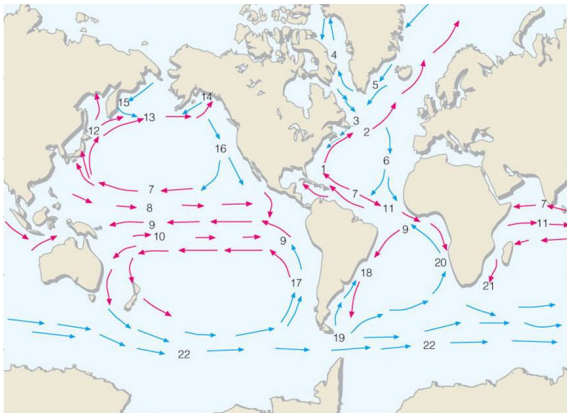
# 5.1.3 - Ocean Circulation

**Background:** We saw that water was heated by infrared and ultraviolet radiation slower than land does; it was the cause of the sea breeze. But being that 71% of Earth's surface is water, most sunlight that reaches the Earth hits the oceans. While occurring less quickly than land, shallow surface water does warm over periods of time due to absorption of solar radiation. Fast moving streams are moving too quickly to absorb enough, and deep ocean waters are much to deep to be reached by solar radiation.

In terms of specific solar radiation, all wavelengths of light (ROYGBIV) are absorbed by shallow water except for the blue wavelength, which is reflected causing the water to look blue. All wavelengths of light are absorbed by the time a depth of 100m has been reached, so deep lakes and oceans are incredibly dark below the surface region. Infrared rays are responsible for determining water temperature and are also absorbed in the upper zone, but only if the water is moving very slowly because it takes an extended amount of infrared rays to heat up water. This is why land heats faster than water does, and it also why rivers that move quickly are always cold. This is also why surface waters are warm and deeper waters are frigid. Latitude dictates the amount of direct solar radiation, and thus infrared light, meaning tropical waters will be warmer throughout the year while polar regions will be colder because of the less direct light. In either case, the surface waters will be the warmest.

**Surface Ocean Currents**

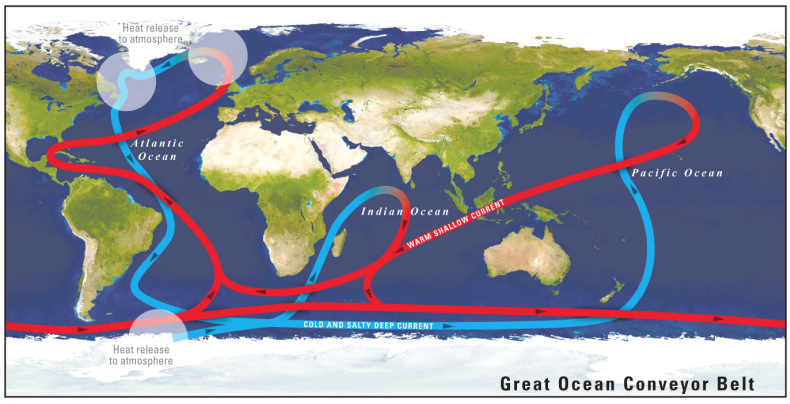
Just like wind currents, pressure and density determine where water will move once two bodies of water interact. As solar energy reaches Earth's oceans most directly in areas near the equator, surface water in that region is warmer.



The surface ocean water is set into motion by energy from the wind creating *surface currents*. The wind belts determine the direction of the flow, but the Coriolis effect and interaction with continents also help determine surface ocean current direction of movement. Warm equatorial surface currents flow and bring warm water to cooler regions. This occurs along the eastern United States, as the general pattern of the Atlantic Ocean is clockwise, bringing warm water up from the Caribbean Sea. Currents coming from areas near the poles where solar energy is less direct are cold currents. As cold currents move toward the equator, they cool the region around them. This occurs along the western United States, as being in the Northern Hemisphere, currents will again travel clockwise, causing water to move towards California from the Alaska area.

