

Cold-Shock Response and Adaptation

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The most common stress that living organisms constantly confront in nature is likely to result from temperature changes. Figure 1 shows the temperature changes in Newark, New Jersey during a one year period. The graph shows both average highest and lowest temperatures of each month as indicated by open and solid circles, respectively. One can see that per month there is a difference of approximately 10°C between the highest and the lowest temperatures and annually the temperatures fluctuate from -5 to 30°C. How do organisms living in this area respond and adapt to the wide temperature changes, in particular, the low-temperature stress or the cold shock? It is interesting to note that these organisms are not exposed to high-temperature stress (heat shock). Nevertheless, while heat-shock effects have been extensively studied in both prokaryotes and eukaryotes, few studies have been carried out to show how living organisms respond to cold shock.

A major reason why heat shock is more thoroughly investigated as compared to cold shock is that heat shock causes a well-defined damage to cells, *i.e.*, protein unfolding or denaturation and that all living organisms from bacteria to humans contain heat-shock proteins, which are induced upon heat shock to assist protein folding. In contrast, cold shock does not produce such well-defined damage. As temperature is downshifted, cell growth slows down and eventually stops.

The research on cold shock raises a number of questions such as which cellular function is affected most upon cold shock, what makes cell growth stop, and whether there are well-conserved or common cold-shock proteins as in case of heat-shock proteins. These questions are not less important compared to those in case of heat shock, and for the last several years interesting results on cellular adaptation and response to cold shock have been obtained.

It is highly important to arrange a symposium of cold-shock response and adaptation to overview the present status of the cold-shock research. I believe that this is the first symposium organized on cold-shock research that encompasses bacteria to humans. In this symposium, Dr. K. Yamanaka, Dr. P. Graumann and Dr. M. A. Marahiel present the molecular mechanisms of cold-shock response and adaptation in *Escherichia coli* and *Bacillus subtilis*, the most studied systems at present. In these systems, it has been shown that there are a number of cold-shock proteins that are induced upon temperature downshift. In particular, small molecular weight proteins consisting of approximately 70 amino acid residues are produced in a large amount;

CspA for *E. coli* and CspB for *B. subtilis*, which are proposed to function as an RNA chaperone to enhance translation by blocking the formation of secondary structures in mRNAs. We also asked Drs. M. Hebraud and P. Potier to present current studies on psychrotrophic bacteria, which preferentially live at low temperatures. Their research deals with an interesting question of how the optimal temperature range for growth is determined, and what determines the lowest permissive temperature for these bacteria.

The research on psychrotrophic and psychrophilic bacteria is also important for human health because they cause food spoilage and cause food-borne diseases.

Drs. D. A. Los and N. Murata present the research on desaturases of cyanobacteria, which play an essential role to maintain the membrane fluidity upon cold shock. Further, Dr. C. Guy presents an overview on the cold-shock research in plants, describing that there are a large number of cold-shock genes identified in plants, and a signal transduction pathway triggered by cold shock. He also discusses important questions such as how to improve plants to be more tolerant to low temperatures. Finally, Dr. J. Fujita, who found a cold-shock inducible RNA-binding protein called CIRP in mammalian cells, presents an extensive review on cold-shock response in mammalian cells.

Although each system seems to respond to cold shock in its unique way, studies from different organisms revealed existence of a few common cellular functions, which have to be dealt with for cold-shock adaptation. One such function is to increase the membrane fluidity and the other is to enhance translation probably at the level of initiation and elongation. I hope that the audience of the present symposium recognizes cold-shock research as a hot topic and that its further advancement will not only yield new exciting discoveries with respect to biological function, but will also aid the improvement of human health and the energy conservation.

We owe the success of this symposium to Dr. K. Yamanaka, who took a major editorial role in this event.

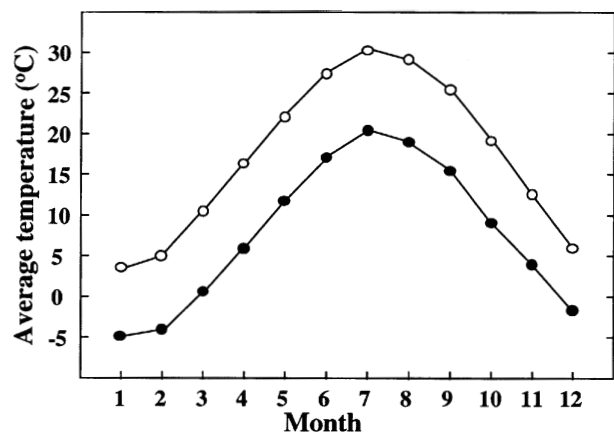


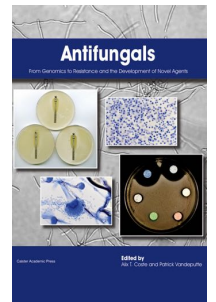
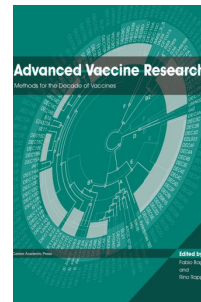
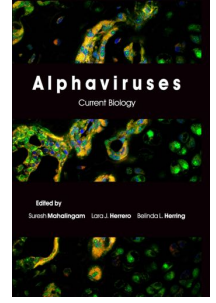
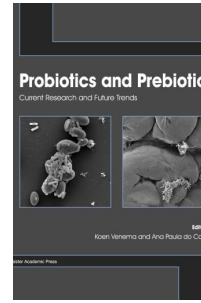
Figure 1. Annual Temperature Changes in Newark, New Jersey. Average highest and lowest temperatures for each month are shown by open and solid circles, respectively. Information was obtained from: <http://weather.yahoo.com/almanac/Newark-NJ-US>.

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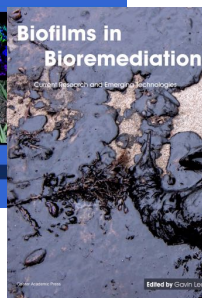
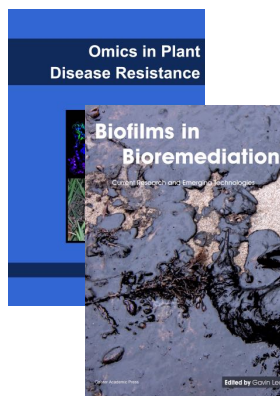
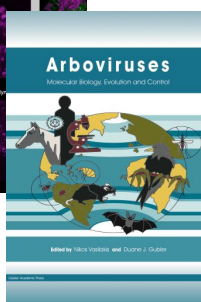
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