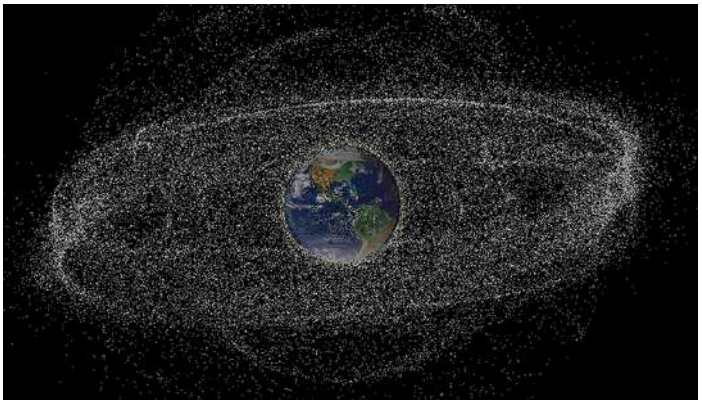
Habitable Earth: Hadean to the Archean

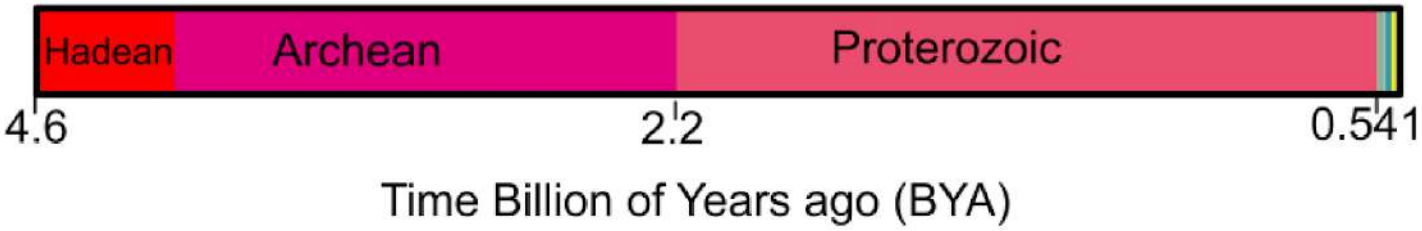
[Click Here for a Video Introduction](#) **-Answer to #1 and hints to get started**

Learning Goal: Study the major events of the Hadean and Archean eons in Earth's early history. Events from this time formed a stable Earth, habitable for life to evolve and change over time.

Word of the Day:

Exosphere-Anything related to space that affects the earth. Examples: Meteorites, comets





Part 1: Bombardment, Outgassing and Earth's Layers forming 4.5-3.8 BYA

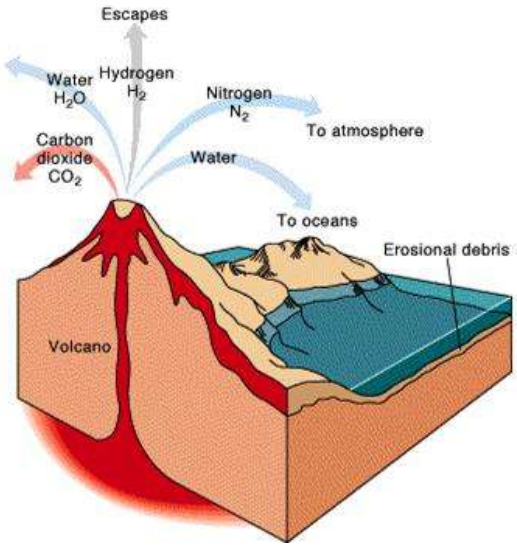
At first, Earth did not have an atmosphere, free water, or a solid crust since the planet was too hot for gases and water to collect and the liquid rock to cool. The atmosphere, oceans, continents that we see today evolved over time.

Earth's early atmosphere was made of hydrogen and helium (_____), this first atmosphere did not last very long for two reasons. First, Hydrogen and Helium are very light elements and Earth's gravity(_____) was not strong enough to keep these gases close to Earth. Second, Earth did not have any protection from solar winds (_____) which pushed the hydrogen and helium out into space.

