

# Honors Marine Ecology

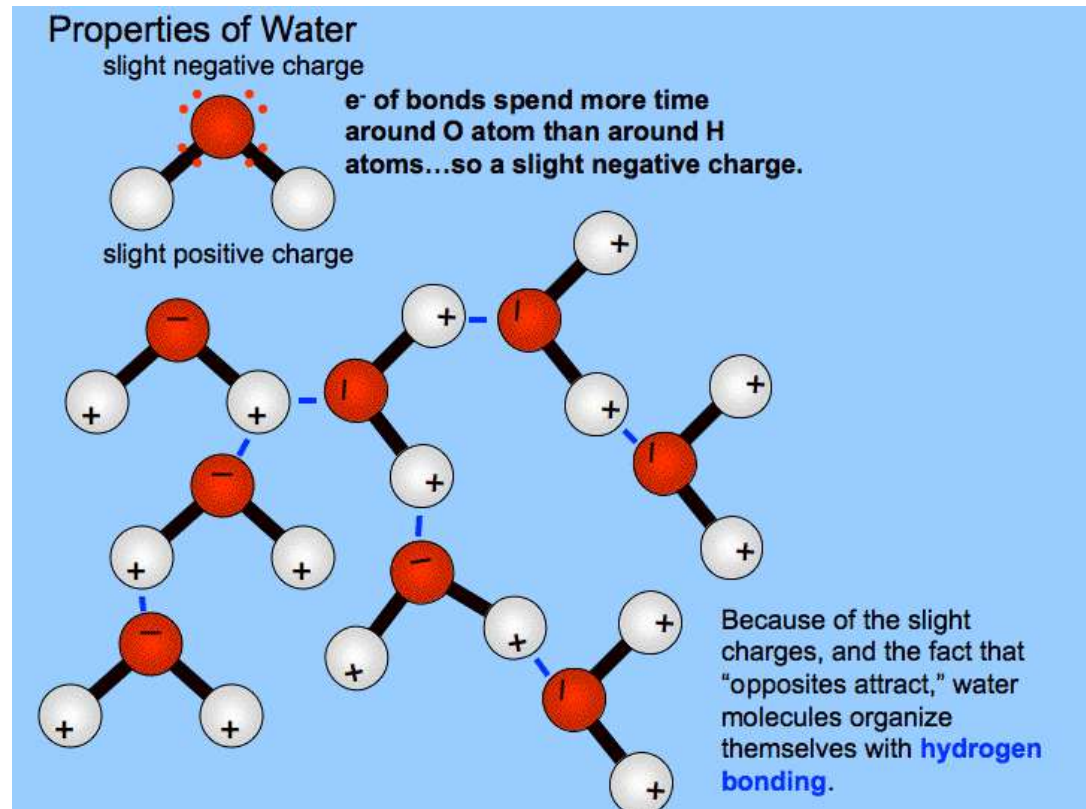
Water, Ocean Water, & Currents

# Water

Water is H<sub>2</sub>O

Water is created when 2 Hydrogen atoms form covalent bonds with an oxygen atom

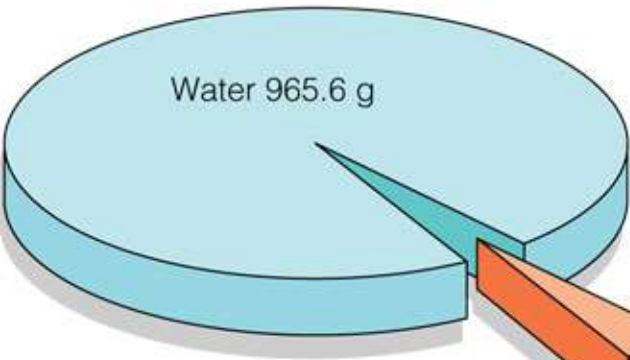
Water is a polar molecule



# Water

- Water is a polar molecule
  - Bond between 2 water molecules = hydrogen bond (easily formed easily broken weak bonds)
  - Water is the universal solvent
    - Numerous ions and molecules dissolve in water
      - NaCl
      - Oxygen
      - Carbon Dioxide

