Section 2

The Transfer of Heat

Reading Preview

Key Concepts

- What are the three forms of heat transfer?
- In what direction does heat move?
- How are conductors and insulators different?

Key Terms

- conduction
- convection
- convection current
- radiation
- conductor
- insulator

Target Reading Skill

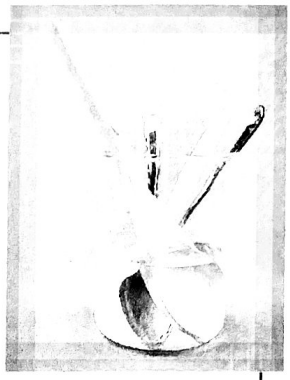
Identifying Main Ideas As you read the How Is Heat Transferred? section, write the main idea in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.

Main Idea

Heat can be transferred in three ways . . .

Detail **Detail** **Detail**

Lab zone **Discover Activity**



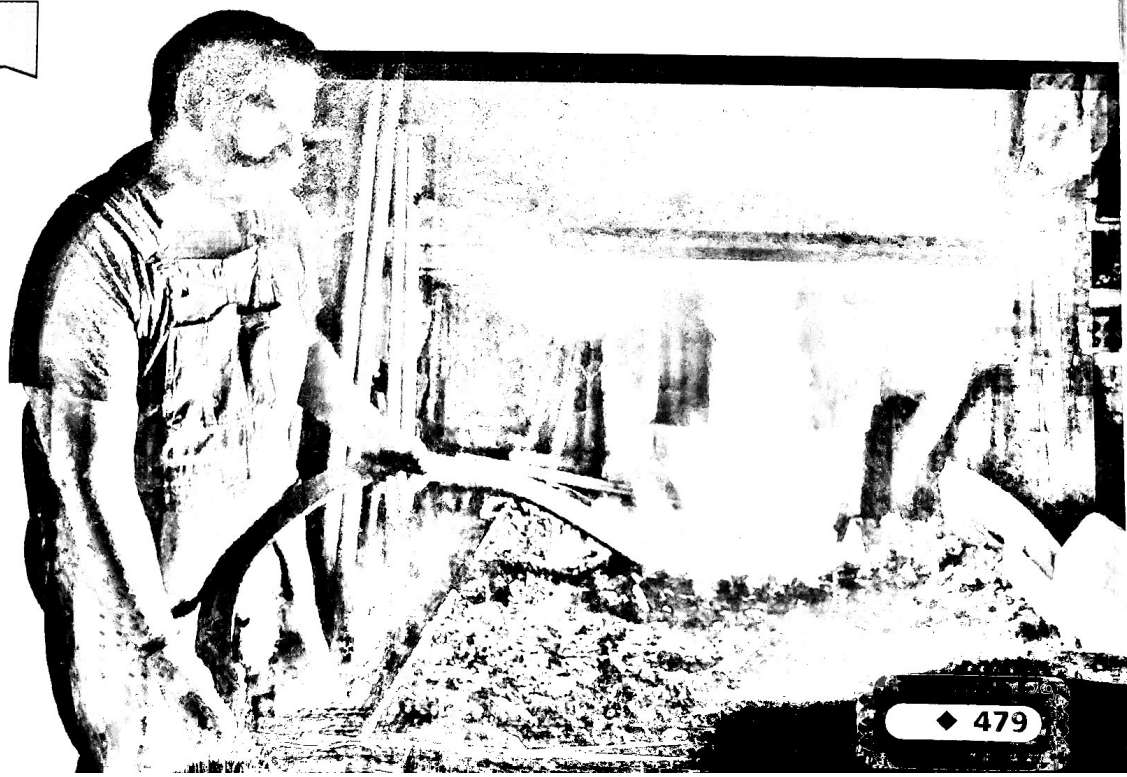
What Does It Mean to Heat Up?

1. Obtain several utensils made of different materials, such as silver, stainless steel, plastic, and wood.
2. Stand the utensils in a beaker so that they do not touch each other.
3. Press a small gob of frozen butter on the handle of each utensil. Make sure that when the utensils stand on end, the butter is at the same height on each one.
4. Pour hot water into the beaker until it is about 6 cm below the butter. Watch the butter on the utensils for several minutes. What happens?
5. Wash the utensils in soapy water when you finish.

