WORLD OCEAN
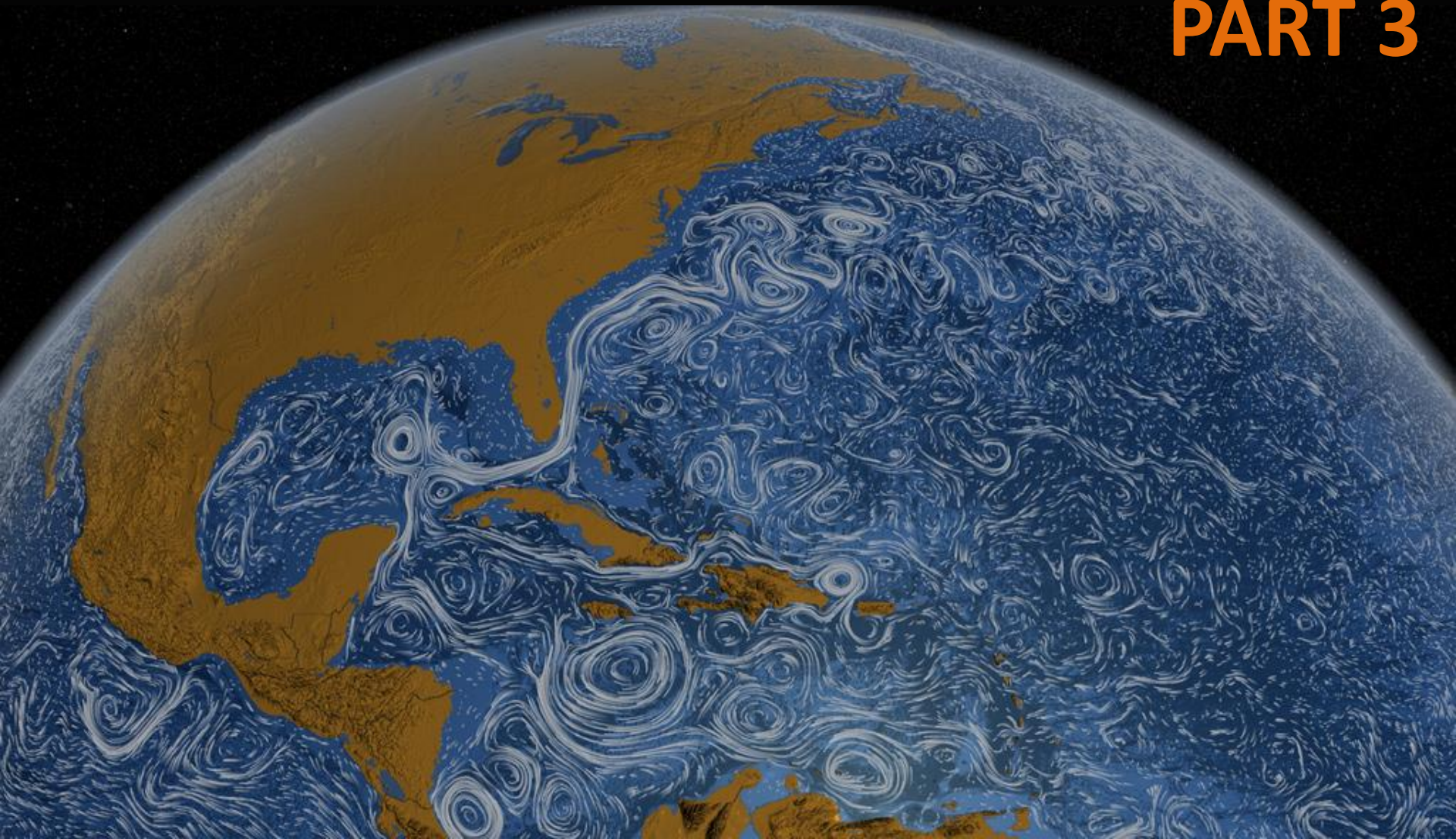
PART 3

Processes at the Ocean Surface:

1. Water <u>heating</u> by the Sun, ↑ temperature

2. Water <u>evaporation</u> (salt is left behind), ↑ salinity

3. <u>Precipitation</u> (fresh water input), ↓ salinity

4. Water <u>cooling</u> (cold winds/ice masses), ↓ temperature

5. <u>Ice melt</u> (fresh water is released), ↓ salinity

6. <u>Ice formation</u> (salt is left behind), ↑ salinity

7. Large <u>river inflow</u> (fresh water is released), ↓ salinity

8. Water <u>movement</u> (pushed by winds/tides)

Processes in the Deep:

9. Water <u>rise and fall</u> (density difference)

10. Deep water <u>downhill flow</u> at the ocean bottom

Interplay of these processes defines ocean circulation.

