# Biochemists reveal details of mysterious bacterial microcompartments

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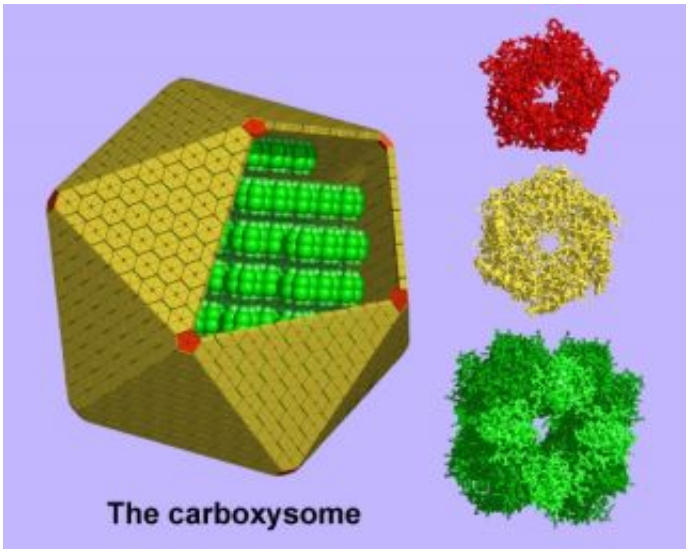


UCLA chemists are studying the structure of a protein shell called the carboxysome. The pentagons (shown in red) sit at the corners of the shell and are critical for causing an otherwise flat layer of hexagons to close. Credit: Todd O. Yeates/UCLA Chemistry and Biochemistry

UCLA biochemists and colleagues have answered an important question about the structure of microcompartments — the mysterious molecular machines that seem to be present in a wide variety of pathogens and other bacteria.

In the Feb. 22 issue of the journal *Science*, the biochemists report how the microcompartment structure closes in three dimensions, forming a

shell around the enzymes encased inside.

If scientists could prevent or disrupt the formation of these microcompartments, they could probably render the bacteria harmless, said research co-author Todd O. Yeates, UCLA professor of chemistry and biochemistry and a member of the UCLA–Department of Energy Institute of Genomics and Proteomics. They do not yet know how to do this, but the current research may provide a framework for targeting microcompartments.

Yeates and his colleagues have identified the proteins that play the critical role in how the structure folds in the carboxysome, a protein shell that is the best-known and most-studied microcompartment. The shell has a structure like a soccer ball or the large, iconic dome structure at the Walt Disney World's Epcot Center.

"A soccer ball has hexagons and 12 pentagons at the corners; the pentagons are essential to close the structure," said Yeates, who is also a member of the California NanoSystems Institute at UCLA and UCLA's Molecular Biology Institute. "The Epcot Center at Walt Disney World has Spaceship Earth, a well-known dome structure composed of triangles that fit into hexagons, but on closer inspection you will find 12 locations where only five triangles come together; the same is true of the Buckminster Fuller-type domes in the desert and many viral structures.

"This principle of closing a structure by combining a large number of hexagons with a small number of pentagons to create a piece of curvature has been understood by architects, molecular biologists studying viruses and soccer ball manufacturers."

That principle is also understood by microcompartments, in which proteins form 12 pentagons to close the structure; fewer than 12 would not completely close it, said Yeates, who calls the proteins "pentameric

carboxysome shell proteins."

The structure of the carboxysome shows a repeating pattern of six protein molecules packed closely together. The carboxysome has more than 3,000 sub-units with six edges and six vertices in a single shell, Yeates said.

In August 2005, Yeates and colleagues reported in the journal Science an underlying principle that governs the assembly of microcompartments: The proteins that form the outer shell form hexagons, which fit together to form extended two-dimensional molecular sheets. The researchers hypothesized that the molecular sheets formed by these hexagons formed the outer shell of the microcompartment and the tiny holes allowed small molecules to move in and out. Yeates and his colleagues have now answered how the shell closes in three dimensions.

Yeates is now studying other microcompartments that are of biomedical importance. Bacteria produce microcompartments when they infect a host, he said.

"We're learning about the kinds of strategies that bacteria have evolved to optimize the efficiency with which they operate or to deal with challenges they face," Yeates said. "In some cases, microcompartments are believed to serve a protective function, protecting the cell."

In the future, Yeates wants to learn how the shell comes to surround the enzymes, how microcompartments are formed and how microcompartments differ from one another. He is also interested in whether it is possible to create "designer microcompartments" that would encase other enzymes.

A key distinction separating the cells of primitive organisms like bacteria, known as prokaryotes, from the cells of complex organisms

like humans is that complex, or eukaryotic, cells have a much higher level of sub-cellular organization.

Yeates' research blurs the distinction between eukaryotic cells and those of prokaryotes by showing that bacterial cells are more complex than scientists had imagined.

If microcompartments can be engineered, biotechnology applications could potentially arise from this research, Yeates said.

Source: University of California - Los Angeles