The Sun's Effect on Climate
Lesson 6a: Uneven Heating

Grade 6	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 6a 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:** How does being near the ocean or another large body of water affect air temperature?
Main learning goal: Water absorbs and reflects (releases) the Sun's energy at different rates than land. These variations in heating and cooling rates influence regional climates by affecting average air temperatures.		
Science content storyline: Other factors influence regional climates beyond latitude, the curved surface of Earth, its consistent tilt, and its orbital path around the Sun. Temperature data show that locations near the ocean experience less temperature variation throughout the year than locations far from large bodies of water, and locations at higher elevations experience cooler average temperatures than locations at lower elevations. What accounts for these variations? Oceans and large bodies of water absorb and reflect (release) solar energy at slower rates than land. This causes air temperatures near large bodies of water to heat and cool more slowly throughout the year. Conversely, air temperatures above land heat and cool at faster rates than water. As a result, interior regions of a continent experience more extreme temperature variations throughout the year. Elevation is another factor that can lead to variations in temperature patterns. Higher elevations generally experience cooler temperatures than lower elevations because the air is less dense and absorbs less heat.		
Ideal student response to the focus question: Water absorbs and releases heat more slowly than land. This affects the air temperatures above land and water. Air temperatures above water are steadier throughout the year, while air temperatures above land have bigger temperature changes. So places near oceans or large bodies of water, like San Francisco, have more steady temperatures all year long, but temperatures in places like St. Louis and Colorado Springs have bigger temperature changes. This helps explain differences in regional climates. Elevation also affects temperatures. It's cooler at higher elevations because the air is less dense and can't hold as much heat.		

Preparation

Materials Needed
- Science notebooks
- Chart paper and markers
- For classroom demonstration:
  - 1 heat lamp
  - 1 cup filled 2/3 with soil
  - 1 cup filled 2/3 with water
  - 2 cooking thermometers
  - Masking tape
  - 1 watch or clock with a second hand
  - Colored pencils (2 different colors for each student)

Student Handouts and Teacher Masters
- 5.2 Investigating Temperatures at the Same Latitude (from lesson 5a)
- *Optional:* 5.3 Map of Three Cities in the United States (from lesson 5b)
- 6.1 Uneven Heating (Part 1: Investigating Soil and Water Temperatures) (1 per student)
- 6.2 Lab Instructions for Uneven-Heating Demonstration (Teacher Master)

Ahead of Time
- Review section 8 (Other Factors That Influence Temperature) in the SEC content background document.
- Follow the directions in handout 6.2 (Lab Instructions for Uneven-Heating Demonstration) to set up a heat-lamp station for the class demonstration. Conduct a trial run the day before this lesson to ensure that everything works correctly.
- *ELL support:* Identify challenging terms or phrases in the lesson and review them in advance with ELL students. The following terms or phrases may be problematic for students: *absorb and release solar energy*, *rate*, *slower rates*, *conversely*, *interior of continents*, *more extreme variation*, *air at higher elevations is less dense and absorbs less heat*.

Lesson 6a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
4 min	**Link to previous lessons:** Students review what they learned in previous lessons about why some places at the same latitude have different temperature patterns.	• Various factors influence climate and temperature patterns on Earth, including latitude, the angle at which sunlight strikes Earth's curved surface, the amount (intensity) of solar radiation a location receives, Earth's orbit around the Sun, and Earth's consistent tilt toward the North Star, which produces opposite seasons in the Northern and Southern Hemispheres. Other factors, such as elevation and proximity to large bodies of water, also influence temperature patterns and regional climates.
2 min	**Lesson focus question:** The teacher introduces the focus question, *How does being near the ocean or another large body of water affect air temperature?*	
10 min	**Setup for activity:** The teacher elicits student ideas about why being near the ocean or another large body of water might affect temperatures.	• Proximity to large bodies of water, such as an ocean, influences temperature patterns on land.
20 min	**Activity:** Using a heat-lamp model, students conduct an investigation measuring the heating and cooling rates of soil and water to simulate how being near a large body of water influences air temperatures on land. After collecting temperature data, students plot the information on line graphs and compare the results.	• Land (soil) and water heat and cool at different rates. Land heats and cools at a much faster rate than water. Water absorbs and reflects (releases) heat more slowly than land. This causes air temperatures near large bodies of water to heat and cool more slowly throughout the year.
