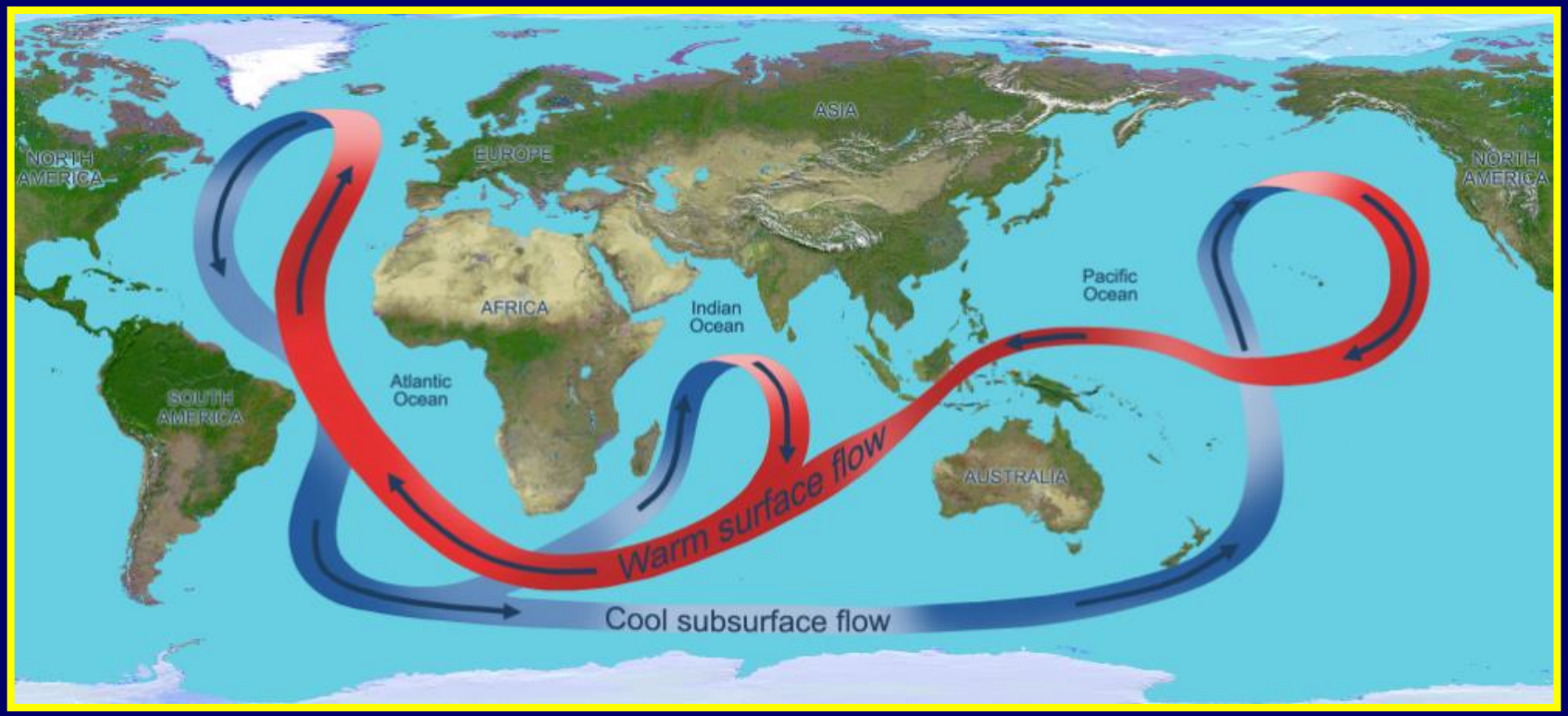
Earth's Heat Balance



Essential Standard 2.3

Explain the structures and processes within the hydrosphere.

Learning Objective 2.3.1

Explain how water is an energy agent due to the transfer of heat by ocean currents and formation of sea and land breezes due to high heat capacity of water.

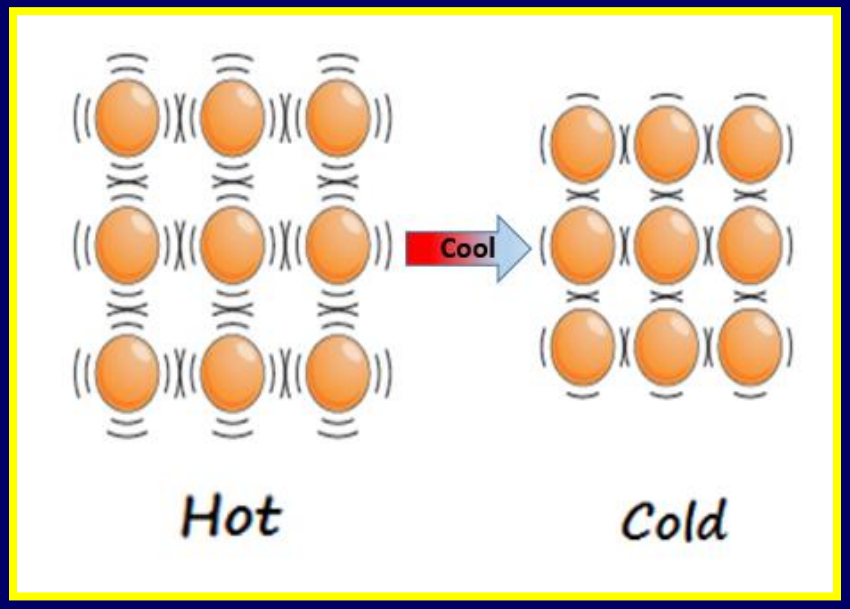
I Can Statements

At the end of this lesson, you should be able to say, with confidence:

- I can explain how deep currents form.
- I can explain how surface currents form.
- I can explain how ocean currents help balance the heat energy on Earth.
- I can explain how the high heat capacity of water helps moderate coastal climates.

Density

Water with high salinity levels have a density than water with lower salinity levels.



Cold water has a higher density than warm water.

