Processes at the Ocean Surface:

1. Water heating by the Sun, ↑ temperature
2. Water evaporation (salt is left behind), ↑ salinity
3. Precipitation (fresh water input), ↓ salinity
4. Water cooling (cold winds/ice masses), ↓ temperature
5. Ice melt (fresh water is released), ↓ salinity
6. Ice formation (salt is left behind), ↑ salinity
7. Large river inflow (fresh water input), ↓ salinity
8. Water movement (pushed by winds/tides)

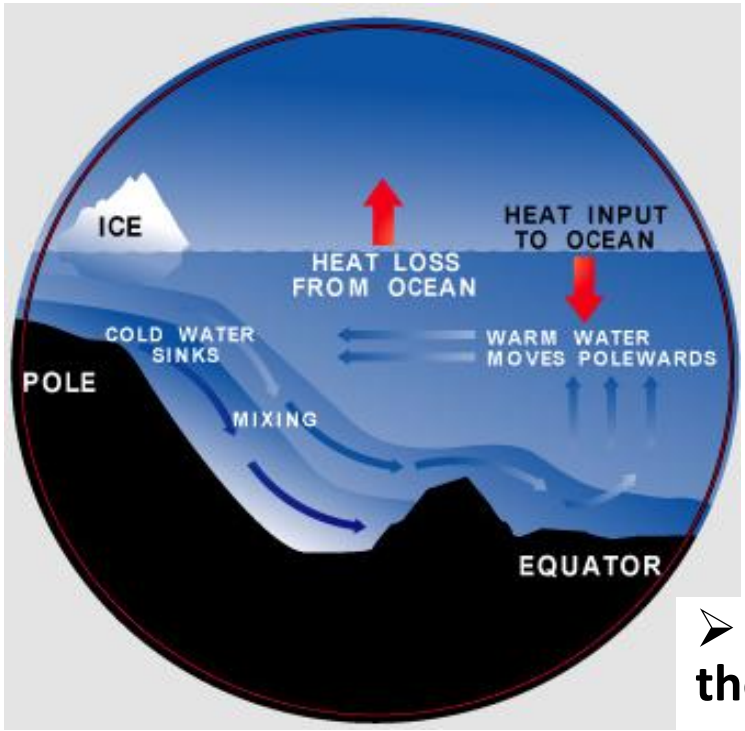
Processes in the Deep:

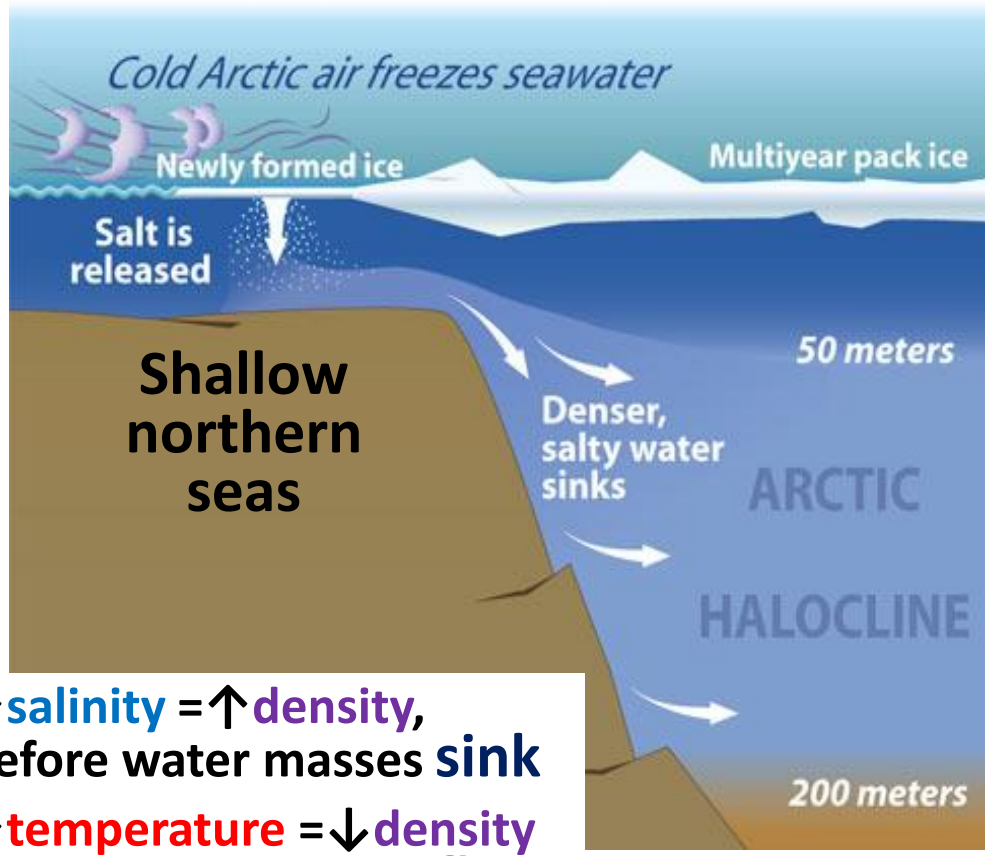
9. Water rise and fall (density difference)
10. Deep water downhill flow at the ocean bottom