8 min	**Follow-up to activity:** Students share the patterns they observed in their temperature data from the heat-lamp demonstration. Then they answer the focus question using science ideas from today's lesson.	• Oceans and large bodies of water absorb and reflect (release) solar energy at slower rates than land. This causes air temperatures near large bodies of water to heat and cool more slowly throughout the year. Conversely, air temperatures above land heat and cool at faster rates. As a result, interior regions of a continent experience more extreme temperature variations throughout the year.
5 min	**Synthesize/summarize today's lesson:** Students revisit temperature data for the three cities from lesson 5. Then they apply science ideas from today's lesson to the temperature data to determine whether the data are consistent with proximity to a large body of water. Afterward, the teacher summarizes key science ideas from the lesson.	• Because water absorbs and reflects (releases) heat energy at slower rates than land, locations near large bodies of water, such as San Francisco, experience more moderate air temperatures throughout the year.
1 min	**Link to next lesson:** The teacher announces that in the next lesson, students will add to their understandings of how elevation and proximity to large bodies of water affect air temperature.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
4 min	**Link to Previous Lessons** **Synopsis:** Students review what they learned in previous lessons about why some places at the same latitude have different temperature patterns. **Main science idea(s):** • Various factors influence climate and temperature patterns on Earth, including latitude, the angle at which sunlight strikes Earth's curved surface, the amount (intensity) of solar radiation a location receives, Earth's orbit around the Sun, and Earth's consistent tilt toward the North Star, which produces opposite seasons in the Northern and Southern Hemispheres. Other factors, such as elevation and proximity to large bodies of water, also influence temperature patterns and regional climates.	Link science ideas to other science ideas. Engage students in communicating in scientific ways.	**Show slides 1 and 2.** In the last two lessons, we learned that some places at the same latitude experience different temperature patterns. From the data we collected, we discovered that latitude isn't the only factor that influences temperatures on Earth. Let's review the ideas we charted at the end of the previous lesson that explain why some places on Earth are hotter than others at different times of the year. **NOTE TO TEACHER:** *Review the chart created at the end of lesson 5b that recorded students' best answers to the unit central question. Have students explain the meaning of each idea in their own words. Ask probe questions to make student thinking more visible and complete. Encourage students to agree or disagree with one another in scientific ways and add to the ideas expressed.* *You may also want to display the physical map of the three US cities from lesson 5b (handout 5.3) and have students review their line-graph data from handout 5.2 (Investigating Temperatures at the Same Latitude). Make sure all of the following science ideas are addressed:* • *The angle at which sunlight hits Earth's*		*Probe questions to ask during this review:* • What do you mean when you say __________? • Can you say that in a complete sentence, please? • Can you tell us more about that? • Does anyone agree or disagree with that idea? • Do you have anything to add?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Summarize key science ideas.	*curved surface at different latitudes causes variations in the amount (intensity) of solar radiation a location receives.* • *Earth's tilt and orbit around the Sun influence when certain places on Earth experience warmer or cooler seasons, like summer and winter in the United States. Earth's consistent tilt toward the North Star produces opposite seasons in the Northern and Southern Hemispheres.* • *Elevation and proximity to large bodies of water influence temperature patterns and regional climates.* **Show slide 3.** So all of these factors explain why some places on Earth are hotter than others at different times of the year: • The angle of sunlight hitting Earth's curved surface at different latitudes • The consistent tilt of Earth on its axis • Earth's orbit around the Sun • Elevation • Being close to an ocean or another large body of water		
2 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *How does being near the ocean or another large body of water affect air temperature?*		In the previous lesson, we discovered that other factors like elevation and being near large bodies of water influence air temperature, but we don't really know why or how. Today we'll focus on the effect oceans and other large bodies of water have on regional		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Set the purpose with a focus question or goal statement.	temperature patterns and see if we can figure out how this happens. **Show slide 4.** Our focus question for this lesson is *How does being near the ocean or another large body of water affect air temperature?* Write the focus question in your science notebooks and draw a box around it. **NOTE TO TEACHER:** *Post the focus question on the board or chart paper so it's visible throughout the lesson.*		
