The Sun's Effect on Climate
Lesson 2a: Angles of Light Energy

Grade 6	Length of lesson: 50 minutes	Placement of lesson in unit: 2a 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
- Chart paper and markers
- Inflatable globe (1 per group)
- For each pair of students:
  - 1 plastic tray (or piece of cardboard)
  - 3 sheets of graph paper
  - 1 flashlight (with a concentrated beam)
  - Ruler, scissors, tape, and pencil

Student Handouts and Teacher Masters
- 1.3 World Map Record Page (from lesson 1a)
- 1.4 Bar Graph of January Temperatures (from lesson 1b)
- 1.5 Bar Graph of July Temperatures (from lesson 1b)
- 2.1 Angles of Light Energy (1 per student)
- 2.2 The Sun's Incoming Energy—Angle Related to Latitude (Teacher Master) (for display; see Ahead of Time)

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.
- Prepare a two-column data chart to record student data following the main activity. Title the chart "Number of Lighted Squares," and use the column headings "Light Hits the Tray Straight On" and "Light Hits the Tray at an Angle" (or "Direct Angle" and "Less Direct Angle"). This chart is also shown in PowerPoint slide 8.
- *ELL support:* You may want to provide explicit context for key terms used in this lesson. Encourage ELL students to compile keyword dictionaries for future reference. Have them use keywords in a sentence or draw pictures.

Lesson 2a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
3 min	**Link to previous lesson:** Students review what they've learned so far about temperature patterns on Earth.	• Temperature patterns on Earth vary according to latitude and time of year. Temperatures are generally warmer closer to the equator and cooler toward the poles.
1 min	**Lesson focus question:** The teacher introduces the focus question, *Why are places closer to Earth's equator hotter than places farther away from the equator?*	
6 min	**Setup for activity:** The teacher sets up an activity to investigate variations in the intensity of light striking a surface at different angles. Then students predict what will happen when they shine a flashlight on a flat surface.	• Light is a form of energy. On Earth, light from the Sun supplies energy to heat the planet and maintain temperatures.
10 min	**Activity:** Students observe what happens when they shine a flashlight on a flat surface positioned at different angles (perpendicular and tilted). Then they collect and record data from their investigation.	• Earth's surface heats unevenly because sunlight (solar radiation or light energy) strikes different parts of the planet more directly or less directly. 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.
15 min	**Follow-up to activity:** Students analyze the data they collected from observing what happens when light hits a flat surface at different angles. Then they compare this model with a model of light striking the curved surface of a globe.	• 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 energy, or heat, per unit area.
10 min	**Synthesize/summarize today's lesson:** Students summarize science ideas from today's tray-and-flashlight activity and use those ideas to write a possible answer to the focus question.	• 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	**Link to next lesson:** Using bar graphs from the previous lesson, students review what they've learned so far about temperature patterns on Earth and relate science ideas to the next lesson.	

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3 min	**Link to Previous Lesson** **Synopsis:** Students review what they've learned so far about temperature patterns on Earth. **Main science idea(s):** • Temperature patterns on Earth vary by latitude and time of year. Temperatures are generally warmer closer to the equator and cooler toward the poles.	Ask questions to elicit student ideas and predictions.	**Show slides 1 and 2.** Let's begin today's lesson by reviewing what we've learned so far about temperature patterns on Earth. **ELL support:** If time permits, include a Think-Pair-Share activity during this review of ELL students' work from previous lessons. **NOTE TO TEACHER:** *For this review, display the World Map Record Page (for January or July) from lesson 1a and refer to the summary of key science ideas from lesson 1b. Invite students to look at their science notebooks and handouts from previous lessons to refresh their memories.* **NOTE TO TEACHER:** *Keep this discussion brief, taking advantage of this opportunity to reinforce the use of scientific vocabulary, including the terms* equator*,* latitude*,* Northern Hemisphere*, and* Southern Hemisphere. What have we learned so far about temperature patterns from our maps and data? If you need to refresh your memory, you can look at your science notebooks and our handouts from other lessons.	Temperatures are warmer closer to the equator and cooler farther away from the equator. Temperatures at the same latitude aren't the same everywhere in the	

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				world, even at the same time of year.	
			Let's look again at this world map from our first lesson. What do we call the lines that tell us how far a place is from the equator?	Latitude lines.	
			Yes, these lines tell us the latitude of different places around the world.		
			At higher degrees of latitude, are the temperatures usually warmer or cooler than they are at the equator? For help, look at your World Map Record Pages for January and July or the bar graphs from yesterday's lesson.	Temperatures are usually cooler, but mainly in January.	
			Does the temperature change very much from January to July at the equator, or at latitudes that are close to the equator?	No, the temperatures aren't very different.	What's your evidence?
				The temperatures on our bar graphs.	Does anyone agree or disagree with this idea?
			Does the temperature change very much from January to July at latitudes that are farther away from the equator?	Yes. In Nome, Alaska, the temperature changes by almost 50 degrees.	What's your evidence?
				The data table of average temperatures.	

