Understanding Heat Transfer: Conduction, Convection and Radiation
S8P2d

Terms to know:

- Conduction – heat transfer from direct contact with a source of thermal energy; energy is passed from particle to particle (happens most easily in solids)
- Convection – heat transfer from movement of particles; warmer particles rise while cooler sink; does NOT happen in solids, only liquids and gases
- Radiation – heat transfer through electromagnetic waves; waves transfer their energy when they come into contact with substance; can happen through space or medium

Terms to know:

- Thermal Conductor – a substance that easily passes thermal energy (heat) through it (examples: metals)
- Thermal Insulator – a substance that prevents thermal energy (heat) transfer (example: wood, plastic)

Heat is energy in motion (or transit).

- It is the transfer of energy from a place of higher temperature to a place of lower temperature.
- Heat only moves toward the lower-temperature body.
- It is incorrect to say an object contains heat. NOTHING contains heat.
- Heat is a process (that's used as a verb not a noun)
- Heat is not a "thing" but an energy transfer.

Thermal energy: the sum of energy within an object.

- It has to do with the kinetic and potential energy within a system of molecules.
- An object contains thermal energy.
- When that thermal energy moves from object to object, that's when we can say heat.
- Thermal energy is the noun, whereas heat is the verb

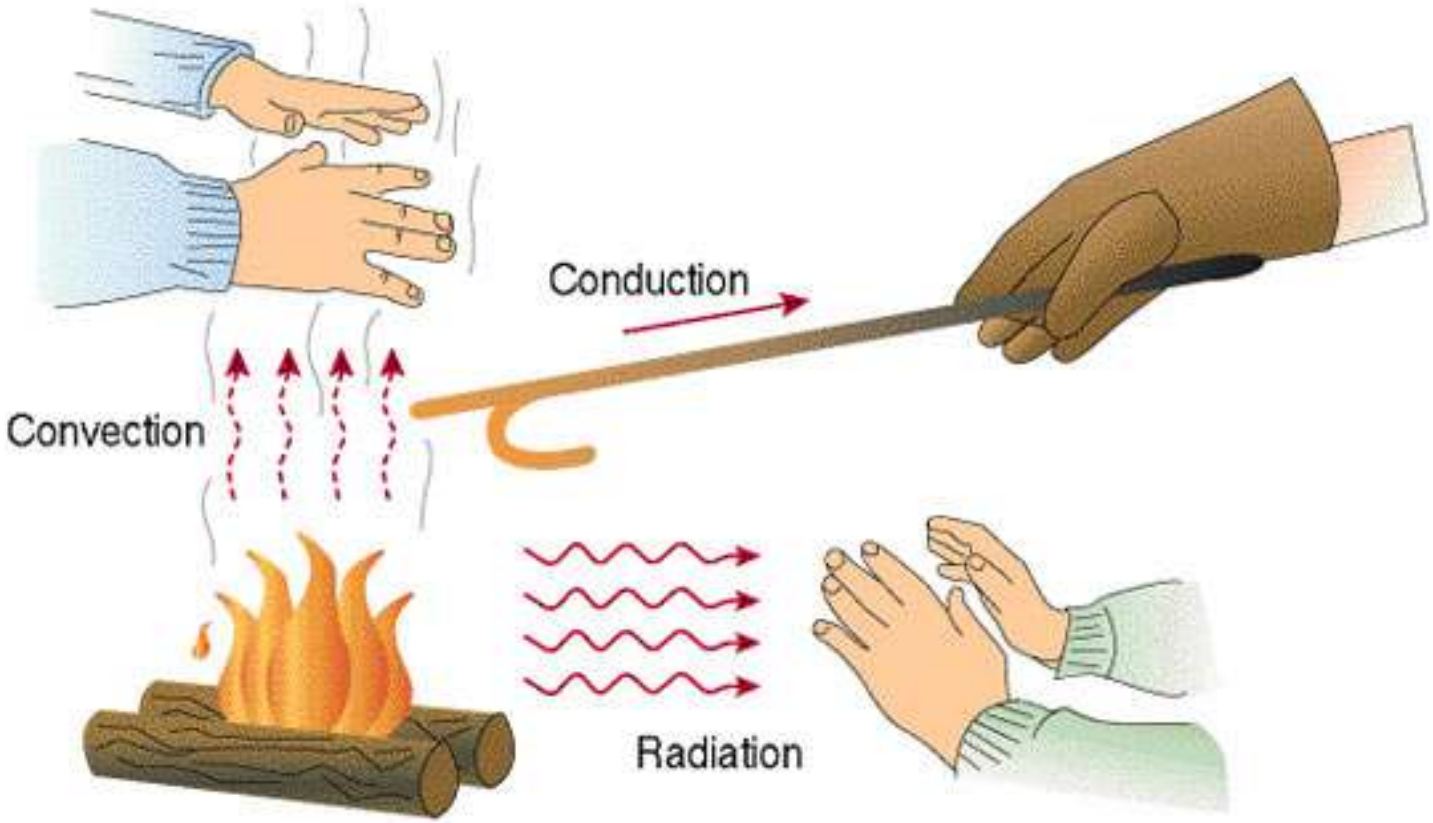
Heat Transfer

- Heat always moves from a warmer place to a cooler place.
- Hot objects in a cooler room will cool to room temperature.
- Cold objects in a warmer room will heat up to room temperature.

Question

- If a cup of coffee and a red popsicle were left on the table in this room what would happen to them? Why?
- The cup of coffee will cool until it reaches room temperature. The popsicle will melt and then the liquid will warm to room temperature.

