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

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| **Grade 6** | **Length of lesson:** 40 minutes | **Placement of lesson in unit:** 4b 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 Earth 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
- Chart paper and markers
- The Earth-Sun model from lesson 3 (1 setup to use as needed)

**Student Handouts and Teacher Masters**
- 2.3 The Sun's Incoming Energy (from lesson 2b)
- 4.1 The Angle of Sunlight and Seasons on Earth (from lesson 4a; page 3 only) (1 per student)
- 4.2 The Sun's Incoming Energy with Tilt—Position 1 (from lesson 4a)
- 4.3 The Sun's Incoming Energy with Tilt—Position 3 (from lesson 4a)
- 4.4 Data Table—Number of Sun's Incoming Rays by Season at Different Latitudes (from lesson 4a)
- 4.5 The Sun's Incoming Energy—Angle Related to Latitude at Position 1 (Teacher Master) (for display; see Ahead of Time)
- 4.6 The Sun's Incoming Energy—Angle Related to Latitude at Position 3 (Teacher Master) (for display; see Ahead of Time)

**Ahead of Time**
- Review sections 6 and 7 (Earth's Tilt, and Putting It All Together) in the SEC content background document.
- Prepare a large class chart for recording group data from handout 4.4 (Data Table—Number of Sun's Incoming Rays by Seasons at Different Latitudes). Alternatively, you could record the data on a transparency or Smart Board.
- Prepare handouts 4.5 and 4.6 for display on a document reader or Smart Board.

**Lesson 4b General Outline**

| Time | Phase of Lesson | How the Science Content Storyline Develops |
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| 5 min | **Link to previous lesson:** Students share their current ideas about what causes seasons on Earth. | • Temperatures are warmer in the summer and cooler in the winter because Earth's consistent tilt causes variations in the intensity of sunlight in the Northern and Southern Hemispheres as Earth orbits the Sun. |
| 3 min | **Lesson focus question:** The teacher introduces the focus question, *Why is it warmer in the summer than in the winter?* | |
| 5 min | **Setup for activity:** Students gather in small groups to discuss differences among various content representations of Earth. | • 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. |
| 10 min | **Activity:** Students work in small groups to compare their data from the previous lesson on the Sun's incoming energy at different latitudes with their data from lesson 2b, and then they answer discussion questions. | • Because of Earth's consistent tilt and the angle 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 energy is more concentrated (intense) in the Northern Hemisphere, causing that hemisphere to warm up and experience summer. Conversely, from December through February, the Sun's energy is more concentrated (intense) in the Southern Hemisphere, causing that hemisphere to warm up and experience summer. |
| 10 min | **Follow-up to activity:** Students analyze how Earth's consistent tilt and the angle of sunlight striking Earth at different latitudes affects temperatures at different times of the year. | • Because of Earth's consistent tilt, the Sun at the equator isn't directly overhead (at a perpendicular angle) at midday all year long. 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. When the Northern Hemisphere tilts toward the Sun, the sunlight is more concentrated (intense), and temperatures become warmer; conversely, when the Northern Hemisphere tilts away from the Sun, the sunlight is more spread out, and temperatures become cooler. The same thing happens in the Southern Hemisphere when the South Pole tilts either toward or away from the Sun. Thus, the angle of sunlight related to Earth's tilt is one critical factor in determining temperatures around the globe. |
| 6 min | **Synthesize/Summarize today's lesson:** Using science ideas about latitude and the angle of sunlight, students revise their answers to the focus question. The teacher summarizes science ideas from the lesson. | • Earth's consistent tilt and the angle at which sunlight strikes Earth 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). |
| 1 min | **Link to next lesson:** The teacher reviews what students have learned so far about temperature and seasons on Earth and announces that next time, they'll examine other factors that influence temperatures on Earth. | |

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| 5 min | **Link to Previous Lesson**<br><br>**Synopsis:** Students share their current ideas about what causes seasons on Earth.<br>**Main science idea(s):**<br>• Temperatures are warmer in the summer and cooler in the winter because Earth's consistent tilt causes variations in the intensity of sunlight in the Northern and Southern Hemispheres as Earth orbits the Sun. | Highlight key science ideas and focus question throughout.<br><br>Link science ideas to other science ideas. | **Show slides 1 and 2.**<br><br>In our last lesson, you wrote down some initial ideas for answering the focus question, *Why is it warmer in the summer than in the winter?*<br><br>Let's hear some of the ideas you've come up with so far. Make sure to support your ideas with evidence.<br><br>**NOTE TO TEACHER:** *The purpose of this brief discussion is to elicit students' current understandings of what causes seasons on Earth. Listen carefully to their ideas and reasoning, noting any misconceptions that will need to be addressed during the lesson.* | It's warmer in the summer because the Earth tilts closer to the Sun. My evidence is the diagram of the four positions of Earth's orbit.<br><br>I think it's warmer in the summer because the US gets more solar radiation than in the winter. On the data table, we had nine lines of solar radiation in the summer and only five in the winter. | What do you mean by "tilts closer to the Sun"? Is Earth closer to the Sun at any place in its orbit? Let's look at the four positions again.<br><br>Tell us more about more and less solar radiation. |
| 3 min | **Lesson Focus Question**<br><br>**Synopsis:** The teacher reviews the focus | Set the purpose with a focus | **Show slide 3.**<br><br>Today, we'll continue investigating the same focus question, *Why is it warmer in the* | | |

