Properties of Matter
Lesson 4a: How Does Heat Cause Matter to Change?

Grade 2	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 4a of 5 two-part lessons on properties in matter, with two additional extension lessons
Unit central questions: What is matter made of? How can matter change?		**Lesson focus question:** How does heat cause matter to change from a solid to a liquid and from a liquid to a solid?
Main learning goal: Adding or removing heat changes the arrangement and motion of the atoms or molecules that make up a particular kind of matter. Solids can become liquids when heat is added and the molecules speed up and move around more freely. Liquids can become solids when heat is removed (the matter cools) and the molecules slow down and vibrate in place.		
Science content storyline: Heating and cooling (removing heat) can cause changes in matter. When heat is added to a solid, its atoms or molecules begin to move faster. Melting happens when the atoms or molecules in a solid move fast enough to break away from their rigid structure and begin flowing around more freely as a liquid. When heat is taken away from a substance and the matter cools, the atoms or molecules slow down and move closer together. Freezing happens when the molecules in a liquid slow down enough to form a rigid structure and vibrate in place as a solid.		
Ideal student response to the focus question: Matter can change from a solid to a liquid when you heat it up and from a liquid to a solid when you take the heat away and the matter cools off. Adding heat to a solid makes the molecules speed up. When they move fast enough, they break away from each other and start moving around more freely as a liquid. Taking heat away from a liquid makes the molecules slow down. When they slow down enough, they join together in a rigid structure and just vibrate in place as a solid.		

Preparation

Materials Needed

- Science notebooks
- Chart paper and markers
- **Optional (from lessons 3a/b):**
  - 1 cup of ice cubes and 1 cup of water
  - 10 Lego water molecules (from lesson 3a)
  - Cardboard box and plastic sandwich bag

Student Handouts and Teacher Masters

- 3.1 Lego Model (1 per group of 4 students) (from lesson 3a)
- 4.1 My Lego Model—Analogy Map (1 per student)
- 4.2 My Lego Model—Analogy Map (Teacher Master)

Ahead of Time

- Review the content background document.
- Review strategy D in the STeLLA strategies booklet, including the sample analysis of the Lego particle-model representation and analogy map.
- **ELL support:** This lesson is heavily language based, so ELL students will need strong support to understand the content and participate in the activities. Introduce students to the lesson content, structure, materials, and activities in advance so they know what's expected of them and can participate more fully in the actual lesson. Review vocabulary words from previous lessons, including *vibrate*, *vibrate in place*, *rigid*, *move freely*, *hydrogen*, *oxygen*, *atoms*, *molecules*, *model*, and the abbreviation H_2O.

