## Astrobiology News October 2019: Using Earth's History to Search for Habitable Planets

The NASA Astrobiology Institute (NAI) is a partnership between NASA and 10 NAI teams located at academic institutions, research laboratories, and NASA Centers. This month, I'd like to tell you a little about the "Alternative Earths" Astrobiology Center at the University of California, Riverside. ${ }^{1}$ As with all NAI centers, Alternative Earths comprises a large team of scientists that span diverse disciplines. This team is focused specifically on exploring how the history of life on Earth might inform the search for signs of life on exoplanets.

The Earth has hosted life for most of its 4.5-billion-year history, but the signs of habitability on Earth have changed considerably over the eons. The Alternative Earths team is modeling what Earth's atmosphere would have looked like in the past by combining data from the geology, chemistry, and biology of Earth's continents, oceans, and atmospheres during four specific time periods. The guiding theme might be described as "follow the oxygen."

Alternative Earth 1 focuses on 3.2-2.4 billion years ago, when the earliest forms of life began releasing oxygen into the atmosphere via photosynthesis; Alternative Earth 2, 2.3-2 billion years ago, when oxygen flooded Earth's atmosphere and oceans; Alternative Earth 3, 1.80.8 billion years ago, examines the relationship between oxygen levels and the emergence of complex life.

Finally, Alternative Earth 4 focuses on exploring the period from 0.8-0.5 billion years ago, and the roles of biological innovation and environmental change in reshaping Earth's ecosystems, atmosphere, and climate during the rise of complex life. The overarching goal is to determine whether the diversification of complex life was a major driver of shifts in oxygen levels and major climate changes.

The team is using their models to create many blueprints for habitability on other worlds by tweaking things like a planet's rotation period, tilt, distribution of continents, and other parameters that influence biological activity and the connections between oceans, land masses, and atmospheres. They are using these blueprints to produce
examples of chemical fingerprints of life (biosignatures) that might be distinguished from the effects of geological, chemical, or other (abiotic) processes on exoplanets. Two promising avenues of exploration are the presence of ozone as a proxy for oxygen, which is more difficult to detect, and how the presence of ozone varies with season.

The scheduled launch of the James Webb Space Telescope (JWST) in 2021 is powerful motivation for research of this nature, since JWST will use "transit spectroscopy" to search for biosignatures in the atmospheres of "nearby" exoplanets. The Alternative Earths team is laying important groundwork for knowing what to look for and how to interpret what we find!

Until next month,
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