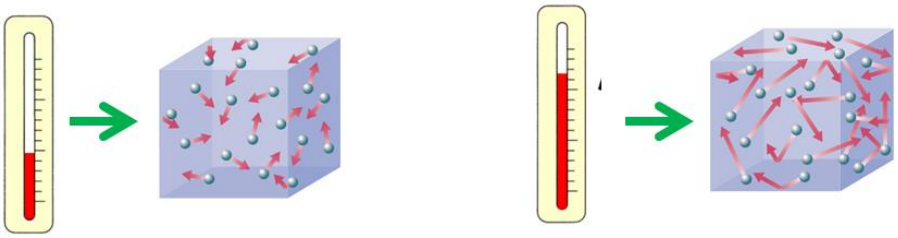
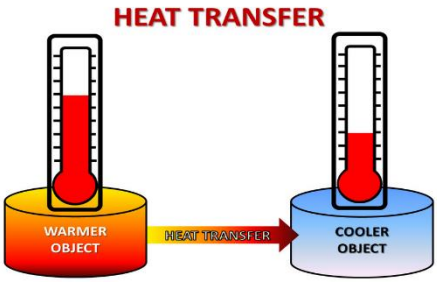
Heat Transfer: Conduction, Convection, and Radiation

Introduction

We have learned that heat is the energy that makes molecules move. Molecules with more heat energy move faster, and molecules with less heat energy move slower. We also learned that as molecules heat up and move faster, they spread apart and objects expand (get bigger). This is called thermal expansion.



Heat is always moving! If you have two objects or substances that are different temperatures, heat will always move **OUT** of the warmer object or substance, and **INTO** the cooler object or substance. This heat transfer will continue until the objects are the same temperature.



So how, exactly, does heat move out of one thing and into another thing? This is called heat transfer. (Remember, we learned that energy transfer is when energy moves from one thing or place to another, but the energy type stays the same). Heat can transfer (or move) in 3 ways: conduction, convection, and radiation. As you read about the three types of heat transfer, pay attention to:

- What the heat is moving through (solids, liquids and gases, or empty space)
- How the heat is being transferred (touch, currents, or waves)

Conduction

Last weekend, I went to the beach. I was walking barefoot on the soft, cool grass. When I got to the sand, I noticed that my feet were burning! Ouch! This is an example of conduction.

Conduction is how heat transfers through **direct contact** with objects that are **touching.** Any time that two objects or substances touch, the hotter object passes heat to the cooler object. (That hot sand passed the heat energy right into my poor feet!)

Think of a row of dominoes that are all lined up. When you push the first domino, it bumps into the second one, which bumps into the third one…all the way down the line. Heat conduction is like the dominoes. Imagine that you place one end of a metal pole into a fire. The molecules on the fire end will get hot. Each hot molecule will pass the heat along to the molecule next to it, which will pass the heat along to the next molecule, and so on. Before you know it, the heat has traveled all the way along the metal pole until it reaches your hand.

Some materials are better conductors than others. That's because some materials are able to pass (conduct) heat more easily. Metals are great conductors. That's why metal objects get hot so easily. Plastic and wood are poor conductors. They will still get hot, but it takes a lot longer for them to pass the heat from molecule to molecule.

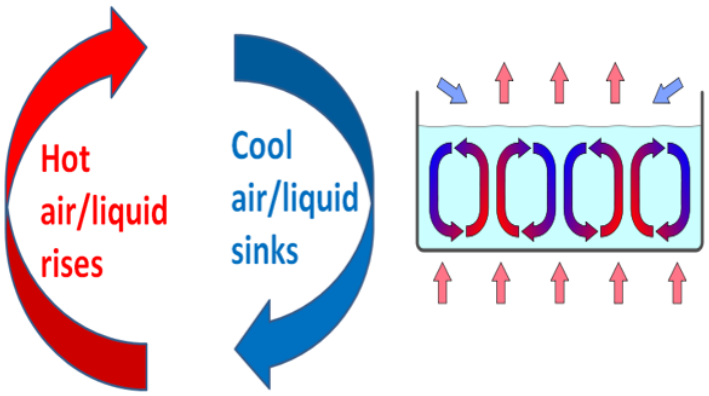
Likewise, solids are better conductors than liquids or gases. That's because solids have molecules that are very tightly packed together, so it's much easier for the molecules to pass the heat along. The molecules in liquids and gases are spread further apart, so they aren't touching as much. It takes longer for liquids and gases to conduct heat.

There are many examples of heat conduction. Any time two object touch, heat conduction will happen. Touching a hot iron is an example of conduction – the heat passes out of the iron and into your hand. So is holding an ice cube – the heat is conducted out of your hand, and into the ice cube (that's why your hand feels cold). Cooking food on the stove is an example of conduction happening twice – the heat from the burner passes into the metal pan, and then the heat from the metal pan passes into the food, heating it up.

Convection

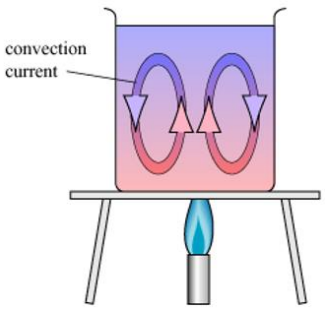
Convection is how heat passes through **fluids**. A fluid is anything that has loosely moving molecules that can move easily from one place to another. Liquids and gases are fluids.

One important property of fluids is that they rise when heated. That's because the molecules spread out and move apart when they get hot. The hot fluid becomes less dense and rises up. Cooler fluid is less dense and so it sinks down. This up-and-down motion creates what are called **convection currents**. Convection currents are circular movements of heated fluids that help spread the heat.