Deepwater Masses

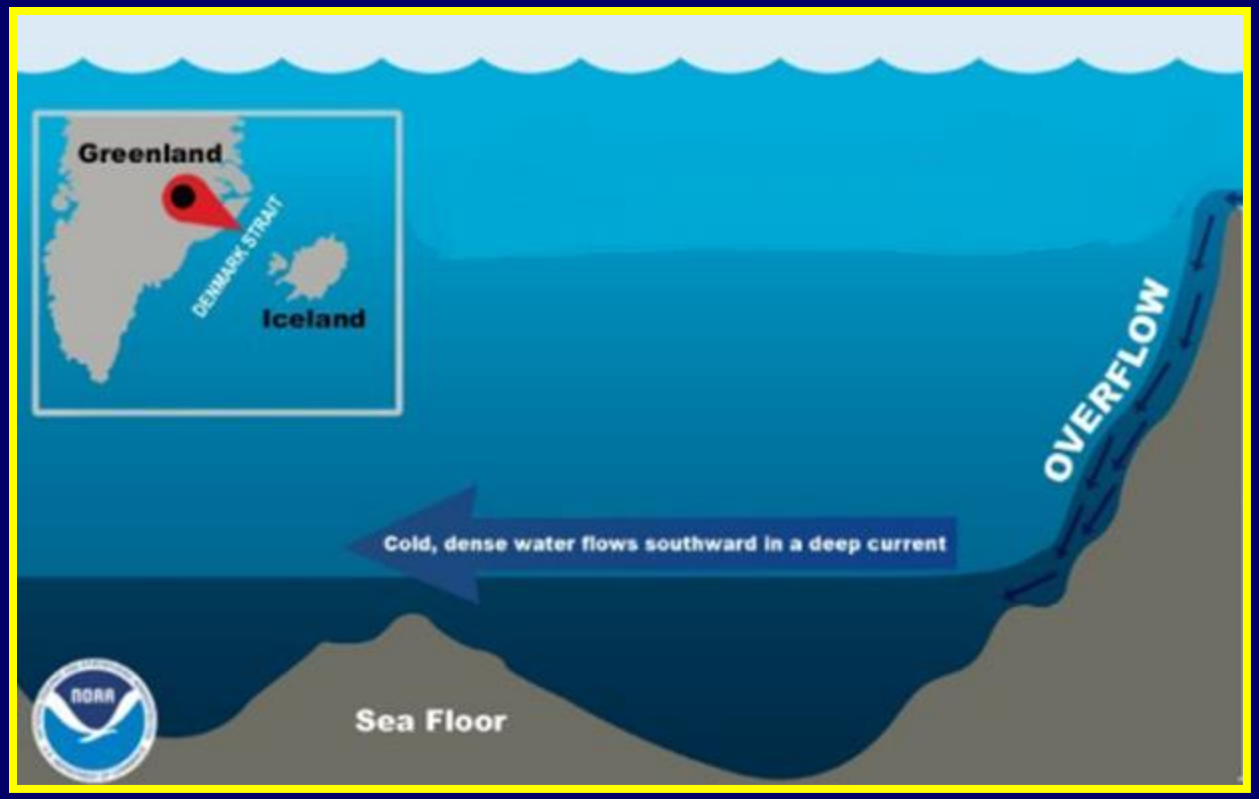
When seawater freezes near the poles, the salt is not incorporated into the ice and collects under the ice.

As a result the water under the ice increases in salinity.

The higher salinity increases the density of the water, causing it to sink and form a deepwater mass.

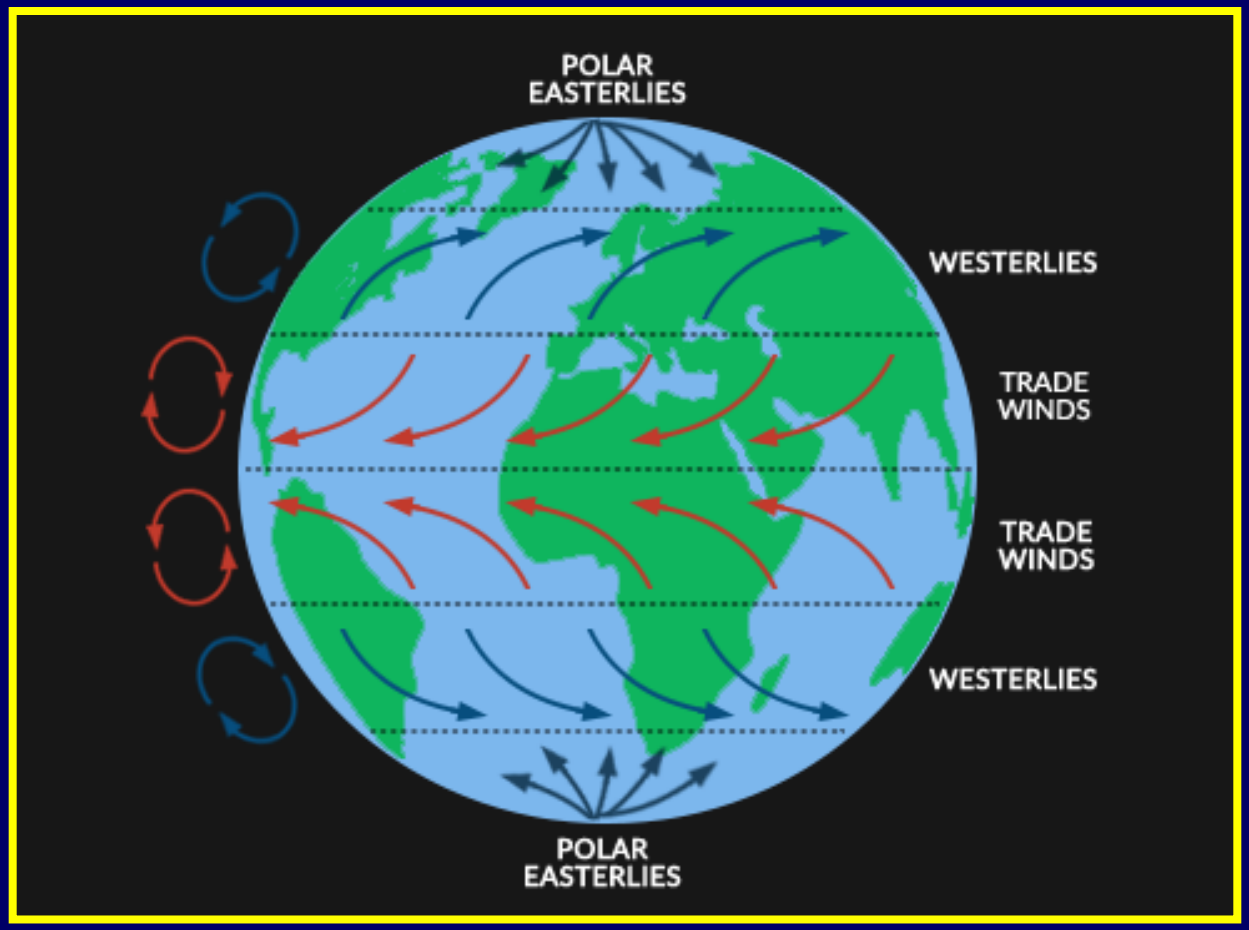
Density Currents

As more and more cold, salty, dense water is added at the poles, the deepwater mass is pushed towards the equator in what is called a density current.



