The Sun's Effect on Climate
Lesson 2b: Concentration of Solar Radiation

Grade 6	**Length of lesson:** 37 minutes	**Placement of lesson in unit:** 2b 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 are places closer to Earth's equator hotter than places farther away from the equator?
Main learning goal: 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 latitudes create uneven heating.		
Science content storyline: Light is a form of energy. On Earth, light from the Sun supplies energy to heat the planet and maintain temperatures. Earth's surface heats unevenly because sunlight (solar radiation or light energy) strikes different parts of the planet more directly or less directly depending on latitude. When light hits a surface more directly (almost straight on or perpendicular to the surface), the energy is more intense and concentrated over a smaller area. When light hits a surface at a less direct angle, the energy is more spread out and less intense. Because Earth is a sphere, sunlight hits the curved surface more directly closer to the equator and less directly closer to the poles. Solar radiation is most direct at, or close to, the equator and thus produces warmer temperatures. Farther from the equator and closer to the poles, solar radiation is less intense, and sunlight strikes Earth at less direct angles, resulting in cooler temperatures.		
Ideal student response to the focus question: At or near the equator, sunlight strikes Earth's surface more directly and is very concentrated. When the sunlight is more intense, the surface is warmer. Moving from the equator to the poles, sunlight hits Earth at a less direct angle, so the Sun's rays are more spread out and aren't as intense. Places near the poles are cooler than places near the equator because the sunlight they receive is more spread out (less concentrated), and the surface doesn't warm up as much.		

Preparation

Materials Needed
- Science notebooks
- Inflatable globe (1 per group)

Student Handouts and Teacher Masters
- 2.2 The Sun's Incoming Energy—Angle Related to Latitude (Teacher Master) (for display; see Ahead of Time)
- 2.3 The Sun's Incoming Energy (1 per student)

Ahead of Time
- Review section 5 (Earth's Shape) in the SEC content background document.
- Prepare handout 2.2 for display on a document reader or Smart Board.

Lesson 2b General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lesson:** Students review what they learned about angles of light energy in the previous lesson and how this relates to the Sun's light energy (solar radiation) and temperature patterns on Earth.	• Light is a form of energy. On Earth, light from the Sun supplies energy to heat the planet and maintain temperatures. Sunlight shines most directly near the equator, so there is more light energy, or heat, per unit area (one square on graph paper). When sunlight hits Earth at a less direct angle toward the poles, it's more spread out and doesn't supply as much light energy, or heat, per unit area.
1 min	**Lesson focus question:** The teacher reviews the focus question from the previous lesson: *Why are places closer to Earth's equator hotter than places farther away from the equator?*	
5 min	**Setup for activity:** Students examine a new content representation of the Sun's light energy (solar radiation) striking Earth's surface at various latitudes.	• Light is a form of energy. We refer to the Sun's light energy as *solar radiation*, which supplies energy to heat the planet and maintain temperatures.
10 min	**Activity:** Students count the rays of sunlight (solar radiation) striking Earth's surface at different latitudes and record their data.	• Because Earth is a sphere, sunlight hits the curved surface more directly closer to the equator and less directly closer to the poles.
5 min	**Follow-up to activity:** Students look for patterns in their data on the Sun's light energy at various latitudes.	• Solar radiation is most direct at, or close to, the equator and thus is more concentrated. Farther from the equator and closer to the poles, sunlight strikes Earth at less direct angles and is less concentrated, or more spread out. Therefore, temperatures are warmer closer to the equator and cooler as one moves toward the poles.
10 min	**Synthesize/summarize today's lesson:** Students compare data from their investigations in today's lesson and the previous lesson. Then they summarize what they learned about the angle of sunlight and temperature patterns on Earth.	• The angle of sunlight affects the heating of Earth's surface. When sunlight strikes Earth's surface at a more direct angle near the equator, the light energy (solar radiation) is more intense and concentrated, and the surface will get warmer. When sunlight strikes Earth's surface less directly moving from the equator to the poles, the light energy, or solar radiation, is less concentrated (more spread out), and the surface doesn't warm up as much.
1 min	**Link to next lesson:** The teacher links science ideas to the next lesson.	

