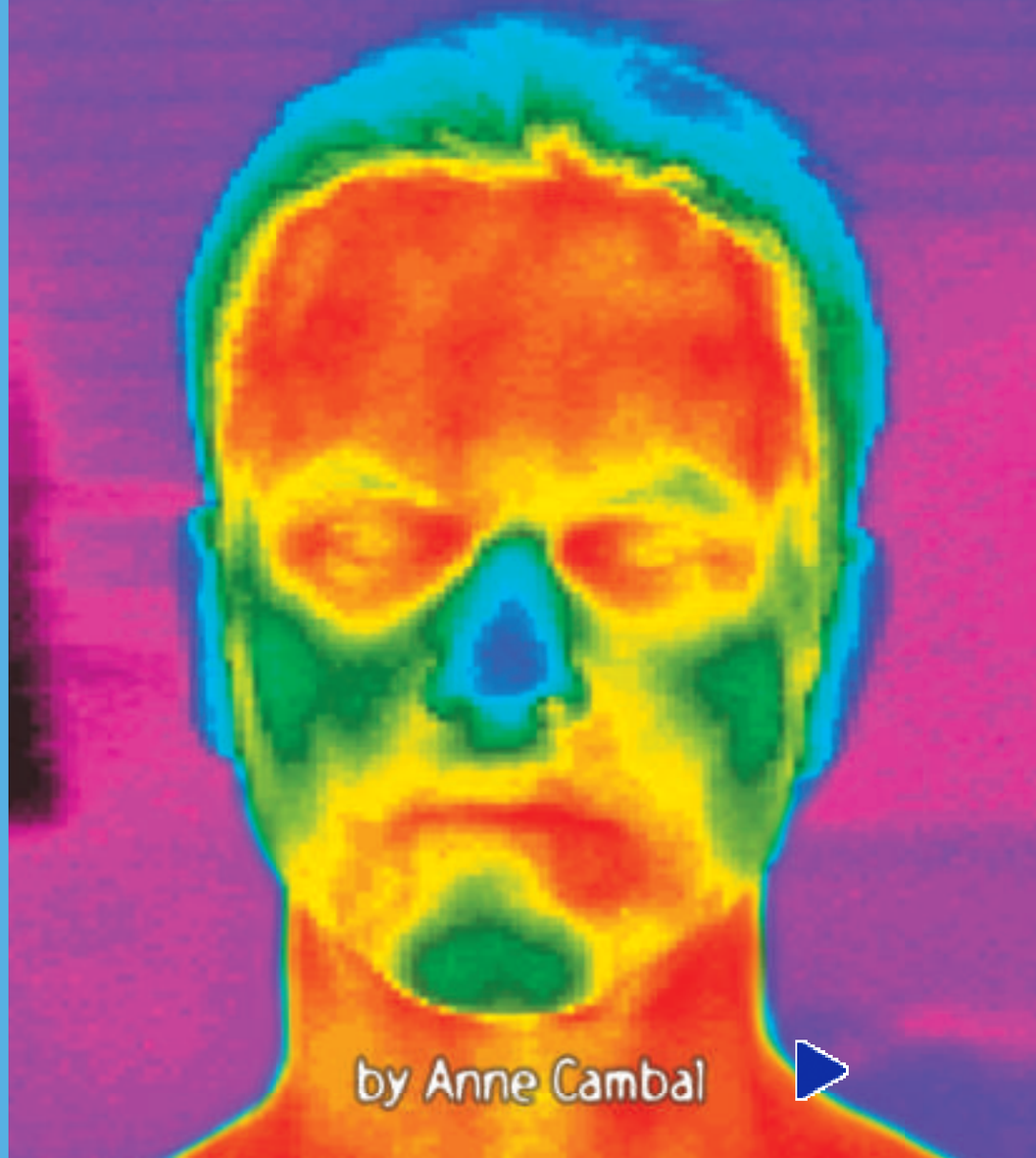
Science

Science

Physical Science

How Hot?



