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Freezing of Living Cells and Tissues: A Great Challenge in Thermal Science and Modern Medicine

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Life is a biochemical reaction process. Rate of the biochemical reaction is temperature-dependent and quickly diminishes at low temperatures, a fact that permits long-term cryopreservation of living cells and tissues for gene/cellular therapy, organ transplantation, bio-banking, and conservation of endangered or transgenic animal species (by gamete preservation). However, there is an apparent contradiction between the concept of the cryopreservation and experimental findings that the living cells can also be damaged by the cryopreservation process itself. To optimally employ low temperature in these biomedical applications, one must develop a fundamental understanding of the heat-mass transfer associated with the freezing/warming processes and its effects on the biological systems at low temperatures. Contrary to popular belief, the challenge to cells during freezing is not the cells' ability to endure storage at very low temperatures (below -190°C); rather it is the lethality of an intermediate zone of temperature (-15 to -60°C) that the cells must traverse twice, once during cooling and once during warming. The central theme of this presentation is to report our research work on: (1) the critical heat-mass transfer mechanisms of the cell/tissue cryoinjury and cryopreservation; and (2) development of optimal conditions and novel technology to prevent the cryoinjury and to ensure the survival of living cells/tissues during the cryopreservation to meet the increased and urgent needs in scientific and medical applications.