Physical Science

Matter and Energy

On Level

Heat Is Energy

LOOK INSIDE FOR:

- Core Curriculum Covered
- Student Book
- Assessments and Reading Activities

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Heat Is Energy

What are some ways that energy can be changed from one form to another?

CORE CURRICULUM STATEMENTS

Energy exists in many forms, and when these forms change energy is conserved.

Energy exists in various forms: heat, electric, sound, chemical, mechanical, light.

Energy can be transferred from one place to another.

Some materials transfer energy better than others (heat and electricity).

Energy and matter interact: water is evaporated by the Sun's heat; a bulb is lighted by means of electrical current; a musical instrument is played to produce sound; dark colors may absorb light, light colors may reflect light.

Heat can be released in many ways, for example, by burning, rubbing (friction), or combining one substance with another.

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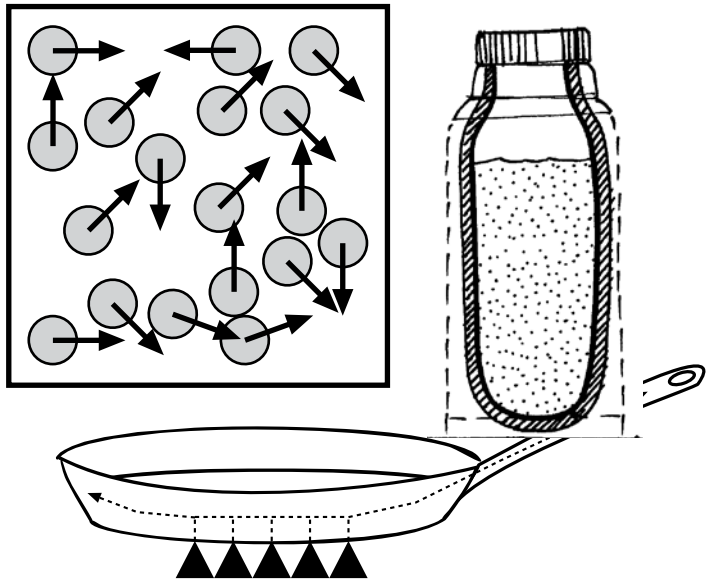
Matter and Energy

Heat Is Energy

by Caitlin Scott



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Curriculum materials for **your** content standards

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– Predict –
What do you think you will learn from reading this book?

Heat Is Essential for Life

Have you ever been outside for a long time on a cold day? You probably didn't get cold right away. Instead, you gradually felt colder and colder. That's because your body **generates** its own heat. However, if the air is colder than your body, your body's heat will be slowly lost.

You know that in the winter you should dress in warm clothes, such as a quilted or down coat, a wool or fleece hat, and mittens or gloves. Warm clothes **insulate** you. They keep your heat from moving away from your body and out into the cold air.

generate: to make
insulate: to keep heat from moving

What would happen if you were outside in winter and got lost or got locked out of your house? Slowly, the sun would set. Without the sun's energy, the air would become colder. Your natural body heat would be lost into the air more quickly, even through your coat, hat, and mittens. You would start to get very uncomfortable, and you might be in danger of freezing.