The three forms of heat transfer



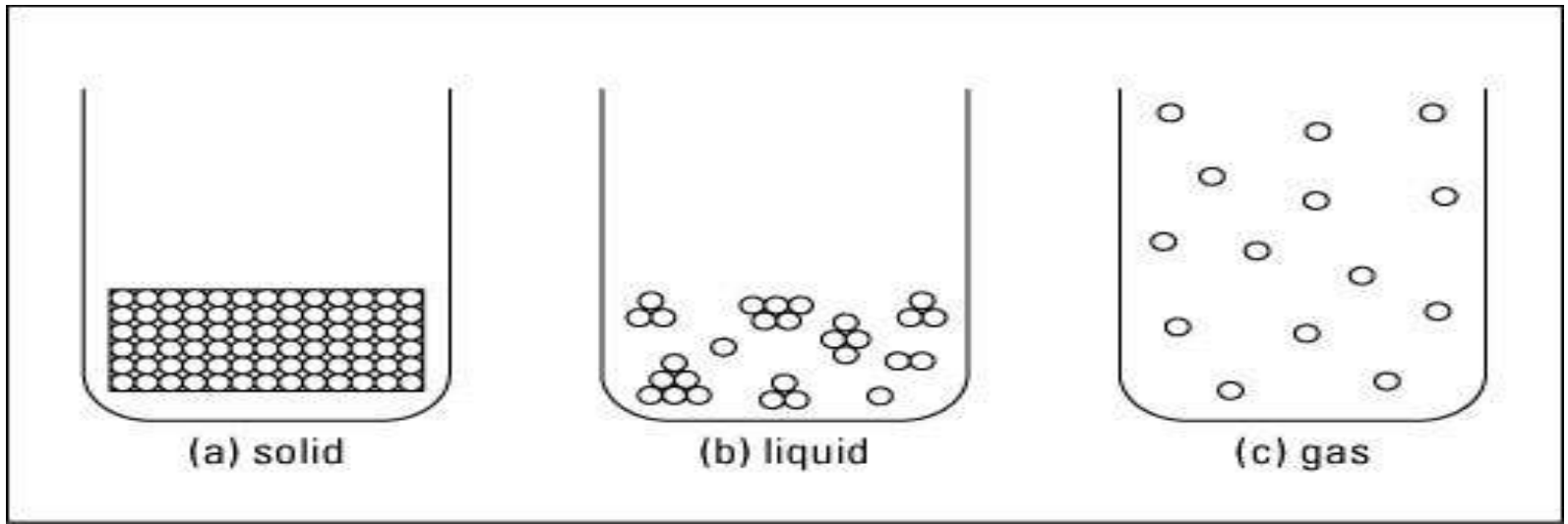
CONDUCTION

Conduction

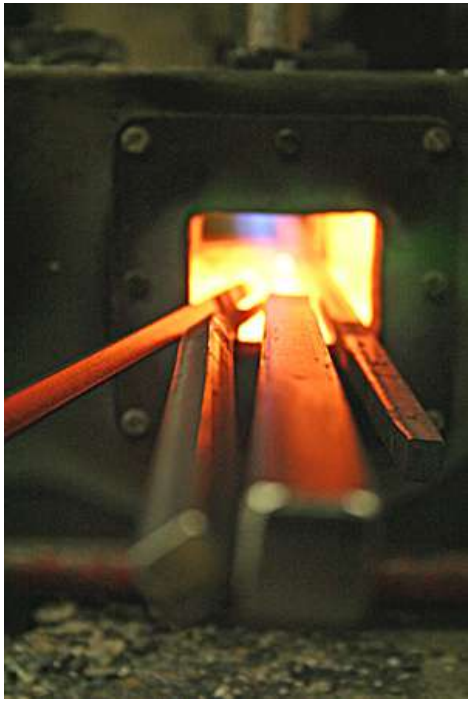
- Heat transfer by DIRECT contact with the source of heat
- Particles in contact with heat vibrate, pass energy through vibration to other particles
- Most significant means of heat transfer within a solid or between solid objects
- Fluids (especially gases) are less conductive.

Why does conduction work BEST in solids?

- Conduction works best (most efficiently) when particles are in contact with each other
- Since in solids particles are touching, transfer is quicker; in liquids and gases, particles are further apart so transfer by conduction is more difficult



Conduction examples



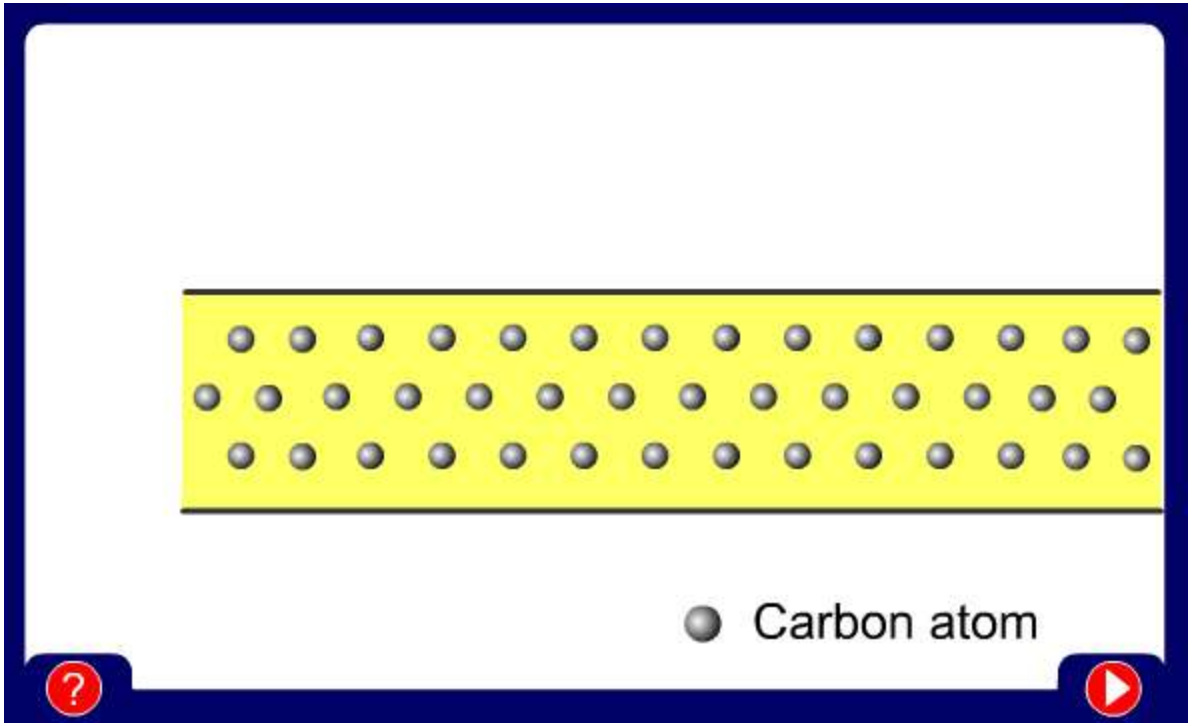
The metal is heating because it is IN the fire

The pot heats up because it is ON the hot stove element.

