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Yoed Rabin

Carnegie Mellon University, USA

Mechanical stress and structural integrity in vitrification processes

Success of cryopreservation by vitrification is the result of coupled phenomena, conveniently classified as associated with the exposure to low temperatures, the propensity to form glass, the toxicity of ice-controlling agents (ICAs), the degradation of biological material in a suspended state, and the development of thermo-mechanical stresses. Cryopreservation success is not dependent merely upon instantaneous effects, but upon the evolution of events along the cryopreservation protocol. While cryopreservation of small specimens frequently benefits from quite homogeneous conditions, higher complexity is introduced to cryopreservation of large-size specimens, where field properties such as temperature, ICA concentration, and mechanical strain vary significantly across the medium. In vitrification of large specimens for example, the cooling rate as a function of temperature vary across the specimen, leading to a spatially distributed probability to form glass. Simultaneously, the toxicity potential of ICAs is also affected by the spatially distributed thermal history. Furthermore, temperature gradients drive a non-uniform thermal expansion distribution in the material, which results in thermo-mechanical stresses and possibly structural damage. With such strongly coupled effects, the path-dependency nature of cryopreservation processes calls for special means of investigation. The current presentation reviews the conditions leading to the development of thermo-mechanical stress and structural damage. This presentation further discusses the unmet need for engineering approaches to the study of cryopreservation, as opposed to the diagnostic approach that historically dominated the field.

Biography

Yoed Rabin is a Professor of Mechanical Engineering at Carnegie Mellon University. He has completed his BSc from the Technicon-Israel Institute of Technology. He has published more than 220 publications in archival journals, conference proceedings, and book chapters. His research interests include “Energy modalities in biology and medicine, including cryopreservation, cryosurgery, hyperthermia, photodynamic therapy, and heat and mass transfer in biological systems”.

rabin@cmu.edu

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