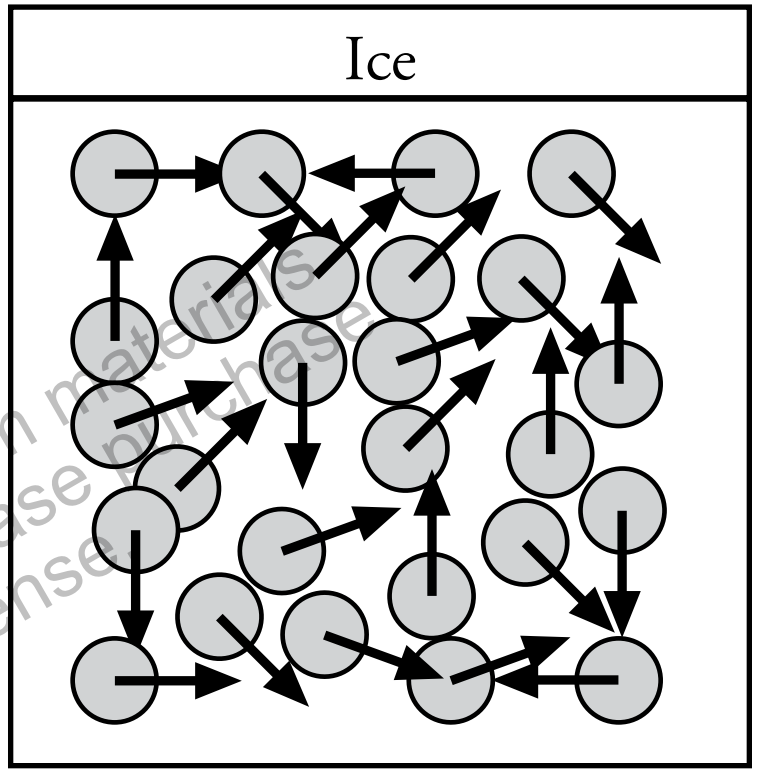
What could you do? First, you might jump up and down or run around to generate more heat, but eventually this would not be enough. You would need to find another source of heat or you might die. Heat energy is essential to human life.

CHAPTER 1

Heat Versus Temperature

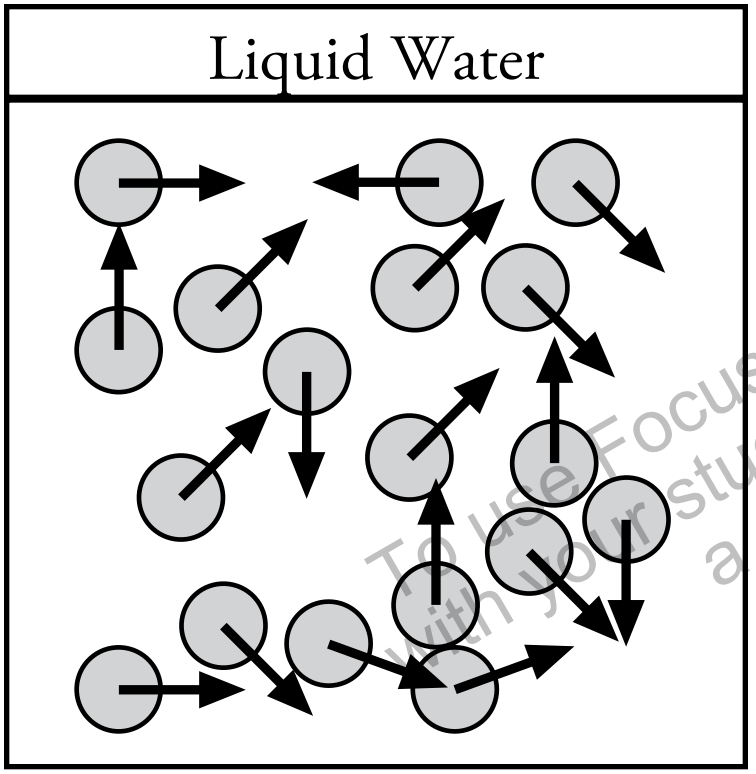
Temperature is a measurement of how hot or cold something is. It is measured using a thermometer. Heat is a form of energy caused by the movement of tiny particles in matter.

Think about water in its three forms—solid, liquid, and gas. In ice, the particles in water are arranged in a set pattern and move slowly. This motion does not generate much heat, therefore ice is cold.



In ice, tiny particles are arranged in a pattern in which they don't move much, so they don't generate much heat.