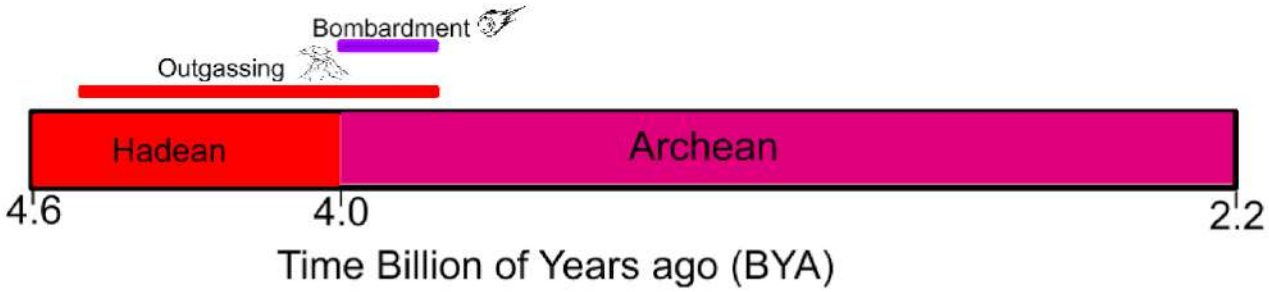
1. Make a chain for the above paragraph, write your answer below

Watch this video “How did the Earth Get its Water?”

Eventually, things started to settle down and gases began to collect. High heat in Earth’s early days meant that there were constant volcanic eruptions(_____), which released gases into the atmosphere. Just as today, volcanic **outgassing** was a source of water vapor, carbon dioxide, small amounts of nitrogen, and other gases(_____). Most outgassing occurred between 4.5 and 3.8 Billion Years ago.



2. Make a chain for the above paragraph, write your answer below.



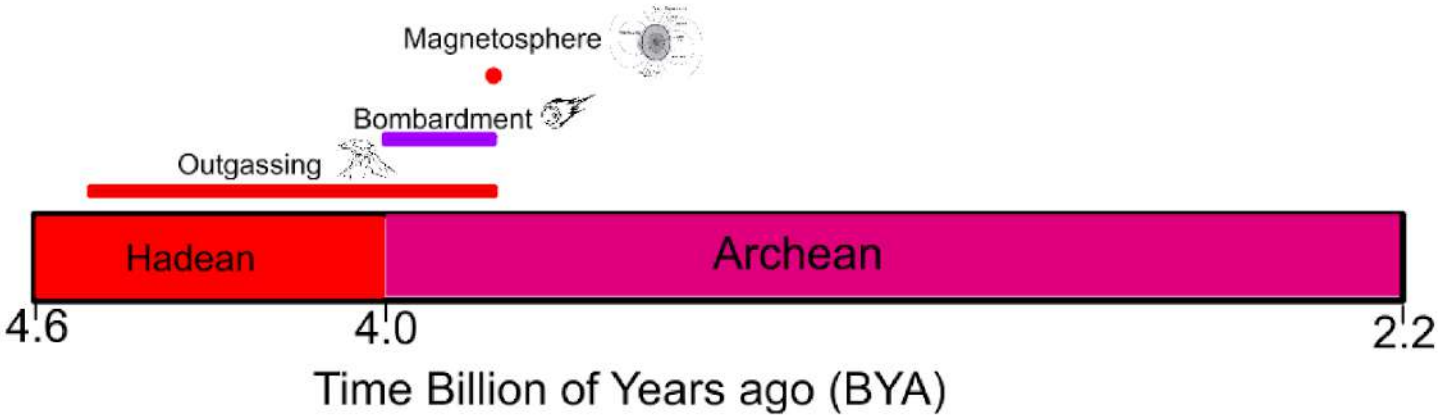
Scientists have calculated that the amount of gas that collected to form the early atmosphere could not have come entirely from volcanic eruptions. In an event known as the late heavy bombardment between 4-3.8 Billion Years Ago frequent impacts by asteroids and comets brought in gases and ices, including water, carbon dioxide, methane, ammonia, nitrogen, and other gases from elsewhere in the solar system. Analysis of Halley's comet, a comet that passes near earth in the 1980s, found that a comet is made of 80% water and the rest made up of Carbon dioxide ice, also called dry Ice.

Calculations also show that asteroids and comets cannot be responsible for all of the gases of the early atmosphere, so both impacts and outgassing was needed to bring the gases, including water, for Earth's atmosphere.

