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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 biomolecular 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: Guruswami (Ravi) Ravichandran is the John E. Goode, Jr. Professor of Aerospace and Professor of Mechanical Engineering, and Director of the Graduate Aerospace Laboratories (GALCIT) at the California Institute of Technology. He received his B.E. (Honors) in Mechanical Engineering from University of Madras, Sc.M. in Engineering and Applied Mathematics, and Ph.D. in Solid Mechanics and Structures from Brown University. He is a member of the European Academy of Sciences and Arts and the International Academy of Engineering. He is a Fellow of American Society of Mechanical Engineers (ASME), Society for Experimental Mechanics (SEM) and American Academy of Mechanics (AAM). He received Doctor honoris causa from Paul Verlaine University and Chevalier de l'ordre des Palmes Academiques from the Republic of France. His awards include A.C. Eringen Medal from Society of Engineering Science, Charles Russ Richards Memorial Award from Pi Tau Sigma and ASME and B.J. Lazan Award from SEM. His research interests are in mechanics of materials, particularly deformation, damage and failure, micromechanics, active materials, biomaterials and experimental methods.