Lesson 4a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
5 min	**Link to previous lesson:** The teacher engages students in a review of the Lego model from the previous lesson, and students share what they learned about how molecules move in a solid and a liquid.	• The molecules in a solid and a liquid are always in motion, but in a solid, the molecules can only vibrate in place. In a liquid, the molecules can move around or flow more freely and slide past one another.
1 min	**Lesson focus question:** The teacher introduces the focus question, *How does heat cause matter to change from a solid to a liquid and from a liquid to a solid?*	
4 min	**Setup for activity:** Students consider why they used a Lego model instead of real water molecules to learn about changes in matter in the real world. Then the teacher reviews how models help scientists learn about the real world.	• All matter is made up of very small pieces. Atoms are the smallest pieces of matter. When atoms combine, they form molecules, which are also very small pieces of matter. Each kind of matter, such as water, is made up of a particular arrangement of atoms or molecules. In a solid, atoms and molecules vibrate in place in a rigid structure. In a liquid, atoms or molecules move around more freely and slide past one another. A model can help us see how molecules move in a solid and a liquid.
12 min	**Activity:** Students complete an analogy map for the Lego model and consider how well the model represents what happens to water molecules in real life when matter changes from a solid to a liquid and from a liquid to a solid.	• All matter is made up of very small pieces. Atoms are the smallest pieces of matter. When atoms combine, they form molecules, which are also very small pieces of matter. Each kind of matter, such as water, is made up of a particular arrangement of atoms or molecules. In a solid, atoms and molecules vibrate in place in a rigid structure. In a liquid, atoms or molecules move around more freely and slide past one another. A model can help us see how molecules move in a solid and a liquid.
15 min	**Follow-up to activity:** Students use their analogy maps to synthesize the science content storyline from this lesson and previous lessons, emphasizing the role of heat in changing the molecular motion of matter from a solid to a liquid and from a liquid to a solid.	• Heating and cooling (removing heat) can cause changes in matter. Melting happens when heat is added to a solid, and the atoms or molecules begin moving fast enough to break away from their rigid structure and flow around more freely as a liquid. Freezing happens when heat is removed from a liquid, and the molecules slow down enough to join together in a rigid structure and vibrate in place as a solid.
7 min	**Synthesize/summarize today's lesson:** Working with a partner, students use key science ideas they've learned about in this unit to develop one or two sentences that answer the focus question.	• Matter can change from a solid to a liquid when heat is added and the molecules move fast enough to break away from their rigid structure and flow around more freely as a liquid. Matter can change from a liquid to a solid when heat is removed and the matter cools. When the molecules slow down enough to join together, they form a rigid structure and vibrate in place as a solid.
1 min	**Link to next lesson:** The teacher announces that in the next lesson, students will construct scientific explanations to show what they know about changes in matter.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
5 min	**Link to Previous Lesson** **Synopsis:** The teacher engages students in a review of the Lego model from the previous lesson, and students share what they learned about how molecules move in a solid and a liquid. **Main science idea(s):** • The molecules in a solid and a liquid are always in motion, but in a solid, the molecules can only vibrate in place. In a liquid, the molecules can move around or flow more freely and slide past one another.	Highlight key science ideas and focus question throughout.	**Show slide 1.** In our last lesson, we used our Lego water molecules to make models of solid water, or ice, and liquid water. Who can describe our models? **Show slide 2.** Are the molecules in liquid water the same as the molecules in solid water, or ice? So we learned from our Lego models that the molecules in solid water and liquid water are the same. Water, or H_2O, always has two atoms of hydrogen and one atom of oxygen. **NOTE TO TEACHER:** *Hold up a Lego water molecule and point out the hydrogen and oxygen atoms.* **Show slide 3.** Based on our Lego models, do the molecules in	We put the Lego water molecules in a box and then in a sandwich bag. Water molecules. Yes. Liquid water and solid water are both water, so they have the same kind of molecules.	What did the Legos represent? Does anyone agree or disagree?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			liquid water and solid water, or ice, move in the same way or in different ways?	The molecules moved in different ways in the box and the bag. In the box, they only jiggled a little bit, but in the bag, they moved all around the inside. In the box, the water molecules were like ice and only vibrated in place. In the baggie, the water molecules moved around each other and flowed like liquid water does.	Tell me more about how the molecules moved. Can you use our science words to describe how the water molecules moved in the box and the baggie? What do you mean by "like ice"? Are the molecules separate from the solid ice? Can anyone add to these ideas?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Summarize key science ideas.	**Show slide 4.** So our Lego models helped us see how water molecules move in a solid and a liquid. In a solid, the molecules can only vibrate in place, but in a liquid they can move around more freely. Today we'll use a special tool called an *analogy map* to help us analyze our Lego model and decide whether it shows what happens in the real world.		
1 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *How does heat cause matter to change from a solid to a liquid and from a liquid to a solid?*	Set the purpose with a focus question or goal statement.	**Show slide 5.** In this lesson, we'll think about a new focus question: *How does heat cause matter to change from a solid to a liquid and from a liquid to a solid?* Write this question in your science notebooks and draw a box around it. **NOTE TO TEACHER:** *Write the focus question on the board for students to refer to throughout the lesson.* Today we'll pull together all of the science ideas we've been learning about in this unit and show what we know about how heat causes matter to change.		
4 min	**Setup for Activity**		**Show slide 6.**		