This person must use a pot holder because her hand would go through conduction if it were ON the cookie sheet.

Conduction

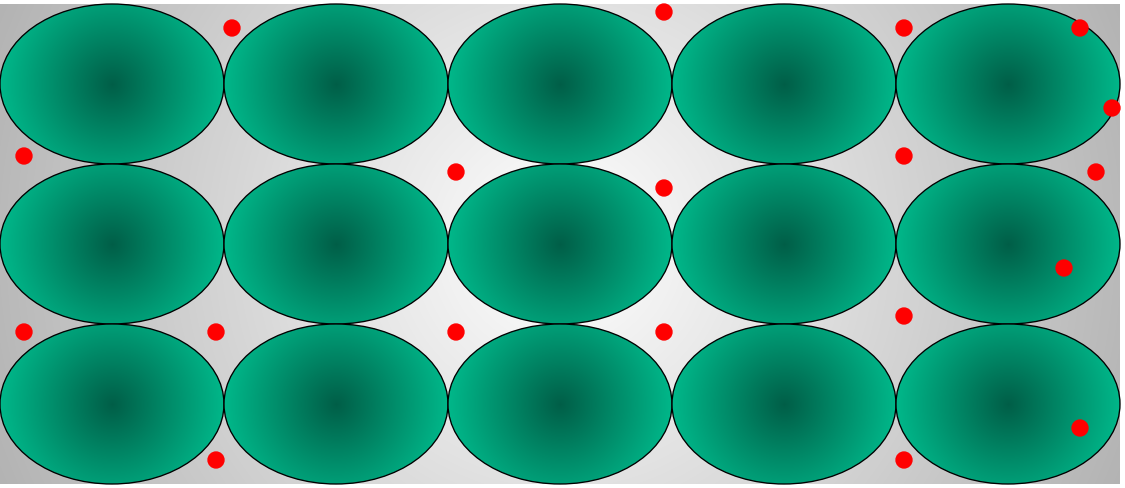
When you heat a metal strip at one end, the heat travels to the other end.



As you heat the metal, the particles vibrate, these vibrations make the adjacent particles vibrate, and so on and so on, the vibrations are passed along the metal and so is the heat. We call this? Conduction

Metals are different

The outer electrons of metal atoms drift, and are free to move.

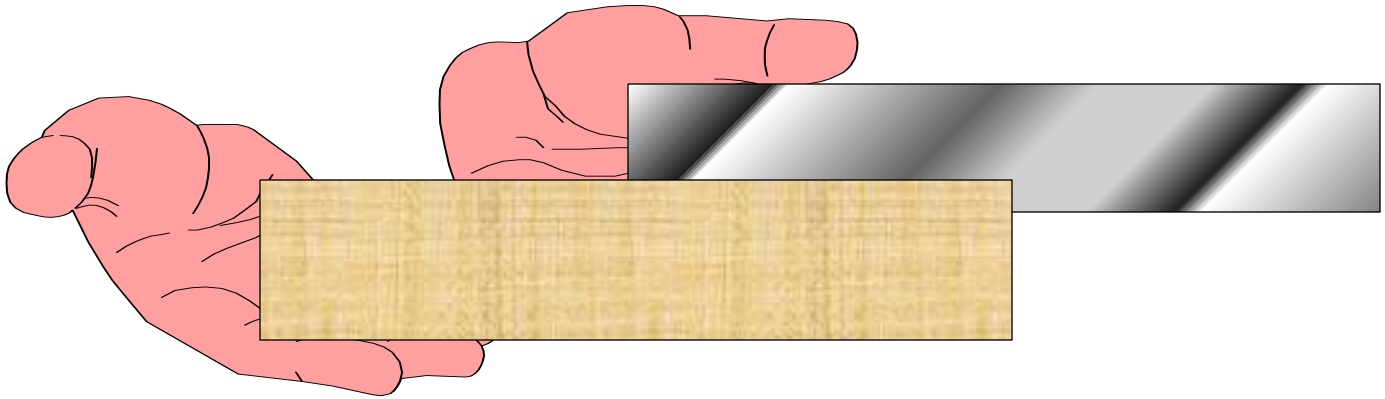


When the metal is heated, this 'sea of electrons' gain kinetic energy and transfer it throughout the metal.

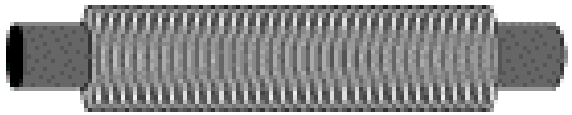
Insulators, such as wood and plastic, do not have this 'sea of electrons' which is why they do not conduct heat as well as metals.

Why does metal feel colder than wood, if they are both at the same temperature?

Metal is a conductor, wood is an insulator. Metal conducts the heat away from your hands. Wood does not conduct the heat away from your hands as well as the metal, so the wood feels warmer than the metal.