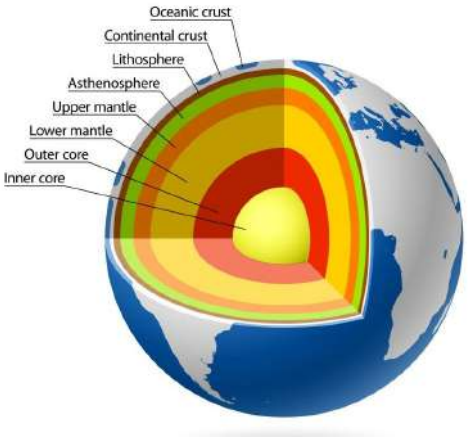
3. Make a chain for the above paragraph, write your answer below

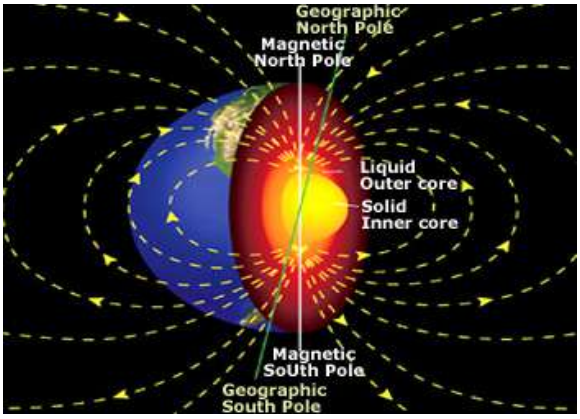
a. What are the "spheres" involved?
b. What are the main steps (what happened first, second, third…..)
c. Make your chain as you did in #1 and #2.

Watch this video “Why Does the Earth Have Layers?”-You saw this one already in unit 8



Volcanic activity during the outgassing phase occurred because the Earth’s layers were forming in a process called **differentiation.** After several million years, the Earth separated into several layers. Iron, nickel and other heavy metals mostly settled to the core; lighter elements remained in the mantle around the core. The lightest elements, such as oxygen and silicon, floated to the top and cooled, forming a solid crust.



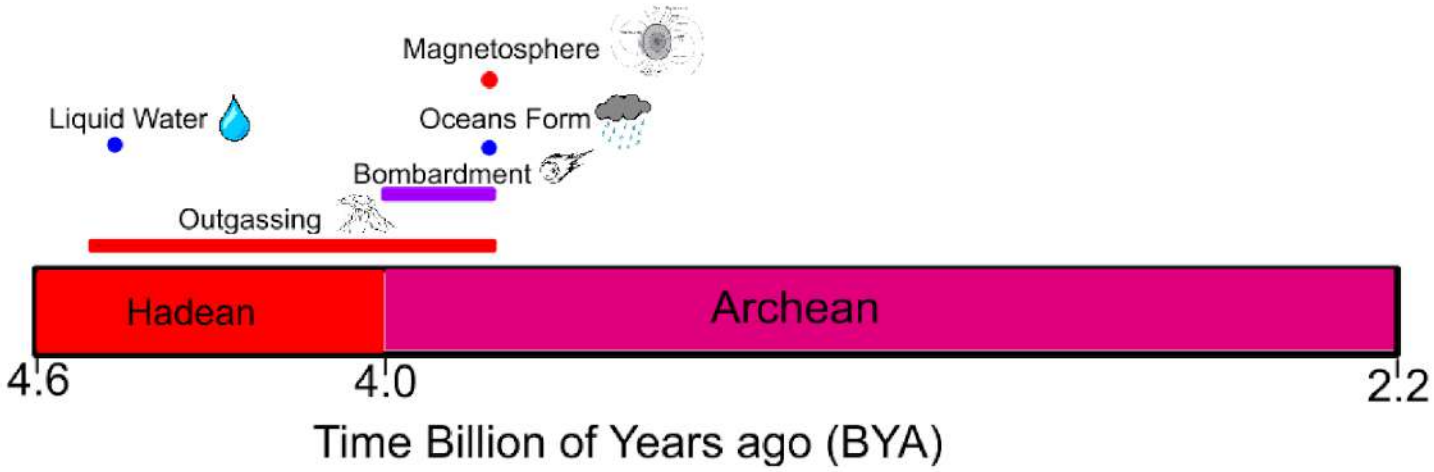


The combination of Earth’s solid inner core and the liquid outer core creates the Earth’s magnetic field. Like a simple bar magnet, Earth has a magnetic field with North and South poles. Unlike a bar magnet, though, Earth’s magnetic field is thought to be generated by a magnetic dynamo. A **magnetic dynamo** is a mechanism that transforms energy from fluid motions in the Earth’s outer core (conventions) into an electrical current that creates a magnetic field. In a dynamo, the convecting fluid (liquid iron, in Earth’s case) must be a conductor of electricity. The creation of the Earth’s magnetosphere created a protective shield around the Earth from solar winds. Solar winds are able to push the atmosphere away from Earth and are harmful to life. With the magnetosphere shield in place, Earth is one step closer to being safe and protected for life in order for life to flourish on Earth.

