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Freezing of Living Cells and Organs: A Great Challenge for Thermal Science and Technology

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Abstract- Low temperature has been utilized to keep living cells and organs dormant but potential alive (i.e. cryopreservation) for tremendous scientific and biomedical applications, including biobanking, cellular/gene therapy, tissue engineering, regenerative medicine, stem-cell/organ transplantation, artificial organs, new drug development, and conservation of endangered species. However, there is a critical contradiction between the purpose of cryopreservation and the experimental findings that the living cells can be killed by the cryopreservation process itself. Contrary to popular belief, the challenge to cells during the cryopreservation is not their ability to endure storage at cryogenic temperatures (below -180 ℃); rather it is "the lethality" of heat-mass transfer process coupled with phase transitions within an intermediate zone of low temperature (-15 to -130 ℃) that a cell must traverse twice, once during cooling and once during warming. The central theme of this presentation is to report the speaker's research work on: (1) fundamental mechanisms of cryoinjury and cryoprotection, (2) micro-heat-mass transfer and its great impact on cell survival during the cryopreservation processes; and (3) development of optimal and novel technology for the cryopreservation to prevent the cryoinjury and to ensure the survival of living cells and organs.