Goldschmidt2018 Abstract

Anoxygenic photosynthesis across temperature and pH space

TRINITY L. HAMILTON[1,2], SENTHIL MURUGAPIRAN[1], JEFF R. HAVIG[3]

[1]Department of Plant and Microbial Biology, University of Minnesota, St. Paul, MN 55108
[2]Biotechnology Institute, University of Minnesota, St. Paul, MN 55108
[3]Department of Earth Sciences, University of Minnesota, Minneapolis, MN 55455

The ability to harvest light and convert it to chemical energy represents one of the most elegant and complex biological innovations. The emergence of oxygen-evolving photosynthesis is credited with altering global biogeochemical cycles that ultimately ushered in complex life. Multiple lines of evidence suggest that the less complex anoxygenic mode of photosynthesis evolved before oxygenic photosynthesis and photosynthetic eukaryotes acquired photosynthetic properties from endosymbiosis with cyanobacteria.

The prevalence of extant cyanobacteria in alkaline hydrothermal ecosystems (below 72°C) coupled to recent reports of putative microbially-related structures in terrestrial hot springs that date back as far as 3.5 Ga suggests niche space for terrestrial thermophilic phototrophs early in the evolution of life on Earth. These observations coupled to the data indicating anoxygenic photosynthesis emerged prior to oxygenic photosynthesis, possibly 1.2 Gya earlier, suggest early evolving anoxygenic phototrophs could have thrived in terrestrial environments, particularly hydrothermal springs, on an early Earth characterized by a reducing atmosphere. The majority of studies in modern hydrothermal systems have aimed at understanding the physiological underpinnings of the temperature and pH constraints on oxygenic photosynthesis. Due to key differences in photosynthetic machinery, and in some cases, niche space, these studies cannot be used to interpret the limits of anoxygenic phototrophy. Thus, there is a paucity of data on the taxonomic and metabolic diversity of anoxgyenic photosynthesis across gradients of temperature and geochemistry.

We employed molecular and isotopic tools to examine the distribution of physiologically diverse anoxygenic phototrophs across temperature and pH space in hydrothermal springs in Yellowstone National Park. Our data indicate temperature and pH select for distinct populations of anoxygenic phototrophs. Furthermore, we report active anoxygenic photosynthesis across a much wider range of temperature and pH space than reported previously, including in springs down to pH 3. Our data improve our current understanding of the distribution of anoxygenic photosynthesis and the physicochemical parameters that constrain their distribution. Analyses of genomes from metagenomes across this pH and temperature space will facilitate phylogenomic reconstructions of acidophily and thermophily in anoxygenic phototrophs and inform our knowledge the physiology of the first anoxygenic phototrophs.