Arpita Upadhyaya

Contact Address:
Department of Physics,
Massachusetts Institute of Technology
Room 13-3054, 77 Mass. Ave.
Cambridge, MA 02139, U.S.A

Phone: (617) 258-5746
Fax: (617) 258-6883
email: `arpitau@mit.edu`
URL: `http://web.mit.edu/arpitau/www`

Education

Ph.D., Physics, University of Notre Dame, Notre Dame, IN, 2000.

M.Sc. (Hons.) in Physics and **B.E. (Hons.)** in Electrical Engineering,
Birla Institute of Technology and Science, Pilani, India, 1994.

Cell Adhesion and Motility, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN 1999.

Biophysics of Cellular Machinery, Simon Fraser University, Burnaby, BC, Canada 1998.

Physiology – Cell and Molecular Biology, Marine Biological Laboratory, Woods Hole, MA 1996.

Professional Experience

Pappalardo Fellow 2002-present
Department of Physics, Massachusetts Institute of Technology.

Postdoctoral Research Associate 2001-2002
Department of Physics, Massachusetts Institute of Technology.

Postdoctoral Research Associate 2000-2001
Department of Mechanical Engineering, Massachusetts Institute of Technology.

Graduate Research Assistant, 1996-1999
Department of Physics, University of Notre Dame.

Teaching Assistant, 1994-1996
Department of Physics, University of Notre Dame.

Fellowships and Awards

Pappalardo Fellowship in Physics, Massachusetts Institute of Technology (2002-2005).

Howard Hughes Medical Institute Educational Program Scholarship Funding, Marine Biological Laboratory (1996, summer).

Zahm Fellowship for Biophysics, Biochemistry and Molecular Biology, University of Notre Dame (1996).

Professional Activities

American Society for Cell Biology, American Physical Society, Biophysical Society.

Reviewed manuscripts submitted to Physical Review *E*, Physical Review Letters, Biophysical Journal and Physics Letters.

Research accomplishments and interests

Force generation by actin polymerization

Actin polymerization adjacent to the cell membrane provides the propulsive force for numerous types of cell motility. I have developed an in vitro model system of protein coated membrane bilayer vesicles to reconstitute actin polymerization based movement. The deformations of the moving vesicles (with known mechanical properties) provide a measure of the spatiotemporal distribution of forces. I am developing a microfluidics based method to encapsulate actin and other proteins into bilayer vesicles as a model for actin polymerization inside a cell.

Cell polarization

Establishment of cell polarity is an essential component of cell motility and embryogenesis. Yeast cells polarize and bud at a single site on the cell membrane by accumulation of proteins in a spatially localized patch. I have started a new line of research on yeast cells using genetic techniques and fluorescence imaging of protein dynamics supplemented by quantitative modeling to study the basic mechanisms behind the initial stages of polarization.

Directional sensing in cells

The ability of cells to orient toward an external chemical gradient is important for many biological processes. In collaboration with M. Poznansky (Harvard Medical School), I have developed quantitative measures to characterize directed motion of human neutrophils in precise chemoattractant gradients prepared using microfluidic devices. I am currently developing microfluidic devices to study the directional response of yeast cells to pheromone gradients.

Surface and elastic forces in developing tissues

Forces arising from surface adhesion and elasticity play an important role in morphogenesis. I have studied the dynamics of spreading of multicellular aggregates on adhesive substrates and of one tissue type over another. I have also quantified the motion of cells in aggregates undergoing adhesion driven rearrangements using a statistical mechanical framework. Tissue growth during development generates elastic stresses that can have dramatic effects on cellular rearrangements and tissue shape. In collaboration with M. Brenner (Harvard) and B. Nguyen (UC Irvine), I have studied the role of elasticity and adhesion in controlling the shape of growing yeast colonies as a simple paradigm for developing tissues.

Mechanical properties of membrane nanotubes

Intracellular membranes such as Endoplasmic Reticulum (ER) and Golgi form networks of membrane nanotubes. The physical properties of the networks are critical for membrane traffic between these structures. I have used optical trapping and high resolution microscopy to measure the membrane tension of tubules in reconstituted networks of ER and Golgi.

Biological springs

Vorticella is a protozoan with a highly contractile, polymeric stalk that contracts by a calcium dependent mechanism. Using high speed microscopy, I have characterized the contractile force and velocity of Vorticella and shown that it does not behave like a simple spring.

Publications

J. A. Glazier and **A. Upadhyaya**, "First steps towards a comprehensive model of tissues", Dynamical Networks in Physics and Biology, ed. D. Beysens and G. Forgacs, (1998).

J. P. Rieu, **A. Upadhyaya**, Y. Sawada, N.B. Ouchi and J. A. Glazier, "Diffusion and deformations of single *Hydra* cells in cellular aggregates ", Biophys. J., **79**, 1903 (2000).