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		Summarize key science ideas.	**Show slide 3.** The slide shows three key science ideas we learned about in previous lessons: 1. Temperature patterns on Earth vary according to latitude and time of year. 2. Temperatures are generally warmer closer to the equator, at lower latitudes, and cooler toward the poles, at higher latitudes. 3. Temperatures aren't the same in January or July in the Northern and Southern Hemispheres. In this lesson, we're going to investigate why temperatures are higher near the equator and lower near the poles.	And our bar graphs.	Can anyone give us another example?
1 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *Why are places closer to Earth's equator hotter than places farther away from the equator?*	Set the purpose with a <u>focus question</u> or goal statement.	**Show slide 4.** Today we'll gather more information about temperature patterns to help us answer this focus question: *Why are places closer to Earth's equator hotter than places farther away from the equator?* Write this question in your science notebooks and draw a box around it. **NOTE TO TEACHER:** *Write the focus question on the board or on chart paper so students can refer to it throughout the lessons.*		

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6 min	**Setup for Activity** **Synopsis:** The teacher sets up an activity to investigate variations in the intensity of light striking a surface at different angles. Then students predict what will happen when they shine a flashlight on a flat surface. **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.	Make explicit links between science ideas and activities **before** the activity.	**Show slide 5.** Next, we're going investigate what happens when light strikes a surface at different angles. You'll be working on this activity in pairs, using a flashlight to represent the Sun and a flat plastic tray *[or piece of cardboard]* with graph paper on it to represent Earth's surface. After the activity, we'll talk about whether this model of light striking a flat surface is similar to sunlight striking a *curved* surface, like the surface of Earth. **NOTE TO TEACHER:** *Show students the setup (flashlight, tray, and graph paper). You may substitute a piece of cardboard for the plastic tray as needed. Distribute handout 2.1 (Angles of Light Energy) and go over the directions for the activity. Invite one pair of students to demonstrate how far they should hold the flashlight from the tray (without turning on the light!) and remind them to talk about the discussion questions with their partners.* **ELL support:** As you go over the directions on the handout, make sure ELL students understand the underlying meaning of the model used for this activity, what each part of the model represents, what the circled area on the graph paper is intended to show, why students are being asked to count squares, and what the two-column chart is for and what it shows.		

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		Ask questions to elicit student ideas and predictions.	**Show slide 6.** Before we begin our activity, what do you predict will happen when you shine the flashlight directly at the tray? If you tilt the tray, do you think the image that the light projects on the graph paper will change in any way? **Turn and Talk:** Talk about these questions with an elbow partner and be prepared to share your predictions with the class. Use the sentence starter on the slide: I predict the image on the graph paper [will/won't] change because ___________. **Whole-class discussion:** So let's hear your predictions. What do you think will happen when you shine a flashlight directly at the tray? Do you think the image that the light projects on the graph paper will change if the tray is tilted?	There will be a circle of light on the graph paper. No, I don't think it will change at all. I think the light might get bigger. There might be less light.	What do you mean by "bigger"? Say more about "less light." Less light from the flashlight?

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					Why do you think there will be less light?
10 min	**Activity** **Synopsis:** Students observe what happens when they shine a flashlight on a flat surface positioned at different angles (perpendicular and tilted). Then they collect and record data from their investigation. **Main science idea(s):** • Earth's surface heats unevenly because sunlight (solar radiation or light energy) strikes different parts of the planet more directly or less directly. 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.	Select content representations and models matched to the learning goal and engage students in their use. Make explicit links between science ideas and activities **during** the activity.	**Show slide 7.** As you and your partner work on this activity, make sure to follow the directions for parts 1 and 2 on your handout. Carefully observe what happens when the light hits the surface of the tray directly and at an angle. Do you notice any change in the amount of light energy hitting the tray in these different positions? When you finish part 1, be sure to talk about the questions at the end of that section before starting part 2. After the activity, we'll record your data on a class chart. While you're working on this activity, think about the question on the slide: Does the data give you any ideas about whether the *amount* of energy from a light source is different when it strikes a surface at an angle? **NOTE TO TEACHER:** *As pairs work through the activity, encourage them to talk about their observations and ideas about what happens to the light energy when it strikes the surface at an angle versus directly (straight on). Circulate around the room, making sure students understand what they should do with the cutouts in part 2. If they seem confused, you may want to review the directions for counting the number of lighted squares on the*		

