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

Grade 6	**Length of lesson:** 40 minutes	**Placement of lesson in unit:** 3b 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: The consistent tilt of Earth on its axis 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 understand that as Earth travels around the Sun in a nearly circular orbit, its axis always tilts in the same direction—toward the North Star. This consistent tilt causes the Northern Hemisphere to lean *toward* the Sun at certain times of the year—specifically during June, July, and August—and *away* from the Sun at other times of the year—during the months of December, January, and February. 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: When we have summer in the United States, Earth's Northern Hemisphere is tilted toward the Sun and the North Star. When we have winter in the United States, the Northern Hemisphere is tilted away from the Sun, but it still points toward the North Star. This means that as Earth orbits the Sun, it doesn't tilt in different directions—the Northern Hemisphere always points toward the North Star. Earth's consistent tilt also means that the Northern Hemisphere gets more direct sunlight in June, July, and August, and the Southern Hemisphere gets more direct sunlight in December, January, and February.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- Class chart of ideas for answering the focus question (from lesson 3a)
- 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 (with stand):
    - 1 Styrofoam ball on a stick (representing 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)
    - 1 stand (to keep Earth's axis tilted at 23.5°)

Student Handouts and Teacher Masters
- 3.1 Earth's Orbit around the Sun (1 copy per student and 1 copy for display; see Ahead of Time)
- 3.2 Image of North Star (Teacher Master) (for display on wall)

Ahead of Time
- Review section 6 (Earth's Tilt) in the SEC content background document.
- Prepare handout 3.1 for display on a document reader or Smart Board.
- Display the North Star image (from handout 3.2) somewhere near the ceiling on a wall of the classroom.
- Arrange the materials at stations around the classroom, (1 setup per group of students).

Lesson 3b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lesson:** The teacher reviews students' initial ideas for answering the focus question from the previous lesson and invites students to add new ideas to the class chart.	• Earth orbits, or revolves around, the Sun once each year. The Northern and Southern Hemispheres experience opposite seasons at the same time of year based on Earth's tilt in relation to the Sun. When the Northern Hemisphere tilts toward the Sun during Earth's orbit, that hemisphere experiences summer while the Southern Hemisphere experiences winter. When the Southern Hemisphere tilts toward the Sun during Earth's orbit, that hemisphere experiences summer while the Northern Hemisphere experiences winter.
1 min	**Lesson focus question:** The teacher reviews the focus question from the previous lesson: *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?*	
3 min	**Setup for activity:** The teacher introduces the science idea that Earth's axis always tilts in the same direction—toward the North Star—during Earth's orbit around the Sun Then the teacher prepares students to demonstrate this idea using their Earth-Sun model.	• As Earth travels around the Sun in a nearly circular orbit, its axis always tilts in the same direction—toward the North Star. Earth's consistent tilt causes the Northern Hemisphere to lean *toward* the Sun at certain times of the year—specifically during June, July, and August—and *away* from the Sun at other times of the year—during the months of December, January, and February. This means that when the Northern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Southern Hemisphere experiences winter. Conversely, when the Southern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Northern Hemisphere experiences 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.
10 min	**Activity:** In small groups, students model Earth's consistent tilt in the same direction as it orbits the Sun. Then they determine which seasons occur in each orbital position and record their ideas on a diagram of the Earth-Sun model.	
10 min	**Follow-up to activity:** Students explain how Earth's consistent tilt affects seasons in the Northern and Southern Hemispheres.	
10 min	**Synthesize/summarize today's lesson:** The teacher summarizes key science ideas from the lesson. Students revise their initial answers to the focus question.	• As Earth orbits the Sun, its axis always tilts in the same direction—toward the North Star—causing different parts of the planet to receive varying amounts of sunlight at the same time of the year. Consequently, Earth's consistent tilt produces opposite seasons in the Northern and Southern Hemispheres.
1 min	**Link to next lesson:** The teacher links science ideas about latitude, Earth's consistent tilt, and the angle of sunlight to the next lesson.	