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5 min	**Link to Previous Lesson** **Synopsis:** Students review what they learned about angles of light energy in the previous lesson and how this relates to the Sun's light energy (solar radiation) and temperature patterns on Earth. **Main science idea(s):** • Light is a form of energy. On Earth, light from the Sun supplies energy to heat the planet and maintain temperatures. Sunlight shines most directly near the equator, so there is more light energy, or heat, per unit area (one square on graph paper). When sunlight hits Earth at a less direct angle toward the poles, it's more spread out and doesn't supply as much light energy, or heat, per unit area.	Highlight key science ideas and focus question throughout.	**Show slide 1.** Let's begin today's lesson by reviewing ideas about angles of light energy from our last lesson. First, we'll use our globe-and-flashlight model to demonstrate what we've learned so far. **NOTE TO TEACHER:** *Ask a student to demonstrate how the angle of sunlight changes along Earth's curved surface as the light strikes the equator and places closer to the poles.* **Show slide 2.** Think about this important science idea: Sunlight shines more directly at the equator and is more spread out moving toward the poles. That's why temperatures are warmer closer to the equator and cooler closer to the poles. What evidence from yesterday's investigations can we use to explain this science idea? Think about the data from our tray-and-flashlight activity showing the number of squares on the graph-paper cutouts that were in the lighted area. Also consider what we learned about angles of light energy from the globe model.	With the tray, we learned that when the light shines at an angle, it's more spread out.	Is the light energy more or less concentrated when it shines at an angle?

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				It's less concentrated. The lighted area on the graph-paper cutout was bigger, so each square got less light. With the globe, the light was more concentrated at the equator because the angle more direct. With the tray, there were fewer lighted squares when the sunlight hit the flat surface directly, so each square got more light energy. That means it's warmer at the equator.	What is your evidence? Who can add to this idea? Say more about concentrated light at the equator.
			Thank you for bringing up the idea of energy. It's important to remember that the Sun's light energy, which is called *solar radiation*, heats the surface of Earth. From our investigations in the last lesson, where is solar radiation more concentrated		

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			on Earth's surface? Where is it less concentrated? Today we'll use a new content representation that will help us gather more data as we continue thinking about how the Sun's energy affects temperatures closer to the equator and farther away.	It's more concentrated at the equator. It's less concentrated at the poles.	
1 min	**Lesson Focus Question** **Synopsis:** The teacher reviews the focus question from the previous lesson: *Why are places closer to Earth's equator hotter than places farther away from the equator?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Our focus question for this lesson is the same as the last lesson: *Why are places closer to Earth's equator hotter than places farther away from the equator?* To help us answer this question, we're going to find out more about temperature patterns related to the angles of light energy we investigated yesterday. **NOTE TO TEACHER:** *Draw attention to the focus question posted in the room and refer to it throughout this lesson.*		
5 min	**Setup for Activity** **Synopsis:** Students examine a new content representation of the Sun's light energy (solar radiation) striking Earth's	Select content representations and models matched to the learning goal and	**Show slide 4.** Today we'll explore another way of representing how the Sun's light energy, or solar radiation, strikes Earth at different locations or latitudes.		

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	surface at various latitudes. **Main science idea(s):** • Light is a form of energy. We refer to the Sun's light energy as *solar radiation*, which supplies energy to heat the planet and maintain temperatures.	engage students in their use. Link science ideas to other science ideas.	**NOTE TO TEACHER:** *Distribute one copy of handout 2.3 (The Sun's Incoming Energy) to each pair of students.* Point to where the Sun would be in this representation. Now point to Earth. What do the lines between the Sun and Earth represent? Yes, these lines represent the Sun's light energy, or *solar radiation*, striking Earth's surface. What do you think happens when solar radiation strikes the surface of Earth? Great connection! Solar radiation supplies Earth with light energy to heat the planet and maintain temperatures so we can survive.	Rays of sunlight traveling through space toward Earth. The Sun's rays. The Sun's energy. Light rays. I think the solar energy heats up the Earth.	Does anyone agree or disagree? Do you have anything to add?

