Examining the evolution of oxygenic photosynthesis on the early Earth and potentially exoplanets

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The evolution of the atmosphere, ocean, and microbial life on the early Earth were inextricably linked. The evolution of oxygenic photosynthesis and the resulting oxygenation of the atmosphere and oceans was arguably one of the most important events in the history of the young planet.

While modern cyanobacteria produce oxygen as a waste product from the oxidation of water, it may not have always been so. There is a large difference in the redox potentials between water used as an electron donor by cyanobacteria and hydrogen commonly used by the more ancient anoxygenic photosynthesis. Members of our group have speculated that an intermediate reductant such as Fe(II) or Mn(II) could have bridged the gap and acted as a transitional electron donor before water. The widespread abundance of Fe(II) in Archean ferruginous oceans would have made it particularly suitable as an electron donor for photosynthesis. Therefore, Fe- or Mn-dependent photosynthesis using one photosystem in cyanobacteria may have been an important step in the evolution of oxygenic photosynthesis.

We have found evidence that this type of metabolism is occurring *in situ* in cyanobacterial mats in high-iron thermal springs using carbon-14 bicarbonate uptake experiments and autoradiography.

Because oxygen is such an important biosignature for the detection of life on exoplanets, ultimately we wish to understand the environmental selective pressures driving the evolution of water oxidation, so they can be potentially generalized and extrapolated to rocky habitable exoplanets.