by Anne Cambal

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Cause and Effect	• Captions • Labels • Text Boxes • Glossary	Heat

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Vocabulary	Extended Vocabulary
conduction	geothermal
conductor	infrared
convection current	Kelvin
insulator	molecules
radiation	probe
thermal energy	thermal columns
	thermographic

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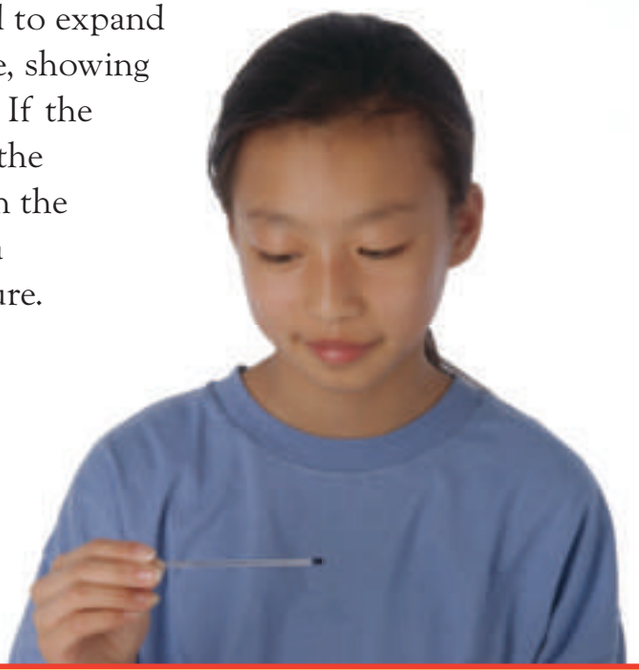
What You Already Know

All matter is made up of tiny particles. In all forms of matter—solid, liquid, and gas—particles move because they have energy.

Particles move faster as matter heats up, and they slow down as matter cools. Thermal energy is the energy made by the movement of the particles in the matter. We feel the movement of thermal energy as heat.

A thermometer is an instrument for measuring temperature. It has a thin glass tube attached to a bulb that holds colored alcohol. When a thermometer touches matter that contains rapidly moving particles, the particles in the thermometer move rapidly as well. This causes the liquid to expand and move up the tube, showing a higher temperature. If the particles slow down, the liquid contracts. Then the thermometer shows a decrease in temperature.



Thermometers can measure body temperature.

Conduction is the transfer of heat energy when one thing touches another. Many metals are good conductors. A conductor allows heat to move easily through it. But substances such as wood, marble, and plastic are insulators. An insulator limits the amount of heat that passes through it.

Metal saucepans are good conductors of heat.

A fluid is a substance that flows but has no definite shape. Fluids such as air or water move by convection. A convection current is a pattern of flowing heat energy. It forms when heated fluid expands. Cooler fluid sinks below warmer fluid. The warm fluid is forced up, and the pattern starts again.

Radiation is energy sent out in waves. Objects exchanging heat through radiation do not need to touch. Radiation can move energy over great distances.

These processes explain how heat is transferred. In the next sections, explore different ways of measuring temperature and learn about the temperature extremes on Earth and in space.

Heat and Temperature

Heat and *temperature* are words that are often used as if they mean the same thing. However, they are not the same. In order to know how hot something is, you need to know its temperature.

All objects are made up of moving particles called molecules. Temperature is a measure of the average speed that the molecules are moving. Heat, on the other hand, is a measure of the total energy of all the molecules in the object. These scientific definitions are probably different from how you usually think of the words *heat* and *temperature*.

penguins on an iceberg in Antarctica

cup of coffee

Which has more heat: an iceberg or a cup of coffee? It's easy to figure out that the iceberg has a lower temperature than a cup of coffee. Now think about the definition of heat. Did you figure out that the iceberg also has more heat? An iceberg is much larger than a cup of coffee. Therefore it contains many more molecules than the cup of coffee. More molecules mean more energy of motion. Although the molecules are moving faster in the coffee, there are more molecules that have energy in the iceberg. So the iceberg has more heat!

