How do microorganisms survive in extreme conditions?

You may have taught how extreme regions like glaciers, mountains, and deep oceans are habitats for many organisms including bacteria, archaea, algae, and yeasts as well as glaciers ice worms, plants and animals. These organisms survive in a temperature usually lower than 5 °C and they continue their natural lives like other organisms living in normal temperature.

Studding psychrophilic proteins can help us unravel adaptation mechanisms in cold regions. On the other hand, exploiting psychrophilic proteins, which need less energy for its activation, is economically beneficial for the processes in which they are involved. Such industries include detergent food, textile manufacturing, pharmaceutical, biofuels, and energy production. For example, if we use detergents contains enzymes that need less temperature to remove oily spots, water temperature in the laundry does not need to be raised. It will save more energy and will not ruin the clothes.

Like human beings, proteins are critical biological macromolecules in other organisms and microorganisms. They function in many cellular mechanisms in the body acting as the key molecules. The most important feature of proteins is their structural parameters. Minute changes in the structure of proteins lead to noticeable changes in cell faith. Based on the temperature, proteins are categorized into mesophiles, thermophiles and Psychrophiles. Microorganisms living at temperatures higher than 100 °C at large depths in seas are endowed with thermophile proteins and those who live in glaciers have psychrophile proteins within their body. These proteins are responsible for the adaptation mechanisms to the environment.

To investigate the differences of protein structures between psychrophilic and mesophilic proteins, we have studied 30 pairs of mesophilic and psychrophilic proteins. In our previous studies, we considered sequence parameters like amino acid composition and distribution as well as structural parameters. Amino acids are building blocks of proteins, shaping proteins to functional structures. Since there are 20 different amino acids with different biochemical features encompasses polar, non-polar, hydrophobic or hydrophilic, amino acid composition of proteins is an underlying cause of various upper protein structure.

Here, for example, we calculate accessible and buried surface by computerized approaches and the results shows a slight differences in surface area of psychrophilic and mesophilic proteins responsible for more flexibility in the psychrophilic proteins. The total surface area of a biomolecule that is approachable by a solvent is called accessible surface area. Imagine catching a ball, the surface of the ball that you are touching is similar to accessible surface area; the difference is that in proteins the surface is catching by water or any other biological molecules. Since proteins does not have completely empty space like a ball, there is another surface in proteins called buried area or buried surface area.

The most important result of this study is that psychrophilicity rules are not merely the inverse rules of thermostability. The results suggest some possible general rules for protein design experiments aimed to produce enzymes catalytically more effective at low temperatures.

Publication

Protein cold adaptation: Role of physico-chemical parameters in adaptation of proteins to low temperatures.
Shokrollahzade S, Sharifi F, Vaseghi A, Faridounnia M, Jahandideh S
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