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			cutouts. **Show slide 8.** Now let's record on the class chart the number of squares you counted on each graph-paper cutout that were in the circle of light. I'd like you to come up in pairs and record your data on the chart. While you're doing this, think about whether this data gives you any ideas about whether the *amount* of energy from a light source might be different when it strikes a surface at an angle. **NOTE TO TEACHER:** *This two-column chart—Number of Lighted Squares—should be prepared ahead of time. (See the overview page.) You might also have students tape their cutouts to the chart to create a visual image that complements the numerical data.*		
15 min	**Follow-Up to Activity** **Synopsis:** Students analyze the data they collected from observing what happens when light hits a flat surface at different angles. Then they compare this model with a model of light striking the curved surface of a globe. **Main science idea(s):** • Sunlight shines most directly near the equator, so there is	Engage students in analyzing and interpreting data and observations. Make explicit links between science ideas and activities **after** the activity.	**Show slide 9.** Now let's talk about what you observed. First, when you held the tray in the two different positions, what happened to the *amount* of light energy coming from the flashlight? Did the *amount of light energy* change or stay the same? **NOTE TO TEACHER:** *Make sure students understand that the amount of light energy is the same because they used the same flashlight at the same distance from the tray. The only thing that changed was the angle of the tray.*	When we tilted the tray, the light energy was different. The light wasn't as bright on the paper when the tray was at an angle, so there's something	Explain "different."

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	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 energy, or heat, per unit area.		That's right! The *amount* of light energy coming from the flashlight didn't change even though the tray position changed. But something about the light energy *did* change when the tray was tilted at an angle. What do you think changed? What do the data tell us? **Turn and Talk:** Talk about this with your partner, and be prepared to share your ideas and evidence. **Whole-class share-out:** So what changed about the light energy when the tray was tilted? Who can briefly summarize what you observed from the data?	different about it. The amount of light coming out of the flashlight was the same; that didn't change. When the light shines straight on, the circle is smaller and has fewer squares. And when the light shines at an angle, it shines on a bigger area with more squares.	Was the flashlight different? Did you hold it at a constant distance? Give a specific example from the data chart. Do you agree with this idea? Why or why not?

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			Show slide 10. Now imagine standing on each of your graph-paper cutouts with sunlight shining on them. First, think about how it would feel standing on the small circle with the sunlight hitting it straight on. Then imagine how it would feel standing on the large circle with sunlight hitting it at an angle. 1. Do you think you'd feel hotter standing on the small circle or the large circle? Why? 2. Which circle wouldn't feel as hot to stand on? Why? 3. Do you think light energy is *more concentrated* when it shines directly on a surface or at an angle? What is your evidence?	*Question 1:* It would be hotter on the small circle because there's more light. I think it would be hotter in the *middle* of the small circle because the light is stronger there. *Question 2:* It wouldn't be as hot on the large circle because the light is spread out more. *Question 3:* The light's more concentrated when it's straight on because it covers fewer squares. There's more light	What do you mean by "more light"? Can you think of another word for "stronger"? Would each square in the large circle have more or less energy than the squares in the small circle?

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			Show slide 11.	energy in the small circle.	More light energy compared to what?
		Highlight key science ideas and focus question throughout.	Today's focus question is *Why are places closer to Earth's equator hotter than places farther away from the equator?* Our tray-and-flashlight model has given us some good ideas for answering this question, but let's gather a little more information first. **Show slide 12.** This time we'll use a different model, with a flashlight representing the Sun and an inflatable globe representing Earth.		
		Ask questions to elicit student ideas and predictions.	What do you predict will happen when you shine the flashlight on the globe? Where do you think the light will shine more directly or straight on?	The light will shine straight on at the equator—in the middle of the globe.	Do you agree with this prediction? Why or why not?
				The globe isn't flat like our trays. I don't think it's the same kind of angle.	What do you mean by "the same kind of angle"?
			Where do you think the light will shine at a less direct angle, like when you tilted the tray? You'll investigate these questions in small groups and see if your predictions are correct.		

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			Each group will have a flashlight and a globe. As you observe what happens when the light shines directly on the globe and at an angle, think about what you expected to see. **NOTE TO TEACHER:** *Students should hold their flashlights about 12 inches from the globe. If necessary, they can raise and lower the flashlights to shine on different parts of the globe, but they should always keep the light parallel to the floor and pointing at a 90º angle toward the globe. Depending on your classroom, students will be able to see the circles of light better if you dim the overhead lights. Following the activity, ask volunteers to record student observations on chart paper during the class share-out.* **Show slide 13.** **Whole-class discussion:** What did you observe when you shined the flashlight on different parts of the globe? What images did the light project on the surface of the globe? Where was the light most concentrated?	The light shined in a circle at the equator. When we moved the flashlight above or below the equator, the circle got bigger. Like on our trays, the light was more spread out.	*Questions to ask during discussion:* • How does that relate to your graph-paper cutouts? • Can anyone add to these ideas? • How does your idea relate to what we did with the flashlight and tray?