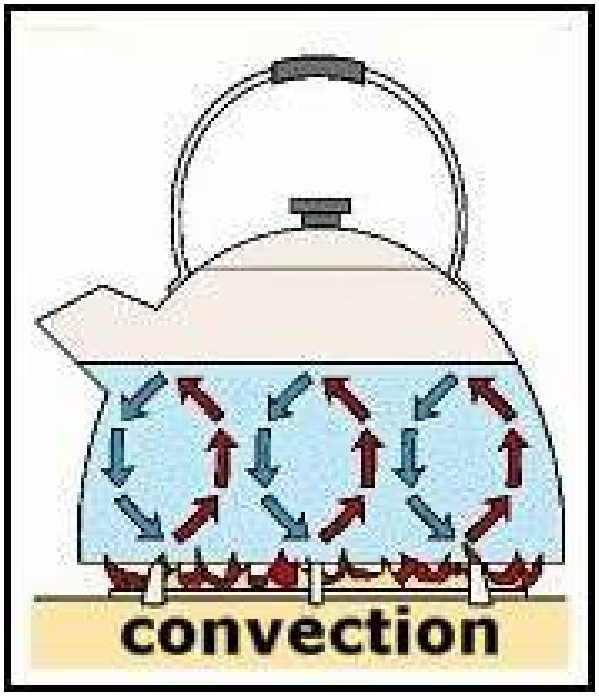
CONVECTION



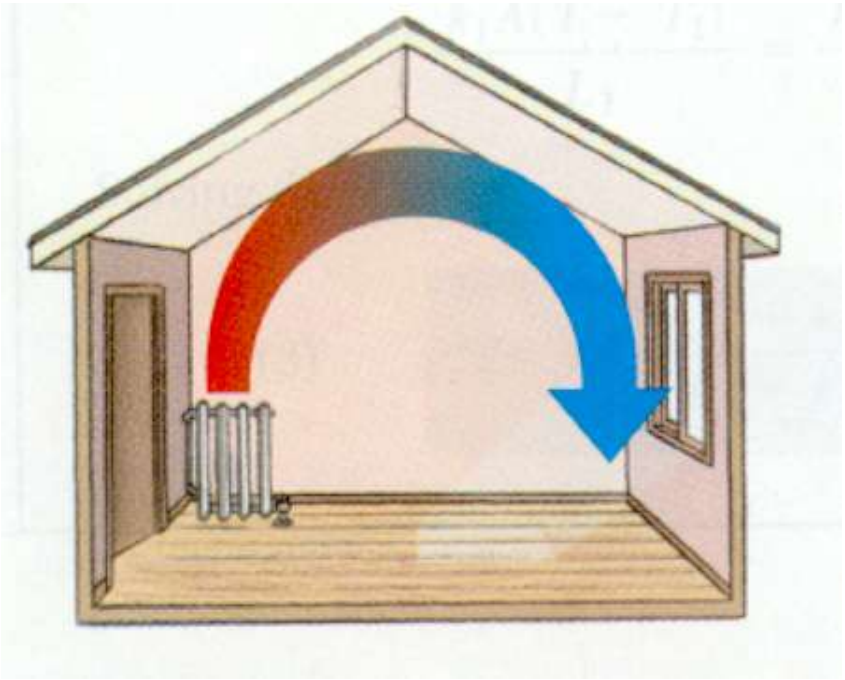
Convection

- Heat transfer that occurs due to the MOVEMENT of particles
- Since particles MUST move for convection to take place, convection DOES NOT OCCUR in solids; it does occur in both liquids and gases
- As energy increases, particles move further apart, making the substance less dense
- Less dense (warmer, particles further apart) rise while more dense (colder, particles closer together) sink

Examples of convection



As water heats, the hotter water is less dense and rises while the colder water sinks, creating a current

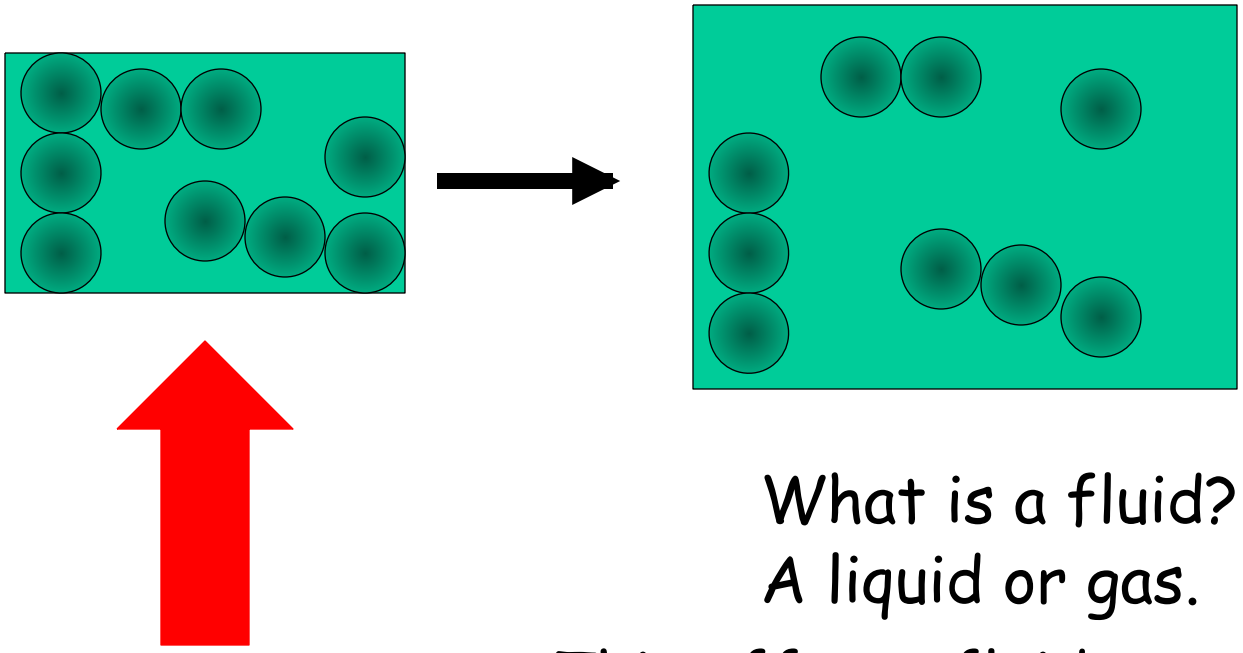


As the air heats up, it rises; colder air then sinks.

Convection

What happens to the particles in a liquid or a gas when you heat them?

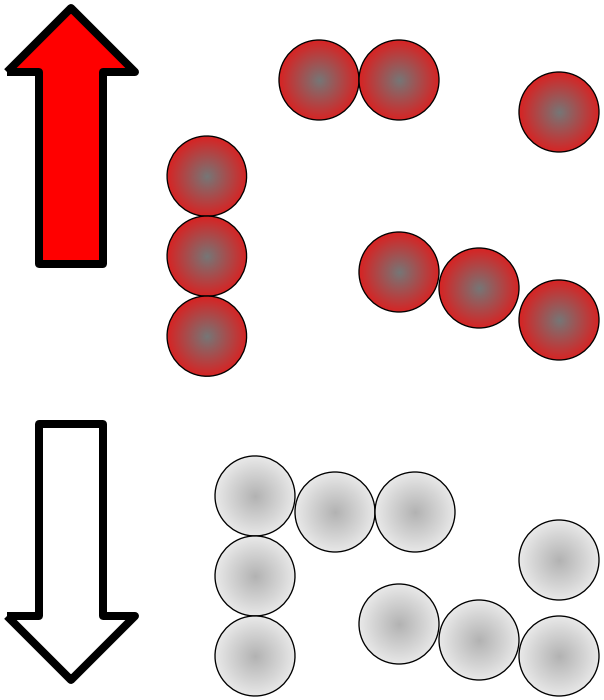
The particles spread out and become less dense.