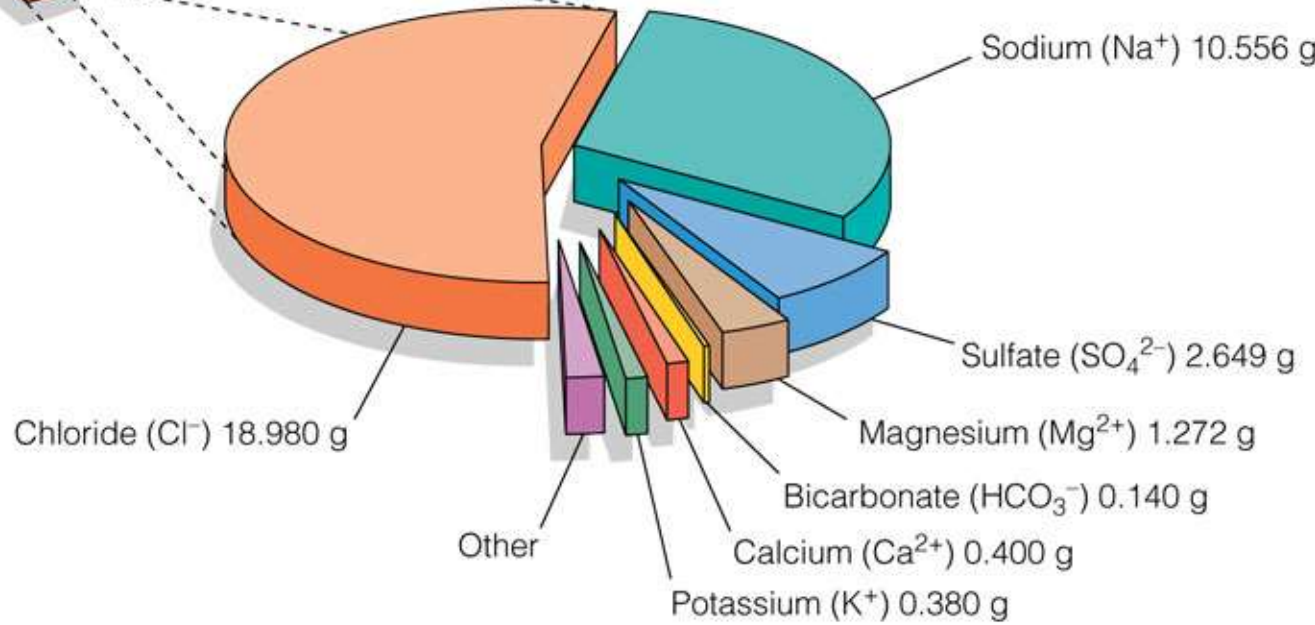
Kilogram of seawater



Water 965.6 g

Most abundant ions producing salinity

Other components (salinity) 34.4 g



Sodium ( $\text{Na}^+$ ) 10.556 g

Sulfate ( $\text{SO}_4^{2-}$ ) 2.649 g

Magnesium ( $\text{Mg}^{2+}$ ) 1.272 g

Bicarbonate ( $\text{HCO}_3^-$ ) 0.140 g

Calcium ( $\text{Ca}^{2+}$ ) 0.400 g

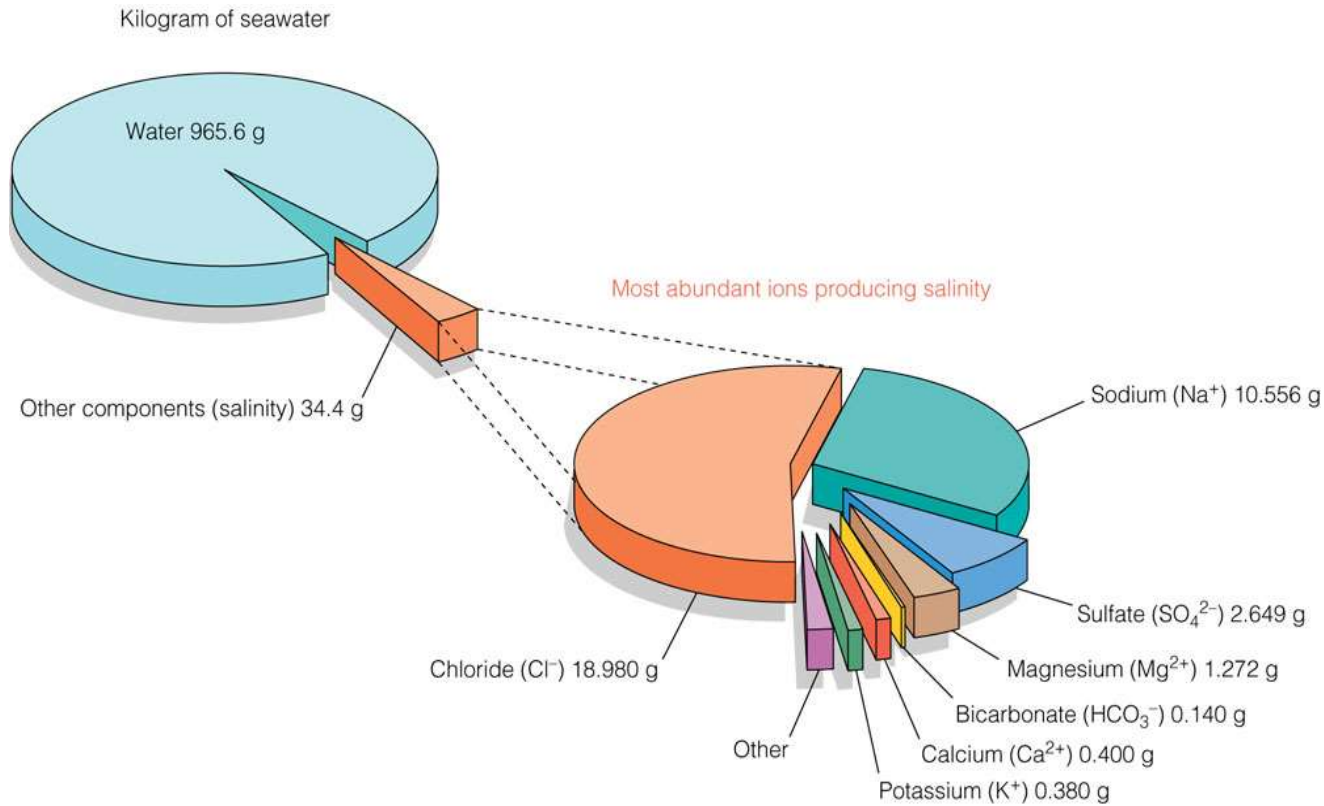
Potassium ( $\text{K}^+$ ) 0.380 g

Chloride ( $\text{Cl}^-$ ) 18.980 g

Other

# Composition of Ocean Water

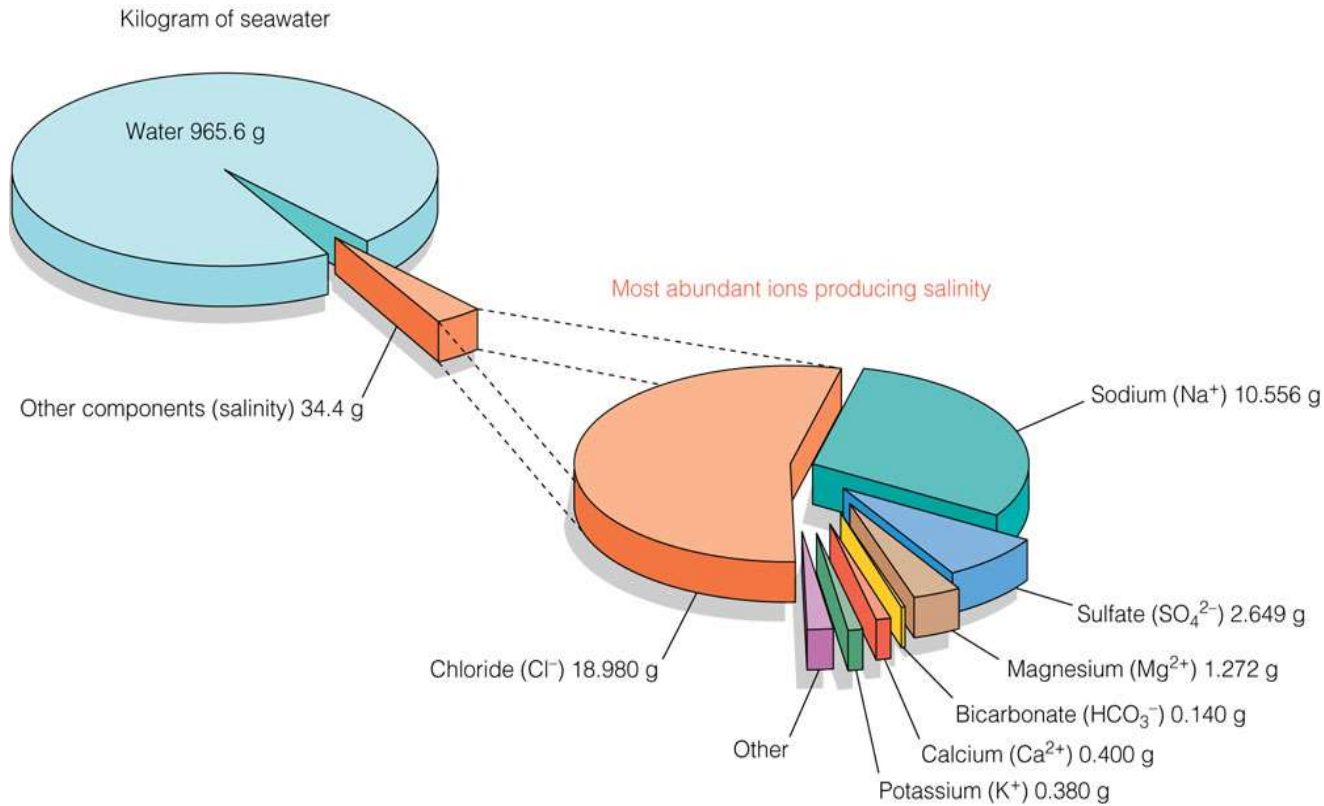
96.5% Water



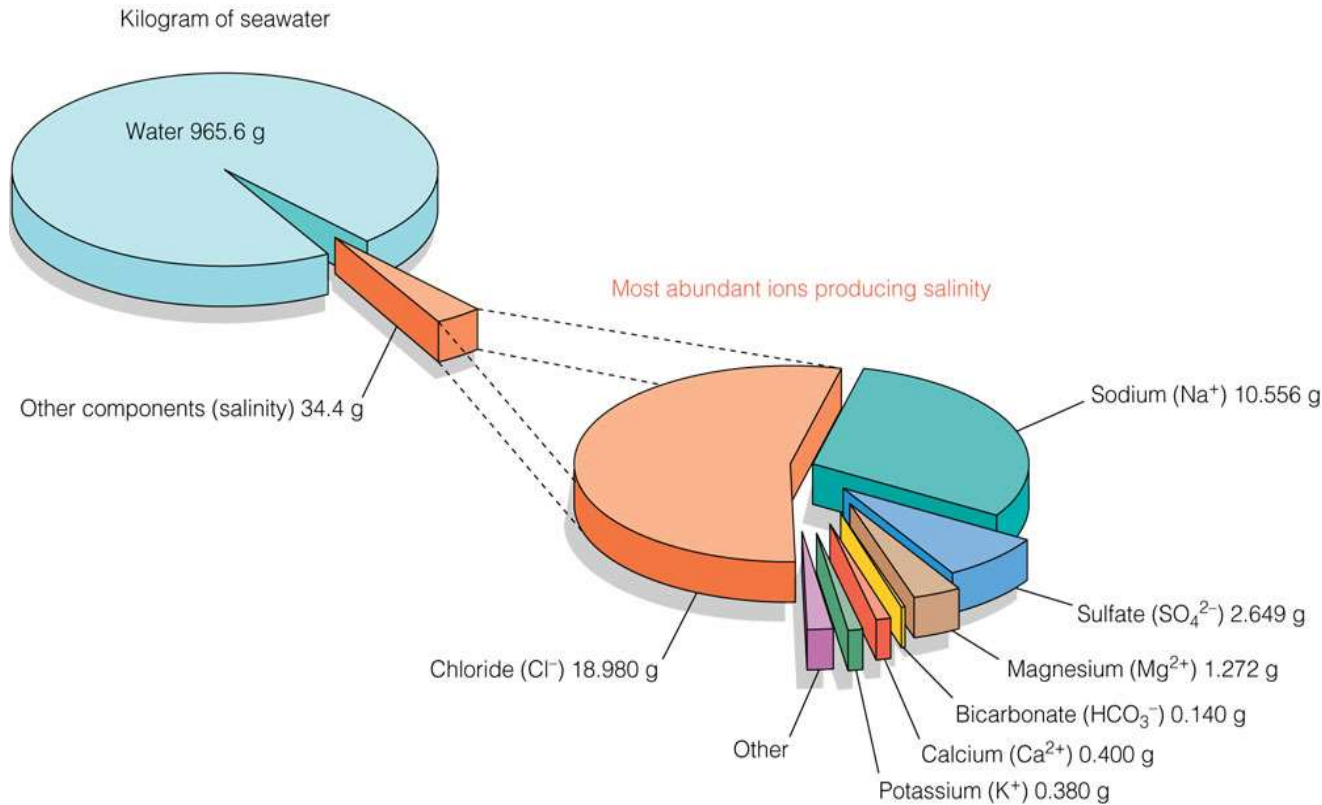
# Composition of Ocean Water

96.5% Water

3.5% Ions

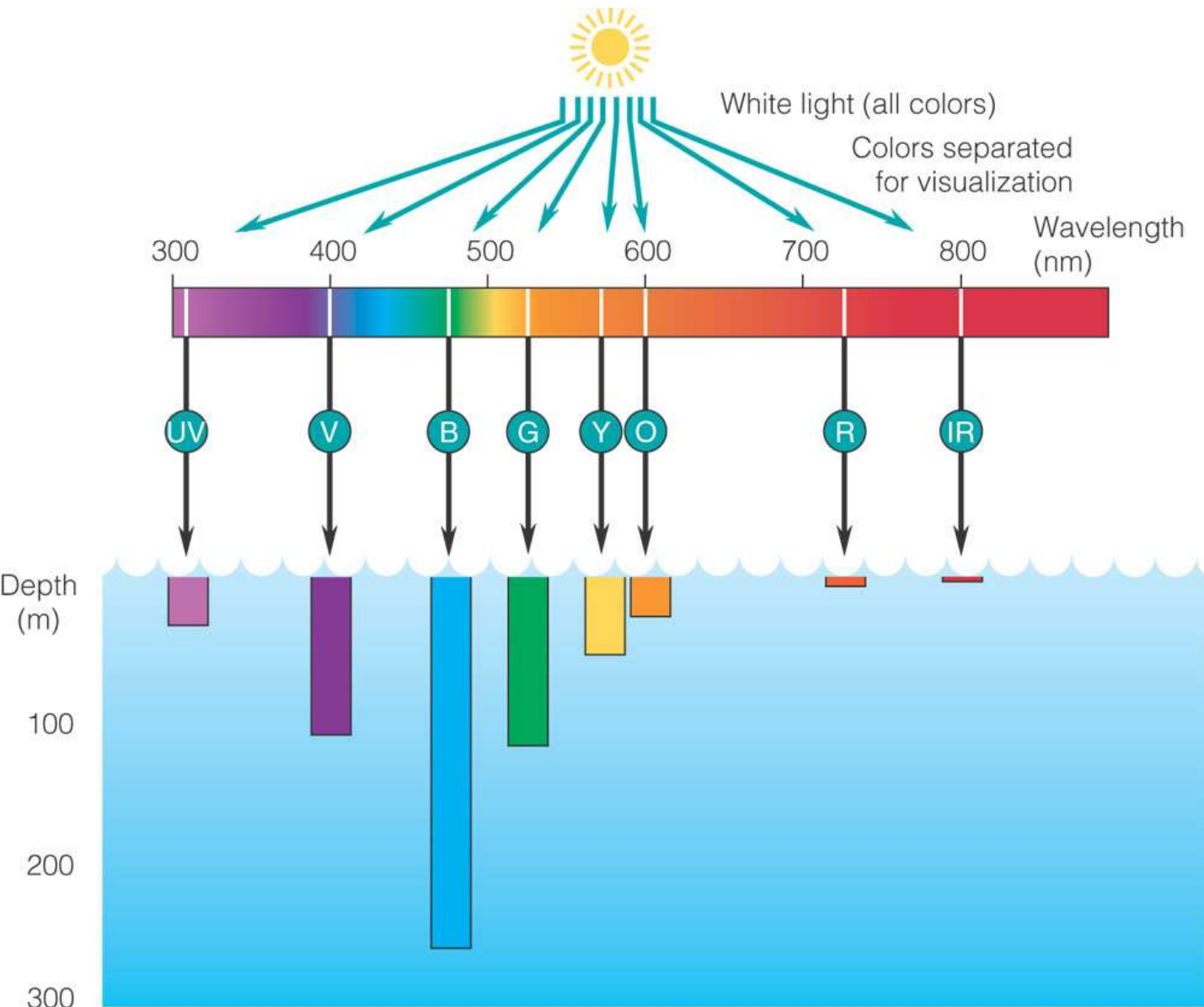


# Composition of Ocean Water



19.3%	$\text{Cl}^-$
10.6%	$\text{Na}^+$
2.7%	Sulfate
1.3%	$\text{Mg}^{+2}$
0.4%	$\text{Ca}^{+2}$
0.4%	$\text{K}^{+2}$
0.1%	Bicarbonate

# The Penetration of Sunlight in Ocean Water



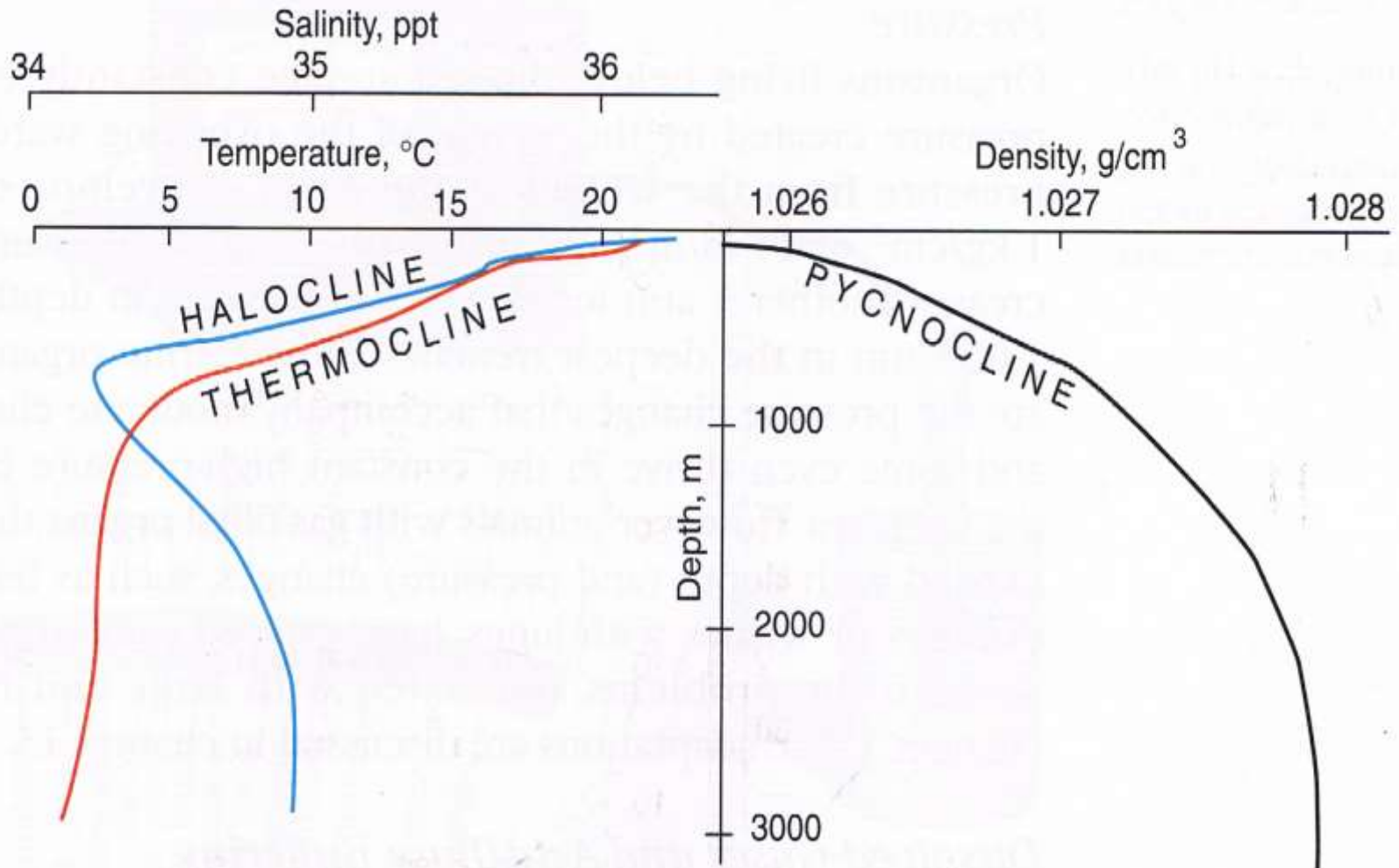
In the clearest water, light's colors begin to drop out at 15 m, all light cannot penetrate beyond 275 m