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| | question, *Why is it warmer in the summer than in the winter?* | question or goal statement. | *summer than in the winter?*<br><br>To figure out the *best answer* to this question, we need to make sense of the data we collected last time about the Sun's incoming energy at different latitudes in Earth's orbit. | | |
| 5 min | **Setup for Activity**<br><br>**Synopsis:** Students gather in small groups to discuss differences among various content representations of Earth.<br>**Main science idea(s):**<br>• 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. | Make explicit links between science ideas and activities **before** the activity. | **Show slide 4.**<br><br>For this activity, you'll be working in your small groups from our last lesson, so let's form those groups now. Then take out your science notebooks, your completed handout 4.4 data table from last time, and handouts 4.2 and 4.3 showing the Sun's incoming energy with Earth's tilt in positions 1 and 3. You'll also need handout 2.3—The Sun's Incoming Energy—from lesson 2.<br><br>**NOTE TO TEACHER:** *Help students locate all the handouts they'll need for this activity: handout 4.4 (Data Table—Number of Sun's Incoming Rays by Season at Different Latitudes), handouts 4.2 (The Sun's Incoming Energy with Tilt—Position 1), 4.3 (The Sun's Incoming Energy with Tilt—Position 3), and 2.3 (The Sun's Incoming Energy).*<br><br>You won't need your Earth-Sun model for this activity, but one will be available in case you need to demonstrate your ideas during our class discussion.<br><br>OK, let's look at our data table from last time. What data did your group collect? | We counted the rays of sunlight that hit Earth in | |

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| | | | | different places.<br><br>At different latitudes. | What do you mean by "different places"? What is the scientific term for this? |
| | | | Now let's compare the diagram of the Sun's incoming energy from lesson 2 (handout 2.3) with the diagrams we used in yesterday's lesson (handouts 4.2 and 4.3).<br><br>What do you notice about Earth in these diagrams? Does Earth look different in the diagram from lesson 2 compared with the other diagrams? In what ways?<br><br>**NOTE TO TEACHER:** *Make sure students recall the relationship between Earth and the Sun in positions 1 and 3 (see handouts 4.2 and 4.3). If further clarification is needed, refer to the Earth-Sun model or the diagram showing the four positions of Earth's orbit (handout 3.1). Remind students that in lesson 2, they hadn't yet discussed Earth's orbit around the Sun or Earth's tilt.* | Earth is tilted in these pictures, but it wasn't tilted in the picture from lesson 2.<br><br>In lesson 2, the solar radiation was only on the left side of Earth. In these pictures, the Sun's energy comes in from the right side in position 1 and from the left side in position 3. | Let's look at Earth's tilt. Does the tilt change from position 1 to position 3, or is it the same?<br><br>Why does the Sun's incoming energy appear on different sides of the diagrams from yesterday's |

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| | | | **Show slide 5.**<br><br>In a moment I'll be passing out the discussion questions your group will talk about during the activity. To answer these questions, you'll need to use the data you collected yesterday on the Sun's incoming energy, as well as the data on the Sun's incoming energy that you recorded on handout 2.3 in lesson 2b.<br><br>First you'll discuss each question with your group, and then you'll write your group's answer in your science notebooks. | | lesson? |
| 10 min | **Activity**<br><br>**Synopsis:** Students work in small groups to compare their data from the previous lesson on the Sun's incoming energy at different latitudes with their data from lesson 2b, and then they answer discussion questions.<br><br>**Main science idea(s):**<br>• Because of Earth's consistent tilt and the angle of sunlight striking Earth at different latitudes, an entire hemisphere receives more direct sunlight at certain times of the year, specifically | Engage students in analyzing and interpreting data and observations.<br><br>Make explicit links between science ideas and activities **during** the activity. | Now let's see if we can make sense of our data about the Sun's incoming energy at different latitudes and times of the year.<br><br>**NOTE TO TEACHER:** *Distribute page 3 of handout 4.1 (The Angle of Sunlight and Seasons on Earth). As groups discuss the questions, circulate around the room to make sure students are using the data table from the previous lesson (handout 4.4) and referring to data from lesson 2b (handout 2.3—The Sun's Incoming Energy). Ask them to show you evidence that supports their answers to each question.*<br><br>**Show slide 6.**<br><br>I'd like each group to come up and record on a class chart the data from your data table on handout 4.4 so we can compare the results. | | |

