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TEACHER'S GUIDE

It's Hot Out Here: Exploring Heat in Our World

Grades 6–8

Contents

Introduction

This Teacher's Guide will help you explore the "It's Hot Out Here" unit with your class.

> In this unit, students will explore how the historical practice of redlining interacts with the patterns of heat distribution within communities. Students will learn how heat affects various surfaces in different ways and therefore affects various areas of a community in different ways. Students will analyze and interpret real data, create and revise models, and design solutions to a real-world problem.

The unit consists of a series of facilitated data explorations, conversations, and activities. It is designed with the assumption that small groups of students have access to several internet-connected devices. Suggested modifications are provided to adapt the unit for classrooms that have a single, shared internet-connected device. This guide provides suggested discussion strategies for each activity, but you know your class best. Adjust these strategies wherever you need to. The strategies provide several approaches for discussions, with the goal of giving all students a situation where they feel comfortable sharing their ideas. There are also multiple levels of scaffolds throughout the unit that you can combine in whatever way best serves your students. Consider utilizing available resources at your school, such as the support of colleagues in other disciplines like social studies. These teachers may have more experience facilitating conversations about social, political, and economic issues and may have suggestions for additional tools, strategies, and resources.

If you would like to receive a copy of the unit in an editable Word format or have feedback on the lesson, please contact NWEA's Academic Services at academic.services@nwea.org.

Disclaimer: This series of lessons is highly visual. It will likely not be accessible for students who have limited vision. If you need a lesson plan adapted for students with different visual abilities, please contact NWEA's Academic Services at academic.services@nwea.org.

The Purpose of This Unit

The goal of this unit is to have students examine a scientific phenomenon of the urban heat effect within its social and political context. Students will develop their science content knowledge as well as their ability to evaluate the impact natural processes have on people. This ability is essential to leveraging engineering and technology to solve problems in the real world.

This unit aligns closely to the Next Generation Science Standards (NGSS)*, as well as state-specific standards. Current science standards in all states emphasize integrating scientific practices, like modeling and interpreting data, with science content knowledge. The NGSS specifically require that science knowledge and practices be used to explain real-world phenomena and observations. The NGSS also require examination of the social, cultural, and environmental factors that impact science and engineering. This unit uses real data from nationally recognized science institutions to explore how extreme heat impacts people in real communities.

Unit Overview

Lesson	Estimated Time	Description	Learning Outcome
A. Heat and Me	Preparation: 2 min Class: 10 min	Students reflect on their experiences walking barefoot on different surfaces.	Different surfaces can feel hotter or colder than others.
B. Heat in Our School	Preparation: 10 min Class: 60 min	Students use an infrared thermometer to measure the temperature of artificial and natural surfaces around their classroom and school.	Artificial surfaces tend to feel hotter than natural surfaces.
C. Heat in Our Community: Part One	Preparation: 10 min Class: 60 min	Students explore the Urban Heat Islands Story Map from the National Aeronautics and Space Administration (NASA) and craft claims about the relationship between surface type and temperature at a community scale.	Areas with more artificial surfaces like roads tend to be hotter than the average community temperature. Areas with more natural surfaces like vegetation tend to be colder than the average community temperature.
Understanding Check-in	Preparation: 5 min Class: 15 min	Students identify one area within a city that will likely be hotter and another that will likely be colder than the surrounding community. Students provide reasoning to explain their claims.	N/A

D. Heat in Our Community: Part Two	Preparation: 25 min Class: 80 min	Students watch a video on redlining and its impacts and then have a class discussion. They analyze data about relationships between historically redlined areas and factors like temperature, vegetation, and current demographics.	The historical practice of redlining systematically segregated people into different neighborhoods by race and limited economic investment in neighborhoods where more residents were people of color. The impacts of this policy continue today: neighborhoods with higher percentages of residents who are people of color tend to have temperatures that are higher than average for the community.
E. Engineering Justice in the Community	Preparation: 10 min Class: 80 min	Students use design thinking and the engineering process to define the problem, brainstorm solutions, and pitch an idea to address the inequitable impacts of heat across communities.	There are ways to address the harmful results of redlining. Although no solution is perfect, it can still improve some component of the problem.
End-of-Unit Assessment	Preparation: 5 min Class: 30 min	Students identify the areas of a community that are likely hotter than those surrounding it, suggest a solution that reduces the impacts of heat in those areas, discuss their ideas about the solution regarding equity, and reflect on their experiences throughout the unit.	N/A

Important Links

Resource	Description	Full Link
Google Earth	Mapping program; used in Lesson C	https://earth.google.com/
Urban Heat Islands Story Map from NASA	NASA-created data interaction; used in Lesson C	https://nasa.maps.arcgis.com/apps/MapSeries/index.html?appid=44b9c8738f0e47e68d9e8ae2c530ed08
The Disturbing History of the Suburbs from the show *Adam Ruins Everything*	Six-minute video about redlining; used in Lesson D	https://www.youtube.com/watch?v=ETR9qrVS17g

Redlining and Exposure to Urban Heat Islands from the Science Museum of Virginia and Esri	Interactive maps; used in Lesson D	https://www.arcgis.com/apps/dashboards/73e329457b6644e7aeff13ecce43c8d8
Heatwaves and Hope from the Climate Atlas of Canada	Four-minute video describing the impacts of heat waves; used as optional scaffolding in Lesson D	https://www.youtube.com/watch?v=N0faoy-7Geg
Health Impacts of Extreme Heat from the Climate Atlas of Canada	Article describing the health impacts of heat; used as optional scaffolding in Lesson D	https://climateatlas.ca/health-impacts-extreme-heat
The Lasting Legacy of Redlining from FiveThirtyEight	Article about redlining and its impacts; used as optional background information in Lesson D	https://projects.fivethirtyeight.com/redlining/
Let's Talk!: Facilitating Critical Conversations with Students from Learning for Justice	Guide to facilitating conversations about equity and justice with students; used as optional background information in Lesson D	https://www.learningforjustice.org/sites/default/files/2021-11/LFJ-2111-Lets-Talk-November-2021-11172021.pdf
The 4 Steps of Brainstorming from the Stanford Life Design Lab	Four-minute video describing the process of brainstorming; used as optional background information in Lesson E	https://www.youtube.com/watch?v=WUnyTM_hX3o&list=PLjwFGCpXfsbdfnnmdkbw4G6TZSRmvf3Zu&index=4
The Rules of Brainstorming from the Stanford Life Design Lab	Two-minute video describing the process of brainstorming; used as optional background information in Lesson E	https://www.youtube.com/watch?v=zSP1PQejeaU&list=PLjwFGCpXfsbdfnnmdkbw4G6TZSRmvf3Zu&index=5

Required Materials and Preparations for Each Lesson

Lesson	Materials and/or Preparations
A. Heat and Me	• Student's Guide (one per student) • Optional: Computer

B. Heat in Our School	• Student's Guide
	• Investigation supplies (per student group):
	  ○ Infrared laser thermometer
	  ○ Two colors of sticky notes or paper with tape
	  ▪ The Student's Guide lists the colors as green and yellow, but any two colors can be used. Ensure that the entire class is consistent

	with which color they use for artificial surfaces and which color they use for natural surfaces. ▪ Be mindful of students who are colorblind; ensure they can distinguish between the two selected colors. An alternative is to add a pattern to one category of sticky note (e.g., put stars on the natural surface sticky notes and no pattern on the artificial surface sticky notes). ○ Basic calculator ○ Optional: A variety of preplanned natural surfaces (e.g., a wooden plank, a plant)
C. Heat in Our Community: Part One	• Student's Guide • Device with internet access (one per student group or one per class) • Predetermined satellite image ○ Use Google Earth to select an area for students to examine, ideally either your local community or Atlanta, Georgia, for consistency with the area used in NASA's Urban Heat Islands Story Map. The area should have a good mix of artificial and natural surfaces. Your satellite image can be either printed for students or projected in the classroom. ○ Students who are colorblind or have limited vision may have trouble with this NASA resource. These students can reference the Surface and Air Temperatures Throughout the Day section under the NASA Story Map's Explore tab. (This section can be found by selecting the fifth dot under the house icon on the left-hand side of the screen.) Students can use the data in that section to see the same patterns as the satellite image.
Understanding Check-in	• Student's Guide • Optional: Line map
D. Heat in Our Community: Part Two	• Student's Guide • Projector or other device to show video • Device with internet access (one per student group) • The Disturbing History of the Suburbs redlining video ○ This video and topic will likely cause strong reactions for some students. The video includes some strong language, including the term "screwed" to describe an unfair situation. • Redlining and Exposure to Urban Heat Islands interactive map ○ Students with limited vision, including students who are colorblind, may have trouble with these maps. Students who are colorblind may not be able to distinguish the colors in a full map but likely will be able to interact with the data once an area is selected. • Optional: Heatwaves and Hope video from the Climate Atlas of Canada describing the impacts of heat waves

	• Optional: Health Impacts of Extreme Heat article from the Climate Atlas of Canada • Optional: The Lasting Legacy of Redlining article from FiveThirtyEight describing the impacts of redlining • Optional: Let's Talk!: Facilitating Critical Conversations with Students from Learning for Justice describing facilitation strategies
E. Engineering Justice in the Community	• Student's Guide • Supplies for student pitches (e.g., paper, markers, other available art supplies or building materials) • Optional: The 4 Steps of Brainstorming from the Stanford Life Design Lab • Optional: The Rules of Brainstorming from the Stanford Life Design Lab
End of Unit Assessment	• Student's Guide • Optional: Line map

Related Standards

Alignment to the listed standards is based on the disciplinary core ideas (DCIs). The DCIs are used throughout the unit with crosscutting concepts (CCCs) and science and engineering practices (SEPs), but they might not be integrated in the same combinations as the performance expectations (PEs).

