Origin of Ocean

Course: Earth System Science
Programme: Five Year Integrated M.Sc., Geography

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Origin of Ocean

The Earth called the “Blue Planet”?

This term makes sense, because over 70% of the surface of the Earth is covered with water. The vast majority of that water (97.2%) is in the oceans. Without all that water, our world would be a different place.

The oceans are an important part of Earth: they help to determine the make-up of the air, they help determine the weather and temperature, and they support great amounts of life.

The composition of ocean water is unique to its location and depth. Just as Earth’s interior is divided into layers, the ocean separated into different layers, called the water column

How the Oceans Formed ?

Scientists have developed a number of hypotheses about how the oceans formed. Though these hypotheses have changed over time, one idea now has the wide support of Earth scientists, called the volcanic outgassing theory.

This means that water vapor given off by volcanoes erupting over millions or billions of years, cooled and condensed to form Earth's oceans

Creation and Collection of Water

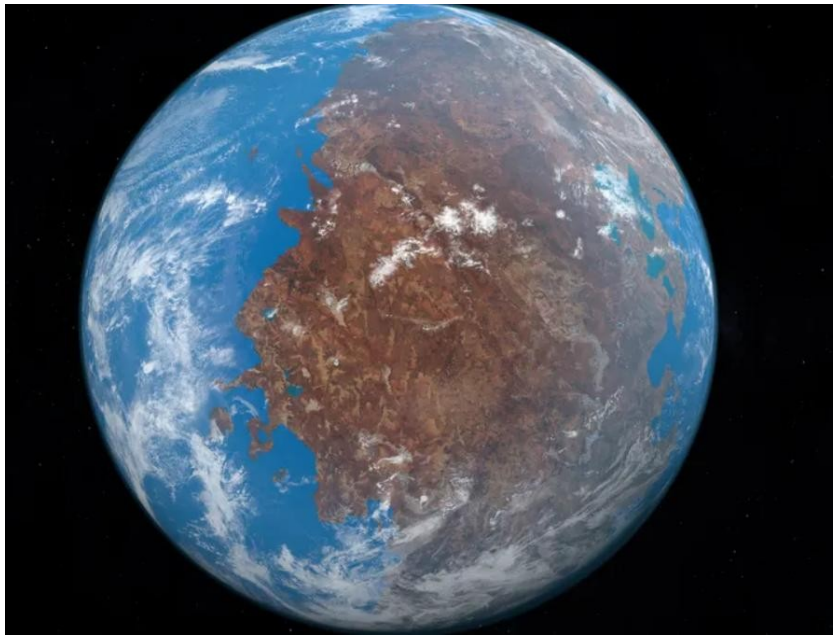
When the Earth was formed 4.5 billion years ago, it would never have been called the Blue Planet. There were no oceans, there was no oxygen in the atmosphere, and no life. But there were violent collisions, explosions, and eruptions.

In fact, the Earth in its earliest stage was molten. This allowed elements to separate into layers within the Earth — gravity pulled denser elements toward the Earth's center, while less dense materials accumulated near the surface. This process of separation created the layers of the Earth as we know them.