Ocean Circulation

## Water in the ocean is in constant motion.

- An **ocean current** is the movement of seawater in a certain direction (like a river in the ocean):
  - ➢ surface currents
  - ➢ wind driven vertical (upwelling/downwelling) currents
  - ➢ thermohaline circulation currents
- Ocean **circulation** is the **combined effect of all currents** that move in oceans.
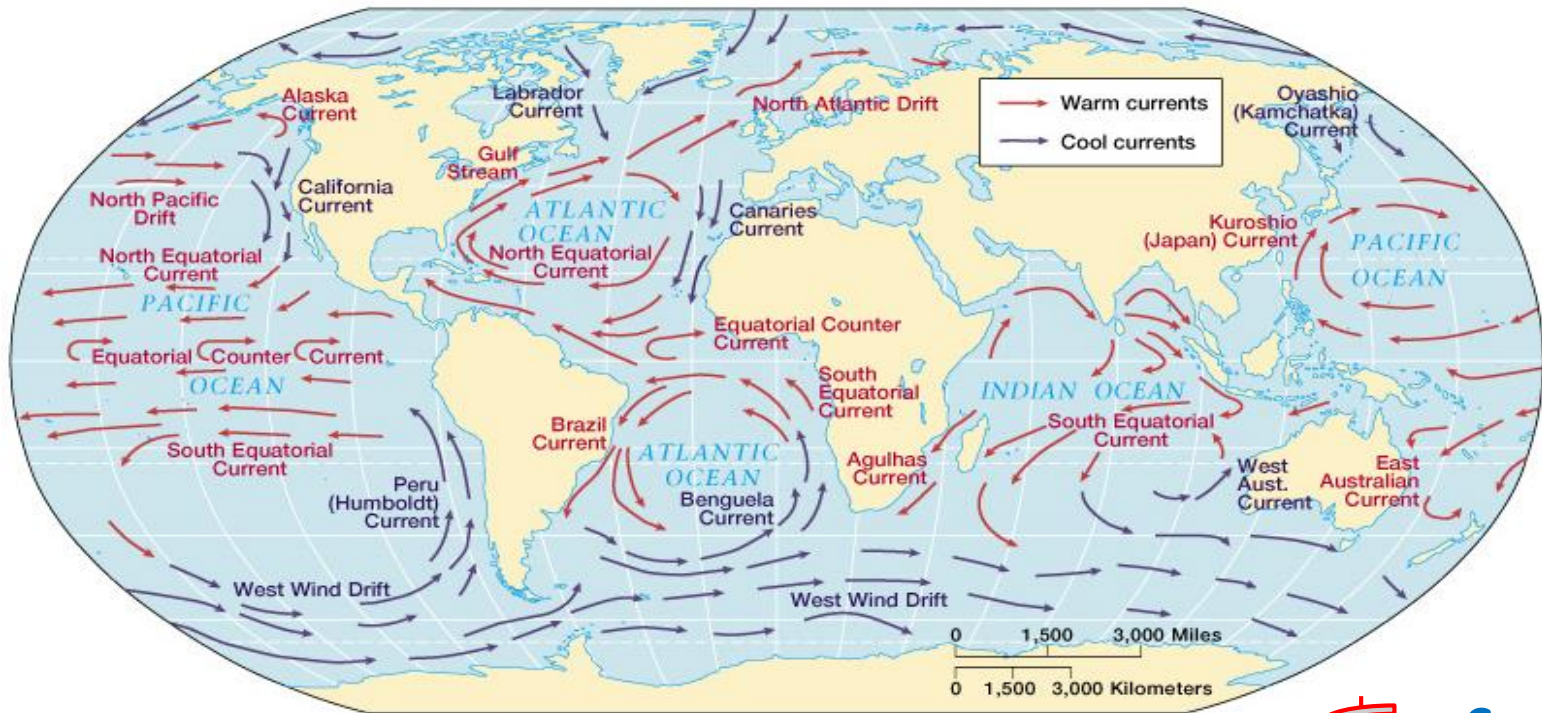
NASA Perpetual Ocean
**https://www.youtube.com/watch?v=xusdWPuWAoU**

Visualization of global ocean *surface* currents 2005-2007
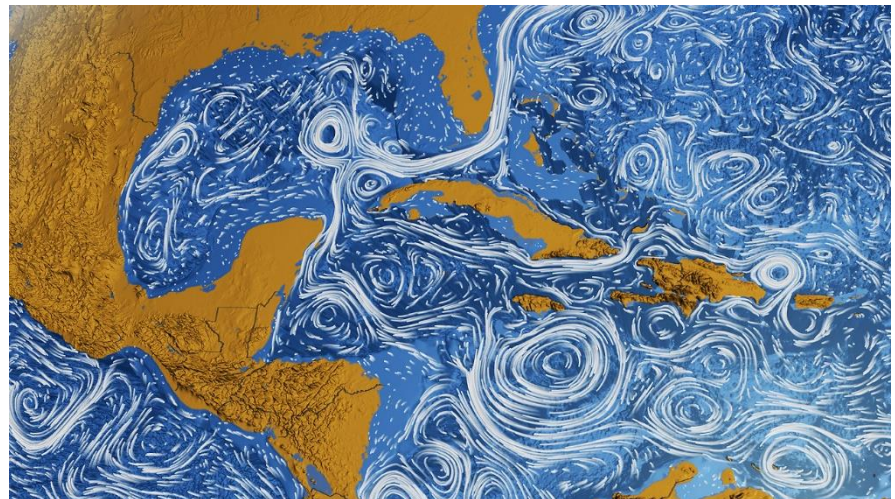
Surface Currents

