Far Red Light Photoacclimation (FaRLiP) at the Dry Limit of Life

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Introduction

In extreme deserts, microbes colonize rocks as a survival strategy. Cyanobacteria are a major component of these endolithic (within rock) communities. They carry out photosynthesis and provide essential organic carbon to the rest of the community. Cyanobacteria photosynthesize using two photosystems (PS I & PS II), light harvesting complexes (phycobilisomes), and chlorophyll a. In endolithic habitats, we found that the solar spectrum is shifted toward far red light[1]. Here, we address the question: **how have cyanobacteria adapted to these extreme conditions?**

Colonized rocks were collected from hyper-arid deserts

Diverse cyanobacteria were isolated from the rock substrates

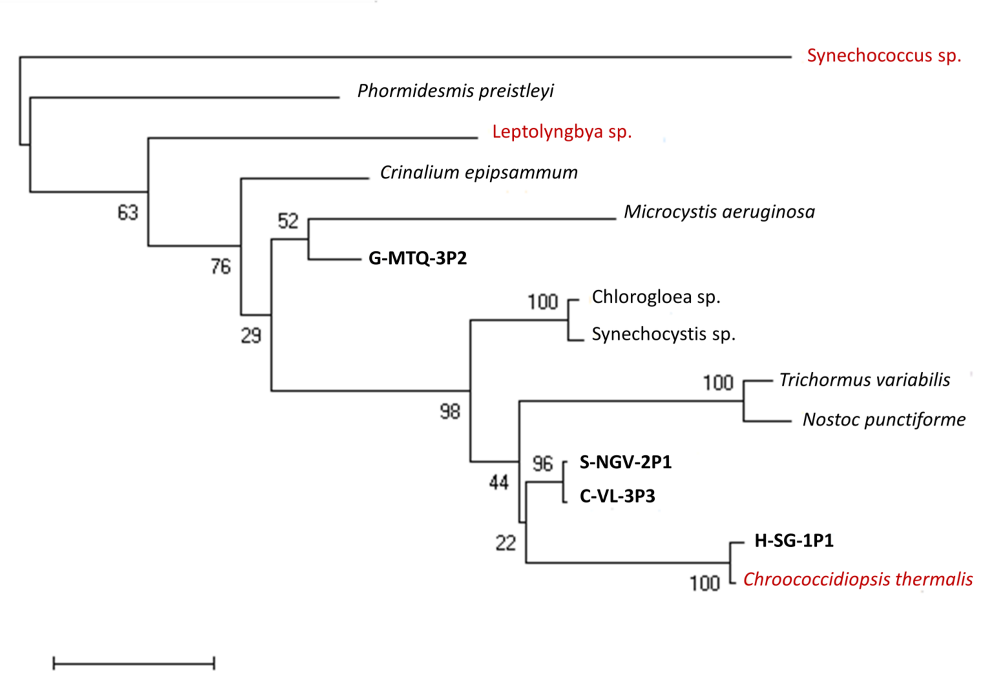

Fig. 1: Phylogenetic tree showing the evolutionary relationships of test strains (bold) & strains previously found to produce chl f (red). *Microcystis*, isolated from a lake, was used as a control. Bar represents 0.1% sequence divergence and bootstrap values are shown at nodes.

Endolithic cyanobacteria grow well under far red light (FRL)