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5 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews students' initial ideas for answering the focus question from the previous lesson and invites students to add new ideas to the class chart. **Main science idea(s):** • Earth orbits, or revolves around, the Sun once each year. The Northern and Southern Hemispheres experience opposite seasons at the same time of year based on Earth's tilt in relation to the Sun. When the Northern Hemisphere tilts toward the Sun during Earth's orbit, that hemisphere experiences summer while the Southern Hemisphere experiences winter. When the Southern Hemisphere tilts toward the Sun during Earth's orbit, that hemisphere experiences summer while the Northern Hemisphere experiences winter.	Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slides 1 and 2.** At the end of our last lesson, we came up with some initial ideas for answering our focus question, *Why it is summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* Review your answers and drawings in your science notebooks. Then we'll talk about the ideas I recorded on our class chart. **Student review time.** So why do you think we have summer in the United States when the people in places like Argentina are having winter? **NOTE TO TEACHER:** *To clarify student thinking, project a few student drawings of Earth's position in its orbit around the Sun.*	It's about Earth's tilt. It seems like the United States, or the Northern Hemisphere, always leans toward the Sun, so why isn't it always summer? It's easier to look at where the North and South Poles are pointing. The South Pole must point toward the Sun sometimes because we know there's 24 hours of	Say more about this. Do all groups agree? Can anyone add a different perspective?

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			Does anyone have any new ideas to add to our chart? Do you have any questions from yesterday's investigation that you're wondering about? So we know that Earth's tilt causes seasons, but we're not exactly sure why. In this lesson, we'll add more ideas to our chart that will clarify our understandings of the relationship between Earth's tilt and different seasons in the Northern and Southern Hemispheres.	daylight in Antarctica, but we don't know exactly when that happens.	Show us what you mean by "pointing." How do you know there's 24 hours of sunlight in Antarctica?
1 min	**Lesson Focus Question** **Synopsis:** The teacher reviews the focus question from the previous lesson: *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Today we'll continue exploring our focus question from last time: *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* By the end of this lesson, you should have enough information to revise your answers to the focus question from yesterday.		
3 min	**Setup for Activity** **Synopsis:** The teacher introduces the science idea		**NOTE TO TEACHER:** *Display handout 3.1 (Earth's Orbit around the Sun) on a document reader or projector. Don't distribute the handout yet. Point out the*		

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	that Earth's axis always tilts in the same direction—toward the North Star—during Earth's orbit around the Sun. Then the teacher prepares students to demonstrate this idea using their Earth-Sun model. **Main science idea(s):** • As Earth travels around the Sun in a nearly circular orbit, its axis always tilts in the same direction—toward the North Star. Earth's consistent tilt causes the Northern Hemisphere to lean *toward* the Sun at certain times of the year—specifically during June, July, and August—and *away* from the Sun at other times of the year—during the months of December, January, and February. This means that when the Northern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Southern Hemisphere experiences winter. Conversely, when the Southern Hemisphere leans toward the Sun,	Make explicit links between science ideas and activities **before** the activity.	*consistent tilt toward the North Star as you discuss this idea with students.* **Show slide 4.** We need to add one more key science idea to our Earth-Sun model to make it more accurate. Most of you know that when Earth orbits the Sun, it doesn't point straight up and down; it tilts. Look at the projected diagram of Earth orbiting the Sun. What does this diagram tell us about the tilt of Earth on its axis during its orbit around the Sun? What do you notice about the direction the axis is pointing? Right! We can see that Earth's axis always tilts in the *same* direction in different positions during its orbit. It doesn't tilt in one direction and then in another direction like it did in some of our simulations yesterday. That's really important to remember as you're modeling Earth's orbit around the Sun. To keep Earth's axis tilting in the correct direction during today's activity, we're going to add a stand to each model of Earth. The end of the stick that represents Earth's axis will go into the stand, and the stand will keep the Styrofoam ball representing Earth	Earth always tilts in the same direction in all four positions as it orbits the Sun.	

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	locations in that hemisphere experience summer, and the Northern Hemisphere experiences 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.	Select content representations and models matched to the learning goal and engage students in their use. Highlight key science ideas and focus question throughout.	constantly tilted at 23.5 degrees. In this diagram, what is Earth's axis constantly pointing toward? That's right! Earth's axis always points in the *general direction* of the North Star. I've posted an image of the North Star on the wall as a reminder to make sure your models are always pointing in the same direction during your simulations. As you move your models around the Sun, don't point Earth's axis directly at the North Star. Just hold the model steady and keep the stand parallel to the ground to maintain the 23.5-degree tilt. **NOTE TO TEACHER:** *Demonstrate how students should hold their models and keep them pointing in the general direction of the North Star as they move them around the Sun. Then distribute handout 3.1 (Earth's Orbit around the Sun) and explain that during the activity, students will record on this diagram the seasons each hemisphere experiences as Earth orbits the Sun.* For today's activity, you'll be working with the same small groups from yesterday. You'll simulate Earth's orbit around the Sun again, but this time, you'll record on your handouts which season each hemisphere is experiencing at each of the four positions during Earth's orbit. After the activity, be prepared to share	The North Star.	