- **Wind driven (caused by friction between water and moving air).**

- **Horizontal currents, occur at the surface.**

- **Push the top 400 m of water .**

- **Form large circular patterns called gyres due to *Coriolis effect* (clockwise in Northern Hemisphere counterclockwise in Southern Hemisphere)**
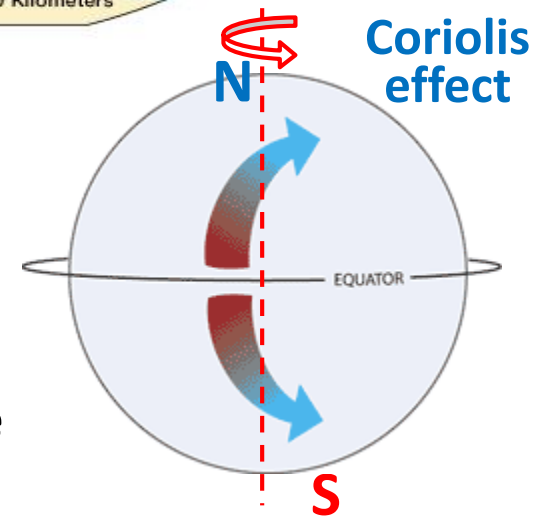
Gulf Stream

The **Gulf Stream** is a **strong, fast** moving, **warm** ocean current that originates in the Gulf of Mexico and flows into the Atlantic Ocean at a speed of about 1-5 mph. It transports nearly **4 billion cubic feet of water per second**, an amount greater than that carried by all of the world's rivers combined.

The Gulf Stream, Winslow Homer, 1899

- **First discovered in 1513 by the Spanish explorer Juan Ponce de Leon and was then used extensively by Spanish ships as they travelled from the Caribbean to Spain.**
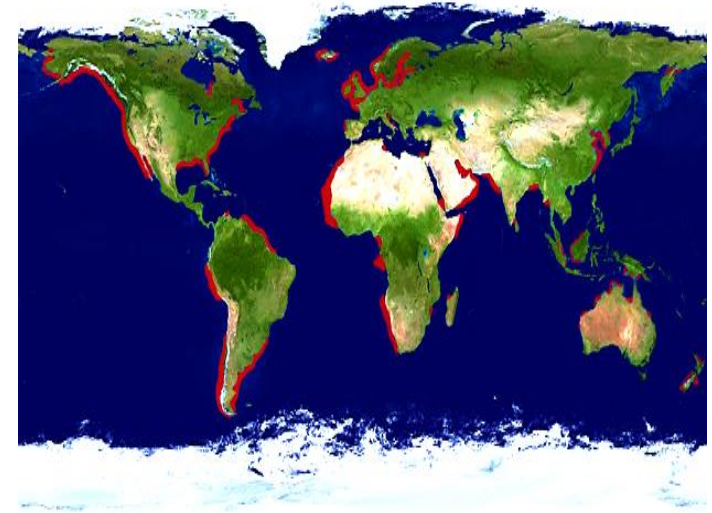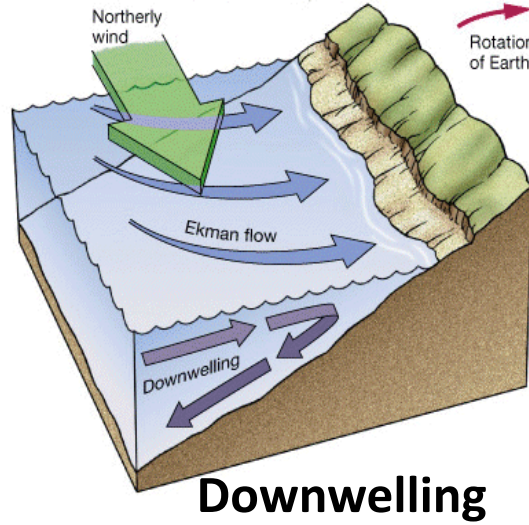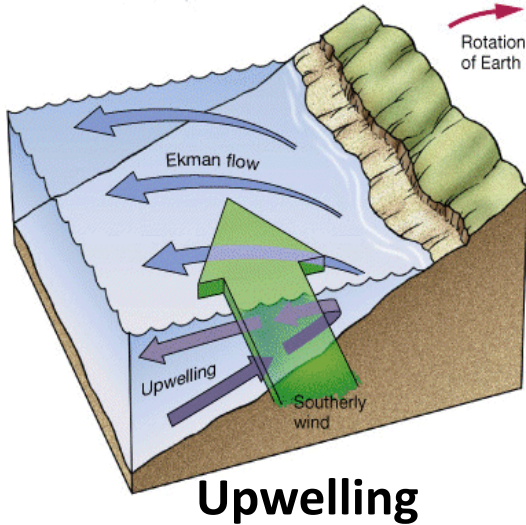
- **In 1786, Benjamin Franklin mapped the current, further increasing its usage.**
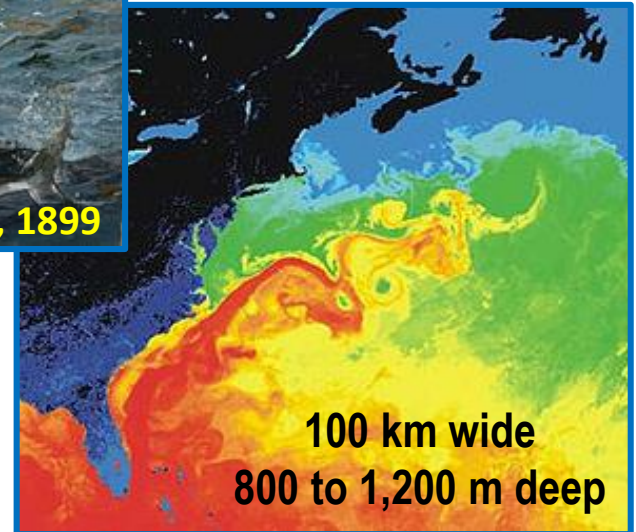
100 km wide
800 to 1,200 m deep

