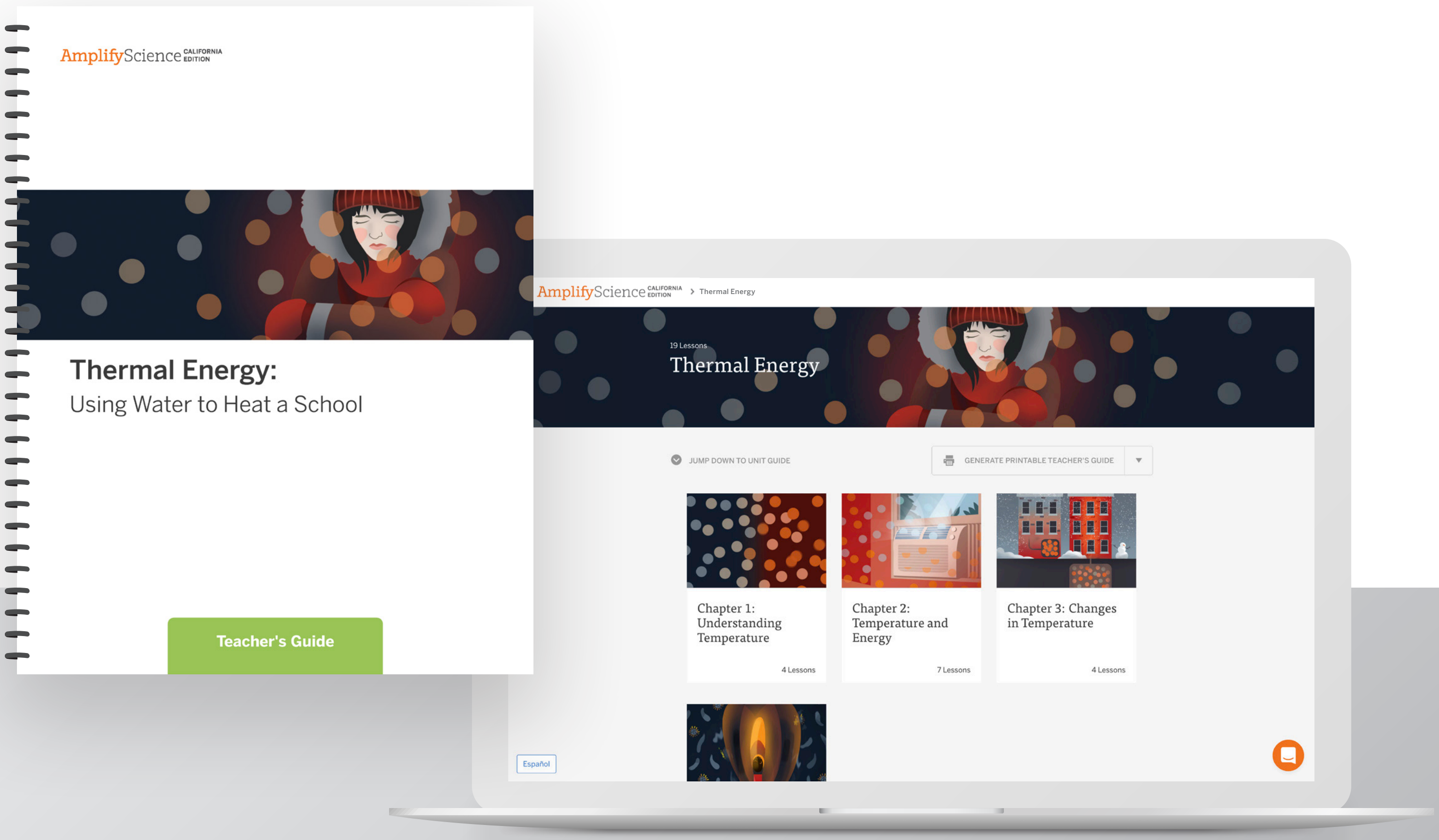
Amplify Science CALIFORNIA

UNIT GUIDE

Thermal Energy



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Welcome to Thermal Energy

Most curricula that address the topic of temperature focus solely on the macroscopic level through different modes of heat transfer. However, this approach frequently fails to move students beyond their intuitive ideas about hot and cold. Although the sensory experience of temperature is intuitive, this intuition obscures the true nature of temperature and why it changes. In contrast, Amplify Science California helps students go beyond intuition and discover that observed temperature changes can be explained by the movement of molecules, which facilitates the transfer of kinetic energy from one place to another.

