

**Big Idea:** Energy exists in different forms and can change from one form to another, but energy is always conserved.

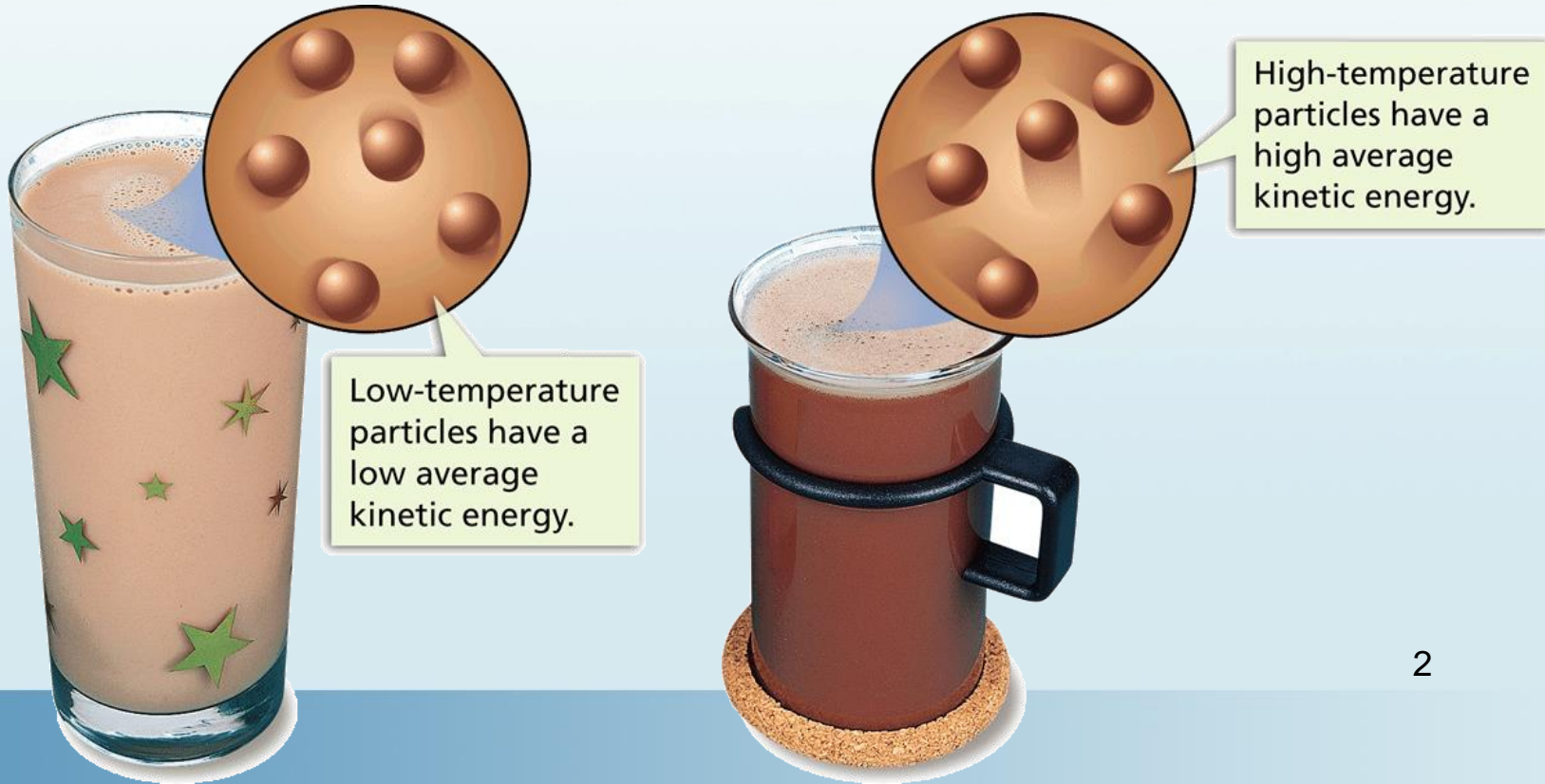


**Unit 2 Lesson 3** Thermal Energy and Heat  
**Essential Question:** What is the relationship between heat and temperature?

# Thermal, Under Where?

## What is thermal energy?

- **Thermal energy** is the total kinetic energy of all particles in a substance.
- Thermal energy is measured in joules (J).



## What is the difference between thermal energy and temperature?

- Temperature is related to the **average** kinetic energy of particles.
- Thermal energy is the **total** kinetic energy of all the particles.
- For example, a glass of water can have the same temperature as a lake, but the lake has much more thermal energy because the lake contains many more water molecules.