Wind Driven Upwelling/Downwelling

Coastal **(Ex: West Coast, Southern Hemisphere)**


Upwelling

Downwelling

- **Vertical currents: <u>coastal</u> and <u>equatorial</u>.**

- **Wind blows, pushes water away (note water is deflected due to Coriolis effect), causes deep cold water to rise up to replace it.**

- **Upwelling brings nutrients to surface: sites of rich fisheries.**

Equatorial
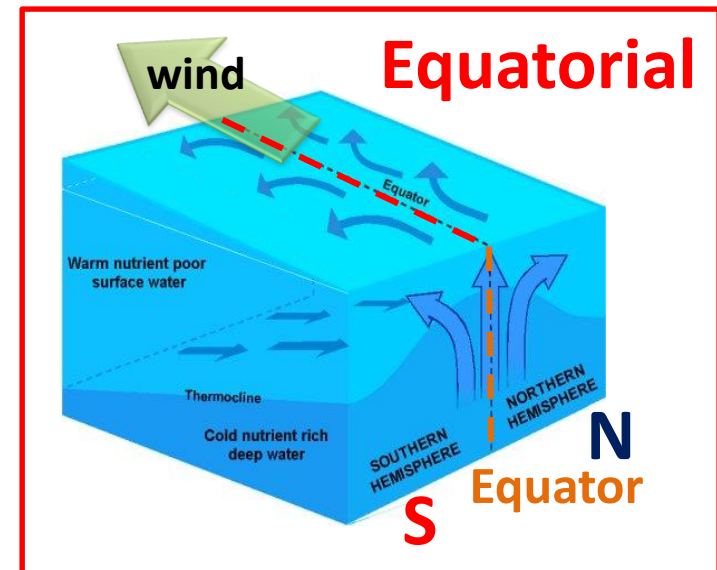
Thermohaline Circulation

Water masses rise and fall because of density differences due to variation of temperature and salinity with depth: <u>vertical</u> currents form.
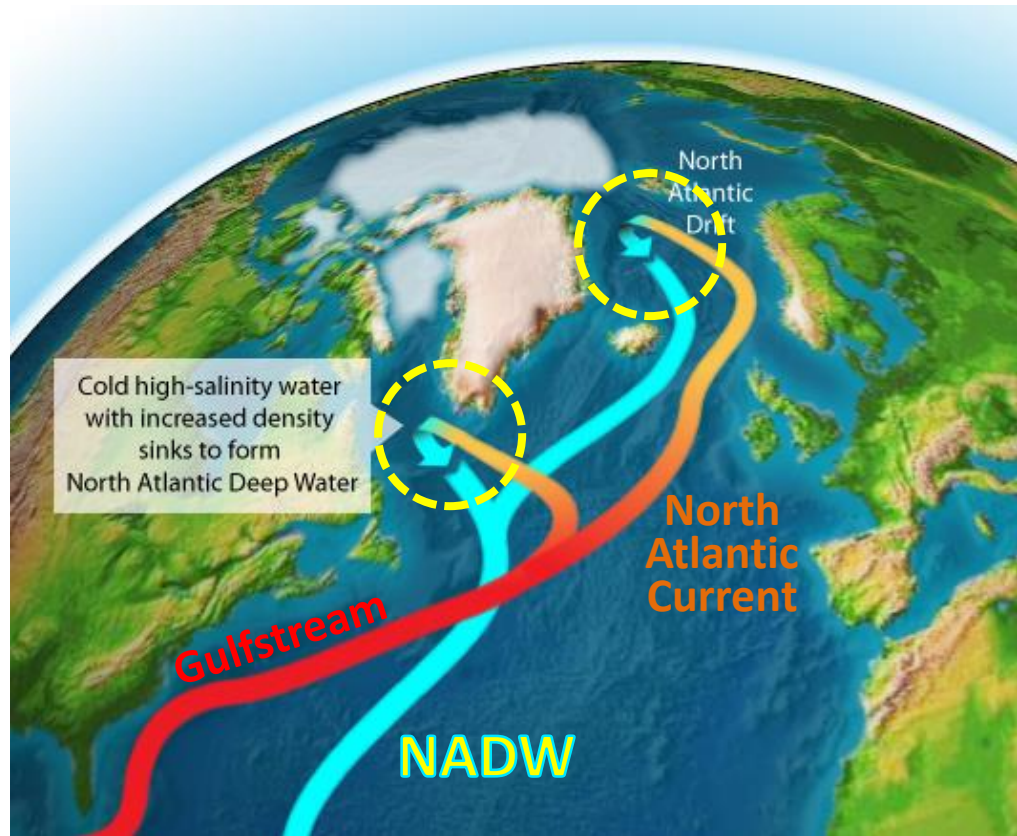

