The Sun's Effect on Climate
Lesson 4a: Earth's Tilt and Seasons

Grade 6	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 4a 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 warmer in the summer than in the winter?
Main learning goal: Earth's consistent tilt and the angle at which sunlight strikes the surface at different times of the year cause the Northern and Southern Hemispheres to experience varying intensities of sunlight and, as a result, opposite periods of warmer and cooler temperatures (seasons).		
Science content storyline: Because of Earth's tilt, the Sun at the equator isn't directly overhead (at a perpendicular angle) at midday all year long. In fact, this happens only twice a year—March 21 and September 21—during the solar equinoxes. On June 21, the Sun is directly overhead at midday at 23.5° N latitude—the Tropic of Cancer—and on December 21, the Sun is directly overhead at midday at 23.5° S latitude—the Tropic of Capricorn. The latitude (in degrees) north and south of the equator is the same as the angle (in degrees) of Earth's tilt. This change in the angle of sunlight over time means that an entire hemisphere receives more direct sunlight at certain times of the year, specifically during the summer months. So the Sun's energy is more concentrated (intense) in the Northern Hemisphere from June through August, and that hemisphere experiences warmer temperatures (summer). Conversely, the Sun's energy is more concentrated (intense) in the Southern Hemisphere from December through February, and that hemisphere experiences warmer temperatures (summer). When the Northern Hemisphere leans away from the Sun, the sunlight is more spread out, resulting in cooler temperatures (winter). The same thing happens when the Southern Hemisphere leans away from the Sun. Thus, the angle of sunlight related to Earth's tilt is one critical factor in determining temperatures and seasons around the globe.		
Ideal student response to the focus question: It's warmer in summer than in the winter because of Earth's tilt. When the Northern Hemisphere tilts toward the Sun, the entire hemisphere receives more direct sunlight, temperatures warm up, and that hemisphere experiences summer. As Earth orbits the Sun during the year, the tilt keeps pointing the same direction (toward the North Star), so during the winter months, the Northern Hemisphere points away from the Sun, and the Sun's radiation hits that hemisphere at less direct angles. This means the Sun's energy is more spread out in the winter, keeping temperatures cooler. The opposite happens in the Southern Hemisphere when it tilts either toward or away from the Sun.		

Preparation

Materials Needed • Science notebooks • Content representations, handouts, models, and diagrams from lessons 1–3 (for review) • Class data chart (Number of Lighted Squares) (from lesson 2a) **Student Handouts** • 4.1 The Angle of Sunlight and Seasons on Earth (pages 1–2 only) (1 per student) • 4.2 The Sun's Incoming Energy with Tilt—Position 1 (1 per student) • 4.3 The Sun's Incoming Energy with Tilt—Position 3 (1 per student) • 4.4 Data Table—Number of Sun's Incoming Rays by Season at Different Latitudes (1 per student)	**Ahead of Time** • Review sections 6 and 7 (Earth's Tilt, and Putting It All Together) in the SEC content background document. • Set up the class data chart (Number of Lighted Squares) from lesson 2a showing the number of squares students counted on their graph-paper cutouts. This will be reviewed at the beginning of the lesson.

Lesson 4a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lessons:** The class reviews key science ideas from previous lessons.	• Temperatures are warmer closer to the equator and cooler farther from the equator partly because the intensity of sunlight varies along Earth's curved surface.
4 min	**Lesson focus question:** The teacher introduces the focus question, *Why is it warmer in the summer than in the winter?* and asks students to write down their initial ideas.	
10 min	**Setup for activity:** The teacher links science ideas from previous lessons to today's activity.	• Earth's 23.5-degree tilt and the resulting angles of sunlight striking Earth's surface at different latitudes cause temperature variations around the globe.
15 min	**Activity:** Using a model of Earth, students work in small groups to explore the relationship between Earth's tilt and the angle of the Sun's incoming rays.	• Because of Earth's consistent tilt and the resulting angles of sunlight striking Earth at different latitudes, an entire hemisphere receives more direct sunlight at certain times of the year, specifically during the summer months. From June through August, the Sun's light energy (solar radiation) is more concentrated (intense) in the Northern Hemisphere, causing that hemisphere to warm up and experience summer. Conversely, from December through February, the solar radiation is more concentrated (intense) in the Southern Hemisphere, causing that hemisphere to warm up and experience summer.
5 min	**Follow-up to activity:** In their small groups, students use the data they collected and recorded on their data tables to develop a preliminary answer to the focus question.	• It's warmer in summer than in the winter because of Earth's consistent tilt. When the North Pole tilts toward the Sun (position 1 in Earth's orbit), the entire Northern Hemisphere receives more direct sunlight (solar radiation), and that hemisphere experiences warmer temperatures (summer). Conversely, when the South Pole tilts toward the Sun (position 3), the Southern Hemisphere receives more direct sunlight (solar radiation), and that hemisphere experiences warmer temperatures (summer).
5 min	**Synthesize/summarize today's lesson:** The teacher summarizes key science ideas from previous lessons that have helped students develop their understandings of what causes seasons on Earth.	• Temperatures vary by latitude, with locations closer to the equator experiencing warmer temperatures, and locations closer to the poles experiencing cooler temperatures. • Earth's curved surface causes sunlight to strike Earth at an angle above and below the equator. This means that sunlight is less intense or concentrated farther away from the equator, and Earth's surface doesn't warm up as much. • Earth's axis always tilts toward the North Star. This consistent tilt produces opposite seasons in the Northern and Southern Hemispheres. When it's summer in the Northern Hemisphere, it's winter in the Southern Hemisphere, and vice versa.
1 min	**Link to next lesson:** The teacher announces that in the next lesson, students will use the data from their data tables to explain why it's warmer in the summer than in the winter.	