**Global Ocean Current**

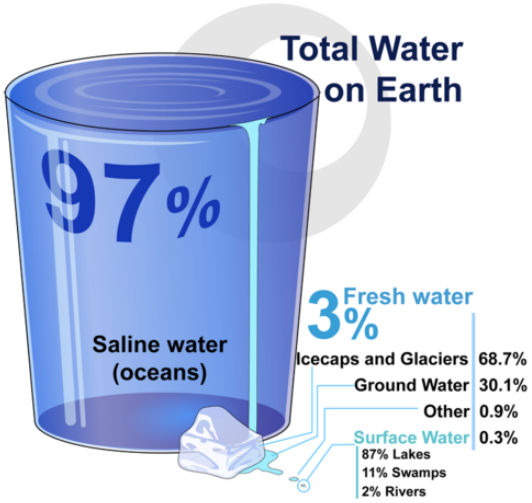
A global *ocean conveyer belt* exists and it is powered by density differences between warm water and cold water. Water warmed by solar energy near the equator expands and is less dense and will float on top of cold water. Cold water from the pole therefore sinks, and then moves very slowly beneath warmer ocean water as it travels toward the equator. Once in the deep ocean, water can stay in this deep ocean current for 10,000s of years before reaching the surface again, which is why the deep ocean once carbon reached the deep ocean in our carbon cycle game during unit 2, it generally stayed there for a while. This entire process where differences in water density between warm and cold water causes cold water to sink at the higher latitudes once it has released it's energy leads to the *ocean conveyor belt.* Warm water is less dense because the water molecules (and other stuff in the water) are spread further apart from each other. Cold water, with their molecules more tightly packed, is more dense and will sink if the two interact.




**Water**

There are two major types of water: freshwater and saltwater. Freshwater is one of Earth's more abundant and important renewable resources. Freshwater is a mixture that contains more substances than just pure water, such as whatever minerals are absorbed as water passed through soil or rock. Freshwater has a density of about 1.0 g/cm$^3$ and freezes at 0°C.

Saltwater is more dense than freshwater, with a density of about 1.03 g/cm$^3$, which means that when the two interact, saltwater will sink below the freshwater. Saltwater also freezes at a much lower temperature, freezing at minus 20°C. Seawater is also a mixture, but it contains more dissolved substances than freshwater. It is a solution of about 96.5% water and 3.5% dissolved salts. Dissolved gases, such as oxygen, nitrogen, and carbon dioxide, are also present along with dissolved nutrients. The salinity (amount of salt) of ocean water varies from place to place. High salinities (amount of salt) are found in areas where evaporation is high or where seawater is freezing, because as saltwater evaporates or freezes, only the water is actually changing states and the salt (and other dissolved compounds) stay where they were. Low salinities occur where freshwater empties into, like the Charleston Harbor.




In photographs taken from space, we can see that our planet has more water than land. It is unexpected and somewhat inconceivable that less than 3% of Earth's water is fresh water. According to the U.S. Geological Survey, most of that three percent is inaccessible. Over 68% of the fresh water on Earth is found in icecaps and glaciers, and just over 30% is found in ground water. Only about 0.3 percent of our fresh water is found in the surface water of lakes, rivers, and swamps. Of all the water on Earth, more than 99 percent of Earth's water is unusable by humans and many other living things!

## Review Questions

1. Does land or does water heat up/cool down faster?
2. How much of the surface of the Earth is covered in water?
3. Why does water appear blue?
4. What do infrared rays do to water?
5. What causes surface currents?
6. East vs West coast of the United States. Which one is getting warm ocean currents and which is getting cold ocean currents? Explain why this is true.
7. What is the difference between warm and cold water in terms of density and what does that mean about the spacing of their molecules?
8. What is the difference between fresh and salt water in terms of density and freezing temperature? Include numbers and units *(Great set up for a table…)*
9. What are 2 scenarios when ocean water will become more saline (more salty)?
10. What is a natural scenario where ocean water will become less saline (less salty)?
11. How much of Earth's water is freshwater?
12. Where (and how much of) is most freshwater on Earth found?
13. Draw me the water cycle with land, an ocean, and a cloud. You should include 5 arrows. Also label each arrow with whether the water is fresh water or salt water.