5) Temperature and total amount of particles determine the thermal energy of a substance.

# Which has more thermal energy?

Bowl of Soup

Small balloon

Tiger

Pot of Soup

Large balloon

House cat

## Heat It Up!

### What is heat?

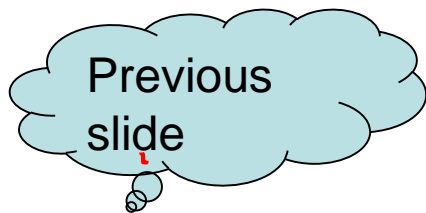
- **Heat** is the energy transferred from an object at a higher temperature to an object at a lower temperature.
- Energy in the form of heat always flows from hot to cold.



Draw an arrow in the direction in which energy in the form of heat would flow.

7)

Object 1	Direction of heat flow	Object 2
Metal rod	←	Fire
Hat	→	Snowman
Ice cube	←	Glass of warm water

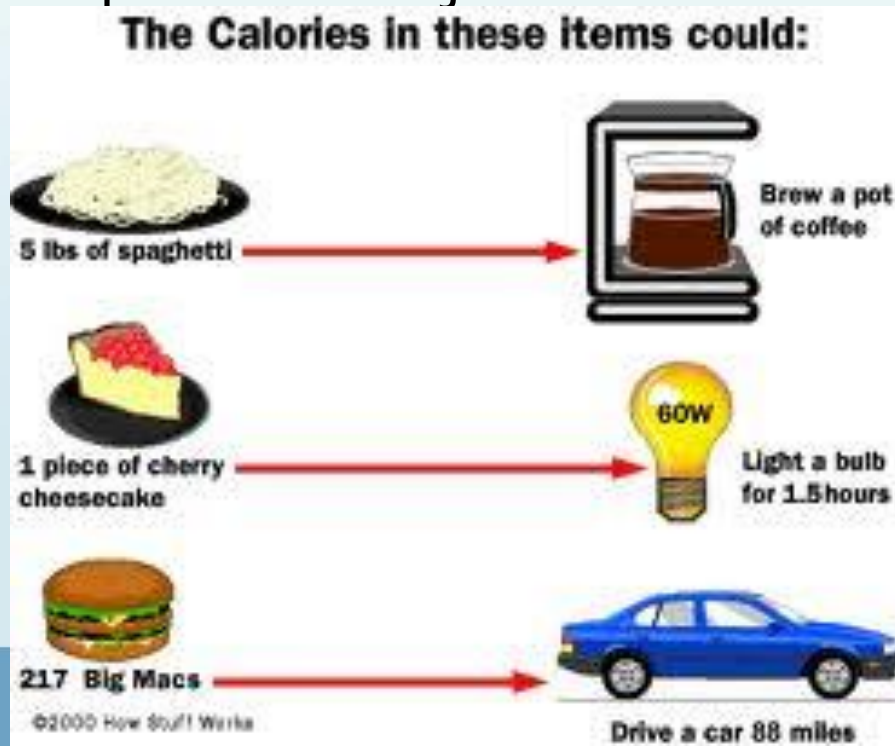


8) Energy as heat is flowing from the girls' warm bodies to the cold air

## How is heat measured?

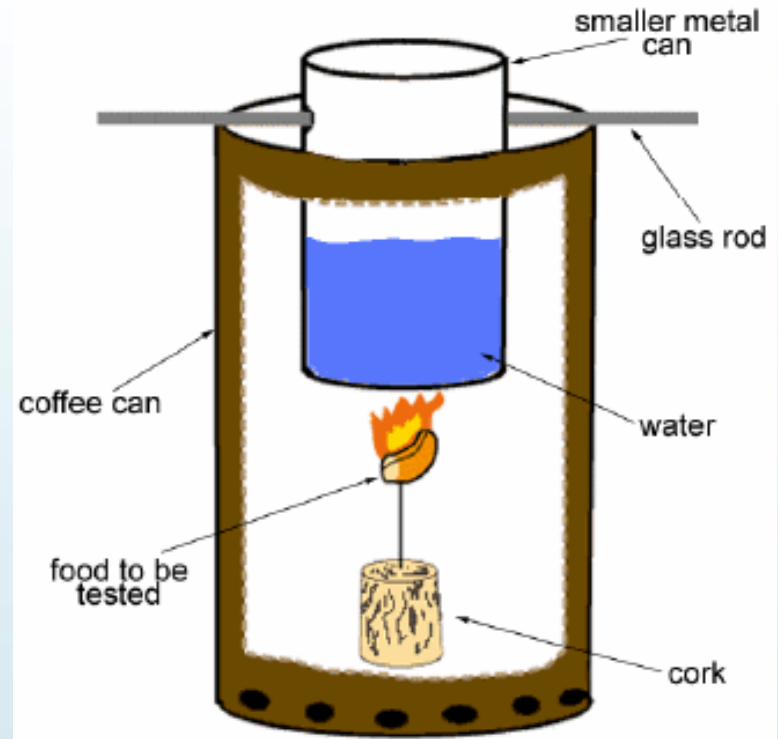
## Heat It Up!

