Developing Innovative Phylogenetic Methods to Establish the Antiquity of Microbial Processes - The Archeal Domain of Life as a Test Case

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Many microbial processes (such as photosynthesis, sulfate reduction, methanotrophy, autotrophy, nitrogen fixation, aerobic respiration, and the oxidation and reduction of iron) play important roles in the modern biogeochemical cycling of carbon, sulfur, nitrogen, oxygen, and iron. It is generally thought that these processes trace back deep in time to the Archean and Proterozoic Earth - playing fundamental roles in the oxygenation of the biosphere, in the generation of banded iron formation, and in the changing chemistry of the oceans through time. However, most microorganisms lack a conventional fossil (or biogeochemical) record and, from the perspective of the geological record, there is no clear consensus as to the antiquity of most major microbial groups and their associated metabolic processes.

This project uses a new, innovative technique (phylogenomic dating) to reconstruct some of the earliest divergences on the tree of life, and to constrain when physiological and ecological processes arose in Earth's history. This information is vital for understanding how early Earth and early life co-evolved - central goals in the fields of microbiology and geology, and a central goal in NASA's Astrobiology program. Understanding how life on Earth evolved, and how to search for ancient biogeochemical processes, will ultimately be critical in the search for life elsewhere. This one-year pilot project aims to construct the data sets and preliminary results needed for a full 3-year grant proposal.

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