Middle School PEs and DCIs

- **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- **MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Social Justice Standards

- **JU.6-8.12:** I can recognize and describe unfairness and injustice in many forms including attitudes, speech, behaviors, practices and laws.
- **JU.6-8.13:** I am aware that biased words and behaviors and unjust practices, laws and institutions limit the rights and freedoms of people based on their identity groups.
- **AC.6-8.20:** I will work with friends, family and community members to make our world fairer for everyone, and we will plan and coordinate our actions in order to achieve our goals.

Lesson	PE/DCI	SEP	CCC	Social Justice Standard
A. Heat and Me	MS-PS1-3	SEP 4	CCC 1	
B. Heat in Our School	MS-PS1-3	SEP 4	CCC 1 CCC 6	
C. Heat in Our Community: Part One	MS-PS1-3	SEP 2 SEP 5 SEP 6	CCC 3 CCC 6	
Understanding Check-In	MS-PS1-3	SEP 6	CCC 3 CCC 6	
D. Heat in Our Community: Part Two	MS-PS1-3 MS-LS2-1	SEP 3 SEP 4 SEP 6	CCC 1 CCC 3	JU.6-8.12 JU.6-8.13
E. Engineering Justice in the Community	MS-ETS1-1 MS-PS1-3 MS-LS2-1 MS-ESS3-3	SEP 6 SEP 7	CCC 2 CCC 4	JU.6-8.13 AC.6-8.20
End-of-Unit Assessment	MS-ETS1-1 MS-PS1-3 MS-LS2-1 MS-ESS3-3	SEP 6	CCC 2	AC.6-8.20

Note: Links to the standards are included in the headings of the table

Discussion Strategies

Several discussion strategies are suggested throughout this unit. These strategies are described below, along with additional strategies you may find useful with your class.

Solo: Students reflect on their own and record their ideas using whatever method makes most sense for the given situation (typically writing or drawing).

Think-Pair-Share: Students receive time to reflect independently, followed by time to discuss their ideas with a partner. Lastly, the pairs share highlights from their discussion with the full group. The final, "share" portion will likely need additional structuring to avoid hearing from the same students every time. One structuring option is to ask students to share what their partners said, rather than to share their own thoughts.

Small group: Students discuss their ideas in small groups without additional guidelines.

Whole group: Students discuss their ideas as a class with the teacher. Encourage students to engage in dialogue with each other, rather than referring to the teacher as an expert. Ask follow-up questions like:

- "What do you think about what (student) said?"
- "How does (student)'s idea change how you are thinking?"
- "How is (student)'s idea like yours? How is it different?"

Musical chairs: Arrange the classroom into a two-layer circle of chairs, with an inner circle facing an outer circle. Each chair should be facing one other chair. Students sit in the chairs and discuss a question with the person in front of them for a given amount of time. Once the time is up, the students in the outer circle shift over one chair and then discuss either the same question or a new question with their new partner. For a quicker setup, this strategy can also be done standing or in two lines.

Gallery walk: Small groups of students discuss given questions and produce an artifact of some kind. This artifact can be in the form of notes responding to questions, a drawing, or some other product that reflects the ideas from the discussion. The artifact is then displayed for others to see. All students walk around the classroom examining the artifacts from other groups.

Traveling posters: Set up posters with different questions around the classroom. Small groups of students travel around the room to each poster, discuss its question, and leave notes about their thoughts. This activity can also be done by students individually, but this may lead to crowding around the posters as students all add their notes. This strategy allows students to see and hear others' thoughts and to add their own in either written or verbal form.

Pyramid discussion: Students start in pairs and discuss a given question. Two sets of pairs then merge and have a discussion as a group of four. Then, two groups of four merge, etc. until the whole class is discussing the question. This strategy is especially helpful for students developing English language proficiency. It gives everyone an opportunity to speak in a low-risk setting and promotes conversation throughout an array of students.

Silent auction: Post several questions or statements around the classroom. In round one, students walk around the room reading the questions and statements and writing responses on sticky notes. In round two, the students walk around the room again, this time adding sticky notes responding to the comments from round one. The new responses are placed directly below the previous round's corresponding sticky note. Continue for as many rounds as desired. The whole activity is done without talking. This is especially useful to encourage the participation of students who are hesitant to speak in class.

Talk time: This strategy can be done in pairs or small groups. Each member of the group shares their ideas on a topic or question for a set amount of time (typically 30 to 60 seconds). During this time, no one else in the group may speak. Once a student has completed their talk time, the group gets 30 to 60 seconds to ask them questions about their idea. The talk time rotates to the next person in the group, until everyone has had a turn. This strategy is useful in situations where one or two people tend to dominate conversations.

Sales pitch: Students work in small groups to discuss a question, make an argument, or design a solution to a problem. Each group prepares a 30-second "pitch" describing their answer, argument, or solution and explaining why they think it is appropriate. This strategy is especially helpful for students who communicate best in non-written formats, such as kinetic forms of communication like dance.

When implementing these strategies, have a space available for students to post their thoughts, comments, and questions during the discussions. These comments can then be discussed as a large group or within smaller groups.

Chat box: Set up a poster or a section of the wall, whiteboard, or chalkboard where students can write or place sticky notes with any thoughts or questions they have.

Wonders, whats, and wows: Divide a poster or a section of the wall, whiteboard, or chalkboard into three categories: wonders (questions the students have), whats (big ideas or takeaways), and wows (surprising or impactful learnings or ideas). Students can write or place sticky notes with their thoughts in these categories.

Source: https://www.cultofpedagogy.com/speaking-listening-techniques/

Unit Lessons

Each lesson includes the following sections: Essential Questions, Estimated Time, Focus Standards, Materials, Implementation Notes, New Terms, and Student Activity.

Within each Student Activity section are a suggested discussion strategy, a description of the activity using the text from the Student's Guide, suggestions for differentiated scaffolding and modifications, and optional scaffolding materials, if applicable. For emerging multilingual students or any students developing English language skills, encourage communication in their native languages whenever practical.

The New Terms section lists words that are particularly important, are likely to be new, or that have a unique meaning in a scientific context. It is especially important for students to understand these terms. Consider providing students with the following table for creating their own glossary throughout the unit Students can add terms on their own or with their groups as they encounter new or difficult words. They can use these entries in conjunction with the Word List provided in the Student's Guide to combine its definition, which uses scientific language, with their own definition that makes sense to them. Students can use as many copies of the table as they need. As they develop their definitions, students could also post them on a class "word wall."

Term/Word	Definition in Scientific Language	Definition in My Own Words (all languages welcome)	Picture that Represents the Word

Lesson A: Heat and Me

Essential Question

- What past experiences have you had with different surfaces having different temperatures?

Estimated Time

5–10 minutes

Focus Standards

PE	**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
DCI	**PS1.A:** Structure and Properties of Matter
SEP	**Planning and Carrying Out Investigations:** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (grades 3–5)
CCC	**Patterns:** Patterns can be used to identify cause and effect relationships.

Materials

- Student's Guide (one per student)
- Optional: Computer

Implementation Notes

The goal of this activity is to activate memories of students' related personal experiences. Students journal for a predetermined amount of time; at least five minutes is suggested, but this is flexible. Remind students that the prompts are to help them get started and that they do not need to respond to every question. Encourage them to use whatever language or combination of languages best allows them to express their ideas; the journal activities throughout the unit are just for them. Have students write or draw for the entire given time. Afterward, you can choose whether you would like students to share in pairs, in groups, with the whole class, or not at all.

New Terms

None

Student Activity

Suggested Grouping/ Discussion Strategy	Think-Pair-Share
Activity	JOURNAL: Write or draw about these questions. Use whatever language helps you share your ideas. Keep writing or drawing for the entire given time. Have you ever walked barefoot or put your hands on the ground on a hot day? • How did it feel? • Were there any moments when your skin felt too hot? • Where were you when your skin felt hot? What were you doing?

	• What did you do to make your skin feel cooler? • What questions do you have?

Lesson B: Heat in Our School

Essential Question

- What patterns exist between temperature and different kinds of surfaces in our school?