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| | during the summer months. From June through August, the Sun's energy is more concentrated (intense) in the Northern Hemisphere, causing that hemisphere to warm up and experience summer. Conversely, from December through February, the Sun's energy is more concentrated (intense) in the Southern Hemisphere, causing that hemisphere to warm up and experience summer. | | **NOTE TO TEACHER:** *Ask one group at a time to come up and record on a class chart the data from handout 4.4 (Data Table—Number of Sun's Incoming Rays by Season at Different Latitudes) so students can see the collective results (see instructions on overview page). Alternatively, you may record the data on a transparency or Smart Board. If one group's data varies widely from the other groups' results, meet with that group separately to determine how the data was interpreted.* | | |
| 10 min | **Follow-Up to Activity**<br><br>**Synopsis:** Students analyze how Earth's consistent tilt and the angle of sunlight striking Earth at different latitudes affects temperatures at different times of the year.<br>**Main science idea(s):**<br>• Because of Earth's consistent tilt, the Sun at the equator isn't directly overhead (at a perpendicular angle) at midday all year long. | Engage students in constructing explanations and arguments.<br><br>Make explicit links between science ideas and activities **after** the activity. | **Show slide 7.**<br><br>Let's examine the data on our class chart showing the amount of solar radiation hitting Earth's surface at different angles and latitudes.<br><br>Do you notice any difference between the number of lines you counted near the equator and closer to the poles?<br><br>**NOTE TO TEACHER:** *Because the difference is roughly 10 lines at or near the equator and between two and four lines near the poles, students might not think there would be much variation in temperatures.* | | |

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| | 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. When the Northern Hemisphere tilts toward the Sun, the sunlight is more concentrated (intense), and temperatures become warmer; conversely, when the Northern Hemisphere tilts away from the Sun, the sunlight is more spread out, and temperatures become cooler. The same thing happens in the Southern Hemisphere when the South Pole tilts either toward or away from the Sun. Thus, the angle of sunlight related to Earth's tilt is one critical factor in determining temperatures around | | *However, they need to connect the relative differences to the squares they counted on the graph-paper cutouts in lesson 2a. Where would the light be more concentrated or more spread out?*<br><br>Where is the Sun's light energy or solar radiation more direct or concentrated in *position 1*?<br><br>Where is the solar radiation more direct or concentrated in *position 3*?<br><br>Did the distance between the Sun and Earth ever change from *position 1 to position 3*?<br><br>**NOTE TO TEACHER:** *If students mention that the tilt caused a little bit of difference in the distance between Earth and the Sun, remind them that in our model, this distance may seem significant, but in real life, the Sun is so far from Earth that it would be like standing three or four feet from an open oven door and moving their hand just one quarter of an inch away. They wouldn't feel any difference in the amount heat with that tiny change. See the content background* | When the Northern Hemisphere was getting more Sun, the Southern Hemisphere was getting less Sun.<br><br>The Sun's light wasn't straight on at the equator in either position. It went up and down from summer to winter.<br><br>No, the distance between them stayed the same.<br><br>The tilt caused just a little bit of change in the distance between Earth and the Sun. | What do you mean by "more Sun" and "less Sun"? Use your data to help us understand your thinking.<br><br>What do you mean by "up and down"? Tell us more about that.<br><br>Say more about "a little bit of change." |

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| | the globe. | | *document for more information.*<br><br>**Show slide 8.**<br><br>So if the *distance* between Earth and the Sun doesn't affect seasons on Earth what does? What do you think makes temperatures warmer or cooler around the world at different times of the year?<br><br>  <br>*Listen to students' ideas. What's visible about student thinking?*<br><br>**Show slide 9.**<br><br>Let's look again at the data from our data table in handout 4.4 and the data from handout 2.3 in lesson 2 that showed sunlight hitting Earth at different latitudes. Remember that in lesson 2, Earth wasn't tilted on its axis in the diagram. | I think Earth tilts toward the Sun in the summer and away from the Sun in the winter in both the Northern and Southern Hemispheres.<br><br>In lesson 2, the light was straight on at the equator. There were 10 lines of light near the equator when Earth had no tilt, but only eight lines when Earth was tilted. | Does the tilt change where the light is straight on or at an angle? Do you think that matters?<br><br>What are you saying about the tilt and the difference in the amount of light? |

