Week Five: October 9th to 12th

- Note taker: Julia Winberg
- OCT 9: Ocean Atmosphere Interactions
    - Solar Energy
        - The sun is the primary source of energy on Earth
        - 1400 watts per meter squared (144 W/m2) at the top of our atmosphere
        - Solar Energy: Circulation of the atmosphere
            - heat heavy at the equator, and then circulated and dissipated by convection cells
            - Tropics are **not** getting constantly warmer, and poles are **not** getting constantly colder
            - **Energy/heat is circulated by density-driven circulation**
- N2 Gas (Dinitrogen) is the most dominant gas in the atmosphere, making up 78.1% of it
- Oxygen (O2) composes 20.9%
- Argon, CO2, traces of others make up the rest
- CO2 is one of the gases that affects the overall temperature of the planet. A small amount of CO2 into our atmosphere can actually have a **big impact** upon it.
- If you'd like to check out the amount of CO2 in our atmosphere currently (depressing), go to http://co2now.org/
- Industrial revolution has seriously impacted atmospheric CO2 levels; In fact it has more than doubled them
- About **4%** of our atmosphere is **water vapor**
- **Greenhouse Effect/ Greenhouse Gases**
    - Greenhouse gases:
        - H2O
        - CO2- CARBON DIOXIDE (bad)
        - CH4 - METHANE (bad)
        - N2O- NITROUS OXIDE (bad)
        - O3 - ozone
        - CFC's - like in hairspray, we've done a good job of getting these under control
- Here's the deal with greenhouse gases:
    - They only absorb long-wave radiation, aka radiation emitted from Earth
    - CH4, Methane, is **25x more powerful than CO2**
    - N2O, Nitrous Oxide, is **298x more powerful than CO2**

    - Greenhouse gases can deflect and maintain radiation. In some cases, this is good. They provide warmth for the planet and make it habitable. Without them the Earth would be super cold, around -18 degrees C, or -0.4 degrees F on average. *With* greenhouse gases, the Earth is around 15 degrees C, or 59 degrees F on average.
    - However, as you probably know, there are **too many** greenhouse gases in the environment. This comes from driving cars, fertilizing farms, and burning biomass.
- 16% of radiation is absorbed by Greenhouse Gases, 3% is absorbed by clouds.
- Some radiation is reflected back (around 30%), Air, clouds, water, and land
- 51% radiation absorbed by water and land
- There is an interplay between outgoing and incoming radiation, and the amount absorbed is what warms our planet
- If the entire planet were flat, the earth would get the same amount of sunlight everywhere.
- **Uneven Solar Heating/ Footprint**
    - The beams of light from the sun change based on location on Earth
    - Solar Energy Input varies with Latitude:
        - There is a **surplus at the equator**
        - There is a **deficit at the poles**
    - Earth transfers heat to the poles with seasons and cycles
    - Hurricanes and Typhoons also transfer heat
    - The Earth is tilted **23.5 degrees** off of center
        - This is supported by the Giant Impact Hypothesis, which we discussed earlier in the semester and is also what is believed to have created the moon.
        - This tilt gives the Earth an **elliptical orbit**
        - The Earth's tilt and elliptical orbit give us seasons!
- The Albedo of the Earth
    - Albedo is a fraction of incident electromagnetic radiation reflected by a surface.
    - Sunlight plays big role here
    - Think of a black car in the summertime: you get into it and the seats practically burn you because they are so hot. This is **HIGH ALBEDO: The black car is a big reflector of sunlight**
    - Think of the aluminum barrier you might put up in your windshield so that your car doesn't get so got sitting in a parking lot in the summer. This is **LOW ALBEDO: The cover is big absorber of sunlight.**

