Current Convection

Georgia Standards of Excellence:

- **S8P2.** Obtain, evaluate, and communicate information about the law of conservation of energy to develop arguments that energy can transform from one form to another within a system.

  d. Plan and carry out investigations on the effects of heat transfer on molecular motion as it relates to the collision of atoms (conduction), through space (radiation), or in currents in a liquid or a gas (convection).

Next Generation Science Standards:

- **MS-ESS2-6.** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Learning Objective:

- Students will produce an experiment demonstrating convection in water.
- Students will test density levels.

Essential Question:

- How does density help to create convection in the ocean?

Key Vocabulary:

- Density
- Thermohaline Circulation
- Convection
- Salinity

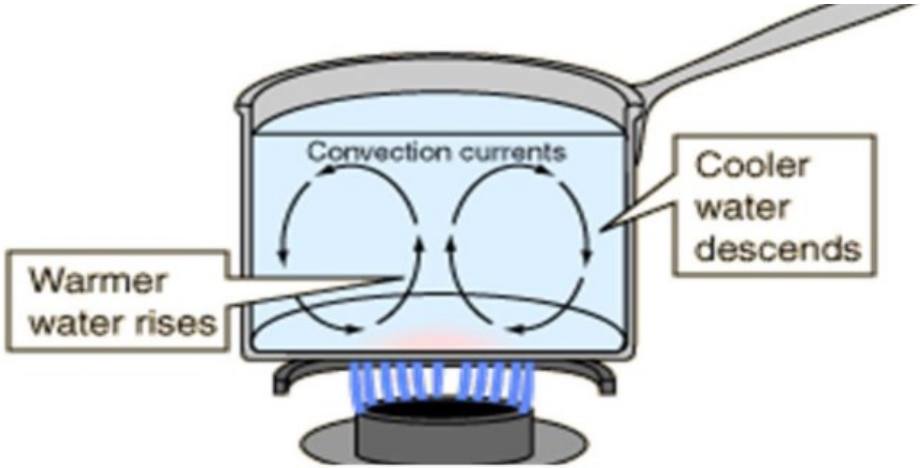
Materials:

- Clear Container
- Food Dye (two colors minimum)
- Icy Tray
- Way to heat water
- Clear cup
- Vegetable Oil
- Water
- Corn syrup
- Rubbing Alcohol
- Three cups

Current Convection

Background Information:

- The Earth is run by solar powered systems from photosynthesis to evaporation to currents. The sun is the driving source in all these processes. In the ocean, as the sun heats water, it becomes less dense. Less dense materials rise if the surrounding area is more dense.
- Since the Earth is a sphere, the Sun heats the equatorial regions more than the polar regions. Due to this imbalanced heating, regions of the ocean become hotter and less dense, eventually evaporating. When the water rises or eventually evaporates, it doesn't create a vacuum. Instead, water from the adjacent area moves in to replace the displaced water. This movement of water creates currents from a process called convection.
- Convection: "the movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat" (Oxford Dictionary).

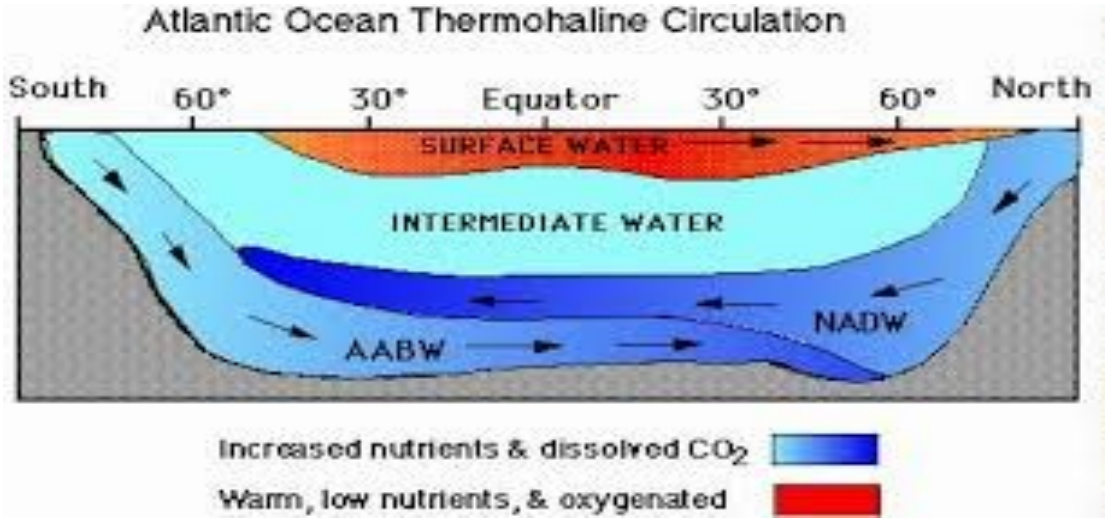


Nave, R. Heat Transfer. Accessed August 21, 2020. http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html.

