Oxygen: a revolution

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Life on Earth is based on the chemistry of **carbon**, whose source is carbon dioxide (CO_2). To be usable in biological reactions, CO_2 must be "energized" by storing e- electrons and protons to compensate for negative electron charges. The invention of **photosynthesis** by some organisms solved this problem very early in the history of evolution by developing a process that allowed life to explode. The first organisms capable of photosynthesis were probably the ancestors of cyanobacteria. They appeared in the primordial ocean of the Precambrian more than three billion years ago. By using solar energy to take electrons from water (H_2O) the consequence has been the production of oxygen (O_2) and protons. The slow accumulation of oxygen in the atmosphere led to a real "revolution in evolution". This accumulation is the result of a balance between production (photosynthesis), consumption (breathing) and storage (coal, limestone...).

After photosynthesis appeared, oxygen concentration in the atmosphere remained low due to the high capacity of minerals to trap it. This event in the history of the Earth is clearly recorded in geological layers rich in iron oxide (Fe_2O_3) up to about - 2.5 billion years ago. After the minerals were saturated with oxygen, it then spread into the atmosphere with major consequences. The quantities resulting from photosynthesis were of a completely different order of magnitude compared to those of the previous period, to the point of becoming a poison for the living species in contact with it. For those who survived, the presence of O_2 was used in a new energy process: breathing using O_2 as the terminal electron acceptor. The energy-rich carbon molecules produced by photosynthesis have become the fuel for respiration, and the O_2 waste oxidizes it. This type of energy-efficient breathing has promoted the development of multicellular organisms and then more complex living forms (Figure 1). Under the effect of solar ultraviolet (UV) radiation, the appearance of oxygen has resulted in the accumulation of ozone in the upper layers of the atmosphere, thus protecting living species from the harmful effects of UV radiation. This natural UV filter allowed life to be taken out "outdoors" for the first time. It is the photosynthetic species that are responsible for creating and maintaining the conditions necessary for life on Earth, as we know it. Such success is due to the limited needs: sun, water and carbon dioxide.

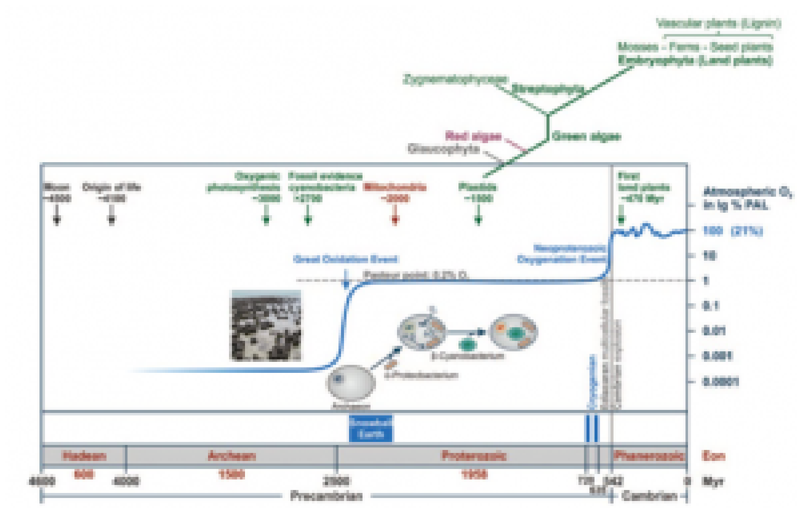

Figure 1. Evolution of oxygen level in the atmosphere over geological time. The Proteozoic period is characterized by various successive phenomena (1) the transition from an atmosphere practically devoid of oxygen to an atmosphere containing about 0.2% oxygen (the Great Oxidation), or 1% of the current oxygen content (PAL), (2) periods of intense glaciation (so-called snowball earth) and (3) the acceleration of the development of living organisms (algae, animals, fungi, plants) with a sharp increase in the oxygen content of the atmosphere (to reach 21% nowadays, after having passed through a peak at more than 30% in Carboniferous). The processes responsible for the accumulation of oxygen in the atmosphere are still poorly understood. Overall, the oxygen content of the atmosphere is the result of various processes. Production (via photosynthesis) and consumption (via respiration) are currently in balance. This was not always the case during geological times and it is the various forms of carbon dioxide storage (trapping, fossilization...) that have caused the oxygen content of the atmosphere to increase significantly, by limiting oxygen consumption through respiration. The oxygen cycle in the biosphere only concerns a small part (less than 1%) of the planet's oxygen, because most of it is stored in the lithosphere. [Source: Adapted from Hagemann et al. stromatolite photography © Paul Harrison via Wikimedia commons]

Registeringggeration to say that the appearance of oxygen photosynthesis is one of the most important events experienced by our planet. It has produced over the course of geological time, and continues to produce, the oxygen we breathe. It has allowed the development of multicellular living forms and has modified the physico-chemical characteristics of the Earth. The appearance of ozone has protected the Earth from ultraviolet solar radiation and caused climate change. These changes have allowed the continents to be colonized by new forms of animal and plant life.

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