Interplay of these processes defines ocean circulation.

Vertical Circulation: Thermohaline

Water masses can rise and fall because of density differences due to variation of temperature and salinity with depth.

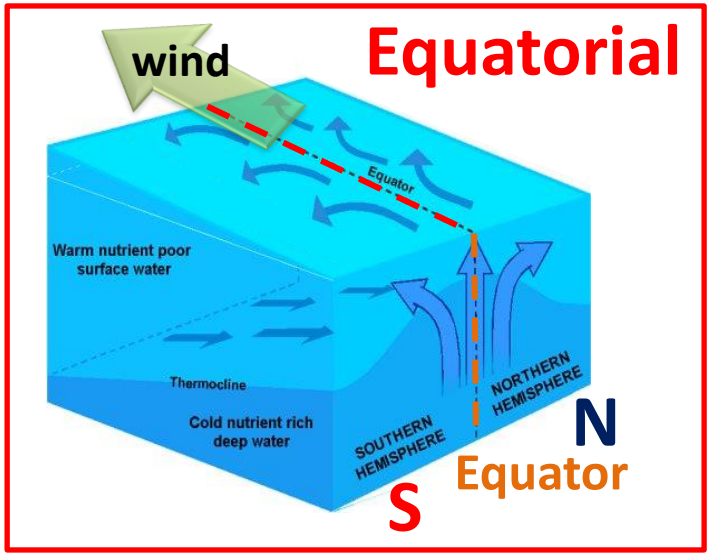




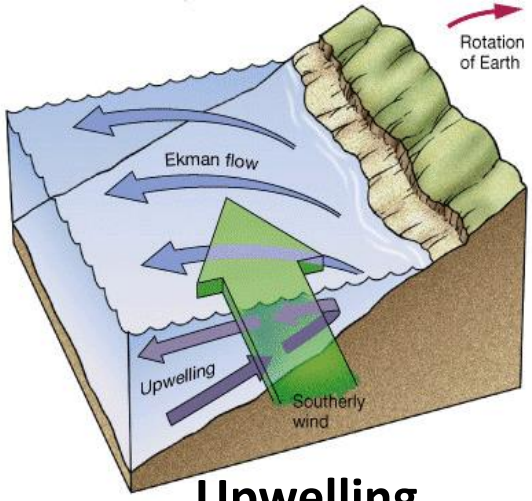
- ↑salinity =↑density, therefore water masses sink
- ↑temperature =↓density therefore water masses float

