

Our Home Planet: The Earth

Physical Sciences

Broward College

Prepared for AST 1002

Horizons in Astronomy

What makes Earth special?

- The Earth has a supported, active tectonic system.
- The Earth has a supported, active atmospheric system.
- The Earth has a supported, active ecosystem.

Earth's Properties

- Distance: 1.49×10^8 km (1 A.U)
- Albedo: 0.39
- Size (Diameter): 12,758 km ($1 D_E$)
- Mass: 5.976×10^{24} kg ($1 M_E$)
- Density: 5.497 g/cm^3
- Length of Day: 24 hours (1 Earth Day)
- Length of Year: 365.25 days (1 Earth Year)



Figure 1. Earth (Wiki)

Earth's Rotation

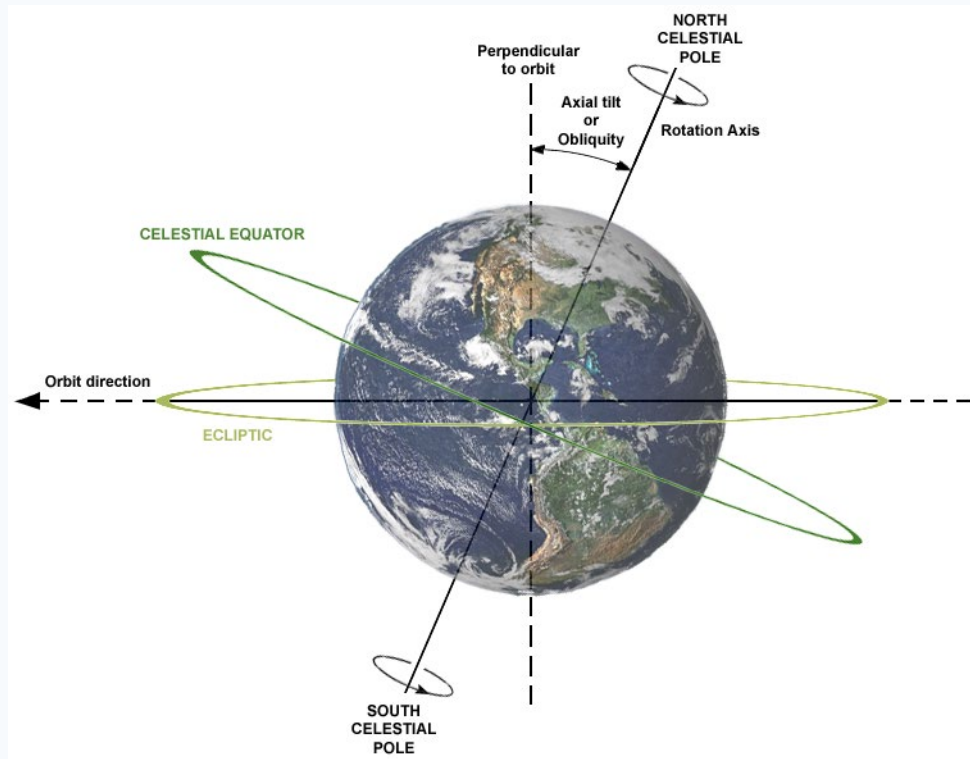
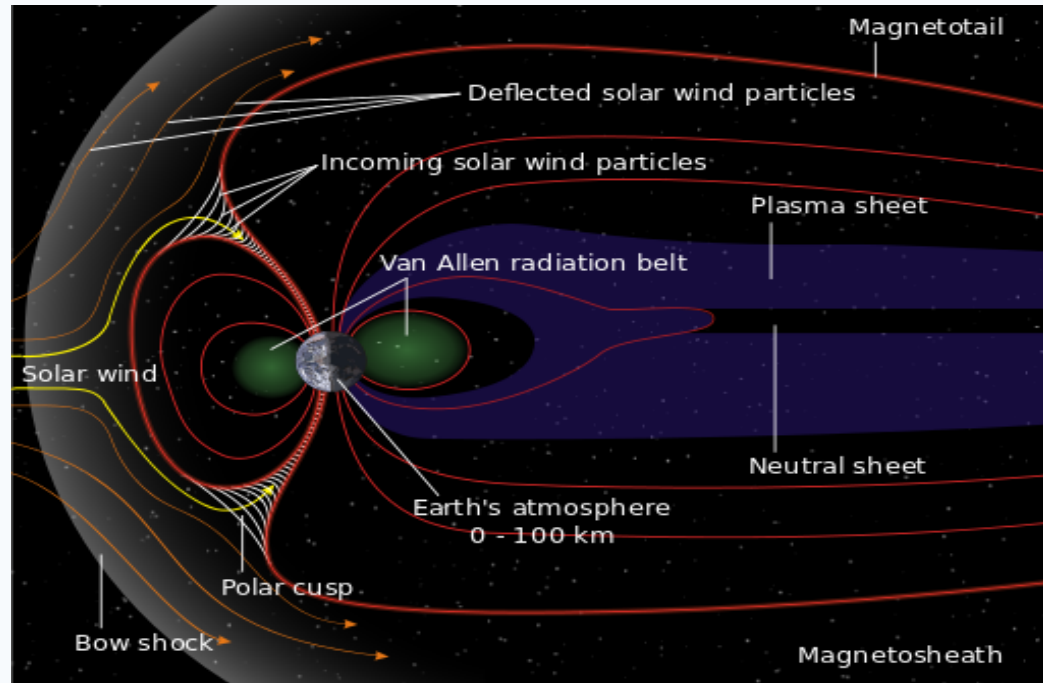


Figure 2. Earth and its Axis Rotation (Wiki)

- The Earth rotates on its axis every 24 hours making it appear the Sun and the Moon rise and set.
- The motion appears to be counterclockwise when viewed a at point north of the Earth. This Coriolis effect exerts the same motion on water and cyclones. It is opposite for the southern hemisphere. This also has an effect on global winds.

Magnetic Field

Figure 3. Earth's Magnetic Field (Wiki)



Earth produces a magnetic field due to its liquid interior. The different layers move at different speeds leading to electron transfer. Electrons moving produce a magnetic field. The field has flipped polarity (north transplants south) many times as observed from cores taken at the Kola peninsula in northern Russia. The field takes 25,000 years or more to flip. The magnetic field protects us from harmful cosmic particles; this interaction we see as Aurora Borealis in the northern and southern polar latitudes. Click the image to see aurora in action.

The Tectonic System

- The Tectonic System is complex system of impact, plutonic, and erosional processes that shape the layers of the Earth.
- The interior of the Earth has not cooled so liquid metals flow from the interior to the exterior.
- The process recycles material of the Earth.

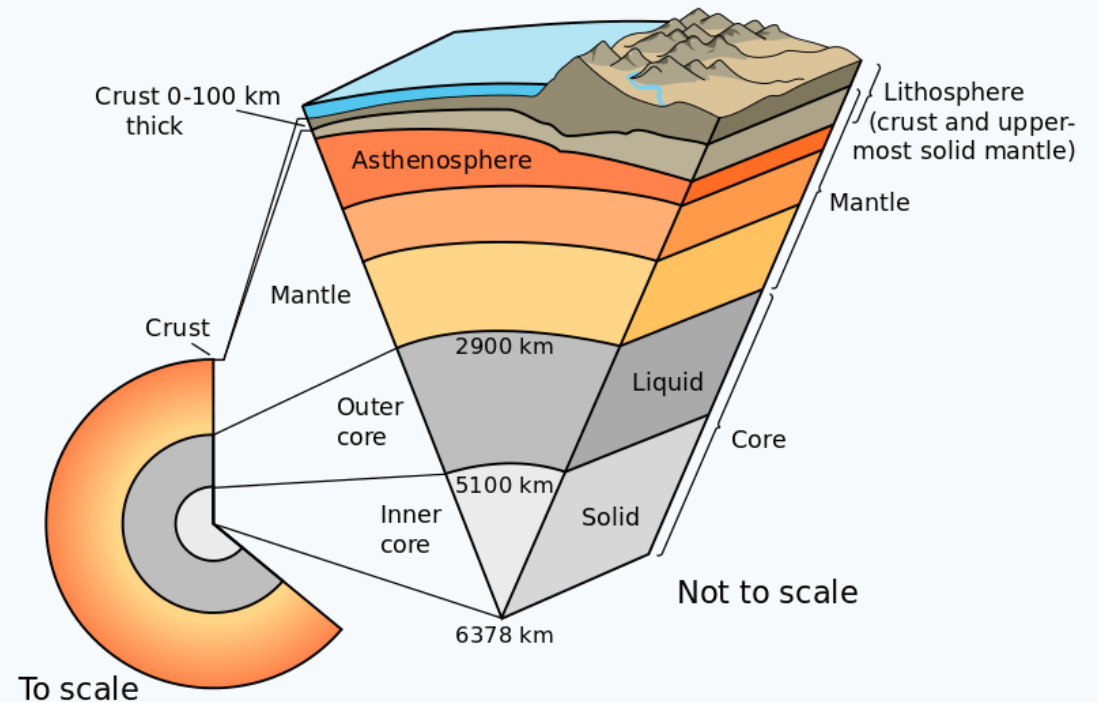


Figure 4. Earth's Cross Section (Wiki)