Current Convection

Background Information:

- Solar energy directly on the ocean water isn't the only thing contributing to convection in the oceans, salinity is also impacting the movement of water.
    - As salinity increases, the density of the water increases because of the addition of salt molecules.
    - In our previous example, the water is getting heated so much it evaporates, but the ocean isn't pure H_2O, it is full of other elements as well as salt. The salt molecules are too tight to evaporate with the water, so it gets left behind to be absorbed by the replacing water. The replacing water is the same temperature as the surrounding water, but now it's taken on more salt. More salt means higher density and therefore the new replacing water will sink.
- In a similar process, when water freezes, like at the poles, the salt is left behind again for similar reasons. That salt is then absorbed by the water coming in to replace it and once again sinks because of a higher density.
- Therefore, salinity and temperature of the water both work together to create currents in the ocean. A single current can run the whole globe effectively creating a giant conveyer belt. This current is known as the thermohaline circulation.



Arguez, Anthony. Thermohaline Circulation. Aug, 20, 2000. Accessed Aug 21, 2020. Retrieved from: http://mail.tku.edu.tw/086138/EnvFutures/WebPages/Global%20warming/Thermohaline%20Circulation.htm

Current Convection

Density Activity Instructions:

1. Pour water, vegetable oil, corn syrup and rubbing alcohol into their own cups. Use as much or as little desired, but all liquid must fit in the designated clear cup.
2. Add a drop of food coloring to water cup and a different color to the corn syrup cup.
3. Have students hypothesize and record predictions of which liquid has the lightest density to the heaviest.
4. Once predictions are completed, allow students to pour liquids into the clear cup.
    5. The liquids will automatically stack based on density.

Convection Activity Instructions:

Before the class experiment prep by:

- Mixing together water and a food dye.
- Pour dyed water into ice trays and freeze.

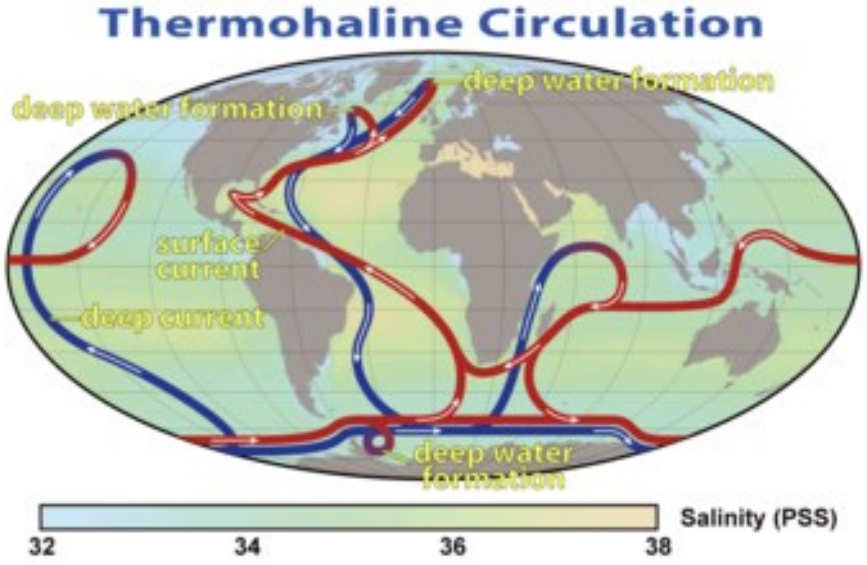
Once class is ready for experiments-

- Boil water
- Pour hot water into clear container. This can be per group, the whole class or individual depending on how many containers, hot water and ice cubes are available.
    - Ensure students can see side of containers.
- Dump the dyed ice into the clear container with boiling water, be careful of any splash.
- Students will see the ice quickly melting and flowing to the bottom of the container. The ice cubes may even swirl a little on the surface.
- Emphasize to students the water flowing down from the ice is cold and sinking to the bottom, demonstrating convection.

Current Convection

Evaluate:

- Discuss student's predictions vs results for the density activity.
- From the convection activity, inquire with students why the cold water dropped to the bottom of the container?
- Have a discussion with students on temperature heating up the oceans and it's impact on density, convection and thermohaline circulation.



Extensions:

After discussing ocean temperature's rising watch this TED video on ocean currents (If pressed for time begin video at 2:46). Then watch this NASA video to see a 3D model of the thermohaline circulation close up.

References:

"Earth Observatory". NASA. Accessed August 18, 2020. https://earthobservatory.nasa.gov/features/EnergyBalance

"Thermohaline Circulation." NOAA. Accessed August 21, 2020. https://oceanservice.noaa.gov/education/tutorial_currents/05conveyor1.html

"Convection". cK-12. Accessed August 18,2020. https://www.ck12.org/physics/convection/lesson/Convection-MS-PS/