Wind Driven Upwelling/Downwelling

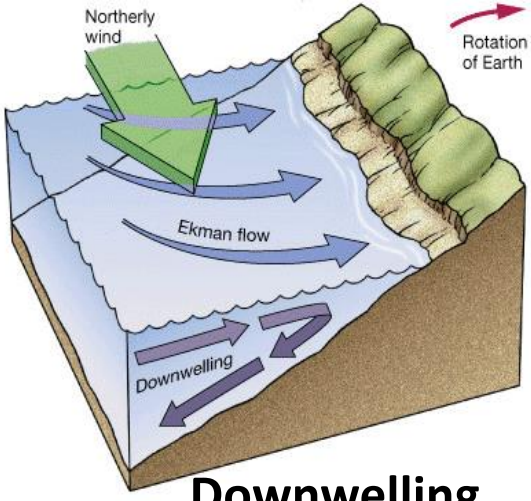
- **Wind blows, pushes water away (note that water is deflected due to Coriolis effect), causes deep cold water to rise up to replace it.**
- **Vertical currents: <u>equatorial</u> and <u>coastal</u>.**
- **Upwelling brings nutrients to surface: sites of rich fisheries.**



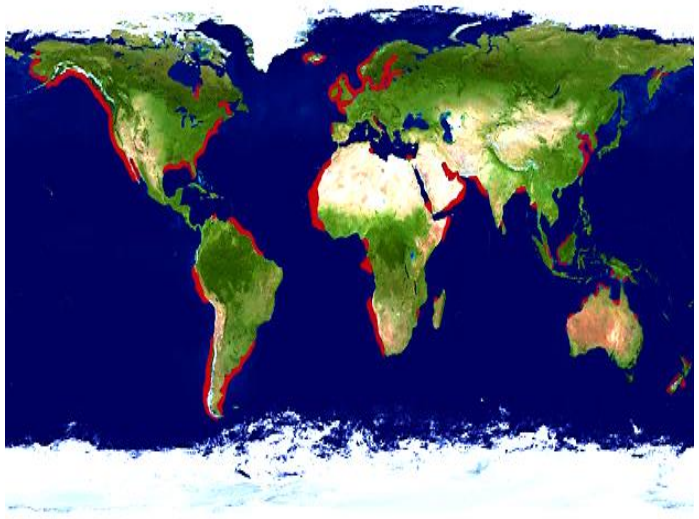
Coastal (Ex: West Coast, Southern Hemisphere)