Seismology

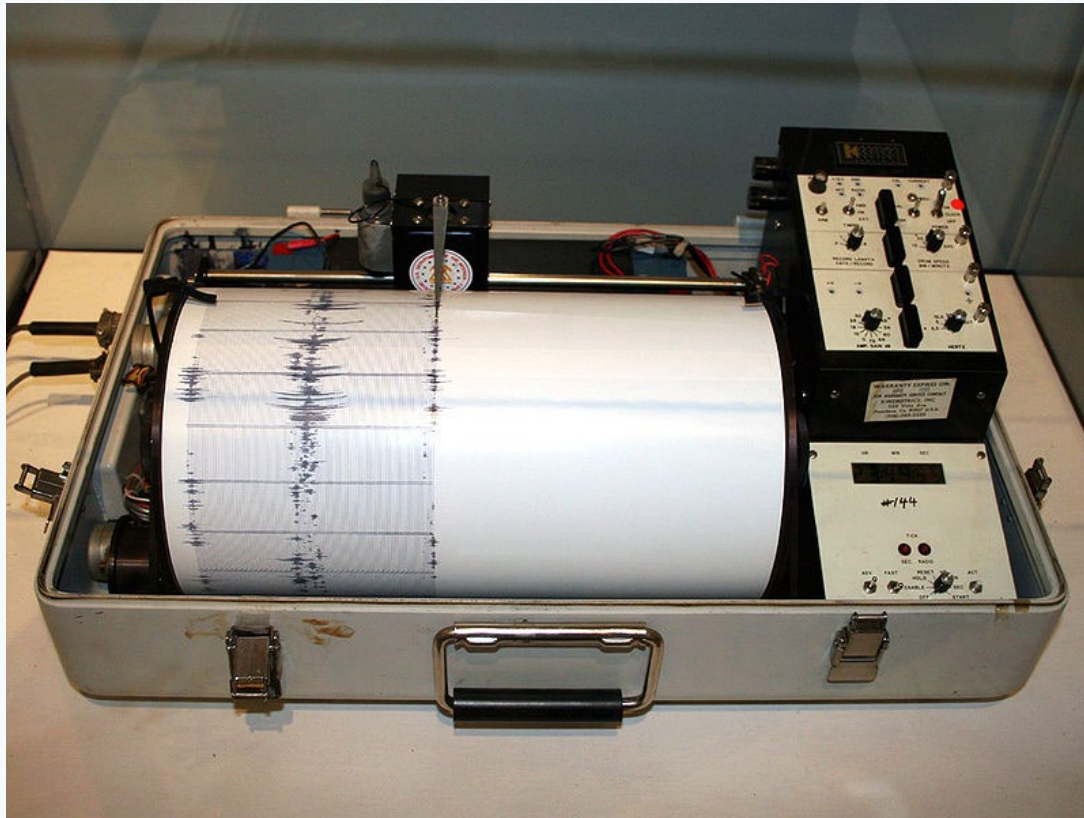
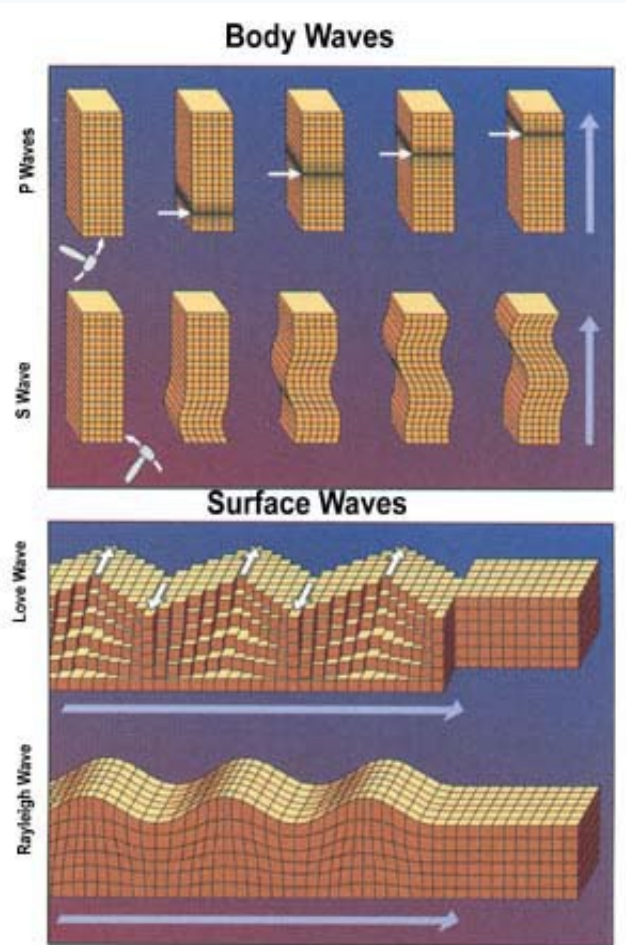


Figure 5. Siesmograph (Wiki)

- We measure the activity of the Earth's tectonic system through the movement of seismic waves through the layers of the Earth.
- We observe waves with a seismograph. The seismograph is a spring which responds to waves. The spring oscillates and the amplitude of the oscillation shows the magnitude of the wave.

Shear (S) and Pressure (P) Waves Shadow Zone



- There are two types of body waves: shear and pressure. Shear waves move like a snake moves over land, side to side. Pressure waves move like a caterpillar over a branch, scrunching along.
- There are also surface waves call L waves.
- The shear waves cannot travel through the liquid outer core are diffracted while most pressure waves can pass. So the pressure waves arrive first while the shear waves arrive second. The surface waves arrive last.

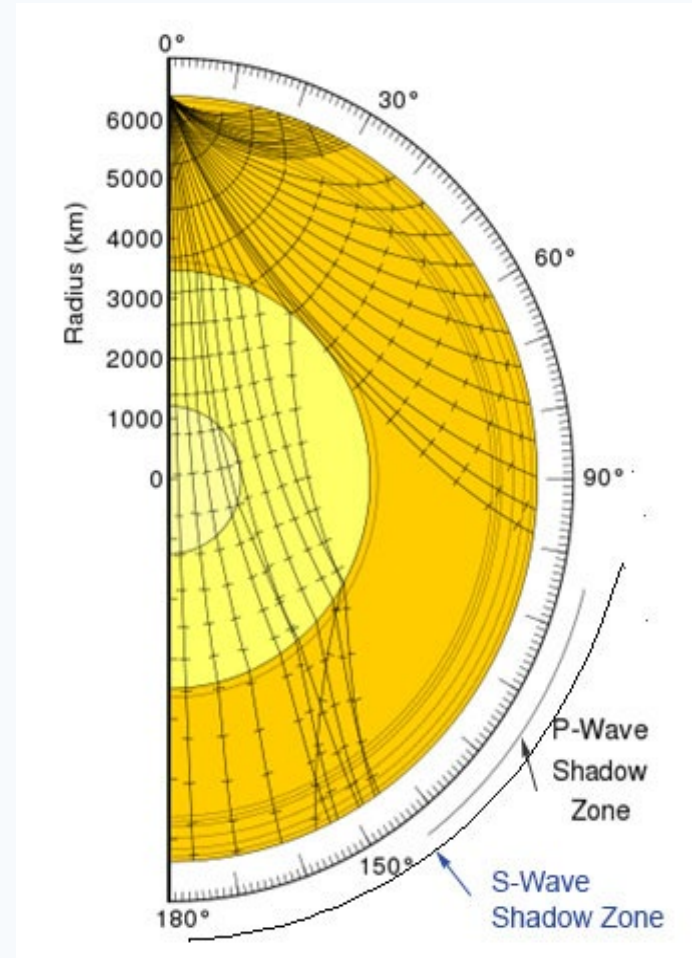


Figure 6. Shear and Pressure Waves (Wiki)

Figure 7. Shadow Zones adapted (Wiki)

