

Conduction, Convection, and Radiation

Popcorn Lesson (Three Methods of Heating)

All forms of matter, whether a solid, liquid, or gas, are composed of atoms or molecules in constant motion. Because of this constant motion, all atoms have thermal (heat) energy. Whenever a substance is heated, the atoms move faster and faster. When a substance is cooled, the atoms move slower and slower. The "average motion" of the atoms that we sense is what we call temperature.

Temperature and heat ARE NOT technically the same thing. Temperature is the average motion of atoms and molecules. Heat is the energy that flows due to temperature differences. Heat is always transferred from warmer to cooler substances.

There are three ways to heat the atmosphere (or anything else, for that matter). These ways include conduction, convection, and radiation. How can you remember these? Let's use an analogy to help you figure this out.

There are three ways to cook popcorn.

1. Put oil in the bottom of a pan. Cover the bottom of the pan with popcorn kernels. Place the pan on the stove and turn on the burner to medium heat. Cover the pan with a lid. Periodically shake the pan so the kernels move around in the oil.
2. Obtain a popcorn popper. Place the popcorn kernels in the popper. Plug in/turn on the popper. Hot air will transfer heat to the kernels, making them expand and pop.
3. Microwave a bag of microwave popcorn.

Each of these methods of cooking popcorn is really an example of the three ways heat can be transferred.

1. Conduction. This method of heat transfer is most familiar to people. If you have ever burned yourself on a hot pan because you touched it, you have experienced this first-hand. Conduction is heat transfer through matter. Metals conduct heat well. Air is not as good a conductor of heat. This is a direct contact type of heat transfer. The only air heated by the Earth is the air at the Earth's surface. As a means of heat transfer, conduction is the least significant with regard to heating the Earth's atmosphere. Which popcorn example does it relate to? #1. The heat is transferred by direct contact from the pan, to the oil, to the kernels of popcorn.
2. Convection. Convection is heat transfer by the movement of mass from one place to another. It can take place only in liquids and gases. Heat gained by conduction or radiation from the sun is moved about the planet by convection. The radiation from the sun heats the air of the atmosphere, but the heating of the Earth is not even. This is because the amount of sunlight an area receives depends upon the

time of day and the time of year. In general, regions near the equator have hotter air. This hot air rises, allowing cooler air to move in underneath the warm air. In our popcorn example this relates to #2. The hot air transfers the heat to the cooler kernels, and when enough hot air heats the kernels they pop.

3. Radiation is the only way heat is transferred that can move through the relative emptiness of space. All other forms of heat transfer require motion of molecules like air or water to move heat. The majority of our energy arrives in the form of radiation from our Sun. Objects that are good absorbers of radiation are good radiators as well. The atmosphere, which does not absorb certain wavelengths of solar radiation, will absorb certain wavelengths of radiation. The particles that reach Earth from the Sun are within a wavelength that the Earth's atmosphere will absorb. When the Sun heats the Earth, the Earth gets warmer in that location and re-radiates heat into the atmosphere, making it doubly warm. This relates to popcorn example #3. The kernels are heated by the radiation in the microwave, and the kernels heat up, giving off more heat to the kernels surrounding it and making it "doubly warm."

Radiation is the primary way that air is heated. Convection currents move that heated air around the earth, and the difference between warm and cold air provide the energy needed to create weather.

The ability of the Earth to absorb heat from the Sun and "hold onto" or re-radiate that heat is important for night-time, when there is no solar radiation reaching a given area. For example, the moon has essentially little or no atmosphere. The side of the moon's surface facing the sun would get all radiation all of the time, and the side of the moon's surface facing away from the sun would get no radiation. That means that the temperature differences between sides of the moon would be huge, because there is little to no atmosphere keep and hold heat. If a planet had a very thick atmosphere, especially one that absorbed a lot of solar radiation, temperatures would be very hot. If a planet had a very thin atmosphere that wasn't that efficient at reradiating heat, temperatures would be cooler on average. It seems such a simple thing, and yet small atmospheric differences (like the composition of the atmosphere, how thick it is, etc.) make huge differences in temperature ranges and pressure readings.