> Unlike a typical curriculum, Amplify Science California anchors learning by inviting students to take on the role of scientists and engineers.

In this unit, students take on the role of thermal scientists. Their job is to help the principal of a fictional school choose a new heating system. The principal is considering two proposed systems—both use water to heat the school, but they do so in very different ways. Working together, students analyze the differences between these two systems at the molecular scale and explain how and why they will heat the school. The unit concludes with a Science Seminar in which students use what they have learned to analyze evidence and participate in a discussion about why water pasteurization kits distributed to victims of natural disaster are failing to work.

Unit Type: Core

Student Role: Thermal Scientists

Phenomenon: One of two proposed heating systems for Riverdale School will best heat the school.

Core Concept: Understanding how objects in contact can heat up and cool down

Target Performance Expectations:

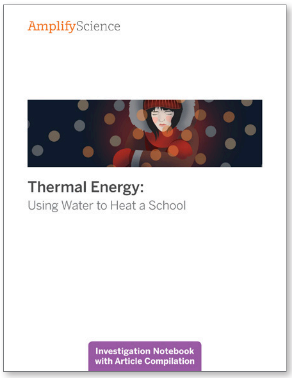
- PS3-3: Thermal Energy Transfer
- PS3-4: Energy and Temperature
- PS3-5: Motion and Energy Transfer

Related Performance Expectations:

- PS1-1: Atomic Theory/Molecules
- PS1-4: Phase Change
- PS2-1: Newton's 3rd Law (Equal and Opposite Forces)

Students figure out the unit phenomenon through the use of a variety of resources.

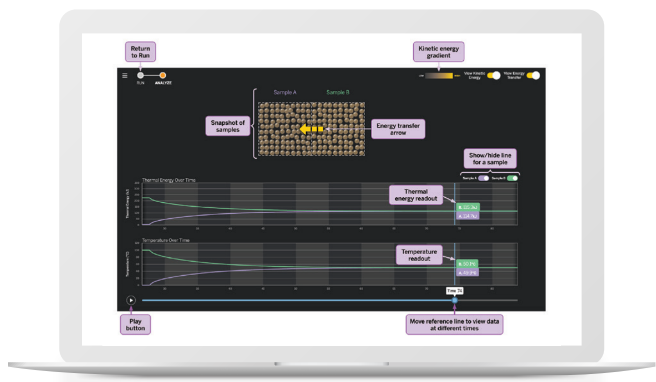
Student Investigation Notebook



Hands-On Kit

Videos

Digital Tools



About technology in this unit:
All Amplify Science California lessons were designed with device sharing in mind, and never assume that every student has a separate device.

In this grade, student-facing technology includes Practice Tools and digital Simulations. When the use of a digital tool is called for in a lesson, teachers have several implementation options:

If limited student devices are available—teachers can have students do activities in pairs or small groups.

If no student devices are available—teachers can project the digital tool to the class and either "drive" the digital tool themself or invite students to "drive" by using their device.

If internet access is unavailable—teachers can "pre-load" the digital tool on their device for use offline.

Chapter 1: The storyline begins

What students investigate:

What is happening when the air in the school gets warmer?

What students figure out:

Things are made of molecules (or other types of atom groups). When a thing gets hotter, its molecules are moving faster. When a thing gets colder, its molecules are moving slower. The way we measure the average speed of the molecules of a thing is called temperature. Therefore, if the heating systems make the school's air warmer, it is because they increase the average speed of the molecules in the school's air.