Shallow northern seas
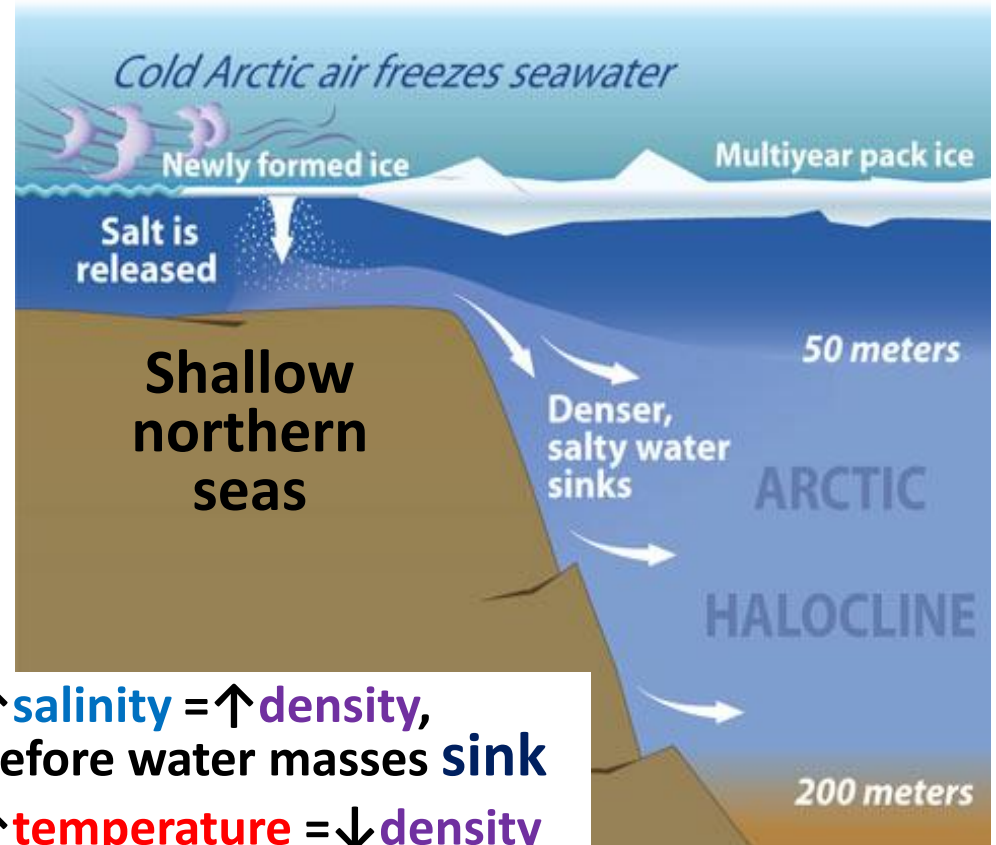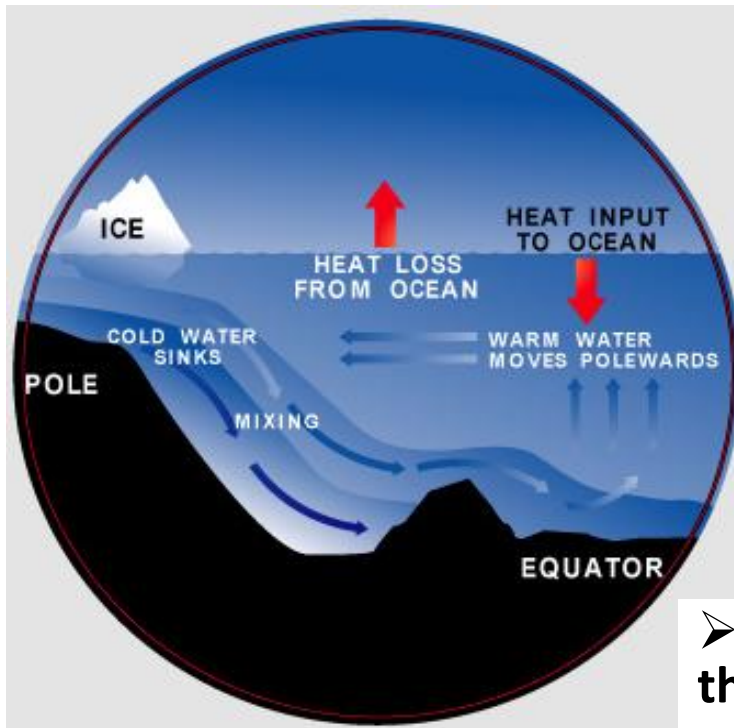
> ↑salinity =↑density, therefore water masses **sink**
> ↑temperature =↓density therefore water masses **float**

Thermohaline currents mix the ocean's waters on a global scale.

Deep Currents

Deep currents are directed by ocean bottom relief: water masses move "down the hill".

- **Originate from <u>polar regions</u>.**

- **Form from warm and saline surface water masses that cool down (↑density) and sink through convection due to increased density.**

- **More *massive* and *move slower* than surface currents.**

- **Cold and saline.**

Cold high-salinity water with increased density sinks to form North Atlantic Deep Water