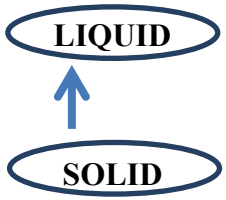
Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	Synopsis: Students consider why they used the Lego model instead of real water molecules to learn about changes in matter. Then the teacher reviews why scientists use content representations and models to help them learn about the real world. **Main science idea(s):** • All matter is made up of very small pieces. Atoms are the smallest pieces of matter. When atoms combine, they form molecules, which are also very small pieces of matter. Each kind of matter, such as water, is made up of a particular arrangement of atoms or molecules. In a solid, atoms and molecules vibrate in place in a rigid structure. In a liquid, atoms or molecules move around more freely and slide past one another. A model can help us see how molecules move in a solid and a liquid.	Make explicit links between science ideas and activities **before** the activity. Highlight key science ideas and focus question throughout.	Let's talk about our Lego model for a moment. Why do you think we used Legos instead of real water molecules to learn about how matter changes from a solid to a liquid and from a liquid to a solid? **Show slide 7.** That's right! Remember what we learned about water molecules in our reading from *A Drop of Water*? Water molecules are much too small to see, let alone pick up and move around. Using a model helped us imagine how these tiny water molecules move in a liquid and a solid. **Show slide 8.** Scientists often use models because things in real life are too small, too big, too dangerous, or too far away to observe firsthand. Models help scientists learn about things in the real world, just like our Lego model helped us learn about water molecules. When scientists use models, they want the models to show as accurately as possible how	Because real water molecules would be too slippery to use. Because real water molecules are too tiny to see.	Does anyone have another idea?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			things work in real life. Today we'll think like scientists and analyze our Lego model to see how well it shows what happens in real life. **NOTE TO TEACHER:** *The STeLLA strategies booklet contains an excellent detailed analysis of the Lego particle model in the section on strategy D. This lesson plan includes a few ideas from that sample analysis, but for a deeper discussion with your students, you might want to glean more ideas from that section to share with them.*		
12 min	**Activity** **Synopsis:** Students complete an analogy map for the Lego model and consider how well the model represents what happens to water molecules in real life when matter changes from a solid to a liquid and from a liquid to a solid. **Main science idea(s):** • All matter is made up of very small pieces. Atoms are the smallest pieces of matter. When atoms combine, they form molecules, which are also	Engage students in analyzing and interpreting data and observations.	So let's find out how well our Lego model reflects what happens in the real world. **NOTE TO TEACHER:** *Distribute handout 4.1 (My Lego Model—Analogy Map) and demonstrate how it works by walking students through the completed sentence in the first row: "One Lego brick is like an atom because the Lego brick is one small piece, and an atom is one small piece of something." After reading the sample sentence, have students complete the next two rows on their own. Allow them to discuss their ideas with an elbow partner, but make sure they record their answers on their own handouts. Circulate around the room as students work, and provide support as needed.* **Show slide 9.**		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	very small pieces of matter. Each kind of matter, such as water, is made up of a particular arrangement of atoms or molecules. In a solid, atoms and molecules vibrate in place in a rigid structure. In a liquid, atoms or molecules move around more freely and slide past one another. A model can help us see how molecules move in a solid and a liquid.	Select content representations and models matched to the learning goal and engage students in their use. Make explicit links between science ideas and activities **during** the activity. Engage students in communicating in scientific ways.	The chart on this handout is an analogy map. This map will help us decide how well our Lego model showed how matter changes in real life. Let's talk through the first row together; then you'll complete the rest of the handout on your own. You may talk with an elbow partner to help you decide what to write, but complete the sentences on your own handout. **ELL support:** Preview the analogy map with ELL students and help them complete it before the lesson so they understand what they're being asked to do and can make sense of the analogies. **Student work time.** **Whole-class share-out:** Who would like to share how you completed the next two sentences on our analogy map? **NOTE TO TEACHER:** *Invite a few students to read one of the sentences they completed on their analogy maps. Then ask other students whether they agree or disagree with each statement or have another idea to add.