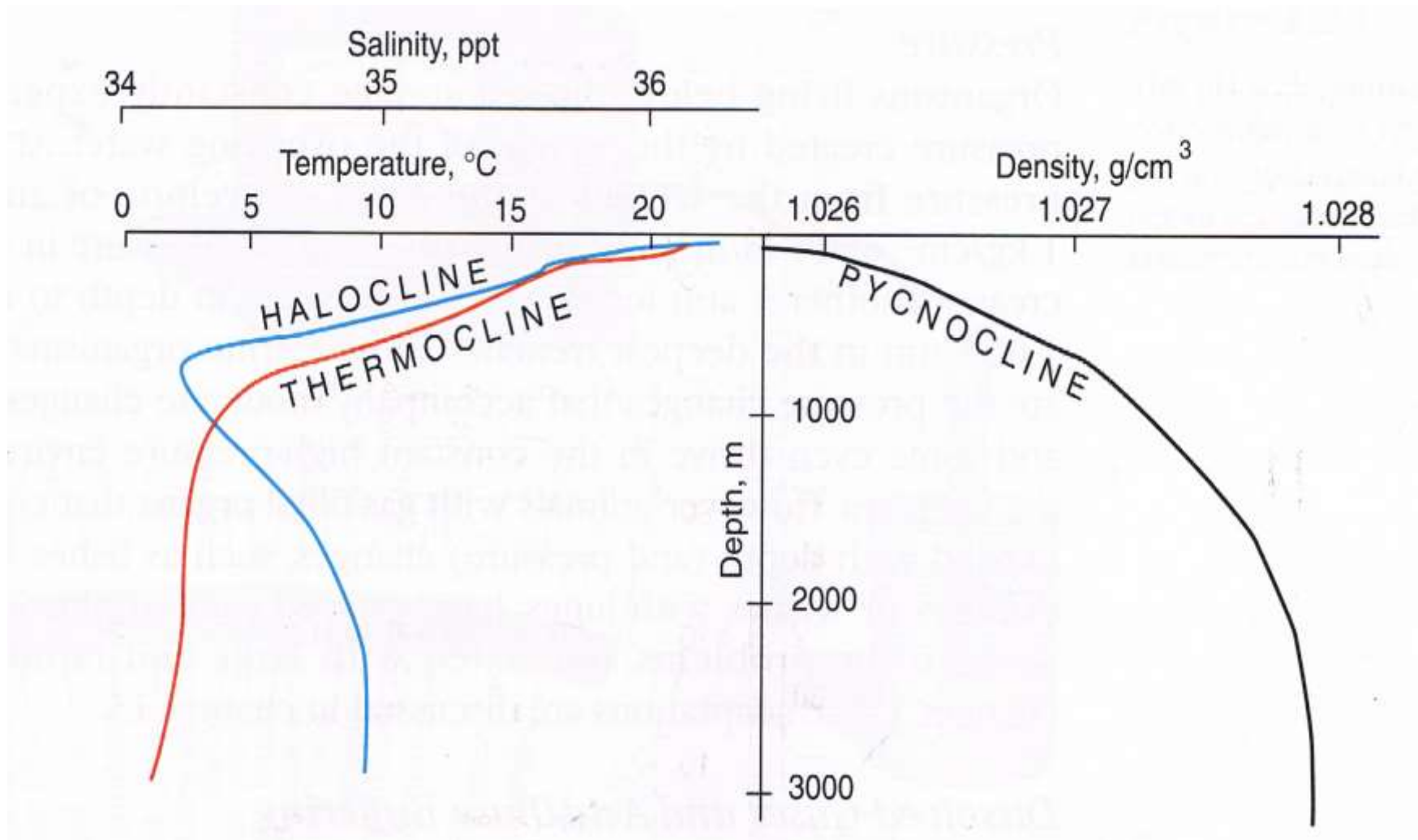
# Water pressure

At sea level (the surface of the oceans) atmospheric pressure is  $1\text{kg/cm}^2$  or 1 atm

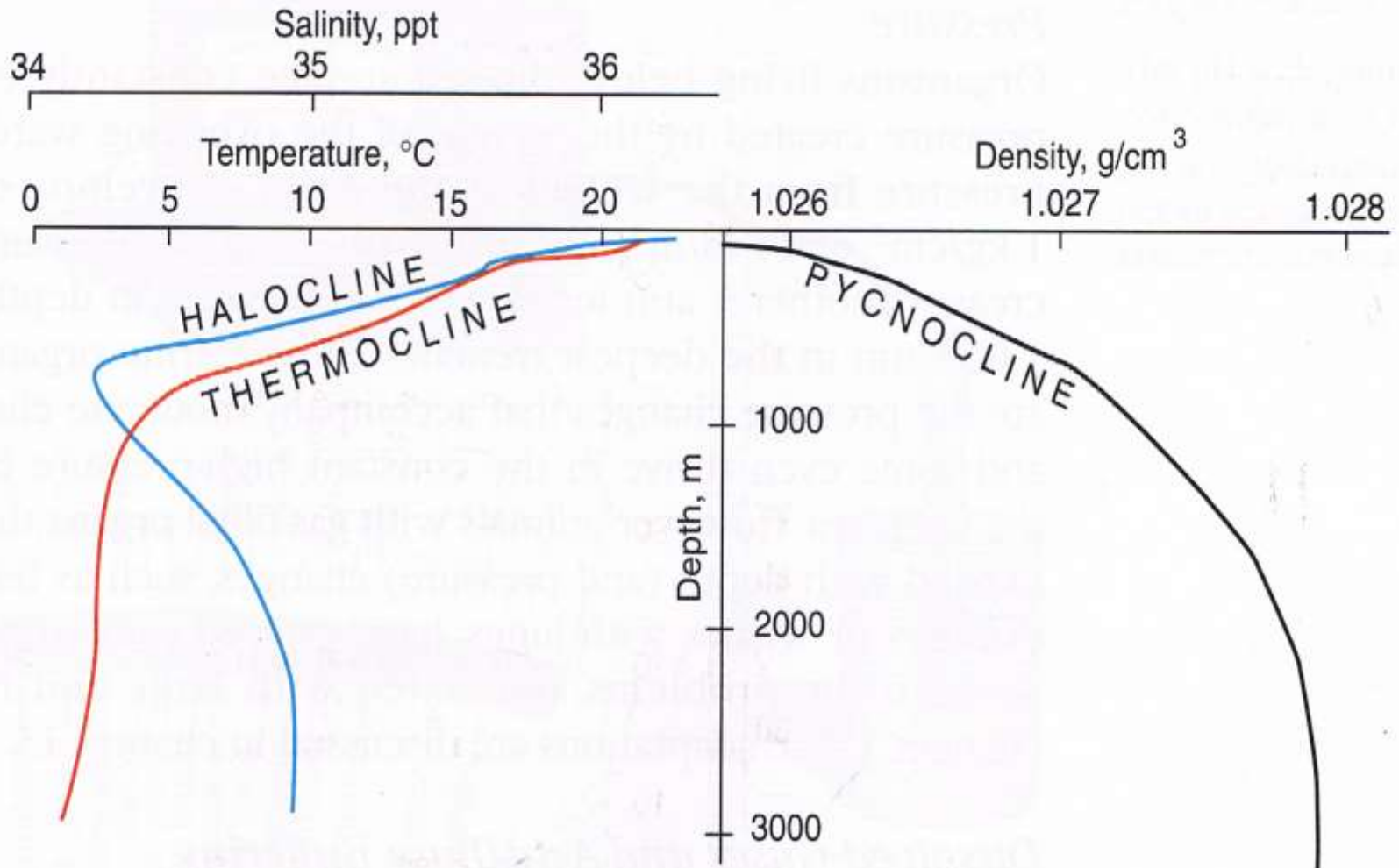
At the deepest parts of the ocean pressure reaches 1,000 atm



**Halocline:** Describes the change in *Salinity* of water as water depth changes



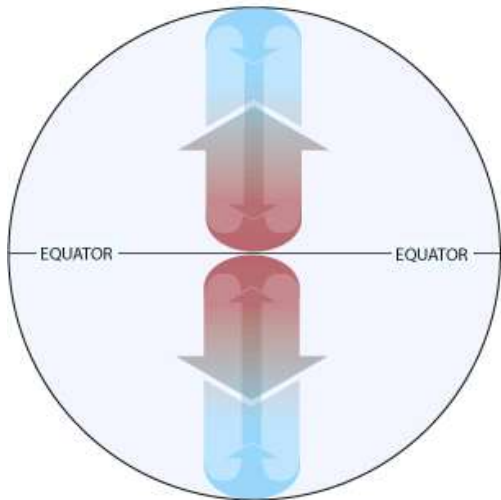
**Pycnocline:** Describes the change in *Density* of water as water depth changes



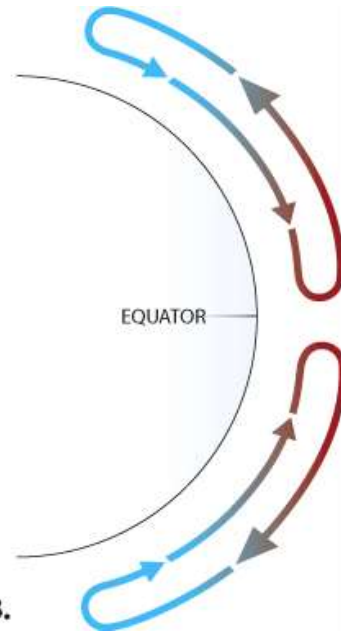
**Thermocline:** Describes the change in *Water Temperature* as water depth changes

# Surface Currents

- If the Earth did NOT rotate on its axis and remained stationary (as represented in the diagram to the left)

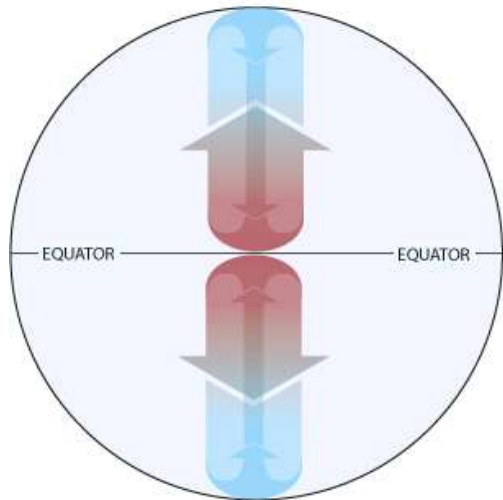


A.

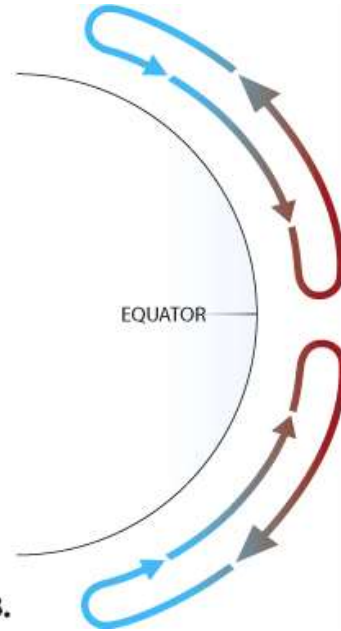


B.

# Surface Currents



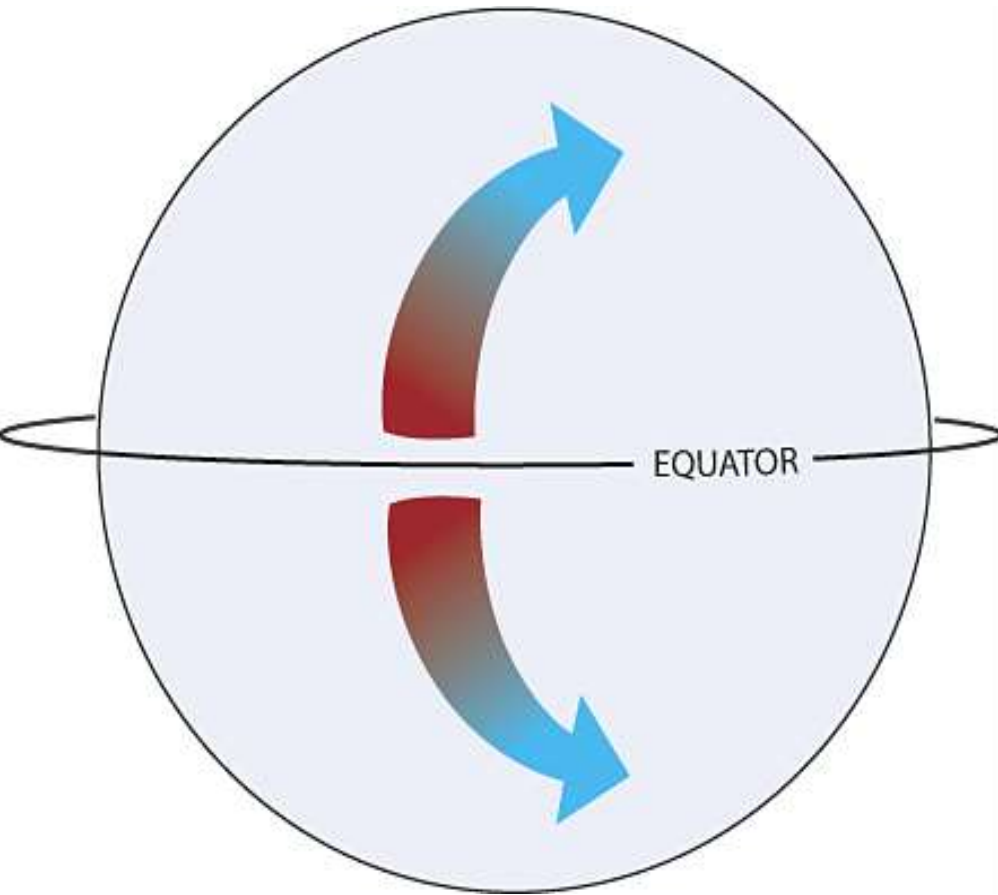
A.



B.