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			your best ideas for answering our focus question: *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere?* Here's a hint: It has something to do with Earth's tilt and orbit around the Sun, but what?		
10 min	**Activity** **Synopsis:** In small groups, students model Earth's consistent tilt in the same direction as it orbits the Sun. Then they determine which seasons occur in each orbital position and record their ideas on a diagram of the Earth-Sun model. **Main science idea(s):** • As Earth travels around the Sun in a nearly circular orbit, its axis always tilts in the same direction—toward the North Star. Earth's consistent tilt causes the Northern Hemisphere to lean *toward* the Sun at certain times of the year—specifically during June, July, and August—and *away* from the Sun at other times of the year—	Make explicit links between science ideas and activities **during** the activity.	**Show slide 5.** **NOTE TO TEACHER:** *Have students break up into their small groups from the previous lesson before beginning the activity. Continue projecting the image of Earth's orbit around the Sun for students to refer to while they work.* As you simulate Earth's orbit around the Sun, don't forget to keep your models pointing in the general direction of the North Star at all times. If you hold your model so it tilts consistently toward the star on the wall with the base of the stand parallel to the ground, you'll stay on track. At each position in Earth's orbit, record on your handouts which season the Northern Hemisphere and the Southern Hemisphere are experiencing. To figure this out, you'll need to determine Earth's tilt and position in relation to the Sun. For example, which hemisphere is leaning toward or away from the Sun? **NOTE TO TEACHER:** *Circulate among*		

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	during the months of December, January, and February. This means that when the Northern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Southern Hemisphere experiences winter. Conversely, when the Southern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Northern Hemisphere experiences 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.		*the groups, asking questions about Earth's tilt and why the hemispheres experience different seasons when Earth is in different positions. Help students orient Earth's axis toward the North Star so the direction of the tilt remains consistent by keeping the base of stand parallel with the ground. Ask students to describe which hemisphere is tilted toward or away from the Sun in each orbital position and explain why this causes various places on Earth to experience different seasons.* *Students might have difficulty with positions 2 and 4 because Earth isn't tilted toward or away from the Sun at those times. Listen to students' ideas about why these positions might result in spring and fall rather than summer or winter.*		
10 min	**Follow-Up to Activity** **Synopsis:** Students explain how Earth's consistent tilt affects seasons in the Northern and Southern Hemispheres. **Main science idea(s):**	Engage students	**NOTE TO TEACHER:** *Continue displaying the image of Earth's orbit around the Sun (handout 3.1) during this discussion.* **Show slide 6.** Let's look again at the diagram of Earth's		

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	• As Earth travels around the Sun in a nearly circular orbit, its axis always tilts in the same direction—toward the North Star. Earth's consistent tilt causes the Northern Hemisphere to lean *toward* the Sun at certain times of the year—specifically during June, July, and August—and *away* from the Sun at other times of the year—during the months of December, January, and February. This means that when the Northern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Southern Hemisphere experiences winter. Conversely, when the Southern Hemisphere leans toward the Sun, locations in that hemisphere experience summer, and the Northern Hemisphere experiences winter. (Note that the seasonal variations we call *summer* and *winter* don't occur at latitudes closest to the equator.) Spring	in constructing explanations and arguments. Make explicit links between science ideas and activities **after** the activity.	orbit around the Sun and talk about which seasons you assigned to each of the four positions. **NOTE TO TEACHER:** *As you guide students through all four positions of Earth's orbit, ask them which season might be represented in each position and why. Also ask which months of the year are represented along Earth's orbital path.* First, let's look at position 1. What part of Earth received more sunlight in this position? What season would it be in the Northern Hemisphere? What about in the Southern Hemisphere? As Earth moves between positions 1 and 2, what months of the year would it be? **Show slide 7.** Now let's answer the same questions for position 3.	The Northern Hemisphere got more sunlight in position 1. Since the Northern Hemisphere got more sun in position 1, it would be summer there. The Southern Hemisphere got less sunlight in position 1, so it would be winter there. It would be June or July, I think.	Does anyone agree or disagree? What is your evidence?