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		Highlight key science ideas and focus question throughout.	**Show slide 5.** These are important science ideas to keep in mind: • The lines in our diagram represent the Sun's rays, or light energy, hitting Earth's surface. Another term for the Sun's light energy is *solar radiation*. • Solar radiation provides Earth with light energy to heat the planet and maintain temperatures so we can survive. Remember the latitude lines on our World Map Record Page from our first lesson? You'll be using these lines during our activity. They'll come in handy as you and your partner count the number of light rays hitting Earth's surface at different latitudes. **Show slide 6.** We're also going to talk about how angles of light energy and the curved surface of Earth affect the *amount* of solar radiation (or the number of light rays) hitting different locations, or latitudes, on Earth. Understanding how and why angles of light energy at different latitudes cause		

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			temperature variations on Earth will help us answer our focus question.		
10 min	**Activity** **Synopsis:** Students count the rays of sunlight (solar radiation) striking Earth's surface at different latitudes and record their data. **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.	Select content representations and models matched to the learning goal and engage students in their use.	**Show slide 7.** Work with your partner to count the number of lines, or rays of sunlight, hitting Earth's surface at these latitudes on your handouts (The Sun's Incoming Energy): • 0–15° N • 0–15° S • 45–60° N • 45–60° S Then write the number of lines for each segment in the correct spaces at the bottom right-hand corner of the handout. But don't stop there! Count as many rays of sunlight in other latitude segments as you can in the time allowed and record that data in the space provided on your handouts. **NOTE TO TEACHER:** *Display the handout on an overhead or document reader. After pairs have completed the activity, record the class data for each segment of latitude on the projected handout. For example, record the number of lines for the segment from 0° to 15° N and so on.*		
5 min	**Follow-Up to Activity**		**Show slide 8.**		

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	Synopsis: Students look for patterns in their data on the Sun's light energy at various latitudes. **Main science idea(s):** • Solar radiation is most direct at, or close to, the equator and thus is more concentrated. Farther from the equator and closer to the poles, sunlight strikes Earth at less direct angles and is less concentrated, or more spread out. Therefore, temperatures are warmer closer to the equator and cooler as one moves toward the poles.	Engage students in analyzing and interpreting data and observations. Make explicit links between science ideas and activities **after** the activity.	Now let's see if we can find a pattern in our data that relates to our tray-and-flashlight investigation from yesterday. **NOTE TO TEACHER:** *Give students time to review their handout data and note the latitude segments with more light rays and fewer light rays. Continue displaying class data on the projected handout.* **Show slide 9.** So is it *really* possible to count the number of light rays hitting Earth's surface? Of course not! But this simplified diagram helps us see that Earth's curved shape changes the angle of sunlight hitting the surface at different latitudes. This explains why temperatures are warmer near the equator and cooler near the poles. **NOTE TO TEACHER:** *Make sure students understand that rays of sunlight can't actually be counted, but models can help them visualize how solar radiation striking Earth at different angles and latitudes causes uneven heating.* **Show slide 10.**		

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			So what patterns did you find in your data? Where on Earth is the Sun's light energy more concentrated? What is your evidence?	More rays of sunlight hit the segment of latitude closest to the equator.	Does anyone have another way of saying this? Can you think of examples in your life when something was more concentrated? Was it stronger or warmer or more intense?
			Where is the Sun's light energy more spread out? What is your evidence? STOP Listen to students' ideas. What's visible about student thinking?	As you move away from the equator, the rays of sunlight are more spread out, and each latitude segment has fewer and fewer lines. I think that the poles may be farther away from the Sun than the equator because the lines that represent the Sun's rays are longer. That's why it's colder at the poles. It takes longer for the Sun to reach them.	That's an interesting

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			Notice that in our diagram, the Sun's rays are evenly spaced. But according to our data, not as many rays strike Earth at higher latitudes as we move away from the equator toward the poles. Can anyone tell me why? Right! Fewer rays reach Earth at higher latitudes because sunlight is hitting the surface at a less direct angle. Since Earth's surface is curved, the Sun's energy is more concentrated at the equator and more spread out as we head north and south from the equator. **ELL support:** Consider discussing with ELL students why latitudes are referred to as higher or lower and how that relates to the number of degrees. What do you think these patterns have to do with *temperatures* near the equator and farther away? That's what we'll talk about next.	Because as we move away from the equator, the Sun's rays hit Earth at a less direct angle.	idea. How much farther do you think the Sun's rays have to travel to the poles? How do you think that compares with the distance from the Sun to Earth?

