Cyanobacteria are the only bacteria capable of oxygenic photosynthesis. They have shaped Earth’s biogeochemical cycles and biodiversity for billions of years. Cyanobacteria are cosmopolitan, but they are especially successful in extreme habitats. Particularly, in polar freshwater ecosystems where they form complex cyanobacteria-dominated microbial mat communities and are important primary producers, driving food webs and carbon cycling. However, adaptation of photosynthesis to polar habitats remains poorly understood. In these habitats, low temperatures are often accompanied by extreme fluctuations in irradiance. High light intensities and ultraviolet radiation are common for shallow meltwater ponds on the ice shelves. In contrast, only a tiny fraction of the surface irradiance is transmitted through the ice at the bottom of perennially ice-covered lakes. This suggests that cyanobacteria have a tremendous capacity to acclimate photosynthesis to challenging conditions. The fundamental principles that govern such adaptations can provide insights not only into engineering more robust or resilient strains for biotech applications, translatable to eukaryotic algae and crops, but also on the biological plasticity that enables the endurance of oxygenic photosynthesis over the long history of our constantly changing planet.

The aim of the project is to characterize in real time, at a physiological and genomic level, how photosynthesis in cyanobacteria acclimates to harsh environmental conditions using adaptive laboratory evolution experiments.

The student will grow Antarctic cyanobacteria in the laboratory to evaluate their fitness and photosynthetic performance under extreme light conditions such as very low or high intensities, different UV radiation levels, and in combination with changes in temperature. Selected populations of Antarctic strains will be gradually acclimated to benign laboratory conditions as to release selective pressures over a period of time. In parallel, laboratory cyanobacteria will be gradually acclimated to harsh polar-like conditions and their fitness compared to Antarctic isolates. Genomes will be sequenced, and genetic changes will be correlated with photosynthetic performance.

The NHM also has collections of over 10,000 historic samples of cyanobacteria, including those collected during Captain Scott’s British Antarctic Expedition over a century ago that will be sequenced using ancient DNA extraction approaches and compared with cyanobacteria isolates and available metagenome data from Antarctica.