Life Sciences 11
Microbiology 5

Name:_____

The Great Oxygenation Event

Cyanobacteria: Responsible for the buildup of Oxygen in the Earth's atmosphere.

The ancient Earth had little free Oxygen (O_2) in its atmosphere, mostly Nitrogen (N_2), Carbon dioxide (CO_2) and Methane (CH_4). About 3.6×10^9 years ago some bacteria evolved photosynthesis but not oxygenic photosynthesis. Their descendants still exist today — the purple sulfur bacteria. Their photosynthesis was:

$$CO_2 + H_2S \xrightarrow{\text{sun}} (CH_2O)_n + S$$

About 1.5 billion years later, some bacteria, the blue green algae, now called cyanobacteria evolved a photosynthesis using H_2O instead of H_2S

$$CO_2 + H_2O \xrightarrow{\text{sun}} (CH_2O)_n + O_2$$

Oxygen is an extremely corrosive gas, toxic to all life at that time, many of the bacteria, including the cyanobacteria were poisoned by it and died. The O_2 reacted with the Iron (Fe) in the water forming FeO and Fe_2O_3 (rust and hematite). This removed the toxic O_2 allowing the cyanobacteria to bounce and produce more O_2, which poisoned them again. These recycled formin banded iron formation

Stromatolites are formed over the years by mats (1-10 mm in thickness) of cynobacteria, among others, found in shallow, mainly marine waters. The microorganisms precipitate mineral particles, which makes the mat thicken, but only the upper part survives. Most stromatolites display characteristically layered structures. Only the layers are visible to the naked eye. Paleoarchean from -3 600 à -3 200 Ma (million years ago). Locality: Western Australia

https://commons.wikimedia.org/wiki/File:Stromatolithe_Pal%C3%A9oarch%C3%A9en_-_MNHT.PAL.2009.10.1.jpg#/media/File:Stromatolithe_Pal%C3%A9oarch%C3%A9en_-_MNHT.PAL.2009.10.1.jpg

Banded Iron Formation at the Fortescue Falls

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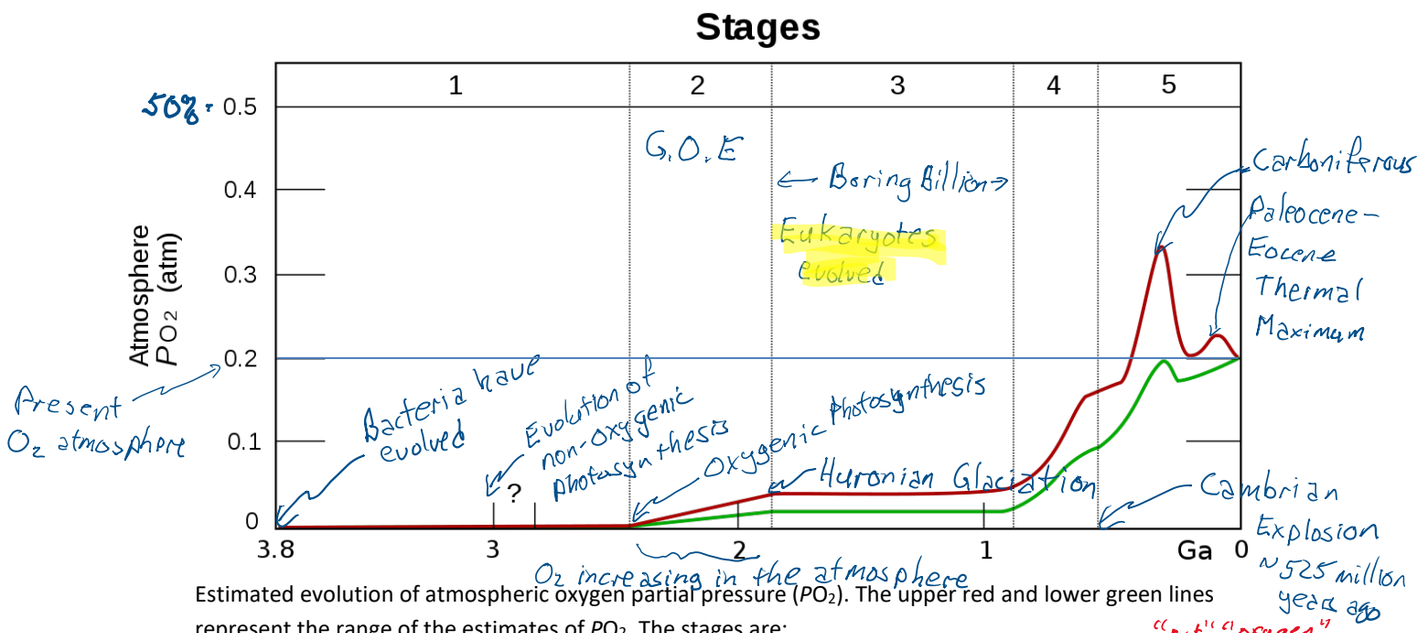

Estimated evolution of atmospheric oxygen partial pressure (PO_2). The upper red and lower green lines represent the range of the estimates of PO_2. The stages are:
Stage 1 (3.85 – 2.45 Gyr ago (Ga)) Practically no O_2 in the atmosphere. The Oceans were also largely anoxic with the possible exception of O_2 gases in the shallow areas.
Stage 2 (2.45 – 1.85 Ga) O_2 produced, and rose to values of 0.02 to 0.04 atm, but absorbed by the oceans and seabed rocks.
Stage 3 (1.85 – 0.85 Ga) O_2 starts to gas out of the oceans, but is absorbed by land surfaces and formation of ozone layer. There was no significant change in O_2 levels.
Stages 4 (0.85 – 0.54 Ga) and 5 (0.54 Ga – present) O_2 sinks filled, the gas accumulates.

By Oxygenation-atm.svg: Heinrich D. Hollandderivative work: Loudubewe (talk) - Oxygenation-atm.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=12776502

The result of removing vast amounts of CO_2 from the atmosphere due photosynthesis was cooling of the planet (since CO_2 is a "green house" gas. This caused the Huronian Glaciation which lasted for 300 000 000 years. A period of intense vulcanism ended the glaciation.
The Great Oxygenation Event was the seminal event for life to live on land. Oxygen didn't just go into the atmosphere, it went into the higher levels of the atmosphere, where UVA and UVB from the sun split O_2 into O and O, which would react with O_2 to form O_3, ozone. The UV radiation then acts on O_3 to break it in O_2 and O. All these reactions absorb the energy from the UV photons which can no longer reach the Earth's surface. This allowed life to crawl onto land over 300 million years ago.

Stromatolites growing in Hamelin Pool Marine Nature Reserve, Shark Bay in Western Australia.

By Paul Harrison - Photograph taken by Paul Harrison (Reading, UK) using a Sony CyberShot DSC-H1 digital camera., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=714512