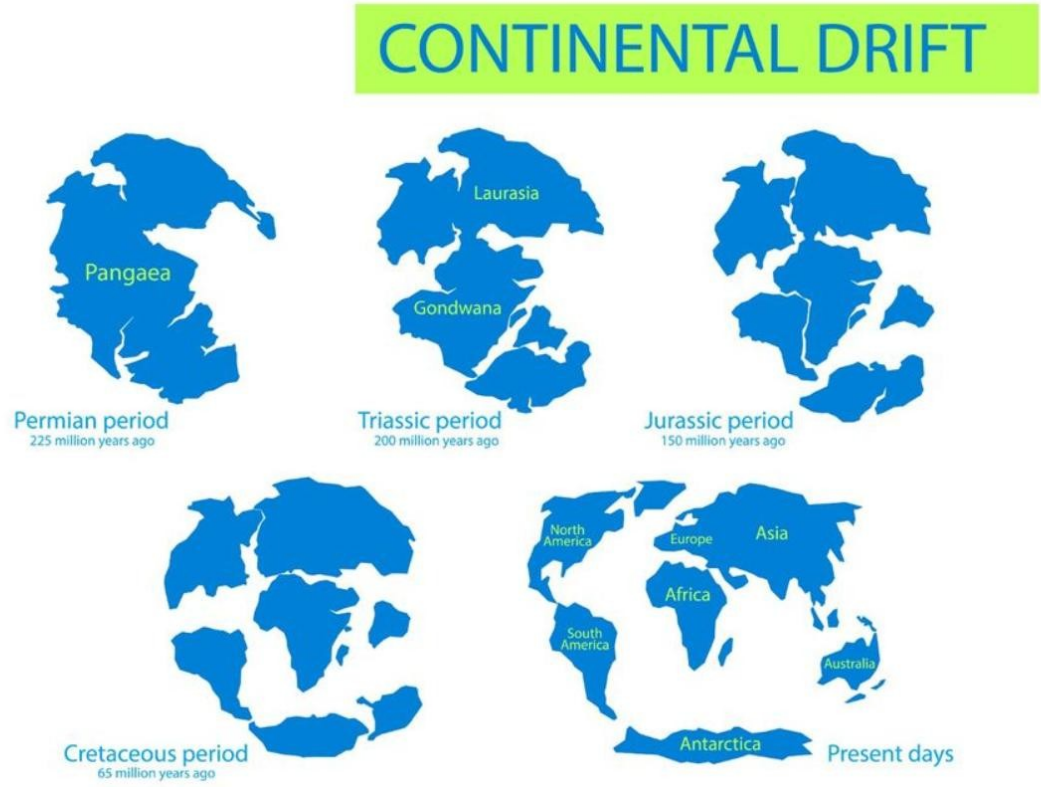
As temperatures cooled, the surface solidified and an atmosphere was created. Volcanic eruptions released water vapor from the Earth's crust, while more water came from asteroids and comets that collided with the Earth.

About 4 billion years ago, temperatures cooled enough for oceans to begin forming

There was one giant landmass called '**Pangea**' which was all land. This huge piece of land was surrounded by one giant ocean called the '**Panthalassa**'. About 200 million years ago, the Pangaea broke up into smaller continents.