Moving Molecules

Ice is a solid. Its molecules are close together. They move only slightly and in fixed positions. Water is a liquid. Its molecules easily flow past each other. Molecules of a liquid are packed less closely than molecules of a solid.

ice molecules

water molecules

Measuring Temperature

Thermometers are used to measure temperature. There are different types of scales used in thermometers. The Celsius and Fahrenheit scales are most common. The temperature on the Fahrenheit scale at which water freezes is 32˚F. Water boils at 212˚F. On the Celsius scale, water freezes at 0˚C. It boils at 100˚C.

Thermometers measure temperature in different ways. A digital thermometer uses a heat-sensitive electronic probe to detect temperature. Other thermometers use a column of liquid—generally alcohol or mercury—in a sealed tube. They have a scale showing degrees.

digital thermometer

mercury thermometer

Liquid crystal thermometers are put on a person's forehead. They indicate temperature by color.

Celsius and Fahrenheit

You've already learned that water freezes (and ice melts) at 0˚C. You also know that water boils (and steam becomes a liquid) at 100˚C. Celsius is part of the metric system. Most of the world uses Celsius to measure temperature. However, the United States uses Fahrenheit. Frozen water that is 32˚F is just as cold as ice that's 0°C. Boiling water that is 212˚F is just as hot as boiling water that is 100˚C. The only difference is in the scales that were used to indicate and measure the two readings.

ice

steam from boiling water

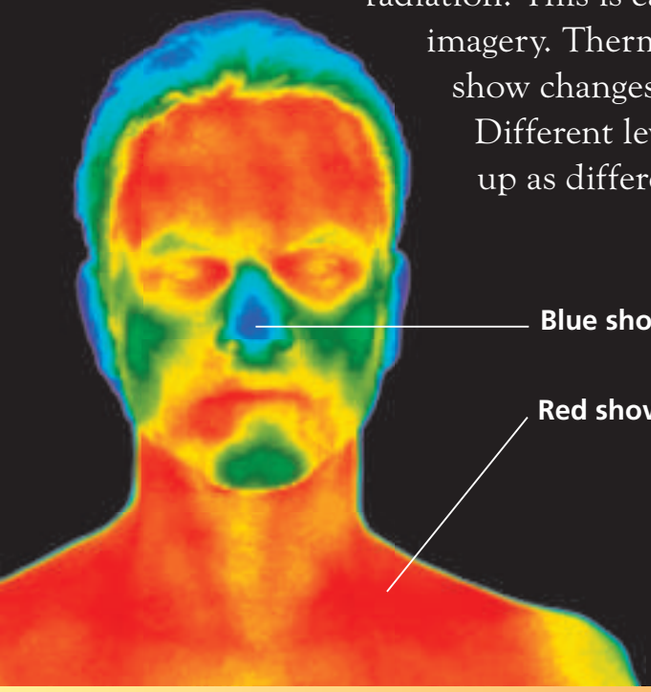
The National Aeronautics and Space Administration, or NASA, uses a thermometer with a different scale to measure temperatures in space. Scientists measure temperature with the Kelvin scale. The Kelvin scale measures greater temperature extremes than we need to measure in everyday life.

The scale you use to measure temperature depends on what and where you are measuring. For example, a veterinarian might measure your dog's temperature using the Fahrenheit scale. Many people in the world use the Celsius scale to measure air temperature.

Heat on the Move

Heat generally flows from matter at a higher temperature to matter at a lower one. A warm dish removed from a heated oven will gradually cool down. The dish passes its heat to the cooler air around it and to the surface on which it's resting. The dish then becomes cooler.

Radiation is one form of heat transfer. Radiation is heat that moves in rays or waves. Although we can't see it without the use of instruments, all objects and materials emit infrared radiation. Infrared radiation is an energy similar to light. We can use special infrared cameras to produce pictures or images that show this radiation. This is called thermographic imagery. Thermographic images show changes in surface heat. Different levels of heat show up as different colors.