4. Make a chain for the above paragraphs, write your answer below. Use the steps in #3 to help you make the chain.

Part 2: The Hydrosphere

Watch this video “Earth the Biography: Oceans | National Geographi

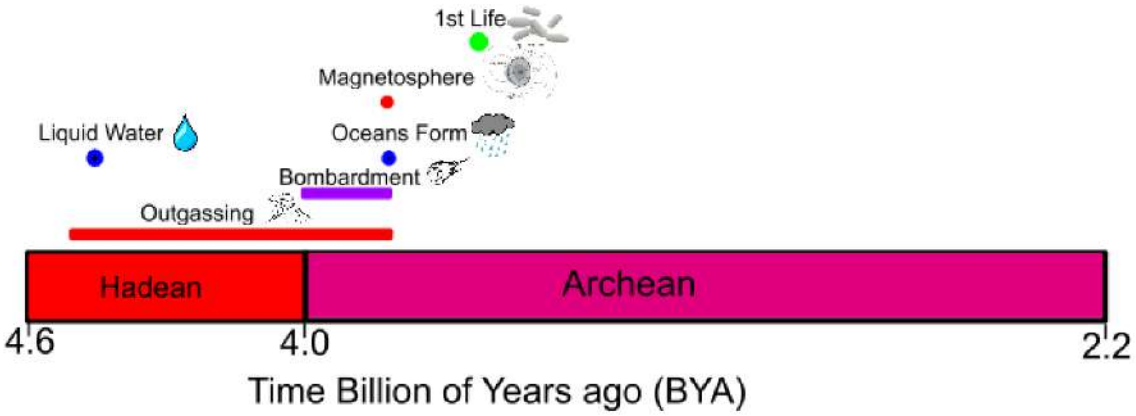


The early atmosphere was rich in water vapor from volcanic eruptions and comets. When Earth was cool enough, water vapor condensed and **rain began to fall**; the water cycle began. At first, the Earth was still too hot for liquid water to stay for very long and evaporated again into the atmosphere. Some evidence suggests that liquid water is found on Earth as early as 4.2 or 4.3 BYA. Over millions of years, enough precipitation collected that the **first oceans could have formed,** by 3.8 BYA the planet had its oceans. Sedimentary rocks formed in oceans can be dated back to about 4 billion years providing evidence for when oceans covered the Earth.

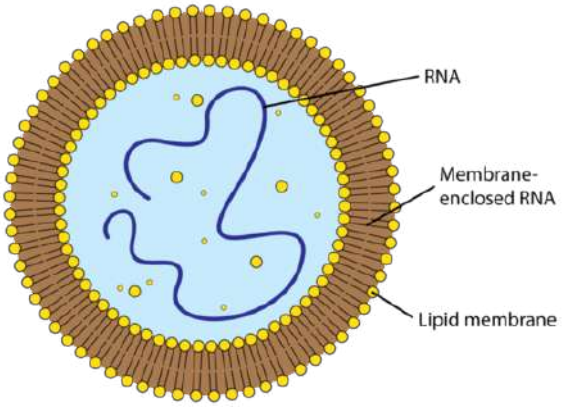
5. Make a chain for the above paragraphs, write your answer below

Part 3: The Biosphere and Its Effects

Watch How did life begin?