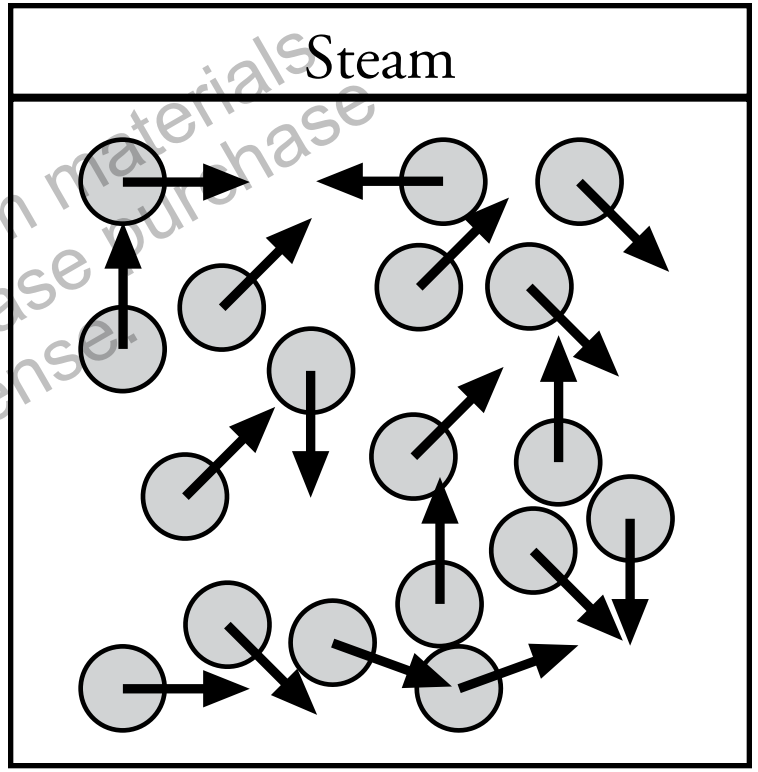
In liquid form, the particles in water move around more. They move more quickly and generate more heat.



In liquid form, particles in water move a bit faster and generate a bit more heat.

– Compare –
Explain why ice is colder than liquid water.

In gas form, the particles of water are farther apart than a liquid, so they move even more quickly and generate lots of heat.



In steam, the particles are farthest apart, so they move most rapidly and generate the most heat.

CHAPTER 2

Heat Transfer

Heat moves, or **transfers**, from a warmer object to one that is cooler. For example, if you are outside on a cold day, your body heat is transferred to the colder air. There are three main types of heat transfer—conduction, convection, and radiation.

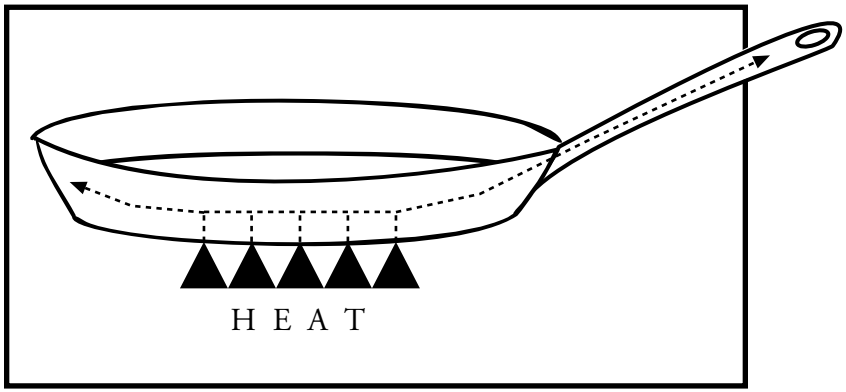
Conduction

Conduction is the movement of heat through solid objects. Think about a metal frying pan with a metal handle. If you are grilling a cheese sandwich, what happens to the metal handle? The handle should get hot after a while. This is because the heat from the stove heats the bottom of the frying pan and then it is transferred up the sides of the pan and into the handle.

transfer—to move from one place to another

Why does heat move like this? Think about the tiny particles in the pan. As the bottom of the pan heats up, they move faster. They bump into other particles in the sides of the pan, so that they start to move faster, too. Finally this bumping moves all the way into the handle.

What would happen if you put a metal lid on the pan? It would eventually heat up, too.



– Explain –
How does conduction cause heat to transfer from a stove to the handle of a frying pan?

Convection

Convection is the transfer of heat through liquids and gases. Heat moves from hotter areas of liquids and gases to colder areas.

Think about what happens when you pour cream into a cup of coffee. The coffee is very hot, but the cream is cool. Because both are liquids, composed mostly of water, the cream and coffee quickly mix together.