Upwelling



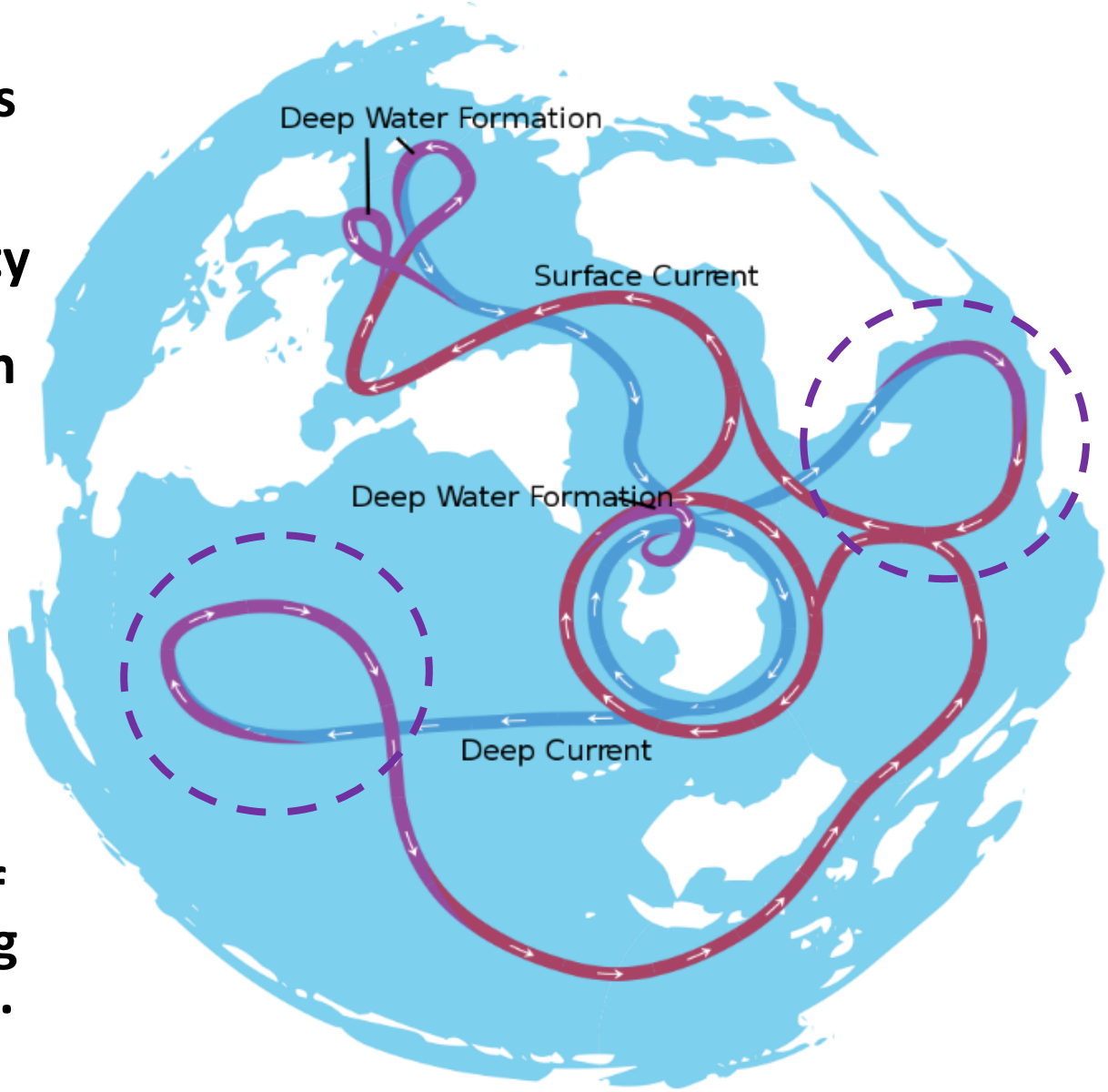
Downwelling



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.**

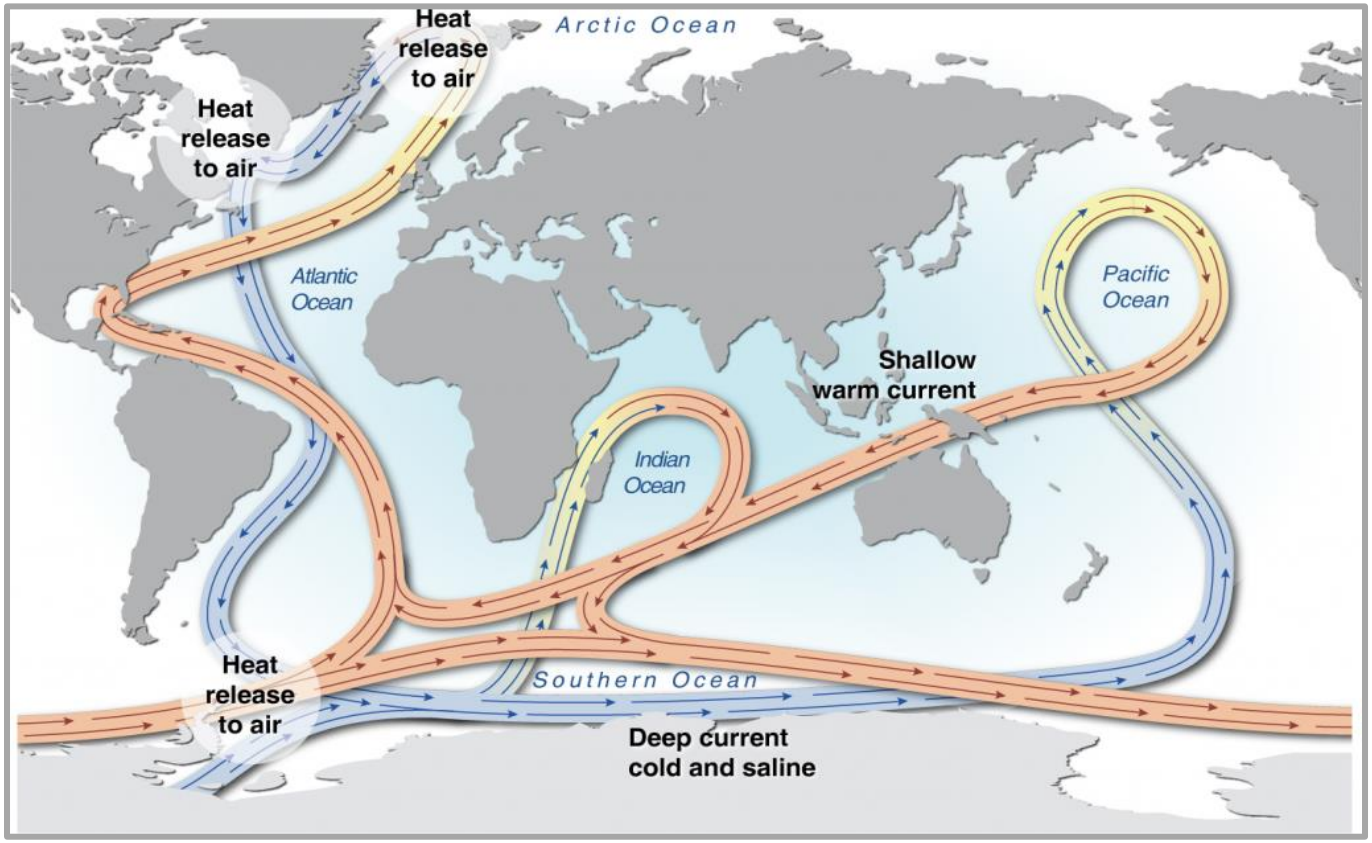
- **Upward flow overturning occurs in the Pacific and Indian Oceans mainly as a result of equatorial upwelling followed by heating.**



Conveyor Belt Circulation