Epicenter

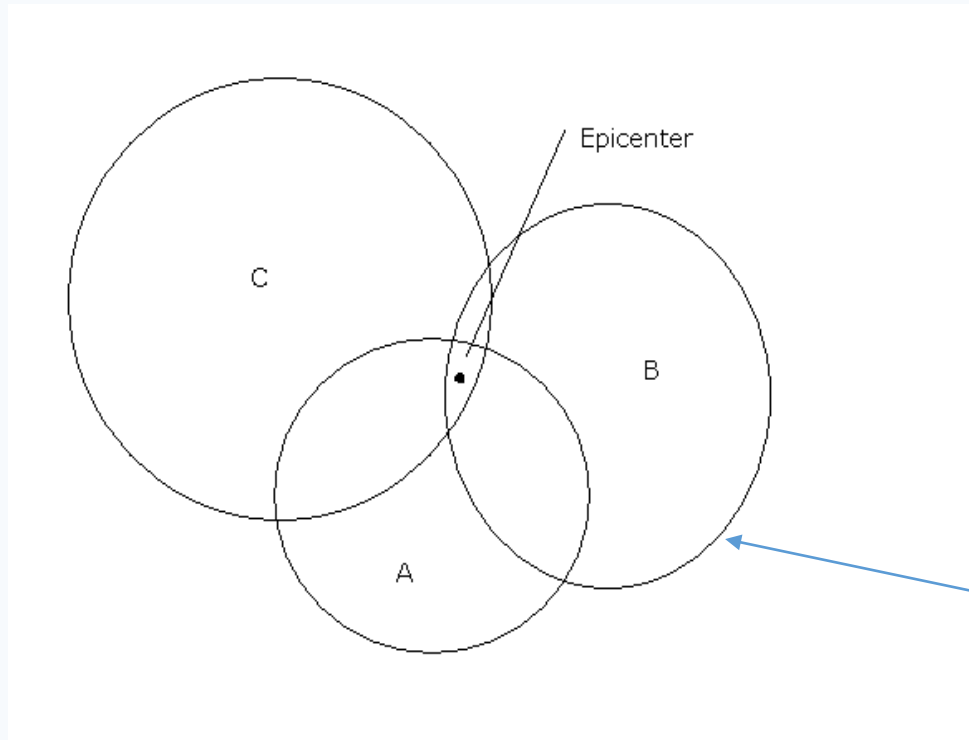
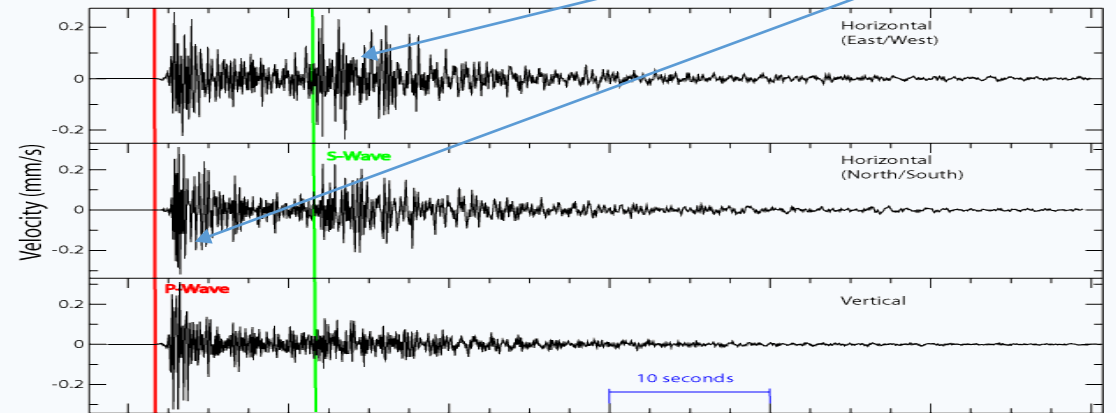


Figure 8. Triangulating the Epicenter

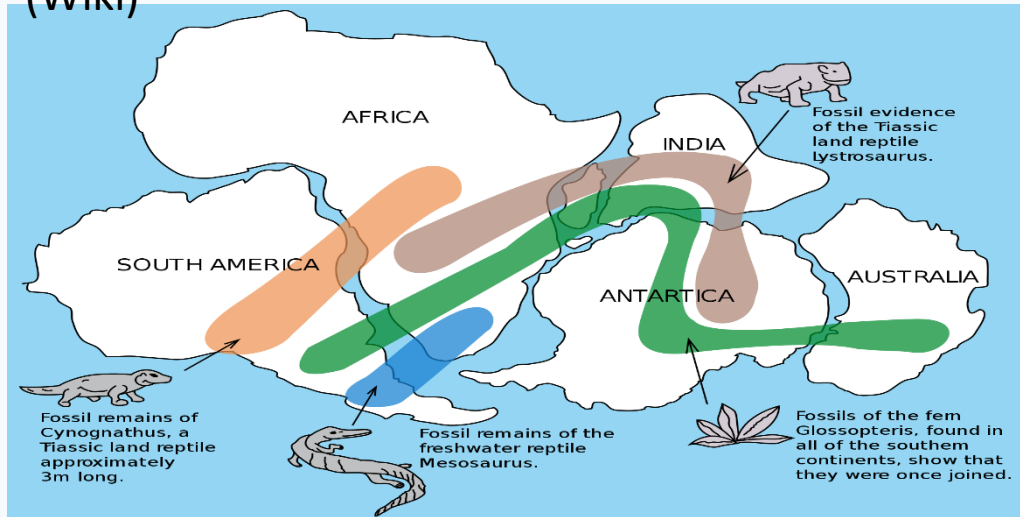
Figure 9. Seismogram showing the arrival of S and P Waves (Wiki)



The epicenter is the geographical location over the focus of the earthquake. The longer it takes for seismic waves to arrive a station; the further away the earthquake. We can triangulate the location of the epicenter using three seismographs.

Paleontology, Geology, and Physics led to...

Figure 9. Animal and Fossil Evidence for Plate Tectonics (Wiki)



Christian du Troit noted the existence of similar fossils and living fauna and flora on several continents. Over the following years geologists plotted the epicenters of earthquakes and Alfred Wegner measured magnetic fields of the crust under the oceans. All this evidence led to the idea the crust of the Earth consists of several plates, Plate Tectonics.

Figure 10. Earthquake Epicenters (Wiki)

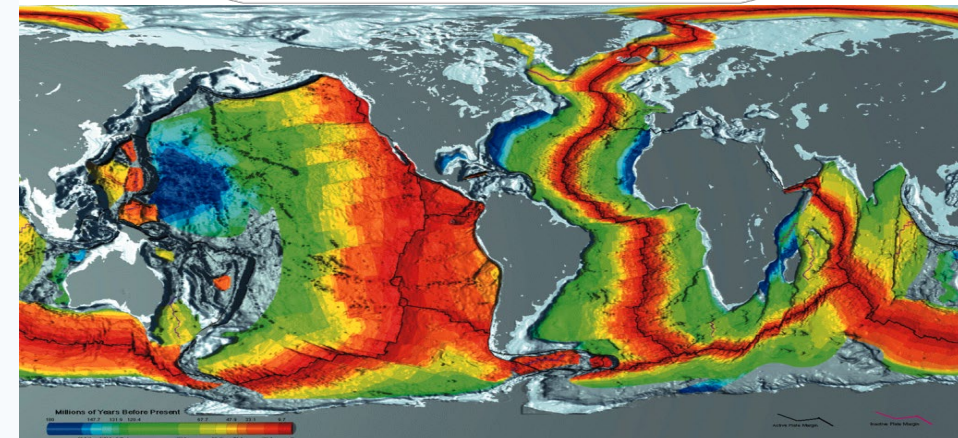
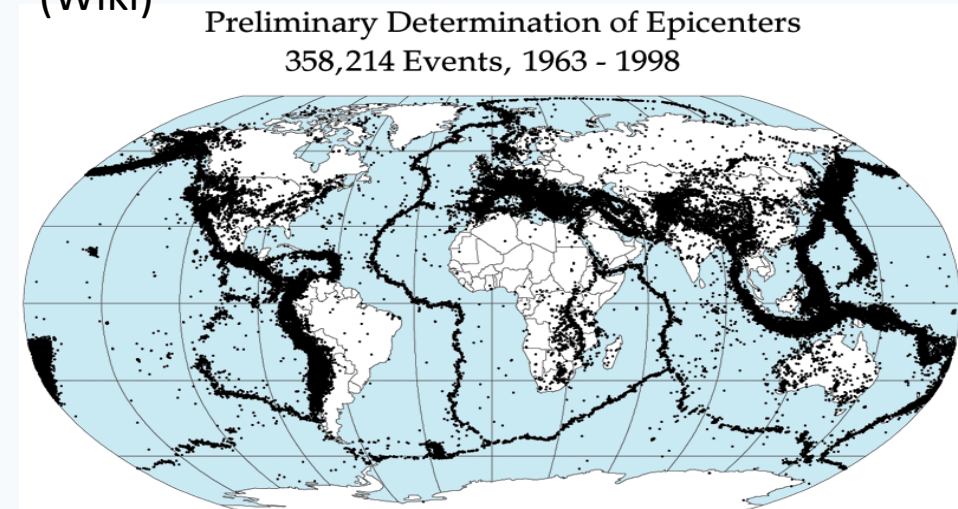