During convection, the particles of the cooler cream sink and the particles of the hotter coffee rise. This mixing allows for a rapid transfer of heat energy from the hot particles to the cooler ones. Soon, the temperature will be the same throughout the mixture. Will it be warmer or cooler than the original temperature of the coffee?

Forced-air heating in a house is another example of convection. This type of heating blows warm air into a house through vents in the floor. With forced air heating, does only the floor get warm? No. Convection causes heat to transfer into the entire room, making it nice and warm.

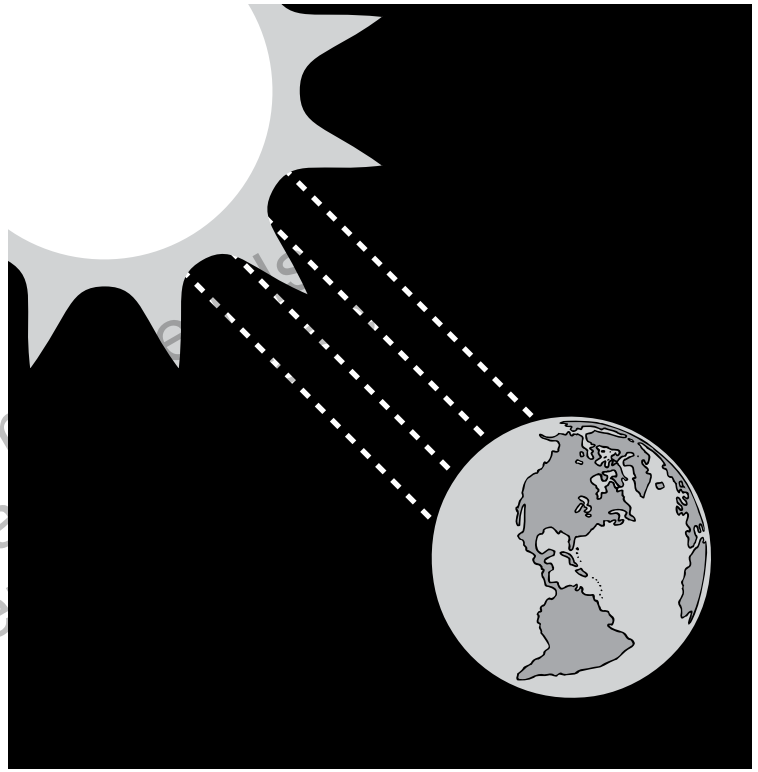
Did you ever wonder why the vents are usually placed on the floor and not in the ceiling? Heat vents are on the floor of a house because warmer air rises to the cooler air near the ceiling. The warmer air travels up to the cooler air and mixes, causing all the air to become warmer.

Radiation

Radiation is heat transfer through a vacuum. A vacuum is an empty space. It has no solid, liquid, or gas particles in it. Outer space, for example, is a vacuum.

What's the one most important heat energy source that radiates to our planet through the vacuum of space? The sun. Light from the sun travels 93 million miles to reach Earth. Life on Earth would be impossible without the heat generated from the sunlight. It would also be impossible without radiation to transfer the sun's heat to Earth.

– Compare –
Explain the difference between conduction, convection, and radiation.



Heat from the sun radiates through the vacuum of space.

– Apply –
Think about all the things you touched today that felt hot. Where did the heat come from? Discuss this with a classmate.

CHAPTER 3

Transfer Materials

You now know that heat moves in three main ways—conduction, convection, and radiation. Some materials allow heat to move through them more quickly. These materials are called conductors. Others slow down the movement of heat. These materials are called insulators.

Conductors

In general, solids are better heat conductors than liquids. And, liquids are better conductors than gases. This is because of how close together the particles are.

In solids, the particles are very close together. Heat moves quickly from one particle to the next. In a liquid, the particles are further apart. Heat moves a little more slowly. In a gas, heat moves even more slowly.

What do we do when we want heat to move quickly from one place to another? We use materials that are good conductors. As you have just read, solids make good conductors.

Think about cooking again. People want heat to transfer quickly from their stoves into their food, so what are pots and pans are made of?