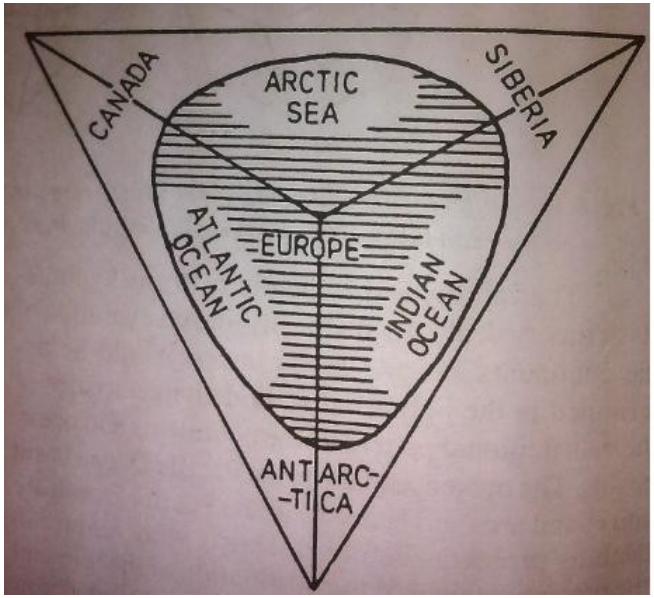


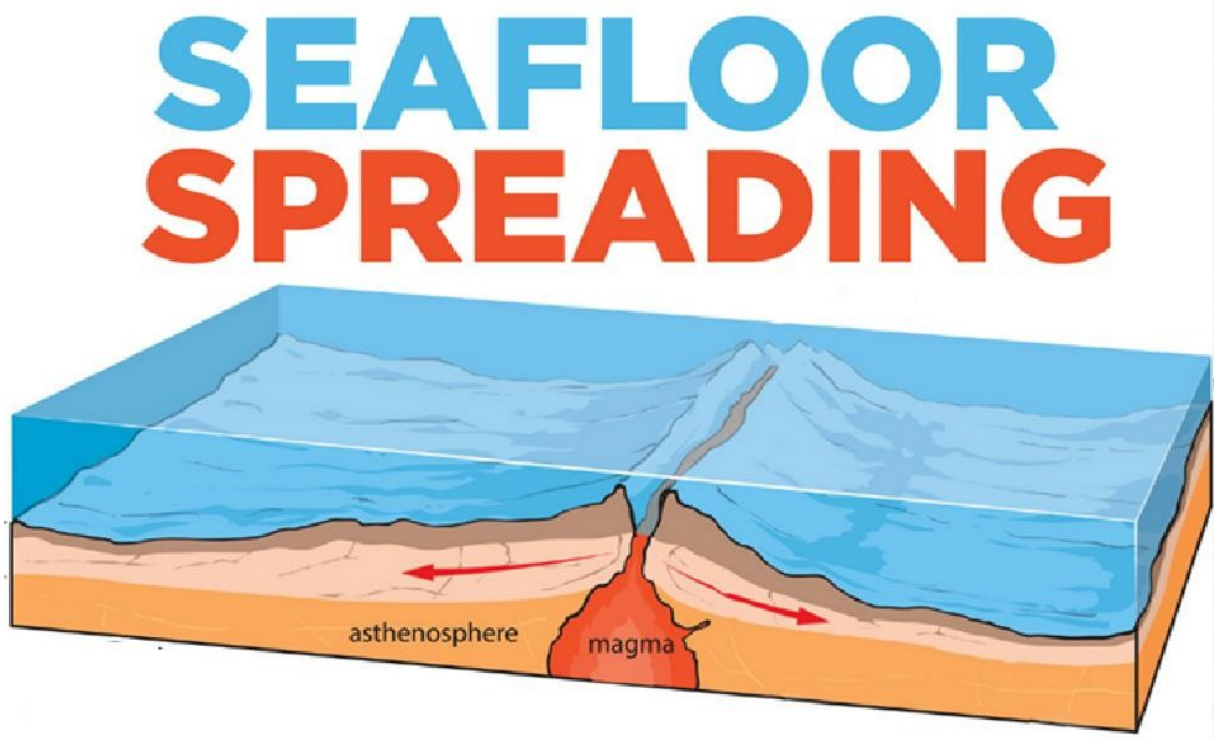
The supercontinent Pangaea formed around 320 million years ago



Tetrahedral Hypothesis

The **Tetrahedral Hypothesis** was postulated by Lothian Green in 1875. According to him there was a tetrahedral arrangement of land and water distribution on the earth (diagram). The tetrahedral in this case would be standing on one point. The four flat faces of the tetrahedron, represented the four oceans. The flat upper surface would be the Arctic Ocean, circled by land





How many oceans are there?

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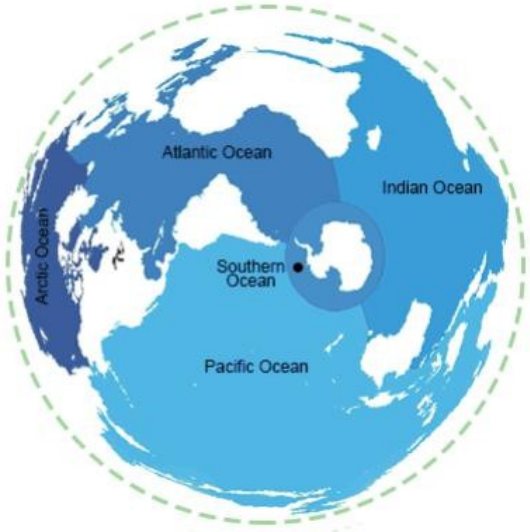
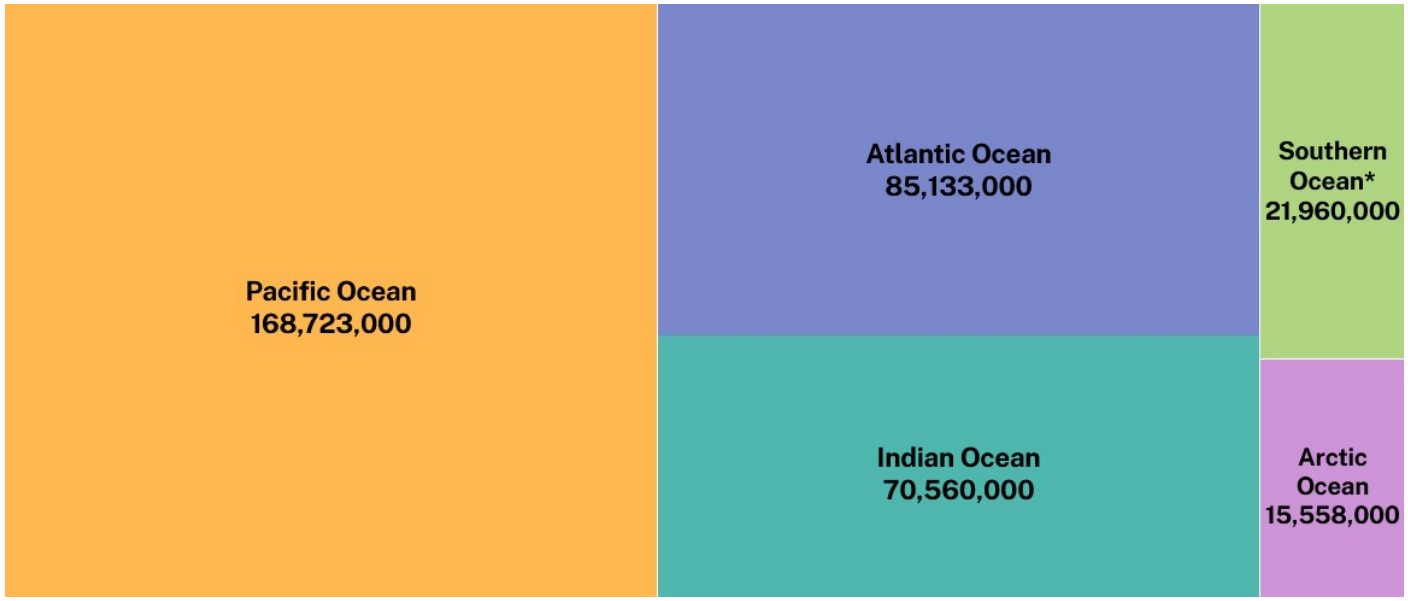
NAMED OCEANS

