The Department of Mechanical Engineering / College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar

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Mechanics of Cell-Matrix Interactions in Three-Dimensions

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Abstract

Biological cells are complex living systems that can be viewed as micromachines, which derive their many mechanical functions from the molecular motors within the cell. The forces cells apply to their surroundings control processes such as growth, adhesion, development, and migration. Experimental techniques have primarily focused on measuring tractions applied by cells to synthetic two-dimensional substrates, which do not mimic in vivo conditions for most cell types. This talk will describe an experimental approach to quantify cell tractions in a natural three-dimensional matrix. Cells and their surrounding matrix are imaged in three dimensions with confocal microscopy; cell-induced matrix displacements are computed using digital volume correlation; and tractions are computed directly from the full-field displacement data. The technique is used to investigate how cells employ physical forces during cell division, spreading and sensing. In a three-dimensional matrix, dividing cells apply tensile force to the matrix through thin, persistent extensions that in turn direct the orientation and location of the daughter cells. During spreading, cells extend thin protrusions into the matrix and apply force using these protrusions. The cell forces induce deformations along directed linear paths in the fibrous matrix. A constitutive model is developed that accurately predicts the propagation of cell-induced displacements through the matrix. The model describes how cells use nonlinearities in the fibrous matrix to enable long-range cell-cell mechanical communication.

Biography

Dr. Ravichandran received BE from University of Madras in 1981, MS and Ph.D. in Engineering from Brown University in 1983 and 1987, respectively, also MS in Applied Math in 1984. Dr. Ravichandran has been at Caltech since joining the faculty as an assistant professor in 1990, and he was named the John E. Goode, Jr., Professor in 2005. He has also served as director of the Graduate Aerospace Laboratories (GALCIT) since 2009. His research group explores the mechanical properties of materials ranging from active materials and biomaterials to metals, bulk metallic glasses, adhesives, and composites. By discovering fundamental insights into the way that materials deform, are damaged, and fail, his group aims to develop new experimental methods for studying these and other phenomena in solid mechanics. He is a member of National Academy of Engineering. He has received numerical awards including Chevalier de l'ordre des Palmes Academiques from Republic of France in 2011, 2014 Werner Köster Prize from ASME, 2014 Society of Experimental Mechanics (SEM) Murray Lecture and Medal, 2013 Eringen Medal from SES and Doctor honoris causa (Dhc) from Paul Verlaine University in Metz, France in 2006. He is also a fellow of ASME and SEM and was the past president of SEM.

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