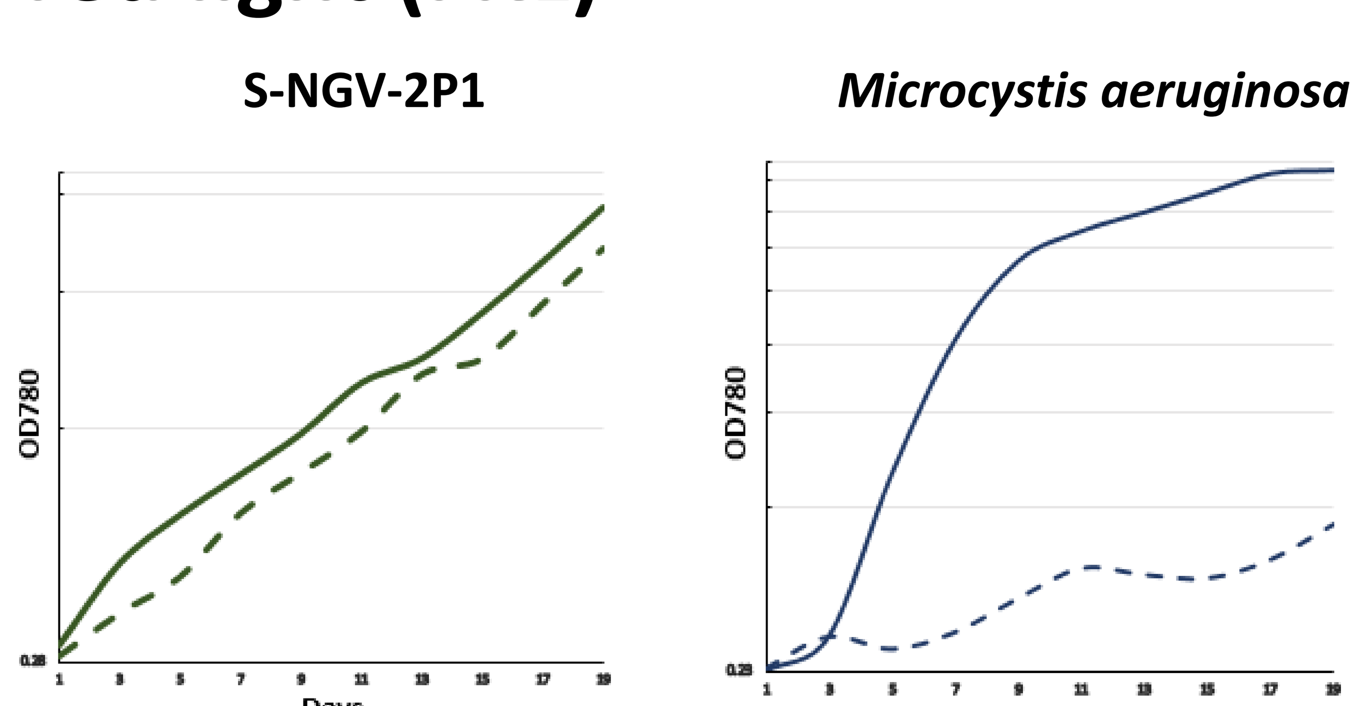

Fig. 2: Growth curves of S-NGV-2P1 (left) and *Microcystis* (right, control) under white light (solid) and FRL (broken line). All endolithic strains grew under FRL. The control did not.