North Atlantic Drift

North Atlantic Current
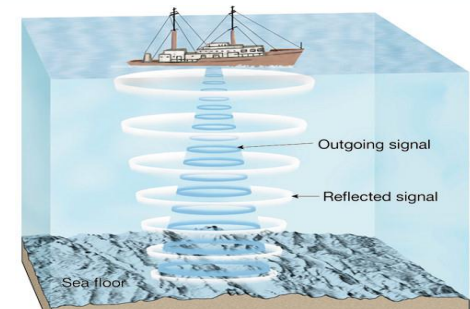
Gulfstream

NADW

Example: North Atlantic Deep Water

North Atlantic Ocean Basin Profile
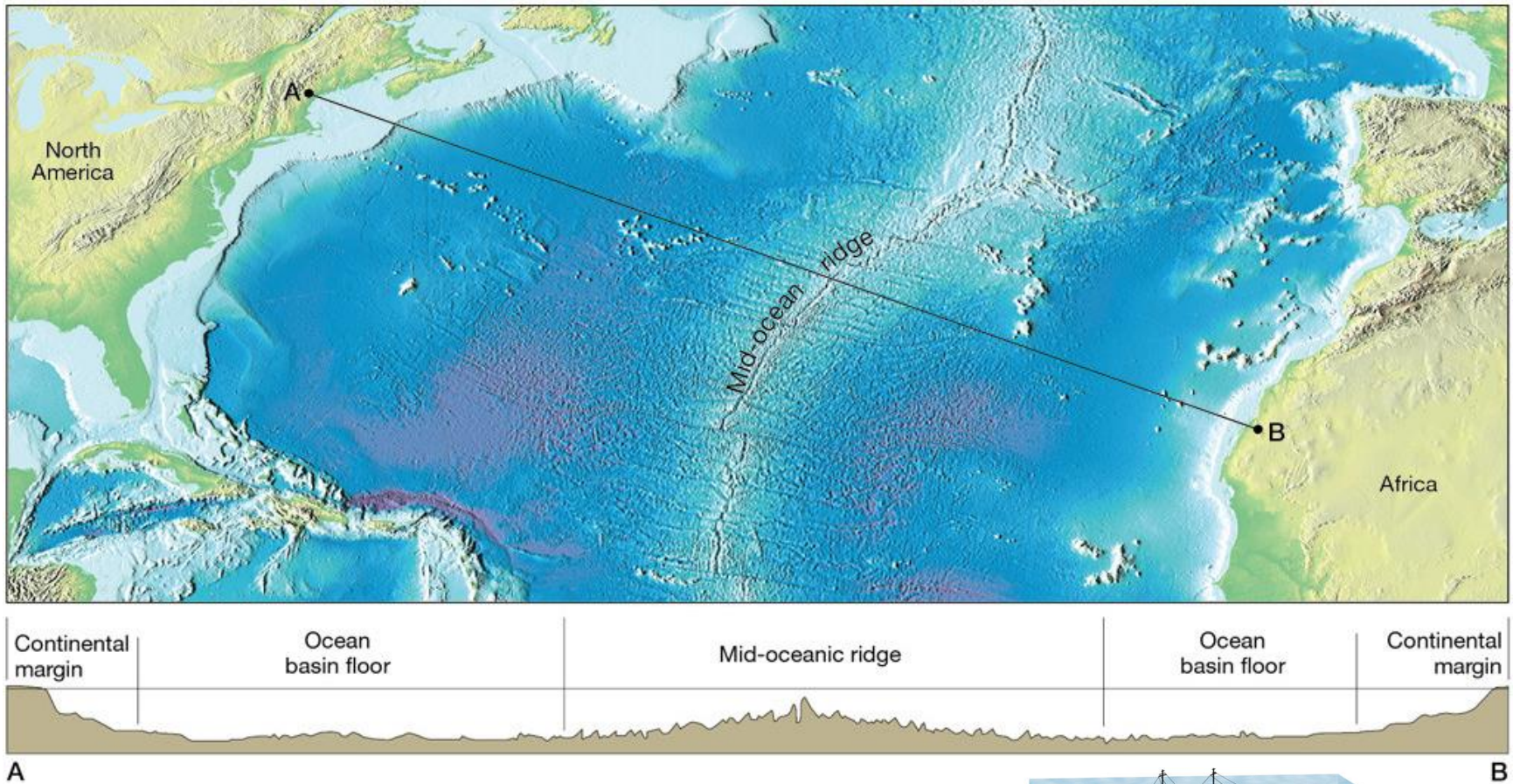
Bathymetry: measurement of ocean depths and floor profiles; done using echo sounders and satellite radar.

Overturning Circulation

- **Deep water** forms in polar regions: in Antarctic when the extremely frigid salty surface water sinks rapidly, and in North Atlantic due to evaporative cooling in Nordic seas.