How they figure it out:

- Investigating the movement of food coloring in warm and cool water
- Investigating molecular movement and temperature in the Sim
- Reading an article about what temperature is and how it is related to kinetic energy and molecular motion
- Creating visual models showing the difference between a substance when it is warmer and cooler

KEY

- CLASS
- HANDS-ON
- HOMEWORK
- MODELING
- READING
- SIM
- STUDENT-TO-STUDENT DISCUSSION
- TEACHER
- TEACHER-LED DISCUSSION
- WARM-UP
- WRITING

DAY 1 | LESSON 1.1

Pre-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Pre-Unit Assessment

DAY 2 | LESSON 1.2

Investigating Hot and Cold

- Warm-Up (5 min)
- Video: A Tale of Two Heating Systems (5 min)
- Introducing the Unit (5 min)
- Investigating Hot and Cold Things (25 min)
- Reflecting on the Investigation (5 min)

DAY 3 | LESSON 1.3

Temperature and Motion

- Warm-Up (10 min)
- Simulating Hot and Cold Water (25 min)
- Reflection (10 min)
- Homework

DAY 4 | LESSON 1.4

Molecules and Temperature

- Warm-Up (5 min)
- Redefining Temperature (15 min)
- Modeling Differences in Temperature (20 min)
- Considering the Heating Systems (5 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 2: The storyline builds

What students investigate:

What causes the air molecules inside the school to speed up?

What they figure out:

Energy isn't created or destroyed—rather it is transferred from one part of the system to another. When two things are in contact, their molecules collide, and kinetic energy transfers from the faster-moving molecules to the slower-moving molecules. These molecules will transfer energy until the system reaches a stable state known as equilibrium, in which all of the molecules are moving at about the same speed. As a result, both heating systems should work to heat the school's air because both have water that starts at a higher temperature than the starting temperature of the school's air.

How they figure it out:

- Observing a video of an investigation in which a container of warm water heats the air around it
- Exploring how one thing warms another and examining molecular collisions during energy transfer in the Sim
- Reading an article about why molecules change speed
- Making visual models that explain energy transfer
- Creating sentences using key vocabulary
- Playing a thermal energy card game to review key ideas

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DAY 5 | LESSON 2.1

Visualizing Motion Energy

- Warm-Up (5 min)
- Video: Air and Water Demonstration (5 min)
- Visualizing Motion as Energy (20 min)
- Word Relationships Routine (15 min)

On-the-Fly Assessment

DAY 6 | LESSON 2.2

"How Air Conditioners Make Cities Hotter"

- Warm-Up (10 min)
- Reading "How Air Conditioners Make Cities Hotter" (20 min)
- Discussing Annotations (15 min)

On-the-Fly Assessment

DAY 7 | LESSON 2.3

Analyzing Evidence and Evaluating Claims

- Warm-Up (5 min)
- Simulating Temperature Change (10 min)
- Rereading "How Air Conditioners Make Cities Hotter" (20 min)
- Choosing a Claim (10 min)
- Homework

DAY 8 | LESSON 2.4

Investigating Energy Transfer

- Warm-Up (5 min)
- Investigating Energy Transfer (15 min)
- Using the Energy Cube Model (20 min)
- Reflecting on Stability and Change (5 min)
- Homework
- Family Homework Experience (Optional)

On-the-Fly Assessment

DAY 9 | LESSON 2.5

Explaining Changes in Temperature

- Warm-Up (5 min)
- Word Relationships (20 min)
- Modeling Temperature Change (15 min)
- Comparing the Heating Systems (5 min)
- Homework

On-the-Fly Assessment

Optional Flextension: *Designing Hot and Cold Packs*

DAY 10 | LESSON 2.6

Critical Juncture Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Critical Juncture Assessment

DAY 11 | LESSON 2.7

Revisiting Energy and Molecules

- Warm-Up (10 min)
- Introducing Energy 3-in-a-Row (10 min)
- Playing Energy 3-in-a-Row (20 min)
- Sharing Experiences (5 min)
- Self-Assessment (Optional)

Self-Assessment

Chapter 3:
The storyline goes deeper

What students investigate:

Which heating system will warm the air in the school more?

What they figure out:

For things at the same temperature, the thing with more molecules has more total kinetic energy (thermal energy) than the thing with fewer molecules. When a thing gains or loses energy, the energy gained or lost is divided among all the molecules of the thing. For that reason, the groundwater system will heat the school more because it uses so much more water than the other system, even though its water is not as warm as in the other system.

