Biophysics and Biochemistry at Low Temperatures

by Felix Franks

Cambridge University Press; Cambridge, 1985

206 pages. £25.00, $44.50

The refrigerator and deep-freeze are essential commonplace items of equipment both on the domestic and commercial scenes and in the laboratory, so commonplace perhaps that few users give much thought to the processes that can take place in materials placed in such devices other than to their basic storage function. The use of low temperatures as a means of preservation of biochemical and biological materials extends over a very wide range from the storage of heat-labile biochemicals and foodstuffs to the storage of cultured cells in molecular biology and plant genotypes in the field of agriculture. In medicine the use of low temperature as a surgical tool is important in the handling of transplant tissue, neurosurgery and cancer therapy.

In this unique book the author has addressed the field of low-temperature biophysics and biochemistry in a systematic manner covering all aspects of the processes which are important when materials and organisms are maintained at low temperatures. There are ten chapters; after setting the scene in the introductory chapter the biophysics and physical chemistry of water and aqueous solutions at subzero temperatures are considered, emphasis being placed on the nucleation of ice which we learn in later chapters is lethal to cells if it occurs in the cytoplasm. The physical chemistry of aqueous solutions is discussed in chapter 3 where some of the not so obvious pitfalls are noted. It is, for example, not such a simple matter to determine correctly pH at low temperatures (the degree of ionization of water decreases remarkably with decreasing temperatures). Cryobiochemistry and the response of proteins to suboptimal temperatures is given a chapter to itself. This chapter in particular should be of general interest to biochemists. Most biochemists are very conscious of heat denaturation of proteins but perhaps not so aware of 'cold denaturation' which as the author points out is more important than heat denaturation and is of real physiological significance to organisms which must survive overwintering. Enzyme reactivity at low temperatures (cryoenzymology) and the use of materials to protect proteins from denaturation at low temperatures are also discussed.

The latter part of the book is concerned with the response of cells to chilling and freezing, the ways in which living organisms cope with low temperatures and the preservation of cells, tissues and organs (cryobiology). Some very fundamental problems are posed in these chapters. Antifreeze peptides first described in Antarctic fish are well known, but the way in which they inhibit ice nucleation in undercooled body fluids is not fully understood and it is not even known whether they affect the homogeneous nucleation temperature of water. The effect of low temperatures on the germination of seeds is of considerable economic significance, yet little appears to be known about the organisation of lipids in the membranes of resting seeds or the way in which membrane-bound proteins are organised in the lipid matrix. The practically important problems associated with laboratory preservation of cells are given a detailed treatment starting from basic thermodynamics before passing onto the mechanisms of cryoprotectant action. In the penultimate chapter we are returned to water and the technology of its metastable states in food processing and storage before concluding with a brief general overview in the final chapter.

This is a unique and interesting book on a subject which impinges on many aspects of science and technology. As would be expected from an author who has written widely on the properties of water and aqueous systems, it is well researched and presented and will surely be of great value to all those concerned with biochemical and biological systems at low temperatures whether in academia or industry.

Malcolm N. Jones