Figure 11. Earth's Oceanic Crust Magnetic Bands (Wiki)

Plate Tectonics

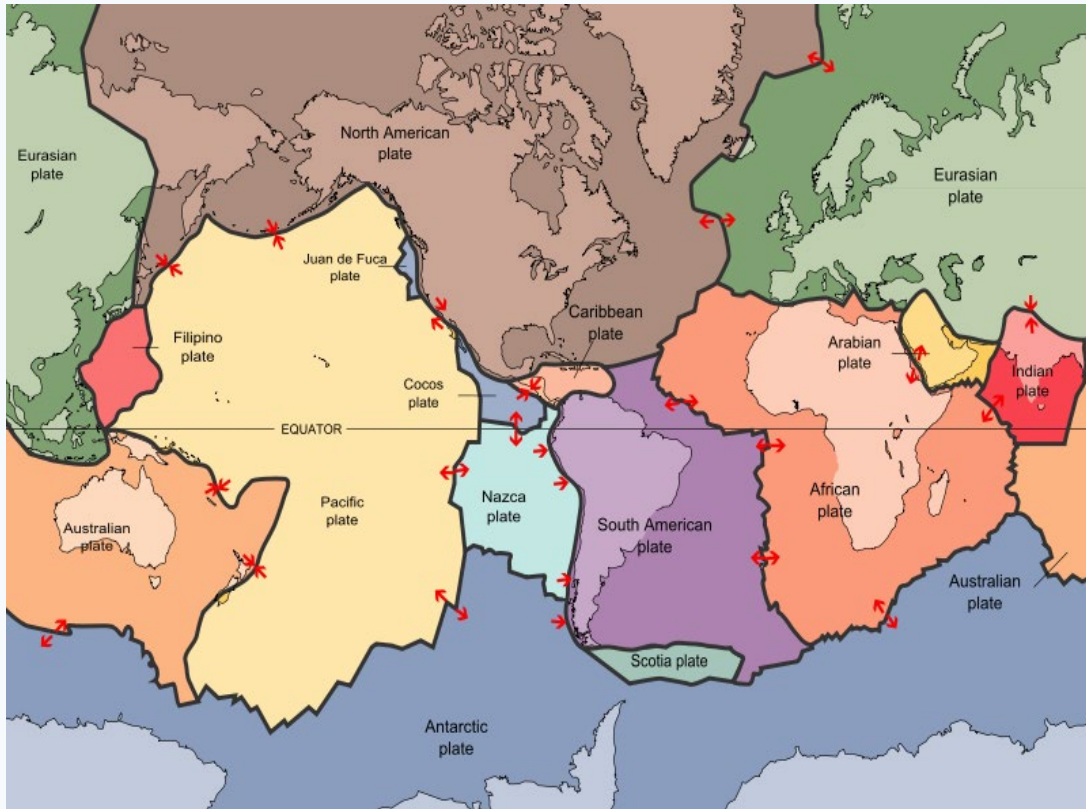


Figure 12. Earth's Crustal Plates (Wiki)

Plate Tectonics is the idea that when the Earth cooled it broke into a collect of plates that move due to convective motion of the mantle. The original continent was call Pangea.

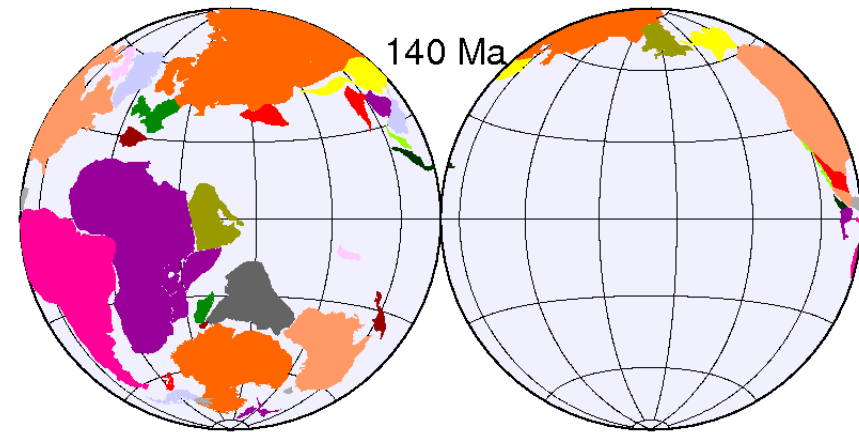


Figure 13. Plate Animation (Copley et al., 2012)

Plate Boundary - Faults

- The boundaries (or faults) between and inside plates come in three types; Divergent, Convergent, and Transform.
- Divergent faults are locations where material is created in the middle of plates.
- Convergent faults are locations where one plate is subducted under another plate.
- Transform plates are locations where one plate slides along another plate.

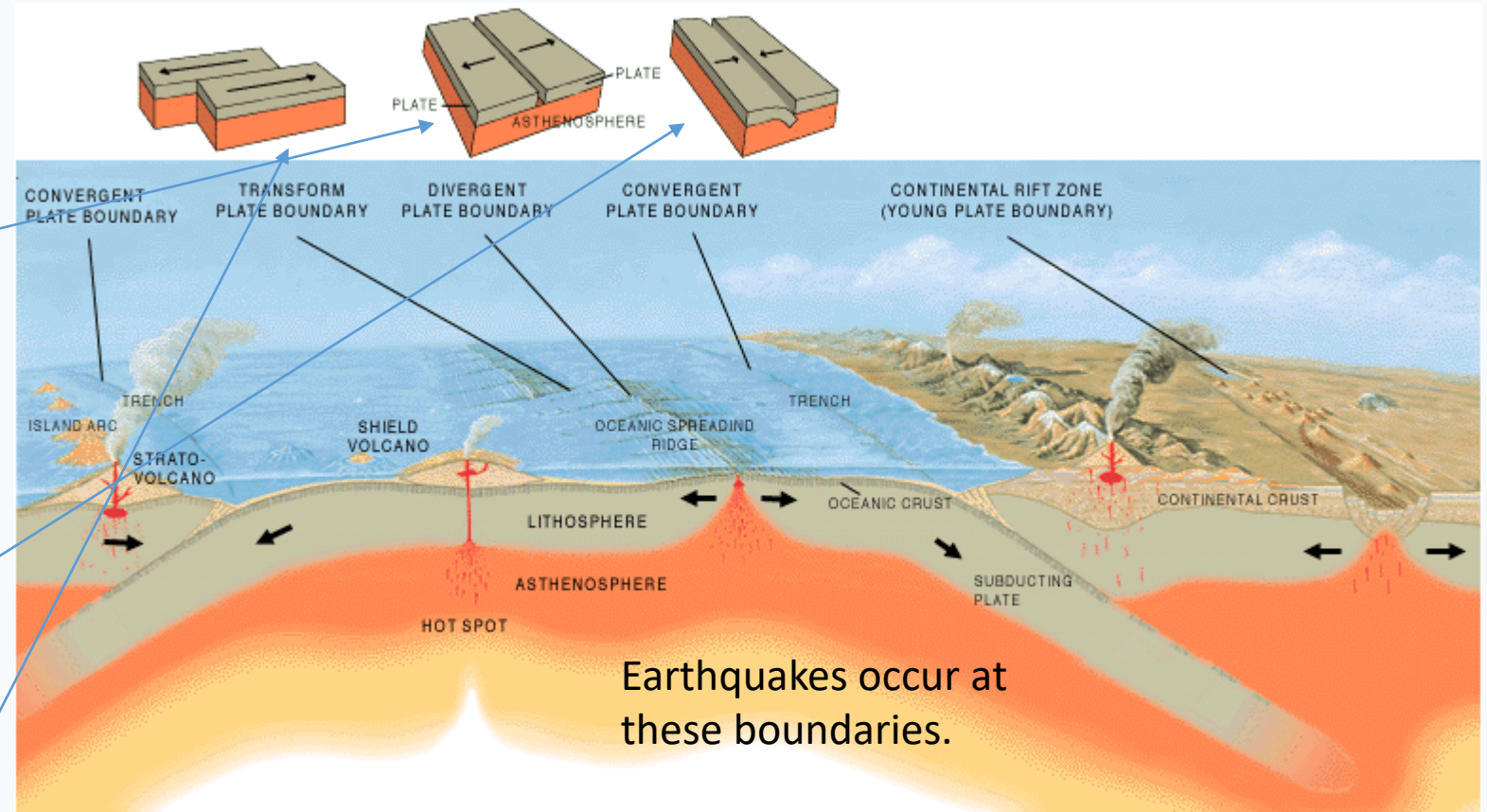


Figure 14. Earth's Crust and Faults (Wiki)

Impacts – When the Earth was Young and Hot



Figure 15. Barringer Crater (Wiki)

- When the Earth was forming, it was impacted several times by asteroids. One asteroid was the size of the Mars and helped to form the Moon
- Most of these early impacts were covered in lava from volcanoes. The craters we see are from impacts after the crust cooled.