How they figure it out:

- Investigating energy transfer with different volumes of water
- Reading an article about size of objects (numbers of molecules) and energy transfer
- Testing energy transfer using objects of different sizes in the Sim
- Making a final model explaining energy transfer
- Writing an explanation of which heating system is better for the school and why

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- WRITING

DAY 12 | LESSON 3.1

"Thermal Energy Is NOT Temperature"

- Warm-Up (5 min)
- Reading "Thermal Energy Is NOT Temperature" (25 min)
- Discussing Annotations (15 min)
- Homework

On-the-Fly Assessment

DAY 13 | LESSON 3.2

Thermal Energy and Temperature Change

- Warm-Up (5 min)
- Rereading "Thermal Energy Is NOT Temperature" (20 min)
- Revisiting the Energy Cube Model (20 min)
- Homework

DAY 14 | LESSON 3.3

Temperature Change and Equilibrium

- Warm-Up (10 min)
- Setting Up the Thermal Energy and Size Demo (5 min)
- Simulating the Demo (15 min)
- Solving the Heating System Question (15 min)
- Homework

On-the-Fly Assessment

DAY 15 | LESSON 3.4

Recommending a Heating System

- Warm-Up (5 min)
- Modeling Differences in Temperature Change (15 min)
- Reasoning About the Groundwater System (20 min)
- Introducing the Homework (5 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 4: Application to a new storyline

What students investigate:

Kits for pasteurizing water were distributed to help victims of a natural disaster heat water and make it safe to drink, but some people still got sick. So why wasn't the water pasteurized? Was it because of a problem with the kits or because some people did not follow the instructions?

What they figure out:

Scientists must communicate how their claims and evidence are supported with reasoning in a convincing scientific argument. A written scientific argument needs to state a claim, describe specific evidence, and explain how the evidence supports the claim to convince its reader. A claim can sometimes be supported more effectively if you consider the combination of several different pieces of evidence.

How they figure it out:

- Analyzing and sorting evidence about temperature, mass, and energy transfer
- Making claims supported by the evidence
- Engaging in oral argumentation in a student-led discourse routine called a Science Seminar
- Writing final arguments

KEY

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- TEACHER-LED DISCUSSION
- WARM-UP
- WRITING

DAY 16 | LESSON 4.1

Pasteurizing Water in an Emergency

- Warm-Up (5 min)
- Water Emergency on Louis Island (10 min)
- Analyzing Evidence (15 min)
- Sorting Evidence (15 min)

DAY 17 | LESSON 4.2

Science Seminar

- Warm-Up (5 min)
- Preparing for the Science Seminar (15 min)
- Introducing the Science Seminar (5 min)
- Participating in the Science Seminar (20 min)
- Homework

On-the-Fly Assessment

DAY 18 | LESSON 4.3

Writing a Scientific Argument

- Warm-Up (5 min)
- Using the Reasoning Tool (15 min)
- Organizing Ideas in the Reasoning Tool (10 min)
- Writing a Scientific Argument (15 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

DAY 19 | LESSON 4.4

End-of-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

End-of-Unit Assessment

All students. All standards.

Rather than treating the standards simply as a list of topics to cover, we designed Amplify Science California to allow for truly in-depth and integrated coverage of the disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). Unlike other programs, however, ours makes the NGSS' vision of "all students, all standards" a reality by creating a unit-specific learning progression for every unit called a Progress Build.

Each Progress Build defines several levels of understanding of the unit's anchoring phenomenon, with each level integrating and building upon the knowledge and skills from lower levels. In this way, each Progress Build provides a clear roadmap for how students' understanding of the phenomenon is expected to deepen and develop with each successive chapter and lesson.

What's more, the program's system of assessments is also tied to these Progress Builds. This carefully crafted integration provides teachers with credible, actionable, and timely diagnostic information about student progress toward the unit's learning goals and grade-level performance expectations. Armed with this powerful data, teachers have the ultimate flexibility to decide when to move on and when to slow down and dive deeper.

Thermal Energy Progress Build

The Progress Build in this unit consists of three levels of understanding. At each level, students add new ideas and integrate them into a progressively deeper understanding of how objects in contact can heat up and cool down.

Progress Build Level 1:
The temperature of an object is related to the kinetic energy of its molecules, which increases as the speed of the molecules increases.

Progress Build Level 2:
Warmer objects transfer energy to cooler objects when they are in contact.

