TERRESTRIAL PHOTOTROPHS ADAPTED TO INFRARED-ENRICHED RADIATION AS A MODEL FOR LIFE ON EXOPLANETS AROUND K AND M CLASS STARS. Benjamin M. Wolf[1], Nancy Y. Kiang [2], Niki Parenteau[3], Robert E. Blankenship[4]. [1]Division of Biology and Biomedical Sciences, Washington University in St. Louis, MO, USA, wolfbenjamin@wustl.edu; [2]NASA Goddard Institute for Space Studies, New York, NY, USA, Nancy.Y.Kiang@nasa.gov; [3]Exobiology Branch, NASA Ames Research Center, Moffett Field, CA 94035, mary.n.parenteau@nasa.gov; [4]Departments of Chemistry and Biology, Washington University in St. Louis, MO, USA, blankenship@wustl.edu.

Introduction: Photosynthetic organisms use the light energy produced by their planet's star to generate energy needed for biomass generation and general metabolism. As primary producers, oxygenic photosynthetic organisms serve as the foundation for sustaining nearly all life on Earth(*1*). Much of the photon flux generated by Earth's Sun is in the visible portion of the spectrum, and the dominant oxygenic photosynthetic organisms here have evolved to use this visible light. However, some organisms filling niches where sunlight has been depleted of its visible wavelengths by other phototrophs have evolved mechanisms to utilize the remaining and abundant lower-energy far-red portion of the spectrum to drive oxygenic photosynthesis using specialized pigments and pigment-proteins(*2*).

While far-red-enriched environments are considered niche environments on Earth, far-red and near-infrared light is relatively more abundant than visible on exoplanets orbiting K and M class stars(*3*). Utilization of these longer wavelengths would be advantageous to phototrophs on such planets, and it is conceivable that similar long wavelength absorption adaptations may exist in most or all phototrophs, supporting entire ecosystems using near-infrared light. These pigments and pigment-proteins provide very distinct photobiological signatures that are significantly red-shifted compared to ordinary phototrophs(*3*). To surmise what these signatures might be on exoplanets, in this study we seek to understand how these adaptations have evolved on Earth by exploring their diversity and discovering their mechanisms.

Isolation of Far-Red Utilizing Species: We have sampled oxygenic phototrophs from a wide range of environments, including marine intertidal zones, various freshwater habitats, and terrestrial environments, and cultured these samples under far-red light. Using this selective far-red light regime, numerous species containing myriad far-red light adaptations have been found. Adaptations to far-red light have primarily consisted of the specialized photosynthetic pigments chlorophylls *d* and *f* and various pigment-proteins which use the protein environment to red-shift the absorption of chlorophyll *a*, which by itself only absorbs visible light. Isolated species have ranged from prokaryotic to eukaryotic and single-celled to multicellular in some cases.

We have characterized the pigment composition, spectroscopic properties, and biochemical features of these previously unknown far-red adapted oxygenic photosynthetic organisms. In particular, we have focused on the ability of several newly isolated prokaryotes in the genus *Acaryochloris* to utilize far-red light using a specialized pigment, chlorophyll *d*, and of a particular aquatic Stramenopile alga to utilize far-red light via aggregation of a specialized chlorophyll *a*-containing light-harvesting complex. Additionally, several organisms from other genera have also been isolated that are capable of using the protein environment to shift the absorption of chlorophyll *a*. Several filamentous cyanobacteria have been found to contain chlorophyll *f* as an auxiliary pigment, conferring the most significant red shifts of any of the isolates.

Astrobiological Relevance of Far-Red Adaptations: All of these adaptations provide photobiological signatures in the form of far-red fluorescence and absorption. Our understanding of how these light harvesting antennas work and the kinds of photobiological signatures they produce will help constrain how to search for extraterrestrial photosynthetic life forms on planets orbiting K and M class stars.

References:

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