- Heat is measured in two ways.
- One way is the **calorie** (cal)
- One **calorie** is equal to the amount of energy needed to raise the temperature of 1 g of water by  $1^{\circ}\text{C}$ .
- Heat is also measured in **joules** (J) because heat is a form of energy.
- One calorie is equal to 4.18 joules.



## How is heat measured?

- In nutrition, 1 Calorie (with a capital C) is actually 1 kilocalorie, or 1,000 calories.
- To find out how many calories are in food, a sample of food is burned inside an instrument called a calorimeter.
- The change in temperature in the calorimeter is used to calculate how much energy is released from the food sample.





## How is heat related to thermal energy?

- Adding or removing heat from a substance will affect its temperature and thermal energy.
- Heat, however, is not the same as thermal energy and temperature.
- Thermal energy and temperature are physical properties of a substance. Heat is the energy involved when these properties change.
- Even though two materials might have the same temperature, their thermal energies might be different.
- Thermal energy depends on how many particles are present in the object.

9) Energy as heat will be transferred from the warmer object to the cooler object **until** both objects are at the same temperature

# Kinetic Energy of Particles of Matter

Temperature = Average Kinetic Energy

Thermal Energy = Total Kinetic Energy

Measured with a Thermometer

Heat = Transfer of Thermal Energy

Adding or removing heat can change the temp

Energy moves from an area of hot to an area of less hot

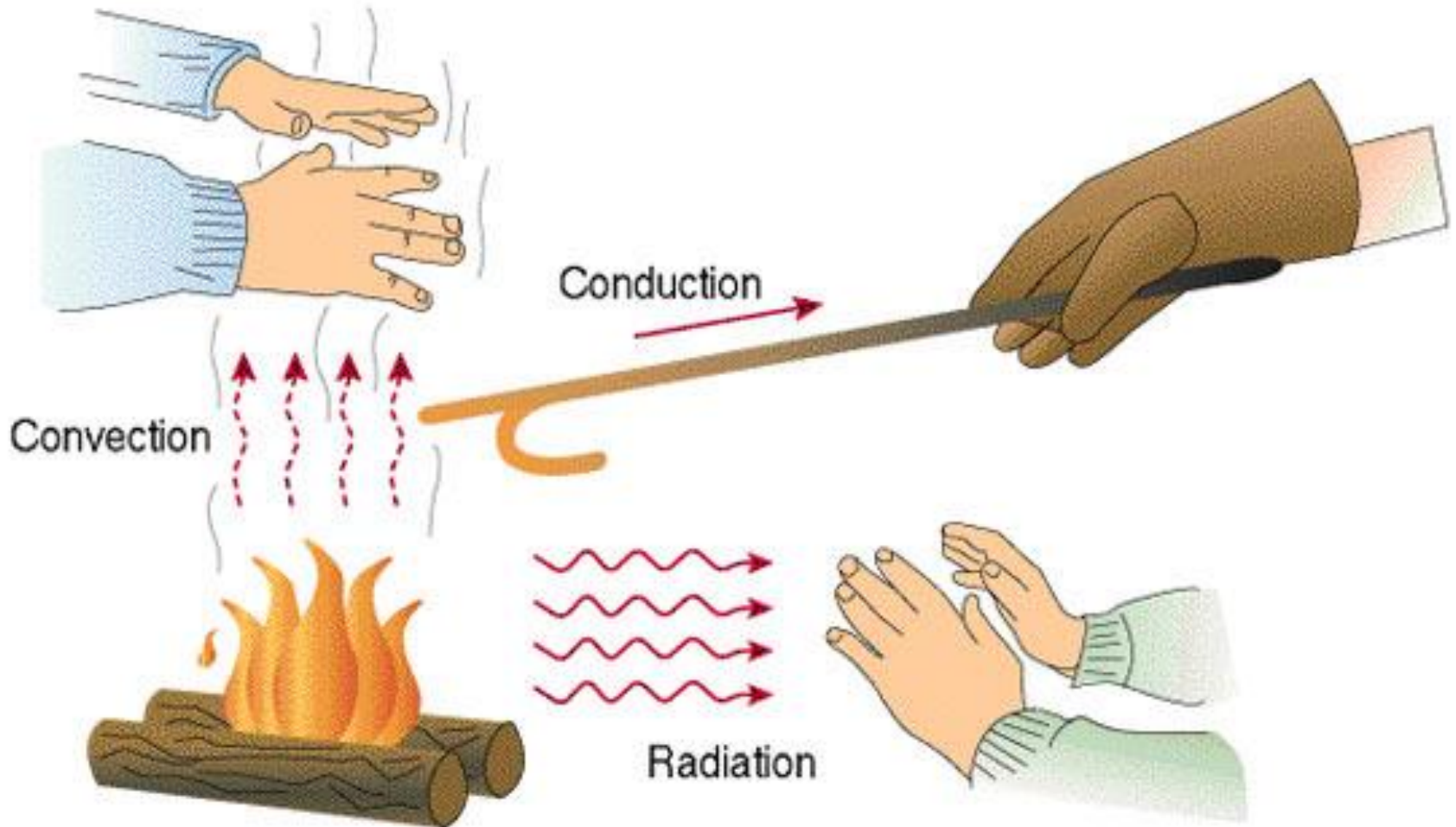
Measured in calorie or Joule

## How can heat affect the state of an object?

- The state of a substance depends on the speed of its particles.
- Adding energy in the form of heat to a substance can result in a change of state.
- Removing energy in the form of heat from a substance can also result in a change of state.

**11) Add energy in the form of heat or subtract energy in the form of heat.**

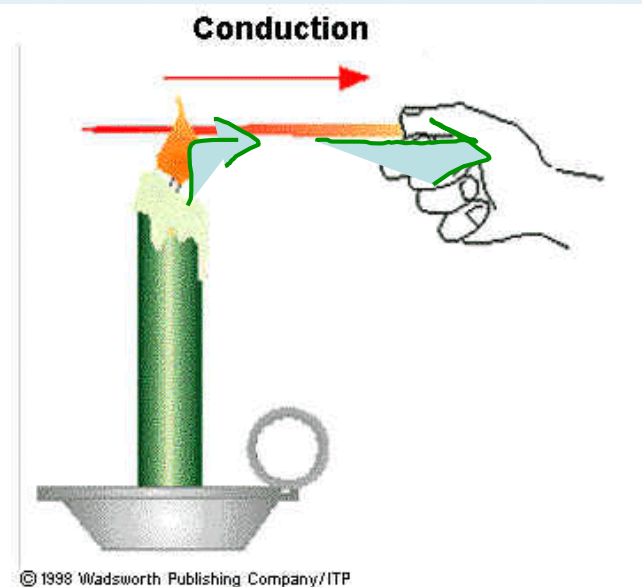
Energy as heat can be transferred in three main ways:



# Keep Your Cool

## What is conduction?

- **Conduction** is the transfer of energy as heat from one substance to another through **direct contact**.
- As long as two objects are in contact, conduction continues until the temperatures of the objects are equal.



# What is conduction?

- A **conductor** is a material that transfers heat very well.
- Metals are typically good conductors.
- An **insulator** is a material that is a poor conductor of heat.
- Wood, paper, and plastic foam are examples of good insulators.