Progress Build Level 3:
The size of the objects in contact affects the amount of energy transfer between them and the amount of temperature change.

Examples of differentiation in this unit

In addition to providing unit-specific Progress Builds that break learning goals into smaller, more achievable levels of understanding, Amplify Science California makes learning accessible for all students through a variety of scaffolds, supports, and differentiation strategies for every lesson. **For a complete list of strategies, see the Differentiation section of every Lesson Brief**.

Below are a few examples of strategies embedded in this unit.

For English learners:

Strategic grouping (Example from Lesson 2.4)

In this lesson, students will be challenged to create a physical model of energy transfer. You may wish to consider grouping English learners with partners who can help explain instructions to English learners. English learners can then use English or their primary language to explain their thinking to their partners. Pair English learners with students who speak their primary language and/or who have a higher English proficiency, who will be positive, and who will be helpful. How to pair students who are less proficient in English with partners who are supportive is an important consideration you may want to make during this and other lessons.

For students needing more support:

Exploring the Scale Tool (Example from Lesson 1.3)

The Scale Tool provides an excellent opportunity for students to further explore scale and the relative size of things. Consider allowing time for students to explore the Scale Tool for a few minutes with their partner. Remind students that when they are considering scale, they are comparing the sizes of different things. Some things you could ask students to locate and compare include humans, marbles, ants, grains of salt, widths of human hair, skin cells, red blood cells, E. coli bacteria, DNA molecules, and water molecules.

Consider using the following prompts to support student discussion:

- *What objects might be the same scale as an ice cube? A building? A lake? A moon?*
- *Is a glucose molecule smaller than a water molecule? How do you know?*
- *Which objects can be seen easily by the human eye? Which objects cannot be seen solely by the human eye?*

For students ready for a challenge:

Designing experiments to show equilibrium (Example from Lesson 3.3)

Students who need more of a challenge can design their own experiments similar to the Thermal Energy and Size Demo. For example, students can test different volumes or temperatures of liquids other than water to see how equilibrium would be affected. Either at home or in class, have students design and test their experiments, and then write about their results using the unit vocabulary terms.

3-D Statements

In order to help teachers recognize the three-dimensional structure of every unit, chapter, and lesson, each unit contains a 3-D Statement document that makes the integration clear.

Making the 3-D statement document all the more effective, the three dimensions are color-coded for easy recognition.

Thermal Energy 3-D Coverage

SEPs	DCIs	CCCs
Science and Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts

Unit Level

Students gather evidence from hands-on activities, a digital simulation, and science texts about thermal energy and temperature at the molecular and macroscale (scale, proportion, and quantity). Using both digital and physical models, students simulate thermal energy transfers in which objects of different masses and starting temperatures eventually reach equilibrium (energy and matter, stability and change). They do this in order to construct scientific arguments about which of two heating systems a fictional school principal should choose for his school.

Chapter Level

Chapter 1: Understanding Temperature

Students gather evidence from a hands-on experiment and a digital model about temperature at the macroscale and molecular scale (scale, proportion, and quantity). They then construct explanations and visual models to communicate their understanding that an increase in the temperature of a substance is an increase in how fast its molecules are moving (energy and matter)

Chapter 2: Temperature and Energy

Students gather evidence from digital and physical models and from a science article about the relationship between motion at the molecular scale and kinetic and thermal energy (energy and matter; scale, proportion and quantity) and about how energy transfers between substances until the system becomes stable when the objects are at the same temperature (stability and change). Students apply their understanding to construct explanations and visual models of how two proposed heating systems would warm a school.