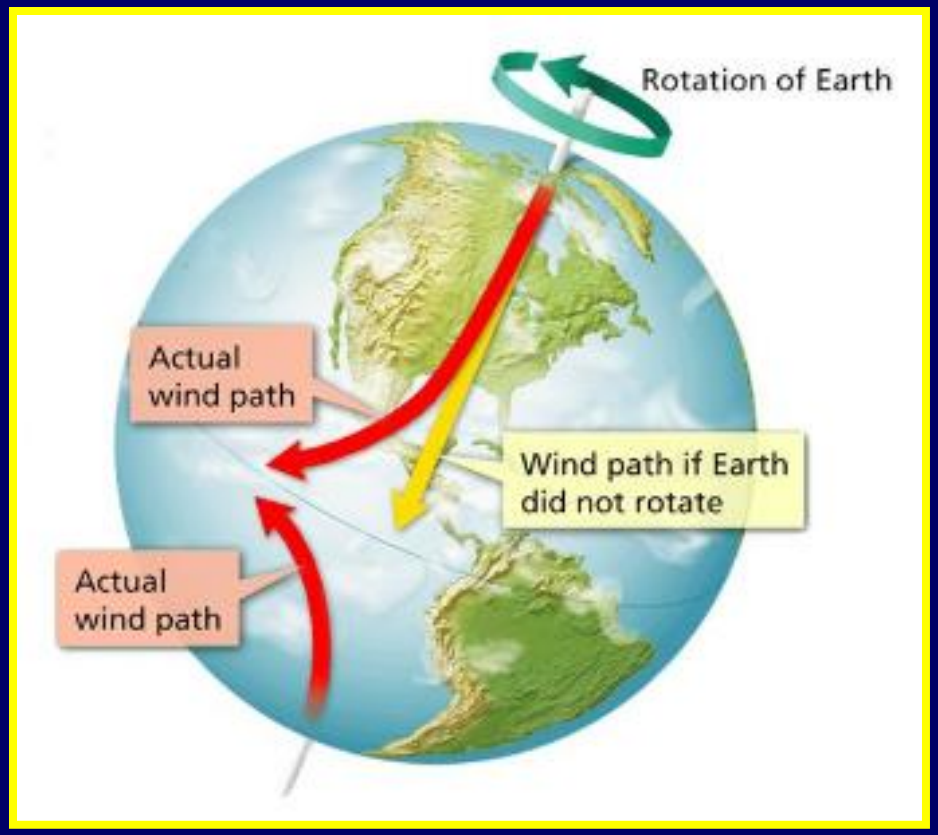
Surface Currents

At the ocean surface, the warmer waters are driven by Earth's global wind systems.



Coriolis Effect

Because the Earth rotates on its axis, wind is deflected to the right in the northern hemisphere and towards the left in the southern hemisphere.

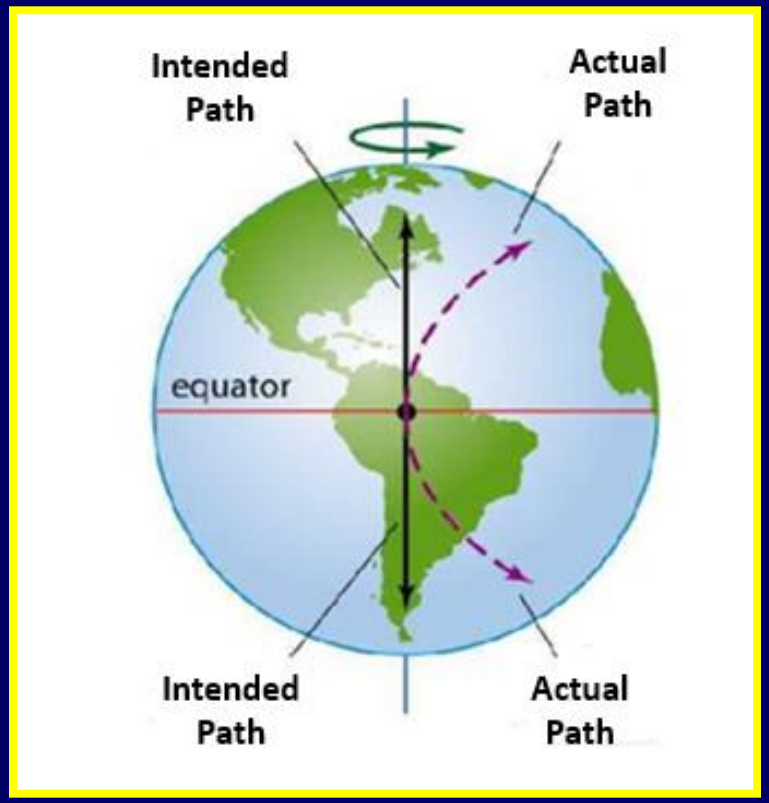


This deflection of the wind is called the Coriolis Effect.

Winds moving towards the equator travel towards the west.

Coriolis Effect

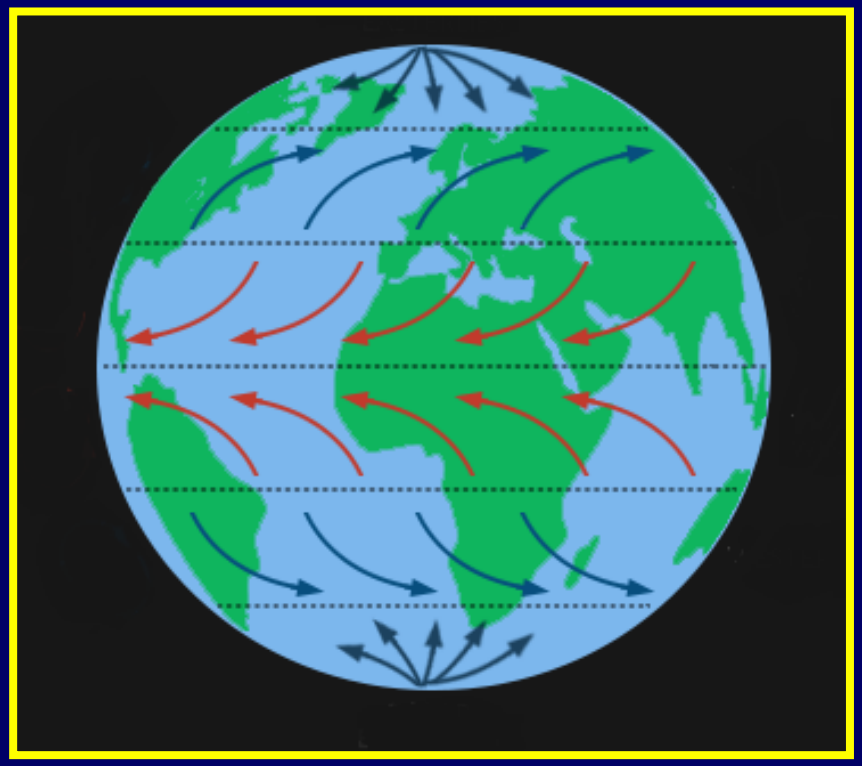
Winds traveling from the equator to the poles are still deflected to the right in the northern hemisphere and to the left in the southern hemisphere.