Arctic, Atlantic, Indian, Pacific, Southern

(modern-day ocean names and boundaries)





Origin of Atmosphere

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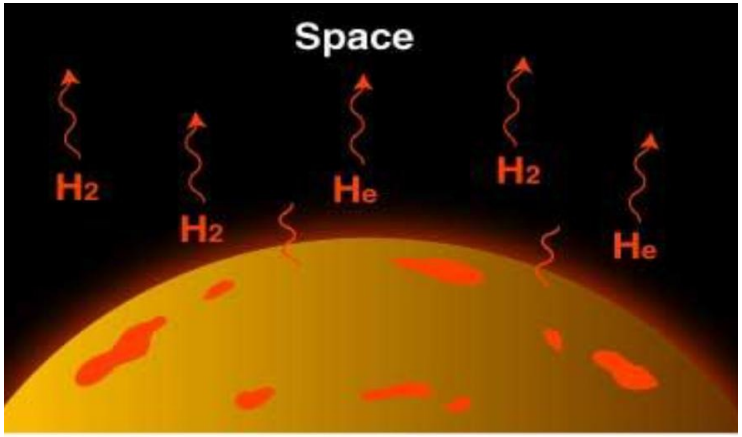
The First atmosphere:

The first of earth's atmosphere, formed when the planet was still very young, was primarily hydrogen and helium (He). This atmosphere is about 4.57 billion years old, and was short-lived. Heat from the molten crust and solar wind dissipated this layer.



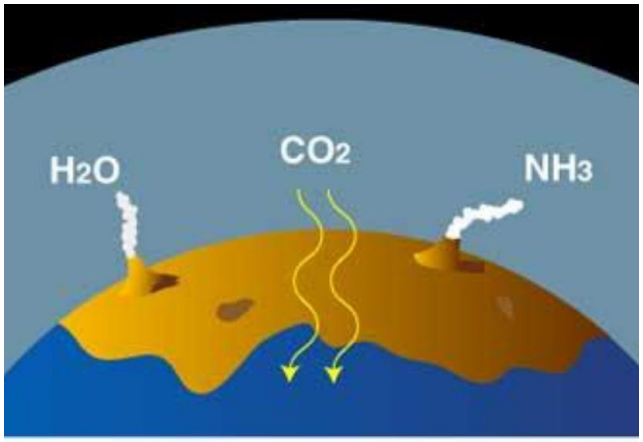
Atmosphere #1

Hydrogen and helium are not heavy enough to make up a stable atmosphere unless the planet is very massive. These elements are more likely to gain escape velocity during random thermal fluctuations.