Think It Over

Observing What happened to the butter? Did the same thing happen on every utensil? How can you account for your observations?

Blacksmithing is hot work. A piece of iron held in the fire of the forge becomes warmer and begins to glow. At the same time, the blacksmith feels hot air rising from the forge, and his face and arms begin to feel warmer. Each of these movements of energy is a transfer of heat.



A blacksmith at work ▶

Go Online
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For: Links on heat transfer
Visit: www.SciLinks.org
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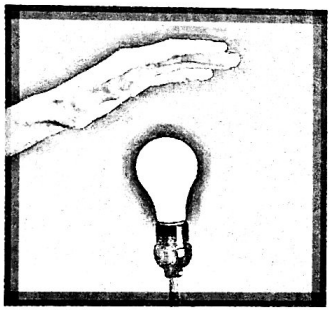
Lab zone Try This Activity

Feel the Warmth

How is heat transferred from a light bulb?



1. Turn on a lamp without the shade. Wait about a minute.
2. Hold the palm of your hand about 10 cm from the side of the bulb for about 15 seconds. **CAUTION:** *Do not touch the bulb. Remove your hand sooner if it gets too warm.*
3. Now hold the palm of your hand about 10 cm above the top of the bulb for about 15 seconds.

Drawing Conclusions
In which location did your hand feel warmer? Explain your observations in terms of heat transfer.

How Is Heat Transferred?

There are three ways that heat can move. **Heat is transferred by conduction, convection, and radiation.** The blacksmith experiences all three.

Conduction In the process of **conduction,** heat is transferred from one particle of matter to another without the movement of the matter. Think of a metal spoon in a pot of water on an electric stove. The fast-moving particles in the hot electric coil collide with the slow-moving particles in the cool pot. The transfer of heat causes the pot's particles to move faster. Then the pot's particles collide with the water's particles, which in turn collide with the particles in the spoon. As the particles move faster, the metal spoon becomes hotter.

If you were to touch the spoon, heat would be transferred to your fingers. Too much heat transferred this way can cause a burn!

In Figure 7, heat from the fire is transferred to the stone beneath it. Then it is transferred from the stone to the metal tools. This transfer of heat from the fire to the tools is due to conduction.

Convection If you watch a pot of hot water on a stove, you will see the water moving. This movement transfers heat within the water. In **convection,** heat is transferred by the movement of currents within a fluid.

When the water at the bottom of the pot is heated, its particles move faster. The particles also move farther apart. As a result, the heated water becomes less dense. You may remember that a less dense fluid will float on top of a denser one. So the heated water rises. The surrounding, cooler water flows into its place. This flow creates a circular motion known as a **convection current.**

Convection currents can transfer heated air. As the air above the fire in Figure 7 is heated, it becomes less dense and rises up the chimney. When the warm air rises, cool air flows into its place.

Radiation **Radiation** is the transfer of energy by electromagnetic waves. You can feel the radiation from a fire in a fireplace all the way across the room. Unlike conduction and convection, radiation does not require matter to transfer thermal energy. All of the sun's energy that reaches Earth travels through millions of kilometers of empty space.

Reading Checkpoint **How does radiation transfer thermal energy?**

FIGURE 7

Methods of Heat Transfer

Heat can be transferred by conduction, convection, or radiation. Heat from a fire is transferred by all three methods.

Interpreting Diagrams *Which of these methods requires the movement of currents with a fluid?*

FIGURE 8
Heat Transfer From Food
The soup's heat is transferred to the bowl, the spoon, and the air.
Predicting *If the soup is not eaten, what will happen to its temperature?*

Heat Moves One Way

If two objects have different temperatures, heat will flow from the warmer object to the colder one. When heat flows into matter, the thermal energy of the matter increases. As the thermal energy increases, the temperature increases. At the same time, the temperature of the matter losing the heat decreases. Heat will flow from one object to the other until the two objects have the same temperature. You have probably seen this happen to your food. The bowl of hot soup shown in Figure 8, for example, cools to room temperature if you don't eat it quickly.

What happens when something becomes cold, such as when ice cream is made? The ingredients used to make it, such as milk and sugar, are not nearly as cold as the finished ice cream. In an ice cream maker, the ingredients are put into a metal can that is packed in ice. You might think that the ice transfers cold to the ingredients in the can. But this is not the case. There is no such thing as "coldness." Instead, the ingredients grow colder as thermal energy flows from them to the ice. Heat transfer occurs in only one direction.