What is a fluid?
A liquid or gas.

This effects fluid movement.

Fluid movement



Cooler, more d<u>ense</u>, fluids sink through w<u>armer</u>, less dense fluids.

In effect, warmer liquids and gases r<u>ise</u> up.

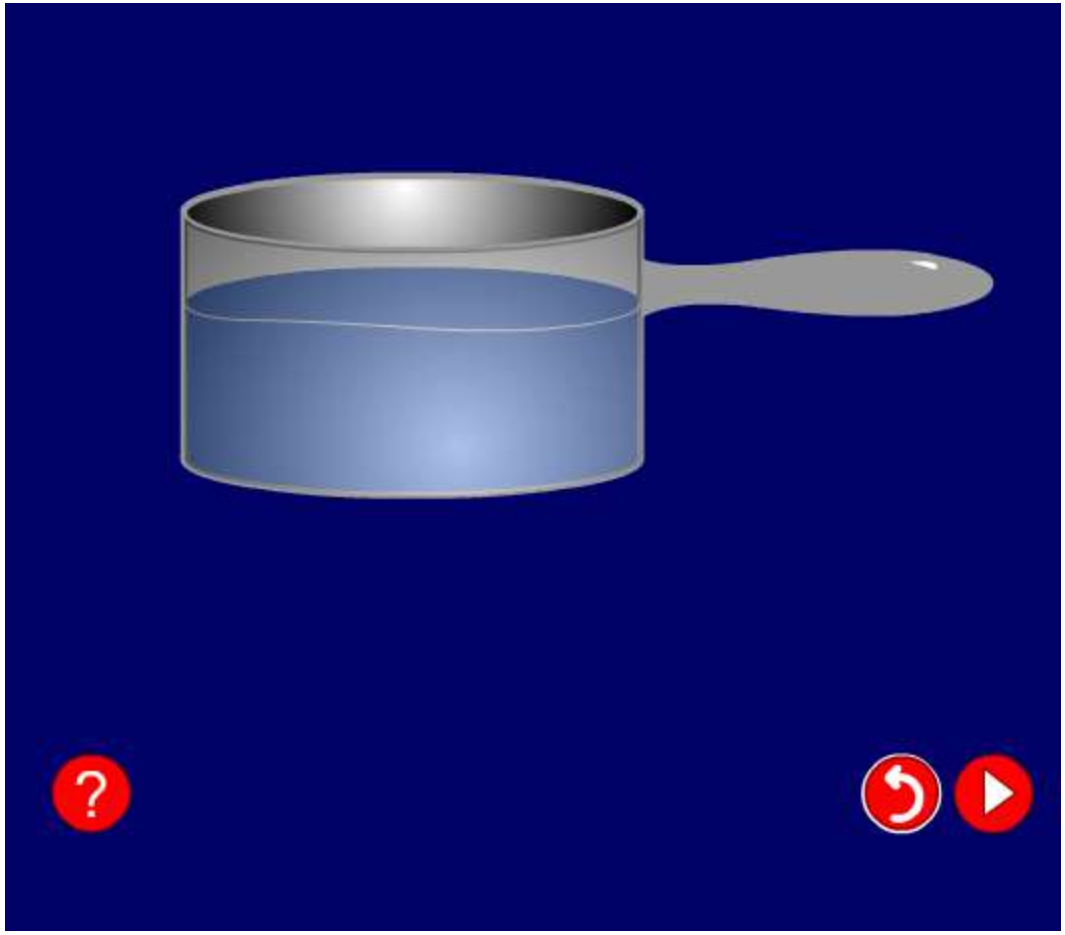
Cooler liquids and gases s<u>ink</u>.