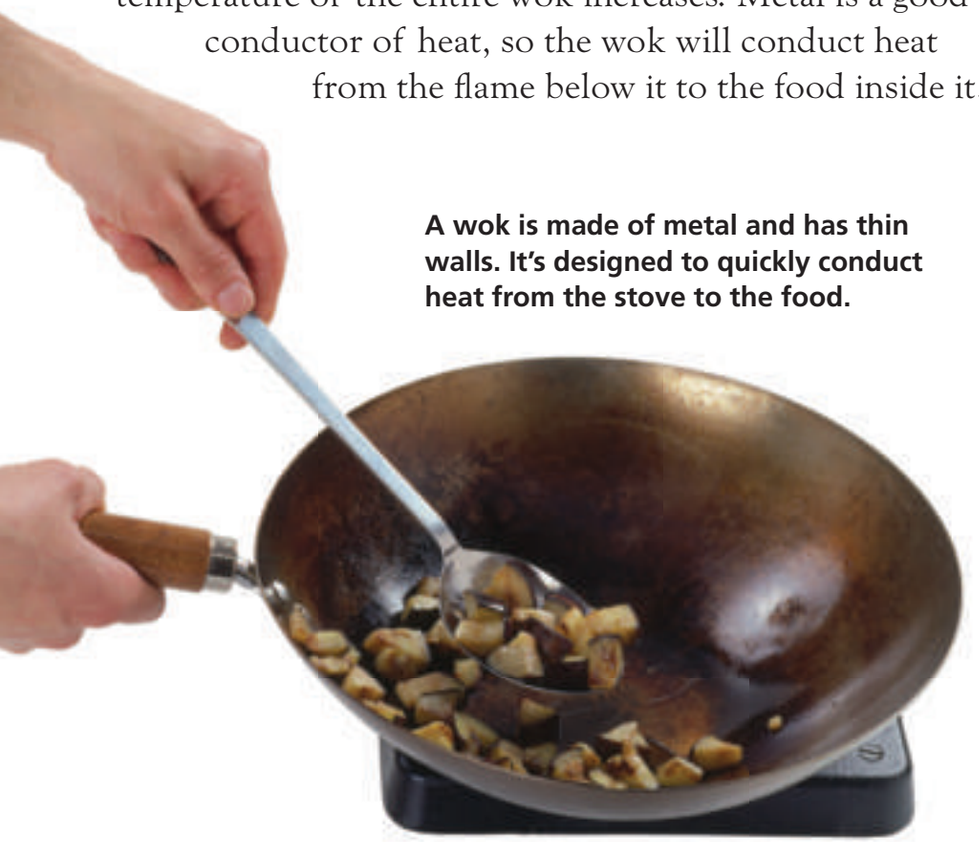
A thermographic image shows variations in heat given off by different parts of the body.

Hang gliders soar on convection currents.

Heat transfer through fluids is called convection. Convection is another way that heat travels. A convection current is produced when heat moves in a pattern. When the Sun heats an area on the ground, the air near the ground is also heated. This warm air expands and rises. Thermal columns, or columns of rising hot air, develop. The moving air within these columns allows hang gliders to soar through the sky. Pilots of gliders and hang gliders look for places on the ground that the Sun will heat well, such as areas covered with blacktop. These areas will be good sources of thermal columns.

Conduction and Insulation

Conduction is another kind of heat transfer. Conduction occurs when vibrating molecules bump and then transfer energy to the molecules next to them. An example of heat transfer by conduction begins when a metal wok, such as the one below, is placed over a flame. In a short time the flame causes the temperature of the metal wok to increase. This, in turn, speeds up the movement of the molecules in the wok. Soon the temperature of the entire wok increases. Metal is a good conductor of heat, so the wok will conduct heat from the flame below it to the food inside it.