10 min	**Setup for Activity** **Synopsis:** The teacher elicits student ideas about why being near the ocean or another large body of water might affect temperatures. **Main science idea(s):** • Proximity to large bodies of water, such as an ocean, influences temperature patterns on land.	Ask questions to elicit student ideas and predictions.	**Show slide 5.** So why do you think being close to an ocean or some other large body of water might affect air temperature? **NOTE TO TEACHER:** *Distribute handout 6.1 (Uneven Heating). In this lesson, students will complete only the first activity on the*	I think being close to the oceans keeps you cooler because it's windy there. The ocean is really cold, so maybe that's why San Francisco has cooler temperatures in the summer.	Say more about why you think the wind makes temperatures near the ocean cooler. How do you think the cold ocean water makes the temperatures cooler in San Francisco?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Make explicit links between science ideas and activity **before** the activity.	*handout (Part 1: Investigating Soil and Water Temperatures).* ***This is intended as a whole-class demonstration.*** *Students will work on the second activity (Part 2: Investigating Elevation) in lesson 6b.* *As you walk students through the activity directions and expectations, make sure to explicitly identify each component of the heat-lamp model and discuss what the model represents and what students are supposed to do with it.* **Show slide 6.** Today we're going to gather some evidence to help us answer our focus question. Before we begin our investigation, let's read the first paragraph and the overview for part 1 on the handout. **NOTE TO TEACHER:** *Have students take turns reading these sections of the handout aloud to the rest of the class.* According to the overview for part 1, what are we going to investigate today? Now look at the supply list. What materials will we be using for this investigation?	Soil and water temperatures. Heating and cooling dirt and water. • A lamp • Cups of soil and water • Thermometers • A timer	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Select content representations and models matched to the learning goal and engage students in their use.	Before we begin our activity, answer the questions for part 1 on page 1 of the handout: 1. How will we make sure the water and soil samples are heating and cooling evenly? 2. How will we track our measurements and make sure they're accurate? During this activity, we'll measure the temperature of the soil and the water every 3 minutes for a total of 18 minutes. For the first 9 minutes, we'll heat the cups of soil and water under a heat lamp. This represents summer when Earth receives the most direct or intense energy from the Sun, or solar radiation. After taking our last temperature reading at 9 minutes, we'll turn off the heat lamp and begin measuring the soil and water temperatures during the cooling phase. We'll do that every 3 minutes as well. This cooling phase represents winter when the solar energy or radiation hitting Earth's surface is less direct and intense. **Show slide 7.** Next we need to fill some roles. First, we'll need two timers who will keep track of when the temperatures need to be read. We also need 14 temperature readers to read the soil and water temperatures for each 3-minute segment and report these readings so the class can record them on the handout.		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			NOTE TO TEACHER: *You'll need a total of 14 temperature readers and two timers. The timers will keep track of the time segments for each phase and let the readers know when to take the temperature readings. Different pairs of temperature readers will read temperatures every 3 minutes for 18 minutes. There are seven total readings for each material (one baseline reading, three heating-phase readings, and three cooling-phase readings). For each 3-minute segment, have one student read the water temperature and one read the soil temperature. Ask pairs to check each other's readings to ensure accuracy of the data.* The timer will watch the time closely, and every 3 minutes, a different pair of temperature readers will check the soil and water temperatures. One reader will measure the soil temperature, and the other will measure the water temperature. Everyone will record the temperature data on your data tables. After all the temperature data has been collected, you'll plot the data points on your line graphs and use different-colored pencils to draw lines connecting the data points for the soil and water temperatures. When your line graphs are complete, you'll compare the data and answer the questions on the handout.		