    - On a larger scale, there is positive feedback between Earth and Albedo. **Ice has high albedo, the ocean has low albedo.**
    - **Losing Arctic sea ice lowers the Earth's Albedo.** The more you lose ice, the more ocean is available to absorb heat, thus, warming the oceans.
- Density variation in the atmosphere
    - Warm air rises
    - Cold air sinks
    - Convection cells apply all over the planet
    - **Low Pressure**: Warm, Dry Area, nice day
    - **High Pressure**: Cool, Wet, Rainy or snowy day
    - Air is always flowing from high to low pressure
    - **Wind:** moving air
- Our planet spins to the East, rotating 360 degrees in one day. However, it doesn't rotate the same speed everywhere.
- For example, if you were asked to run all the way around the Earth, where would it be easiest? The poles. Where would it be the most difficult? Around the equator. In class, we went over this example.
- As Earth rotates, different latitudes travel at different speeds
- The change in speed with latitude causes the **Coriolis Effect.**
- **The Coriolis Effect**
    - because Earth spins, this causes a change in perspective based on location
    - Effect changes with latitude; No effect at the equator, maximum effect at poles
    - Northern Hemisphere: Deflection to the right
    - Southern Hemisphere: Deflection to the left
    - Things appear to bend (optical illusion)- Video watched in class
    - Affected by change in Earth's rotating velocity with latitude: 0km/hr at poles, more than 1600 km/hr at the equator
    - The Coriolis impacts atmospheric and ocean circulation
- Convection cells
    - Low pressure Center
    - Convection cells **not** perfectly shaped, wobbly, misshapen; a series of **six** of them hug the Earth (Three on either side of equator)
    - **Hadley Cells:** close the equator, on either side
    - **Ferrel Cels:** Closer to poles
    - **Polar Cells:** at poles
    - Trade Winds: Westerlies, Northeast Trade Winds, and Southeast Trade Winds, Doldrums (If you want to see a graphic about the direction of these

winds as they look against Earth's surface, check the powerpoint from this day)
        - Subtropical highs; also known as the Horse Latitudes ****
        - The six convection cells stick ocean and atmospheric circulation by redistributing heat across the face of the planet
- ITCZ
    - Inter-tropical Convergence Zone
    - Changes with season
    - Atmospheric Equator (as opposed to a geographical equator)
    - The location of the atmospheric equator changes as the Earth orbits; when the ITCZ is over a land mass, there is a bigger shift because of latent heat of water vs. land
- Monsoons distribute rainwater across certain areas, like India
- Dryer Season in Colder months ****
- Coast: day and night shifts in breezes. Look at the ppt that describes a land breeze and a seabreeze
    - Ocean has a heat capacity

October 10th 2018

Ocean Currents (Chapter 9)

- Winds: named for the direction in which they are coming from; A southerly wind is coming from the South and blowing north
- Currents: named for the direction in which they flow. An easterly current is flowing from the West to the East
- Ocean Circulation
    - Transports approx. 20% of latitudinal heat
    - Wind drives water horizontally
    - Transporting nutrients and organisms like fish in the Gulf Stream
    - Moving water can be density or gravity driven, vertically, mixing the water
    - Ocean Circulation affects weather and climate, commerce (sailing and power boats)
- Wind can actively move water down 1km in the water column. Phrased differently: Up to One kilometer deep in the water column, wind can actively move water. It can influence 1km downward into the water column.
- The REST is gravity driven
- Surface Currents are **wind driven** and they are 10% of ocean currents

- **Density driven currents** are the majority of currents in the ocean, made up of vertically mixing water in the water column.
- Measuring currents
    - Current meters: Torpedo, spinning propellor that measures currents
    - Temperature Sensors, Oxygen sensors attached
    - Satellites, measuring changes in height of seal level and how water is distributed
- Surface Currents
    - Due to friction between wind and water
    - Picture cooling off a hot tea or maybe soup, when you blow on it, the water moves
    - 2% of wind's energy is transferred to the ocean surface; friction slows this down
    - a 100 knot wind makes for only a 2 knot current
    - Knot: 1 Nautical Mile, or 1.15 miles
- There are somewhere around 3,984 floats in the ocean recording data on currents right now (ARGO).
    - The floats have neutrally buoyant settings and they can descend into the water column and stay at a certain depth; every so often they will come up to the surface and beam information, then drop back down
    - Eventually, they die and sink down to the bottom of the ocean (litter), and they can also get caught in fishing nets
- Gyre (pronounced Jai-ur)
    - Large systems of rotations ocean currents, large wind movements
    - There are **five** gyres: **North Atlantic, South Atlantic, Indian, North Pacific, and South Pacific**
    - Gyres are primarily driven by wind
    - Different distributions of animals are affected by gyres
    - gyres line up with the map of large currents in the ocean
    - North Atlantic Gyre: Gulf stream, North Atlantic Currents (Warm), Canary Current (cold), N. Equatorial Current (Warm)
    - Ocean basins and gyres are defined by warm and cold currents. Warm currents move up from Equator to poles, Cold currents move down from poles to equator
- Western Boundary Currents
    - Warm: Narrow, Deep, Fast
    - Less than 100km wide (narrow)
    - 2km deep
    - move 100s of km per day (fast)

