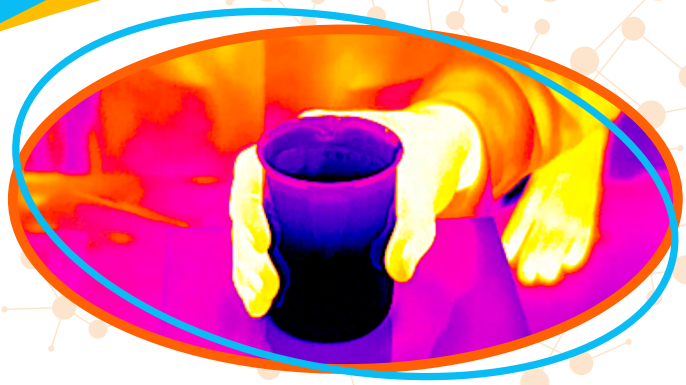
GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.



TEACHER GUIDE

INTRODUCTION TO THERMAL ENERGY

GRADES 6–8

COMMON MISCONCEPTIONS

- **Particles that make up a substance move only under certain conditions.**
  Students may believe that the particles (atoms or molecules) in a solid do not move, that particles move only when heated, or that particles move only when the substance they make up is moving. In fact, the particles in any matter that exists above absolute zero are constantly vibrating, and the speed of those vibrations increases as thermal energy is added to that matter.

- **Cold is a different phenomenon than heat and can travel to warmer areas.**
  Heat is the movement of thermal energy from a warmer area to a cooler area, and thermal energy always travels in that direction—never from cold to hot.

- **Changes in state of matter are caused by heat molecules or by a change in the number, mass, composition, or properties of individual particles making up the matter.**
  Heat refers to the movement of thermal energy, and the movement of thermal energy into a substance increases the average kinetic energy of the particles (atoms or molecules) making up that substance. As particles move faster, they tend to spread further apart, and the resulting changes in the arrangement—not the mass, composition, or individual properties—of particles causes changes in state.

HEAT, TEMPERATURE, AND THERMAL ENERGY

All matter is made of particles (atoms or molecules) that are constantly vibrating; this motion would only stop at absolute zero. The energy associated with this random particle motion is called *thermal energy*. The amount of thermal energy contained in a substance depends on the speed of particle motion, the mass of the substance, interactions among the particles, and the state of matter. Temperature is a measure of the average kinetic energy of particles of matter. Therefore, temperature is directly proportional to but not a direct measurement of thermal energy. Though we use the word in different ways in everyday life, *heat* as a scientific term refers only to the transfer of thermal energy from one area or object to another as a result of a difference in temperature between the two areas or objects. Thermal energy always moves from an area with a higher temperature to an area with a lower temperature. Heat moves most efficiently through conduction because particles can collide and transfer their kinetic energy directly. Heat can also move through radiation because infrared radiation is emitted by one object and then absorbed by another object.

CHANGING STATES OF MATTER

The fact that all matter is made up of particles (atoms or molecules) can be used to explain changes in states of matter. As thermal energy is transferred to a substance, the particles making up that substance move faster and tend to spread farther apart. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. In a liquid, the molecules are constantly in contact but are moving about relative to each other. In a gas, they are moving more rapidly and are widely spaced, except for when they happen to collide.

CHEMICAL REACTIONS THAT CAUSE THERMAL ENERGY CHANGES

A chemical reaction occurs when the atoms that make up one or more substances (reactants) are rearranged to form one or more new substances (products). Many reactions involve a change in the total amount of energy stored in the bonds of the products versus the reactants, and reactions can absorb or release energy. The energy absorbed or released can be in the form of heat, light, or sound. Reactions that release heat can transfer thermal energy to the surroundings, and reactions that absorb heat can remove thermal energy from the surroundings.

TEACHER TIPS

The focus of this lesson is on the transfer of thermal energy. Metals feel colder than nonmetals and cause the ice to melt faster for the same reason. They transfer thermal energy more easily than nonmetals. In the case of the melting ice, a metal pan or block easily transfers its thermal energy into the ice cube, causing it to melt. A foam block or plastic cutting board transfers its thermal energy much more slowly and therefore causes the ice to melt more slowly.

Encourage student questions from the ice melting blocks video to motivate Investigation 1. The investigation is most authentic if it is driven by student questions. Facilitate student discourse among each other and publicly with the class to support consensus-building. It is important for the class to take stock in competing ideas and then use evidence to figure out science ideas. It is particularly important to push students to tie their claims to evidence because the evidence will likely contradict the initial idea that ice will melt faster on objects that feel warmer. Be sure to remind students of important lab safety considerations when working with hot water in Investigation 2.

ABOUT THIS LESSON

This lesson was created by the National Science Teaching Association (NSTA) to pair with the Generation Genius video and support *NGSS*.

They have requested we provide the following background with this lesson:

The Next Generation Science Standards (NGSS) are the national standards on how students learn science, and they are based on contemporary research presented in *A Framework for K–12 Science Education (the Framework).* The shift in science teaching and learning required by the Framework is summarized in this infographic: A New Vision for Science Education.

At the start of each Generation Genius lesson, students are presented with a phenomenon, then they try to explain it. Students will notice they have gaps in their knowledge and ask questions, which motivates them to build ownership of science ideas they need in order to explain how or why the phenomenon occurred. The way students build ownership of science and engineering ideas is through active engagement in the science and engineering practices (SEPs). This process of sensemaking, or doing science to figure out how the world works, is one of the major shifts the *Framework* encourages.

To engage in the SEPs, students should be part of a learning community that allows them to share their ideas, evaluate competing ideas, give and receive critiques, and reach consensus. Students can start by sharing ideas with a partner, then with a small group, and finally, with the whole class. This strategy creates opportunities for all students to be heard, build confidence, and have something to contribute to whole-class discussions. Each Generation Genius lesson provides conversational supports to facilitate such productive student discussions to contribute to sensemaking.

Excited to continue your shift toward the new vision for science education? Check out the Generation Genius Teacher Guide page on the NSTA website for resources and strategies to engage every student in your classroom in **doing** science.