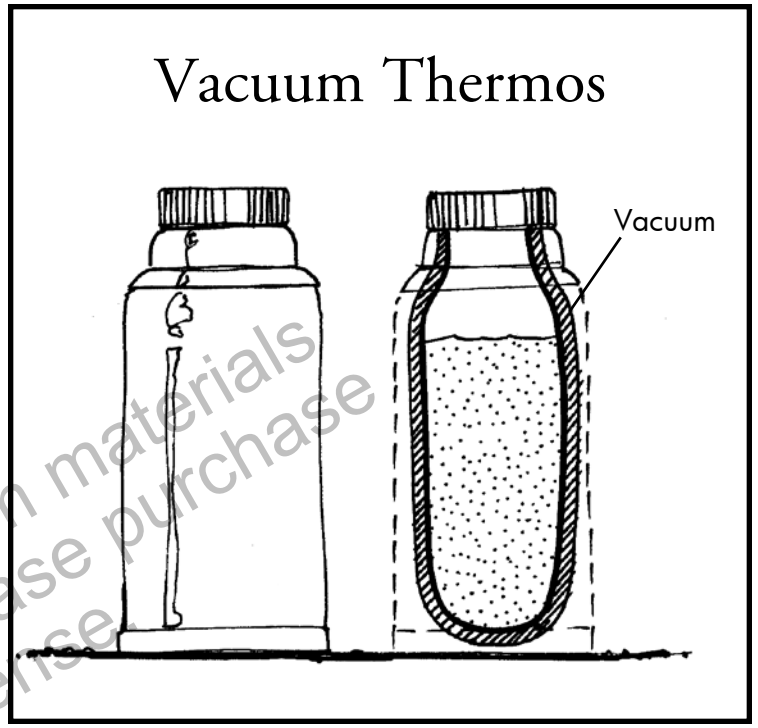
Most often pots and pans are made of metals. This is because most metals are good conductors. Glass is also a good conductor, so some baking dishes are also commonly made of glass. Diamonds are good conductors of heat, too, but diamonds are too expensive to use to make pots and pans.

Insulators

Sometimes we want things to stay warm. When we do, we use insulators. An insulator doesn't conduct heat well. In other words, it slows the movement of heat from one object to another. Coats, hats, and gloves keep you warm in winter because the cotton, wool, or fur that they are made from are good insulators.

The best insulator for conduction and convection is a vacuum. This is because heat travels when particles bump into one another, making heat move from one particle to another. There are no particles in a vacuum. So, heat cannot be conducted.

A vacuum thermos is great for keeping cold liquids cold and hot liquids hot. This kind of thermos has an inner lining and an outer lining. Between these two linings is a vacuum that slows heat transfer by conduction or convection.



This vacuum thermos keeps heat from moving between the liquid inside and the air outside the thermos.

Gases, such as air, are also good insulators. This is because the particles in gases are far apart.

Builders sometimes add fiberglass insulation in walls. Fiberglass has tiny air pockets. These air pockets do not allow heat to move easily from the inside of the house to the cooler outside.

CHAPTER 4

The Mpemba Effect

Scientists from many different countries have done important work that helps us understand heat energy. These scientists have been both men and women. They have been young and old. One important discovery was made by Erasto B. Mpemba. He made his discovery when he was just a 15 year-old high school student in Tanzania, Africa.

For a long time, people thought that liquids cooled, or lost heat, at a **constant** rate. They thought cool water would freeze more quickly than warm water. It just makes good common sense. But, Mpemba proved everyone wrong.

constant: not changing; staying the same

Mpemba was making ice cream in his high school science class. This experiment was supposed to show how liquids change to solids. But, Mpemba did not follow all the directions. He did not cool his cream and sugar mixture before putting it in the ice cream maker. A funny thing happened. His ice cream was done before the rest of the class.

He tried the experiment with hot and cool mixtures again. Again, the warm mixtures froze more quickly. Mpemba had made an important discovery. Other scientists did experiments that showed Mpemba was right. Sometimes warm liquids freeze faster than cold liquids.

Scientists are still trying to figure out why. They call Erasto's discovery the Mpemba Effect.

