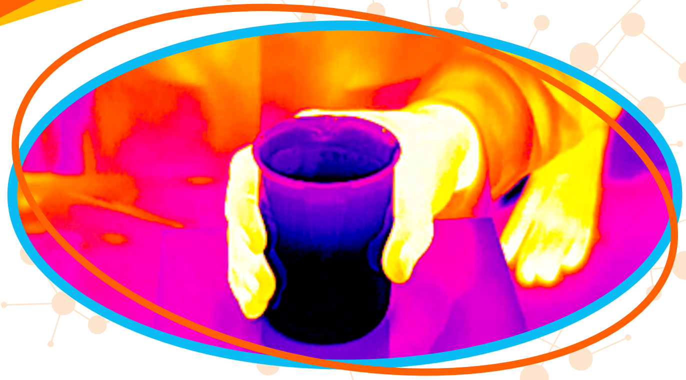
GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.



LESSON PLAN

INTRODUCTION TO THERMAL ENERGY
GRADES 6-8

SUMMARY

Students will carry out an investigation to develop a model that uses microscopic patterns to explain why ice melts faster on some materials than on others.

NEXT GENERATION SCIENCE STANDARDS CORRELATION

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Science & Engineering Practices	Connections to Classroom Activity
Planning and Carrying Out Investigations **Constructing Explanations and Designing Solutions** **Developing and Using Models**	• Students use evidence gathered from two investigations to develop and revise model-based explanations of why ice melts faster on some materials than on others.
Disciplinary Core Ideas	**Connections to Classroom Activity**
PS3.A: Definitions of Energy Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.	• Students use science ideas related to thermal energy, temperature, particle motion, and heat transfer gathered from the Generation Genius video and two investigations to develop and revise model-based explanations of why ice melts faster on some materials than on others.

Disciplinary Core Ideas	Connections to Classroom Activity
The term *heat* as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, *heat* is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary) The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the *total internal energy*) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary) **PS3.B: Conservation of Energy and Energy Transfer** The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. Energy is spontaneously transferred out of hotter regions or objects and into colder ones.	

Cross Cutting Concepts	Connections to Classroom Activity
Scale, Proportion, and Quantity **Energy and Matter** **Cause and Effect**	• Students represent microscopic patterns in their models and use these patterns to explain observations at the macroscopic scale to explain how the flow of thermal energy causes ice to melt faster on some materials than on others.

DURATION

90 min.

ENGAGE

Tell students you have a new phenomenon to show them, and have them make a chart on paper with three

MATERIALS

- Materials for Group A objects: metal pots, pans, mixing bowls, cookie sheets, etc. (enough for each group to select 1 metal object)
- Materials for Group B objects: nonmetal (glass, ceramic, stoneware, or silicone) baking dishes, mixing bowls, plates; plastic or wood cutting boards; ceramic tiles, or pieces of foam or cardboard (enough for each group to select 1 nonmetal object)
- Ice cubes of similar size and shape (2 per group)

columns labeled *See, Think, and Wonder*. Show the [Amazing Ice Melting Blocks](#) video. As students watch the video, have them record observations ("I see …"), possible explanations of the phenomenon ("I think …"), and questions that they would like to investigate ("I wonder …"). It may be helpful to watch the video multiple times and to revisit the see-think-wonder chart. Use the following questions to prompt students' thinking as they view and process the video:

- What did you see happening in the video?
- What is causing the ice to melt?
- Why do you think the ice melts faster on one block than the other?
- What do you think is the same or different about the blocks?
- What questions do you have?

- Towel or paper towels
- Thermometer (surface thermometer with infrared or liquid crystal strip would be ideal, but a regular classroom thermometer can also be used)
- Stopwatch or timer (optional)
- Materials for optional Investigation 2
  - Water
  - Microwave-safe mug
  - Microwave
  - Metal spoon
  - Plastic or wooden spoon

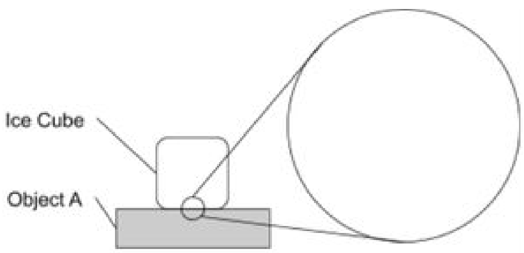
Tell students you are going to conduct an investigation to help answer some of their questions.