## Flannel Shirt

- conductor
- insulator



## Iron skillet

- conductor
- insulator



## Copper pipe

- conductor
- insulator

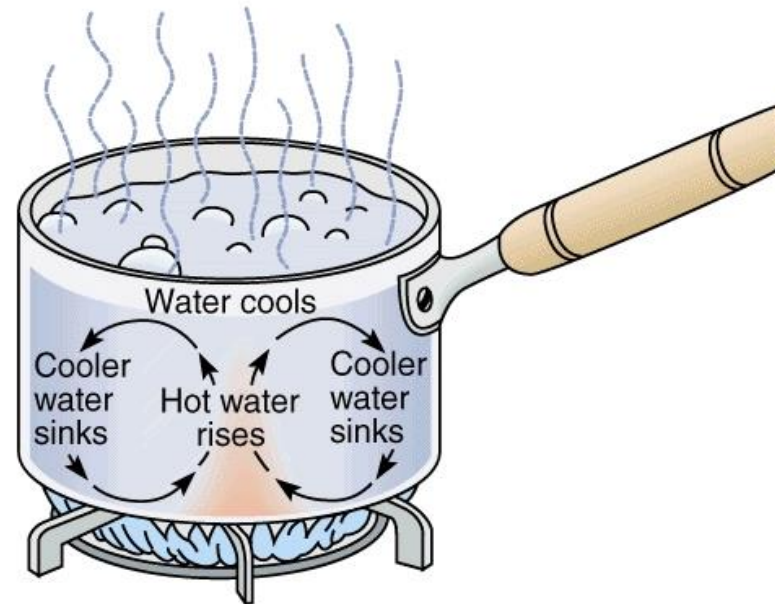


## Oven Mitt

- conductor
