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Press Release

How “dead” bacteria return to life

Tübingen researchers discover strict genetic timetable for resuscitation of dormant cells

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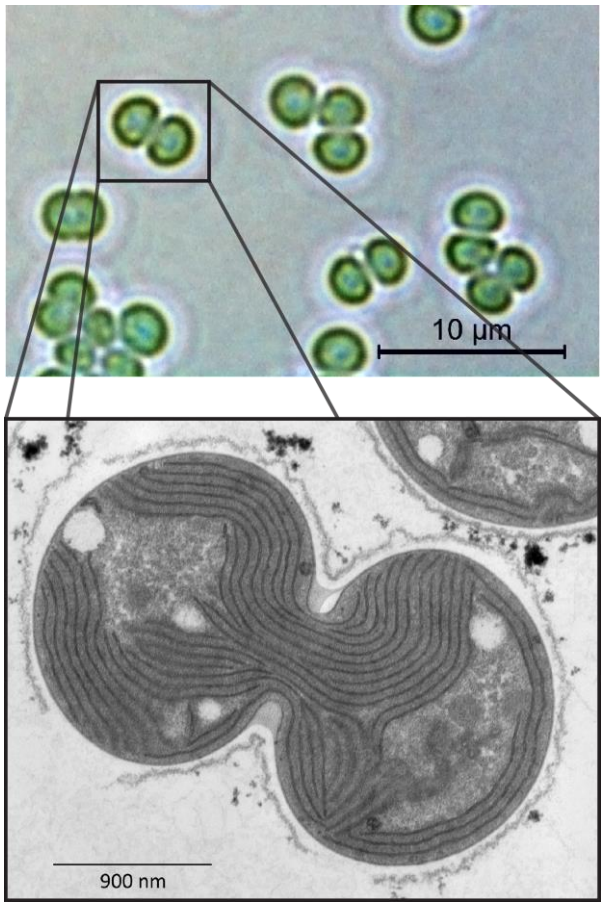
Many bacteria – including dangerous pathogens – can make radical changes to their metabolism, switching into a dormant state which allows them to survive periods in which no growth is possible. Such dormancy occurs for instance when the microbes do not have enough food. International researchers working with Professor Karl Forchhammer and Alexander Klotz at University of Tübingen’s Interfaculty Institute of Microbiology and Infection Medicine have become the first to analyze the awakening process of cyanobacteria. They found that the cells’ revival process followed a strict genetic timetable. The results of their study have been published in the latest issue of *Current Biology.* The findings provide insight into a previously unknown survival strategy of bacteria and enable the researchers to draw key conclusions about cell aging processes.

The blue-green photosynthesizing cyanobacteria belong to the oldest group of bacteria; traces of them go back more than three billion years. Their activity released oxygen into the atmosphere, enabling life on Earth in its current forms. Cyanobacteria continue to play an important role in environmental cycles. When nitrogen as major nutrient is lacking, many cyanobacteria cease growing and go into a dormant state. They dismantle their photosynthesis apparatus and lose their color. In this way they can survive long periods without nutrients. Yet when exposed to an accessible supply of nitrogen, they return to normal life within 48 hours. “The cells only appear dead. Their vital functions reappear out of nowhere,” says Karl Forchhammer. Until recently little was known what happened to bring about this apparent resurrection of bacterial cells.

“In our experiments, the cell revival program began almost the instant we added nitrate,” Forchhammer says. “The process is highly organized.” In the first phase, the bacteria suppressed all remaining photosynthesis activity and instead tapped into their reserves to obtain energy quickly. Cellular processes were switched on according to a strict step-by-step timetable. First to be activated were the production of protein synthesizing

mechanisms along with the intake and processing of nitrogen. “Not until twelve to 16 hours later did photosynthesis begin; and full capacity was reached after 48 hours. Then the cells began to grow and divide again,” according to Alexander Klotz, doctoral candidate in the Molecular Principles of Bacterial Survival Strategies research training group, which is headed by Professor Forchhammer. The researchers’ observations indicate that important switches in the awakening process are located in sections of uncoded RNA. They are copies of DNA which are not translated into proteins; they have regulatory functions.

“This genetically coded program of dormancy and revival allows cyanobacteria to colonize environments in which the nitrogen supply is inconstant,” Forchhammer says. “It is one of the ways how they can survive environmental stress and were thus able to survive for more than three billion years of evolution.” The dormancy phenomenon is also found in many other bacteria, particularly those which colonize environments which face frequent shortages of nutrients. “You could see the dormant stage as a kind of seed bank, a reservoir of cells which can propagate quickly as soon as the environmental conditions become favorable,” the researchers say. “This is how for instance pathogens revive from dormancy and set off infections.” The findings of this study have uncovered a principle which is valid for many types of bacteria, according to Forchhammer. “It will help us to better control the spread of dangerous bacteria,” he says.



Cyanobacteria *Synechocystis* sp. PCC 6803. Top: Under the optical microscope, bottom: under the transmission electron microscope. Images: Alexander Klotz

Cutting off the nitrogen supply: A cyanobacteria culture prior to nitrogen removal (left), after several days (middle), and after more than three weeks (right). Photo: Alexander Klotz

Publication:

Alexander Klotz, Jens Georg, Lenka Bučinská, Satoru Watanabe, Viktoria Reimann, Witold Januszewski, Roman Sobotka, Dieter Jendrossek, Wolfgang R. Hess, Karl Forchhammer: Awakening of a dormant cyanobacterium. Resuscitation of chlorotic cells reveals a genetically determined program. *Current Biology,* DOI 10.1016/j.cub.2016.08.054

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