HEAT TRANSFER

Now that we understand heat capacity, we can move forward into heat transfer. We know that deep oceans are cold and the surface is warmest. Why? Where is the heat coming from and how does it move around the oceans? Earlier we discussed how heat is transferred from your skin to the sweat on it to make it evaporate. How does that happen? Heat (or kinetic energy) is transferred from an area where it's currently high – your skin -- to an area where it's lower, your sweat and the air. The heat transfer continues until **equilibrium** is reached – or until all the molecules in a given area have the same energy. There are three ways to transfer this energy: conduction, convection, and radiation.

Conductive heat transfer is what happens in this picture when heat is transferred along the handle of the pot. This heat is transferred between atoms in contact with each other. In a solid, molecules transfer vibrational energy physically to their bonded neighbors. Imagine linking arms with everyone in class, so you're trapped in a solid form and then try to transfer energy just by bouncing in place. Conduction also happens in liquids and gases – in these cases, heat or kinetic energy is transferred during collisions. **Convective heat transfer** is a much more efficient method of heat transfer for gases and liquids. During convection, millions of molecules of gas or liquid transport heat quickly by diffusion or currents. For example, in this image, you can see that at the bottom of the pot, heat is *conducted* by the hot surface to the water at that hot surface. That heat makes that water expands and become less dense. That water then rises to the top of the pot, displacing the colder denser water at the surface, which then sinks to the bottom and is heated by the conductive pot. Through this process, the heat is rapidly *convected* through the entire fluid in a continuous cycle. During **radiation heat transfer**, electromagnetic waves are released from a hot source and spread outwards through space in all directions. When those waves collide with other objects, they excite the molecules in that object and raise their temperature. Heat is radiated from all objects with a temperature, that is from all objects whose molecules have any internal kinetic energy at all. Thermal radiation is generated when heat from the movement of charged particles within atoms is converted to electromagnetic radiation. This image shows, and we know from personal experience, the radiative heat that's transferred from a hot fire to the objects around it. In this image, we see the hot fire RADIATING heat outwards. The bottom metal of the pot picks up some of that radiation and heats up. That heat is then CONDUCTED through the pot to the water in contact with it. The water molecules within the pot mix with each other and transfer heat evenly within by CONVECTION.

We see here the real-life examples of the different speeds of conduction versus convection. Hot water convects on our stove and rapidly transfers heat everywhere, evenly throughout the water. That heat is now evenly distributed around all the spaghetti noodles, and they can heat up through conduction across the boundary. The spaghetti can be cooked completely in 5 minutes. Conversely, placing a baked potato in the oven means cooking through conduction. The air in the oven may convect and be evenly distributed. But to heat up the inside of the potato requires conduction from the potato surface into the very center – molecule by molecule. Baking a potato can take up to 1 hour, because the transfer of heat is slow, as one atom slowly bumps into and transfers velocity to the atom next to it. We can speed it up by inserting a metal nail, because metals conducts more quickly, but it will still take well over a half hour. A faster way to bake a potato is to use a microwave, which sends out radiation waves that are absorbed by water molecules throughout the potato. Those water molecules get excited and conduct or share their energy with their nearby partners.

All of these methods of heat transfer are seen in the world around us. For example, we've seen convection so far when talking about how the asthenosphere drives plate tectonics and how convection in the outer core creates Earth's magnetic field. Both of these processes are the result of Earth transferring its deep heat up towards its surface in a slow attempt to reach equilibrium. In the weeks ahead we will talk more about how convecting currents of water and air transport heat across the globe. We'll also discuss how the Sun's radiation and the Earth's thermal radiation combine to create a greenhouse effect and keep the Earth's surface warm enough to support life. In the oceans, the heat that warms the surface comes from the sun's radiation. As already discussed, that radiation penetrates only through the photic zone with less and less available as we descend below the surface. In some areas, the sunlight is gone after 10 feet or less. How does that heat distribute itself further: convection. Is conduction happening anywhere in the oceans? Conduction is how heat is transferred from hot rocks to the water, either hot rocks erupting on the seafloor or coastal rocks warmed by the sun. We'll continue to discuss ocean temperatures and the variations we see across the globe in the weeks to come.

Pause now.

For more information and more detail, continue on to the next video in this series.

[End credits]

Seawater Physical Properties Series:
Part I: Water Molecule Shape
Part II: Water Phases
Part III: Water Density
Part IV: Heats of Water
Part V: Light, Viscosity, & Pressure
Part VI: Heat Transfer

Heat Transfer
Geoscience Video Tutorial
Produced by Katryn Wiese
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