EXPLORE

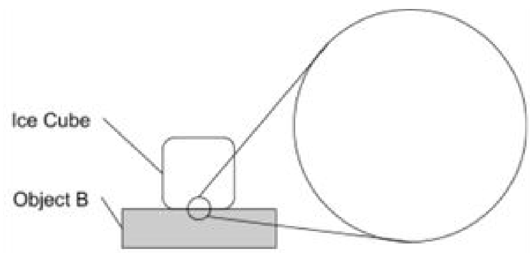
Share these procedures with your students, and have students follow them to carry out their investigation:

1. Select one object from Group A and one object from Group B.
2. Copy the **Investigation 1: Melting ice on two different kitchen objects** data table onto a blank piece of paper. Include the name of the objects you selected from Groups A and B.

Object A



Object B



	Object A	Object B
Initial Observations		
Room Temperature		
How does the object feel to the touch?		
Temperature of Object		
Predicted Results		
On which material will ice melt the fastest? ... the slowest?		
Actual Results		
How long did it take the ice cube to melt on each material		

3. Record the room temperature.
4. Touch each object and record how they feel to the touch. Does one object feel “warmer” or “cooler”?
5. Record the temperature of each object.
6. Make a prediction about which object will cause the ice to melt faster and which one will cause the ice to melt slower.
7. Place one ice cube on each object, and start a timer or record your starting time.
8. Observe the ice cubes and record how long it takes the cube to melt on each object.

After students record the temperatures of their two objects, call their attention to the fact that the temperatures are likely to be equal. Ask students to think about how this compares with how the objects felt to the touch, and tell students that they will need to keep this in mind as they make predictions and explain their results.

After students complete the investigation, use the following questions to guide a discussion to help students make sense of the investigation:

- What patterns did you observe? (Students might have noticed that the ice seemed to melt faster on metal objects than on nonmetal objects, ice seemed to melt faster on objects that felt “cooler” to the touch, the starting temperatures of the objects were the same, etc.)
- How did these patterns compare with your predictions?
- How do these patterns help you explain why the ice melts faster on some objects than on others?
- What do you think might be happening at the microscopic level that would help you explain the patterns you observed?

EXPLAIN

Ask students to think about what causes ice to melt and why it might melt faster on some materials than others. Then ask them to develop an initial model to explain why the ice melted faster on one object than another. Share the Melting Ice Model Scaffold with students to guide them as they draw their initial models.

Use the following guidance to support students in developing an initial model to explain their observations in Investigation 1:

- Your model should show all the parts of the system. The scaffold shows the object and the ice cube. Are there any other components that you need to include?
- Your model should also show how the parts of the system interact. Think about these questions:
  - What is changing?
  - How is energy moving?
  - How is each part of the system affecting other parts of the system?
- Your model also needs to show what is happening at the microscopic level that helps you explain your observations. Use the “zoom-in circles” to show what you would see at the microscopic level if you had a special tool that allowed you to do so.

Remind students their models don’t need to be perfect; they will have a chance to revise them after collecting additional evidence.

End of Day 1

Tell students you are going to watch the Generation Genius video on thermal energy to gather some information that will help them improve their models. You can use the Before Discussion questions to activate students’ prior knowledge before watching the video and the After Discussion questions to reinforce key ideas from the video.

WATCH THE GENERATION GENIUS INTRODUCTION TO THERMAL ENERGY VIDEO AS A GROUP

ELABORATE

Tell students they will now have a chance to revise their models based on new information they gathered from the video. Use the following questions to help students organize their ideas from the investigation and interactive lesson:

- What did we do?
- What did we learn?
- How does this help us explain why ice melts faster on some surfaces than others?

Now prompt students to revisit their models for the ice melting phenomenon. Tell students to think about what causes ice to melt and why it might melt faster on some materials than others. For each object they tested in Investigation 1, have students revise their initial model to explain why the ice melted faster or slower on that object. Students should use the zoom-in circles to show what they think is happening at the microscopic level that can help them explain their observations.