Reading Checkpoint **Can heat flow from one object to a warmer object? Why or why not?**

Lab zone Skills Activity

Inferring

You pull some clothes out of the dryer as soon as they are dry. You grab your shirt without a problem, but when you pull out your jeans, you quickly drop them. The metal zipper is too hot to touch! What can you infer about which material in your jeans conducts thermal energy better? Explain.

Conductors and Insulators

Have you ever stepped from a rug to a tile floor on a cold morning? The tile floor feels colder than the rug. Yet if you measured their temperatures, they would be the same—room temperature. The difference between them has to do with how materials conduct heat. A material can be either a conductor or an insulator. **A conductor transfers thermal energy well. An insulator does not transfer thermal energy well.**

Conductors A material that conducts heat well is called a **conductor.** Metals such as silver and stainless steel are good conductors. A metal spoon conducts heat better than a wooden spoon. Some materials are good conductors because of the particles they contain and how those particles are arranged. A good conductor, such as a tile floor, feels cool to the touch because it easily transfers heat away from your skin.

Insulators A material that does not conduct heat well is called an **insulator.** Wood, wool, straw, and paper are good insulators. So are the gases in air. Clothes and blankets are insulators that slow the transfer of heat out of your body.

A well-insulated building is comfortable inside whether it is hot or cold outdoors. Insulation prevents heat from entering the building in hot weather and from escaping in cold weather. Much of the heat transfer in a building occurs through the windows. For this reason, insulating windows have two panes of glass with a thin space of air between them. The trapped air does not transfer heat well.

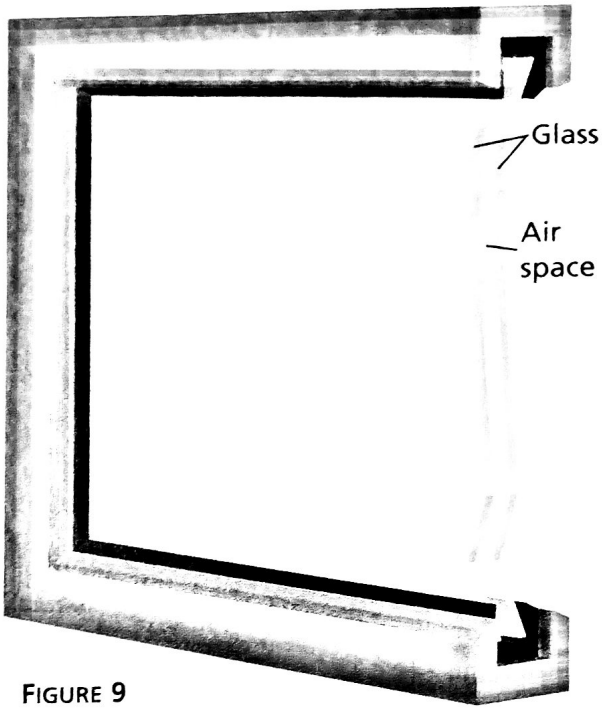


FIGURE 9
Insulating Windows
Air between the panes of this window acts as an insulator to slow the transfer of heat.

Reading Checkpoint **Is air better as an insulator or as a conductor?**

Section 2 Assessment

Target Reading Skill

Identifying Main Ideas Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Describing** What are conduction, convection, and radiation?
   b. **Classifying** Identify each example of heat transfer as conduction, convection, or radiation: opening the windows in a hot room; a lizard basking in the sun; putting ice on a sprained ankle.
   c. **Inferring** How can heat be transferred across empty space?
2. a. **Reviewing** In what direction will heat flow between two objects with different temperatures?
   b. **Applying Concepts** How does a glass of lemonade become cold when you put ice in it?
3. a. **Identifying** What kind of substance conducts thermal energy well?
   b. **Making Judgments** Would a copper pipe work better as a conductor or an insulator? Why do you think so?
   c. **Interpreting Diagrams** Why are two panes of glass used in the window in Figure 9?

Writing in Science

Explanation Suppose you are camping on a mountain, and the air temperature is very cold. How would you keep warm? Would you build a fire or set up a tent? Write an explanation for each action you would take. Tell whether conduction, convection, or radiation is involved with each heat transfer.