But now the winds are traveling towards the east, instead of the west.

Direction of Surface Currents

Surface currents are mostly determined by the direction of the global wind systems.

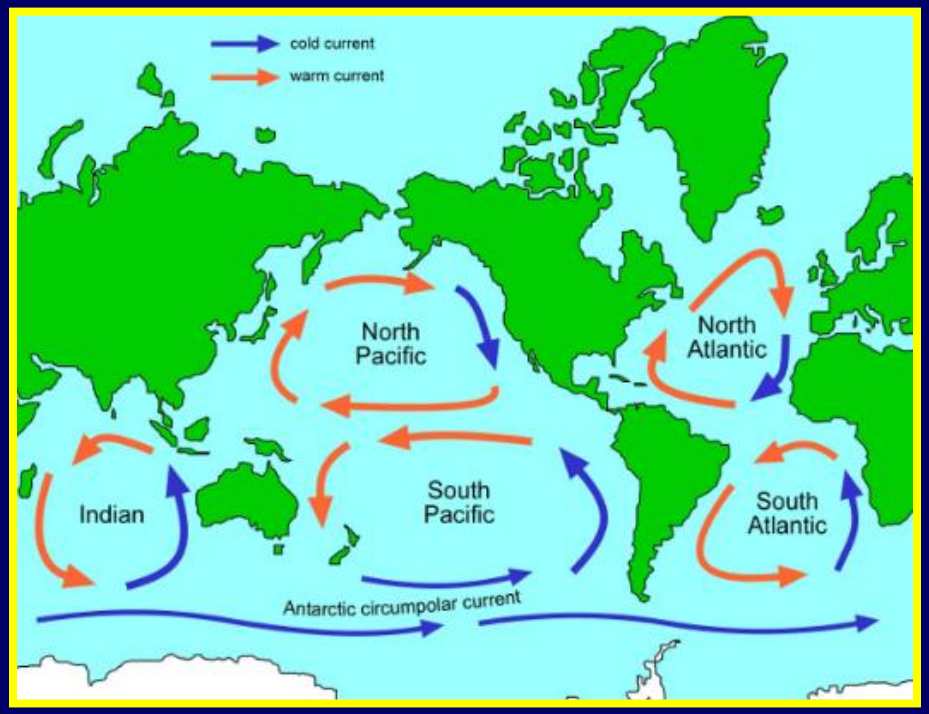


Surface currents traveling towards the equator travel westward.

Surface currents traveling towards the poles travel eastward.

Gyres

When ocean currents encounter a land mass, the water is deflected towards the north or south.



As a result of both the Coriolis Effect and landmasses, ocean currents travel in circular systems called gyres (Ji urz).

Gyres rotate clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere.

The Gulf Stream

The Gulf Stream is part of the North Atlantic gyre and brings warm water up from the Equator; along the east coast of the United States; over to Iceland, and finally over to England.

The Gulf Stream

The warm ocean current keeps the climate in those areas warmer and more humid than it would be just based on latitude.

Tropical garden in Devon, England.

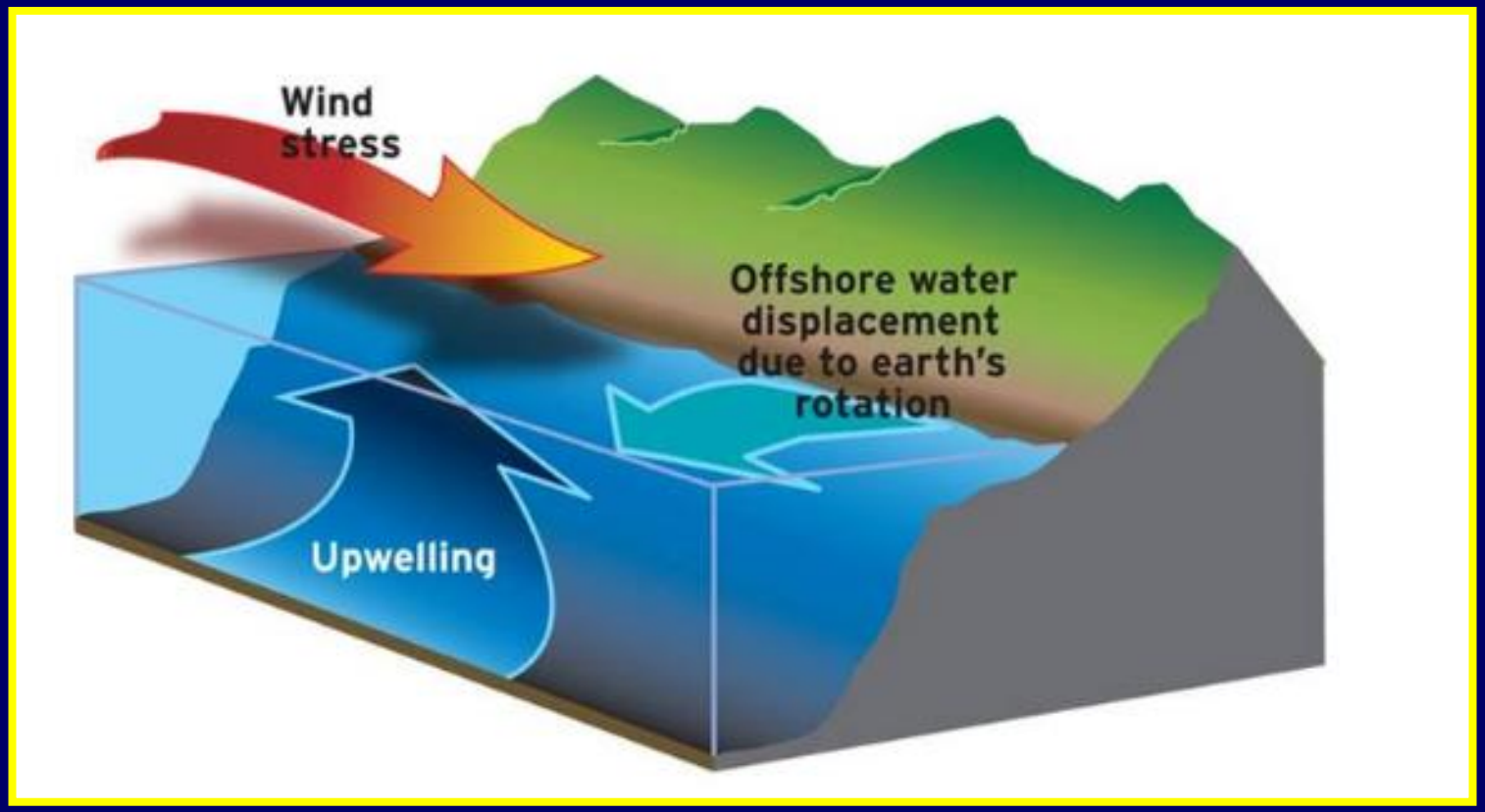
Surface and Deepwater Currents

Warm surface currents, controlled by the wind, travel towards the poles.