- Eastern Boundary Currents
    - Cold: Wide, Shallow, Slow- moving cool water to the equator
    - Greater than 1000km wide
    - 0.5km deep (shallow)
    - moves 10s of km per day (slow)
    - Even though cold water is denser than warm water, this water is less saline, making it able to scoot along the top of the ocean
- Lots of current activity means lots of productivity, and productivity levels match upwelling and currents across the globe.
- Mixing up biomass, bringing phytoplankton to the surface increases productivity in an area, achieved by upwelling
- Ekman Transport
    - Spiral of layers of water that are deflected by friction to one direction (Coriolis Effect)
    - Each layer pushes the layer of water underneath it a little more to the right (or left in the southern hem.)
    - Powerpoint from this class has great graphics about Ekman spirals
- Ekman transport accounts for upwelling and downwelling. Upwelling occurs when rising cold water fills in for water moved during Ekman transport.
- Downwelling occurs when water on the surface is moved by Ekman Transport and hits a continental shelf and is pushed down, running deep along a coast, bringing warm water down to the bottom of the ocean.
- Ekman Spiral
    - speed and direction of flow of surface waters at various depths
- Vertical movement of Water
    - Upwelling: movement of deep water to surface. Cold, nutrient-rich, abundant marine life, high productivity
    - Downwelling: from the surface down to the bottom. Warm, nutrient-depleted water. Not associated with high productivity.
- Eddy
    - Circular movement of water formed along and edge of a permanent current
    - Moving at 1m/sec
    - 150-300km down
    - Cold (counterclockwise, seaward side of current) or warm (clockwise, landward side of current)
    - will appear for days to weeks and then disappear
- Physical Happenings changing the ocean
- Curtis Ebbesmeyer

        - lots of ships moving across the world. One, leaving China carrying a pallet of rubber duckies, drops pallet into the ocean in 1992. 29,000 rubber duckies now adrift.
        - Ebbesmeyer traces the duckies. 10k drift north, 19k drift South, 17k head to British beaches (FROM CHINA), are found on shores 15 years later in 2007
- Deep Water Circulation, Also called:
    - Thermohaline circulation
    - Abyssal Circulation
    - Meridional Overturning Circulation
    - Global Conveyor Belt
    - ALL DRIVEN BY DENSITY, caused by density difference
    - Density is a function of Temperature (Thermo) and Salinity (Haline)
- Tracers
    - Looking at the movement of water - certain chemicals (like those listed below) allow us to track, follow (i.e., trace) the movement of water around the ocean.
    - Chemicals: Tritium, Radiocarbon, Nutrients, Oxygen, CFCs (man-made)

90% of all water movement is driven by Density

- Sun only heats ~100m later, making deep water cold
- Density and Temperature are a mirror image: The warmer the water, the less dense it is
- Winds cool surface water. Temperature lowers, Density rises, it sinks
- Temperature has a greater effect on density
- Evaporation increases salinity
- Importance of Deep Water Circulation
    - Vertical Stratification- Like a lid- important in dynamics and biology.
    - Cold water fixes more carbon dioxide than warm water- Heat transport influences Earth's climate
    - Driving oxygenated water downward
    - Fixing CO_2- The deep ocean stores anthropogenic carbon dioxide, takes 1000s of years for one mixing
- Sources of Deep Water
    - Low latitude: strong thermocline, water stratified
    - High latitude: vertically well mixed
- Water masses
    - Parcels of water moving throughout ocean with narrow range of Temp, Salinity

    - Deep water
        - Rivers and masses underneath, deep in ocean
        - All have own characteristics of Temp and Sal., make for profile structure that is invisible
- NADW North Atlantic Deep Water
    - Forms in North Atlantic
    - Most of the world's deep water comes from North Atlantic

Oceanography
10-12-2018
Guest Lecturer Pete Buston

Why Some Animals Forgo Reproduction in Complex Societies

Darwin identifies problems he doesn't understand.