– Hypothesize –
Why do you think warm liquids might freeze faster than cold liquids? Talk about it with a friend.

Glossary

constant—not changing; staying the same

generate—to make

insulate—to keep heat from moving

transfer—to move from one place to another

To Find Out More . . .

Want to learn more about heat?

Try these books

Energy Projects for Young Scientists by Richard Craig Adams and Robert Gardner. Franklin Watts, 2003.

Environmental Experiments About Renewable Energy by Thomas R. Rybolt and Robert C. Mebane. Enslow Publishers, 1994.

Access these Web sites

Energy Kids Page: The Energy Information Administration
http://www.eia.doe.gov/kids/

U.S. Department of Energy for Students and Kids
http://www.energy.gov/forstudentsandkids.htm

Write for More Information

Energy Information Administration
1000 Independence Ave., SW
Washington, DC 20585
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

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Published by FOCUScurriculum

866-315-7880

www.focuscurriculum.com

Order Number: PS-23OL

Created by Kent Publishing Services, Inc.

Designed by Signature Design Group, Inc.

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Assessments

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Print pages 20–22 of this PDF for the assessments.

Heat Is Energy

Check Understanding

Write your answer on the lines provided.

1. Define the term *heat.*

_____

_____

_____

Explain how heat affects the movement of particles in matter.

_____

_____

_____

_____

_____

_____

2. A student put a pot of water on a hot stove. He also put a thermos filled with water on a hot stove. After several minutes, the temperature of the water was greater in the pot than in the thermos.

Explain what caused the temperature to be different in each container.

1) _____

_____

_____

_____

_____

2) _____

_____

_____

_____

_____

Heat Is Energy

Check Understanding

Write your answer on the lines provided.

3. A student conducted an experiment by placing a metal spoon in a cup of hot tea. She recorded the temperature of the spoon before placing it in the hot tea. After five minutes she took the spoon out and recorded the temperature again. The temperature of the spoon was higher on the second reading.

What process of heat transfer occurred?

_____

Explain how the temperature of a metal spoon was raised when placed in a hot cup of tea.

_____

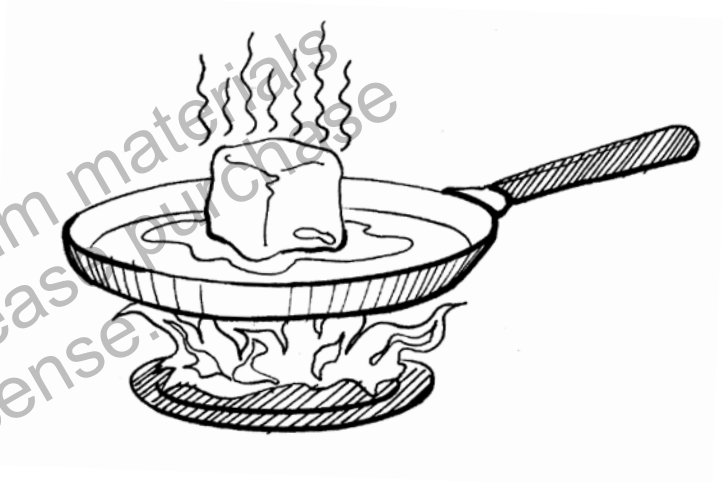
_____

_____

_____

_____

4. The diagram below shows ice melting in a hot metal pan. The handle of the pan is made of wood.



Explain why the handle of the pan is made of wood and not metal.

_____

_____

_____

_____

_____

Heat Is Energy

Assessment Scoring Guidelines

1. Heat is a form of energy caused by the movement of tiny particles in matter.

When tiny particles of matter move quickly, they generate heat. The faster they move, the more heat is generated.

2. The temperature of the water in the pot increased because heat from the stove was able to pass through the pot and into the water. The pot was a good conductor of heat.

The water in the thermos did not increase as much because a thermos has a vacuum inside it. Heat does not transfer well in a vacuum. A vacuum is a good insulator of heat.

3. Conduction was the process of heat transfer.

Heat from the water was transfered to the spoon. The particles if matter in the spoon then began to move. This caused heat to be generated in the spoon.