- Upward flow **overturning** occurs in the Pacific and Indian Oceans mainly as a result of equatorial upwelling followed by heating.
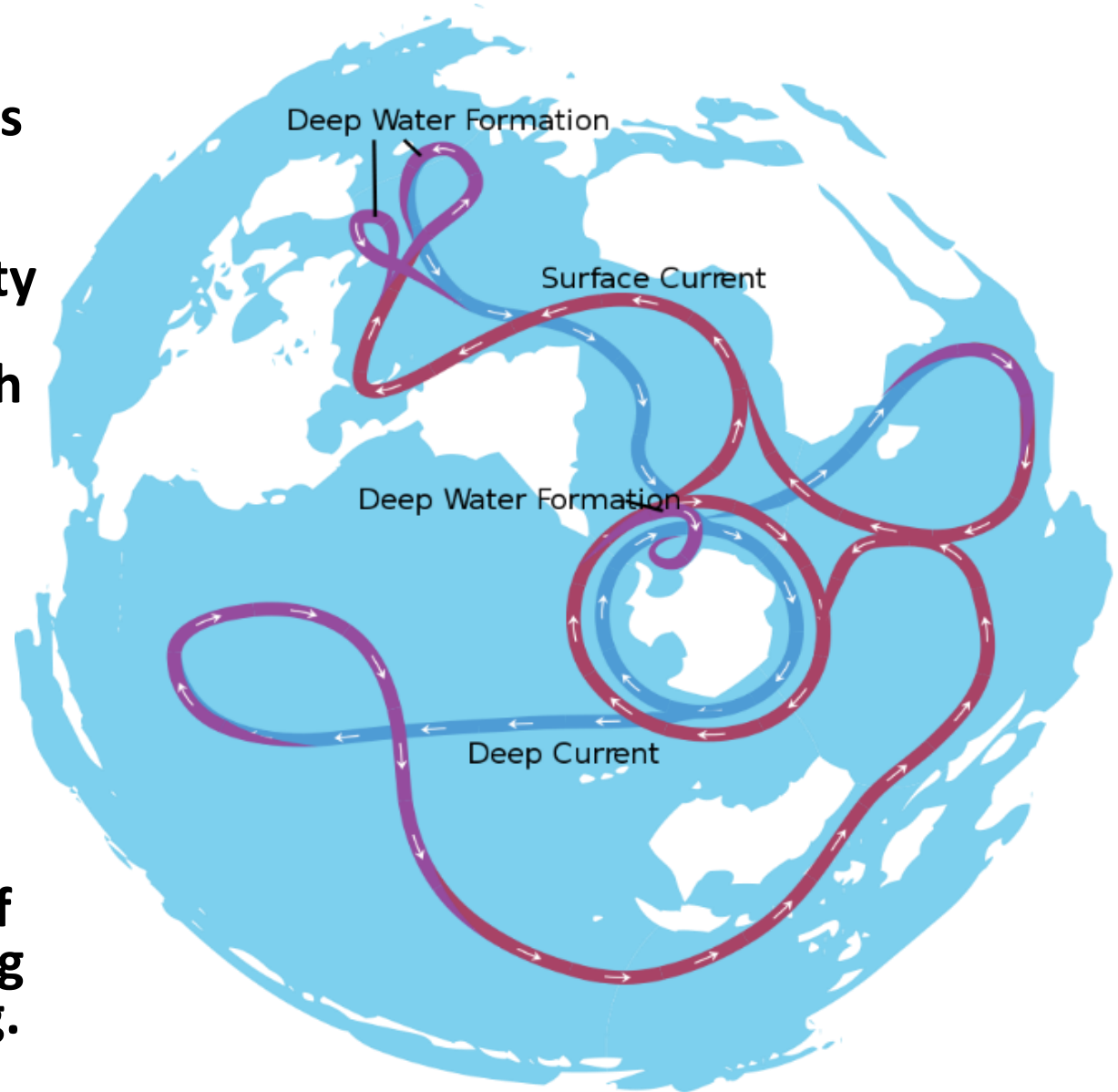
Conveyor Belt Circulation

***Vertical* currents combined with *surface* currents result in global conveyor belt movement of water.**

It takes several hundred years for the conveyor belt to turn over the ocean's waters and make one complete trip around the Earth.
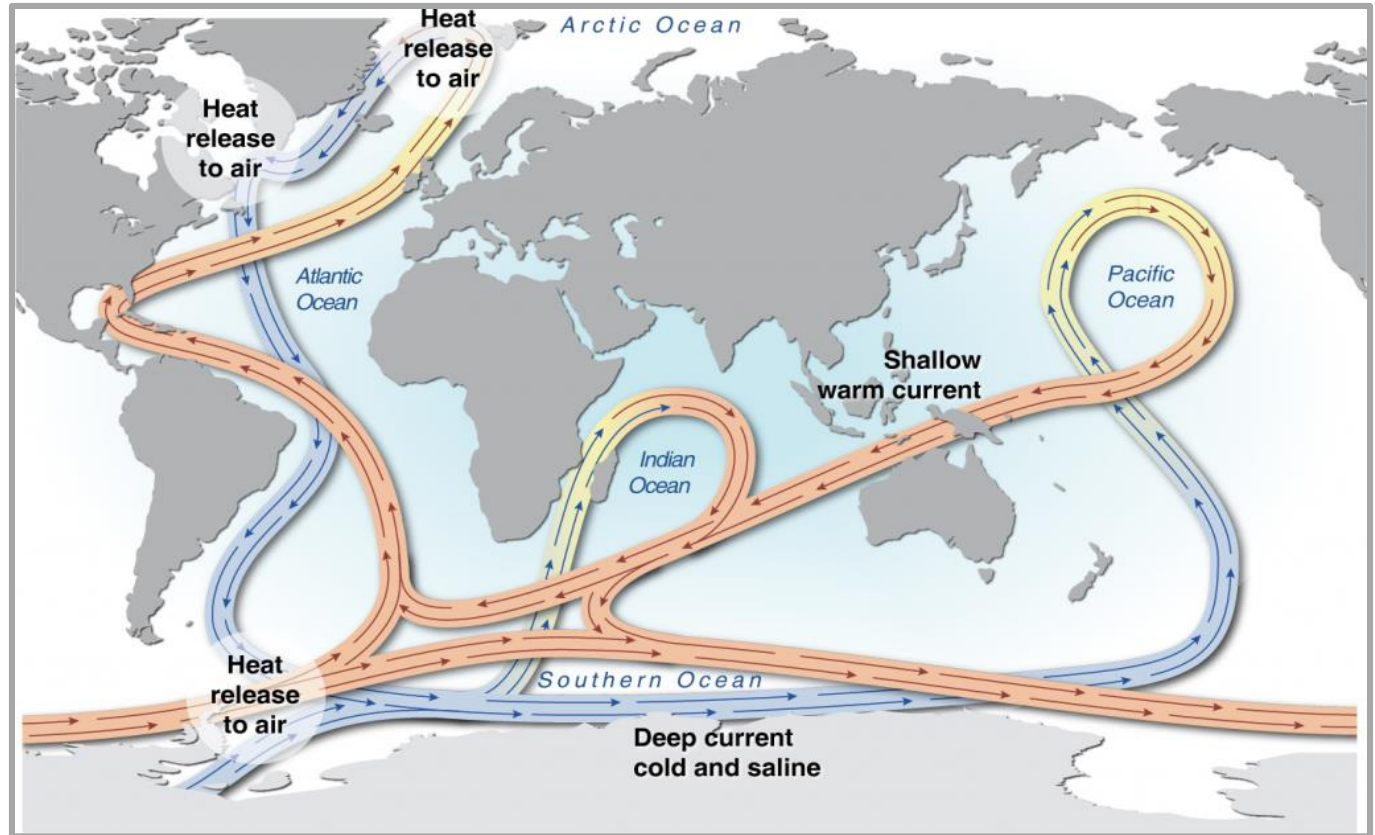
The ocean plays a major role in the distribution of the Earth's heat through deep sea circulation.