Building Up the Crust – Plutonic Process

Volcanic Mountains – Mountains that are created due to magma originating from the mantle on plate boundaries and hot spots inside plates.

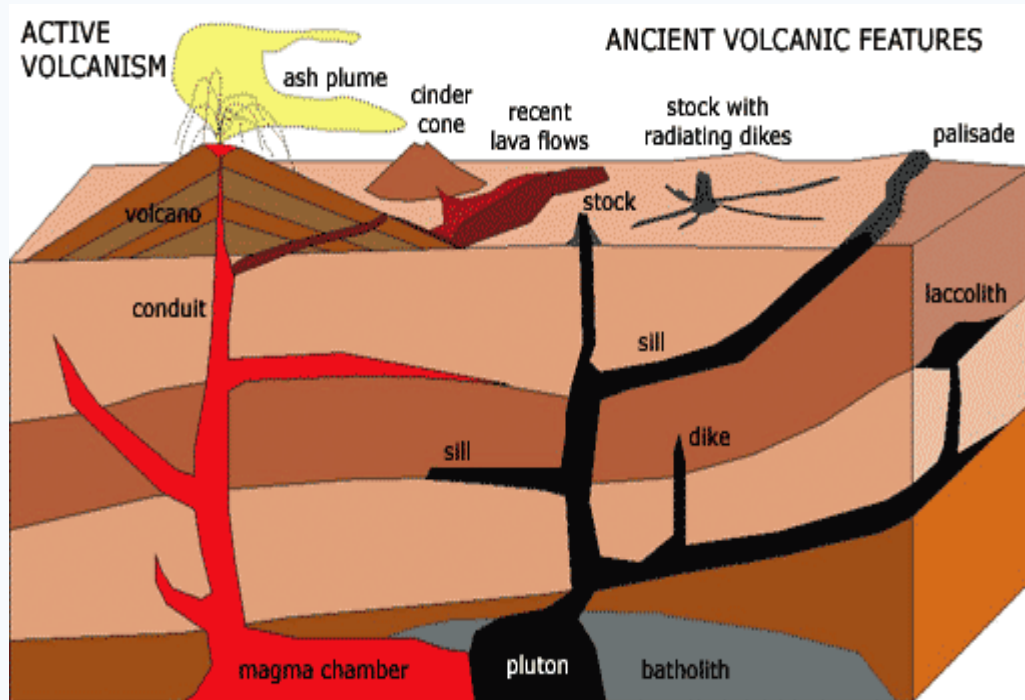


Figure 17. Volcanic Mountain Process (Wiki)

Folded/Faulted Mountains – Mountains that created due to stress and strain along convergent or transform faults.

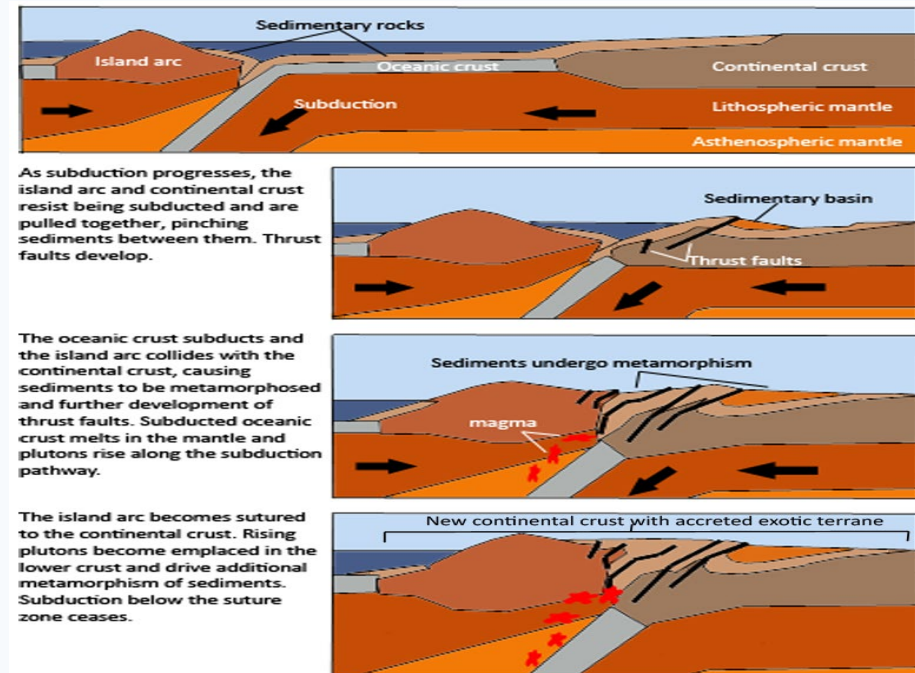


Figure 18. Folded/Faulted Mountain Process (Wiki)

Tearing Down the Crust – Weathering

Water Weathering: Erosion due to water in the both solid and liquid form. The material either is abraded due to movement of the ice and water or is dissolved into the ice or water.