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			Where was the light more spread out?		
		Link science ideas to other science ideas.	Those are good observations! We can see that the light shines directly at the equator and is more spread out as it moves toward the poles. From our tray-and-flashlight model, we know that when light shines on a surface at an angle, the light energy, or solar radiation, is more spread out.		
		Select content representations and models matched to the learning goal and engage students in their use.	Here's another way to visualize the Sun's energy, or solar radiation, hitting Earth straight on and at an angle. **Show slide 14.** **NOTE TO TEACHER:** *In addition to the PowerPoint slide, display the teacher master (handout 2.2, The Sun's Incoming Energy—Angle Related to Latitude) on a projector or document reader so that students can refer to it during the Synthesize and Summarize phase.*		
			First, what do you notice about the angle at which the Sun's energy, or solar radiation, strikes Earth's surface at different latitudes?	The sunlight shines directly at the equator.	Come up and point to the place you're looking at.
			What do you observe at the equator, near the latitude of the United States, near the North Pole, and near the South Pole?	There's an angle near the latitude of the United States.	What do you mean by "angle"? Please show us.

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			Now look carefully at the arrows that represent solar radiation or the Sun's rays. Notice that these rays always hit Earth's surface straight on. But the surface of Earth is curved, isn't it? This curved surface causes sunlight to hit Earth at a less direct angle above and below the equator.	It's almost flat at the North Pole. The angle is the same at the South Pole as it is at the North Pole.	Show us what you mean by "flat." What is "flat"?
10 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students summarize science ideas from today's tray-and-flashlight activity and use those ideas to write a possible answer to the focus question. **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.	Engage students in making connections by synthesizing and summarizing key science ideas.	So because Earth is a sphere, sunlight strikes the curved surface more directly at the equator and less directly above and below the equator. **Show slide 15.** How does our tray-and-flashlight model illustrate this key science idea? Think about concentrated light energy and angles. **NOTE TO TEACHER:** *Draw students' attention back to the diagram from handout 2.2 (The Sun's Incoming Energy—Angle Related to Latitude).* Look again at the diagram of Earth that shows the Sun's incoming energy. How is this model similar to our tray-and-flashlight model?	When we tilted the tray, the light hit the tray at an angle. That's like the Sun hitting Earth above or below the equator. The flashlight was supposed to be the Sun, and we never tipped the	

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			How is it different from that model? **NOTE TO TEACHER:** *To make this diagram of Earth even more visual for students, have them place their graph-paper cutouts on the globe to see where the light would be more direct and at an angle. Discuss the following questions until you're confident that students understand what it means when solar radiation strikes Earth's surface at an angle.* • Where on this diagram would solar radiation, or light energy, be *more concentrated* or less spread out? • Where would solar radiation, or light energy, be *less concentrated* and more spread out? • Where do you think it would be warmer? Where would it be cooler? Why do you think so? **Show slide 16.**	flashlight. The light was always straight on like the arrows are in this diagram. The tray is flat, but Earth isn't. I guess that's why we tipped the tray so the light would hit it at an angle.	
		Highlight key science ideas and focus question throughout.	Using science ideas we learned about today, write a possible answer to our focus question in your science notebooks: *Why are places closer to Earth's equator hotter than places farther away from the equator?* Here's a hint: Think about the angle of		

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			sunlight.		
5 min	**Link to Next Lesson** **Synopsis:** Using bar graphs from the previous lesson, students review what they've learned so far about temperature patterns on Earth and relate science ideas to the next lesson.	Summarize key science ideas. Link science ideas to other science ideas.	**NOTE TO TEACHER:** *Have students take out the bar graphs from lesson 1b (handouts 1.4 and 1.5).* To review what we've learned so far about temperature and latitude, let's look at the bar graphs from our last lesson. What do these graphs tell us about temperature patterns closer to the equator and closer to the poles? **Show slide 17.** Today we learned one of the reasons why it's hotter near the equator than farther away: Closer to the equator, the Sun's rays hit Earth more directly, or straight on, so the light energy, or solar radiation, is more concentrated and intense. Closer to the poles, it's cooler because the sunlight hits Earth's surface at a less direct angle and is more spread out or less intense. In the next lesson, we'll use another content	It's cooler above and below the equator, especially the farther you move north and south. The temperatures are also about the same north and south of the equator.	You've made an important point. Does anyone want to add to these ideas?

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			representation to gather more information about this.		