Vertical **currents combined with** ***surface and deep*** **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 <u>ocean plays a major role</u> in the <u>distribution of the Earth's heat</u> through deep sea circulation.

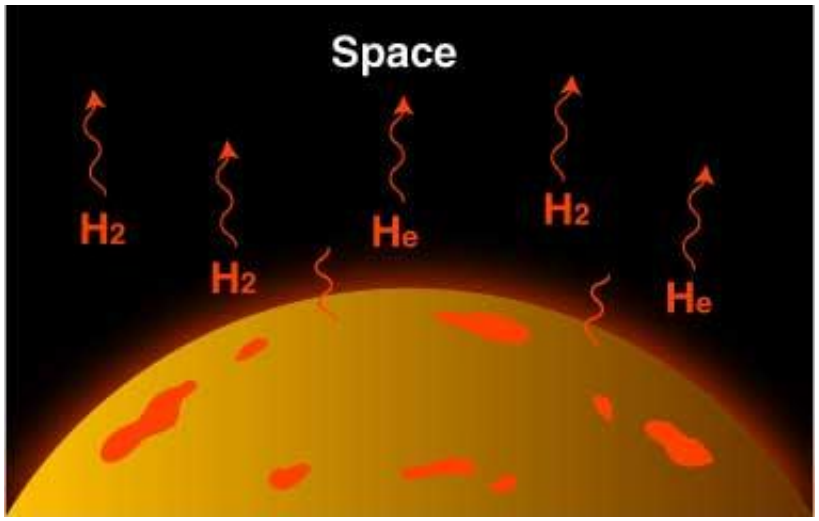
Atmosphere

from Greek ἀτμός [*atmos*] "vapor"and σφαῖρα [*sphaira*] "sphere"