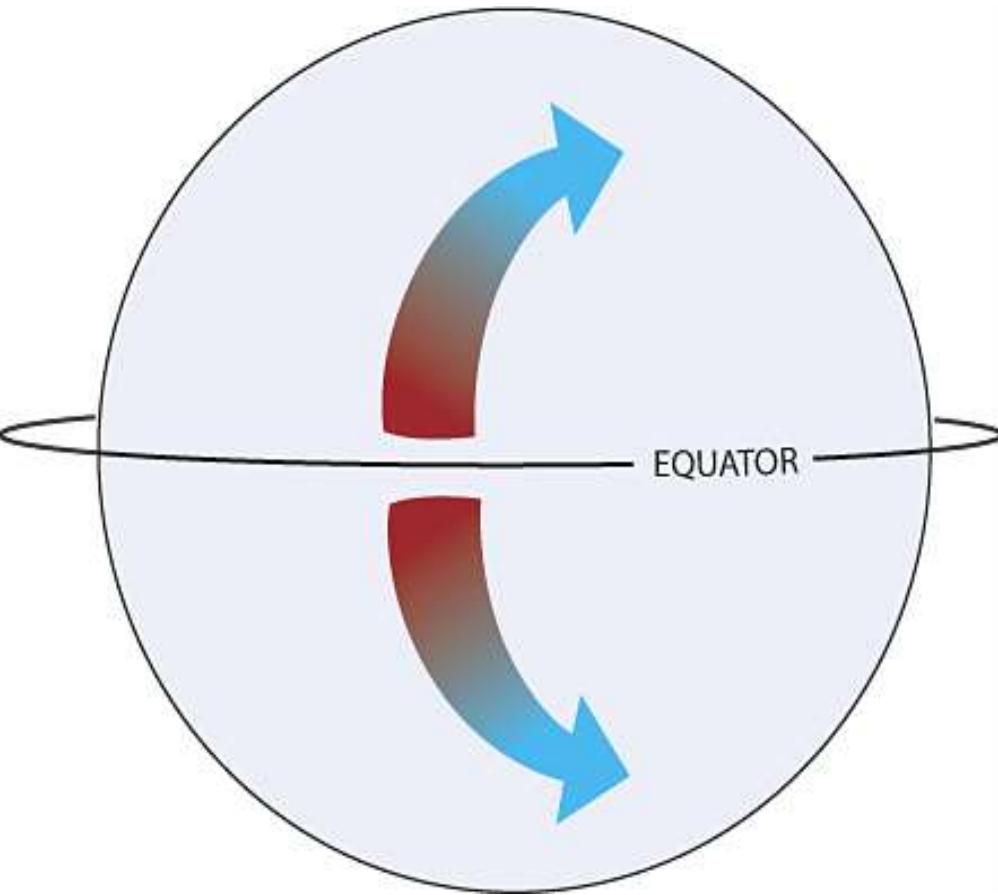
- The atmosphere would only circulate between the Earth's polar regions and the equator
- A simple back and forth pattern

# Coriolis Effect



- The rotation of the Earth on its axis **deflects** the atmosphere towards the right in the Northern Hemisphere and towards the left in the southern hemisphere
- Creates a curved path for atmospheric movement

# Coriolis Effect

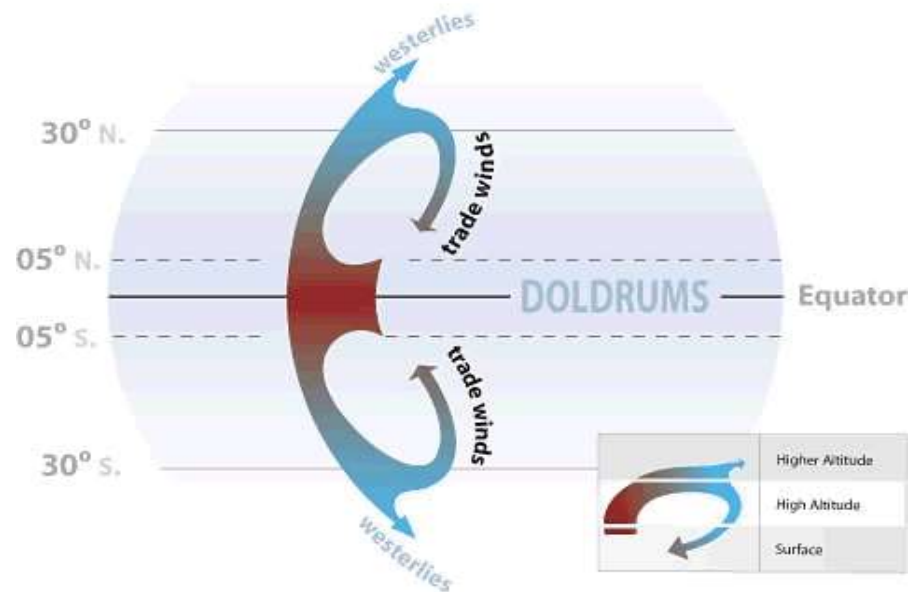


- The deflection of the atmosphere sets up the complex global wind patterns which drive surface ocean currents
- This deflections is called the Coriolis effect



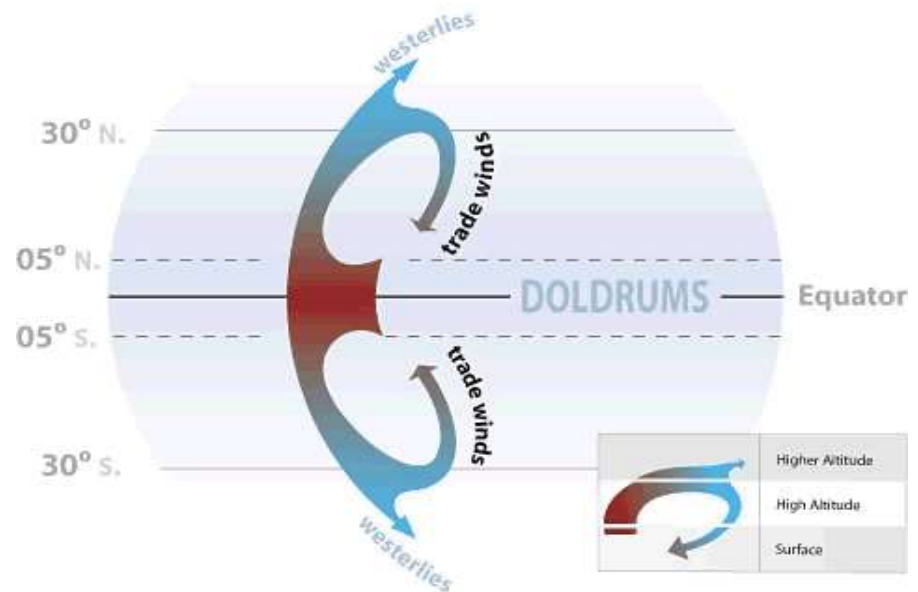
# Trade Winds

- Atmospheric circulation and the Coriolis Effect create global wind patterns including the **trade winds** and the **westerlies**



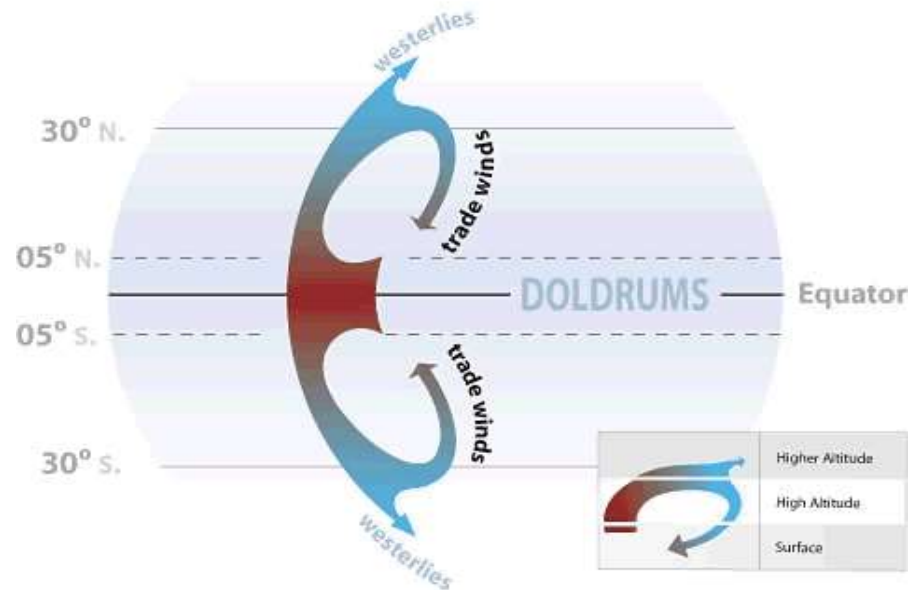
# Trade Winds

- In the Northern Hemisphere
  - Air moving from Equator to north
  - Coriolis Effect deflects the wind towards the right
  - Air cools and descends near 30 degrees North Latitude
  - Descending winds blow from Northeast to Southwest



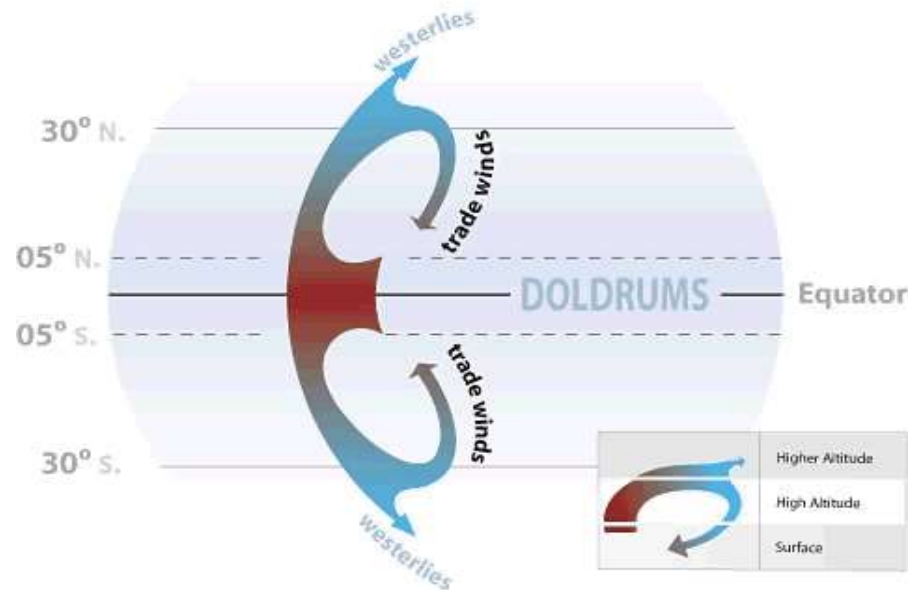
# Trade Winds

- In the Southern Hemisphere
  - Air moving from Equator to south
  - Coriolis Effect deflects the wind towards the right
  - Air cools and descends near 30 degrees South Latitude
  - Descending winds blow from Southeast to Northwest



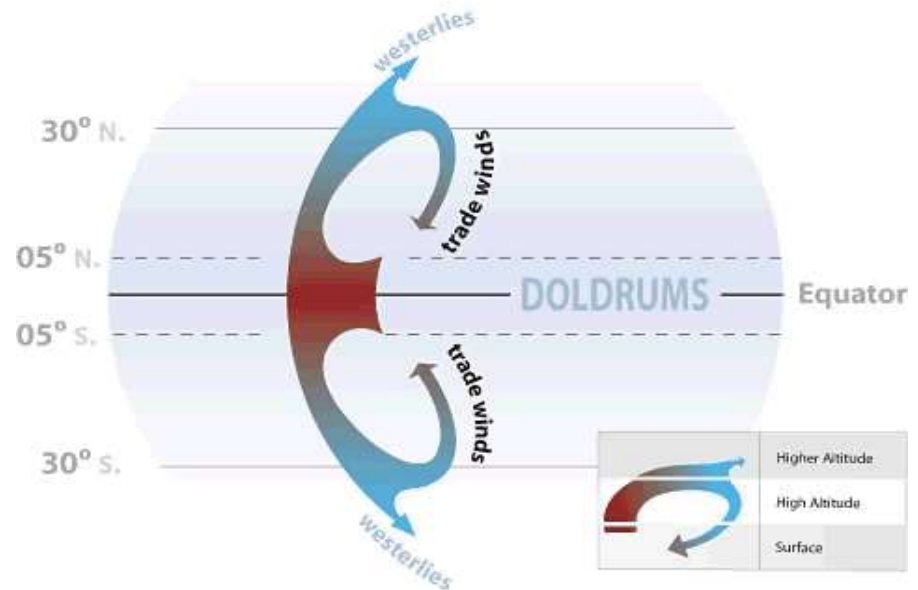
# Trade Winds

- Traditionally used by wind-driven merchant vessels to aid the journey between Europe and the Americas



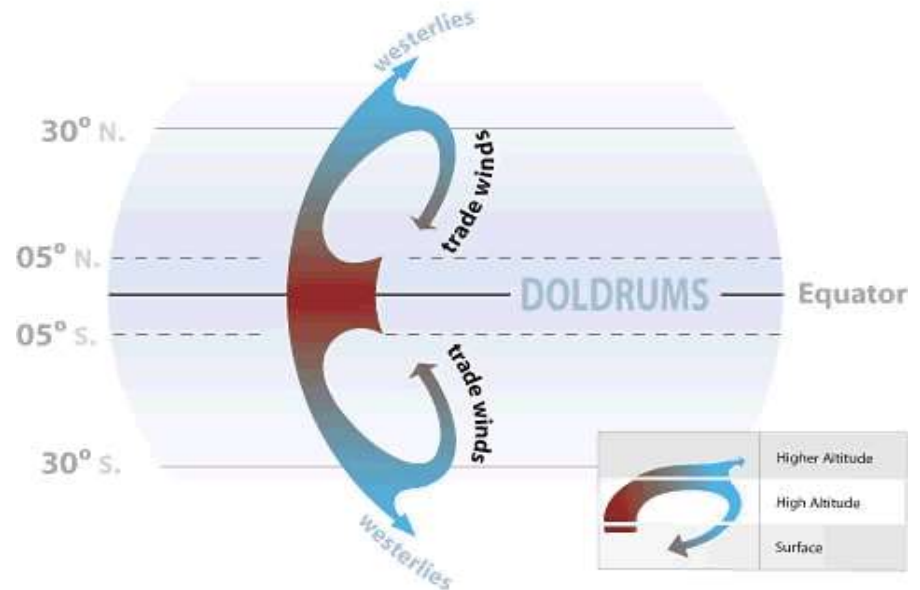
# The Doldrums

- At Intertropical Convergent Zone (the doldrums)
  - Trade winds meet to create an area of calm between 5 degrees North and 5 degrees South