20 min	**Activity** **Synopsis:** Using a heat-lamp model, students conduct an investigation	Select content representations and models matched to the learning goal and	Let's have two temperature readers come up and take baseline temperatures of the soil and water. Now everyone record these temperatures on		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	measuring the heating and cooling rates of soil and water to simulate how being near a large body of water influences air temperatures on land. After collecting temperature data, students plot the information on line graphs and compare the results. **Main science idea(s):** • Land (soil) and water heat and cool at different rates. Land heats and cools at a much faster rate than water. Water absorbs and reflects (releases) heat more slowly than land. This causes air temperatures near large bodies of water to heat and cool more slowly throughout the year.	engage students in their use. Ask questions to elicit student ideas and predictions.	your data tables. **NOTE TO TEACHER:** *Ask the temperature readers to state the baseline temperature readings aloud so the class can record them on their data tables. Then ask one reader to turn on the heat lamp and tell the timers to begin tracking the first 3-minute segment. Make sure to stop every 3 minutes for new temperature readings!* *During the heating phase, focus on helping students understand how this demonstration models more direct sunlight in the summer and less direct sunlight in the winter at different locations on Earth. Between temperature readings, encourage students to discuss their ideas.* What do you notice about the baseline temperature readings for the soil and the water? What do you predict will happen to the cups of soil and water now that the heat lamp is on? **Show slide 8.** What do you think each of these items represent in the real world? What does the heat lamp represent? Yes, it represents solar energy.	They're almost the same. They'll both get hot. The Sun.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			When the heat lamp is turned on, what does that represent? What about when it's turned off?	When the lamp is on it represents summer, and when it's off, it represents winter.	
			NOTE TO TEACHER: *Make sure students understand that when the heat lamp is on, it represents summer, when the Sun's energy is more direct and air temperatures are warmer. When it's turned off, it represents winter, when the Sun's energy is less direct and air temperatures are cooler. Students may also think the heat lamp represents day and night (which is another way this demonstration can be used), but for this lesson, it represents times of the year when the Sun's rays are more or less direct.*		
			What do you think the cup of water represents?	Oceans.	
			NOTE TO TEACHER: *Make sure students understand that the water represents large bodies of water, such as lakes or oceans. The impact of smaller bodies of water, such as small lakes, ponds, or rivers, on local temperatures isn't as significant as larger bodies of water.*	Lakes.	What kinds of lakes? Big ones, small ones, or both?
			What do you think the cup of soil represents?	Land. Continents.	
			Show slide 9.		
		Highlight key science ideas and	In what ways do you think this investigation could help us answer our focus question, *How does being near the ocean or another large body of water affect air temperature?*	It could help us find out	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		focus question throughout.	**NOTE TO TEACHER:** *During this discussion, make sure the timer is keeping track of the time segments, and each new pair of temperature readers is ready to measure the soil and water temperatures at 3, 6, and 9 minutes. After each reading, make sure students record the temperature data on their data tables.*	how being near an ocean affects the temperatures of places on land.	What city did we look at that is near a large body of water?
				San Francisco.	What city did we look at that is far away from the ocean in the middle of the continent?
				St. Louis. Colorado Springs.	
			Now that we've recorded some temperature readings, do you notice any difference between the soil and water temperatures during this heating phase?	The soil is heating up faster than the water.	
			NOTE TO TEACHER: *After the first 9 minutes, ask a student to turn off the heat lamp.*		
			Now let's see what happens to the soil and water temperatures during this cooling phase.		
		Ask questions to elicit student ideas and predictions.	Do you predict that the soil or the water will cool faster? Why?		
			NOTE TO TEACHER: *During the cooling phase, ask questions to elicit student observations and ideas. After each reading, ask students to describe any differences in the soil and water temperature.*		
			Do you notice any difference between the soil and water temperatures as they're cooling?	The water is cooling	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			OK, now that we've finished our temperature readings, let's complete our line graphs. First, plot each data point on your graphs and then draw one line connecting the data points for the soil temperatures and one line connecting the data points for the water temperatures. Make sure to use a different colored pencil for each line. Afterward, we'll compare our results and discuss the questions on the handout.	faster than the soil.	
