

A BRIEF HISTORY OF LIFE ON EARTH*

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The diversity of species, ecosystems and landscapes that surround us today are the product of perhaps 3.7 billion (*i.e.*, 3.7×10^9) to 3.85 billion years of evolution of life on Earth (*Mojzsis et al.*, 1996[4]; *Fedo and Whitehouse*, 2002[?]). Life may have first evolved under harsh conditions, perhaps comparable to the deep-sea thermal vents where chemo-autotrophic bacteria are currently found (these are organisms that obtain their energy only from inorganic, chemical sources).

A subterranean evolution of life has also been suggested. Rock layers deep below the continents and ocean floors, that were previously thought to be too poor in nutrients to sustain life, have now been found to support thousands of strains of microorganisms. Types of bacteria have been collected from rock samples almost 2 miles below the surface, at temperatures up to 75 degrees Celsius. These chemo-autotrophic microorganisms derive their nutrients from chemicals such as carbon, hydrogen, iron and sulphur. Deep subterranean communities could have evolved underground or originated on the surface and become buried or otherwise transported down into subsurface rock strata, where they have subsequently evolved in isolation. Either way, these appear to be very old communities, and it is possible that these subterranean bacteria may have been responsible for shaping many geological processes during the history of the Earth (*e.g.*, the conversion of minerals from one form to another, and the erosion of rocks) (*Fredrickson and Onstott*, 1996[2]).

The earliest evidence for photosynthetic bacteria - suspected to be cyanobacteria - is dated at sometime between 3.5 and 2.75 billion years ago (*Schopf*, 1993[?]; *Brasier et al.*, 2002[?]; *Hayes*, 2002[?]). These first photosynthetic organisms would have been responsible for releasing oxygen into the atmosphere. (**Photosynthesis** is the formation of carbohydrates from carbon dioxide and water, through the action of light energy on a light-sensitive pigment, such as chlorophyll, and usually resulting in the production of oxygen). Prior to this, the atmosphere was mainly composed of carbon dioxide, with other gases such as nitrogen, carbon monoxide, methane, hydrogen and sulphur gases present in smaller quantities.

It probably took over 2 billion years, from the initial advent of photosynthesis for the oxygen concentration in the atmosphere to reach the level it is at today (*Hayes*, 2002[?]). As oxygen levels rose, some of the early anaerobic species probably became extinct, and others probably became restricted to habitats that remained free of oxygen. Some assumed a lifestyle permanently lodged inside aerobic cells. The anaerobic cells might, initially, have been incorporated into the aerobic cells after those aerobes had engulfed them as food. Alternatively, the anaerobes might have invaded the aerobic hosts and become parasites within them. Either way, a more intimate symbiotic relationship subsequently evolved between these aerobic and anaerobic cells. In these cases the survival of each cell was dependent on the function of the other cell.

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The evolution of this symbiotic relationship was an extremely important step in the evolution of more complex cells that have a nucleus, which is a characteristic of the Eucarya or eucaryotes (eu = good, or true; and karyon = kernel, or nucleus). Recent studies of rocks from Western Australia have suggested that the earliest forms of single-celled eucaryotes might be at least 2.7 billion years old (*Anon, 2001*[1]). According to contemporary theories, there has been sufficient time, over those 2.7 billion years, for some of the genes of the invading anaerobe to have been lost, or even transferred to the nucleus of the host aerobe cell. As a result, the genomes of the ancestral invader and ancestral host have become mingled and the two entities can now be considered as one from a genetic standpoint.

The evolutionary history of the Eucarya is described in various standard references and so is not covered in detail here. Briefly, eucaryotes constitute three well known groups - the Viridiplantae or green plants, the Fungi, and the Metazoa or animals. There are also many basal groups of eucaryotes that are extremely diverse - and many of which are evolutionarily ancient. For example, the Rhodophyta, or red algae, which might be the sister-group to the Viridiplantae, includes fossil representatives dating from the Precambrian, 1025 billion years ago. The Stramenopiles includes small, single-celled organisms such as diatoms, fungus-like species of water moulds and downy mildews, and extremely large, multicellular brown seaweeds such as kelps.

The earliest known green plants are green algae, dating from the Cambrian, at least 500 million years ago. By the end of the Devonian, 360 million years ago, plants had become quite diverse and included representatives similar to modern plants. Green plants have been extremely important in shaping the environment. Fueled by sunlight, they are the primary producers of carbohydrates, sugars that are essential food resources for herbivores that are then prey to predatory carnivores. The evolution and ecology of pollinating insects is closely associated with the evolution of the Angiosperms, or flowering plants, since the Jurassic and Cretaceous periods.

Fungi, which date back to the Precambrian times about 650 to 540 million years ago, are also important in shaping and sustaining biodiversity. By breaking down dead organic material and using this for their growth, they recycle nutrients back through ecosystems. Fungi are also responsible for causing several plant and animal diseases. Fungi also form symbiotic relationships with tree species, often in nutrient-poor soils such as are found in the humid tropics, allowing their symbiont trees the ability to flourish in what would otherwise be a difficult environment.

Metazoa, which date to over 500 million years ago have also been responsible for shaping many ecosystems, from the specialized tubeworms of deep sea, hydrothermal vent communities of the ocean floor, to the birds living in the high altitudes of the Himalayas, such as the impeyan pheasant and Tibetan snow cock. Many species of animals are parasitic on other species and can significantly affect the behavior and life-cycles of their hosts.

Thus, the evolutionary history of Earth has physically and biologically shaped our contemporary environment. Many existing landscapes are based on the remains of earlier life forms. For example, some existing large rock formations are the remains of ancient reefs formed 360 to 440 million years ago by communities of algae and invertebrates (*Veron, 2000*[3]).

Glossary

Definition 1: Photosynthesis

the formation of carbohydrates from carbon dioxide and water, through the action of light energy on a light-sensitive pigment, such as chlorophyll, and usually resulting in the production of oxygen

References

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