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New study illuminates ability of hot-water bacteria to survive cold shock

RIKEN researchers have made a breakthrough in understanding how bacteria in hydrothermal vents can survive extreme changes in temperature.

A new study sheds light on how a type of bacteria that lives in deep-ocean hydrothermal vents can survive, and even thrive, despite extreme changes in water temperature. It also sheds light on the structure of a protein named RbfA and its role during protein assembly.

The bacteria, *Thermus thermophilus*, is what is known as a thermophilic organism, able to thrive at high temperatures of around 65 C. Analysis of its genome was completed in 2004, and it is commonly used in a variety of applications in biotechnology. It was originally found in a hydrothermal vent, a fissure that emits jets of geothermally heated water, on the ocean floor near Japan.

The RIKEN study focused on how the bacteria is able to adapt and continue to grow, despite undergoing sudden cooling known as 'cold shock.' This involves a sudden change of temperature from 65C to near freezing, such as may happen when bacteria stray out of the hot water streaming from a hydrothermal vent into the surrounding cold ocean water.

The team, including scientists from Riken's Genomic Sciences Center in Yokohama, studied the role of a protein known as Ribosome binding factor A, or RbfA, in adapting to such cold shocks. Ribosome protein molecules play an important role in cell division, in accurately expressing the genetic information contained in an organism's DNA.

The RbfA protein is in effect a cold-shock response protein, present in very low concentrations in the cell at temperatures of around 65 C. Following a drop in temperature, the cell rapidly produces more RbfA. The scientists were able to construct a three-dimensional map of the structure of RbfA via computer analysis of data obtained with a special type of microscope called a cryo-electron microscope.

Following this, the team was able to theorize about precisely how RbfA acts under conditions of cold shock. Ribosomes are involved in the assembly of proteins from the genetic information contained in the cell's DNA. This information is transferred via molecules known as messenger RNA, in a process called translation.

The team was able to identify the exact part of the messenger RNA helix that the RbfA protein acts on during protein construction - it acts to ensure the correct folding and maturation of the new protein under cold shock conditions. In this way, it enables the bacteria to continue to grow and divide, ensuring its survival even under extreme environmental changes.

Later, the scientists compared the structure of RbfA from *T. thermophilus* with RbfA from other bacteria, such as *E. coli*, which is found in the lower intestines of mammals, although it is also known to colonize the edges of hot springs. They studied the differences in structure that enable *T. thermophilus* RbfA to continue to synthesize proteins effectively at low temperatures.

Bacteria have been found living in the most extreme environmental conditions on Earth, and appear to have few limits in terms of the places they can survive. In addition to the heat of thermal vents, they have been found living in the extreme cold of a subglacial lake in Antarctica. This research gives more understanding of their remarkable adaptability. It also sheds light on the structure of RbfA and its role during protein assembly.

This study was conducted in collaboration with scientists from State University of New York at Albany and Goethe-Universität Frankfurt am Main.

Original work:

Datta, P., Wilson, D., Kawazoe, M., Swami, N., Kaminishi, T., Sharma, M., Booth, T., Takemoto, C., Fucini, P., Yokoyama, S. and Agrawal, R. Structural Aspects of RbfA Action during Small Ribosomal Subunit Assembly. *Molecular Cell*, published online on Nov 8, 2007

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