- insulator

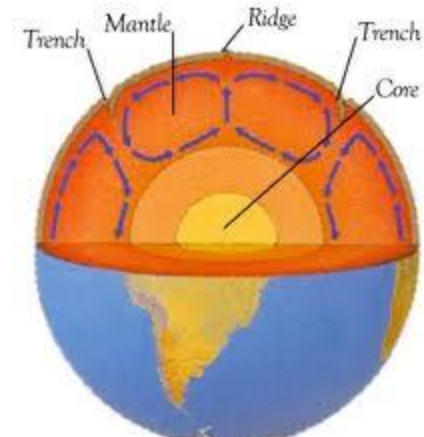
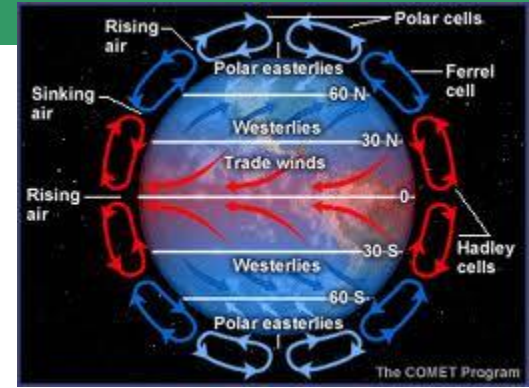
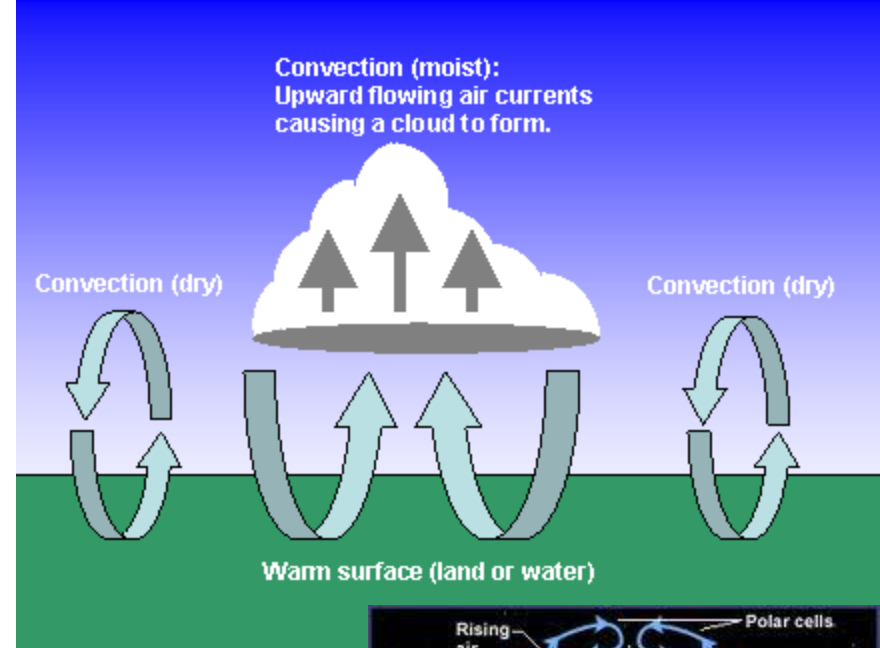
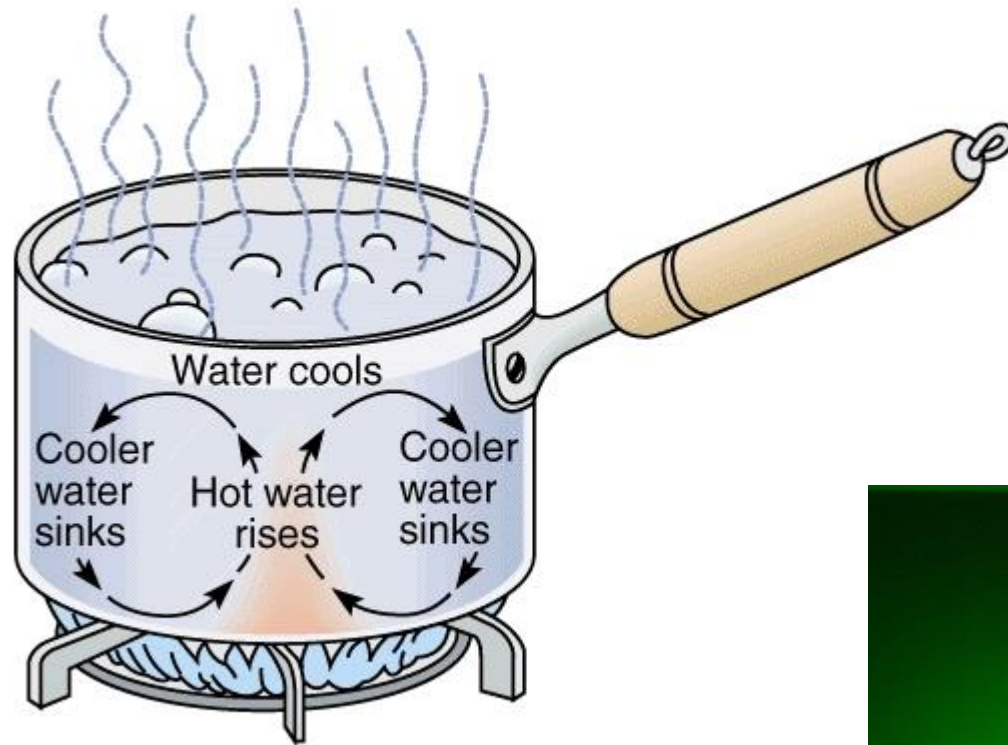
## What is convection?