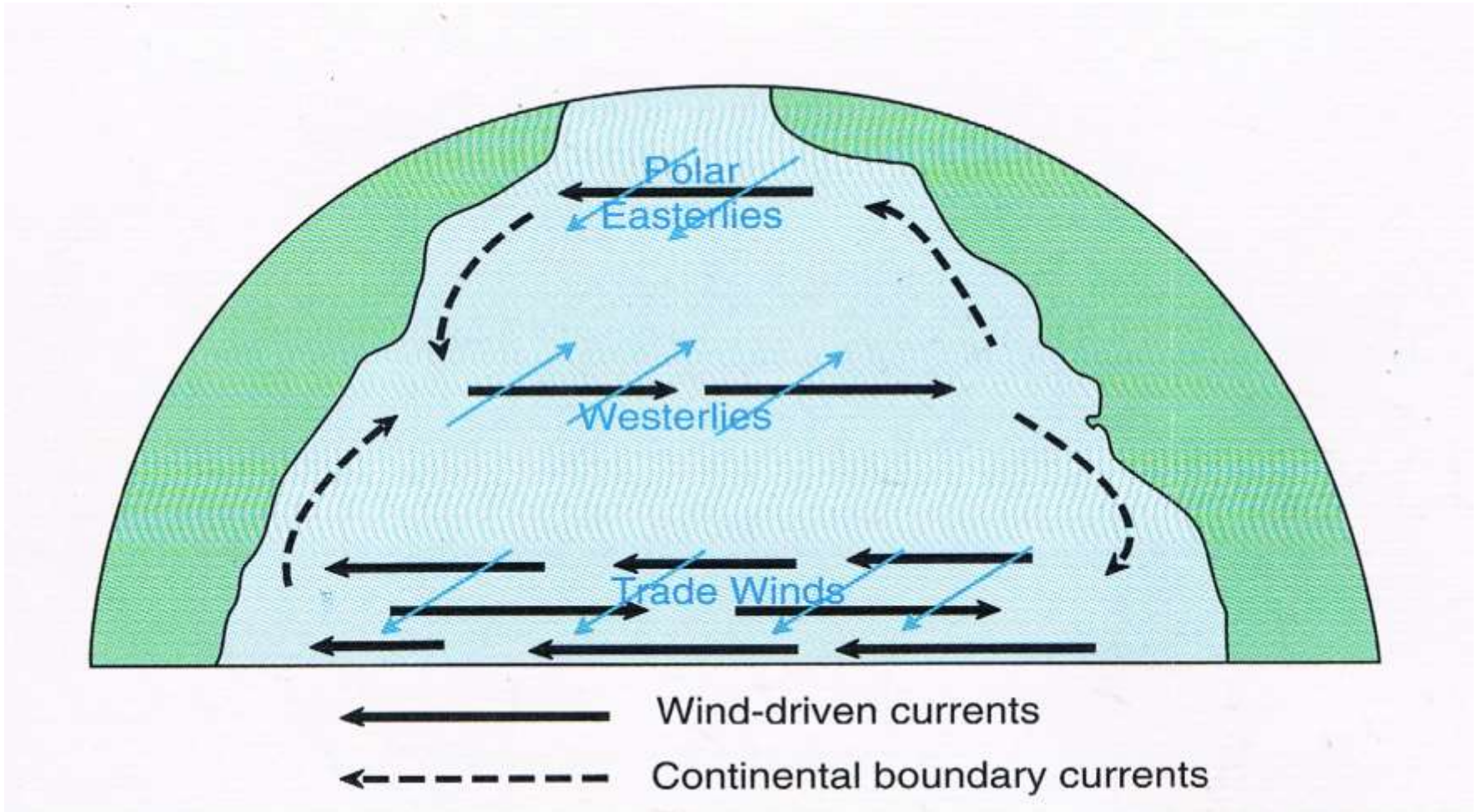


# The Westerlies

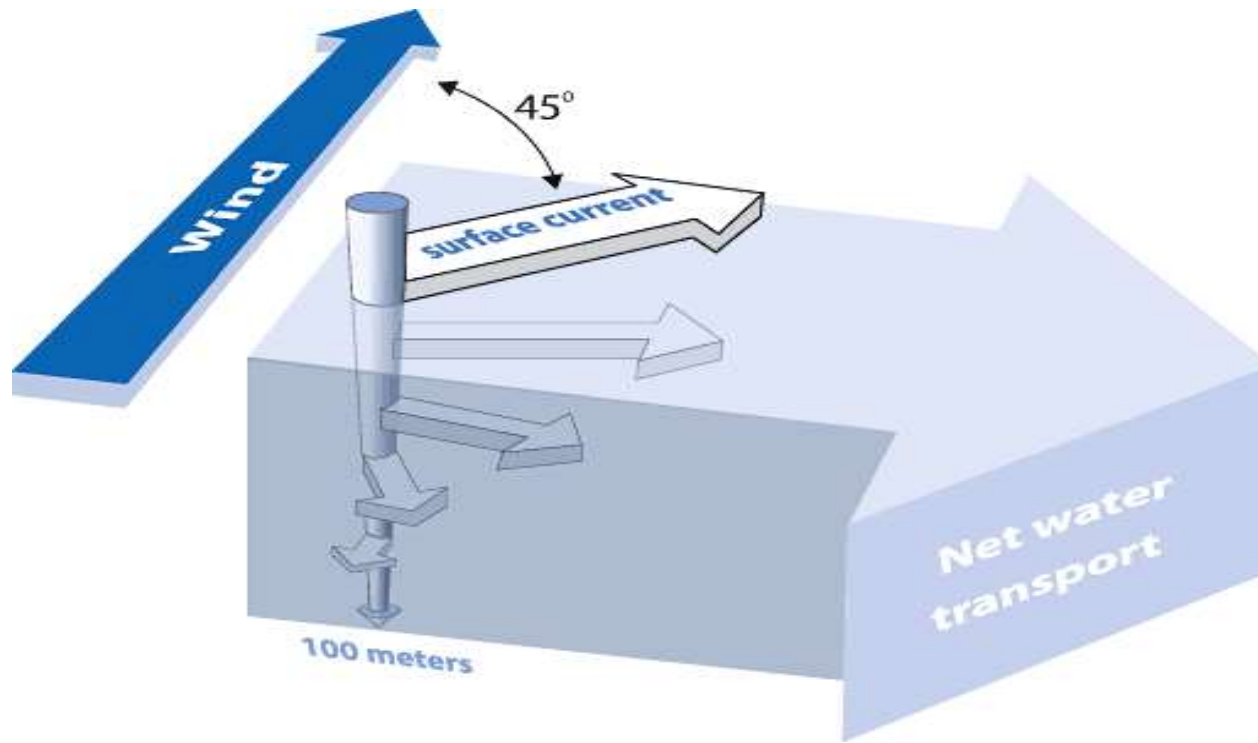
- Air that does NOT descend at 30 degrees North and South continue to poles
- These winds are called the Westerlies



# More Winds



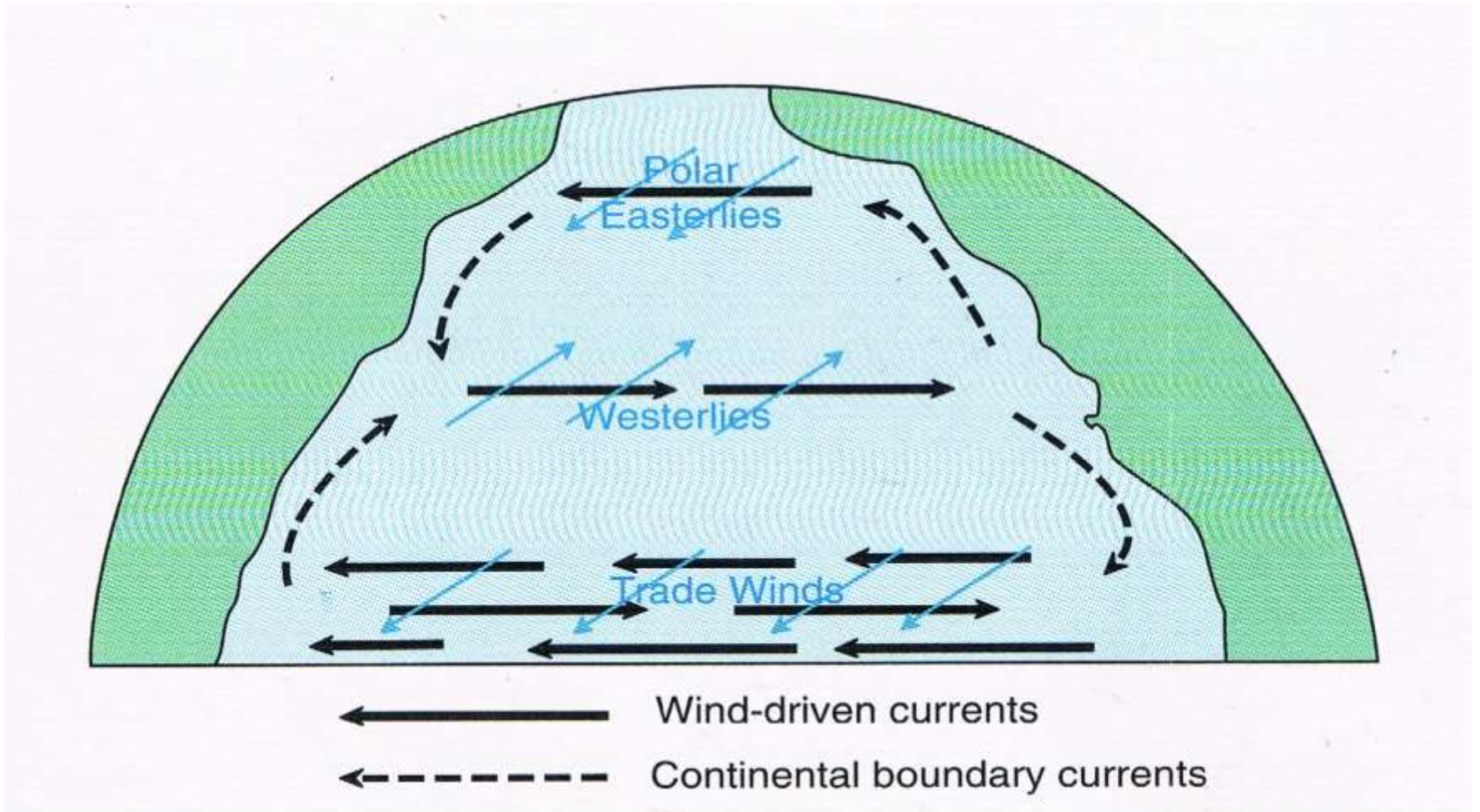
# Elkman Spiral

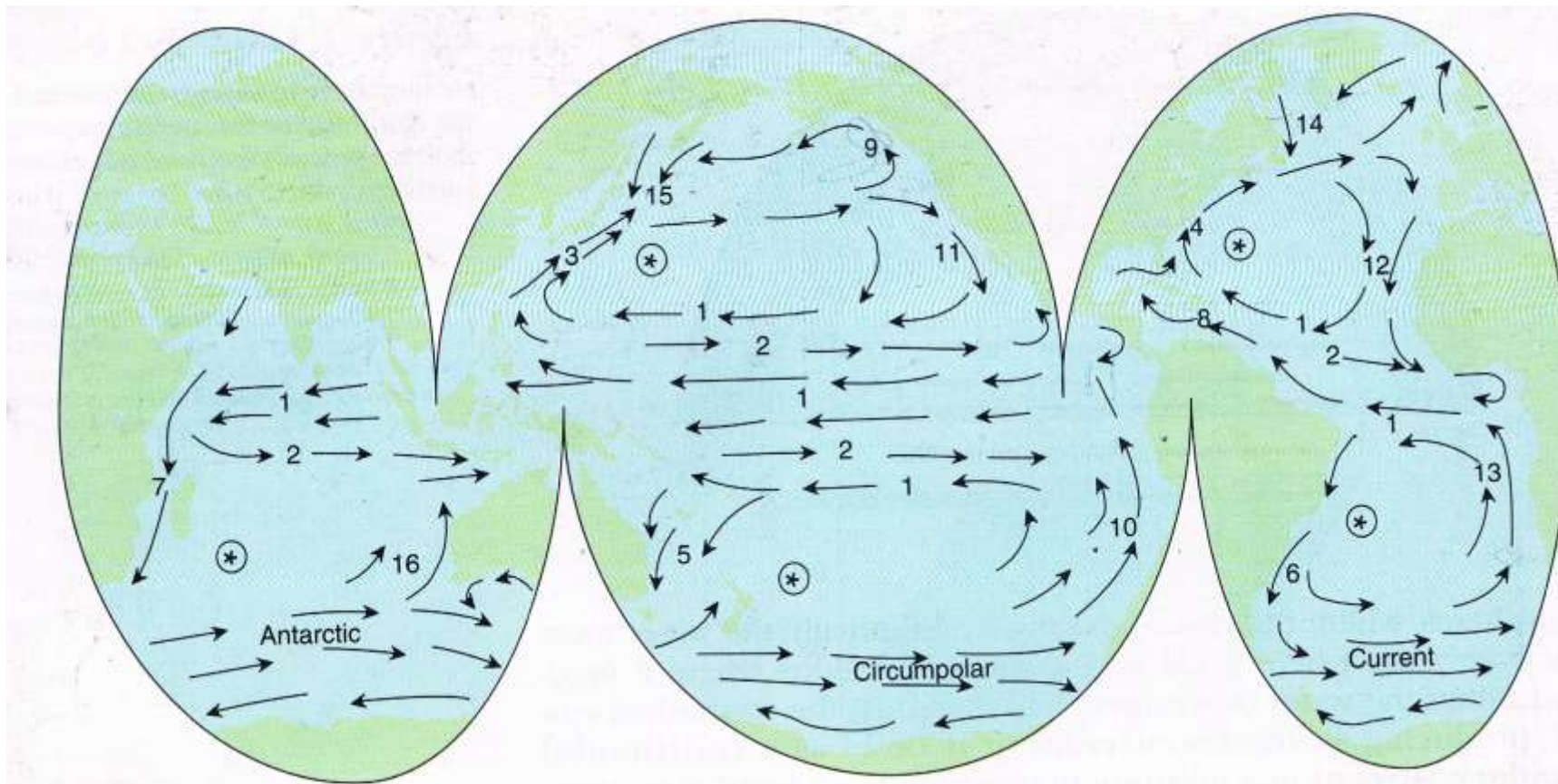


- Occurs when Coriolis Effect move perpendicular to net water transport
- Wind pushes surface water in a 45 degree angle
- The angle decreases as depth increases, but influence goes down 100m
- Causes a spiral effect