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5 min	**Link to Previous Lessons** **Synopsis:** The class reviews key science ideas from previous lessons. **Main science idea(s):** • Temperatures are warmer closer to the equator and cooler farther from the equator partly because the intensity of sunlight varies along Earth's curved surface.	Summarize key science ideas. Select content representations and models linked to the learning goal and engage students in their use. Engage students in analyzing and interpreting data and observations.	**Show slides 1 and 2.** Before we begin today's lesson, let's review what we've learned so far about the Sun's effect on climate and temperatures on Earth. **NOTE TO TEACHER:** *Display the bar graphs from lesson 1b (handouts 1.4 and 1.5, Bar Graph of January Temperatures and Bar Graph of July Temperatures). Then highlight the graph-paper cutouts from lesson 2a (handout 2.1) and review the data from handout 2.3 (The Sun's Incoming Energy). Also have the Earth-Sun model from lesson 3 available for reference and display the diagram of Earth's orbit around the Sun (handout 3.1).* Remember the bar graphs from **lesson 1** showing temperature data for the Northern and Southern Hemispheres in January and July? What did we learn from these graphs about temperatures around the world? What temperature patterns did we observe? In **lesson 2**, we explored how light energy hits a surface at different angles. How does the angle of sunlight affect temperatures on Earth? What did we use to investigate this?	We learned that it's warmer closer to the equator and colder farther away. When the light hits a surface more directly,	Can you use the Earth-Sun model to show us what you mean?

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				it's hotter, and when it hits a surface at an angle, it's cooler. We shined a flashlight at a tray straight on and at an angle.	
			What did we use to investigate the angle of sunlight hitting Earth's curved surface?		Show me what you mean by "at an angle." What was at an angle?
				We used a globe and a flashlight. We also used a diagram showing the Sun's rays hitting Earth, and we counted the lines.	
			`		What did we learn by counting the rays of sunlight hitting Earth's surface?
			In **lesson 3**, how did our Earth-Sun model and simulation of Earth's orbit around the Sun help us understand seasons?		
				We learned that seasons are opposite in the Southern Hemisphere.	What do you mean by "opposite"?
				Earth's tilt means we have seasons.	Tell me more about Earth's tilt.
			Today we'll continue our investigation of Earth's orbit around the Sun and how the angle of sunlight hitting Earth's curved surface affects temperatures		Do you agree with this idea?

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			and seasons.		
4 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *Why is it warmer in the summer than in the winter?* and asks students to write down their initial ideas.	Set the purpose with a focus question or goal statement.	**Show slide 3.** Today's focus question is *Why is it warmer in the summer than in the winter?* Copy this question into your science notebooks and draw a box around it. Then jot down some initial ideas for answering the focus question. Use the science ideas you've learned about so far and make sure to explain your thinking. We'll share these ideas at the beginning of the next lesson. **NOTE TO TEACHER:** *Post the focus question where students can easily refer to it throughout the lesson.* **ELL support:** Have ELL students engage in a Think-Pair-Share activity so they can discuss their ideas and answers with a partner.		
10 min	**Setup for Activity** **Synopsis:** The teacher links science ideas from previous lessons to today's activity. **Main science idea(s):** • Earth's 23.5-degree tilt and the resulting angles of sunlight striking Earth's surface at different latitudes cause temperature variations	Make explicit links between science ideas and activities **before** the activity.	**Show slide 4.** Yesterday we explored Earth's orbit around the Sun using a diagram that showed Earth in four different orbital positions. What did each of these positions look like? Let's have one small group demonstrate these positions using your Earth-Sun model. **NOTE TO TEACHER:** *Ask one of the small groups from the previous lesson to demonstrate the four positions of Earth's orbit using their Earth-Sun model from lesson 3. Display a copy of*		

