Surprising new species of light-harvesting bacterium discovered in Yellowstone

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Amaya Garcia, a member of the team that discovered the new bacterium, stands next to the colorful microbial mats in Octopus Spring in Yellowstone National Park. Credit: David Strong, Penn State

In the hot springs of Yellowstone National Park, a team of researchers has discovered a novel bacterium that transforms light into chemical energy.

The discovery of the chlorophyll-producing bacterium, Candidatus Chloracidobacterium (Cab.) thermophilum, will be described in the 27 July 2007 issue of the journal *Science* in a paper led by Don Bryant, the Ernest C. Pollard Professor of Biotechnology in the Department of Biochemistry and Molecular Biology at Penn State University, and David

M. Ward, Professor of Microbial Studies in the Thermal Biology Institute and Department of Land Resources and Environmental Sciences at Montana State University, and colleagues.

Yellowstone National Park is known as a tourists' wonderland that is full of animals, strange rock formations, geysers, and colorful hot springs, but it is also a scientific reservoir housing what may be the world's largest diversity of thermophilic (heat-loving) bacteria. Yellowstone habitats have been explored since the 1960s for new organisms that may have important applications in biotechnology, for cleaning up pollution (bioremediation), or in medicine. The research team led by Bryant and Ward found the new bacterium living in the same hot springs as the most famous Yellowstone microbe, Thermus aquaticus, which has revolutionized forensics and other fields by making the polymerase chain reaction (PCR) a routine procedure.

Remarkably, the new genus and species Cab. thermophilum also belongs to a new phylum, Acidobacteria. The discovery marks only the third time in the past 100 years that a new bacterial phylum has been added to the list of those with chlorophyll-producing members. Although chlorophyll-producing bacteria are so abundant that they perform half the photosynthesis on Earth, only 5 of the 25 major groups, or phyla, of bacteria previously were known to contain members with this ability.

"The microbial mats give the hot springs in Yellowstone their remarkable yellow, orange, red, brown, and green colors," explains Bryant. "Microbiologists are intrigued by Octopus and Mushroom Springs because their unusual habitats house a diversity of microorganisms, but many are difficult or impossible to grow in the lab. Metagenomics has given us a powerful new tool for finding these hidden organisms and exploring their physiology, metabolism, and ecology."

Metagenomics is a means of studying organisms without having to culture them. Bulk samples are collected from the environment, then DNA is isolated from the cells and sequenced by so-called shotgun sequencing on a very large scale. Analysis of the DNA sequences reveals what types of genes and organisms are present in the environment. The team focused on two genes: 16S ribosomal RNA, a crucial component of the machinery used by all living cells to manufacture proteins; and the gene for a protein called PscA, which is essential for converting light energy into chemical energy. 16S ribosomal RNA is distinctive in each species.

Says Bryant, "Finding two new genes with a computer is not enough to justify naming a new organism. You need to prove those genes come from the same genome." Because the two genes were close together in the genome, the team was successful in isolating a single fragment containing both. "We were lucky that a former graduate student in Ward's lab, Jessica Allewalt, had already grown a culture of mixed microbes from the mats," Bryant explains, "although she didn't realize at the time that the mixture contained Cab. thermophilum."

Cab. thermophilum grows near the surface of the mats together with cyanobacteria, or blue-green algae, where there is light and oxygen, at a temperature of about 50 to 66 degrees Centigrade (122 to 151 degrees Fahrenheit). The organism was found in three hot springs --Mushroom Spring, Octopus Spring, and Green Finger Pool -- in the Lower Geyser Basin, not far from the Old Faithful Geyser.

Unexpectedly, the new bacterium has special light-harvesting antennae known as chlorosomes, which contain about 250,000 chlorophylls each. No member of this phylum nor any aerobic microbe was known to make chlorosomes before this discovery. The team found that Cab. thermophilum makes two types of chlorophyll that allow these bacteria to thrive in microbial mats and to compete for light with cyanobacteria.

This discovery is particularly important because members of the Acidobacteria have proven very hard to grow in laboratory cultures, which means their ecology and physiology are very poorly understood. Most species of Acidobacteria have been found in poor or polluted soils that are acidic, with a pH below 3. However, the Yellowstone environments are more alkaline, about pH 8.5 (on a scale of 1 to 14). Bryant notes, "Judging from their 16S rRNA sequences, the closest relatives of Cab. thermophilum are found around Mammoth Hot Springs in Yellowstone and hot springs in Tibet and Thailand. As we look more closely, we may find relatives of Cab. thermophilum in the microbial mats of thermal sites worldwide."

"Finding a previously unknown, chlorophyll-producing microbe is the discovery of a lifetime for someone who has studied bacterial photosynthesis for as long as I have (35 years)," says Bryant. "I wouldn't have been as excited if I had reached into that mat and pulled out a gold nugget the size of my fist!" He adds, "I am really grateful to Dave Ward for the chance to work with him and his students in the park and to visit Montana frequently. Our collaboration is a great example of how science really becomes exciting when scientists from different disciplines interact."

Source: Penn State

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