- **An <u>atmosphere</u> is a layer of gases surrounding a material body of sufficient mass that is held in place by the gravity of the body.**
- **The Earth's atmosphere protects life on Earth by absorbing ultraviolet solar radiation, warming the surface through heat retention (*greenhouse effect*), and reducing temperature extremes between day and night.**

- The atmosphere is a **gas**.
- The atmosphere is a **fluid**.
- The atmosphere has a **mass of about 5.15×10^{18} kg** (~1-millionth of the Earth's mass!)

Evolution of the Early Atmosphere

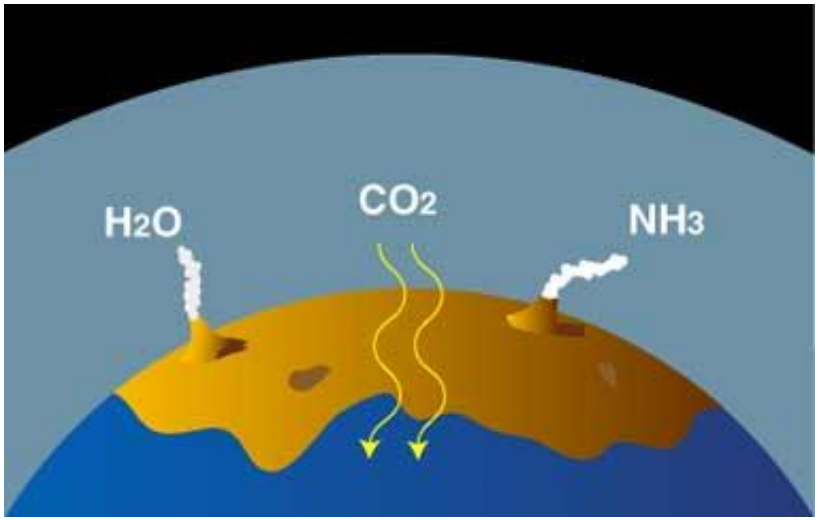


- **Primitive <u>first</u> atmosphere**

(*stellar gas* composition: H, He, CH_4 – hot and light, able to quickly escape to space)

- ***Outgassing*** **and the <u>second</u> atmosphere**

(volcanoes released H_2O, NH_3, Ar, CO_2 – <u>still no oxygen</u>!)