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| | | | When you compare the number of lines of solar radiation hitting Earth at the latitudes listed on this slide, what do you notice? What do the data from the handouts tell you? Is the number of lines the same when Earth is tilted and when it isn't?<br><br>• 0–15° N latitude<br>• 0–15° S latitude<br>• 45–60° N latitude<br>• 45–60° S latitude<br><br>So if the number of lines isn't the same at these latitudes when Earth is tilted and when it isn't, what does that tell you about the intensity of sunlight hitting a tilted and untilted Earth?<br><br>**NOTE TO TEACHER:** *After this discussion, display teacher masters 4.5 and 4.6 (The Sun's Incoming Energy—Angle Related to Latitude at Position 1 and The Sun's Incoming Energy—Angle Related to Latitude at Position 3) to help students visualize how Earth's tilt affects the angle at which solar radiation strikes Earth's surface during different seasons. Relate these content representations to the teacher master from lesson 2a that showed Earth with no tilt (handout 2.2, The Sun's Incoming Energy—Angle Related to Latitude).*<br><br>**Show slide 10.**<br><br>Look at this diagram of solar radiation hitting Earth at different latitudes when Earth's orbit around the Sun is in *position 1*. | The number of lines hitting Earth isn't the same. | |

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| | | | What do you notice about the angle of sunlight in relation to Earth's tilt?<br><br>**Show slide 11.**<br><br>Now look at this diagram of solar radiation hitting Earth at different latitudes when Earth is in *position 3* of its orbit.<br><br>What do you notice about the angle of sunlight in relation to Earth's tilt?<br><br>**NOTE TO TEACHER:** *You might point out that the Sun's rays are more direct at the Tropic of Cancer in position 1 when the Northern Hemisphere experiences summer, and more direct at the Tropic of Capricorn in position 3 when the Southern Hemisphere experiences summer. A common misconception is that the equator receives direct sunlight all year long, but with a tilted Earth, that isn't the case.*<br><br>*It's also important to remind students that in real life, we can't actually count individual rays of sunlight. Models simply help us understand how solar radiation is more concentrated in some areas and less concentrated in other areas.* | | |
| 6 min | **Synthesize/Summarize Today's Lesson**<br><br>**Synopsis:** Using science ideas about latitude and the angle of sunlight, | Engage students in making connections by synthesizing and | **Show slide 12.**<br><br>In lesson 2, we talked about these science ideas:<br><br>• When sunlight strikes Earth at a more | | |

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| | students revise their answers to the focus question. The teacher summarizes science ideas from the lesson.<br><br>**Main science idea(s):**<br>• Earth's consistent tilt and the angle at which sunlight strikes Earth 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). | summarizing key science ideas.<br><br>Highlight key science ideas and focus question throughout.<br><br>Summarize key science ideas. | direct angle, the light energy, or solar radiation, is more concentrated or intense, and Earth's surface gets warmer.<br>• When sunlight strikes Earth at a less direct angle moving from the equator to the poles, the light energy, or solar radiation, is less concentrated or intense, and Earth's surface doesn't warm up as much.<br><br>**Show slide 13.**<br><br>Based on today's activity, how can these science ideas help you answer today's focus question, *Why is it warmer in the summer than in the winter?*<br><br>Write a new answer to this question in your science notebooks, and make sure to support your ideas with evidence from the data table in handout 4.4.<br><br>**Show slide 14.**<br><br>As we wrap up today's lesson, let's review these important science ideas:<br><br>• The Northern Hemisphere experiences summer in June, July, and August because Earth's tilt toward the Sun causes more direct or intense light energy to hit Earth's surface at northern latitudes during these months.<br>• The Southern Hemisphere experiences summer in December, January, and | | |

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| | | | February because Earth's tilt toward the Sun causes more direct or intense light energy to hit Earth's surface at southern latitudes during these months.<br>• The angle of sunlight related to Earth's tilt is one key factor in determining seasons and temperatures around the globe. | | |
| 1 min | **Link to Next Lesson**<br><br>**Synopsis:** The teacher reviews what students have learned so far about temperatures and seasons on Earth and announces that next time, they'll examine other factors that influence temperatures on Earth. | Link science ideas to other science ideas. | **Show slide 15.**<br><br>Today we learned that as Earth orbits the Sun, the tilt of Earth's axis toward or away from the Sun causes different places to receive different amounts of solar radiation, which results in warmer and cooler temperatures at different times of the year.<br><br>In previous lessons, we explored several factors that affect temperatures and seasons on Earth, including latitude, the angle of sunlight, the consistent tilt of Earth on its axis, and Earth's orbit around the Sun affect temperatures and seasons on Earth.<br><br>What other factors might influence temperatures on Earth? Have you ever traveled to the mountains? What were the temperatures like? Or when you visit the beach in the middle of winter, is it hotter or colder than where you live?<br><br>Think about this, and we'll talk about your ideas next time. | | |