MCEN GRADUATE SEMINAR

MECHANICS OF INTERSTITIAL GROWTH IN DEGRADABLE HYDROGEL SCAFFOLDS

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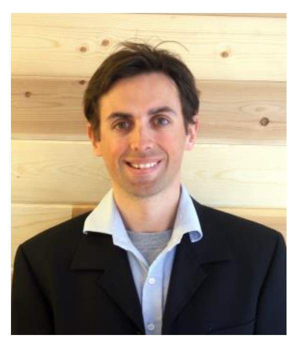
Abstract:
Despite tremendous advances in the field of tissue engineering, a number of obstacles are still hindering its successful translation to the clinic. One of these challenges has been to design cell-laden scaffolds that can provide an appropriate environment for cells to successfully synthesize new tissue while providing a mechanical support that can resist physiological loads at the early stage of in-situ implementation. A solution to this problem has been to balance tissue growth and scaffold degradation by creating new hydrogel systems that possess both hydrolytic and enzymatic degradation behaviors. Very little is known, however, about the complex behavior of these systems, emphasizing the need for a rigorous mathematical approach that can eventually assist and guide experimental advances. To address this issue, we introduce a model for interstitial growth based on mixture theory, that can capture the coupling between degradation, swelling, and transport of extracellular matrix (ECM) molecules released by cartilage cells (chondrocytes) within a hydrogel scaffold. The model particularly investigates the relative roles of hydrolytic and enzymatic degradations on ECM diffusion and their impacts on two important outcomes: the extent of ECM transport (and deposition) and the evolution of the scaffold's mechanical integrity. Numerical results based on finite element analysis show that if properly tuned, enzymatic degradation differs from hydrolytic degradation in that it can create a degradation front that is key to maintaining scaffold stiffness while allowing ECM deposition. These results therefore suggest a hydrogel design that could enable successful in-situ cartilage tissue engineering.

Biographical Sketch



Dr. Vernerey is an associate professor and Vogel faculty fellow in the Department of Mechanical Engineering at the University of Colorado, Boulder. He received his Ph.D. from Northwestern University in 2006 in the field of theoretical and applied mechanics with a concentration on continuum mechanics and multiscale methods. His expertise lies in using theoretical and computational approaches to better understand and control the mechanics of active soft matter, and more specifically, the interaction between soft colloidal particles (such as cells and liposomes) and the surrounding porous media. Applications range from bio-separation, targeted drug delivery and tissue engineering. Dr. Vernerey is the author of more than 40 scientific publications in peer-reviewed journals, has received the NSF career award in 2013 and is currently the principal investigator of several projects funded by the National Science Foundation and the National Institute of Health.