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Modeling Mass Transport During Cell Cryopreservation and Determining Parameters for Cellular Lysis Upon Thawing

Cells are cryopreserved in concentrated media that becomes even more so as temperatures are reduced and extracellular ice forms. If cooling rates are slow, the cells remain in equilibrium with the extracellular environment until they are plunged into liquid nitrogen. It often is ideal to warm extremely rapidly, melting the surrounding media as quickly as possible. This results in cells that are relatively concentrated compared to their surrounding media. This concentration gradient drives water into the cells, causing them to swell and, potentially, rupture. This phenomenon is known to occur but has not been well explored and documented mathematically. Here we use a differential equation model for mass transport in cells to explore and understand the conditions under which this damage will and will not occur. We determine the appropriate model and solution technique, and analyze results in the context of the original application.