This is part of reason why hydrogen and helium are very rare in earth's atmosphere's atmosphere today

The Secondary Atmosphere:

Water related sediments have been found dating from as early as 3.8 billion years ago. About 3.4 billion years ago, nitrogen was the major part of the then stable "**second atmosphere".**



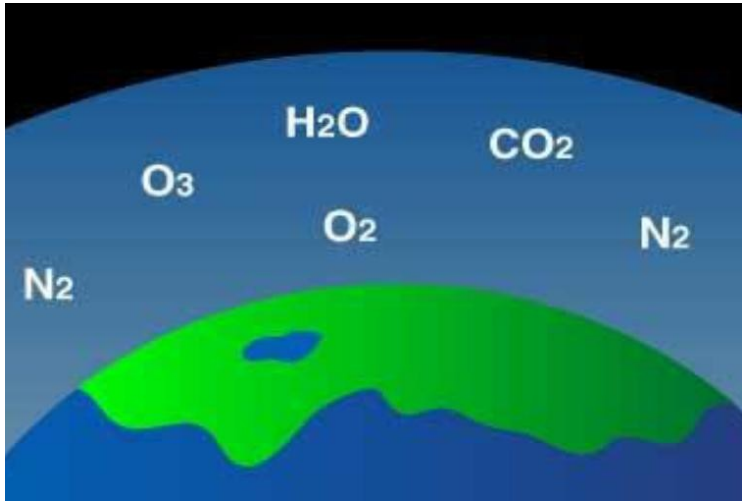
Atmosphere #2

An influence of life has to be taken into account rather soon in history of the atmosphere, since hints of early life forms are to be found as early as **3.5 billion years ago.**

During this period, the rocks gave off large quantities of gases including nitrogen, ammonia, carbon monoxide and water vapor as well-a mixture similar to that given off by volcanoes and fumaroles today. Like modern volcanic gases, the primeval atmosphere is thought to have contained only the slightest trace of oxygen, so it would have been poisonous to almost all modern life forms.

The Third Atmosphere:

This time span was the Phanerozoic Eon (time when abundant animal life existed and time when diverse hard-shelled animals first appeared), during which oxygen-breathing metazoan life forms began to appear.



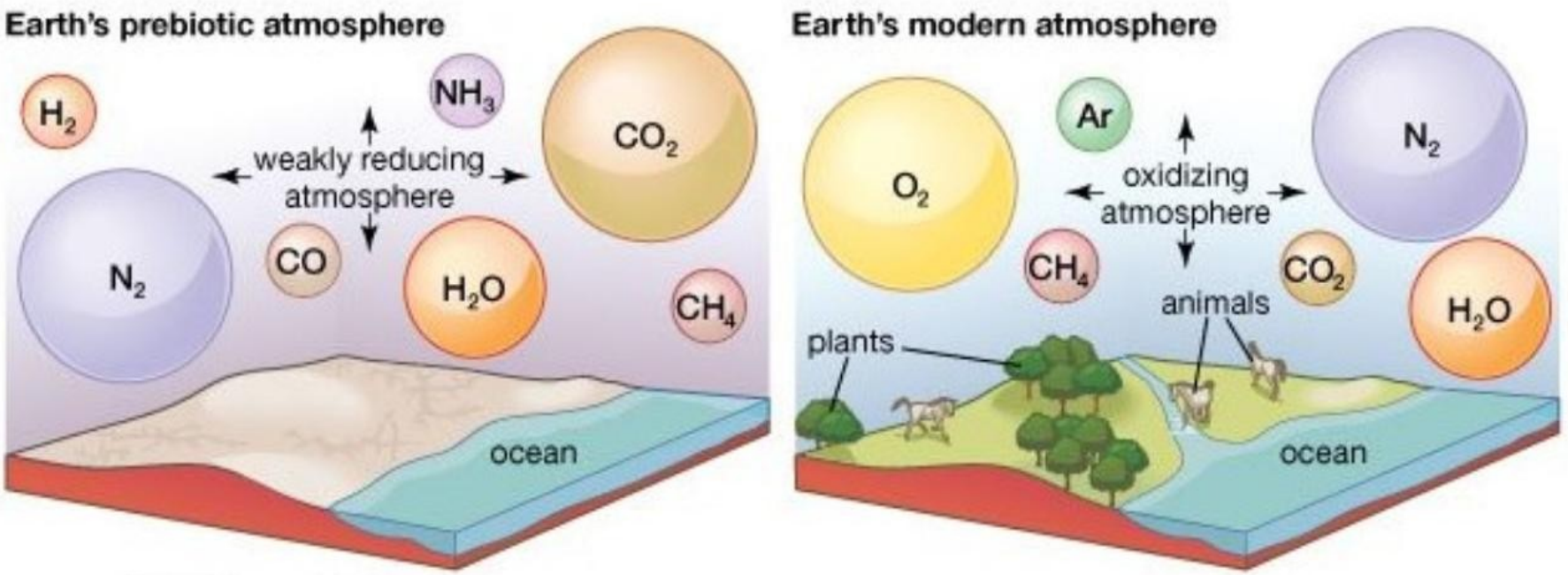
By **3.5 billion years ago**, life had emerged, in the form of "Archaea". Archaea are a major group of single celled organisms without nuclei.