Estimated Time

60 minutes

Focus Standards

PE	**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
DCI	**PS1.A:** Structure and Properties of Matter
SEP	**Analyzing and Interpreting Data:** Construct and interpret graphical displays of data to identify linear and nonlinear relationships.
CCC	**Patterns:** Graphs, charts, and images can be used to identify patterns in data. **Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Materials

- Student's Guide
- Investigation supplies (per student group)
    - Infrared laser thermometer
    - Two colors of sticky notes or paper with tape
        - The Student's Guide lists the colors as green and yellow, but any two colors can be used. Ensure that the entire class is consistent with which color they use for artificial surfaces and which color they use for natural surfaces.
        - Be mindful of students who are colorblind; ensure they can distinguish between the two selected colors. An alternative is to add a pattern to one category of sticky note (e.g., put stars on the natural surface sticky notes and no pattern on the artificial surface sticky notes).
    - Basic calculator
    - Optional: A variety of preplanned natural surfaces (e.g., a wooden plank, a plant)

Implementation Notes

This lesson pairs with the reflection in Lesson A: Heat and Me. If your class completed Lesson A on a different day, you may want to have students review their reflections. Lesson B can be completed in groups that are as large or small as you prefer. The limiting factor to group size will likely be the number of available infrared laser thermometers. These thermometers can be purchased online for less than 15

dollars. You can also use infrared forehead thermometers, but the accuracy will be low. If you have access to only one thermometer, the data collection portion of the lesson can be done together as a whole class. Alternatively, you can run stations, where one student group at a time collects temperature data from one station, while the other groups complete their reflections at other stations. The data collection can be very quick. You will need multiple sets of data to best engage in data analysis with the whole group.

Because this lesson involves authentic, student-collected data, there is always the possibility that the data will not show the anticipated patterns. If the students' data is not showing a correlation between the kind of surface and the temperature, this is an opportunity to discuss experimental design. For example, the class could discuss questions like:

- What did you think about when you picked which surfaces to measure?
- How were the conditions around the surfaces the same? How were they different?
- What things might change the temperature of the surfaces you measured (e.g., sunlight versus shade, outside versus inside)? Were any of those things different across the surfaces you measured? How might those differences affect our data?
- How would you change how you collected data if you could do this activity again?

Following this discussion, if time allows, let students redo the data collection and class histogram. See if the patterns change. This is an opportunity to point out that scientists redo experiments regularly, both to improve their experimental design and to check that their data is reproduceable.

New Terms

artificial surfaces, average, data, natural surfaces, patterns, temperature

Student Activity

Before beginning the activity in the Student's Guide, ask students to identify a nearby surface that they think might feel hotter than others and one that might feel colder than others, based on their reflections. They will explore these surfaces in this lesson.

Step 1	
Suggested Grouping/ Discussion Strategy	Solo
Activity	Look around the classroom and outside the window. • What kinds of surfaces do you see? • What surfaces are artificial? What surfaces are natural? In the table, write or draw a picture of the surfaces you notice.
Suggested Scaffolding/ Modifications	If students struggle to distinguish between artificial and natural surfaces, you can go over some examples together as a whole class. If this continues to be an issue, the class could label several surfaces by using the sticky notes from step 3 of this lesson (one color or pattern for natural, one color or pattern for artificial). It is more important for the students to develop an understanding that different kinds of surfaces react differently to heat than it is for students to know whether a specific surface is artificial or natural.

Step 2	
Suggested Grouping/ Discussion Strategy	Think-Pair-Share or small group
Activity	With a partner or group, find three to five different surfaces (for example, a desk, a carpet, a leaf) to measure the temperature of with an infrared thermometer. • Measure the temperature of each surface three times. • Record your results in this table. Find the average by adding the temperature from each trial and dividing that total by the number of trials ([Trial 1 + Trial 2 + Trial 3] / 3).
Notes for Teachers	This step of the activity works best if your class can go outside. If that is not possible, consider having some natural surfaces available for students to choose from, such as a wooden board, a plant, or a bowl of water. Consider what conditions are affecting the temperatures: Is the surface in the shade? In the sunlight? Inside? Outside? The patterns will be clearest if all measurements are taken in the same conditions. This is an opportunity to discuss variables and controls in real-world investigations.
Suggested Scaffolding/ Modifications	If you do not have enough thermometers to accommodate several small groups, you can do this step as a whole class. You can also set up one measurement station near several kinds of surfaces or set up a few measurement stations with one surface at each. Have students cycle through the station(s) to take their measurements. Another option for accommodating a limited number of thermometers is to pair this step of the activity with the reflection activity from Lesson A. Students can complete their reflections while taking turns collecting temperature measurements. You will need at least 10 data points, but preferably more, for steps 3 and 4 to illustrate trends. See the Implementation Notes section of this lesson for more information.

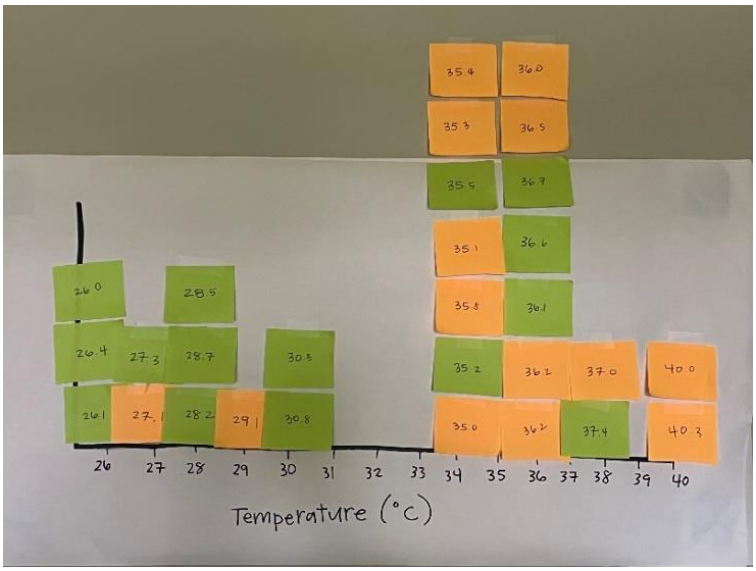
Step 3	
Suggested Grouping/ Discussion Strategy	Same pairs or small groups as step 2
Activity	Record each average temperature on a sticky note. • Use a green sticky note for natural surfaces and a yellow sticky note for artificial surfaces.
Notes for Teachers	The Student's Guide lists the colors green and yellow for the sticky notes, but any two colors can be used. Ensure the colors are distinguishable to students who are colorblind, or add another characteristic like patterns in the data display. Instead of using sticky notes, students can also use tape with scrap paper of different colors or different shapes. This provides the same experience but reduces paper waste and sticky note use.

Suggested Scaffolding/ Modifications	If you have many student groups and they are struggling with this step (or if you do not have many sticky notes), you can have each group choose only one artificial surface average temperature and one natural surface average temperature to record on sticky notes. You will need to ensure that the groups are not all picking outliers from their data, like the highest or lowest temperature they measured.

Step 4	
Suggested Grouping/ Discussion Strategy	Whole group
Activity	Data analysis through a sticky note histogram.

Notes for Teachers	• For this whole-group activity, ask the students these questions:
	  ○ What is the highest average temperature anyone in the class recorded?
	  ○ What is the lowest average temperature anyone in the class recorded?
	• Use this information to scale the x-axis on a class histogram. The histogram can be made on chart paper, a chalkboard, a whiteboard, or any other surface that you can write on and attach sticky notes.
	• Have one representative from each group place each sticky note in its appropriate section on the histogram.

Sample Histogram



Step 5	
Suggested Grouping/ Discussion Strategy	Pyramid discussion
Activity	What patterns do you notice in the class data? What questions do you have about the results? Record your notes.

Notes for Teachers	Once the histogram is complete, guide students through a period of observation, in which they consider the questions in step 5. This activity is about making observations and noticing patterns—not about trying to explain them.
Suggested Scaffolding/ Modifications	The Student's Guide provides sentence starters. These can be removed if they are not helpful. You can also start this activity with solo think time in order to give students a chance to generate their own ideas.

Step 6	
Suggested Grouping/ Discussion Strategy	Solo
Activity	JOURNAL: Write or draw about these journal questions. Use whatever language helps you share your ideas. Keep writing or drawing for the entire given time. • What did you learn? What surprised you? What questions do you have? What should we do next to learn more? • Are there any areas or seats in the classroom that you think will feel warmer than others? Why? How might this affect us as members of the classroom?
Notes for Teachers	You can also use this reflection as an exit ticket or an understanding check-in. If you choose to use this as an understanding check-in, be sure to give the students advance notice that you will be reading their responses.
Suggested Scaffolding/ Modifications	We highly encourage having students add their thoughts to a chat box or a wonders, whats, and wows wall. This allows students to have a chance to both reflect on their own and share with the class. It also validates students and provides a record of their questions and ideas for you to refer to as the unit progresses.

Lesson C: Heat in Our Community: Part One

Essential Questions

- What kinds of surfaces are in our community?
- How do the characteristics of the surface affect its temperature?
- How does this affect me and other members of my community?

Estimated Time

30 minutes

Focus Standards

PE	**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
DCI	**PS1.A:** Structure and Properties of Matter

SEP	**Using Mathematics and Computational Thinking:** Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. **Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Developing and Using Models:** Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
CCC	**Scale, Proportion, and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Materials

- Student's Guide
- Device with internet access (one per student group or one per class)
- Predetermined satellite image
    - Use Google Earth to select an area for students to examine, ideally either your local community or Atlanta, Georgia, for consistency with the area used in NASA's Urban Heat Islands Story Map. Your satellite image can either be printed for students or be projected in the classroom.

Implementation Notes

This activity can be modified to be done in pairs, small groups, or as a whole group, depending on the degree of support your students need and the number of internet-connected devices your class has. The Student's Guide provides sentence starters for some tasks in this activity, but they can be removed if you prefer.