- **Convection** is the transfer of energy as heat by the movement of a liquid or gas. (FLUID)
- Convection occurs when a cooler, denser mass of gas or liquid replaces a warmer, less dense mass of gas or liquid by pushing it upward.
- When water is boiled, the water moves in roughly circular patterns because convection.
- This motion is due to density differences that result from temperature differences.
- The motion is called a **convection current**.

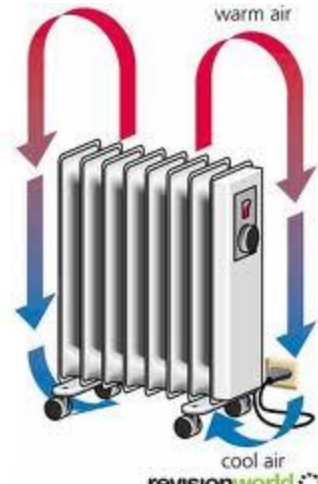
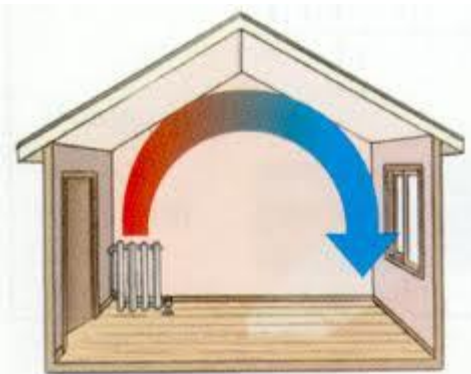




# Convection

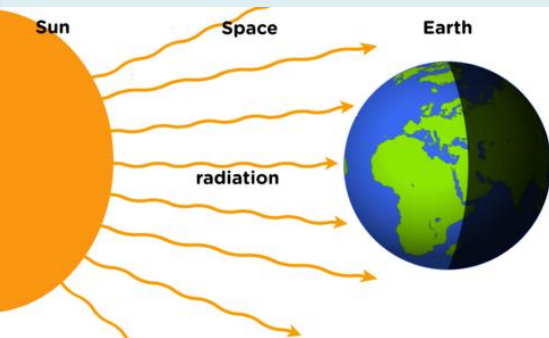


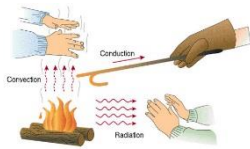
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## What is radiation?

- **Radiation** is the transfer of energy by electromagnetic waves.
- Examples of EM waves: visible light, microwaves, infrared light
- When radiation is emitted from one object and then absorbed by another, the result is the transfer of heat.
- Radiation can travel through empty space.