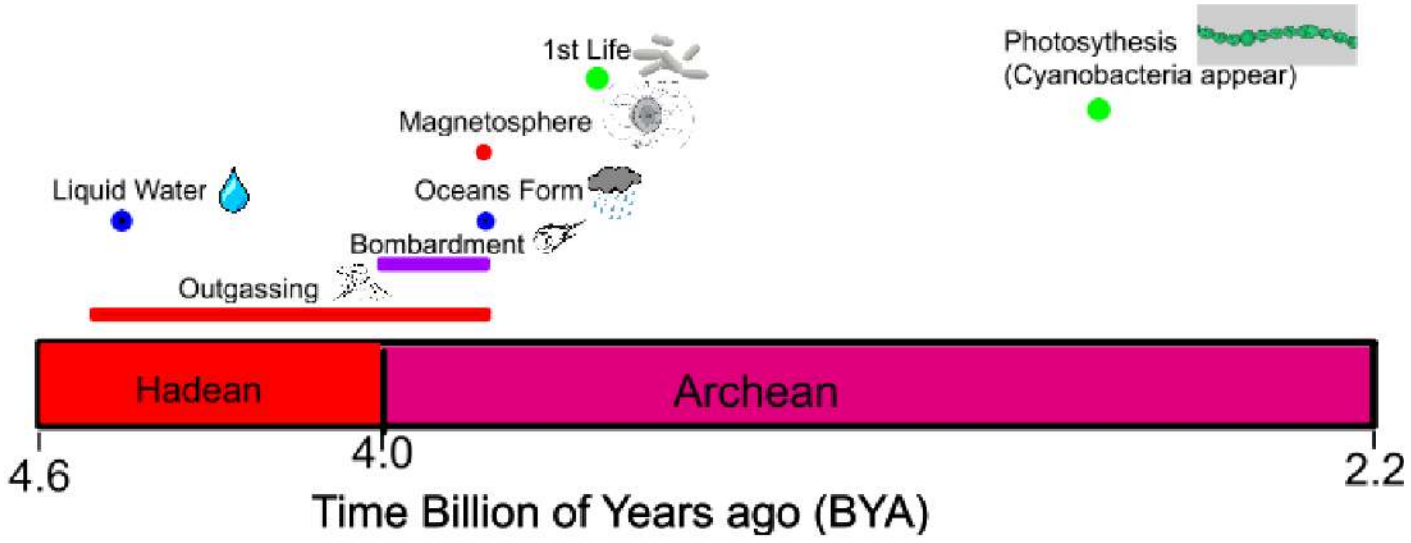


By the Archean, the planet was covered with oceans and the atmosphere was full of water vapor, carbon dioxide, nitrogen, and smaller amounts of other gases from outgassing and bombardment. The atmosphere did not have oxygen. The Earth has cooled, and layers of the Earth including the core makes our first shield, the magnetosphere, is in place. The environment is habitable. The first living thing on Earth evolved 3.5 Billion Years Ago. The first cells were most likely primitive prokaryotic-like cells, even more simplistic than bacteria. These cells were probably simplistic RNA, surrounded by a membrane. All living things need a source of energy and the first living thing was most likely a chemotroph. Earth's early oceans, volcanoes, now under the Earth's Ocean, are spewing out gases perfect for a chemotroph to use for energy.



6. Make a chain for the above paragraphs, write your answer below.

Watch What are Stromatolites?