This activity uses a satellite image of your choice from Google Earth and a map of surface temperatures in Atlanta, Georgia, from NASA. Assess whether it is more important for your students to look at a satellite image of their own community or to look at the same location, Atlanta, for both visualizations. If the satellite image and the interaction both show Atlanta, students can directly use the NASA data to consider their predictions and to confirm or reevaluate their ideas. If the satellite image shows the students' own community, it may help them interpret the image and connect the scientific concepts with their own lives. If you choose to use a local satellite image, consider helping students orient themselves in it. Can they find the school, a favorite park, or a distinctive building in the area?

New Terms

claim, evidence, heat energy, inputs, model, reasoning, relationship, satellite image, system

Student Activity

Step 1	
Suggested Grouping/ Discussion Strategy	Think-Pair-Share
Activity	Look at the satellite image. This is a picture taken from space. Discuss these questions. Write or draw notes in the organizer. • What do you notice in this image? • What information does this image give? • What kinds of surfaces do you see? • What surfaces are artificial? What surfaces are natural?
Notes for Teachers	This image may not be accessible for students who are colorblind or have limited vision.
Suggested Scaffolding/ Modifications	The satellite image can be printed out for students, accessed on an internet-connected device in groups, or projected onto a screen for the full class. If you are not printing out the image, you can add it to a shared online document where students can add annotations for step 2.

Step 2	
Suggested Grouping/ Discussion Strategy	Same Think-Pair-Share groups as step 1
Activity	Based on our investigation of surfaces in our classroom and school, which area in the image do you think will be hottest? • Circle the area in the image that you think will be hottest compared to the areas around it. • Write a claim-evidence-reasoning statement to explain why you think that area will be hottest.
Suggested Scaffolding/ Modifications	This can be turned into a gallery walk activity or a pyramid discussion where students see what other groups predicted and why.

Step 3	
Suggested Grouping/ Discussion Strategy	Gallery walk (groups display their answers to steps 3–6)
Activity	Examine the information in the Explore tab of the NASA Story Map interaction. Write a sentence describing the relationship between the kind of surface and the temperature.
Notes for Teachers	This activity can be done as a whole class or in groups, depending on the amount of support students need and the availability of devices. If using small groups, point out where they can find the Explore tab in NASA's Story Map, and then give the students some freedom in their groups to explore the interaction and notice patterns. If doing this activity together as a whole class, select the Explore tab and move around in the focus area to show locations of student interest. Students should notice patterns between types of surfaces (e.g.,

	paved surfaces, grass, water, wooded areas) and temperature. They may notice other patterns as well. Once most students seem comfortable understanding the relationship between the kind of surface and the temperature, go to the Relationship Between Surface Temperature and Vegetation section under the Explore tab. (This section can be found by selecting the second dot under the house icon on the left-hand side of the screen.) Move the gray line on the screen back and forth according to students' questions and interest. Students should notice the pattern that more vegetated areas tend to be cooler than less vegetated areas. Students who are colorblind or have limited vision may have trouble interacting with these maps. These students can reference the Surface and Air Temperatures Throughout the Day section under the Explore tab. (This section can be found by selecting the fifth dot under the house icon on the left-hand side of the screen.) Students can use the data in that section to see the same patterns.
Suggested Scaffolding/ Modifications	Students will construct a claim for this section. The Student's Guide includes a prewritten frame for this claim. This frame can be changed or removed to provide students with less support, if desired.

Step 4	
Suggested Grouping/ Discussion Strategy	Gallery walk (groups display their answers to steps 3–6)
Activity	Draw a line to complete the graph showing the relationship between amount of vegetation and temperature. Describe the relationship you show in the graph.
Suggested Scaffolding/ Modifications	The Student's Guide includes a shell for the graph. This shell can be changed or removed to provide students with less support, if desired. Students also receive sentence starters for their description of the relationship in the graph; these can be edited or removed as well. Completing both the description and the graph provides insight into whether students both understand the relationship *and* can show this relationship in a graph.

Step 5	
Suggested Grouping/ Discussion Strategy	Gallery walk (groups display their answers to steps 3–6)
Activity	Draw a model showing how heat energy interacts with different kinds of surfaces around a school. Think about the activity questions and how they affect your model:

	• What are the main parts of the system? • What are the inputs of heat energy? (Where does the heat energy come from?) • How does heat energy move and change throughout the system? • What happens when the heat energy interacts with surfaces on Earth? • How does the interaction between the heat energy and different surfaces affect people? (What is the outcome?)
Suggested Scaffolding/ Modifications	The Student's Guide includes a starter illustration for the model. This starter can be changed or removed to adjust the degree of support. The guiding questions could also be edited or removed. Students may need support making the connection between heat energy and temperature. They may also need support to understand the ideas that the heat energy is coming from the Sun and that the amount of incoming heat energy is the same regardless of what kind of surface it interacts with. The guiding questions are designed to help students make those connections.

Step 6	
Suggested Grouping/ Discussion Strategy	Gallery walk (groups display their answers to steps 3–6)
Activity	Discuss these questions about your model. You do not need to write your answers. • What questions do you have about the relationships in your model? • What information would you need in order to answer those questions?
Suggested Scaffolding/ Modifications	The gallery walk can begin after groups have completed their models and graphs. This gives students an opportunity to see other ideas for the model. To provide additional support, you can facilitate a whole-class discussion about the models with questions like these: • What similarities did you notice between the models? • What was a difference you noticed in someone else's model that changed how you are now thinking about your own model? • What is something you want to revise about your model? These questions will help prepare students to revise their models in step 7.

Step 7	
Suggested Grouping/ Discussion Strategy	Solo
Activity	Use your new ideas to change or revise your model as needed.

Notes for Teachers	This is an opportunity to ensure that every student draws their own version of the model for this system. Each student needs their own model because they will reference them in a later lesson.
Suggested Scaffolding/ Modifications	Students can use this time to personalize the group models if they have evolving ideas or to make sure they have their own copy of the group model in their notes if they need the support of the group's ideas.

Understanding Check-In

Essential Questions

- How does the structure of a city affect the temperatures in different areas?

Estimated Time

10–15 minutes

Focus Standards

PE	**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
DCI	**PS1.A:** Structure and Properties of Matter
SEP	**Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
CCC	**Scale, Proportion, and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

Materials

- Student's Guide

Implementation Notes

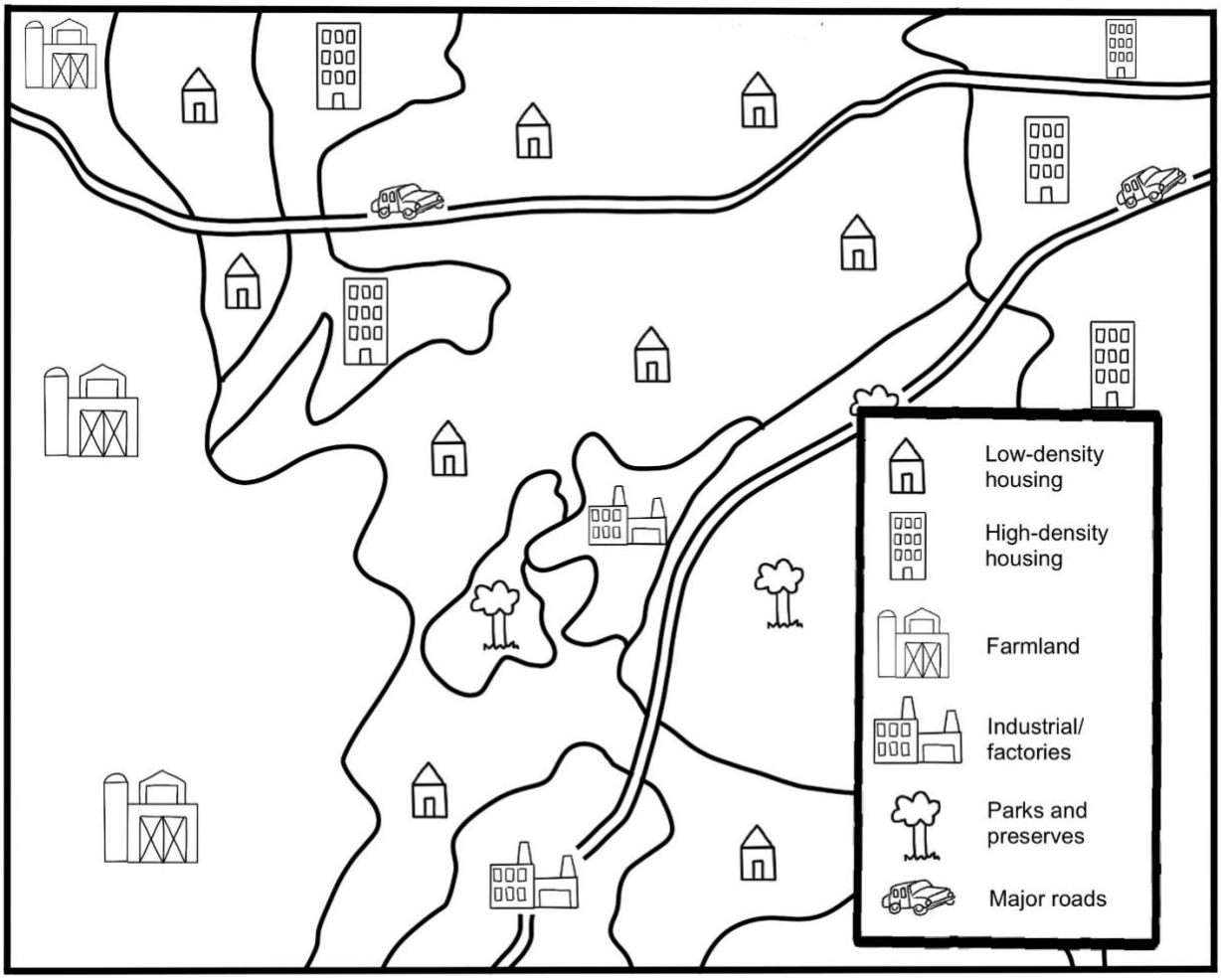
This is a mid-unit formative assessment opportunity. It mirrors what students did in Lesson C. Understanding how kinds of surfaces, vegetation, and temperature are connected is critical for moving forward into the next lessons.