Water movement

Cools at the surface

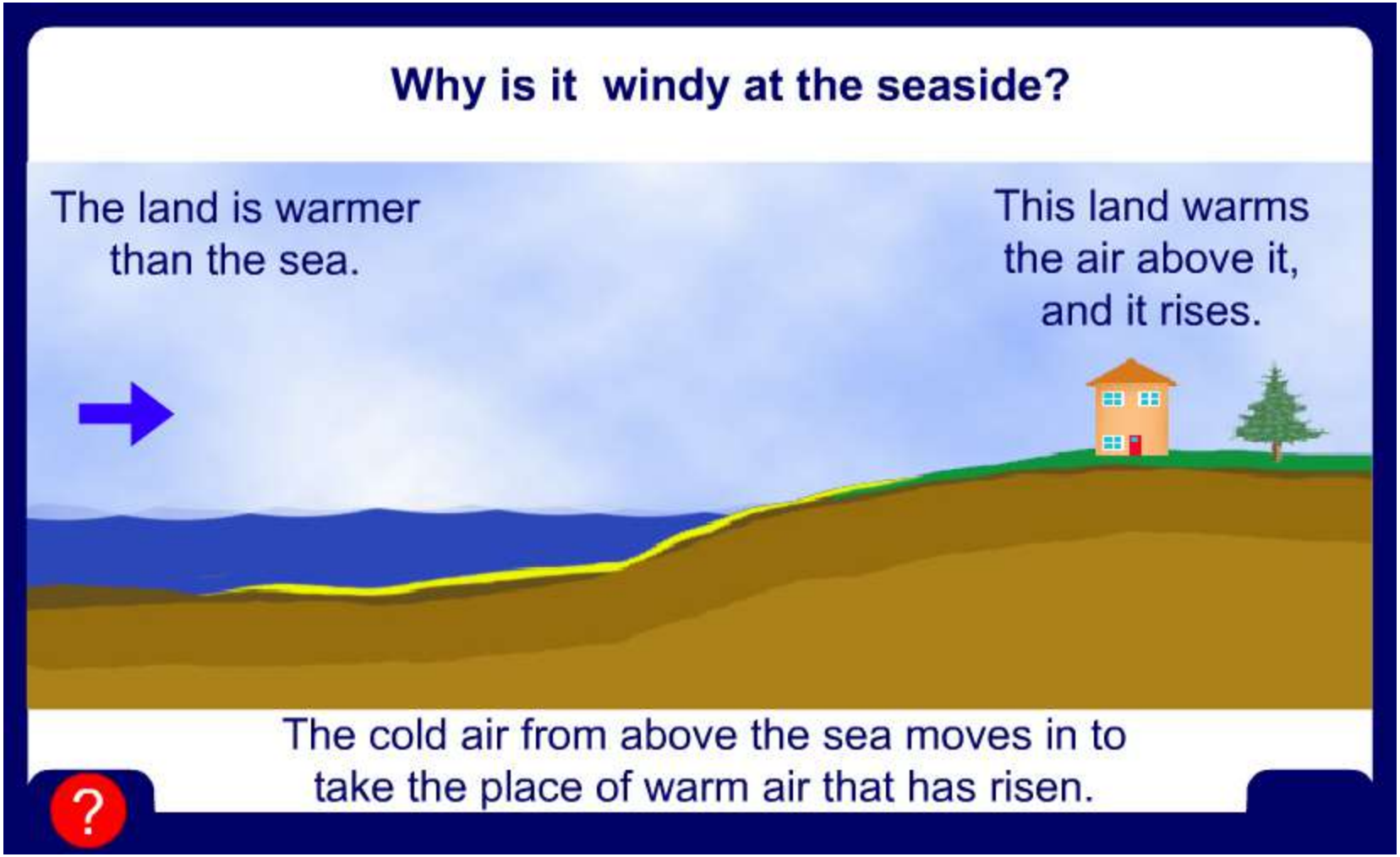
Convection current

Cooler water sinks



Hot water rises

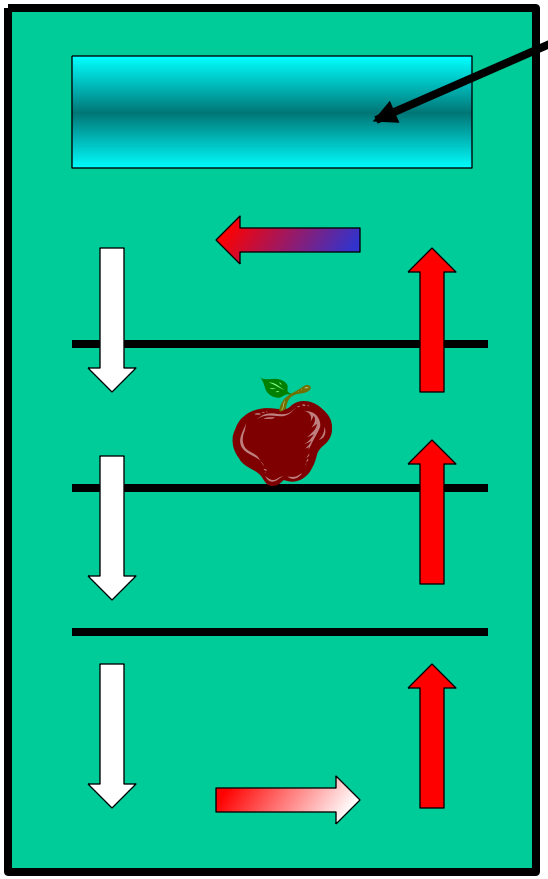
Why is it windy at the seaside?



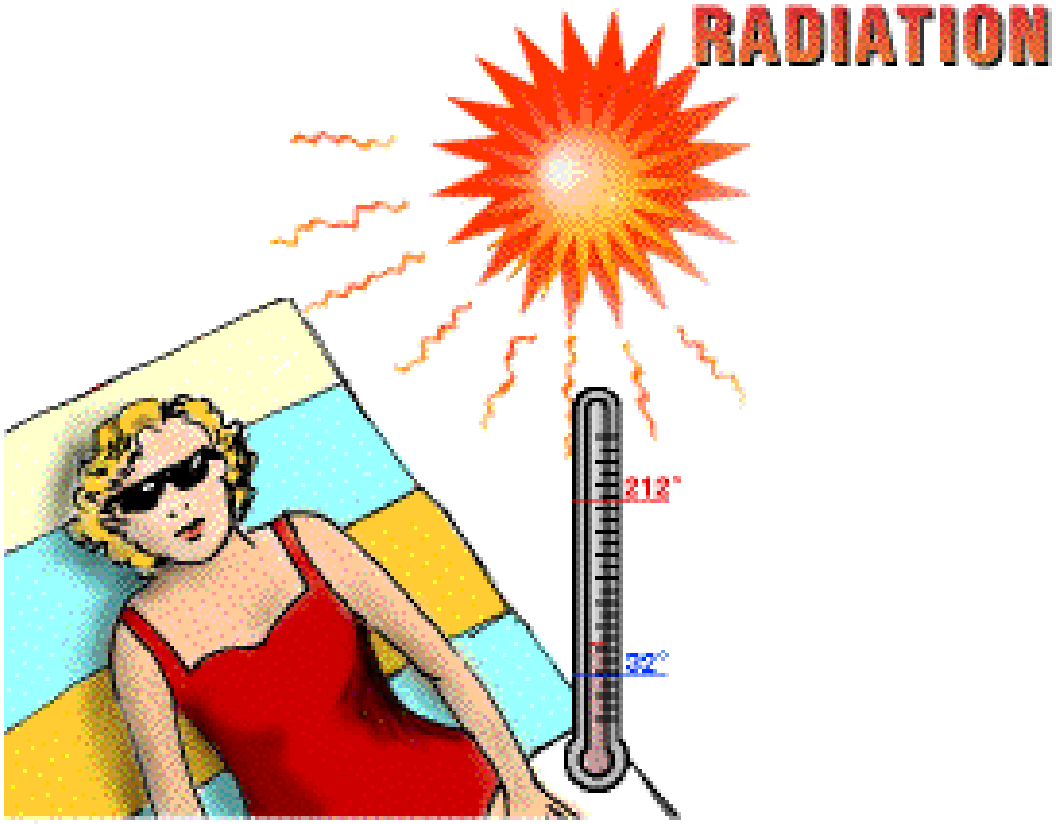
Cold air sinks

Where is the freezer compartment put in a fridge?

It is put at the top, because cool air sinks, so it cools the food on the way down.



It is warmer at the bottom, so this warmer air rises and a convection current is set up.

