BIO ENGINEERING SEMINAR

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Statistical mechanics provides novel insights into microtubule stability and mechanism of shrinkage

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Microtubules are nanomachines that grow and shrink stochastically making use of the coupling between chemical kinetics and the mechanics of its constituent protofilaments (PFs). We investigate the stability and shrinkage of microtubules, taking into account inter-protofilament interactions and bending interactions of intrinsically curved PFs. Computing free energy as a function of the PF tip position, we show that the competition between curvature energy, inter-PF interaction energy, and entropy leads to a rich landscape with a series of minima that repeat over a length-scale determined by the intrinsic curvature. Computing Langevin dynamics of the tip through the landscape, and accounting for depolymerization, we calculate the average unzippering and shrinkage velocities of GDP protofilaments and compare them with experimentally known results. Our analysis predicts that the strength of the inter-PF interaction has to be comparable to the strength of the curvature energy, and questions the prevalent notion that unzippering results from the domination of bending energy of curved GDP PFs. Our work demonstrates how the shape of the free energy landscape is crucial in explaining the mechanism of MT shrinkage in which the unzippered PFs will fluctuate in a set of partially peeled-off states, and subunit dissociation will reduce the length.

About the speaker:

Mandar Inamdar got his B. Tech in Civil Engineering from IIT Bombay in 2000. He then joined Caltech, from where he obtained his Masters degree in Civil Engineering in 2001. Subsequently, he worked with Rob Phillips at Caltech on various problems in Biophysics and Statistical Mechanics and obtained his PhD in Applied Mechanics in 2006. After a brief post-doc in the mechanics department at Brown University, in 2007 he joined Civil Engineering department at IIT Bombay, where he currently is an Associate Professor. His research is mostly theoretical and focused around applied mechanics and mechanobiology.