Student Activity

Suggested Grouping/ Discussion Strategy	Solo
Activity	Understanding check-in tasks. See the Student's Guide for the specific questions.
Suggested Scaffolding/ Modifications	If the satellite image requires too much ink to print, you can put the assessment into a shared online document and allow students to answer digitally. Alternatively, you can replace the satellite image with the line art map provided in the Optional Scaffolding Materials section. This line art map would also enable students who are colorblind or otherwise have difficulty viewing the satellite images to engage with the assessment.

Optional Scaffolding Materials

Line Art Map 1



Lesson D: Heat in Our Community: Part Two

Essential Questions

- What kinds of surfaces are in my community and the areas around it?
- How does this affect me and other members of my community?

Estimated Time

60 minutes

Focus Standards

PE	**MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. **MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
DCI	**PS1.A:** Structure and Properties of Matter **LS2.A:** Interdependent Relationships in Ecosystems
SEP	**Analyzing and Interpreting Data:** Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. **Planning and Carrying Out Investigations:** Plan an investigation individually and collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, how many data are needed to support a claim. **Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
CCC	**Scale, Proportion, and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Patterns:** Graphs, charts, and images can be used to identify patterns in data.
Social Justice Standards	**JU.6-8.12:** I can recognize and describe unfairness and injustice in many forms including attitudes, speech, behaviors, practices and laws. **JU.6-8.13:** I am aware that biased words and behaviors and unjust practices, laws and institutions limit the rights and freedoms of people based on their identity groups.

Materials

- Student's Guide
- Projector or other device to show video
- Device with internet access (one per student group)
- The Disturbing History of the Suburbs redlining video
- Redlining and Exposure to Urban Heat Islands interactive map

- Optional: Heatwaves and Hope video from the Climate Atlas of Canada describing the impacts of heat waves
- Optional: Health Impacts of Extreme Heat article from the Climate Atlas of Canada
- Optional: The Lasting Legacy of Redlining article from FiveThirtyEight describing the impacts of redlining
- Optional: Let's Talk!: Facilitating Critical Conversations with Students from Learning for Justice describing facilitation strategies

Implementation Notes

This lesson explicitly addresses systemic, race-related issues in relationship to urban heat islands. Consider what norms, behaviors, and prework your specific classroom needs in order to have a productive conversation around these topics. Be prepared to give students time to process and discuss if they need it.

Students will watch a video about redlining. This video and topic will likely cause strong reactions for some students. The video includes some strong language, including the term "screwed" to describe an unfair situation. **Teachers must prewatch this video before beginning this lesson with students.** Prewatching this video is essential to ensuring you are prepared for students' questions about this topic. If you are not familiar with the topic of redlining, The Lasting Legacy of Redlining by FiveThirtyEight can provide additional background. It can also be helpful to do a simple internet search for information about how redlining policies have affected your local area.

The Redlining and Exposure to Urban Heat Islands resource includes maps of many metropolitan areas. Consider which area will be most meaningful for your students.

New Terms

community, distributed, impact, impervious surfaces, minority, neighborhoods, redlining, tree cover

Student Activity

Step 1	
Suggested Grouping/ Discussion Strategy	Think-Pair-Share
Activity	JOURNAL: Think about a time when it was hot in your community. Write or draw your ideas about these questions. Use whatever language helps you share your ideas. After you have finished your journaling, use the table on the next page to organize your notes. • How do you feel when it is really hot? • How do hotter temperatures affect you, your family, and people in your community?
Suggested Scaffolding/ Modifications	The Student's Guide provides a table that separates these questions into categories by the scale of impact ("Impacts on You," "Impacts on Your Family," "Impacts on Your Community") and the type of impact ("Health," "Transportation," "Energy Use, "Recreation/Play," "Other"). This table is meant to scaffold and support student thinking. If this table will not be helpful for your students, they can do a more open-ended reflection in response to the activity

	questions. You can also change, remove, or add to the given categories. If students are struggling to think of a variety of impacts, you can watch this Heatwaves and Hope video from the Climate Atlas of Canada. Students can also read the Why Does Heat Cause So Many Health Problems? and Who Is Vulnerable to Heat sections from Health Impacts of Extreme Heat, also from the Climate Atlas of Canada.

Step 2	
Suggested Grouping/ Discussion Strategy	Whole class (watch the video), then solo (reflect and journal), then traveling posters (discussion after journaling)
Activity	JOURNAL: You are going to watch a short video about a practice called redlining. After the video, think about the journal questions. Write or draw your thoughts. • What is redlining? • Who was harmed by redlining in the past? Who is harmed by redlining now? • What was the cause of the harm? • How do you think this relates to the patterns we have been noticing between kinds of surfaces and temperatures?
Notes for Teachers	Be prepared for emotional responses to this video. Students may feel angry, guilty, or any number of other emotions. See page 20 of Let's Talk!: Facilitating Critical Conversations with Students for strategies on how to interact with students that have a strong emotional response. Think about what additional support may be available from your colleagues: Is there a school counselor who can provide advice or support? Is there another teacher who has had these types of conversations with students and can provide insights? Also be prepared to share your own responses and how redlining's impacts on you are the same or different from the impacts on your students. If redlining has benefited you, be honest and acknowledge that impact.
Suggested Scaffolding/ Modifications	Giving students time to reflect on their own about this video is critical. This allows every student to process their thoughts and emotions around the practice of redlining. If students are struggling to understand redlining and its connection to them after the video, use the redlining comic book template provided in the Optional Scaffolding Materials section. The template includes text describing redlining in straightforward language. Students can work together in groups or on their own to illustrate the given text.

	Some students may be very hesitant to participate in large-group discussions about this topic. The combination of unstructured solo reflection with a more structured group discussion (using the traveling posters strategy) may help ensure that all students have an outlet for their thoughts. We also recommend maintaining a wonders, whats, and wows or chat box space for the class. This space is useful throughout the unit but is particularly important during discussions like this one.

Step 3	
Suggested Grouping/ Discussion Strategy	Gallery walk (form groups in step 3 that will display their ideas in step 4)
Activity	You are going to explore an interactive map. The map shows several kinds of information about a specific area. This image explains some of the information you will find on the map. Explore the redlining map at this website. Select a variety of neighborhoods and examine the data for each one. Use this table to record your data. You can use the blank columns to record additional categories of information if you like.
Notes for Teachers	Use the pointer tool in the top-left corner of the map to select specific neighborhoods. Once a neighborhood is selected, the data at the top of the screen will change to describe that specific area. If no neighborhood is selected, the data refers to the shaded portions of the city compared to the entire metro area or the most recently selected area. Students with limited vision, including students who are colorblind, may have trouble with these maps. Students who are colorblind may not be able to distinguish the colors in a full map but likely will be able to interact with the data once an area is selected.
Suggested Scaffolding/ Modifications	The Student's Guide includes an introduction to the redlining map that points out some crucial navigation tools and defines some key terms. Students can review this map introduction in their gallery walk groups, or you can review it as a class before releasing students into their groups. Some students may need more support in understanding what the terms mean. If you have only limited access to devices with internet access, this map can be explored as a whole group. If exploring as a whole group, a chat box or wonders, whats, and wows space can help more students participate. The Student's Guide provides a table that students can use to record their data as they look for patterns. The table includes some blank columns so students can add their own categories for data

	collection. This table can be removed to give students an opportunity to decide for themselves if they need a data table and to construct their own version. The goal for this task is proficiency in pattern identification more than data collection. If students are struggling to see patterns, you can give them the redlining graph frame from the Optional Scaffolding Materials section. This graph would provide you the opportunity to discuss how data representations can help clarify patterns in data.