Conveyer Belt 3D
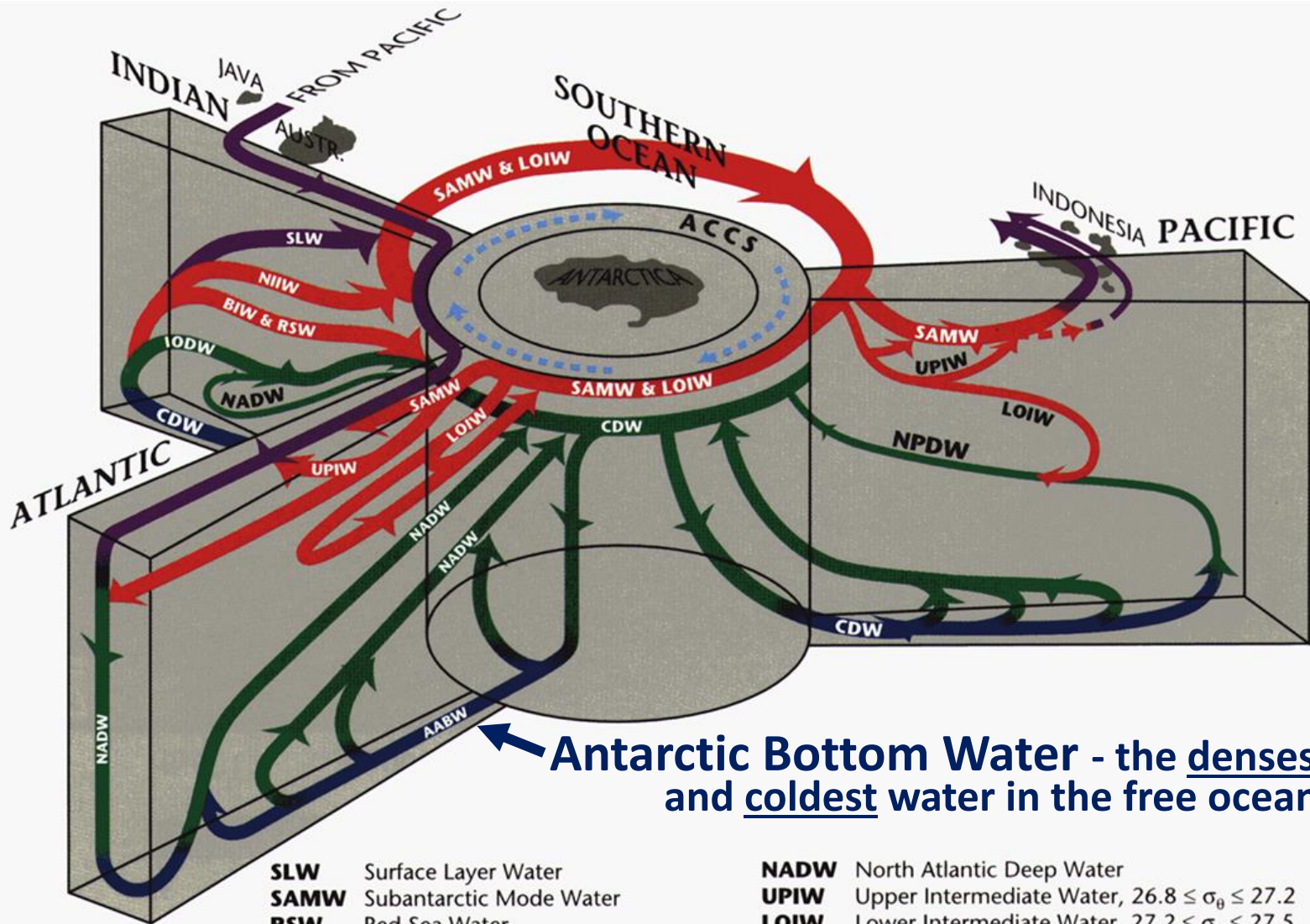
Antarctic Bottom Water - the <u>densest</u> and <u>coldest</u> water in the free ocean.

SLW	Surface Layer Water		**NADW**	North Atlantic Deep Water
SAMW	Subantarctic Mode Water		**UPIW**	Upper Intermediate Water, $26.8 \leq \sigma_\theta \leq 27.2$
RSW	Red Sea Water		**LOIW**	Lower Intermediate Water, $27.2 \leq \sigma_\theta \leq 27.5$
AABW	Antarctic Bottom Water		**IODW**	Indian Ocean Deep Water
NPDW	North Pacific Deep Water		**BIW**	Banda Intermediate Water
ACCS	Antarctic Circumpolar Current System		**NIIW**	Northwest Indian Intermediate Water
CDW	Circumpolar Deep Water			