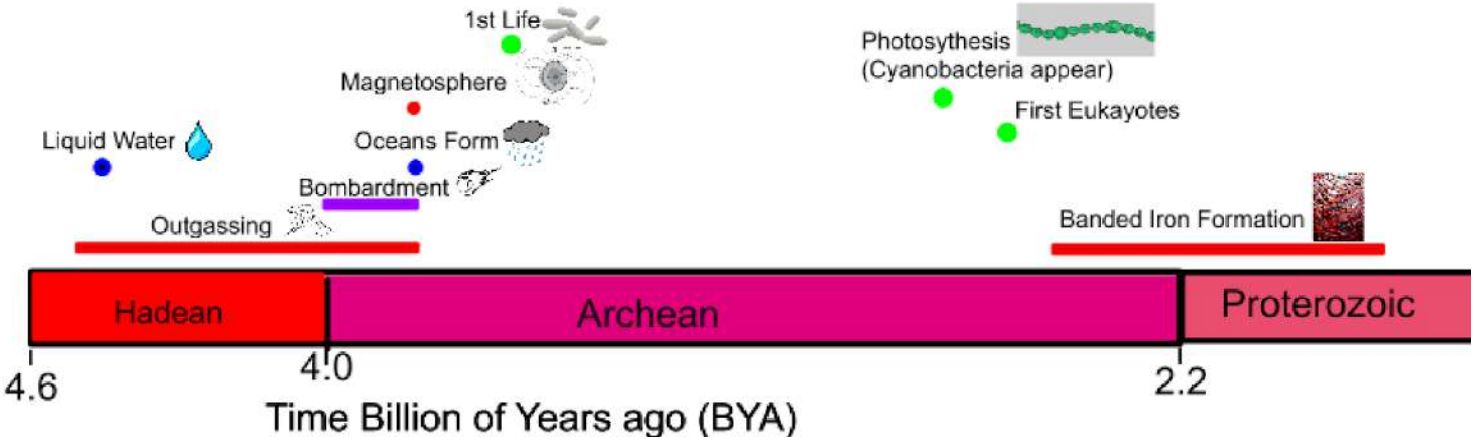


Over time, as other organic compounds such as DNA and proteins developed, cells evolved more complex structures. By about 2.7 billion years ago, a new way of obtaining energy evolved. This new way was photosynthesis. Through photosynthesis, organisms could use sunlight to make food from carbon dioxide and water. A byproduct of photosynthesis is oxygen. When photosynthesis evolved, all of the sudden oxygen was added in large amounts in the atmosphere and oceans.

These organisms were the first autotrophs, they got their energy from the sun. They provided food for themselves and for other organisms that began to consume them. Evidence for the first photosynthesizing organism is found in fossilized stromatolites. Stromatolites are shallow-water organisms made from cyanobacteria, a primitive photosynthesizing cell.

7. Make a chain for the above paragraphs, write your answer below.

Watch [How Banded Iron Was Formed]



The oceans at this point in time had large amounts of iron from weathering and erosion of the early continents. These iron-rich oceans changed when the oxygen produced from the photosynthesizing cyanobacteria bonded with the oxygen. The oxygen combined with the iron making iron-oxide, seen as a reddish layer in sedimentary rocks formed from this time. These rock formations called **The banded-iron formations (BIFs)**, formed as early as 2.5 billion years ago and continued to form until 1.8 billion years ago. The BIF's stopped forming once all the iron in the ocean bonded with the oxygen. Now that most of the iron is bonded with the oxygen the levels of oxygen went up in both the atmosphere and ocean.

Banded Iron formations are important for the mining towns of Northern Minnesota called the Iron Range. Northern Minnesota such as Hibbing built around the mining of the iron. The iron ore that was then shipped off to the industrial cities of Detroit, Michigan, and Gary, Indiana whose industries are dependent on the iron ore from Northern Minnesota.

8. Make a chain for the above paragraphs, write your answer below.

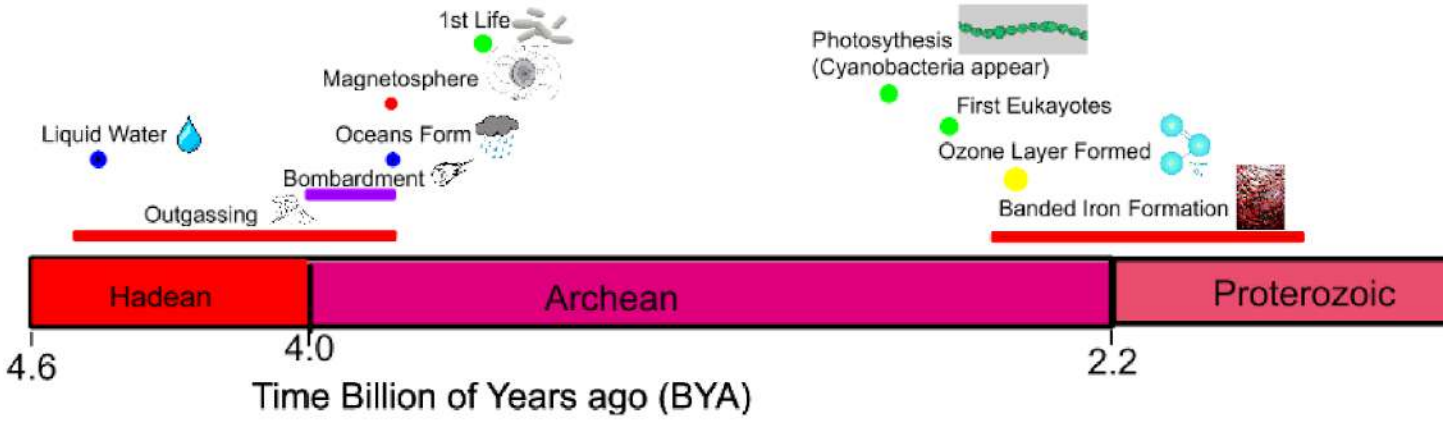
Watch The Time Oxygen Almost Killed Everything