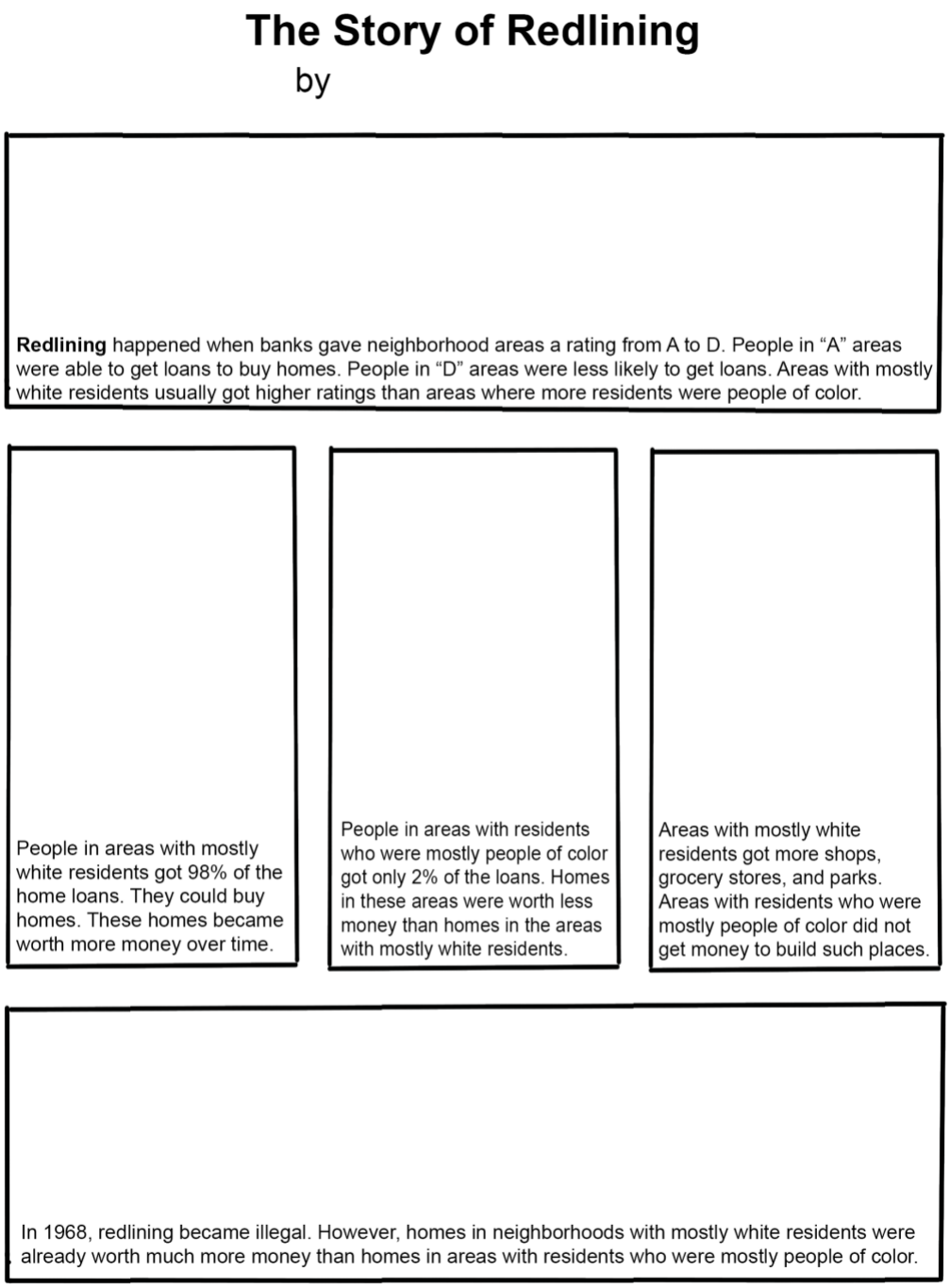
Step 4	
Suggested Grouping/ Discussion Strategy	Gallery walk (displaying ideas from step 4)
Activity	Discuss these activity questions. Write or draw your thoughts. • What do you notice in this map? What information does the map give? Where did the information come from? • What patterns or relationships do you notice between the different types of data shown in the boxes at the top of the map? What made it easier to notice or keep track of the patterns? What else could you do to notice or track patterns? • What patterns did you notice because of what neighborhoods you picked? Would the patterns be different if you had picked different neighborhoods? How can you make sure you are noticing the pattern that best applies to the whole city? • Who is harmed most by this phenomenon? How are the impacts of temperature distributed across people?
Suggested Scaffolding/ Modifications	See suggestions from step 3.

Step 5	
Suggested Grouping/ Discussion Strategy	Solo
Activity	JOURNAL: Think about the relationships you noticed in all the maps and the impact heat has on you and other members of your community. Write or draw about any of these journal questions. Write or draw for the entire given time. • How did this make you feel? • What did you learn? • What surprised you? • What do you have questions about? • What do you think we should do next?

Suggested Scaffolding/ Modifications	If students are comfortable sharing, this reflection can be used as an exit ticket question. You could also provide separate paper for this reflection if students want to keep their thoughts private and separate from their work in this unit.

Optional Scaffolding Materials

Redlining Comic Book (can be enlarged)

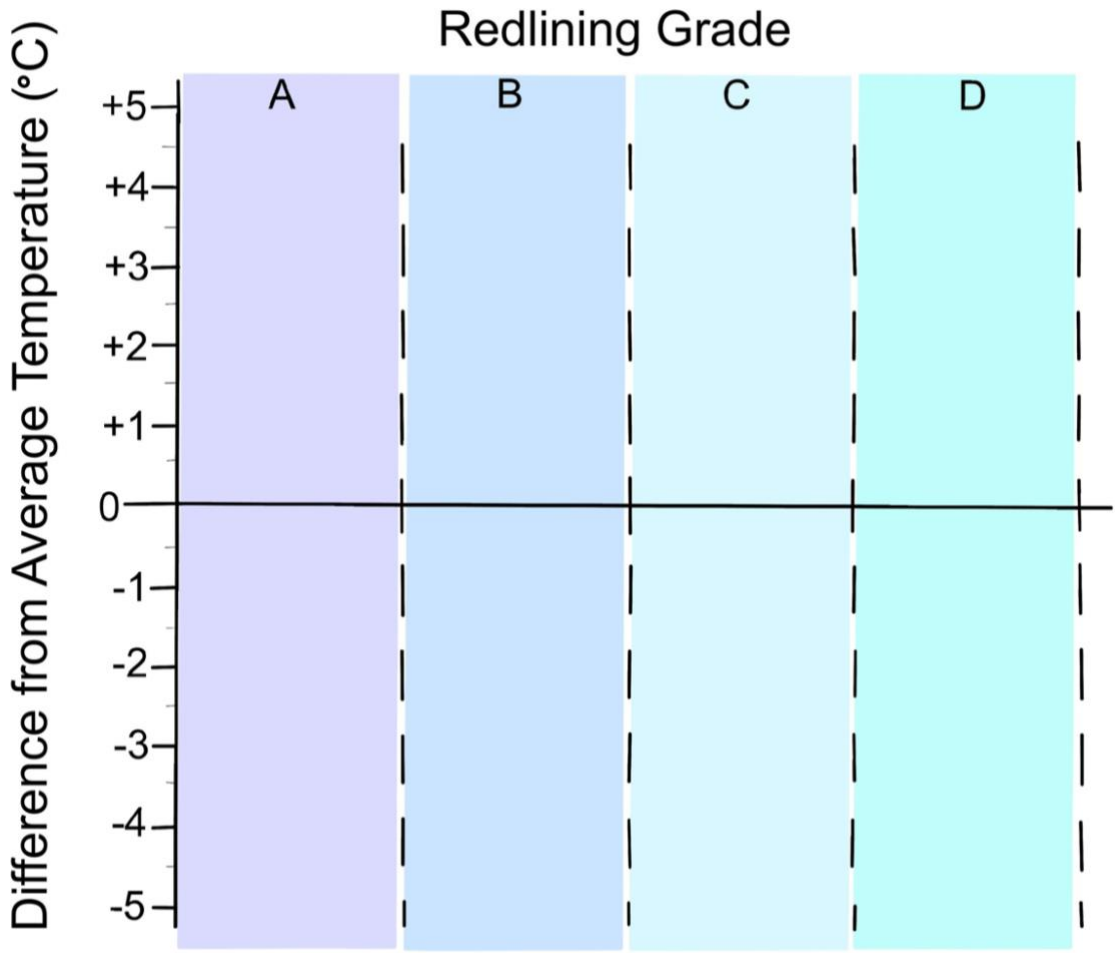


Public schools get money from the government. The amount a school gets depends on how much money the houses in the area are worth. Even today, schools in areas with mostly white residents get more money than schools in areas with residents who are mostly people of color.

Schools spend money on experienced teachers, special classes, sports equipment, music and art activities, field trips, and many other things.

How do you think redlining has affected you?

Redlining Graph



Lesson E: Engineering Justice in the Community

Essential Question

- How can we address the inequitable impacts of heat on people in my community?

Estimated Time

45 minutes

Focus Standards

PE	**MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

	MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
DCI	**ETS1.A:** Defining and Delimiting Engineering Problems **PS1.A:** Structure and Properties of Matter **LS2.A:** Interdependent Relationships in Ecosystems
SEP	**Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system. **Engaging in Argument from Evidence:** Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.
CCC	**Systems and Systems Models:** Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems. **Cause and Effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.
Social Justice Standards	**JU.6-8.13:** I am aware that biased words and behaviors and unjust practices, laws and institutions limit the rights and freedoms of people based on their identity groups. **AC.6-8.20:** I will work with friends, family and community members to make our world fairer for everyone, and we will plan and coordinate our actions in order to achieve our goals.

