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ROLE OF MOLECULAR CHAPERONES IN COLD ADAPTATION OF BACTERIA

M. K. Chattopadhyay

Centre for Cellular and Molecular Biology, Hyderabad - 500 007 (India)

Molecular chaperones are proteins, which ensure correct folding of cellular proteins and RNA. They also help in refolding of the denatured proteins and degradation of the aggregated proteins. Thus they play the role of a quality control system in the cell.

Heat shock proteins (HSPs) are induced in living cells under a variety of stress conditions. Some of the HSPs can behave as molecular chaperones. During thermal stress, cold stress and osmotic stress, cellular proteins tend to aggregate and hence it is the chaperoning effects of the HSPs, which appear to be responsible for their stress protective role.

The role of HSPs in cold adaptation of bacteria is beginning to be understood. It was shown a couple of years ago that rate of survival of a strain of *Escherichia coli* after incubation at -80^{o}C for 24 hours could be significantly improved by warming the solution at 42 ^{o} C for 30 minutes before cold storage. The induction of the heat shock proteins (Dna K/Dna J) in the heat treated sample was also demonstrated (Chow and Tung 1998). The Clp B protein, which is essential for thermotolerance in Cyanobacteria and Eukaryotes, was found to be induced by moderate chilling in the cyanobacterial strain *Synechococcus* PCC 7942. Following a shift from 37^{o}C to 25^{o}C, growth and photosynthesis were more adversely affected in a mutant having deletion in the *clp B* gene, compared to the wild type *Synechococcus* PCC 7942 (Porankiewicz and Clarke 1997). The role of the Htp G protein (a prokaryotic homolog of the heat shock protein Hsp 90) in both thermal adaptation and cold acclimation of the same organism was also reported some time back (Hossain and Nakamoto 2002).

The postulation, that HSPs promote survival of bacteria at low temperature, has been bolstered further by an investigation by Ferrer et al (2003). They showed that growth rate of a strain of *E. coli* rapidly decreased below 20^{o}C and it was unable to grow below 7.5^{o}C. They also showed that ability of two chaperonins (a class of molecular chaperones) viz Gro EL and Gro ES, isolated from *E coli*, to refold denatured proteins was rapidly decreasing below 15^{o}C. These two proteins are responsible for correct folding/assembly of more than 30% of the cellular proteins. The investigators postulated that the inability of the bacterium to grow at low temperature could be explained in terms of the decreased ability of its chaperonins to function at low temperature. In order to corroborate their postulation, they chose a cold-adapted bacterium *Oleispira antarctica* (isolated from Antarctic seawater) as a model and estimated the protein refolding activity of its two chaperonins viz, Cpn 60 and Cpn 10 at different temperatures. The proteins were found to have 16-fold higher activity at 4 to 12^{o}C compared to their activity at 30^{o}C. By cloning and expressing the genes encoding these two chaperonins in *E coli*, they were able to get a recombinant strain of *E coli*, which could grow below 4^{o}C. The rate of its growth was much higher at low temperatures compared to that of the parent strain. In one experiment it was found to grow 141-fold higher than the parent strain at 8^{o}C.

The finding, that even a mesophilic organism could grow at low temperature by recruitment of the chaperonins from a cold adapted organism, is of immense significance. Besides demonstrating the role of HSPs in cold adaptation of bacteria, it provides new scope for bioremediation. Using the same technique, bacterial degradation of garbage (including petroleum products) in cold environment of glaciers and polar regions may be facilitated. Proteins from psychrophilic organisms, produced in *E coli* by cloning and expression of the corresponding genes, lack stability in many cases. Using this strategy it may also be possible to stabilize them. The report therefore bears major impetus both for theoretical biology and biotechnology.

REFERENCES

1. Chow K-C and Tung W L. Overexpression of dna *K*/ dna *J* and *gro EL* confers freeze tolerance to *Escherichia coli. Biochem Biophys Res Commun* **253,** 502-505 (1998)
2. Ferrer M, Chernikova T N, Yakimov M M, Golyshin P N and Timmis K N. Chaperonins govern growth of *Escherichia coli* at low temperatures. *Nat Biotechnol* **21,** 1266-1267 (2003)
3. Hossain M M and Nakamoto H. Htp G plays a role in cold acclimation in cyanobacteria. *Curr Microbiol* **44,** 291- 296 (2002)
4. Porankiewicz J and Clarke A K. Induction of the heat shock protein Clp B affects cold acclimation in the cyanobacterium *Synechococcus* sp.strain PCC 7942. *J.Bactertiol* **179:** 5111-5117 (1997)