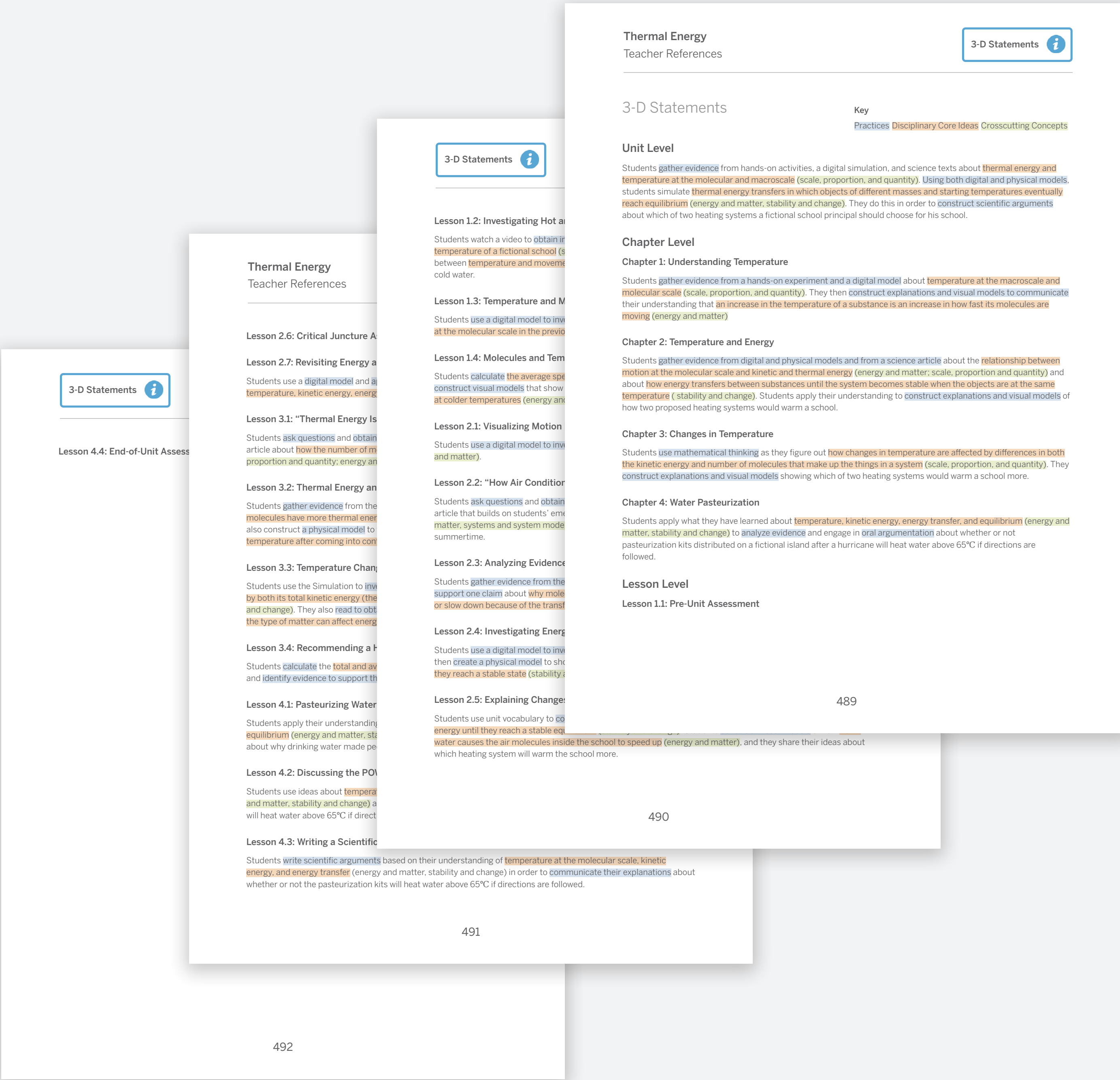
Chapter 3: Changes in Temperature

Students use mathematical thinking as they figure out how changes in temperature are affected by differences in both the kinetic energy and number of molecules that make up the things in a system (scale, proportion, and quantity). They construct explanations and visual models showing which of two heating systems would warm a school more.

Chapter 4: Water Pasteurization

Students apply what they have learned about temperature, kinetic energy, energy transfer, and equilibrium (energy and matter, stability and change) to analyze evidence and engage in oral argumentation about whether or not pasteurization kits distributed on a fictional island after a hurricane will heat water above 65°C if directions are followed.

To review the 3-D Statements at the lesson level, see the Lesson Brief section of every lesson.



Thermal Energy
Teacher References

3-D Statements

3-D Statements

Key
Practices Disciplinary Core Ideas Crosscutting Concepts

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Lesson Level

Lesson 1.1: Pre-Unit Assessment

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Notes

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For more information on Amplify Science, visit **amplify.com/science/california**.

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