Near the poles, the density of the water increases due to higher salinity and colder temperatures, causing the water to sink and be pushed towards the equator.

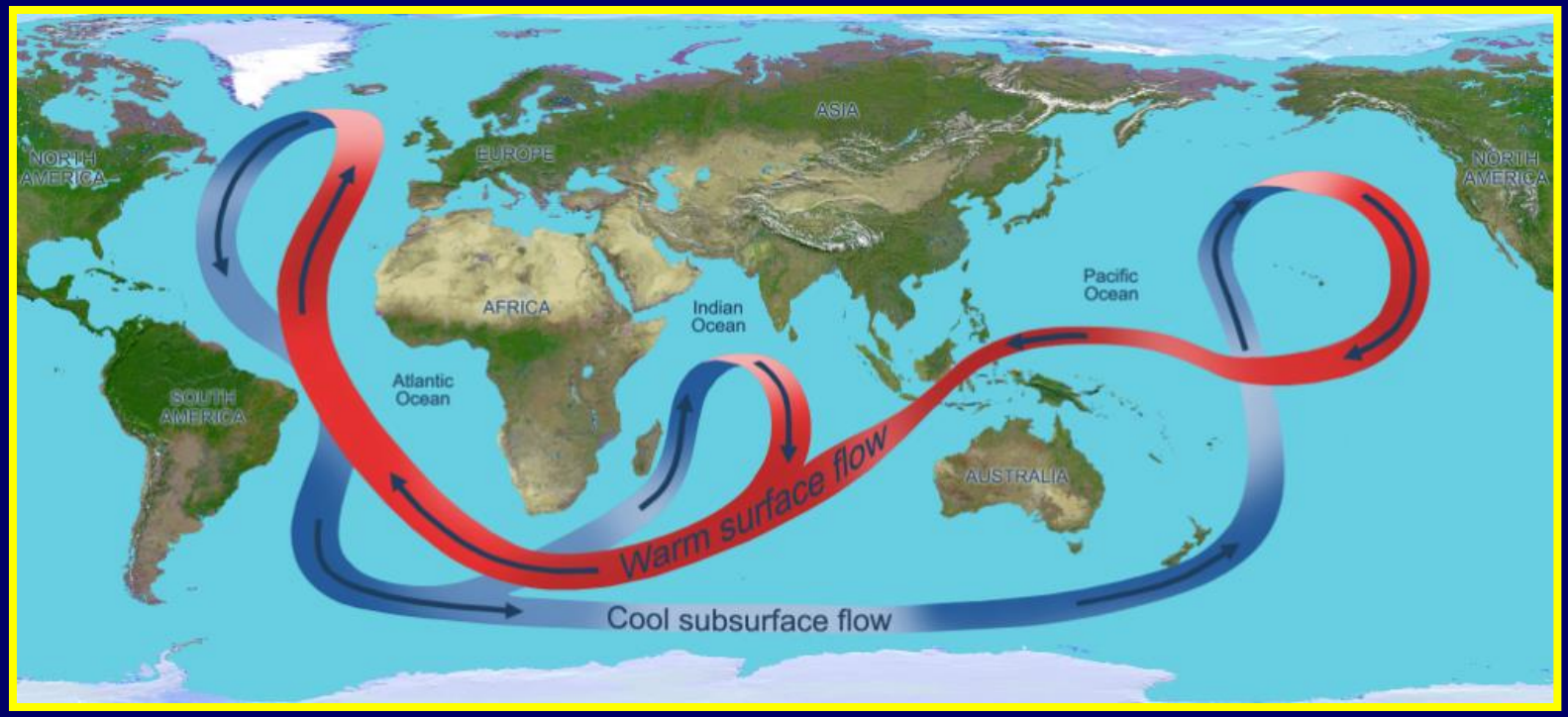
Surface and Deepwater Currents

Near the equator, the Coriolis effect pushes the warm surface water off the coasts, towards the open ocean, and deep cold water rises to replace it.