# More Winds





(\*) Gyre center

Major warm currents:

- 1 Equatorial currents
- 2 Equatorial countercurrents
- 3 Kuroshio
- 4 Gulf Stream
- 5 East Australia
- 6 Brazil
- 7 Somali
- 8 Antilles
- 9 Alaska

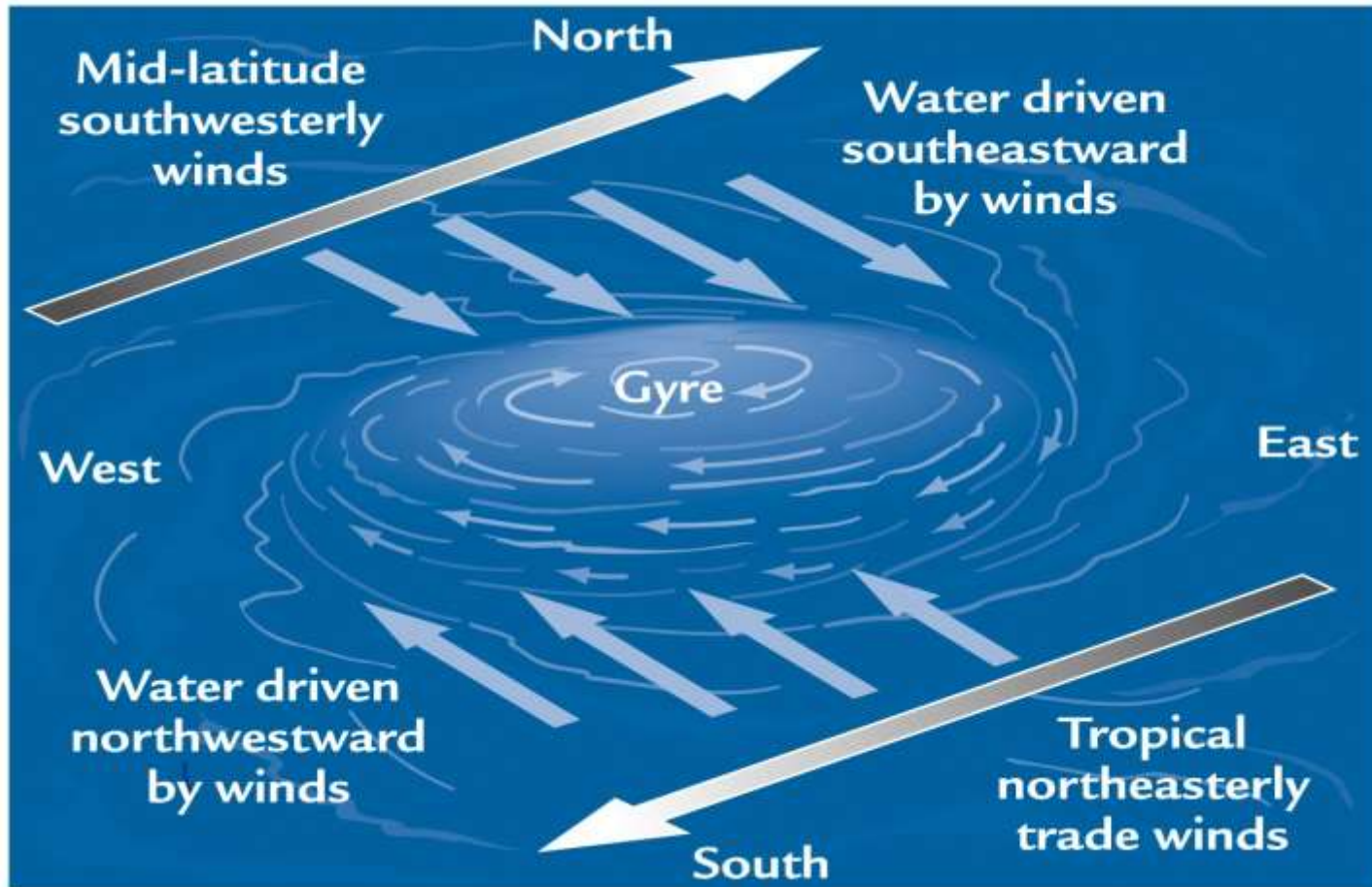
Major cold currents:

- 10 Peru
- 11 California
- 12 Canary
- 13 Benguela
- 14 Labrador
- 15 Oyashio
- 16 West Australia



# Winds Drive Ocean Currents

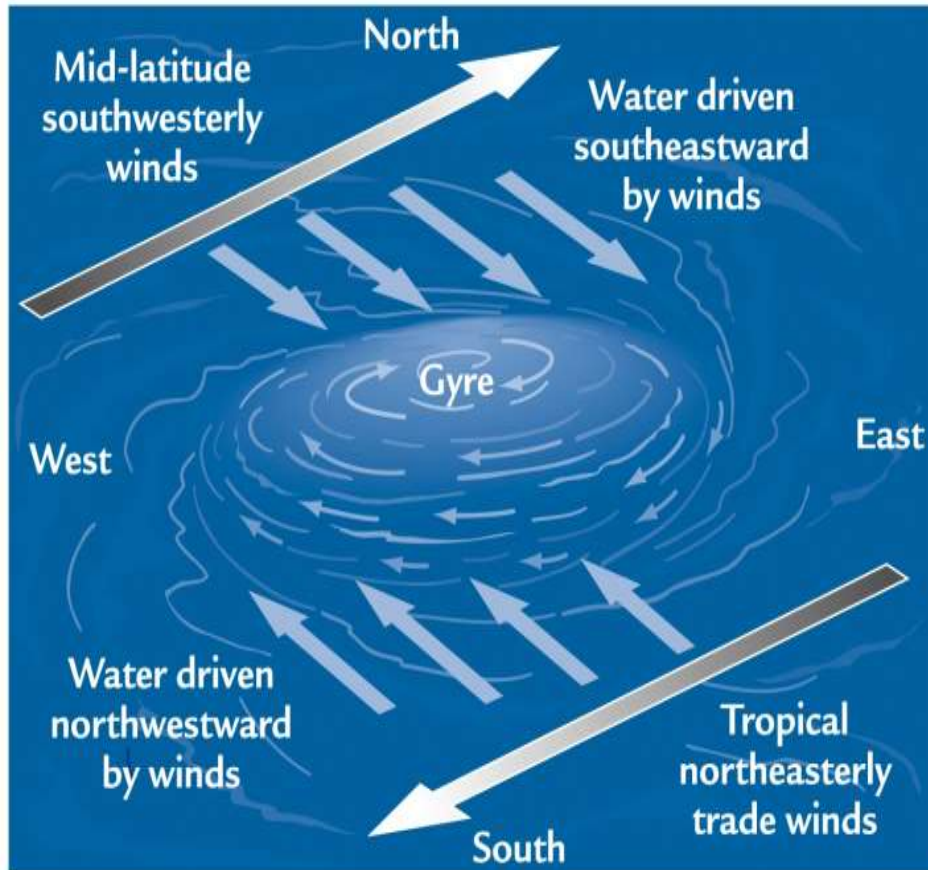
## Gyres



Global Currents drag on the water's surface, causing it to move and build up in the direction the wind is blowing

# Winds Drive Ocean Currents

## Gyres

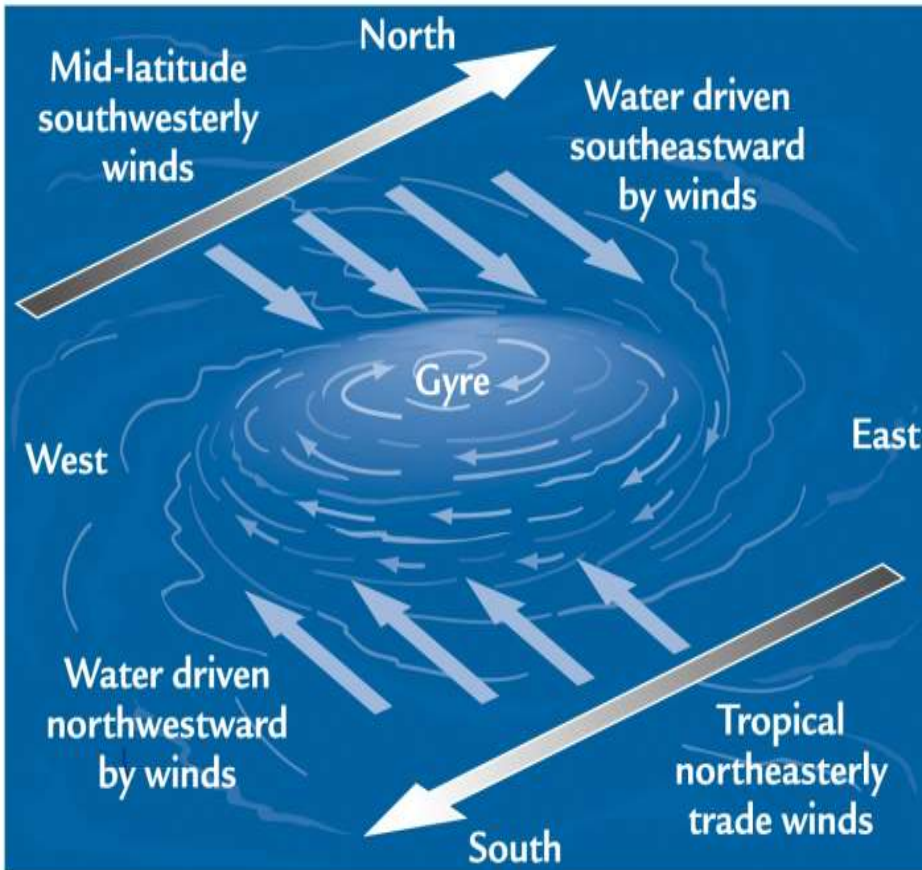


Coriolis Effect causes major ocean currents to move to the right in the Northern Hemisphere (clockwise) and to the left in the Southern Hemisphere (counter-clockwise).