Example	Conduction, convection or radiation
When you put some food in the microwave, it gets hot.	<b>RADIATION</b>
<b>A hot burner warms a cold pot</b>	conduction
A heater on the first floor of the school makes the air on the second floor warm	<b>CONVECTION</b>

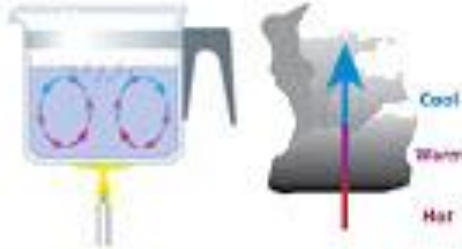
# Conduction

Energy is transferred by direct contact



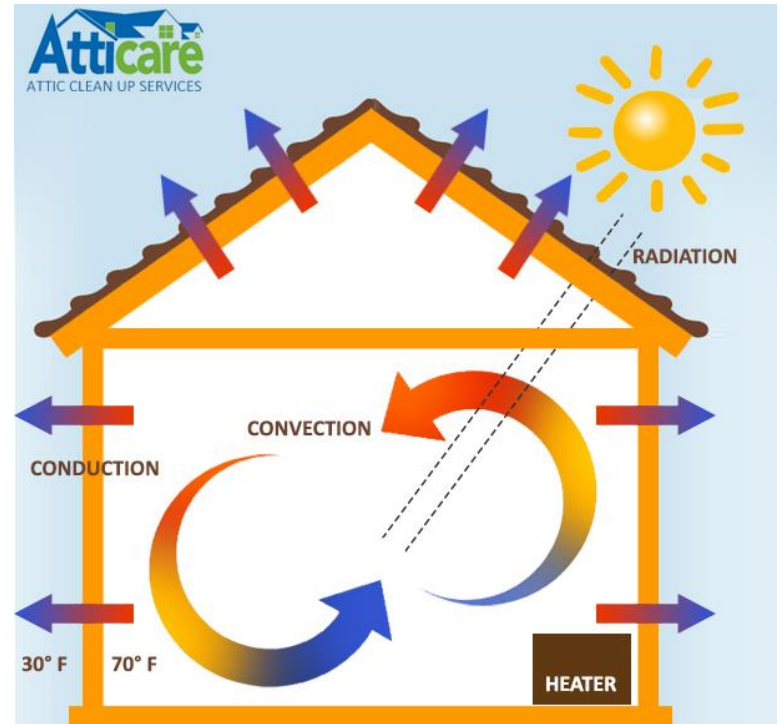
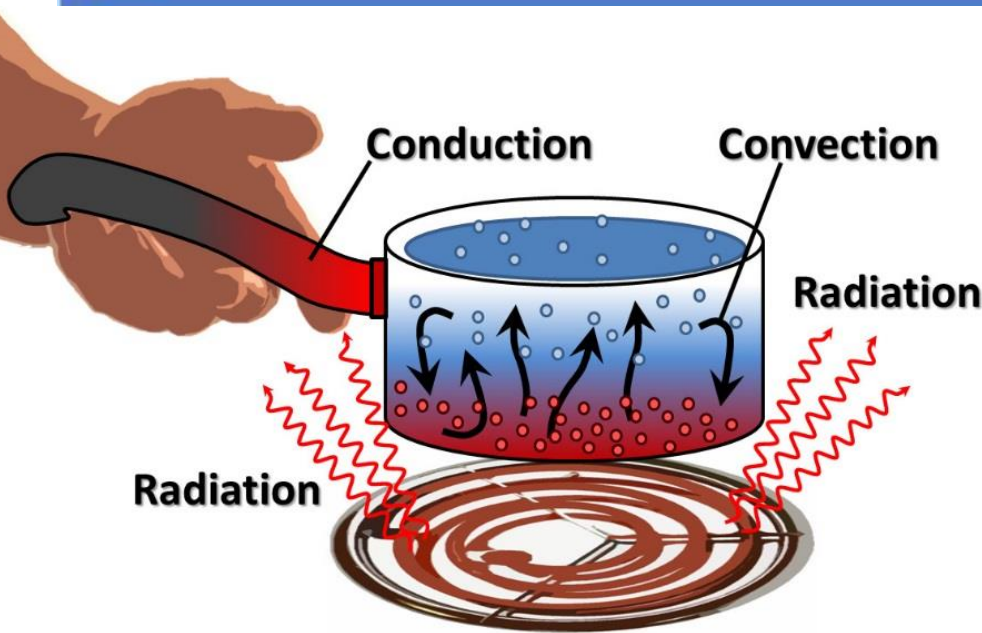
# Convection

Energy is transferred by the mass motion of molecules



# Radiation

Energy is transferred by electromagnetic radiation





# Simple Heat Engine

- 2) The spiral spins and eventually comes to a stop and reverses the spin.
- 3) The thermal energy (heat) from the light bulb transfers the energy to the air causing the air to rise (convection current) through the spiral making the spiral spin.
- 4) You could make the spiral spin faster by using a higher wattage bulb.
- 5) Electrical energy  $\rightarrow$  Thermal energy  $\rightarrow$  kinetic energy of the moving air (convection current)  $\rightarrow$  kinetic energy of the spiral  $\rightarrow$  potential energy stored up in the wound up string.