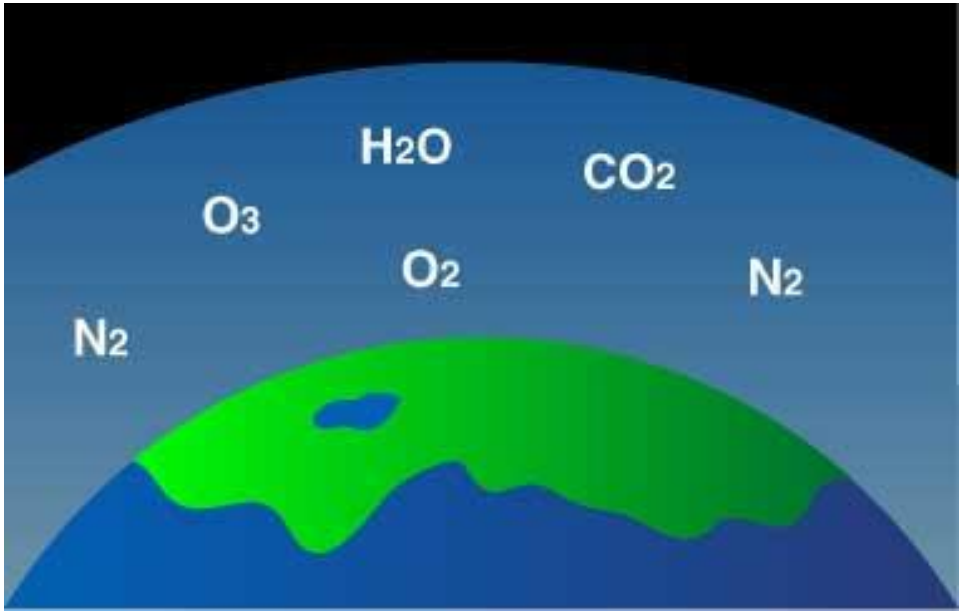


The Modern Atmosphere
upon which life depends was created by life itself!

The evolution of life and atmosphere are closely linked – life produces free oxygen (photosynthesis) and cycles carbon (limestone formation).

- ***Free oxygen is very reactive!***
- ***Oxidized*** **modern atmosphere**

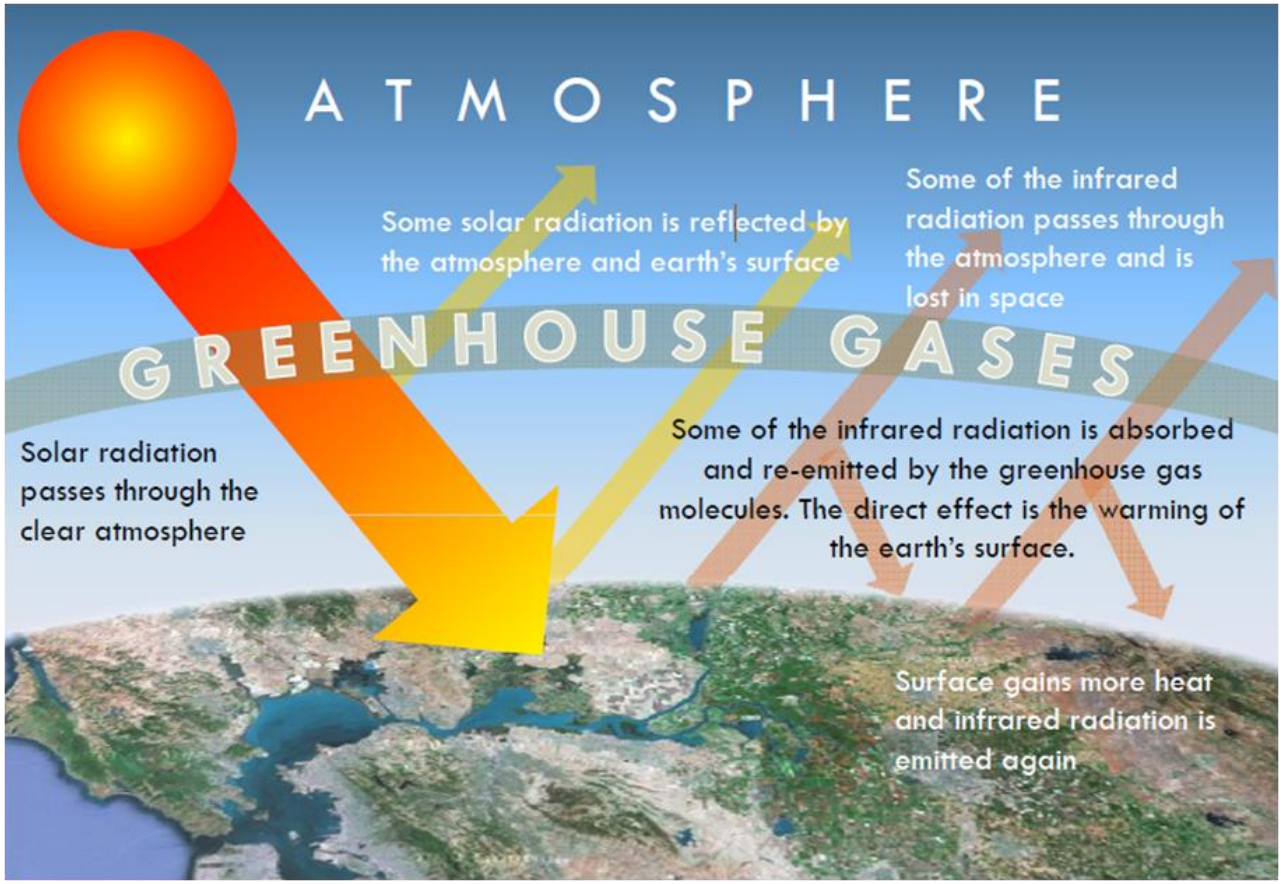
(mostly N_2, O_2,
***and very little H_2O and CO_2…* playing a *very important role*!)**