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	and fall occur when the hemispheres lean neither toward nor away from the Sun along Earth's orbit.		**Show slide 8.** What seasons do positions 2 and 4 represent? How would you describe Earth's tilt in these positions relative to the Sun? In these positions, do you think both hemispheres would receive the same amount of sunlight or different amounts? Why? **NOTE TO TEACHER:** *As students analyze their data, make sure they understand why Earth's consistent tilt and orientation toward the North Star during its revolution around the Sun are key science ideas that explain the cause of seasons on Earth.* **Show slide 9.** Based on our Earth-Sun model, would you say that Earth is closer to the Sun when it's summer in the United States? Why or why not?	They must represent spring and fall, but I don't understand why. Earth isn't tilted toward or away from the Sun. It's beside the Sun somehow. I think they'd receive different amounts of sunlight. Isn't it warmer in the spring than in the fall? No, the distance between Earth and the Sun stayed the same in all of the	Say more about your ideas. Can anyone add to this idea? What makes you think that? What is your evidence from our Earth-Sun model?

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				positions, but one hemisphere does lean closer to the Sun in positions 1 and 3.	
			Is Earth closer to the Sun when it's summer in Argentina? Why or why not?	Doesn't the Southern Hemisphere move closer to the Sun in that position?	
			If Earth isn't closer to the Sun in the summer, why do we have warmer temperatures?	It's because of Earth's tilt!	Tell me more about what Earth's tilt has to do with summer and winter.
		Highlight key science ideas and focus question throughout.	In many book illustrations, Earth's orbit around the Sun looks like an oval, but it's really more circular—as in our model. So even though Earth is slightly closer to the Sun at certain points during its orbit, that doesn't mean we experience summer. And when Earth is slightly farther away from the Sun in its orbit, that doesn't mean we experience winter. Seasons on Earth aren't caused by slight changes in distance from the Sun. They're caused by Earth's tilt! We'll talk more about these science ideas in the next two lessons.		
10 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher		**NOTE TO TEACHER:** *Continue displaying the image of Earth's orbit around the Sun and refer to it as you*		

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	summarizes key science ideas from the lesson. Students revise their initial answers to the focus question. **Main science idea(s):** • As Earth orbits the Sun, its axis always tilts in the same direction—toward the North Star—causing different parts of the planet to receive varying amounts of sunlight at different times of the year. Consequently, Earth's consistent tilt produces opposite seasons in the Northern and Southern Hemispheres.	Summarize key science ideas. Engage students in making connections by synthesizing and summarizing key science ideas.	*summarize the patterns students observed.* **Show slide 10.** Let's summarize the patterns we observed in Earth's orbit during our activity: 1. Earth *always* tilts in the *same direction*—toward the North Star. *[Highlight this in each position on the projected diagram of Earth's orbit around the Sun.]* 2. Earth's Northern Hemisphere points *toward* the Sun (position 1) at certain times and points *away* from the Sun (position 3) at other times. 3. When the Northern Hemisphere points toward the Sun, the Southern Hemisphere points away from the Sun (position 1). 4. When Earth is in *position 1*, it's summer in the Northern Hemisphere and winter in the Southern Hemisphere. 5. When Earth is in *position 3*, it's summer in the Southern Hemisphere and winter in the Northern Hemisphere. Who can summarize a few other patterns you noticed?	In positions 2 and 4, it isn't summer or winter in the north or the south. It's fall or spring.	Tell me more about where Earth receives more sunlight in those

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				The seasons are opposite in positions 1 and 3.	positions. What do you mean by "opposite"?
		Highlight key science ideas and focus question throughout.	**Show slide 11.** Now let's return to our focus question, *Why is it summer in the United States (the Northern Hemisphere) when it's winter in Argentina (the Southern Hemisphere)?* Look at your initial ideas for answering this question in your science notebooks. Do you still agree with these ideas? Have your ideas changed since our last lesson? Do you want to make any changes or add any new ideas to your answer? Take a minute or two and write a revised answer for the focus question in your notebooks, making sure to include any new ideas and evidence from the Earth-Sun model.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher links science ideas about latitude, Earth's consistent tilt, and the angle of sunlight to the next lesson.	Link science ideas to other science ideas.	**Show slide 12.** Today we discovered that Earth's tilt and position as it orbits the Sun explain why it's summer in the United States when it's winter in Argentina. Tomorrow we'll investigate what Earth's *consistent tilt* and the *angle of sunlight* at different latitudes have to do with the *amount* of sunlight the Northern and Southern Hemispheres receive at different		

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			times of the year. **NOTE TO TEACHER:** *Students will use their Earth-Sun models again in the next lesson, so keep them handy.*		