About **2.7 billion years ago**, they were joined by microbes called cyanobacteria. Cyanobacteria were the **first oxygen producing phototropic organism** and slowly began to suck in carbon dioxide from the atmosphere and release oxygen.

Table 1-1: Evolution of the Earth's atmosphere.

Name of Stage	Duration of Stage (Billions of Years Ago)	Main Constituents of the Atmosphere	Dominant Processes and Features
Early Atmosphere	4.4 to 4.0	H_2O, hydrogen cyanide (HCN), ammonia (NH_3), methane (CH_4), sulfur, iodine, bromine, chlorine, argon	Lighter gases like hydrogen and helium escaped to space. All water was held in the atmosphere as vapor because of high temperatures
Secondary Atmosphere	4.0 to 3.3	At 4.0 billion H_2O, CO_2, and nitrogen (N) dominant. Cooling of the atmosphere causes precipitation and the development of the oceans. By 3.0 billion CO2, H2O, N2 dominant. O2 begins to accumulate.	Continued release of gases from the lithosphere. Water vapor clouds common in the lower atmosphere. Chemosynthetic bacteria appear on the Earth sometime between 3.9 and 3.5 billion years ago. Life begins to modify the atmosphere.

Living Atmosphere	3.3 to Present	N_2 - 78%, O_2 - 21%, Argon - 0.9%, CO_2 - 0.036%	Development, evolution and growth of life increases the quantity of oxygen in the atmosphere from <1% to 21%. 500 million years ago concentration of atmospheric oxygen levels off. Humans begin modifying the concentrations of some gases in the atmosphere beginning around the year 1700.


Earth's prebiotic atmosphere
H2
NH3
CO2
weakly reducing
atmosphere
N2
CO
H2O
CH4
ocean
Earth's modern atmosphere
Ar
N2
O2
oxidizing
atmosphere
CH4
CO2
H2O
animals
plants
ocean

•The present composition of earth's atmosphere is chiefly contributed by nitrogen and oxygen.
•There are three stages in the evolution of the present atmosphere.
•The **first stage** is marked by the loss of primordial atmosphere.
•In the **second stage,** the hot interior of the earth contributed to the evolution of the atmosphere.
•Finally, the composition of the atmosphere was modified by the living world through the process of photosynthesis.
•The **early atmosphere**, with hydrogen and helium, is supposed to have been stripped off as a result of the solar winds.
•This happened not only in case of the earth, but also in all the terrestrial planets, which were supposed to have lost their **primordial atmosphere through the impact of solar winds.**
•During the cooling of the earth, gases and water vapour were released from the interior solid earth.
•This started the evolution of the present atmosphere.
•The early atmosphere largely contained **water vapour, nitrogen, carbon dioxide, methane, ammonia and very little of free oxygen..**

•The process through which the gases were outpoured from the interior is called **degassing.**

•Continuous **volcanic eruptions** contributed water vapour and gases to the atmosphere.

•As the earth cooled, the water vapour released started getting condensed.

•The carbon dioxide in the atmosphere got dissolved in rainwater and the temperature further decreased causing more condensation and more rains.

•The rainwater falling onto the surface got collected in the depressions to give rise to oceans.

•The earth's oceans were formed within 500 million years from the formation of the earth. This tells us that the oceans are as old as 4,000 million years.

•Sometime around 3,800 million years ago, life began to evolve.

•However, around 2,500-3,000 million years before the present, the process of photosynthesis got evolved.

•Life was confined to the oceans for a long time.

•Oceans began to have the contribution of oxygen through the process of photosynthesis.

•Eventually, oceans were saturated with oxygen, and 2,000 million years ago, oxygen began to flood the atmosphere

Thank You