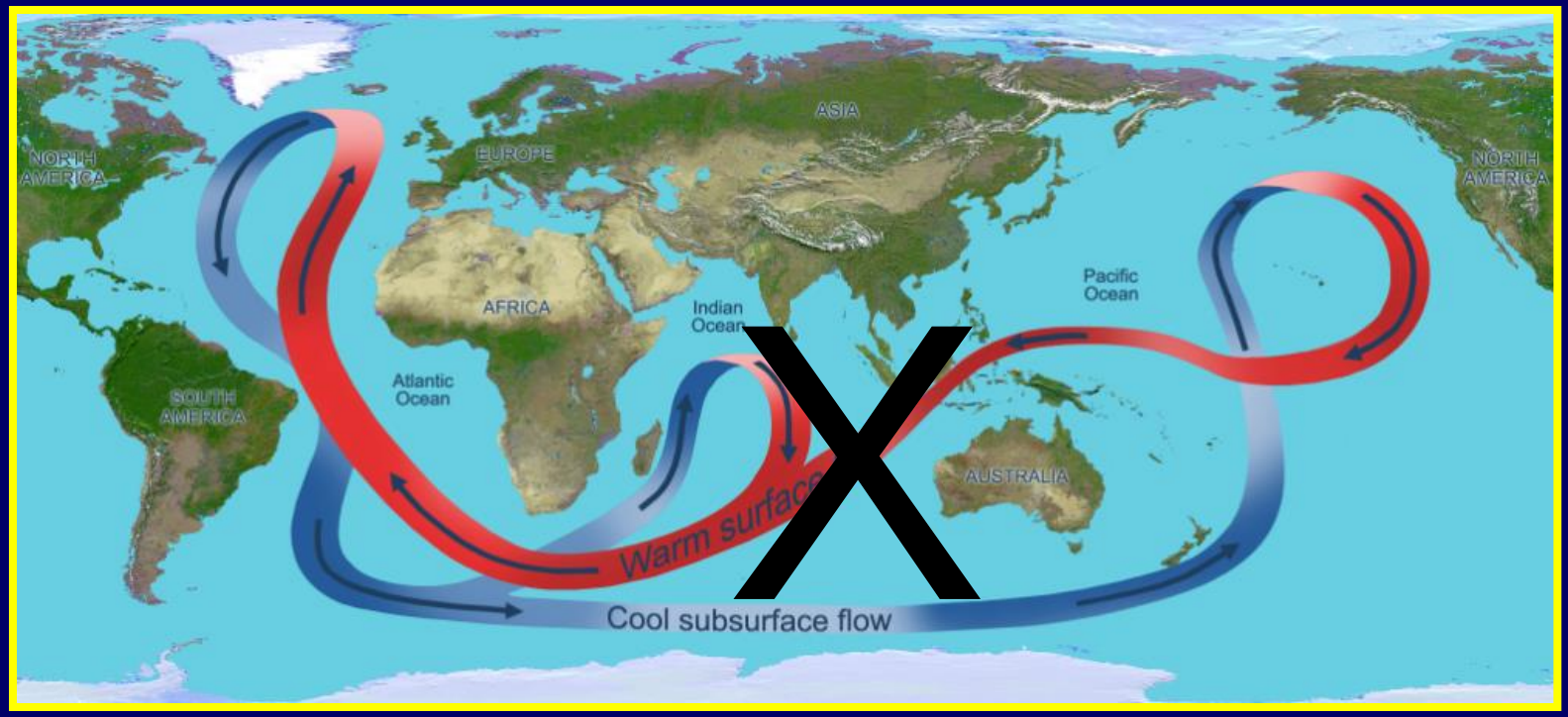
Global Conveyor System

This interaction of wind-driven warm surface currents and density-driven deep ocean currents creates a global conveyor system that helps balance Earth's heat.



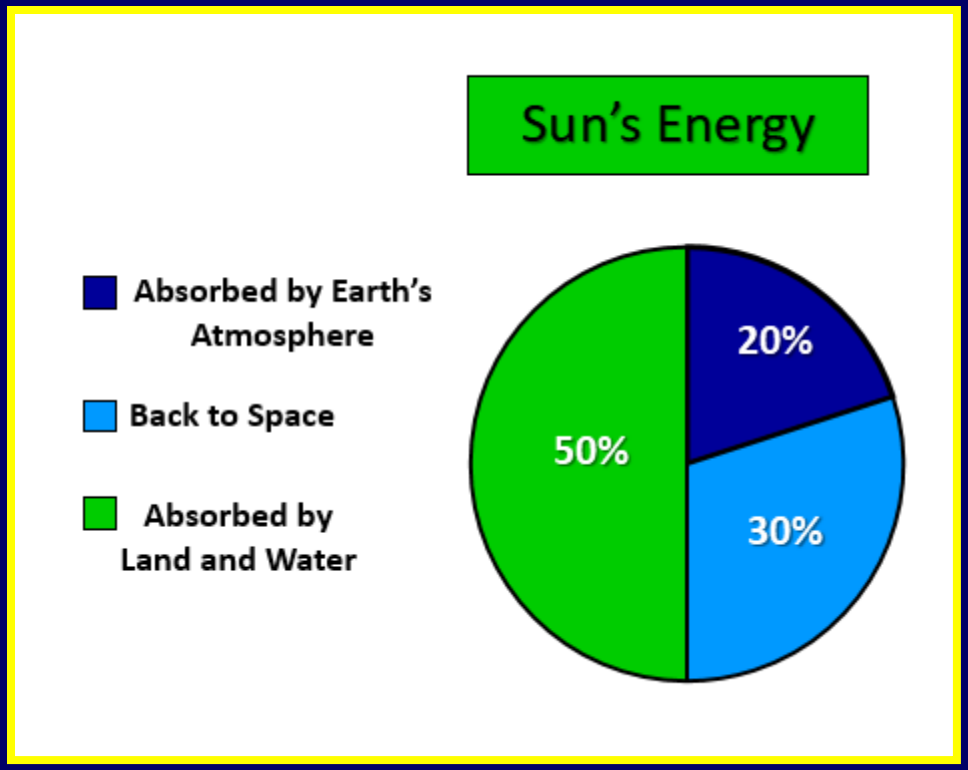
Balancing Earth's Heat

Without the global conveyor system, it would be a lot colder near the poles and a lot hotter near the equator because the transfer of heat would no longer occur.



Sunlight Energy

About half or 50% of the sunlight energy that reaches Earth is absorbed by the land and water on Earth's surface.



Different Rates

Even though the water and the land receive the same amount of sunlight, they both absorb the heat at different rates.

Heat Capacity

The reason has to do with what is called the heat capacity of the material involved.

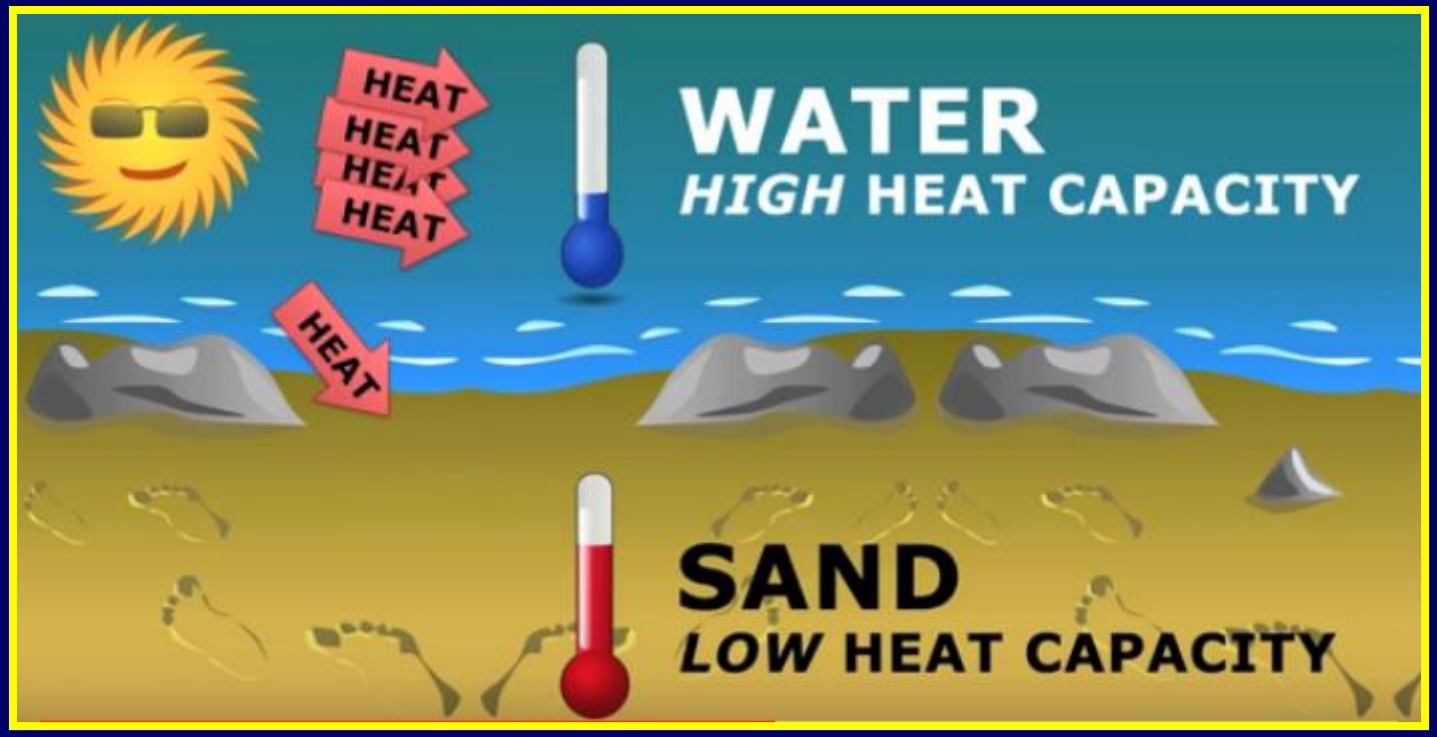
Heat capacity is the capacity a material has to gain or lose heat.

