved the 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. Does anyone agree or disagree with how this group's ideas about summer in the Northern Hemisphere? Can anyone add to this group's ideas? Use the model to

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			Encourage students to communicate in scientific ways by saying, "I/We ____ [agree/disagree] with ____ because _____."	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.	demonstrate your ideas. Show me what you mean by "tilted." Which groups had similar ideas? Who agrees or disagrees? Can you show us why you agree or disagree?
5 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students write a preliminary answer to the focus question, synthesizing what they've discovered so far about the cause of seasons on Earth. **Main science idea(s):** • The Northern and Southern Hemispheres experience opposite seasons at the same time of year. When the Northern Hemisphere tilts toward the Sun, that hemisphere experiences	Highlight key science ideas and focus question throughout. Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 10.** Let's revisit our focus question, *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* Based on today's investigation of Earth's orbit around the Sun, write a possible answer to this question in your science notebooks and draw pictures to illustrate your ideas. Make sure to include your reasons and evidence, and be prepared to share your ideas with the class. **Whole-class share-out:** Let's hear some of your initial ideas about why we have summer in the Northern Hemisphere when places like Argentina are experiencing winter? I'll record our ideas on chart paper so we can talk about		

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	summer, and the Southern Hemisphere experiences winter. When the Southern Hemisphere tilts toward the Sun, that hemisphere experiences summer, and the Northern Hemisphere experiences winter.		them at the beginning of tomorrow's lesson. **NOTE TO TEACHER:** *If time allows, invite several students to share their answers. Record on chart paper their initial ideas, and possibly their misconceptions, about what causes seasons on Earth and why the Northern and Southern Hemispheres experience opposite seasons at the same time. You'll revisit these ideas at the beginning of the next lesson.*  *Listen to students' ideas. What's visible about student thinking? Don't correct their ideas at this point; just listen and record them on chart paper to discuss during the next lesson.*		
1 min	**Link to Next Lesson** **Synopsis:** The teacher links science ideas about Earth's tilt and opposite seasons in the Northern and Southern Hemispheres to the next lesson.	Link science ideas to other science ideas.	**Show slide 11.** Today we used a model to simulate Earth's yearly orbit around the Sun. This model gave us some clues for answering our focus question, but we still need more information. Next time we'll add another important piece to our puzzle that will help us make sense of seasons on Earth and understand more clearly why it's summer in the United States when it's winter in Argentina.		