These massive areas of spiraling water are called **Gyres**

# Winds Drive Ocean Currents

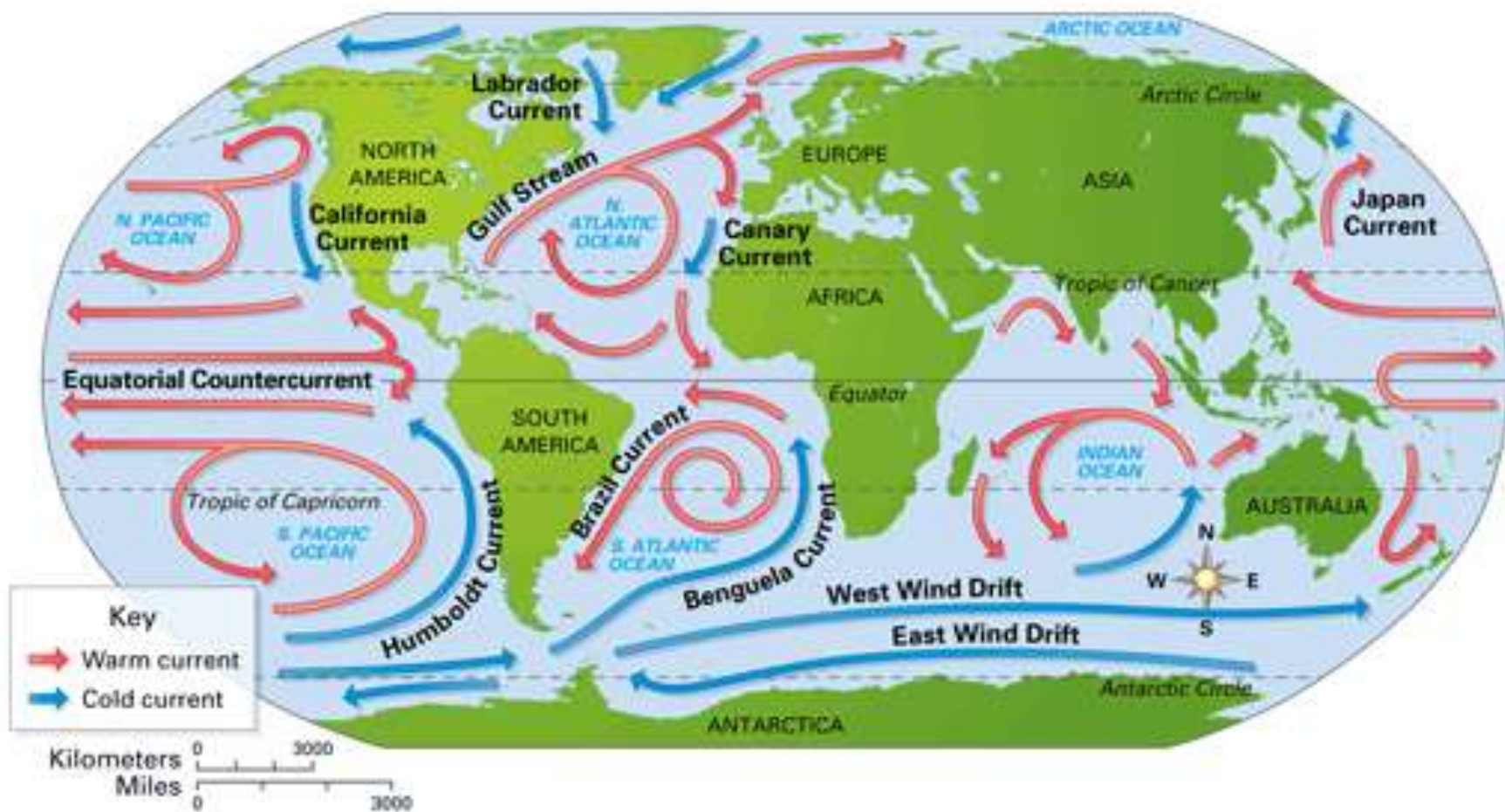
## Gyres



### 5 Major Gyres

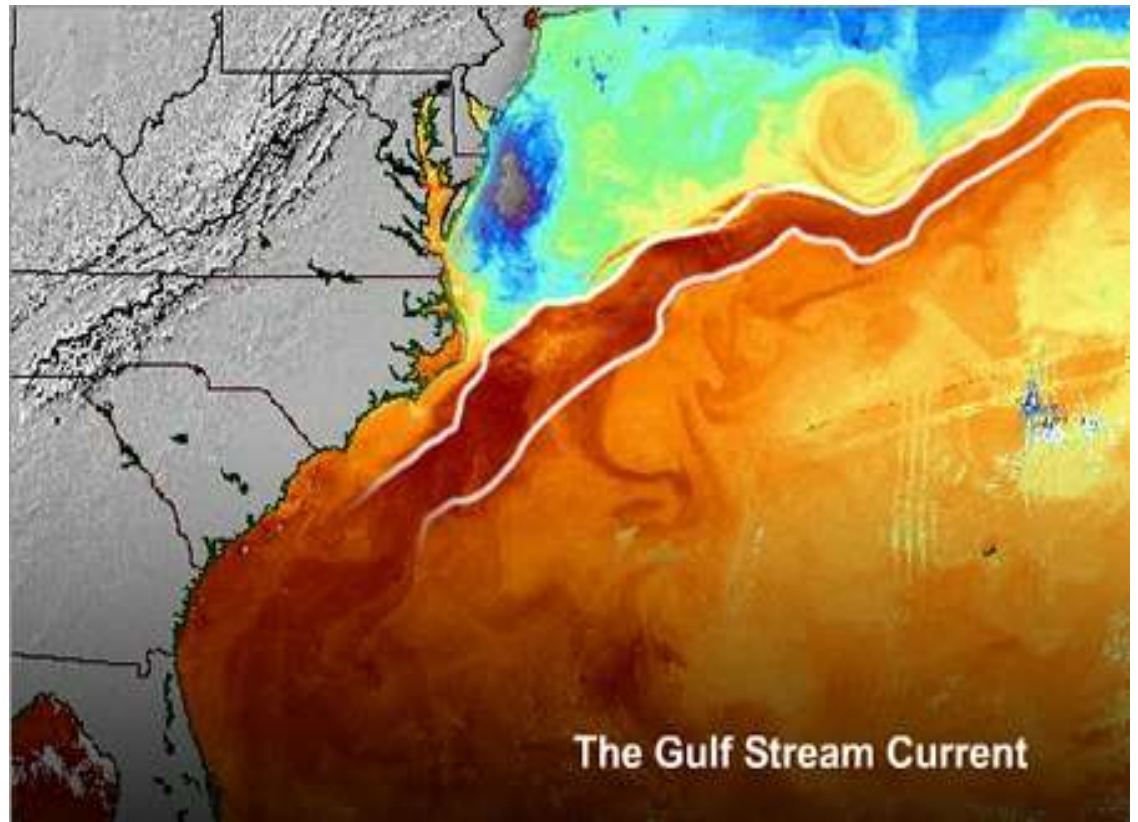
- **North Atlantic**
- **South Atlantic**
- **North Pacific**
- **South Pacific**
- **Indian**



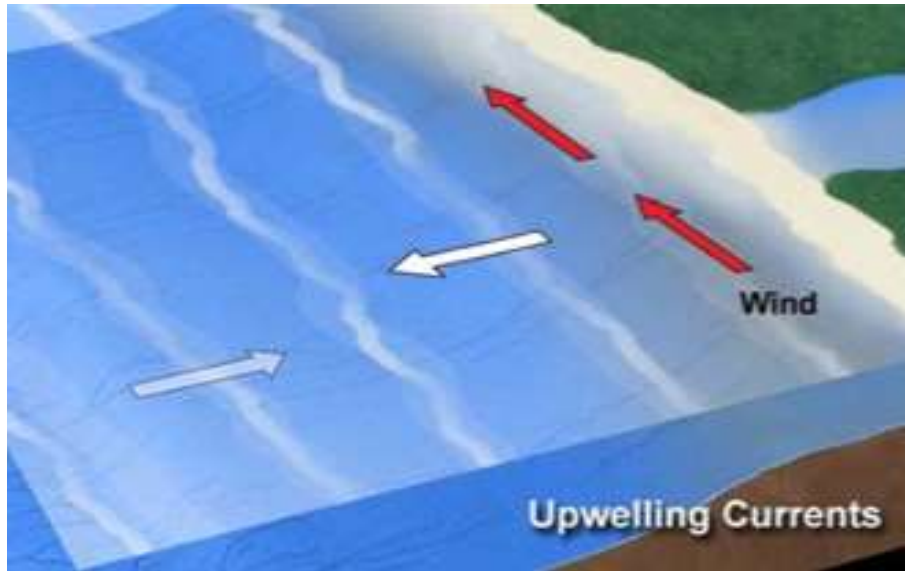


# Gulf Stream Current

The Atlantic Coast experiences warm water as currents move from equatorial regions northward



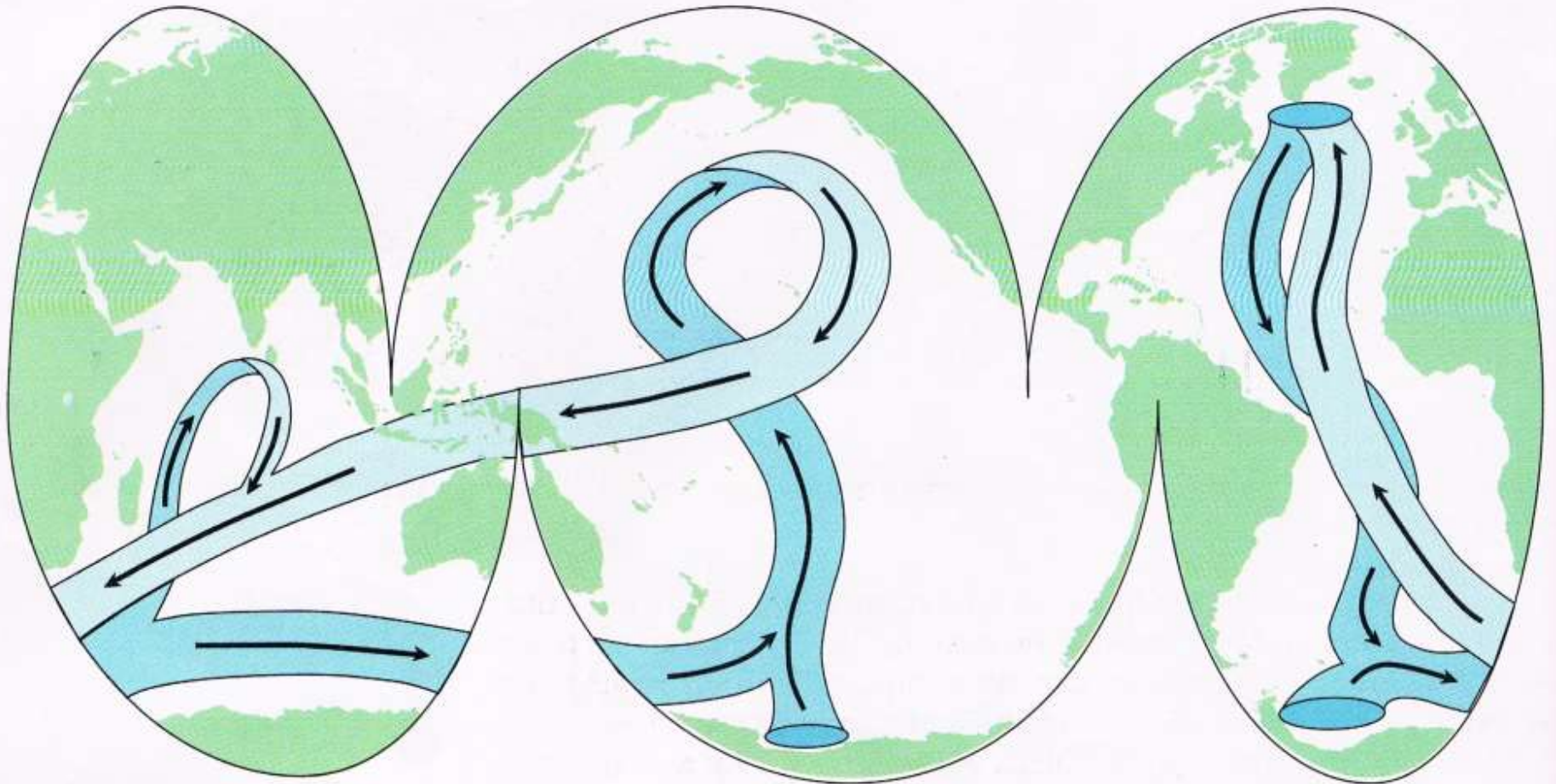
# Upwelling Currents



- Upwelling occurs when winds blowing across the ocean surface push water away from an area and subsurface water rises up to replace the diverging surface water

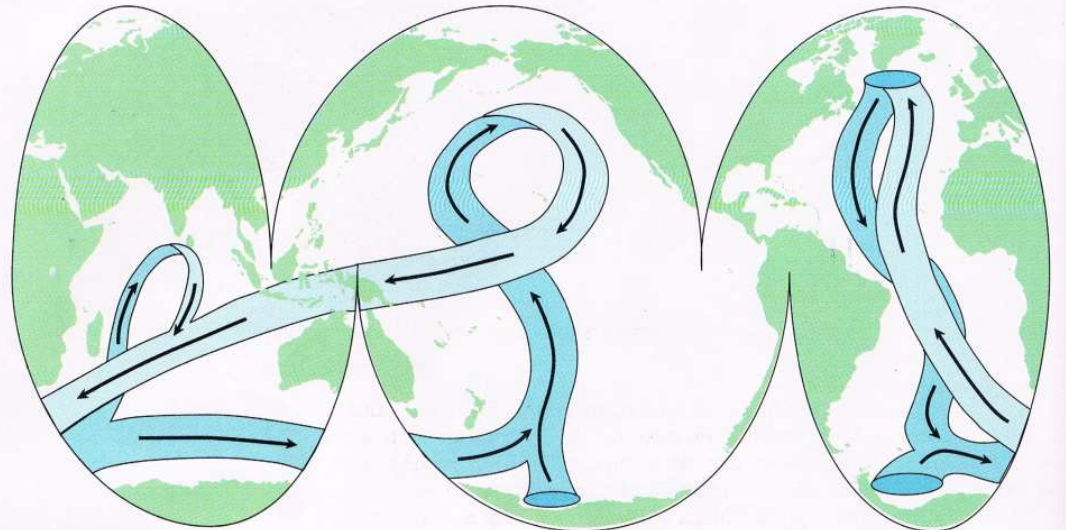


# The Global Conveyor Belt



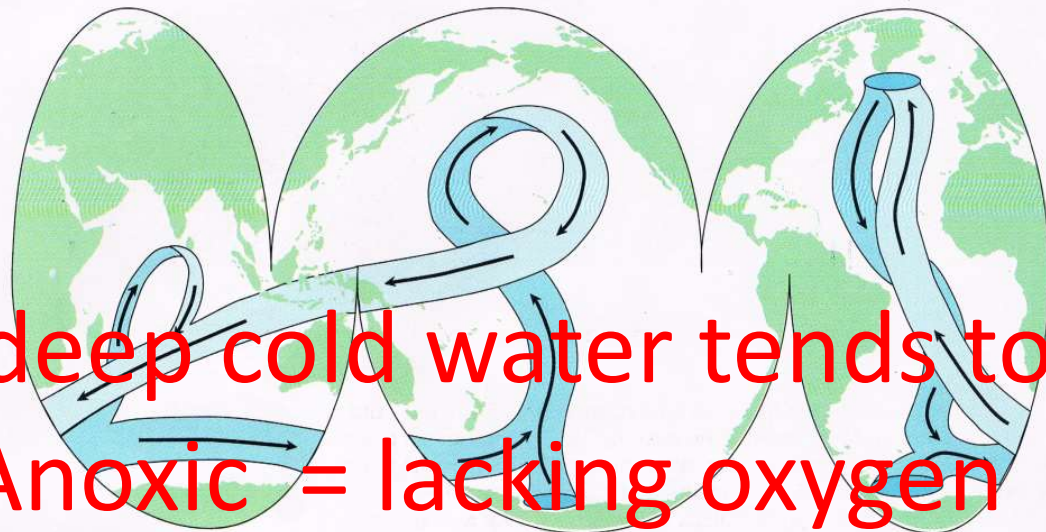
# The Global Conveyor Belt

- The combination of the Thermocline and the Halocline drive the global movement of deep water currents
- When ocean water arrives at the poles, it sinks
  - Cold water is more dense than warm water
  - Formation of sea ice makes ocean water more dense