4. The handle is made of wood because wood does not conduct heat as well as metal. It is safer to hold the pan by the wood handle because it will not be as hot.

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English Language Arts Activities

Heat Is Energy

Print pages 24–28 of this PDF for the reading activities.

Main Idea and Supporting Details

The main idea is the writer's main point, while supporting details give more information about this main idea.

Read this paragraph from *Heat Is Energy*.

In general, solids are better heat conductors than liquids. And, liquids are better conductors than gases. This is because of how close together the particles are.

In solids, the particles are very close together. Heat moves quickly from one particle to the next. In a liquid, the particles are further apart. Heat moves a little more slowly. In a gas, heat moves even more slowly.

Main Idea

Solids are better heat conductors than liquids, and liquids are better than gases.

Supporting Details

- In solids, the particles are very close together, so heat moves quickly from one particle to the next.
- In a liquid, however, the particles are further apart, so heat moves a little more slowly.
- In a gas, because the particles are even further apart, heat moves even more slowly.

TRY THE SKILL

Read this passage from *Heat Is Energy*.

The best insulator for conduction and convection is a vacuum. This is because heat travels when particles bump into one another, making heat move from one particle to another. There are no particles in a vacuum. So, heat cannot be conducted.

Now complete this graphic.

Main Idea

Supporting Details

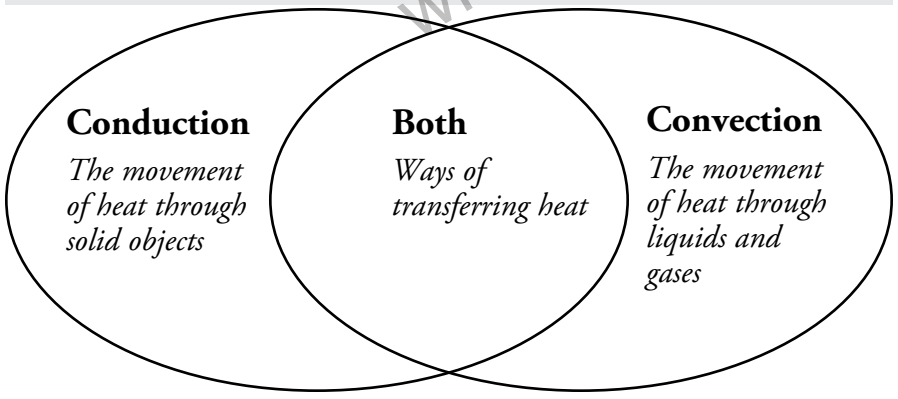
Compare and Contrast

Comparing and contrasting can help you understand what you read. Comparing tells how things are alike. Contrasting tells how things are different.

Read these paragraphs from *Heat Is Energy*. Then, read the Venn diagram that compares and contrasts.

Conduction is the movement of heat through solid objects. Think about a metal frying pan with a metal handle. If you are grilling a cheese sandwich, what happens to the metal handle? The handle should get hot after a while.

Convection is the transfer of heat through liquids and gases. Heat moves from hotter areas of liquids and gases to colder areas. Think about pouring cream into a cup of coffee. The coffee is very hot, but the cream is cool. The cream quickly mixes with the coffee.



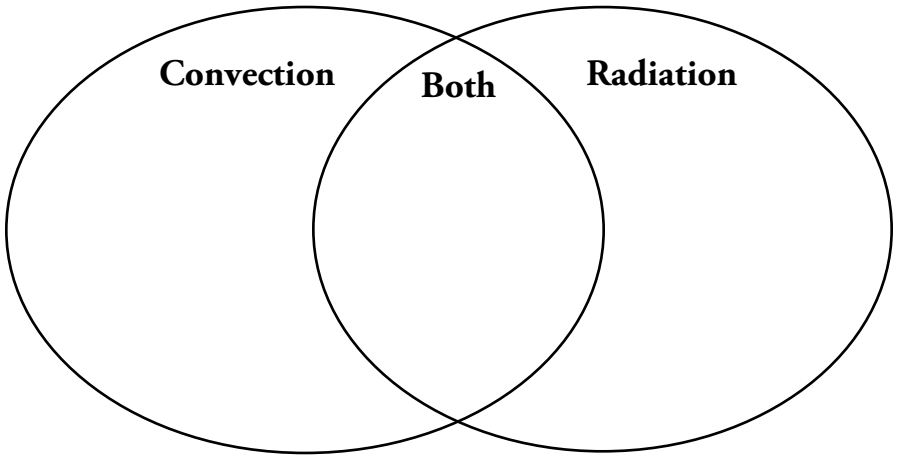
TRY THE SKILL

Read the paragraphs. Think about comparing and contrasting. Then complete the Venn diagram.