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10 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students compare data from their investigations in today's lesson and the previous lesson. Then they summarize what they learned about the angle of sunlight and temperature patterns on Earth. **Main science idea(s):** • The angle of sunlight affects the heating of Earth's surface. When sunlight strikes Earth's surface at a more direct angle near the equator, the light energy (solar radiation) is more intense and concentrated, and the surface will get warmer. When sunlight strikes Earth's surface less directly moving from the equator to the poles, the light energy, or solar radiation, is less concentrated (more spread out), and the surface doesn't warm up	Highlight key science ideas and focus question throughout. Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 11.** First, let's revisit today's focus question, *Why are places closer to Earth's equator hotter than places farther away from the equator?* What have we learned from our investigations yesterday and today that can help us answer this question? **Show slide 12.** **Turn and Talk:** Using the data you've gathered so far about angles of light energy, talk with your partner and come up with the *best answer* to our focus question. Look at your handouts and science notebooks to refresh your memory. Use the words on the slide to construct a scientific explanation for why it's hotter closer to the equator and cooler as you move toward the poles. **Word list:** • Angle of sunlight • Light energy/solar radiation • Equator and poles • More direct/less direct • Curved surface of Earth • More/less concentrated • Warmer and cooler		

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	as much.		• Latitude Be prepared to share your answers and explanations. **NOTE TO TEACHER:** *Make sure students understand what you mean by "using the data." Direct their attention to yesterday's data chart showing the number of lighted squares on graph-paper cutouts, and today's data showing the number of light rays hitting Earth's surface at different latitudes. You may also want to display handout 2.2 (The Sun's Incoming Energy—Angle Related to Latitude) from lesson 2a on a document reader or Smart Board throughout this activity.* **Whole-class share-out:** So why do you think it's hotter near the equator than farther away? Let's hear some of your answers to the focus question, and make sure to include evidence from our data.	It's hotter closer to the equator because more sunlight hits there. The rays of sunlight are closer together or more concentrated. The data I have to support this idea is that I	Can you say more about that? How do the Sun's rays relate to how warm it is?

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				counted more lines of sunlight closer to the equator. It's colder farther from the equator because the sunlight is more spread out, so any given spot doesn't get as much light energy. The data I have to support this idea is that the flashlight was dimmer when it hit the tray at an angle. The light energy covered a bigger space, so it was more spread out.	Is the amount of light energy different if you're above or below the equator? Where on Earth would you say was like the flashlight shining on the angled tray? If you were to put your two graph-paper cutouts on different places on the globe, where would they go based on the amount of light energy hitting them?
			Show slide 13.		

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		Summarize key science ideas.	Today we investigated the angle of sunlight striking Earth's curved surface and used the data we've gathered to explain why places closer to the equator are hotter than places farther away. We discovered that when sunlight strikes Earth's surface more directly near the equator, the light energy, or solar radiation, is more intense and concentrated, making the surface warmer. But when sunlight strikes Earth's surface at less direct angle moving toward the poles, the light energy, or solar radiation, is less concentrated, and the surface doesn't warm up as much. **Show slide 14.** Now it's your turn to summarize these science ideas *in your own words*! In your science notebooks, describe how the Sun's light energy hits Earth's surface and how this affects temperatures in different locations. Draw a picture to illustrate your ideas. **ELL support:** Allow time for ELL students to think, pair, and share before writing down what they've learned.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher	Link science ideas	**Show slide 15.** Today we learned how the angle of sunlight		

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	links science ideas to the next lesson.	to other science ideas.	hitting Earth's surface at different latitudes affects temperatures. At the equator, the Sun's rays hit Earth's surface more directly than anywhere else, so now we know why it's hotter near the equator than it is farther away! Tomorrow we'll talk about why temperatures are different in the Northern and Southern Hemispheres at the same time of year.		