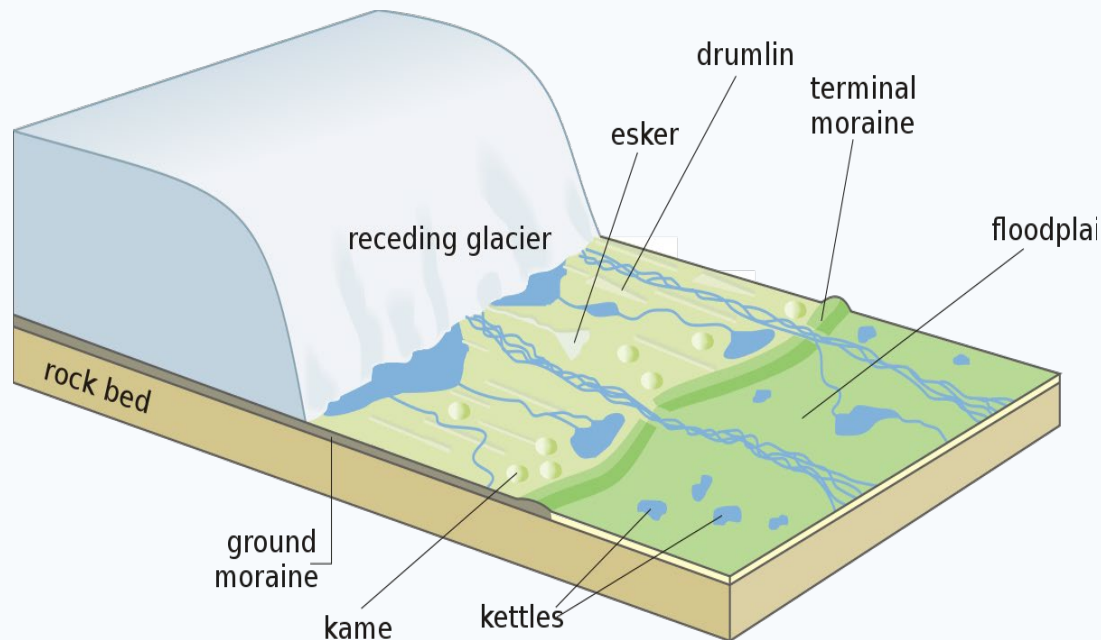
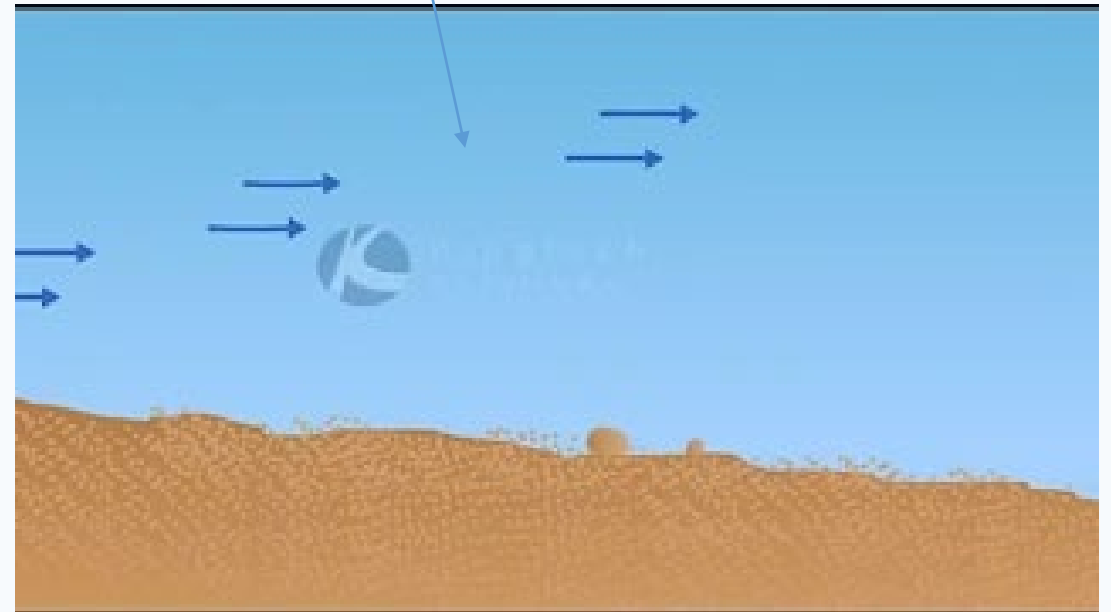
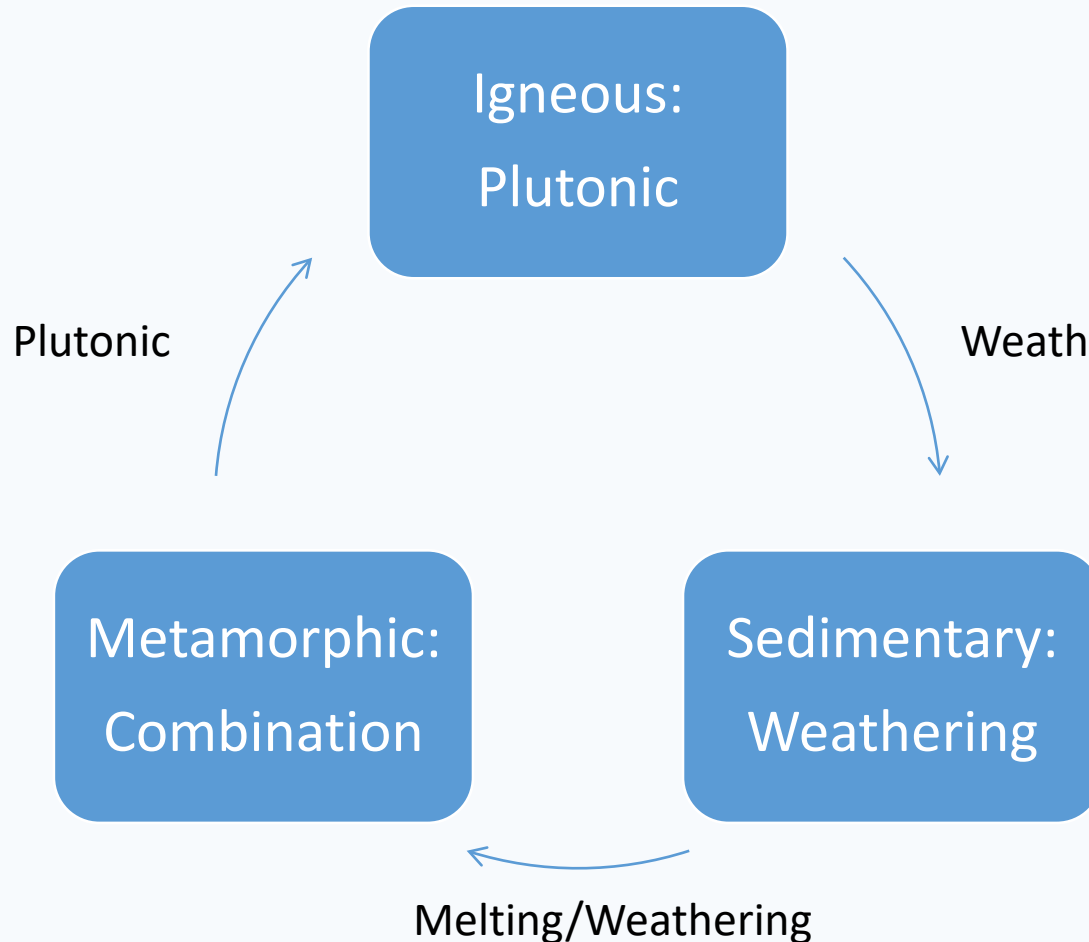


Figure 19. Water Erosion (Wiki)

Wind Weathering: Erosion due to wind. The material either abraded due to buffeting of the molecules of air or is dissolved into the gases comprising the air. Click on the image to see wind erosion in action.



Recycling the Material – The Rock Cycle



- The formation of the Earth igneous rocks.
- The Earth developed an atmosphere which eroded the crust creating sedimentary rocks.
- The crust broke apart into plates creating stress and strain on the rocks creating metamorphic rocks at the faults.
- These cycles continue today and keep recycling the rocks.

Figure 20. Rock Cycle (Wiki)

The Atmospheric System

- Composition
 - 78% Nitrogen
 - 21% Oxygen
 - 1% Argon
 - 0.3% Other
- The Earth is warmed by the Sun and that heat is maintained by the elements in our atmosphere by the Greenhouse Process.
- We have observed that the temperature changes as you ascend into our atmosphere. Where that changes quickly, we observe another layer.

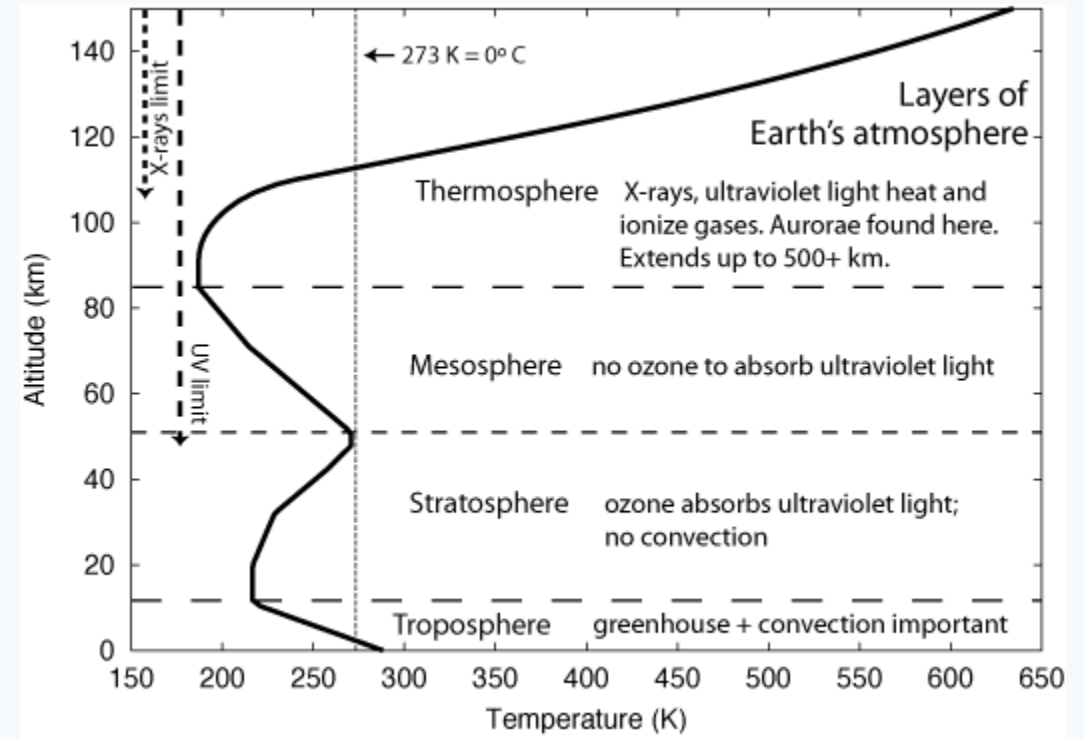


Figure 21. Earth's Atmospheric Profile (Strobel, 2014)

Recycling the Air - Hydrological Cycle

- Evaporation from the Earth's oceans
- Transportation of vapor over land
- Condensation on the land
- Return of water via streams and rivers