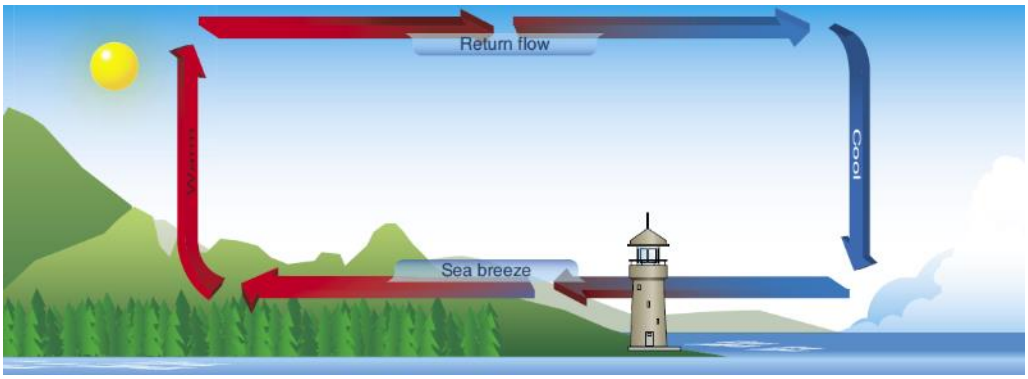
Here's an example. Last night I heated up soup for dinner. Yum! At first, the soup was cold in the pan. The soup at the bottom of the pan was closest to the hot stove burner, right? So the soup at the bottom heated up first. As it heated, the molecules spread apart and became less dense. So the heated soup rose up to the top.

As the hot soup rose up, the cooler soup at the top sank down to the bottom. When it was at the bottom, it was closest to the heat, so THAT soup got hot and rose up. As the soup continued heating, the hot soup rose and the cold soup sank. If you were to look closely, you would see the soup moving up and down in the pot. The up-and-down movement was a convection current. The convection current helped spread the heat around, until all of the soup was heated up.



Convection currents explain why the air is hotter at the top of a room and cooler at the bottom. Convection currents also explain why water is warm at the top of the ocean, but gets colder as you swim deeper.

One natural example of convection currents is wind. As the Sun shines down on an area of land, it heats the air above the ground. That warm air rises. As it rises, cooler air moves in to take the place at the bottom. This moving cooler air creates…wind! Wind happens all over Earth because Earth heats unevenly. There are always colder parts and warmer parts. The wind blows from the cooler parts of Earth to the warmer parts.



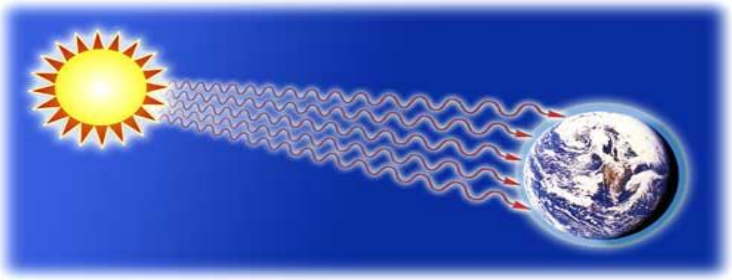
Other examples of convection are: boiling a pot of water on the stove; using a hot radiator to warm the air in a room; and using heated air to make a hot-air balloon rise up into the sky.

Radiation

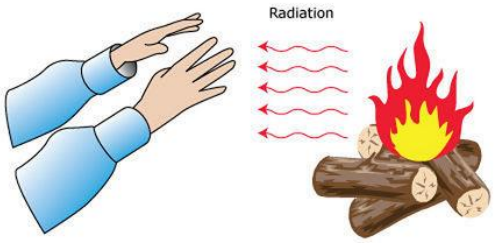
So we've learned that conduction moves heat easiest through solids, and convection moves heat through liquids and gases. So how does the heat from the Sun get to Earth? There are no molecules in space! And how do you feel the heat from a campfire, even if you're sitting several feet away?

The answer is radiation. Radiation is how heat moves through places where there are **no molecules**. Radiation is actually a form of electromagnetic energy. Remember we learned that electromagnetic energy moves in waves? Well, radiation is heat moving in **waves**. Radiation does NOT need molecules to pass the energy along.

All objects radiate heat, but some radiate much more heat than others. The biggest source of radiation is the Sun – it sends a HUGE amount of heat to Earth through electromagnetic waves. (Last weekend, at the beach, I could definitely feel the wonderful heat radiation from the Sun. I guess that's why I got a sunburn. Oops! A little too much radiation!)



Light bulbs radiate heat. Try it! Hold your hand a few inches away from a light bulb. You can feel the heat, right**? In fact, a good way to remember radiation is that it is how you can feel heat <u>without touching it</u>.** Heat passes through the empty space until it reaches your hand. That's radiation! A fire is another example of radiation. Even YOU are an example. Your body gives off heat! (That's why a classroom gets warm when there are a lot of people sitting in it.)



Review

Remember – heat always passes from a warmer object to a cooler object until all objects are the same temperature.

Conduction is how heat travels between objects that are touching. Conduction travels fastest through solids, but liquids and gases can also conduct heat. Some materials, like metal, can conduct heat very quickly, while other materials (like plastic or wood) conduct heat very slowly.

Convection is how heat travels through fluids – liquids and gases. Hot fluids rise up, while cold fluids sink down. This up-and-down motion is called a convection current. Convection current spreads the heat in a circular, up-and-down pattern.

Radiation is how heat travels through empty space. Radiation does NOT require molecules to travel through. Any time you can feel heat without touching it, you are experiencing radiation.