Co-evolution of early environments and microbial life

T. LYONS[1*], C. TINO[1], R. ANDERSON[2], G. FOURNIER[3], A. KAPPLER[4], W. LEAVITT[5], C. MAGNABOSCO[6], E. STÜEKEN[7], A. ZERKLE[7]

[1]Dept. of Earth Sciences, University of California, Riverside, USA (*correspondence: timothy.lyons@ucr.edu)
[2]Dept. of Biology, Carlton College, Northfield, MN, USA
[3]Dept. of Earth, Atmo., and Planet. Science, Massachusetts Institute of Technology, Cambridge, MA, USA
[4]Center for Applied Geoscience, Eberhard-Karls-University Tübingen, Germany
[5]Dept. of Earth Sci., Dartmouth College, Hanover, NH, USA
[6]Center for Computational Biology, Flatiron Institute, New York, NY, USA
[7]School of Earth and Environmental Sciences, University of St. Andrews, UK

Two archives in Earth history capture the evolution of life and its co-evolving ecosystems with interpretable fidelity: chemical and fossil traces preserved in rocks and the histories captured within genomes. The earliest vestiges of life are recognized mostly in isotopic fingerprints of specific microbial metabolisms, while fossils and organic biomarkers become important later. Molecular biology suggests histories that we can overlay on the physical and chemical traces of evolving life, along with the signatures of coeval environmental evolution expressed most importantly in the transition from an oxygen-poor to oxygen-rich world. This talk will explore in wide-reaching terms the history of microbial life on Earth and the degree to which it shaped and was shaped by fundamental transitions in the chemical properties of the oceans, continents, and atmosphere. We will review the diversity and evolution of early microorganisms and how they impacted Earth's biogeochemical cycles—in particular those for C, N, S, and Fe and their relationships to oxygen production and accumulation in the early biosphere. Highlights will include the largest-scale controls and consequences of microbial evolution: nutrients, redox state, tectonic drivers/solid Earth processes, weathering, primary production, ocean chemistry, climate change, and changing atmospheric compositions. Comparisons between molecular results and chemical data in the rock record reveal gaps between the beginnings of microbial pathways implied by the genomic data and their subsequent ecological proliferations. Significant ecological impact often resulted in changing ocean chemistry and associated metabolic fingerprints captured in the chemical properties of ancient rocks.

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