

2009-2010 Graduate Seminar Series

The Department of Mechanical Engineering – Engineering Mechanics

Proudly Presents

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Michelle L. Oyen is a Lecturer in Mechanics of Biological Materials in the Mechanics and Materials Division and the Engineering for the Life Sciences group in the [Cambridge University Engineering Department](#). She holds a B.S. degree in Materials Science and Engineering and an M.S. Degree in Engineering Mechanics, both from [Michigan State University](#) and a Ph.D. degree in Biophysical Sciences and Medical Physics from the [University of Minnesota](#). She joined Cambridge Engineering in 2006 following an appointment as Research Scientist at the [University of Virginia](#) Center for Applied Biomechanics. She is a member of the [Materials Research Society](#) and the [ASME Bioengineering Division](#), a principal editor for the [Journal of Materials Research](#), a moderator of [iMechanica](#) and a founding committee member and webmaster for the new UK-based Bioengineering Society.

Thursday, Mar. 18, 2010 3:00 – 4:00 p.m. Room 112, ME-EM Bldg.

Characterization of Poroelastic Properties of Hydrated Tissues by Indentation Testing

It has been established that changes in the mechanical properties of tissues are associated with disease state, due to altered structure-properties relationships at the level of tissue microstructure. Further, it has been shown that the time-dependent response of tissues is more sensitive than the elastic response to some changes in connective tissues. As such, there is a clear need for the development of characterization techniques that allow for the measurement of multiple facets of material behavior. Bone and other hydrated biological tissues are characterized as poroelastic: the mechanical response can be described with a continuum two-phase model that incorporates fluid flow through a porous elastic solid. Although poroelasticity has been studied for many decades, the coupled nature of poroelastic constitutive equations results in a problem that is typically solved only with numerical or computational models. Thus, poroelastic analyses have not been popular for routine data analysis. In the past decade, however, automated nanoindentation testing has allowed for the generation of large volumes of mechanical data, and the need for high-throughput data analysis for time-dependent materials has been established. In the current study, a new method is developed for high-throughput data analysis based on a master library of indentation creep curves for spherical indentation of a poroelastic material. Indentation tests are compared for hydrated equine bone samples tested at two disparate length-scales, encompassing both nanoindentation and microindentation instruments, and demonstrating two distinct families of controlling porosity within the same physical sample. Consistent with prior pilot studies on bone nanoindentation, the hydraulic permeability obtained from nanoindentation tests is significantly smaller than that found from microindentation tests and yet the elastic modulus values obtained from the two sets of tests do not differ. The same framework is used in characterizing compliant gels with significantly smaller stiffnesses and greater permeabilities than bone—because the approach is based on master curves, materials with any values of mechanical properties can be studied within the same framework without the need to run material-specific simulations. This study demonstrates the potential for gaining greater understanding of mechanical responses in hydrated materials while remaining in a simple experimental indentation testing framework conducive to high-throughput materials characterization.

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