*  Listen to students' ideas. What's visible about student thinking? Now let's look at the remaining four rows on our analogy map.		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			What do these sentences ask you to think about? What words do you see that give you a clue? What do these words make you think of from our last lesson? What science ideas did we learn about from the Lego water molecules in the box and the baggie? Now I'd like you to pair up with an elbow partner and complete the rest of the sentences on the analogy map. As you work together, think about our Lego model and what you learned about how water molecules move. **NOTE TO TEACHER:** *If necessary, have students help you complete the fourth row: "The Lego bricks in the cardboard box are like solid water (ice) because the molecules in a solid can't move very much, just like the Legos in the box." Then have pairs work together to complete the remaining rows. Circulate around the room and provide support as needed.* **Student work time.**	I see the words *molecules*, *solid*, *liquid water*, *box*, *vibrating*, and *moving around freely*. The Lego water molecules in the box and the baggie. We learned about how water molecules move in a liquid and a solid.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			Whole-class share-out: Who would like to share how you completed the remaining sentences on our analogy map? **NOTE TO TEACHER** *Invite a few students to read one of the sentences they completed on their analogy maps. Then ask other students whether they agree or disagree with each statement or have another idea to add. As students share their ideas, ask them whether they think their Lego model helps them understand more about how matter, especially water, behaves in the real world. Can they imagine molecules of solid and liquid water moving the way their model suggests they do?*  Listen to students' ideas. What's visible about student thinking?		
15 min	**Follow-Up to Activity** **Synopsis:** Students use their analogy maps to synthesize the science content storyline from this lesson and previous lessons, emphasizing the role of heat in changing the molecular motion of matter from a solid to a liquid and from a liquid to a solid. **Main science idea(s):**		**NOTE TO TEACHER:** *The goal of the follow-up discussion is to help students visualize what happens to the Lego water molecules in the box when heat is added and what happens to the molecules in the baggie when heat is removed. During this conversation, use resources from previous lessons, including the cups of ice cubes and water, the Lego water molecules with the cardboard box and baggie, and the graphic from lesson 2b showing how adding or removing heat changes matter from a solid to a liquid or from a liquid to a solid.*		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	• Heating and cooling (removing heat) can cause changes in matter. Melting happens when heat is added to a solid, and the atoms or molecules begin moving fast enough to break away from their rigid structure and flow around more freely as a liquid. Freezing happens when heat is removed from a liquid, and the molecules slow down enough to join together in a rigid structure and vibrate in place as a solid.	Engage students in analyzing and interpreting data and observations.	Let's add another idea to our analogy map. What happens to matter—to atoms and molecules—when heat is added and removed? **Show slide 10 (only the circled words and the arrow).** Remember the diagram we made in lesson 2?  What happened when we added heat to ice, chocolate, and crayon pieces? Yes! All three kinds of matter melted or turned into liquid after we added heat, didn't they? **Show slide 11.** Now let's think about how this relates to our Lego model of solid water or ice. How did the molecules of solid water move in the cardboard box?	They all melted! They vibrated in	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			What if we added heat to the vibrating molecules in the box? What do you think might happen to the solid ice?	place. I don't know!	
		Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking. Engage students in communicating in scientific ways.	**NOTE TO TEACHER:** *Advance the animation on slide 11 to show the Legos in the box and the words "Add Heat." If students share science ideas that aren't scientifically accurate, ask questions to probe and challenge their understandings of the properties of matter. Engage other students in helping their classmates move toward more-scientific understandings. As needed, refer to the resource document Common Student Ideas about Properties of Matter.*	I think the atoms and the molecules will melt.	That's an interesting idea. Tell me more about atoms and molecules melting. What do others think? Do the atoms and molecules melt when heat is added? What does our Lego model show us about what happens to atoms and molecules when matter changes from a solid to a liquid?