# The Global Conveyor Belt

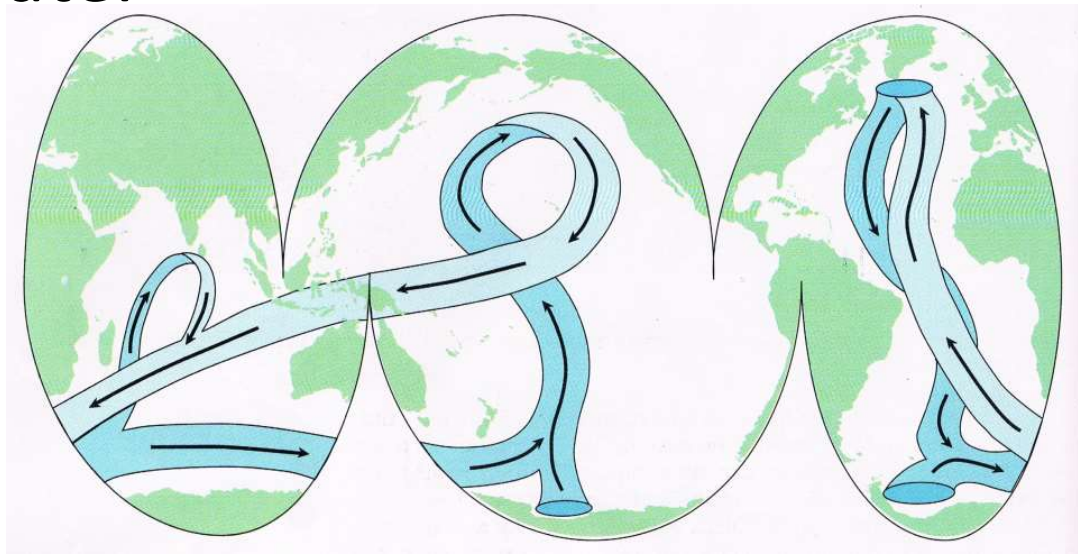
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This deep cold water tends to be  
Anoxic = lacking oxygen

# The Global Conveyor Belt

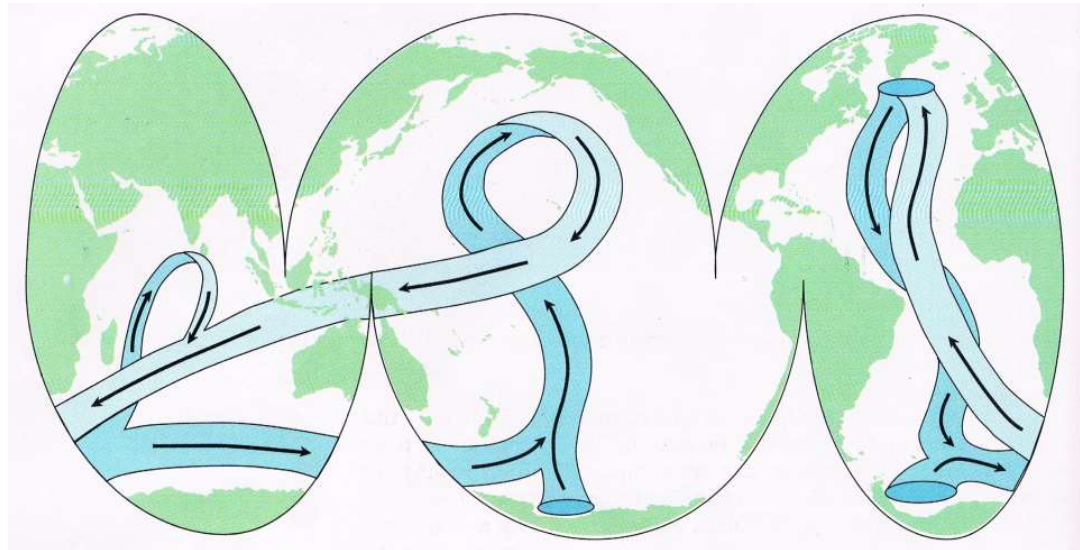
- Cold, salty, dense water sinks at the Northern polar region and heads south along the western Atlantic basin
- When the current hits Antarctica it becomes recharged and picks up more cold, salty and dense water





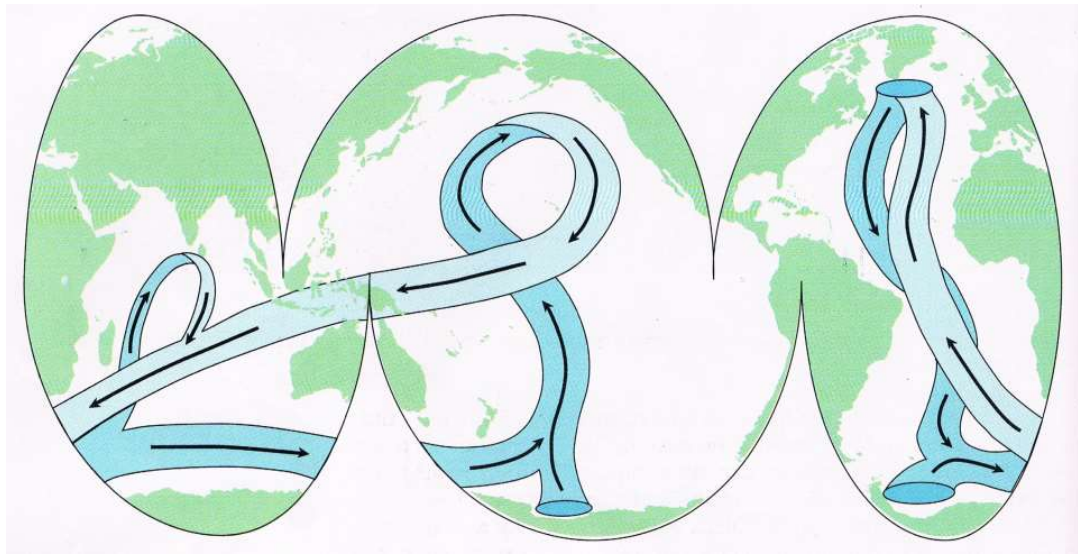
# The Global Conveyor Belt

- The Main Current splits into 2
  - One goes northwards to the Indian ocean
  - Other heads towards the western Pacific



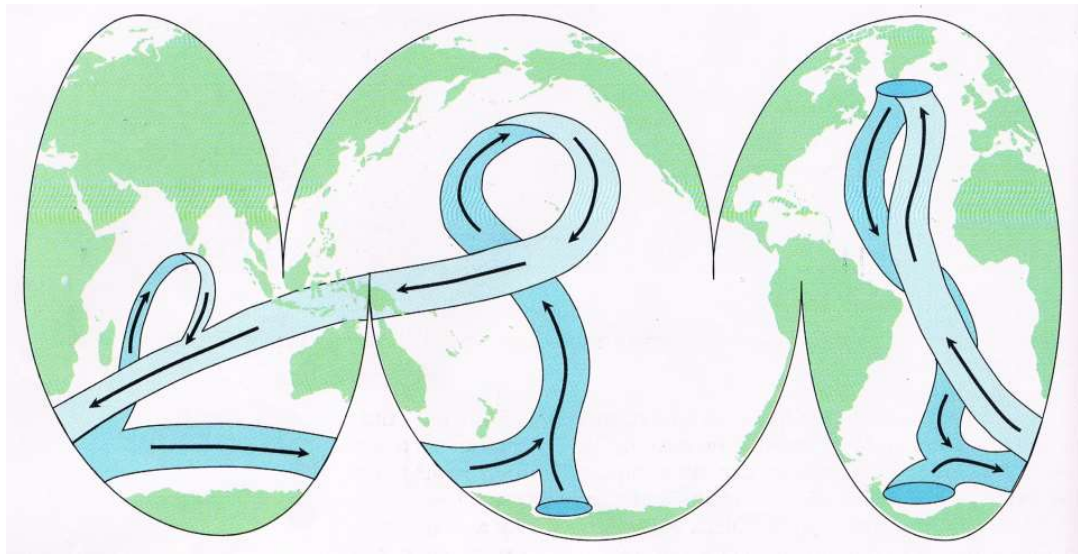
# The Global Conveyor Belt

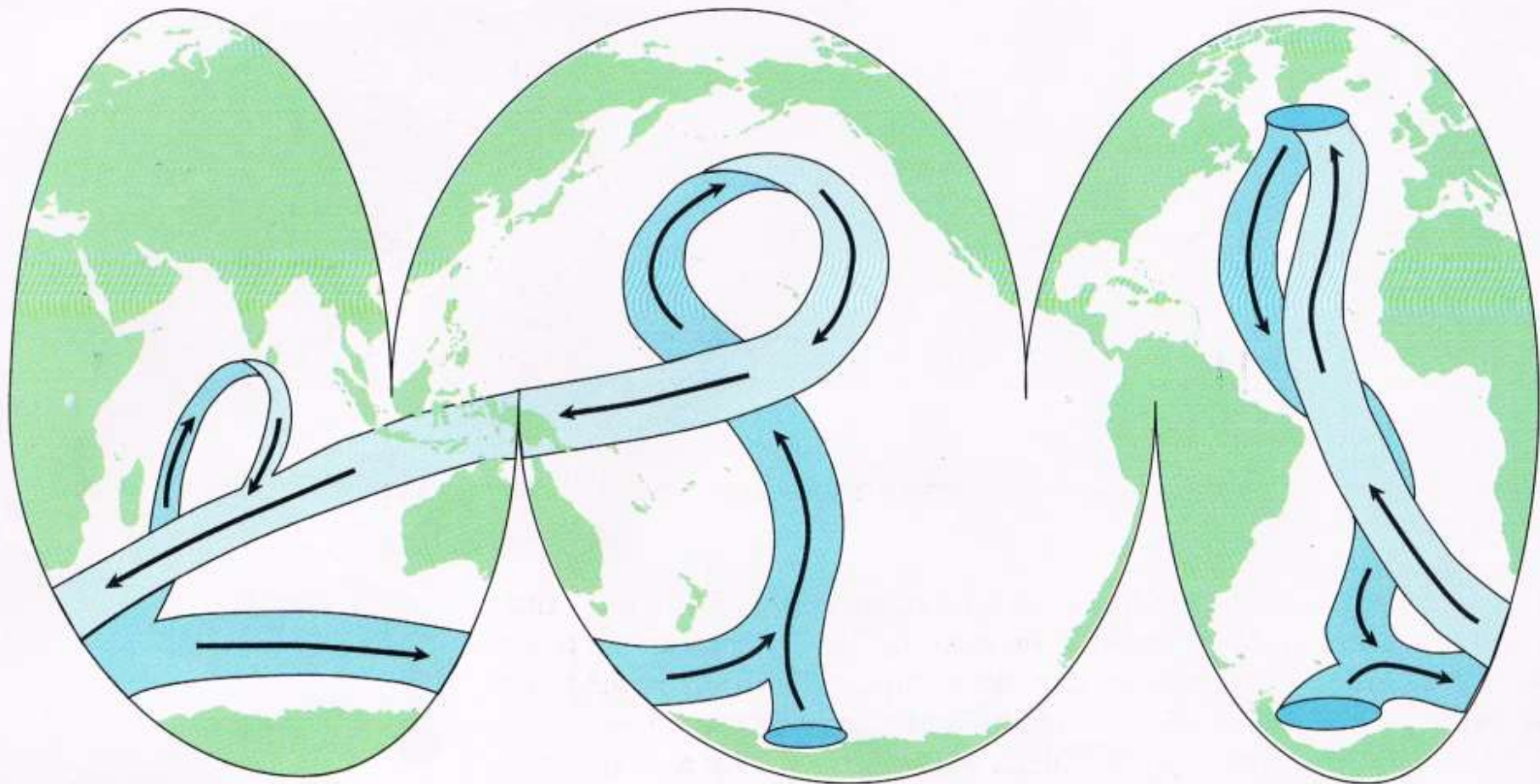
- The two branches of current warm (as the current moves close to the equator) and rise as they travel northward
- The two branches then loop back around southward and westward



# The Global Conveyor Belt

- The now-warmed surface water continues circulating around the globe. They eventually return to the North Atlantic where the cycle begins again







# Global Conveyor Belt : The Game