Materials with a high heat capacity can absorb a lot of heat energy before it experiences an increase in temperature.

Materials with a low heat capacity will experience an increase in temperature after very little heat absorption.

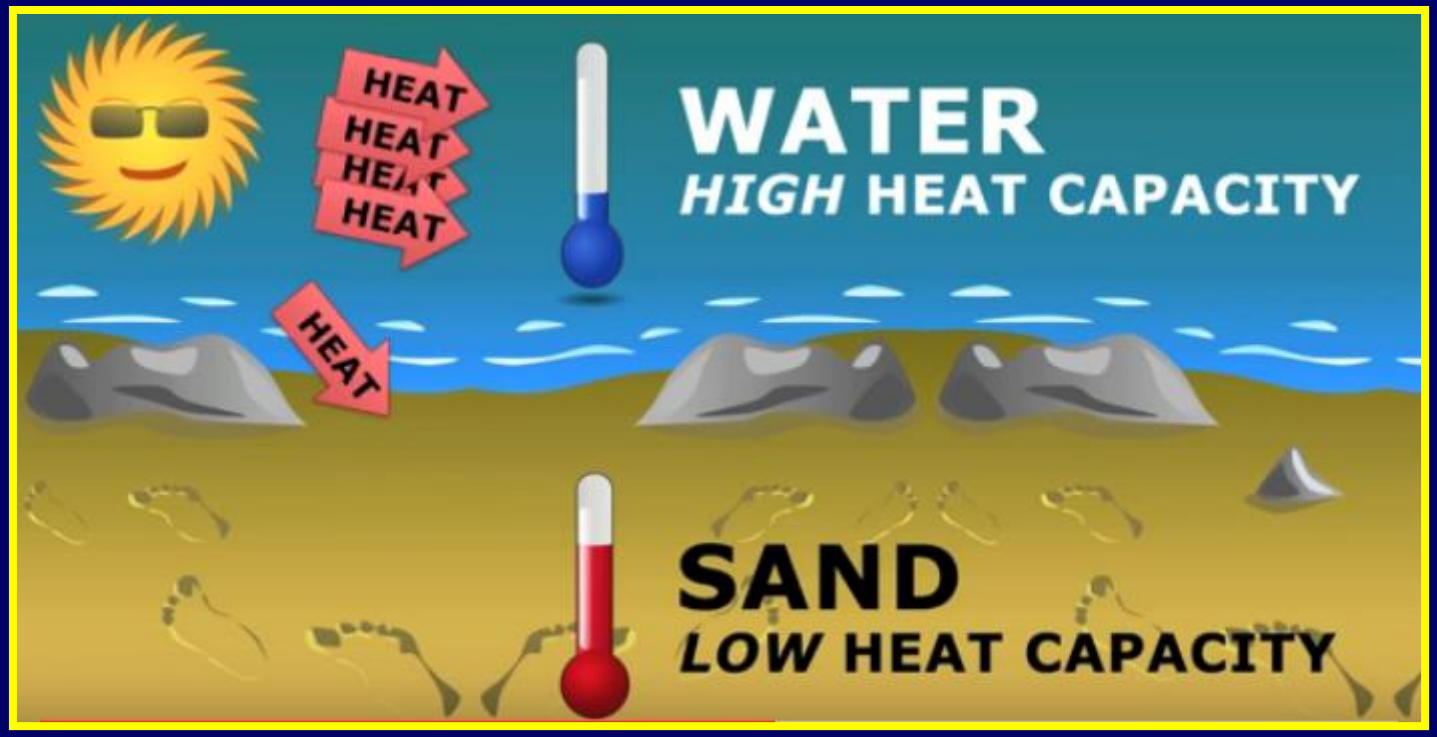
High Heat Capacity of Water

Water has a very high heat capacity. So, water can absorb a lot of heat before the temperature of the water actually increases.



Low Heat Capacity of Sand

Sand has a very low heat capacity. So, the temperature of the sand increases after just a little bit of heat absorption.



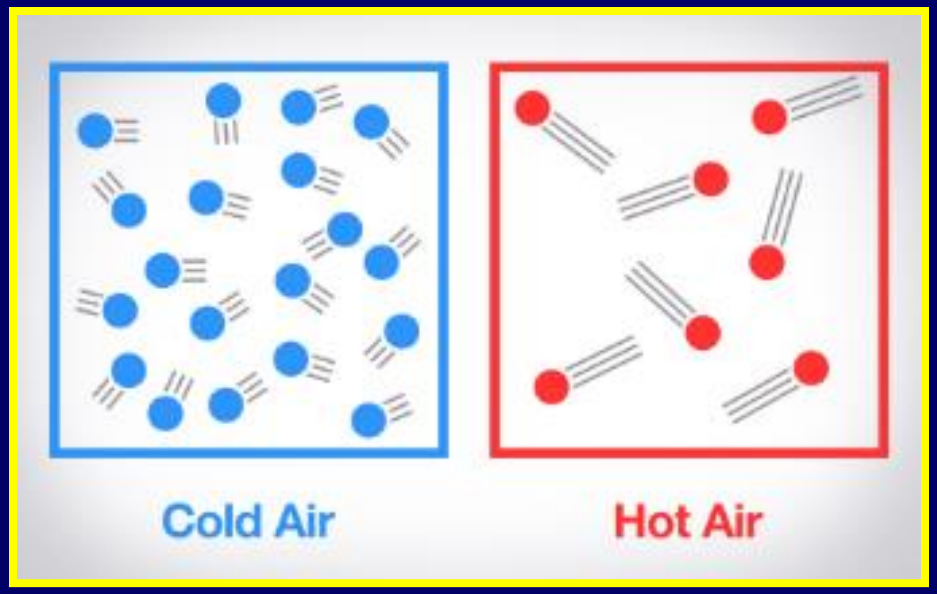
Heat Capacity

Once the heat source is removed, substances with low heat capacities will cool down faster than substances with high heat capacities.

On the beach at night, the sand feels very cool, but the temperature of the water doesn't change much from what it was during the day.

Effect of Temperature on Air

Warm land or warm water transfer heat to the air above. As the air is warmed, its molecules begin moving faster and spread out, making the air less dense.