Materials

- Student's Guide
- Supplies for student pitches (e.g., paper, markers, other available art supplies or building materials)
- Optional: The 4 Steps of Brainstorming video from the Stanford Life Design Lab
- Optional: The Rules of Brainstorming video from the Stanford Life Design Lab

Implementation Notes

The goal of this lesson is to start thinking about solutions that reduce the inequitable impacts of heat in our communities. Students will not finish the lesson with fully developed ideas, but if you like, the lesson could be extended to involve more-detailed proposals. The lesson uses the "engineering justice" process, which is a content-agnostic way to think through social justice-related science and engineering problems. This process is something you can integrate into your regular science content and use repeatedly. Students become more adept at this process the more they use it. Each step of this lesson represents one step in the process (e.g., step 1 is "imagine something better," step 2 is "define and describe the problem," etc.)

New Terms

constraints, criteria, factors, ideal, limitations, pitch, problem, solution

Student Activity

Step 1	
Suggested Grouping/ Discussion Strategy	Solo
Activity	JOURNAL: **Imagine something better:** Think about the relationships you have been learning about between kinds of surfaces, heat energy, and people in your community. Write or draw your thoughts about this journal question. Use whatever language helps you share your ideas. What does an ideal community look/feel/sound like for you?
Notes for Teachers	The purpose of this reflection is to start the positive action of imagining alternatives. Students do not need to focus specifically on the issue of the inequitable impacts of urban heat islands; they will have more focused opportunities to reflect on that later in the lesson. This is an opportunity to think very broadly and optimistically about what an ideal community might be like.
Suggested Scaffolding/ Modifications	Some students may be enthusiastic about sharing their community ideas with a larger group. You could provide an opportunity for whole-group sharing or have students share their community ideas in small groups as an introduction to step 2 of this lesson.

Step 2	
Suggested Grouping/ Discussion Strategy	Sales pitch (same groups for steps 2–6)
Activity	**Define and describe the problem:** Fill out the table with information about the problem. A. What is the problem you want to solve? *or* What is the need? B. Why do you want to solve this problem? C. How would you know that the problem is solved or improved? Draw a model that shows how the problem formed and what factors affect the problem. (Feel free to use your model from Lesson C.) As you draw your model, consider these questions: • What are the main parts of the system? • What are the inputs of heat energy? (Where does the heat energy come from?) • How does heat energy move and change throughout the system? • What happens when the heat energy interacts with surfaces on Earth?

	• How does the interaction between the heat energy and different surfaces affect people? (What is the outcome?)
Suggested Scaffolding/ Modifications	All students should have a model from Lesson C to start with in this lesson. If not, you may want to reference the information in steps 5–7 of Lesson C to support students as they think through this new model or have a whole-group discussion about the bulleted questions. Students may need support making the connection between heat energy and temperature. They may also need support to understand the ideas that the heat energy is coming from the Sun and that the amount of incoming heat energy is the same regardless of what kind of surface it interacts with. The guiding questions are designed to help students make those connections.

Step 3	
Suggested Grouping/ Discussion Strategy	Sales pitch (same groups for steps 2–6)
Activity	**Frame the problem:** Write the problem as a question. The question should be open-ended but specific.
Notes for Teachers	See The 4 Steps of Brainstorming video from the Stanford Life Design Lab for support on how to frame problems productively using this format.
Suggested Scaffolding/ Modifications	The Student's Guide provides a frame and an example for a problem question. If students are having trouble forming their questions, you may want to do a whole-group brainstorm around the problem question. Alternatively, you can provide a problem question to the class to structure student brainstorming sessions. An example problem question for this activity is: How might we change the community in order to lower the temperature of the hottest areas in the community?

Step 4	
Suggested Grouping/ Discussion Strategy	Sales pitch (same groups for steps 2–6)
Activity	**Brainstorm:** Use the space to write or draw as many ideas for a solution as you can. Write down everything you can think of, even if the idea isn't perfect. Use whatever language helps you share your ideas.
Notes for Teachers	See The Rules of Brainstorming video from the Stanford Life Design Lab for strategies for effective brainstorming.
Suggested Scaffolding/ Modifications	You can also do a phased brainstorm that starts individually and then moves to small groups. This gives all students an opportunity to consider the issue and provide their thoughts.

Step 5	
Suggested Grouping/ Discussion Strategy	Sales pitch (same groups for steps 2–6)
Activity	**Develop a solution:** Pick one idea from your brainstorm that you want to explore more. Fill out the table for that idea. • What is the idea? • How does this idea impact the problem? • What criteria/constraints does this solution meet? (Look back at question C in step 2 of this lesson.) • What are the limitations of this idea? What parts of the problem are not solved by this idea?
Notes for Teachers	See suggestion from step 4.
Suggested Scaffolding/ Modifications	You can also do a phased brainstorm that starts individually and then moves to small groups. This gives all students an opportunity to consider the issue and provide their thoughts.

Step 6	
Suggested Grouping/ Discussion Strategy	Sales pitch (same groups for steps 2–6)
Activity	**Share your solution:** Write a 30-second pitch telling someone what your idea is and why you think it works for this problem.
Notes for Teachers	This step in the activity is an opportunity for students to be creative and may be an entry point into science for students who have not previously felt valued there. Encourage students to use the skills in their groups to enhance the pitches (e.g., making a poster if someone loves drawing, building a simple prototype if someone loves physical engineering, acting out a brief skit if someone enjoys performing). Students have lots of space for imagination, as long as the pitch stays under 30 seconds.
Suggested Scaffolding/ Modifications	The Student's Guide includes sentence starters for the pitch. These sentences can be removed if they are not helpful. After this lesson, students may need an additional outlet for their ideas, thoughts, and concerns about the inequitable impacts of heat across communities. Consider recommending they write letters to the members of their city council, research local urban-greening organizations, or expand the 30-second pitch into a more formal proposal. If you want to go big, students could prepare an application for a grant to fund and complete an urban-greening project. Sometimes local organizations offer grant opportunities. Here are some specific national grants for classroom projects or urban-greening projects: • NEA Foundation Student Success Grants • Voya Unsung Heroes Grants

	• Casey's Cash for Classrooms Grants • Whole Kids Foundation Garden Grant Program • American Heart Association Teaching Garden Grant Program

End-of-Unit Reflection

Essential Questions

- How does the structure of a city affect the temperature in different areas?
- How can we fairly reduce the effects of heat in the most impacted areas?
- What was important to you from this unit?

Estimated Time

20–30 minutes

Focus Standards

PE	**MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. **MS-LS2-1**: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
DCI	**ETS1.A:** Defining and Delimiting Engineering Problems **PS1.A:** Structure and Properties of Matter **LS2.A:** Interdependent Relationships in Ecosystems
SEP	**Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system.
CCC	**Cause and Effect:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.
Social Justice Standards	**JU.6-8.20:** I will work with friends, family and community members to make our world fairer for everyone, and we will plan and coordinate our actions in order to achieve our goals.

Materials

- Student's Guide

Implementation Notes

This assessment serves as both an understanding check-in and an opportunity for students to provide feedback on what parts of the unit resonated with them most. This reflection is intended to be done individually, but you should modify it as needed for your class. Encourage students to answer in

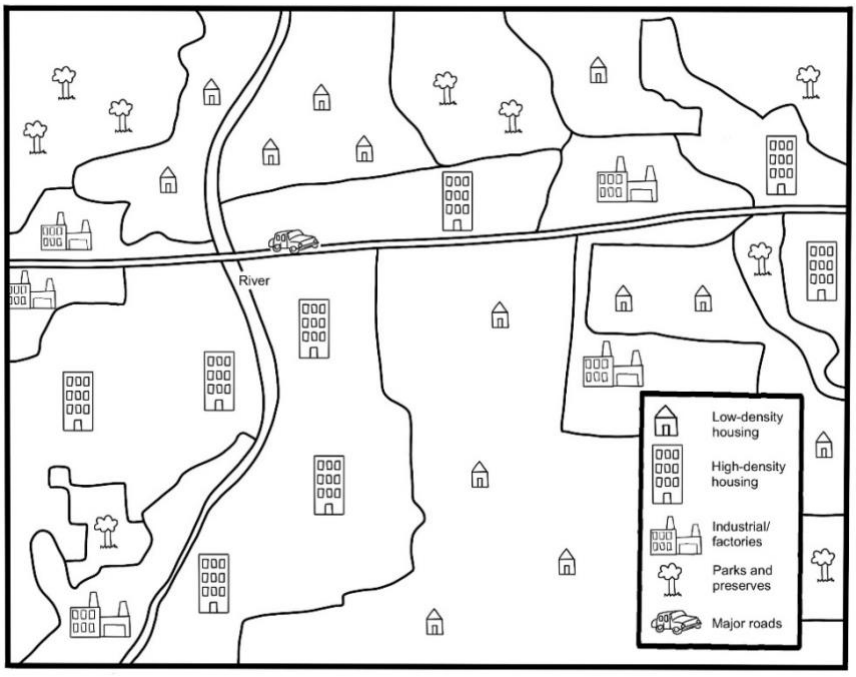
whatever way best reflects their ideas, including bullet points, incomplete sentences, or labeled diagrams. The ideas, not the language format, are the critical component.