8 min	**Follow-Up to Activity** **Synopsis:** Students share the patterns they observed in their temperature data from the heat-lamp demonstration. Then they answer the focus question using science ideas from today's lesson. **Main science idea(s):** • Oceans and large bodies of water absorb and reflect (release) solar energy at slower rates than land. This causes air temperatures near large bodies of water to heat and cool more slowly throughout the year. Conversely, air temperatures above land heat and cool at faster rates. As a result, interior regions of a continent	Engage students in analyzing and interpreting data and observations.	**Show slide 10.** **Turn and Talk:** Now I'd like you and an elbow partner to discuss question 1 on page 3 of your handouts: *What patterns do you observe when you compare the soil and water temperatures during the heating phase? What about during the cooling phase?* Write your observations on your handouts, and be prepared to share them with the class. **Whole-class share-out:** So what patterns did you notice when you compared the soil and water temperatures during the heating and cooling phases? **Show slide 11.** Now let's read question 2 on the handout. How do you think the data you collected support this statement? As we review our temperature data, think about how it relates to places near the ocean or		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	experience more extreme temperature variations throughout the year.		other large bodies of water. How warm was the soil after 9 minutes under the heat lamp? How warm was the water after 9 minutes? How many degrees of temperature did the soil and water gain during the heating phase? How many degrees of temperature did the soil and water lose during the cooling phase? Which material (the soil or the water) gained or lost the most heat? Which material gained or lost the least heat over time? How might our soil and water data relate to air temperatures surrounding a large body of water or land? In other words, if the air is close to a large body of water, what do you think might happen? **ELL support:** You may need to help ELL students make sense of their data during the class discussion. **NOTE TO TEACHER:** *If students are struggling to relate the soil and water temperatures to air temperatures, ask them this question: If you were air, would you be the warmest over land or water during the heating phase? Remind them that the heating phase represents summer when the Sun's*	The soil. The water. The air around the water might heat up slowly and cool slowly, like it did with our cup of water. The air around land might heat up faster and cool faster, like it did with our cup of soil.	What about if the air is around land?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			energy is hitting Earth's surface more directly. Also ask, "If you were air, would you be the warmest over land or water during the cooling phase?" Then remind students that the cooling phase represents winter, when the Sun's energy is hitting Earth less directly.		
5 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students revisit temperature data for the three cities from lesson 5. Then they apply science ideas from today's lesson to the temperature data to determine whether the data are consistent with proximity to a large body of water. Afterward, the teacher summarizes key science ideas from the lesson. **Main science idea(s):** • Because water absorbs and reflects (releases) heat energy at slower rates than land, locations near large bodies of water, such as San Francisco, experience more moderate air temperatures throughout the year.	Engage students in constructing explanations and arguments. Summarize key science ideas.	Let's review our line-graph data for the three cities from lesson 5. **NOTE TO TEACHER:** *Give students time to locate handout 5.2 (Investigating Temperatures at the Same Latitude).* **Show slide 12.** **Think-Pair-Share:** Compare today's temperature data for the soil and water with your line-graph data for the three cities and think about this question: *How might the results of today's investigation help us explain the temperature data for the three cities?* **Show slide 13.** Share your ideas for answering this question with a partner and complete this sentence in your notebooks for each city: • The temperature patterns of [San Francisco/Colorado Springs/St. Louis] are [consistent/not consistent] with being near a large body of water because _____________. **Show slide 14.** Today's investigation highlighted these key		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			science ideas: • Water absorbs and reflects (releases) heat energy at slower rates than land. • This means that air temperatures near oceans or other large bodies of water heat and cool more slowly over time. • Cities near large bodies of water experience fewer temperature variations throughout the year than cities that aren't near large bodies of water. **ELL support:** It may be helpful to chart these ideas as a class and display them for easy reference. **NOTE TO TEACHER:** *Have students write these ideas in their science notebooks.* At the beginning of our next lesson, we'll find out which of our three cities has temperature patterns that are consistent with being near a large body of water. Be prepared to share your answers to those questions and support your ideas with evidence.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the next lesson, students will add to their understandings of how elevation and proximity to large bodies of water affect air temperature.	Link science ideas to other science ideas.	**Show slide 15.** So far we've discovered that cities at the same latitude don't always have similar temperature patterns. Next time, we'll learn more about how factors like elevation and being near the ocean affect air temperature. So stay tuned!		