A. Upadhyaya, J. P. Rieu, Y. Sawada, J. A. Glazier, "Anomalous diffusion and non-Gaussian velocity distribution of *Hydra* cells in cellular aggregates", Physica A, **293**, 549 (2001).

J. C. M. Mombach, R. M. C. de Almeida, G. L. Thomas, **A. Upadhyaya**, and J. A. Glazier, "Bursts and cavity formation in *Hydra* cell aggregates: Experiments and simulations", Physica A, **297**, 495 (2001).

M. J. Powers, K. Domansky, M. R. Kaazempur-Mofrad, A. Kalezi, A. Capitano, **A. Upadhyaya**, P. Kurzawski, K. E. Wack, D. B. Stolz, R. Kamm, and L. G. Griffith, "A microfabricated array bioreactor for perfused 3D liver culture", Biotechnol. Bioeng. **78**, 257 (2002).

A. Upadhyaya, J. C. Chabot, A. Andreeva A. Samadani and A. van Oudenaarden, "Probing polymerization forces using actin propelled lipid vesicles", Proc. Nat. Acad. Sci. **100**, 4521 (2003).

A. Upadhyaya and A. van Oudenaarden, "Biomimetic systems for studying actin-based motility", Curr. Biol. **13**, R734 (2003).

N. B. Ouchi, J. A. Glazier, J. P. Rieu, **A. Upadhyaya**, and Y. Sawada, "Improving the realism of the cellular Potts model in simulations of biological cells", Physica A, **329**, 451 (2003).

A. Upadhyaya and M. P. Sheetz, "Measurement of membrane tension in tubulovesicular networks of ER and Golgi using optical tweezers", Biophys. J. **86**, 2923 (2004).

B. T. Nguyen, **A. Upadhyaya**, A. van Oudenaarden and M.P. Brenner "Elastic instability in a growing yeast droplet", Biophys. J., **86**, 2720 (2004).

A. Upadhyaya and A. van Oudenaarden, "Actin polymerization: forcing flat faces forward", Curr. Biol. **14**, R467 (2004).

W. G. Tharp, **A. Upadhyaya** *et al.* "Directional decisions and gradient perception in neutrophil migration away from a chemokine", (submitted to Nat. Cell. Biol., 2004).

A. Upadhyaya, J. Wong, M. Daniels and A. van Oudenaarden "Contraction force and velocity of *Vorticella*: an ultrafast biological spring", (submitted to Biophys. J., 2004).

A. Upadhyaya, H. Carrel and A. van Oudenaarden, "Crushing and symmetry breaking of actin coated lipid vesicles", (preprint, 2004).

A. Upadhyaya and L. Mahadevan, "Quantitative analysis of hepatocyte spheroid spreading on adhesive substrates", (preprint, 2004).

Recent Invited Talks

- Biocomplexity Workshop, University of Notre Dame, 2002.
- Department of Applied Mathematics and Theoretical Physics, Cambridge University, 2002.
- Computation in Cell Biology, ASCB Meeting, San Francisco, 2002.
- National Center of Biological Sciences, Bangalore, 2002.
- Theory Division, Los Alamos National Laboratory, 2003.
- Boston Complex Fluids Society Meeting, U. Mass. Boston 2003.
- Department of Physics, University of Pennsylvania, 2003.
- Department of Physics, Indian Institute of Science, Bangalore 2004.
- Department of Mechanical Engineering, Massachusetts Institute of Technology, 2004.

References

Dr. Alexander van Oudenaarden
Deptartment of Physics,
13-2008
Massachusetts Inst. of Technology,
77 Massachusetts Avenue
Cambridge MA 02139
(617) 258-4446
avano@mit.edu

Dr. Michael P. Sheetz
Deptartment of Biological Sciences
PO Box 2408, Columbia University
Sherman Fairchild Center, Rm. 713
1212 Amsterdam Ave.
New York, NY. 10027
(212) 854-4857
ms2001@columbia.edu

Dr. James A. Glazier
Director, Biocomplexity Institute,
Department of Physics, Swain West 159
727 East Third Street,
Indiana University, Bloomington
Bloomington, IN 47405-7105
tel: (812) 855-3735, fax:(812) 855-5533
jglazier@indiana.edu

Dr. Michael P. Brenner
Division of Engineering and Applied Sciences
Harvard University
Cambridge MA 02138
tel: (617) 495-3336
brenner@deas.harvard.edu

Mark C. Poznansky, MD, Ph.D.
Harvard Medical School
AIDS Research Center
Mass. General Hospital (East)
13th St. Charlestown MA 02129.
tel: (617) 724-6375
Mark_Poznansky@dfci.harvard.edu