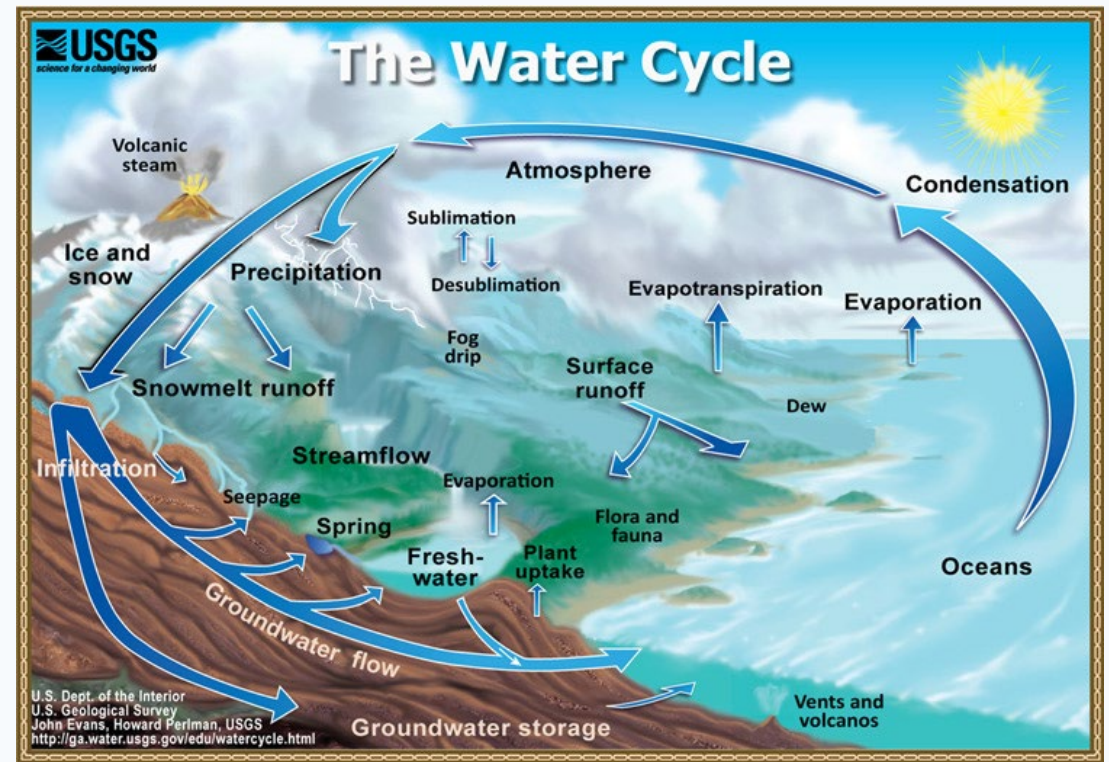


Figure 22. Water Cycle (Wiki)

Water in the Atmosphere

- Our atmosphere contains water. The amount of water it can hold is called absolute humidity. If the amount of water the atmosphere actually holds (relative humidity) approaches the absolute humidity, condensation nuclei form in the air.
- The condensation nuclei form different sizes of clouds depending on the pressure, volume, and temperature of the air.
- When a collection of these clouds form and move due to air pressure they are called a front and create weather.

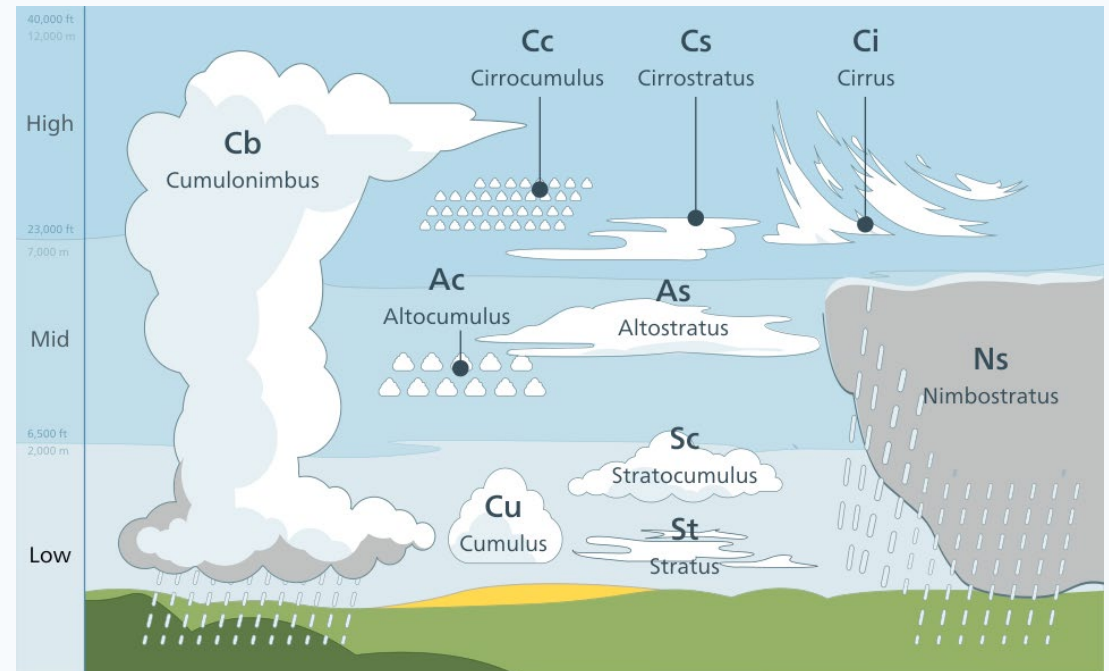


Figure 23. Types of Clouds (Wiki)

Weather - Fronts



Climate

- General pattern of weather in a particular area due to the rotation and heating of the Earth
 - High latitudes: polar
 - Middle latitudes: temperate
 - Low latitudes: tropical
- Marine climates are near the water. Continental are in-land.
- Humid climates have more than 180 days of rain. Semi-arid climates have between 179 – 75 days of rain while arid climates have less than 75 days of rain.

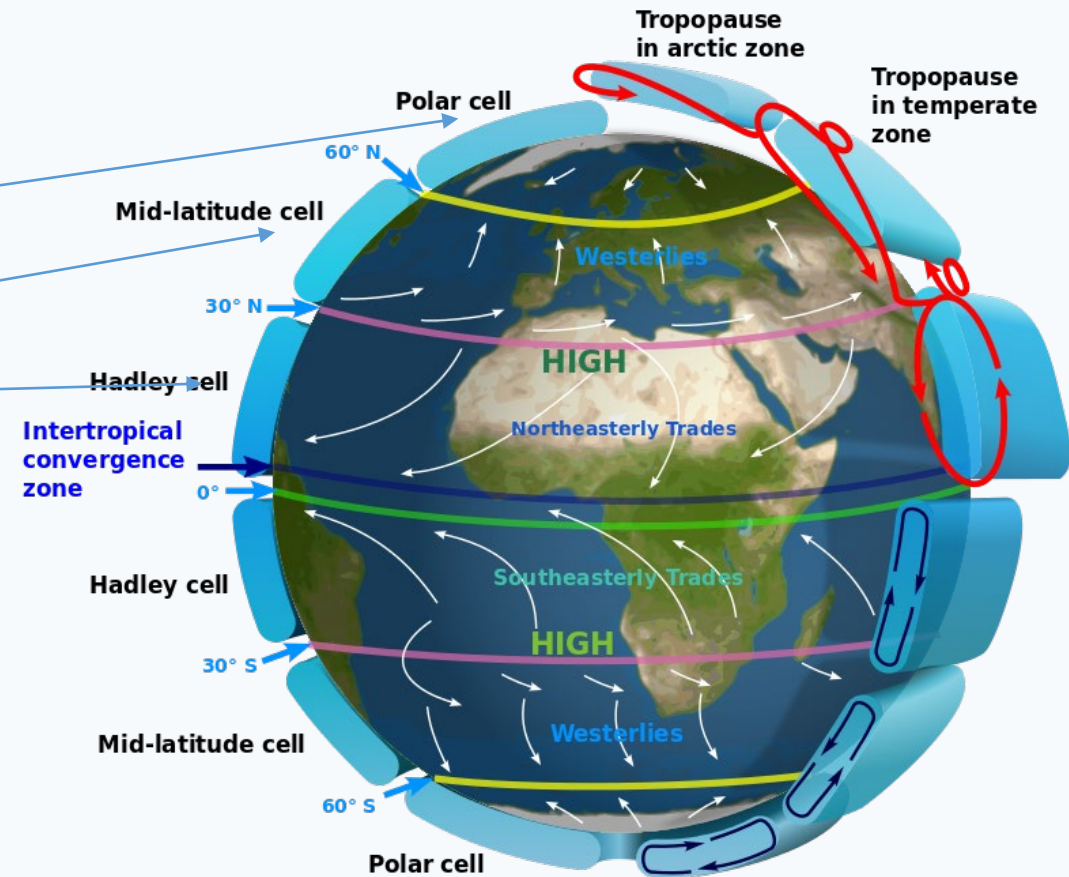


Figure 23. Earth's Global Winds (Wiki)

The Ecosystem

- Once the Earth cooled from its formation certain elements came together and formed amino acids. These amino acids formed the basis Deoxyribonucleic acid (DNA).
- It is unknown on how DNA expressed itself into living single cell creatures; but the process happened many times with cycles of creating and extinctions until 3 billion years ago. At this time, life finally took a foothold until the present time.

