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Ice 'swords' in the Taylor Valley, Dry Valleys, Antarctica, in Autumn 2007. Image courtesy of P. Amato, INRA, France.

ENVIRONMENTAL MICROBIOLOGY

Freezing energizes bacterial metabolism

The biochemical and molecular properties that allow cold-adapted bacteria, or psychrophiles, to survive and grow in extremely cold conditions are increasingly well characterized. Now, in the first analysis of psychrophilic energy metabolism below freezing point, Pierre Amato and Brent Christner reveal that the cellular levels of ATP and ADP increase at low temperature.

Extremely low temperatures present several hurdles to microbial survival and growth, including decreased membrane fluidity, decreased enzyme-substrate affinity and decreased reaction rates. Psychrophilic bacteria have evolved mechanisms, such as increased membrane lipid unsaturation, increased enzyme concentration and cold-shock protein induction, to overcome these problems.

Amato and Christner began to address how bacterial metabolism is affected in freezing conditions by analysing the effects of low temperature on the levels of ATP and ADP in *Psychrobacter cryohalolentis* K5. Owing to their key roles in the transfer of biochemical energy, the concentrations and proportions of ATP and ADP can be used to provide information on the metabolic state of the cell. The authors found that in *P. cryohalolentis* cells, ATP concentration was significantly increased in cells incubated between −15 and −80 °C compared with cells incubated at −5 to +22 °C. Similarly, the concentration of ADP increased between −15 and −80 °C, suggesting that the increase in ATP levels was not simply due to decreased consumption in freezing conditions. Use of the proton ionophore carbonyl cyanide *m*-chlorophenyl hydrazone to uncouple oxidative phosphorylation decreased temperature-dependent adenylate accumulation, indicating that energy adaptation to frozen conditions requires a functioning proton motive force.

Why would psychrophiles benefit from modifying their cellular adenylate levels? Increasing adenylate concentrations could maintain metabolic reaction rates by offsetting the decreased rates of enzymatic reactions. Alternatively, accumulation of ATP and ADP at sub-zero temperatures might provide an energy reserve for repair and maintenance pathways or enable faster resumption of normal metabolism when favourable growth conditions are reintroduced. Further work is needed to distinguish between these alternatives.

> "…energy adaptation to frozen conditions requires a functioning proton motive force."

Andrew Jermy

ORIGINAL RESEARCH PAPER Amato, P. & Christner, B. C. Energy metabolism response to low temperature and frozen conditions in *Psychrobacter cryohalolentis*. *Appl. Environ. Microbiol.* 5 Dec 2008 (doi:10.1128/AEM.02193-08)