Now revisit the original phenomenon by watching this extended Ice Melting Blocks video. In addition to the original phenomenon, this video shows the initial temperature of the blocks and shows how the blocks interact with heat-sensitive liquid crystal sheets. Have students use this additional evidence to support their explanations. Have students use their models to explain why the ice melts faster on one block than the other, and have them infer the type of material for each block. You can find an explanation of the blocks in the Flinn Scientific Chem Fax! Ice Melting Blocks.

EVALUATE

There are multiple ways to assess your students' understanding of this topic. The exit ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game) and/or the paper quiz. All these resources are located right below the video in the assessment section.

EXTENSION

If time allows, students can complete Investigation 2, which engages them with a new phenomenon that will help them make sense of heat and how it moves.

Share the **Hot Spoons formative assessment probe** with your students. Have students share their initial answers and reasoning. Prompt students to clarify their thinking, but be careful not to give away the explanation at this point.

Tell students you are going to try this out, but with a twist. The five friends were using metal spoons, but you

Hot Spoons

Five friends were mixing hot chocolate. They wondered why their metal spoons were so hot. This is what they said:

Jamal: I think heat from the hot chocolate moves through the spoon to my hand.

Penelope: I think my hand is heating up the spoon as I hold it.

Iris: I think the metal spoon attracts heat from the hot chocolate.

Mindy: I think it is because the metal spoon holds heat better than the ceramic mug.

Frank: The spoon was cold before, so I think the hot chocolate pulled the cold out of the spoon.

are going to compare metal and nonmetal spoons in hot water. Ask students how they think a plastic or wooden spoon would compare with a metal spoon, and have students share their predictions.

Have students create the **Investigation 2: Temperature of two different kitchen spoons in hot water** data table to record their predictions and observations. As students make their initial observations, call their attention to the surprising fact that metal objects consistently feel "cooler" than nonmetal objects like the plastic/wooden spoon, even when they have the same temperature. Prompt students to think about why the metal spoon feels cooler if it actually is the same temperature as the plastic/wooden spoon. Have students record their initial observations and predictions.

	Metal Spoon	**Plastic/Wooden Spoon**
Initial Observations		
Room Temperature		
How does the spoon feel to the touch?		
Temperature of Object		
Predicted Results		
How will the spoon feel after 5 minutes?		
What will the temperature of the spoon be after 5 minutes?		
Actual Results		
How does the spoon feel after 5 minutes?		
What is the temperature of the spoon afer 5 minutes?		

Microwave 6 ounces of water in a microwave-safe mug for 90 seconds. The water will be near boiling, so use caution in handling the mug of hot water. Have students place the two spoons into the hot water, and let the spoons sit for 5 minutes. After 5 minutes, students should record their final observations.

Use the following prompts to help students make sense of the investigation:

- Did your prediction match your results?
- What patterns do you observe in the data from both investigations? (Students might notice the following patterns: Both objects were the same starting temperature, but one felt colder than the other; the objects that felt cold had/caused the biggest changes—fast-melting ice cube/highest temperature change.)
- Why do you think the metal spoon warmed up faster than the plastic/wooden spoon? What might be happening at the microscopic level that helps us explain this?
- How does this help us understand the ice melting investigation? How does the energy flow in this investigation compare with the energy flow in Investigation 1?

Revisit the Hot Spoons formative assessment probe. Give students time to reread and respond to the probe. Then have students share their responses and thinking. At this point, press students to use evidence from the investigation to justify their explanations. If a student is committed to an explanation other than Jamal's, then press them to revisit the evidence from the investigation.

The best answer is Jamal's: "I think heat from the hot chocolate moves through the spoon to my hand." The second law of thermodynamics puts constraints on how energy flows in a system. Warmer objects transfer energy to cooler objects, not the other way around. Thermal energy from the hot chocolate heats the metal spoon, which is a good conductor, and the energy is then transferred from the spoon to Jamal's hand. The energy gained from the hot chocolate caused the particles in the spoon to move faster. This energy is then transferred from the spoon to Jamal's hand as these faster-moving particles collide with the slower-moving particles in his hand. The other answers express common misconceptions about heat and its movement.