Student Activity

Suggested Grouping/ Discussion Strategy	Solo
Activity	End-of-unit assessment. See the Student's Guide for the specific questions.
Notes for Teachers	A possible extension of this assessment is to have students share their solutions with the group. Also consider having a structured discussion around question 3, which asks whether it is fair to improve only part of the city. This could provide rich insight into evolving student ideas around equity and justice in science contexts.
Suggested Scaffolding/ Modifications	If the satellite image requires too much ink to print, you can put the assessment in a shared online document and allow students to answer digitally. Alternatively, you can replace the satellite image with the line art map provided in the Optional Scaffolding Materials section. This line art map would also enable students who are colorblind or otherwise have difficulty viewing the satellite images to engage with the assessment. You can give students the option of reviewing their previous work in the unit for ideas and support.

Optional Scaffolding Materials

Line Art Map 2 (can be enlarged for students)



Additional Resources

Frequently Asked Questions (FAQs)

This set of questions is intended to be used to introduce the unit to families or other interested parties. It is addressed particularly to people who may have concerns about using a social justice-oriented lesson plan in a science classroom.

- **What is the goal of this unit?**
  The goal of this unit is to have students examine a scientific phenomenon of the urban heat effect within its social and political context. Students will develop their science content knowledge as well as their ability to evaluate the impact natural processes have on people. This ability is essential to leveraging engineering and technology to solve problems in the real world.

- **What are the key concepts students will learn about?**

  Students will learn about the urban heat island effect and the practice of redlining. The "urban heat island effect" refers to the pattern in which city centers and areas with more paved surfaces and buildings tend to be hotter than surrounding areas. "Redlining" is a historical practice in which the Home Owners' Loan Corporation used a grading system (grades A–D) to evaluate the perceived risk involved in providing financial support to people in specific neighborhoods. The grading was highly aligned with the race of the residents in the given neighborhood. In particular, areas with a higher proportion of Black residents compared to white residents tended to receive a lower grade and thus were systematically denied financial resources. Redlining became illegal through the Fair Housing Act of 1968, but the practice continues to have consequences today.

- **What will students be doing during the unit?**

  Students will be reflecting on their own experiences. They will interact with online data dashboards from the National Aeronautics and Space Administration (NASA) and the Science Museum of Virginia. This data covers physical characteristics like land type, temperature trends, and vegetation alongside social factors like population demographics, median home value, and historical Home Owners' Loan Corporation grade (the redlining grade). Links to this data are provided below. Students will use scientific practices to analyze this data, look for patterns, make and support claims about the relationships they notice, and discuss how those relationships impact people. Students will design solutions to the problem of urban heat islands, considering the needs of the communities that are affected by this problem the most.

  Data resources:

  - Urban Heat Islands Story Map from NASA: https://nasa.maps.arcgis.com/apps/MapSeries/index.html?appid=44b9c8738f0e47e68d9e8ae2c530ed08
  - Redlining and Exposure to Urban Heat Islands interactive maps from the Science Museum of Virginia and Esri: https://www.arcgis.com/apps/dashboards/73e329457b6644e7aeff13ecce43c8d8

- **How does this unit fit with current science standards?**

  This unit aligns closely to the Next Generation Science Standards (NGSS), as well as state-specific standards. Current science standards in all states emphasize the integration of scientific practices, like modeling and interpreting data, with science content knowledge. The NGSS specifically require that science knowledge and practices be used to explain real-world phenomena and observations. The NGSS also require examination of the social, cultural, and environmental factors that impact science and engineering. This unit uses real data from nationally recognized science institutions to explore how extreme heat affects people in real communities. The data is not sculpted or curated in any way to influence what patterns students notice.

- **Why are students learning about a historical social policy (redlining) in science class?**

  As stated by the NGSS, "Science is a human endeavor." In fact, current standards in all states reference the idea that science is a human activity with ethical implications. This means that science and its impacts are deeply connected to social, cultural, and political factors. These factors influence both how science is done and what its effects are. Students need practice evaluating how such social, cultural, and political factors influence science so that they can think critically about the information they encounter in the real world and can contribute to the ever-growing body of scientific knowledge.

- **My school/district/state has banned books about and/or passed laws that forbid using critical race theory (CRT). How does this unit relate to CRT?**

  CRT refers specifically to a framework created in university law schools to examine how racial dominance has shaped laws and society. That is not what this unit examines. This unit focuses on the science standards while relating them to students' own experiences in the world in order to increase engagement and adhere to best practices in learning.

- **Where can I find more information about topics addressed in this unit?**

  Listed below are links to two articles about the impacts of redlining and a blog post about the importance of examining social, cultural, and political contexts in science:

  - Racist Housing Practices from the 1930s Linked to Hotter Neighborhoods Today by NPR: https://www.npr.org/2020/01/14/795961381/racist-housing-practices-from-the-1930s-linked-to-hotter-neighborhoods-today
  - Housing Discrimination Made Summers Even Hotter by Bloomberg: https://www.bloomberg.com/news/articles/2020-01-22/the-link-between-redlining-and-extreme-urban-heat
  - Starting the Conversation: 4 Equity Onramps for the Science Classroom on *Teach. Learn. Grow.*: https://www.nwea.org/blog/2022/starting-the-conversation-4-equity-onramps-for-the-science-classroom/

References and Additional Information

Topic	Resource	Description	Website Address
Impacts of heat	Heatwaves and Hope from the Climate Atlas of Canada	Video describing the impacts of heat waves	https://www.youtube.com/watch?v=N0faoy-7Geg
Impacts of heat	Health Impacts of Extreme Heat from the Climate Atlas of Canada	Article describing the health impacts of heat	https://climateatlas.ca/health-impacts-extreme-heat
Impacts of inequitable policies	Housing Discrimination Made Summers Even Hotter by Bloomberg	An article about the connection between urban heat and redlining	https://www.bloomberg.com/news/articles/2020-01-22/the-link-between-redlining-and-extreme-urban-heat
Impacts of inequitable policies	How Red Lines Built White Wealth: A Lesson on Housing Segregation in the 20th Century by the Zinn Education Project	An active lesson that uses role-playing to explore the history and impacts of redlining	https://www.zinnedproject.org/materials/how-red-lines-built-white-wealth-color-of-law-lesson
Impacts of inequitable policies	The Lasting Legacy of Redlining from FiveThirtyEight	An analysis of the degree to which previously redlined communities are racially segregated today	https://projects.fivethirtyeight.com/redlining/
Impacts of inequitable policies	The Lines that Shape our Cities by the Digital Scholarship Lab at the University of Richmond	A series of data visualizations that further describe the environmental impacts of redlining policies	https://storymaps.arcgis.com/stories/0f58d49c566b486482b3e64e9e5f7ac9
Impacts of inequitable policies	Racist Housing Practices from the 1930s Linked to Hotter Neighborhoods Today by NPR	An article about the connection between urban heat and redlining	https://www.npr.org/2020/01/14/795961381/racist-housing-practices-from-the-1930s-linked-to-hotter-neighborhoods-today

Environmental Justice	Environmental Justice Screening and Mapping Tool from the Environmental Protection Agency	A mapping tool that allows users to compare environmental and quality-of-life data in order to identify areas with environmental justice concerns (Note: This resource takes some practice to use effectively.)	https://ejscreen.epa.gov/mapper/
Environmental Justice	Environmental Justice! by the Smithsonian Science Education Center	A large collection of videos and other resources related to environmental justice	https://storymaps.arcgis.com/stories/7ab1771671464 9a28861e523dce3a035
Equity conversations	Let's Talk!: Facilitating Critical Conversations with Students from Learning for Justice	A guide with practical strategies for facilitating conversations related to race, injustice, and other difficult topics	https://www.learningforjustice.org/sites/default/files/2021-11/LFJ-2111-Lets-Talk-November-2021-11172021.pdf
Equity conversations	Starting the Conversation: 4 Equity Onramps for the Science Classroom from NWEA's *Teach. Learn. Grow* blog.	A blog post about how to have equity conversations in science classrooms and why these conversations are important	https://www.nwea.org/blog/2022/starting-the-conversation-4-equity-onramps-for-the-science-classroom/
Equity conversations	Social Justice Standards from Learning for Justice	Standards describing which social justice concepts are appropriate at each grade level	https://www.learningforjustice.org/frameworks/social-justice-standards
Equity conversations	The Underrepresentation Curriculum Project by URC	A set of lessons designed to analyze equity, diversity, and inclusion within the STEM community	https://underrep.com/
Equity conversations	Justice in the Science Classroom from Learning for Justice	A webinar about integrating social justice into the science classroom	https://www.learningforjustice.org/professional-development/webinars/justice-in-the-science-classroom
Design thinking	Brainstorming by the Stanford Life Design Lab	A series of short videos about how to brainstorm effectively	https://www.youtube.com/playlist?list=PLjwFGCpXfsbdfnnmdkbw4G6TZSRmvf3Zu

NGSS Standards	Next Generation Science Standards: Appendix E	Learning progressions for disciplinary core ideas (DCI)	https://www.nextgenscience.org/sites/default/files/resource/files/AppendixE-ProgressionswithinNGSS-061617.pdf
NGSS Standards	Next Generation Science Standards: Appendix F	A description of the science and engineering practices (SEP)	https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf
NGSS Standards	Next Generation Science Standards: Appendix G	A description of the crosscutting concepts (CCC)	https://www.nextgenscience.org/sites/default/files/resource/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

District of Columbia adopting the Next Generation Science Standards (2013).

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