A wok is made of metal and has thin walls. It's designed to quickly conduct heat from the stove to the food.

Inuit children dress in insulating clothes to keep warm in Alaska's cold climate.

Heat conducts through some materials better than others. Poor conductors, such as wood and air, are called insulators. These materials help to trap or hold heat rather than transferring it. This is called insulation. Multiple layers of cold-weather clothing help people keep warm in very cold temperatures. The layers of clothing and the air pockets in them trap and hold warm air next to the body. Dressing in layers helps you stay warm when you are outside in very cold weather.

Buildings need insulation too. Heating and cooling expenses are usually more than half of a home's energy costs. Adding insulation to the attic of a home can greatly reduce the cost of energy. When it is cold outside, insulation helps keep warm air inside a building. It does the reverse in hot weather. Then it helps keep a building cool.

Earth's Extremes

Temperatures vary from state to state and around the world. The people of San Antonio, Texas, have a different idea of summer than those in Reykjavik, Iceland. Spring in Thunder Hawk, South Dakota, is not the same as it is in Tokyo, Japan. Scientists track and record temperature, wind, and other weather extremes around the world.

So far the hottest place on Earth is Al Aziziyah, Libya. The temperature reached 57.3°C (136°F) on September 13, 1922. The coldest temperature ever recorded is –89.2°C (–128.6°F). This occurred in Vostok, Antarctica, on July 21, 1983.

Ice can be found around the world. There are glaciers on every continent except Australia. About three-fourths of the world's fresh water is frozen in glaciers. The Bering Glacier is the longest in the United States. It's more than 204 kilometers (127 miles) long.

Death Valley, California, is the second-hottest location on Earth. In 1913, a temperature of 56.67°C (134°F) was recorded there.

When volcanoes erupt, they can shoot hot lava high into the air.

In volcanic eruptions, red-hot lava bursts from deep inside Earth to the outermost surface. This molten, or melted, rock can be as hot as 1,200°C (2,200°F).

Geysers and hot springs are geothermal. They are heated by the interior of Earth. They produce water that is significantly higher in temperature than the air around them.

Ultimate Temperatures

Suppose you are traveling though our solar system. What kinds of temperatures do you think you would find? The temperature on the surface of the Sun is about 5,500°C (9,900°F)! The Sun affects weather not only on Earth but also in space.

The temperature on the planets varies quite a bit. Mercury reaches about 400°C (755°F) when it is closest to the Sun. When it is farthest from the Sun, it cools to –175°C (–280°F). When the Moon faces the Sun, it may reach a temperature of 101°C (215°F). When the Moon rotates away from the Sun, its temperature can be as low as –153°C (–243°F). Clouds of carbon dioxide gases in its atmosphere help the surface of Venus stay very warm—about 464°C (867°F). The temperature on Mars ranges from –83°C (–118°F) before dawn to –33°C (–28° F) in the afternoon.

Temperature is important to living matter. On Earth, people have learned to adapt to a range of temperatures, but within certain limits. Many plants and animals cannot survive if the temperature of their environment changes much. It is everyone's job to protect Earth for all who live here.

The temperatures in space vary tremendously due to the effects of the Sun.

Glossary

geothermal	relating to Earth's interior heat
infrared	energy similar to light
Kelvin	a scale used by scientists to measure temperature
molecules	moving particles that make up matter
probe	a small instrument used to explore a wound or an opening
thermal columns	columns of rising hot air
thermographic	used for the purpose of detecting heat

What did you learn?

1. Why does an iceberg have more heat than a cup of coffee?

2. Give examples of when someone might measure temperature using the Fahrenheit scale and using the Kelvin scale.

3. Put these substances in order based on how well they conduct heat: wood, glass, silver. List the best conductor first.

4. **Writing** in Science Eagles use convection currents to glide through the sky. Write to explain how they use these currents. Use examples from the book to support your answer.

5. **Cause and Effect** What causes a metal wok to feel hot when it is placed over a flame?