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	around the globe.		*handout 3.1 (Earth's Orbit around the Sun) on a document reader or projector for students to refer to during this discussion.* Do you agree or disagree with this model of Earth's orbit? Why? What would you add or change to make this simulation more scientifically accurate? Make sure to communicate your ideas in scientific ways. **Show slide 5.** **NOTE TO TEACHER:** *Display handout 2.2 (The Sun's Incoming Energy—Angle Related to Latitude) on a document reader or projector so students can refer to it during the following discussion.* Now let's take a quick look at the diagram from lesson 2 showing the Sun's incoming energy hitting Earth's surface at different angles based on latitude. What's different about the position of Earth in this diagram compared with our Earth-Sun model from yesterday's lesson? **NOTE TO TEACHER:** *Hold up one of the Earth-Sun models for students to compare with the projected diagram (handout 2.2).* Great observation! Yes, in our Earth-Sun model, Earth is tilted at 23.5 degrees, which is the actual position of Earth when it orbits the Sun. **Show slide 6.**	Earth is tilted in our model, but it isn't tilted in the diagram from lesson 2.	

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		Ask questions to elicit student ideas and predictions.	Today we're going to build on what we've learned by investigating whether Earth's tilt changes the angle of sunlight striking Earth's surface at different latitudes. What do you predict? Do you think the tilt of Earth on its axis will change whether sunlight will strike Earth's surface more directly or at an angle? When you share your predictions, try using the sentence starter on the slide: I predict that Earth's tilt [will change/will not change] whether sunlight will strike Earth's surface more directly or at an angle. My evidence is _____. **NOTE TO TEACHER:** *After students share their predictions, have them gather in their small groups from last time and set up their Earth-Sun models.*	I predict that Earth's tilt won't change whether sunlight will strike Earth's surface more directly or at an angle. Because the Sun always shines straight on at the equator. I think the light will hit Earth more sideways. The light is always at an angle at the North Pole because it's so cold, so I don't think Earth's tilt will make a difference.	Tell me why you think so. What do you mean by "sideways"? Does anyone disagree with this prediction? Why? What do you mean

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				I think the light will be more concentrated in the summer and more spread out in the winter.	by "at an angle"? How is cold related to the angle of light? Say more about the light in the summer and winter. Do you think this will happen only in the Northern Hemisphere?
15 min	**Activity** **Synopsis:** Using a model of Earth, students work in small groups to explore the relationship between Earth's tilt and the angle of the Sun's incoming rays. **Main science idea(s):** • Because of Earth's consistent tilt and the resulting angles of sunlight striking Earth at different latitudes, an entire hemisphere receives more direct sunlight at certain times of the year, specifically during the summer	Engage students in using and applying new science ideas in a variety of ways and contexts.	Before we begin today's activity, let's go over the directions together. **NOTE TO TEACHER:** *Distribute pages 1 and 2 of handout 4.1 (The Angle of Sunlight and Seasons on Earth), as well as handout 4.4 (Data Table—Number of Sun's Incoming Rays by Season at Different Latitudes). (**Note:** Students will complete page 3 of handout 4.1 in the next lesson.)* **Show slide 7.** Will someone please read aloud the Purpose section on handout 4.1, The Angle of Sunlight and Seasons on Earth? **Show slide 8.** Now will someone please read the Task section aloud?		

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	months. From June through August, the Sun's light energy (solar radiation) is more concentrated (intense) in the Northern Hemisphere, causing that hemisphere to warm up and experience summer. Conversely, from December through February, the solar radiation is more concentrated (intense) in the Southern Hemisphere, causing that hemisphere to warm up and experience summer.		As you work on this activity in your groups, you'll need to pay attention to a number of things. What are some of those things? Right! You'll need to observe the angle of sunlight, the time of year, and Earth's orbit and tilt. **Show slide 9.** Next, let's look at the data table in handout 4.4. What are you going to record on this table? Do you remember counting the lines on the diagram of Earth in lesson 2? What did the lines represent? What were you actually counting? That's right. The lines represented the Sun's incoming rays, but in that diagram, Earth wasn't tilted, was it? Today you'll use the data your group collects to find out whether Earth's tilt changes the angle of	The angle of sunlight. The time of year. Earth's orbit. The tilt of Earth on its axis. We're going to record the number of Sun's incoming rays at different latitudes during different seasons. The lines were the Sun's rays hitting Earth at different latitudes.	