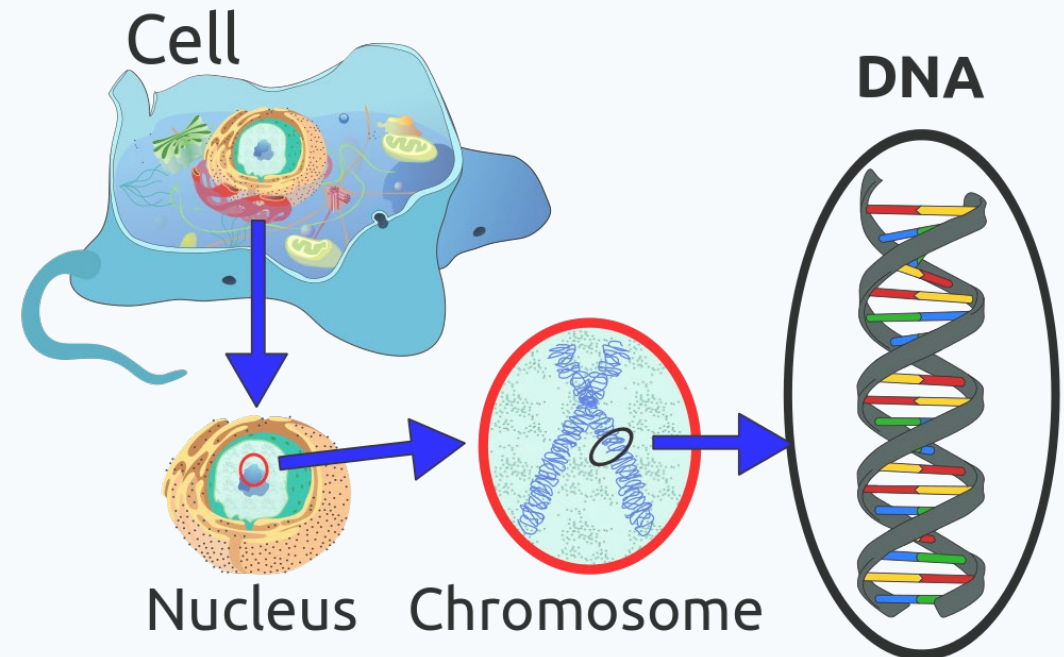


Figure 24. DNA as Nuclear Material for Cells (Wiki)

Evolution and Biodiversity

- As noted by the naturalist Charles Darwin, certain traits in populations of animals were propagated by the species due to environmental conditions and group dynamic pressures. These changed if either one of these changed; the survival of the most adaptable.
- This showed how different creatures evolved into other creatures leading to the biodiversity we see today in the world.
- The different creatures depend on each other in biospheres, a combinations of animals and climate.

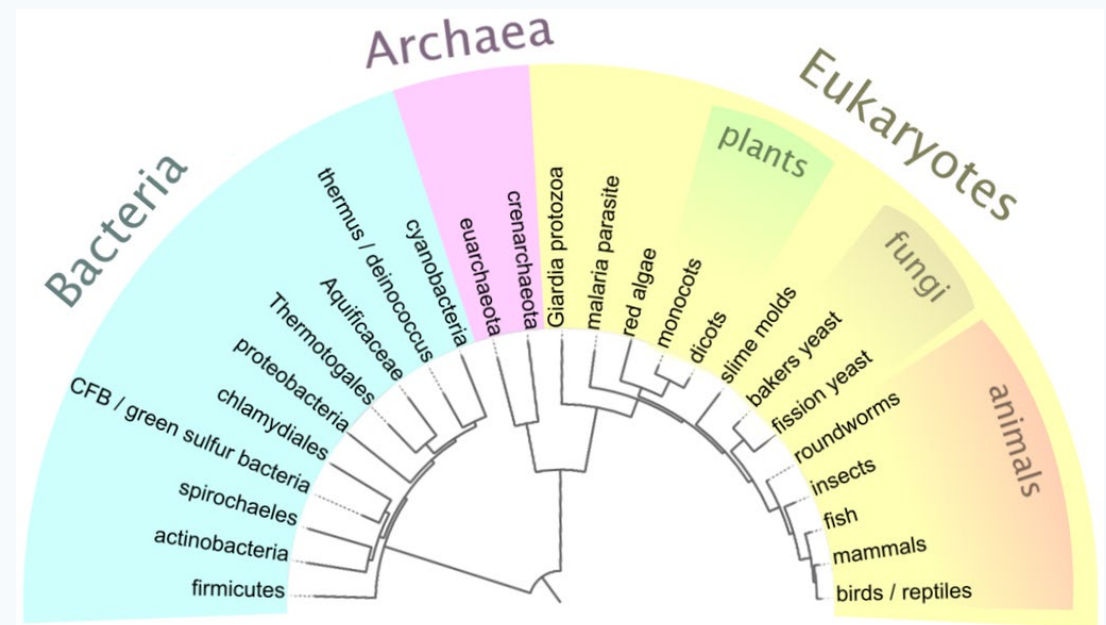


Figure 25. Animal Classification Tree (Wiki)

Recycling the Nutrients - Biospheres

- Living creature evolved to be interdependent. They formed food webs depending on the creatures present and climate.
- The primary step are flora; plants are the producers in the environment as they absorb the Sun's light and create plant material to feed the primary consumers.
- The secondary step are fauna; animals feed on the plants and other animals to survive.
- The final step are the decomposers; the bacteria and fungi return the nutrients and moisture to the environment.

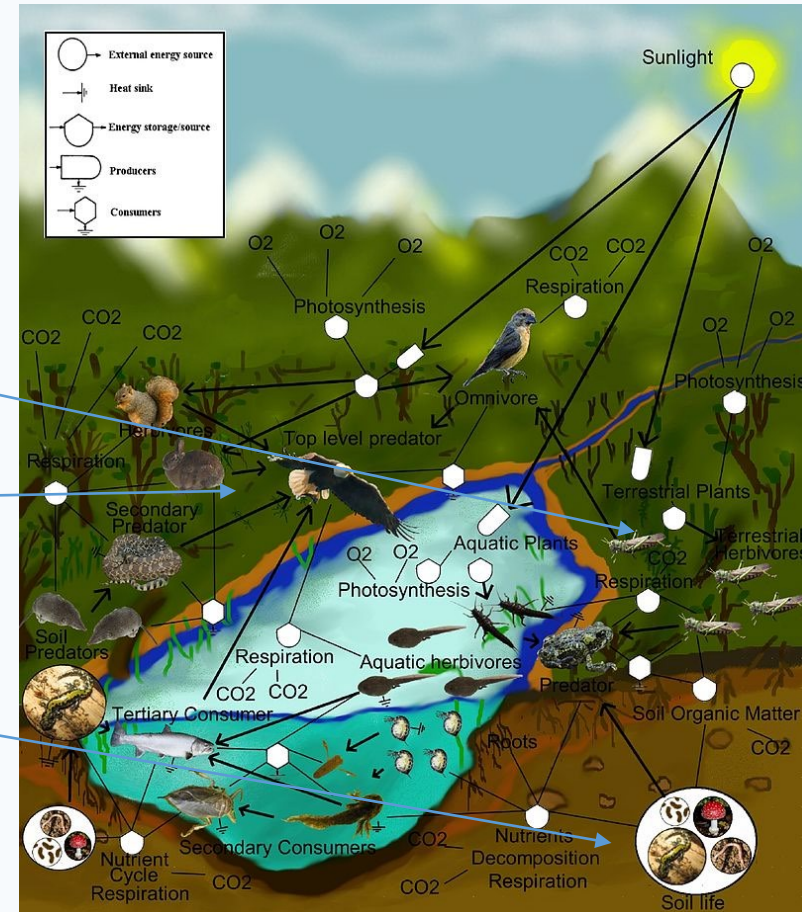


Figure 26. Marine Biosphere (Wiki)

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