# Simple Heat Engine

6) Thermal energy is kinetic energy of the particles.

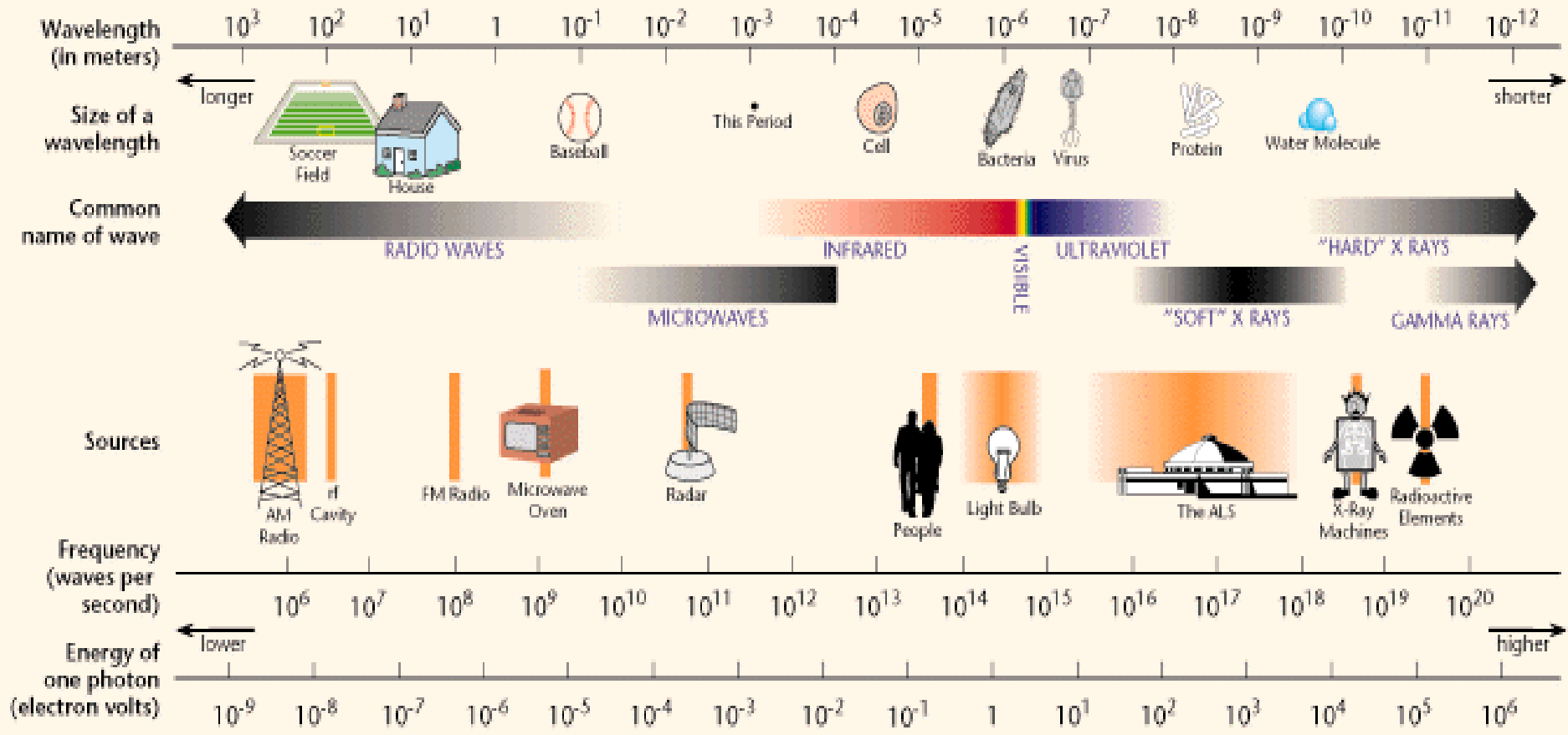
Temperature is the measurement of heat and average kinetic energy of all the particles of an object.

Heat is energy that is transferred from objects at a higher temperature to objects at a lower temperature.

Heat can change the temperature of an object.

7) Power plants, car engines uses heat to produce motion. Car engines uses heat from the combustion of fuel

# THE ELECTROMAGNETIC SPECTRUM



## Practical Uses of Radiation

- A solar cooker is a device that cooks food using mirrors that concentrate radiation from the sun.
- In parts of the world that are far from electricity and clean water, solar cookers are a cheap and portable way to sterilize water for drinking.
- Many people like to use solar cookers because they do not require any fuel and do not release harmful emissions.