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			sunlight hitting Earth's surface at different latitudes. The results might surprise you! **Show slide 10.** As your group begins the activity, make sure you follow the directions on handout 4.1 (The Angle of Sunlight and Seasons on Earth). As you count the lines of radiation at different latitudes, each of you should record this data on your own data tables. I'll distribute other handouts when your group is ready for them. **NOTE TO TEACHER:** *Distribute handouts 4.2 and 4.3 (The Sun's Incoming Energy with Tilt for positions 1 and 3) when groups are ready for them. If necessary, help them complete their data tables.*		
5 min	**Follow-Up to Activity** **Synopsis:** In their small groups, students use the data they collected and recorded on their data tables to develop a preliminary answer to the focus question. **Main science idea(s):** • It's warmer in summer than in the winter because of Earth's consistent tilt. When the North Pole tilts toward the Sun (position 1 in Earth's orbit), the entire	Engage students in analyzing and interpreting data and observations. Highlight key science ideas and focus question throughout.	**Show slide 11.** Now look at the data you recorded on your data tables showing the number of the Sun's incoming rays at different latitudes by season. Using the data and what you've learned in previous lessons, work together in your small groups to develop an answer to our focus question, *Why is it warmer in the summer than in the winter?* Then write this answer in your science notebooks. You'll have an opportunity to share your ideas at the beginning of our next lesson.		

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	Northern Hemisphere receives more direct sunlight (solar radiation), and that hemisphere experiences warmer temperatures (summer). Conversely, when the South Pole tilts toward the Sun (position 3), the Southern Hemisphere receives more direct sunlight (solar radiation), and that hemisphere experiences warmer temperatures (summer).				
5 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher summarizes key science ideas from previous lessons that have helped students develop their understandings of what causes seasons on Earth. **Main science idea(s):** • Temperatures vary by latitude, with locations closer to the equator experiencing warmer temperatures, and locations closer to the	Summarize key science ideas.	Let's briefly review some of the science ideas we've learned about so far in this unit. **Show slide 12.** In **lesson 1**, we learned that temperatures vary by latitude. In general, it's warmer closer to the equator and cooler farther away from the equator. What was our evidence for this? **Show slide 13.** In **lesson 2**, we learned that Earth's curved surface causes sunlight to strike Earth at an angle above	The temperature data from the bar graphs that we put on our world maps.	

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	poles experiencing cooler temperatures. • Earth's curved surface causes sunlight to strike Earth at an angle above and below the equator. This means that sunlight is less intense or concentrated farther away from the equator, and Earth's surface doesn't warm up as much. • Earth's axis always tilts toward the North Star. This consistent tilt produces opposite seasons in the Northern and Southern Hemispheres. When it's summer in the Northern Hemisphere, it's winter in the Southern Hemisphere, and vice versa.		and below the equator. When sunlight hits Earth more directly, the light energy (or solar radiation) is more concentrated and intense, and Earth's surface will warm up more. When sunlight hits the surface at an angle, the light energy is more spread out and less intense, and the surface doesn't warm up as much. What was our evidence for this? **Show slide 14.** In **lesson 3**, we learned that the tilt of Earth's axis always points in one direction—toward the North Star. This consistent tilt produces opposite seasons in the Northern and Southern Hemispheres. When it's summer in the Northern Hemisphere, it's winter in the Southern Hemisphere, and vice versa. What was our evidence for this?	We used a flashlight and graph paper on a tray to find out where the light was concentrated and where it was spread out. With a globe, we saw that the light hit the curved surface of Earth at an angle, not straight on. We used a model of Earth's orbit around the Sun to help us figure out why we	

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			That's some great thinking! In our next lesson, we'll add to these science ideas as we learn more about how Earth's tilt affects the amount of sunlight hitting the surface at different latitudes.	have different seasons in the Northern and Southern Hemispheres. The diagram of the four positions helped us see where sunlight was shining during Earth's orbit around the Sun. We used the image of the North Star on the wall to help us keep the tilt of Earth's axis pointing in the same direction during Earth's orbit.	
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the next lesson, students will use the data from their data tables to explain why it's warmer in the summer		**Show slide 15.** Next time we'll share our initial ideas for answering the focus question and analyze our data to figure out why it's warmer in the summer than in the winter. Do you think Earth's tilt has anything to do with it?		

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	than in the winter.				