Tiered Mentoring Program

What are the limits of light energy necessary to support life?

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Background: Understanding the physical and chemical limits of life on Earth is an essential first step to understanding the possibility of extraplanetary life (astrobiology). Life requires energy, and the primary sources are chemical and light energy. Phototrophs harvest light energy between 400-700 nm wavelengths while a few species, such as purple bacteria, can harvest light energy from the lower energy near-infrared region of the spectrum (700-973 nm) using different photosynthetic and photoreactive proteins. Additional research into life that can survive in various light conditions (energy from even lower wavelengths and low intensities) is required to understand the lowest limits of light needed to support life.

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Terrestrial caves can be considered potential sites to carry out such research as they naturally demonstrate a range of light energy gradients (both light wavelengths and the amount of light energy per unit area) in their entrances. This leads to the stratification of different microbial communities that are adapted to use the available light sources depending on where they live. Surprisingly, even in the darkest zones of caves, longer wavelengths are available due to the reflection and refraction of light bouncing deeper into the caves. In 2019, we identified cyanobacteria even in the dark zones of caves in New Mexico that can harvest these lower energy near-infrared regions for photosynthesis under extremely low light levels. Thus, we can observe light-harvesting activities of life in caves in the complete dark where a light source is required to see your hand in front of your face.

Our Project: Our project aims to understand the limits of intensity and wavelength of light that can support life, using cave entrances as a novel study site. Samples will be analyzed for microbial community composition of known phototrophic species using 16S rRNA. The presence of genes involved in photosynthetic pigments and photo-reactive protein production will be identified using metagenomics. The expression of pigments will be analyzed using different analytical methods and instruments, including the pigment extractions using organic solvent partitioning and HPLC, ART-FTRI, GC-MS, Raman spectroscopy, and fluorescent absorption and emission data. Culture-based techniques under cave-relevant light conditions will be used to determine whether phototrophy is supported under the conditions found in the cave. Finally, direct cell counts will be carried out in each sample to estimate the relative abundance of available light energy-supported life under each light condition until we determine the limits of light-supported growth. Together these results should help us estimate the initial light energy limits necessary to support life in this model system.

What you can Learn (but not limited to): Microbiology techniques and culture methods, making different types of media, sample preparation for different analytical methods, experimental designs, and the use of various laboratory instruments such as pH meter, autoclave, pipettes, centrifuge, and microscopy.

Click here for more information about Dr. Barton's lab