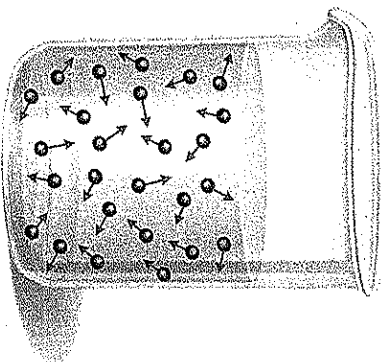


## Thermal Energy

**SEE ALSO**  
 255 Atoms  
 261 Molecules  
 300 Forms of Energy

All matter is made of particles called atoms and molecules. These particles are in constant motion. They vibrate, rotate, or move from one place to another in a random manner. Some move faster than others. Since these particles are in motion, they have kinetic energy. Kinetic energy is the energy an object or substance has due to its motion.

**Match!**  
 The prefix *therm-* means "heat."



Molecules of water have kinetic energy.

**Thermal energy** is the total amount of kinetic energy contained in all the particles of a substance. The greater the kinetic energy of the particles in the substance, the more thermal energy the substance has. But thermal energy also depends on the number of particles in a substance. The more particles a substance contains, the greater its thermal energy.

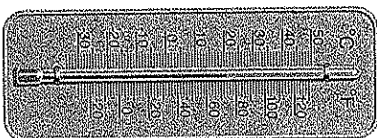
**SEE ALSO**  
 202 Ocean Water  
 302 Temperature versus Heat

**Science Alert!**  
 More thermal energy does not necessarily mean a higher temperature. For example, the ocean, because it is so massive, has far more thermal energy than a pot of boiling water.

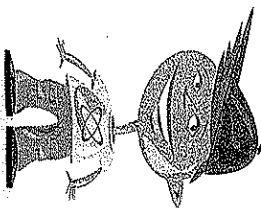
## Temperature versus Heat

When you think of temperature, you probably think "hot" or "cold." To scientists, **temperature** is a measure of the *average* kinetic energy of the particles in a substance. The more kinetic energy the particles have, the higher the temperature of the substance. Unlike thermal energy, however, temperature is not affected by the number of particles the substance contains.

Two common units of temperature are degrees Celsius ( $^{\circ}\text{C}$ ) and degrees Fahrenheit ( $^{\circ}\text{F}$ ).



A thermometer is a device used to measure temperature.



## Did You Know?

An object may feel hot or cold, but you can't tell its temperature just by touching it. That's because your skin can only detect *differences* in temperature, not temperature itself. For example, if your hands are very cold, even a cool object will feel warm.

So if thermal energy is the total kinetic energy of the particles of a substance, and temperature is the average kinetic energy of the particles, what is heat? **Heat** is the transfer of thermal energy between substances that are at different temperatures. The energy is always transferred from the warmer substance (the one with the higher temperature) to the cooler substance (the one with the lower temperature). The term *heat* is also commonly used in place of the term *thermal energy*.

**SEE ALSO**  
 072 Taking Temperature Readings

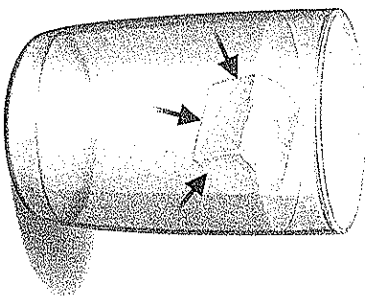
**SEE ALSO**  
 303 Equalization of Temperatures  
 304 Methods of Heat Transfer

303

**Equalization of Temperatures**

Whenever two objects come in contact with each other, heat will transfer (flow) from the object with the higher temperature to the object with the lower temperature. The heat will continue to flow until the temperature of the two objects has equalized, or reached the same temperature.

For example, suppose you place an ice cube in a glass of water. Because the water is warmer than the ice, heat flows from the water to the ice until the two reach the same temperature. Heat does not flow from the ice to the water.



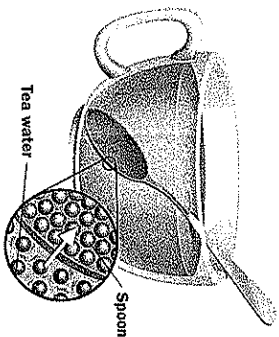
Heat flows from the warmer substance to the cooler substance.

304

**Methods of Heat Transfer**

There are three methods of heat transfer: conduction, convection, and radiation.

**Conduction** is the transfer of heat from a warmer substance to a cooler substance through direct contact. When two substances come into contact, their particles collide. The energy from the faster-moving particles is transferred to the slower-moving particles, until the particles in both substances are moving at the same speed and their temperature has equalized. Conduction is what causes the handle of a spoon placed in a cup of hot tea to warm up.



Transfer of thermal energy by conduction

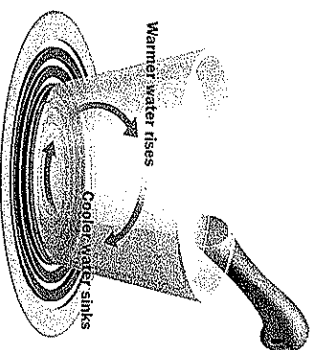
**SEE ALSO**

317 Current Electricity

**Did You Know?**

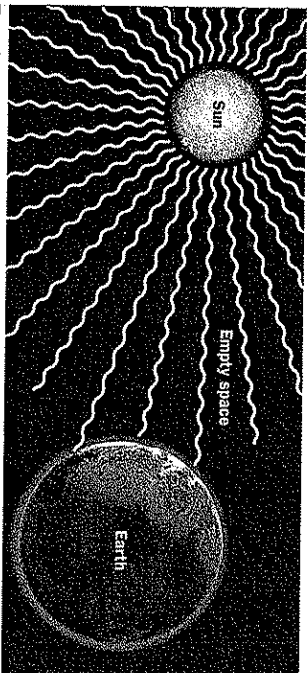
A conductor is a substance that conducts thermal energy (and other forms of energy) well. Metals tend to be better heat conductors than other solids.

**Convection** is the transfer of heat in a fluid through currents. Suppose you place a pot of cold water on a hot stove. As the water at the bottom of the pot heats up, it becomes less dense (its particles spread out and become less compact). Because the warm water is less dense than the cold water above it, the warm water rises and displaces the cold water. The cold water, in turn, sinks. The movement of water that results is called a **convection current**. The convection current transfers thermal energy throughout the water in the pot.



Transfer of thermal energy by convection

**Radiation** is the transfer of energy as electromagnetic waves. Unlike conduction and convection, which involve the collision or movement of particles, radiation can occur through empty space. The sun heats Earth through the process of radiation.



Transfer of energy by radiation

**SEE ALSO**309 Electromagnetic Spectrum  
305 Waves