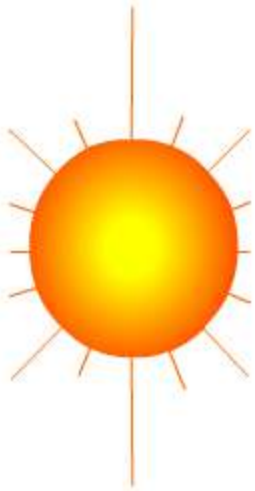

RADIATION
212°
32°

Transfer of heat by radiation

- Transfer of heat energy by electromagnetic waves
- EM waves carry the thermal energy AWAY from the object with the higher energy (i.e. warmer object) to the object with lower energy (i.e. colder object)
- Can transfer heat through a medium OR through space
- Waves transfer the energy to the object

The third method of heat transfer

How does heat energy get from the Sun to the Earth?

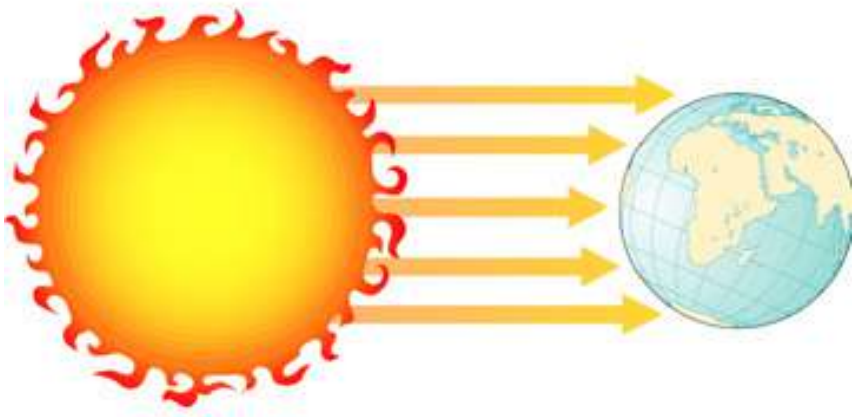


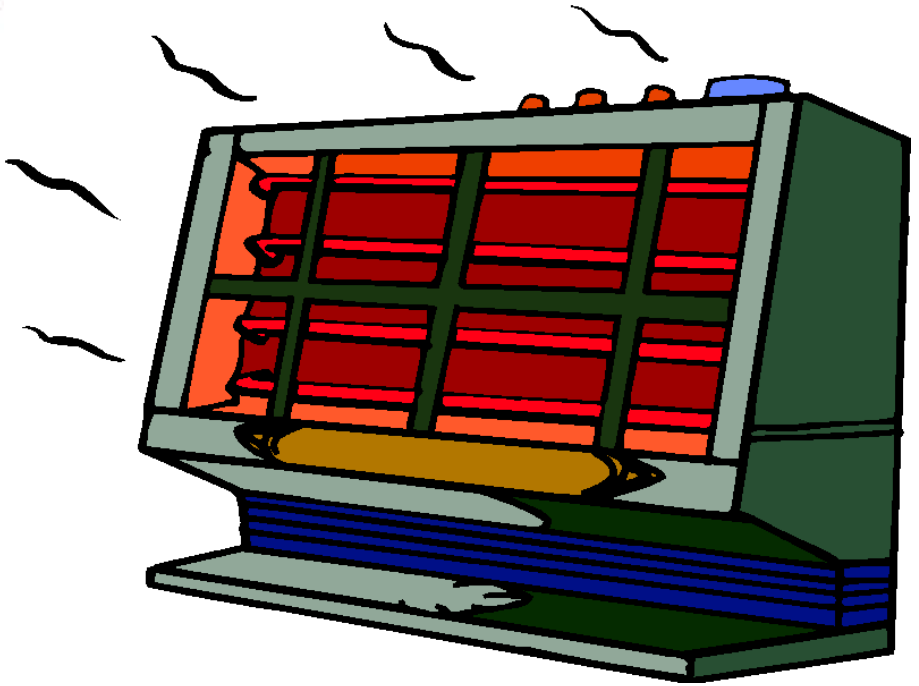
?

There are no particles between the Sun and the Earth so it CANNOT travel by conduction or by convection.

RADIATION

Examples of radiation





Radiation

Radiation travels in straight lines

True/~~False~~

Radiation can travel through a vacuum

True/~~False~~

Radiation requires particles to travel

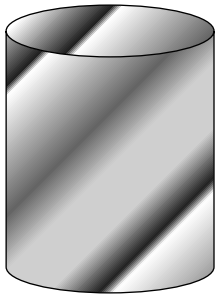
~~True~~/False

Radiation travels at the speed of light

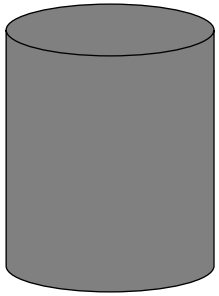
True/~~False~~

Absorption experiment

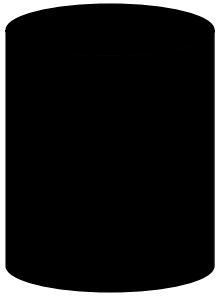
Four containers were placed equidistant from a heater. Which container would have the warmest water after ten minutes?



Shiny metal



Dull metal



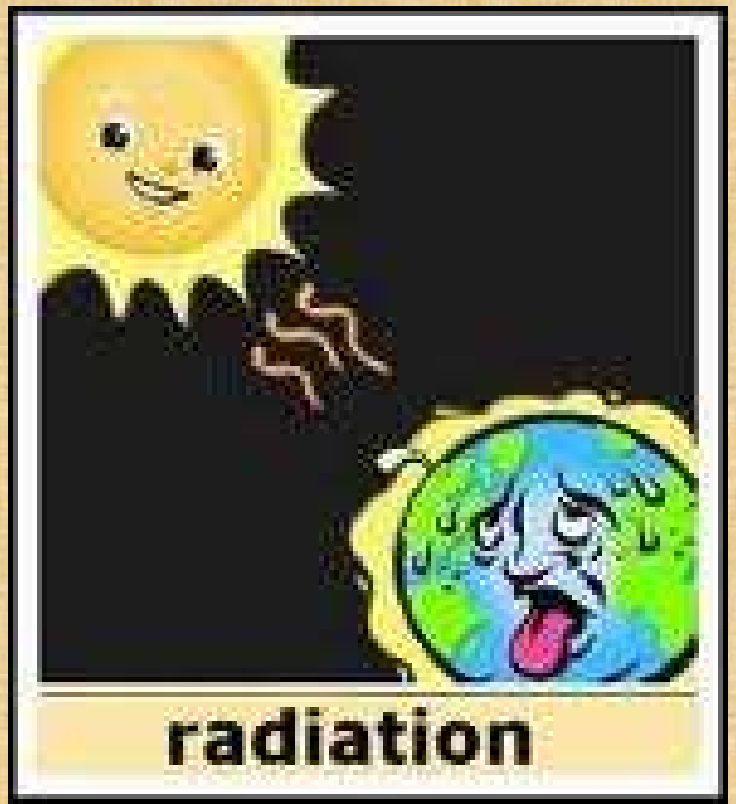
Dull black

Shiny black

The dull black container would be the warmest after ten minutes because its surface absorbs heat radiation the best. The shiny metal container would be the coolest because it is the poorest at absorbing heat radiation.