After photosynthesis evolved and oxygen started to accumulate in the atmosphere a major shift in atmospheric gases occurred. This has been dubbed the “oxygen catastrophe.” Oxygen was toxic to most early cells because they had evolved in its absence. The first cells were anaerobic and are were killed by the increased oxygen in the atmosphere. As a result, many of them died. although entire species died out and went **extinct** during the oxygen catastrophe/Great oxidation event, it was a great opportunity for aerobic bacteria. The organisms that survived developed a use for oxygen through cellular respiration, the process by which cells can obtain energy from organic molecules 2.4 BYA

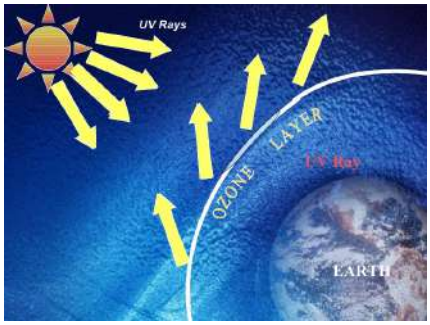
These where aerobic organisms that use oxygen to obtain energy from organic molecules much like how animals get energy from food.

9. Make a chain for the above paragraphs, write your answer below.

Watch What is the Ozone Layer?

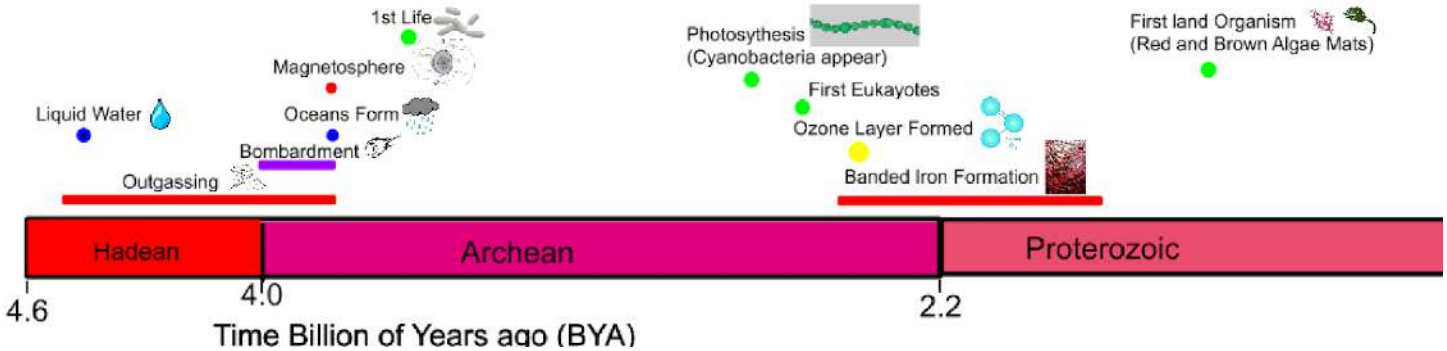


Oxygen produced from photosynthesis organisms continued to collect in the atmosphere and for life to expand on earth, oxygen in the atmosphere was needed. Oxygen is also needed to make ozone, a molecule made of three oxygen atoms, O_3. Ozone collects in the atmosphere and blocks harmful ultraviolet radiation from the Sun. Without an ozone layer, life in the early Earth was almost impossible. The ozone layer was complete about 2 Billion Years Ago. With Earth’s second shield, the ozone layer, life is protected, and living things can continue to evolve in both size and location.



10. Make a chain for the above paragraphs, write your answer below.

Part 4: Habitable Earth ready for complex life and life out of the water



Once all the oxygen bonded with the iron in the oceans making the Banded Iron Formations, Oxygen was able to accumulate in the atmosphere. Evidence found in rocks and fossils confirms that there was virtually no oxygen dissolved in the oceans until about 2 billion years ago. The oceans have only been oxygen-rich starting around 1.8 billion years ago. For eukaryotes to thrive, oxygen has to be present in the atmosphere in higher amounts than existed on early Earth. The more advanced the eukaryote (such as multicellular plants and animals), the more oxygen is required. Scientists believe that low levels of oxygen in Earth's early atmosphere is the major reason that it took so long for eukaryotes to evolve and also why they barely eked out an existence for so much of Earth's history, while their prolific prokaryotic cousins thrived.

11. Make a chain for the above paragraphs, write your answer below.