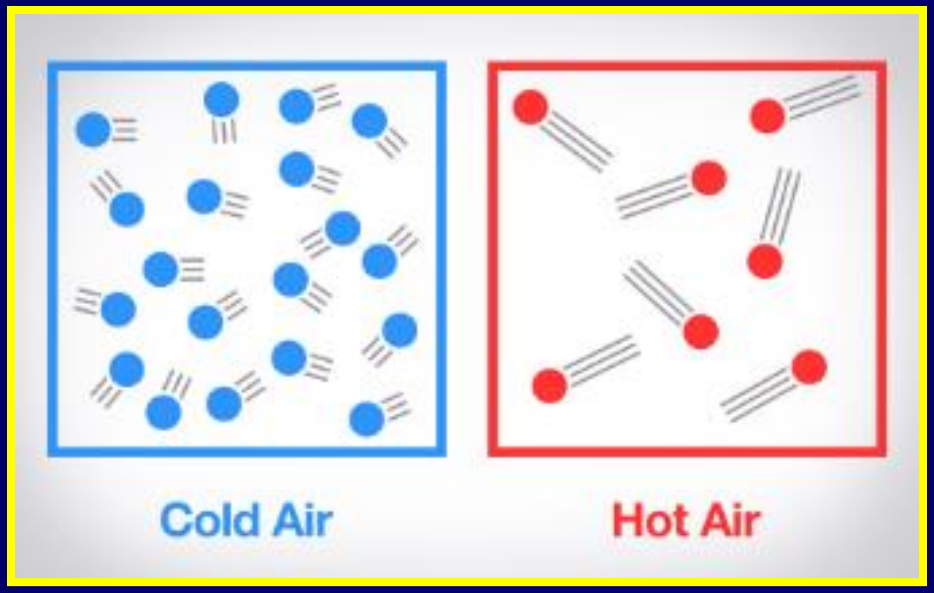


As the air becomes less dense, it begins to rise.

Effect of Temperature on Air

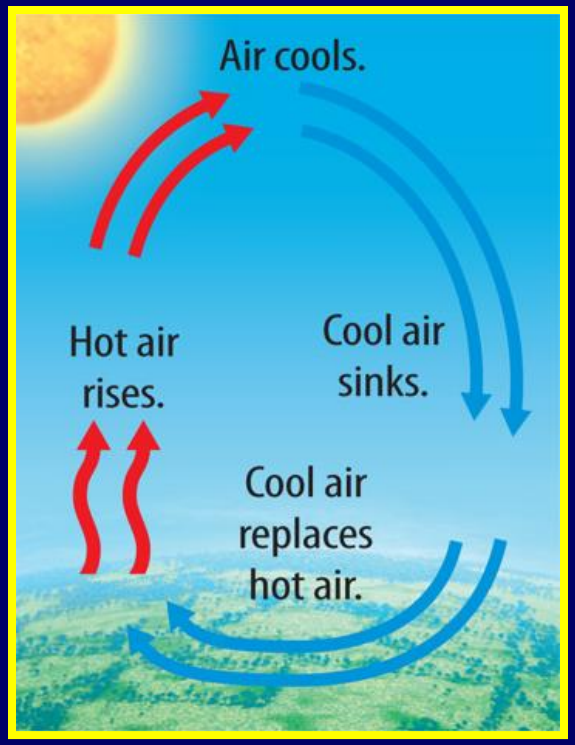
One the other hand, cool sand or water tends to cool the air above. As the air cools, the molecules slow down and become compacted, making the air more dense.

As the air becomes more dense, it sinks.



Wind or Breeze

As hot air rises, it begins to cool. Once it is cool, it begins to sink. The process repeats, creating a cycle of moving air.



This process is called convection and results in the creation of a gentle wind or breeze.

Sea Breeze

During the day, the hot air over the land rises and the cooler air, over the sea, moves towards land to replace the hot air.

This movement of air creates a very gentle sea breeze.

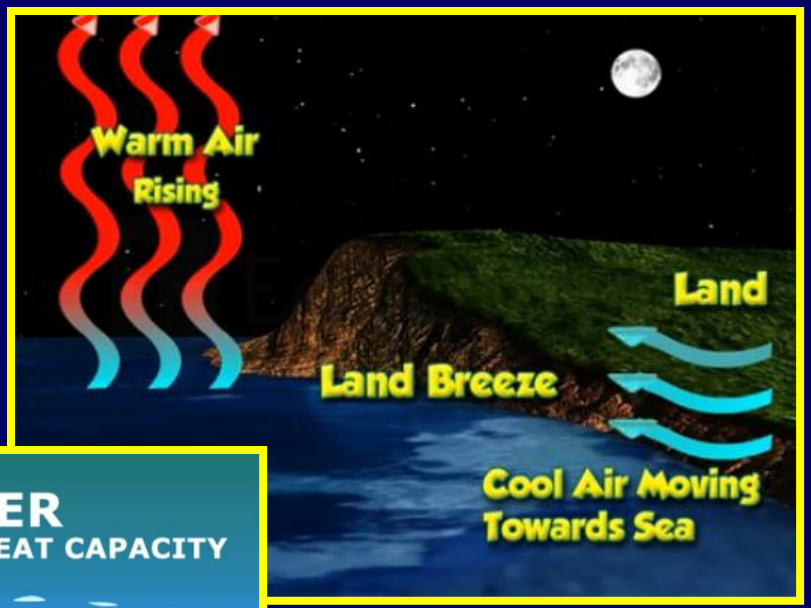
Land Breeze

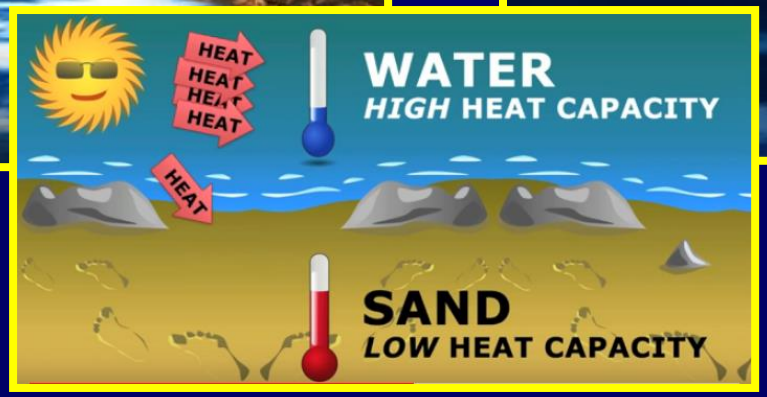
During the night, the land cools down much faster than the sea. So, the air over the sea is warmer and rises. The cooler air over the land then moves in to replace the rising sea air.

This movement of air creates a very gentle land breeze.

Moderate Coastal Climates

Due the sea and land breezes that are a result of the high heat capacity of water, coastal climates tend to be more moderate than inland climates.





The End