-Sterile females in animal societies, the daughters help the queen reproduce, but don't do it themselves.

-Not clear how their genes get into the next generation, why do the phenotypes exist if they are not reproducing.

Social vertebrates have flexibility in their behavior, explained by these two ideas kin selection and ecological constraints

Kin selection

1. Reproduce directly by producing own offspring
2. Assisting relatives because they have parts of your genes

Hypothesis- Helpers enhance breeders and they are closely related

Ecological constraints

1. They can stay on their natal territory
2. They can disperse

Hypothesis-will stay when there is a constraint, likelihood of dispersal increases when there is not a constraint

Naked mole rat example- can't do it alone, need others to help find food (ecological restraint)

Coral Reef Fish Societies

No one had tested this in the ocean because many fish disperse as larvae. Emerald Goby and clownfish form groups similar to the mammal invertebrate hosts that provide protection. (anemones for clownfish and coral for the Gobys) Each group has a breeding pair and a few non-breeders. In clownfish the female is the largest and then everyone gets smaller. In Gobys the breeding pair is the same size then everyone else is smaller.

Pete Buston used these four ideas to describe his data,

Kin selection

- The non-breeders help breeders in some way and are closely related
- 100 groups of clownfish in one year monitored growth and survival and reproduction of 71 groups and conducted experiments removed of non-breeders from 14 groups
- Clownfish have markings that are unique so Buston could keep track of them.
- Non-breeders do not enhance the survival growth or reproduction success of the breeding pair (very similar means on the with and without graphs)
- Genetic work was done, they are not family groups, not closely related to each other
- Kin selection DOES NOT explain the evolution of non-breeding pairs in clownfish.
- So something else interesting is going on

Future selection

- The third way to pass on genes, not pass them on now but in the future
- The 1970s birds where studied doing this, when the breeder died the non-breeder goes on to take over the territory
- Buston experimentally took away a breeder.
- Never did an outside nonbreeder take over
- The largest non-breeder took over and successfully breed
- It is necessary to pass on genes, they will wait for 15 years to inherit the anemone, they will change sex in four months to take over (if female dies and the next largest is male he will change and become the dominant female)
- The same thing happens in gobies
- Future selection DOES HELP explain the evolution of nonbreeding behavior

Ecological constraints

- Focus on payoff OUTSIDE of the anemone

- Imagine it would take you ten years to check out at Trader Joes and there is an open register, but someone would beat you up as you moved lines. Would you still move?
- Wong created a cross factored experiment in Gobys. Manipulated the saturation (how many fish) and the length between habitats
- Likelihood of dispersal decreased as habitat saturation increased and the risk of movement increased. So if the corals where farther apart they wouldn't go, and if there were
- Ecological constraint DOES HELP explain the evolution of nonbreeding behavior. Explains why they wait rather than go to breed elsewhere but it doesn't explain why they don't fight the guys in front of them

Social constraints (between non-breeders)

- Focus on the factors that lower the payoff INSIDE the anemone.
- Two options they can wait or they can fight
- Will wait when there is a social constraint but will fight when manipulated
- First insight was from weird data
    - Dominate individuals will sometimes evict immediate subordinates (if a subordinate gets big he is a threat and will most likely be killed by the dominant)
    - Size ratios were not random, there were few cases where they were the same size
    - Well defined size ratios are maintained by subordinates regulating their growth, used Emerald Goby to test this
- Subordinates will wait when there is a social constraint but will fight when manipulated by scientists
- Subordinates are usually 93% of the size of the fish above them. More likely to get evicted when the ratio is closer to one
- Below the natural line (the size ratio), they have zero chance of winning the fight
- Subordinates wait because there are social constraints! They do not contest because they will most likely lose
- Eviction in wild means the dominant will push the subordinate out of the coral and wait for him to get eaten
- Wong proved this is not a food limitation, an experiment was done where they were fed through a pipette but then the fish stopped eating once they got to the size ratio
- The math here is very similar to our everyday lives, fish don't grow because of the threat of eviction just like you don't speed because of the threat of a ticket
- Social constraint DOES HELP explain the evolution of nonbreeding behavior. Explains why they don't fight the guys in front of them