		Link science	That's right! If we add heat to the solid water, or	Maybe the molecules will move more, like they do in liquid water.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		ideas to other science ideas.	ice, the molecules will begin to move more. In fact, they'll start moving so much, they'll change into liquid molecules like the ones in the plastic baggie. **NOTE TO TEACHER:** *Advance the slide animation again to show the Legos in a baggie. Help students make sense of the model and relate it to how molecules behave in the real world.* Who can describe the way the molecules move in the baggie? **Show slide 12.** Look at the ice cubes and liquid water on this slide. **NOTE TO TEACHER:** *Click through the animation on the slide.* What happens when we add heat to solid matter? What happens to the *molecules* in solid matter when we add heat? Imagine the difference between a solid and a liquid. Does that give anyone an idea about what might happen to the	They move more. They move around in the bag. They can move around each other. The solid matter becomes a liquid.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			moving molecules? **NOTE TO TEACHER:** *As needed, remind students of the analogy maps they completed earlier.* **Show slide 13 (only the circled words and the arrow).** Now let's think about what happens when we remove heat and the liquid matter cools. What	They move around more. They move faster! The molecules act like they have more energy! Adding heat! They don't vibrate anymore, and they move all around.	Yes, the molecules move around faster and act like they have more energy. What causes the molecules to do this? How about the position of the molecules when we add heat? Do they still vibrate in place? Can anyone add to that idea?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			happens to the water molecules? **NOTE TO TEACHER:** *Click through the animation to reveal the photos of the Legos in the sandwich bag and the cardboard box and the words "Remove Heat."*	The molecules slow down? They don't have as much energy. If the molecules slow down enough, like if they're in the freezer, they'll turn into ice and just vibrate in place again.	Tell me more about why you think the molecules slow down. If the molecules slow down, what do you think will happen that could make the water turn into ice?
7 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Working with a partner, students use key science ideas they've learned about in this unit to develop one or two sentences that answer the focus question. **Main science idea(s):** • Matter can change from a	Highlight key science ideas and focus question throughout. Engage students in making connections by synthesizing	**Show slide 14.** Let's revisit our focus question, *How does heat cause matter to change from a solid to a liquid and from a liquid to a solid?* I'd like you to work with an elbow partner and come up with one or two sentences that answer this question. Use science ideas about matter and the words on the slide in your explanations: • Solid		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	solid to a liquid when heat is added and the molecules move fast enough to break away from their rigid structure and flow around more freely as a liquid. Matter can change from a liquid to a solid when heat is removed and the matter cools. When the molecules slow down enough to join together, they form a rigid structure and vibrate in place as a solid.	and summarizing key science ideas.	• Liquid • Water molecules • Add heat • Take heat away • Vibrate in place • Move around freely • Move faster • Slow down Think about our investigation with the ice, the chocolate, and the crayons and our Lego water molecules in the box and the baggie. What happened when we added heat and then took heat away? Talk about your ideas and then write your sentences in your science notebooks. **NOTE TO TEACHER:** *The purpose of this activity is to prepare students for constructing written explanations and arguments for the focus question in the next lesson. If time is running short, work together as a class to construct an answer to the focus question using the science ideas students have been learning about. Then have students write the answer in their science notebooks.* **Whole-class share-out:** What sentences did you come up with to answer our focus question? Let's hear some of your ideas. **NOTE TO TEACHER:** *Invite a few students to*		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Engage students in communicating in scientific ways.	*share their sentences and encourage others to agree or disagree, add on, or ask questions.*  Listen to students' ideas. What's visible about student thinking? How are they making sense of their earlier observations?		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the next lesson, students will construct scientific explanations to show what they know about changes in matter.	Link science ideas to other science ideas.	**Show slide 15.** Today we learned more about how heat causes matter to change from a solid to a liquid and from a liquid to a solid. Next time, you'll have an opportunity to show what you know about how solid and liquid matter change and why.		