Radiation: transfer of thermal energy by electromagnetic waves through a medium or empty space

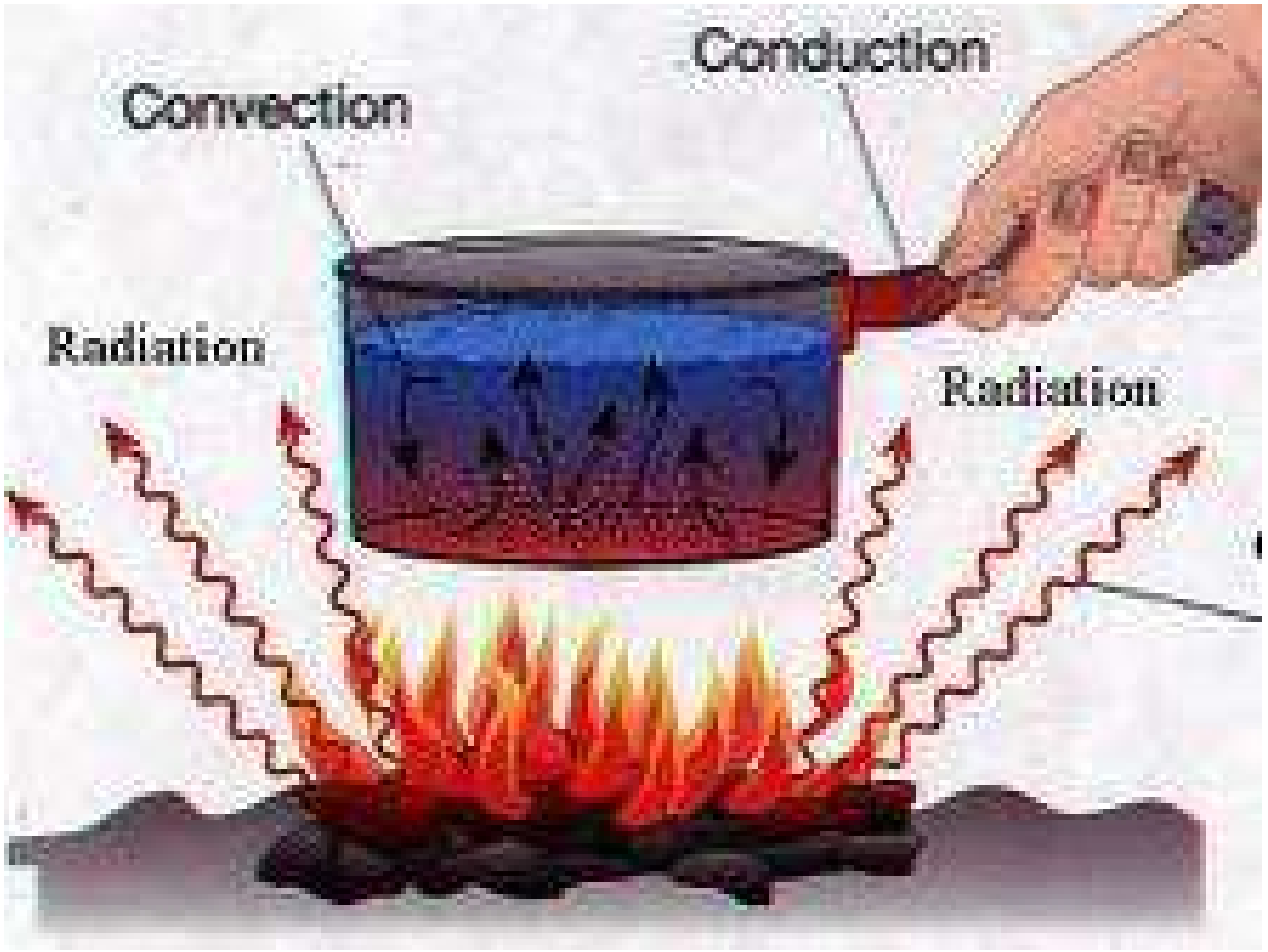
Example:



To summarize:

- Conduction
  - Heat transfer from direct contact
  - Particles vibrate and transfer energy from particle to particle
  - Example: cooking on a stove
- Convection
  - Heat transfer from molecule movement
  - Happens with liquids and gases
  - Due to density differences
  - Example: Hotter water moves to the top of a pot; cooler water falls
- Radiation
  - Travels through space
  - Does not need a medium (eg. Sunlight) but can travel through one
  - Example: space heaters

The three forms of heat transfer



Convection questions

Why does hot air rise and cold air sink?

Cool air is more dense than warm air, so the cool air 'falls through' the warm air.

Why are boilers placed beneath hot water tanks in people's homes?

Hot water rises.

So when the boiler heats the water, and the hot water rises, the water tank is filled with hot water.

Radiation questions

Why are houses painted white in hot countries?

White reflects heat radiation and keeps the house cooler.

Why are shiny foil blankets wrapped around marathon runners at the end of a race?

The shiny metal reflects the heat radiation from the runner back in, this stops the runner getting cold.

1. Which of the following is not a method of heat transfer?

A. Radiation

B. Insulation

C. Conduction

D. Convection

2. In which of the following are the particles closest together?

A. Solid

B. Liquid

C. Gas

D. Fluid

3. How does heat energy reach the Earth from the Sun?

A. Radiation

B. Conduction

C. Convection

D. Insulation

4. Which is the best surface for reflecting heat radiation?

A. Shiny white

B. Dull white

C. Shiny black

D. Dull black

5. Which is the best surface for absorbing heat radiation?

A. Shiny white

B. Dull white

C. Shiny black

D. Dull black