PHYSICAL MATHEMATICS SEMINAR

A model for cryopreservation and a homogenization of bacterial nutrient uptake

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ABSTRACT:

I present two different problems involving multiscale mass transport with biological applications, one relating to cryopreservation and the other to bacterial nutrient uptake

In the first part of this talk, I consider a problem from cryopreservation - the process of preserving biological constructs by cooling them to temperatures low enough to halt metabolic processes. In general, cooling too quickly results in the formation of lethal intracellular ice, while cooling too slowly amplifies the toxic effects of the cryoprotective agents (CPA) added to limit ice formation. I present a mathematical model to understand and quantify these observations, tracking the temperature and chemical concentration in three different regions: ice, extracellular liquid medium, and cell. This results in a three-phase, six-variable system with two moving boundaries, which I solve using a combination of numerical and asymptotic methods. I show how to use these to characterize the cell damage caused by freezing, accounting for supercooling and CPA toxicity, and hence to predict optimal cooling rates.

In the second part of this talk, I show how the effective nutrient uptake over a colony of bacteria depends on the bacterial properties by systematically upscaling an appropriate reaction-diffusion system. I use asymptotic homogenization to obtain an effective equation which takes the bacterial information into account. This quantifies when the intuitive volume and surface area scalings are each valid, as well as the correct form of the effective uptake when neither of these scalings is appropriate, informing larger-scale models involving bacterial nutrient uptake

TUESDAY, NOVEMBER 19, 2019
2:30 PM – 3:30 PM
Building 2, Room 131

Reception following in Building 2, Room 290
(Math Dept. Common Room)

http://math.mit.edu/seminars/pms/

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