Convection is the transfer of heat through liquids and gases. Heat moves from hotter areas of liquids and gases to colder areas. Think about pouring cream into a cup of coffee. The coffee is very hot, but the cream is cool. The cream quickly mixes with the coffee.

Radiation is heat transfer through a vacuum. A vacuum is an empty space. It has no solids, liquids, or gases in it. Outer space, for example, is a vacuum.

What's the one most important heat energy source that radiates to our planet through the vacuum of space? The sun. The light from the sun travels 93 million miles to reach Earth.



Suffixes

Suffixes are short syllables at the end of words that change the meaning of the word. The suffixes *-or* and *-er* can change a verb to a noun. They mean a person or thing that does the verb. For example, a driver is someone who drives.

The suffix *–tion* can also change a verb to a noun. It means the act of doing the verb. For example, attention is when you attend or pay attention to something.

Read this passage from *Heat Is Energy* and find the words that ends with these suffixes.

Heat moves in three main ways—conduction, convection and radiation. But, some materials allow heat to move more quickly. Others slow down the heat. Materials that speed up heat are called conductors. Those that slow heat down are called insulators.

What words end with the suffixes *-or* and *-tion*?

conduction, convection, radiation, conductors, insulators

Use what you know about the suffixes *-or* and *-tion* to determine the meanings of *conduction* and *conductors*?

Conduction means transferring heat through solids. A conductor is an object that transfers heat well.

TRY THE SKILL

Here are some more words that use these suffixes. Use what you know about this suffix to match the words with their definitions.

Word
1. conduction
2. insulator
3. insulation
4. radiator
5. radiation

Definition

A. not allowing heat to transfer from one object to another _____

B. transferring heat through a vacuum _____

C. an object that transfers heat through a vacuum _____

D. transferring heat through solids _____

E. an object that does not allow heat to transfer well _____

Short Essay Questions

Some questions require more than a one-word answer. You are expected to write several sentences. These steps will help you plan your answer:

1. Read the question carefully. Underline any key words.
2. Make sure you know how to answer. Should your answer be a fact, an opinion, an explanation, or an example? Are you supposed to compare two things?
3. Write your main idea first. Then add details to support that idea.
4. Write in complete sentences. Check your spelling and grammar.

TRY THE SKILL

Use the tips to answer these questions. Use the back of this sheet for more room to write.

1. Compare heat and temperature. Tell how they are the same and different. Give an example to show the difference.

_____

_____

_____

_____

_____

2. The water cycle causes clouds and rain. How does convection cause the water cycle?

_____

_____

_____

_____

_____

Answer Key

Main Idea and Supporting Details

Main Idea:

The very best insulator is a vacuum.

Supporting Details:

- Vacuums insulate well, because heat travels when particles bump into one another and make heat move from one particle to another.
- There are no particles in a vacuum; therefore heat cannot be transferred within a vacuum.

Compare and Contrast

Convection: Movement of heat through liquids and gases

Both: Ways heat is transferred

Radiation: Heat transfer through a vacuum

Suffixes

1. D

2. E

3. A

4. C

5. B

Short Essay Questions

1. Heat and temperature both measure thermal energy. Heat describes total energy, but temperature measures the amount of heat. For example, a baby and his mother are the same temperature. However, the mother is bigger and has more particles, so she has more heat or total energy.

2. Convection moves heat through liquids and gases. Heat moves from hotter areas to cooler ones. By convection, the sun heats liquid water, causing it to change into gas. Then convection makes this warm air rise into the cooler air and form clouds.