What is Greenhouse Effect?

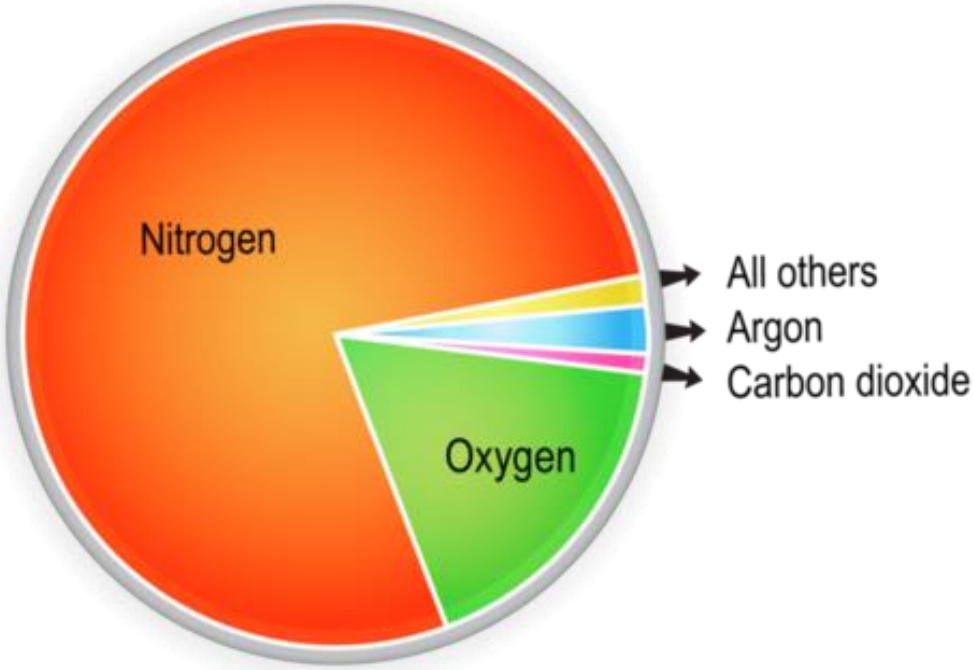
The warming of the atmosphere by absorbing and emitting infrared radiation while allowing shortwave radiation to pass through.

The gases mainly responsible for the Earth's atmospheric greenhouse effect are water vapor and carbon dioxide.



Atmospheric Gases

- **Nitrogen - 78%**
- **Oxygen - 21%**
- **Argon - .93%**
- **Water vapor – 0 to 4%**



- ***Traces*** **of neon, helium, methane, krypton, xenon, hydrogen, ozone, and…**
- **…carbon dioxide - .0415% (end of year 2020)**
  - **keeps Earth warm and is used by plants to make food**