Old life capable of revealing new tricks after all

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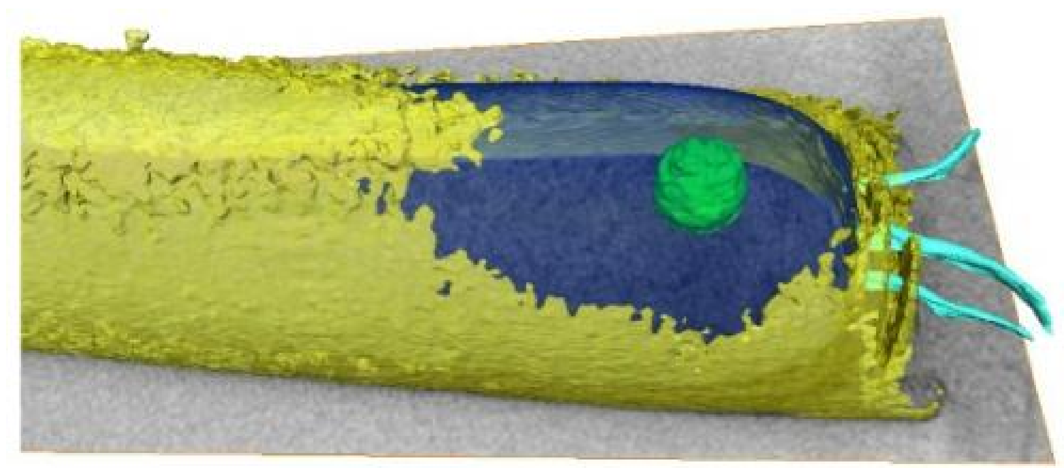

3-D model of M. hungatei, with granule (green). A rendering of the M. hungatei, showing a granule at one end, represented by the gree sphere.

(PhysOrg.com) -- Archaea are among the oldest known life-forms, but they are not well understood. It was only in the 1970s that these single-celled microorganisms were designated as a domain of life distinct from bacteria and multicellular organisms called eukaryotes.

Robert Gunsalus, a UCLA professor of microbiology, immunology and molecular genetics, developed an interest in Archaea because of their ability to thrive in harsh environments. Now, using state-of-the-art imaging equipment at the California NanoSystems Institute (CNSI) at UCLA, he has shown for the first time that a type of Archaea known as

Methanosprillum hungatei contains incredibly efficient energy-storage structures.

The findings are published in the July 5 issue of the journal *Environmental Microbiology*.

M. hungatei is of considerable environmental significance because of its unique ability to form symbiotic relationships with syntrophic bacteria to break down organic matter and produce methane gas. Yet while their important role in the food chain has been studied, little has been known about how they generate and store energy.

Gunsalus has researched anaerobic organisms like M. hungatei — microbes that thrive in oxygen-depleted environments where energy is often extremely limited — for a number of years. And when Hong Zhou, a professor of microbiology, immunology and molecular genetics, arrived at UCLA in 2006, Gunsalus saw an opportunity to delve further into their mysteries.

"When Hong came to UCLA, his reputation in imaging nanoscale structures was already well established," said Gunsalus, who is also a member of the UCLA–Department of Energy Institute for Genomics and Proteomics. "His arrival on campus brought together the expertise to do what no one had yet done — a detailed study of the sub-cellular structures in M. hungatei."

Much of the actual imaging work for the study was performed by Dan Toso, a graduate student in Zhou's lab, using equipment from the Electron Imaging Center for Nanomachines (EICN), a core lab at the CNSI directed by Zhou. When Toso and the rest of the team produced the most detailed images yet made of the M. hungatei interior, they were surprised by the appearance of granules, structures measuring approximately 150 nanometers in diameter that store energy.

"Once we imaged the M. hungatei, we noticed how dark the granules appeared," said Zhou, a researcher at the CNSI. "The darkness arises from their density, and by studying this density, we discovered their energy-storage capacity."

The group was able to determine the granule density — about four times that of water — by using a Titan scanning transmission electron tomography (STEM) microscope, cryo-electron microscopy, and energy-dispersive X-ray spectroscopy, all part of the EICN lab's extensive tool set.

The tiny granules, which account for less than 0.5 percent of the cell, are so efficient that they each store 100-fold more energy than the entire rest of the cell. Each M. hungatei produces two granules, one at each end of the cell. Because all M. hungatei produce granules in the same location, and typically at the same time in their life-cycle, it is likely that their DNA contains specific genetic instructions for the creation and positioning of the granules.

The researchers hope to utilize knowledge gained from the recent sequencing of the M. hungatei genome by the U.S. Department of Energy Joint Genome Institute to further study the structures. If the specific genetic instructions for creating granules can be found in the genome, it might be possible to use the granules as a sort of chemical battery for engineered synthetic cells.

Beyond their energy-storage capacity, M. hungatei still have more secrets to reveal, according to the researchers. They also produce a distinct nanostructure sheath around their cell membrane that might serve as a sort of protection, or "cell armor," against the harsh environments in which they are typically found. Though the sheaths were discovered in the 1970s, the technology necessary for studying them in detail had yet to be developed at that time.

"M. hungatei have evolved unique features in order to survive in very harsh and low-energy environments," Gunsalus said. "The presence of cutting-edge equipment and world-class experts at UCLA allows us to closely study them, hopefully revealing their myriad of secrets."

The researchers' next goals are to elucidate the exact biological function of the granules and sheaths in M. hungatei. Many functions have been proposed for the granules, including as energy sources for cell division, or to power flagella that move the cells, or even as a protection against metal toxicity from heavy metals like iron or copper.

Provided by University of California Los Angeles

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