Endolithic cyanobacteria produce chlorophyll f under FRL

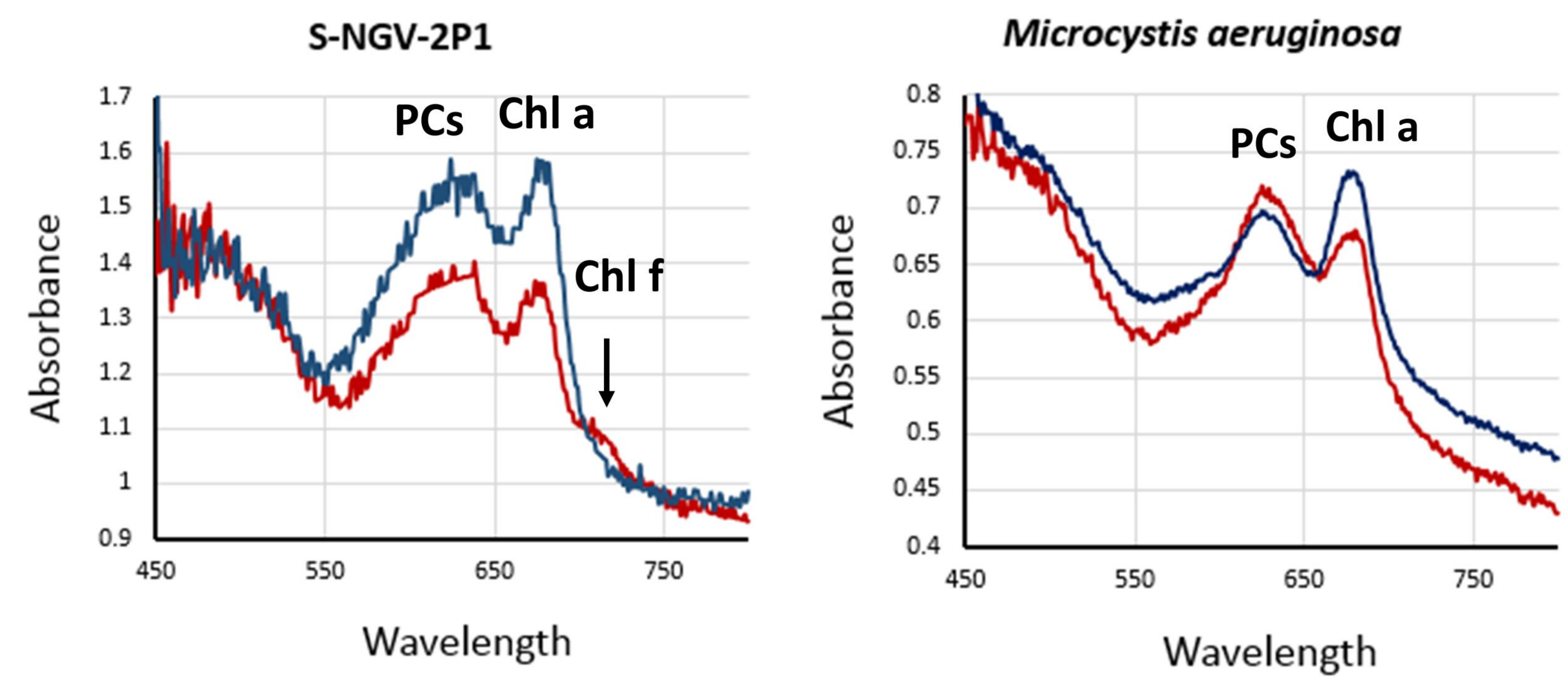

Fig. 3: Absorbance spectrum of cultures grown in WL (blue line) and FRL (red line). Only endolithic cyanobacteria showed a typical chlorophyll f peak when grown in FRL.

Endolithic cyanobacteria remodel their photosystems under FRL

Analysis of endolithic cyanobacteria metagenomes showed that they all encode a chlorophyll f synthase (which converts chl a to chl f), supporting our finding of chl f in cultures grown under FRL.

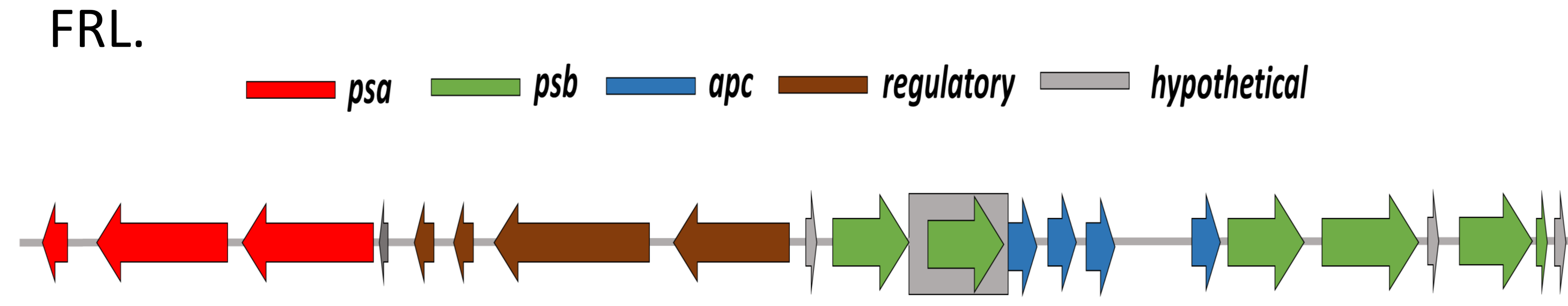

Fig. 4: Gene cluster found in the genome of strain H-SG-1P1 includes PS II genes (green); PS I genes (red); phycobilisome genes (blue); regulatory genes (brown); chl f synthase (boxed). BLAST alignment of H-SG-1P1 chl f synthase revealed 73% identity with that of *C. fritschii*. This gene cluster is similar to the canonical 21-gene cluster previously found in cyanobacteria from microbial mats that are adapted to FRL[2].

Conclusions and Future Work

Cyanobacteria isolated from rock substrates have evolved specific adaptations to their low-light environment. We found that they encode a chlorophyll f synthase in their genome and posses a canonical FRL acclimation (FaRLiP)[2] gene cluster, suggesting that they remodel their photosystems to absorb light in the far red.

Next steps: Quantitative RT-PCR to measure gene expression and confirm that the production of chlorophyll f synthase is induced by FRL.

Acknowledgements

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Literature Cited

[1]Meslier et al. 2018. Fundamental drivers for endolithic microbial community assemblies in the hyperarid Atacama Desert. Env Microbiol 20:1765-1781

[2]Gan et al. 2015. "Occurrence of Far-Red Light Photoacclimation (FaRLiP) in Diverse Cyanobacteria." *Life*. 5, 4-24