ME Seminar

MECHANICAL ENGINEERING
INDIAN INSTITUTE OF SCIENCE

Multiscale buckling of epithelial shells

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ABSTRACT

Numerous natural and engineered structures are shaped as thin curved shells. When subjected to excessive compressive loading, these shells undergo buckling instabilities that result in wrinkling patterns with complex dynamics. Epithelial tissues such as those enclosing embryos or lining glandular organs are a class of thin shells that displays three distinctive mechanical features: they are viscoelastic over the time scales of physiological loading, they carry an active surface tension, and their stress-bearing elements are distributed across scales. The conditions under which these material properties enable buckling, and the subsequent structural changes are not understood. Here we establish the buckling dynamics of epithelial shells of controlled geometry over several orders of magnitude in time and space. We developed an experimental system that allows us to sculpt epithelial shells and subject them to controlled pressure differentials. We show that, under rapid pressure reductions relative to a characteristic viscoelastic time of the system, the tissue develops buckling patterns with different degrees of symmetry that depend on its size and shape. By contrast, slow deflations allow the tissues to accommodate large strain variations without buckling. Strikingly, we find that epithelial buckling is a multiscale phenomenon involving supracellular folds but also subcellular wrinkles in the actin cortex. Our study shows that epithelial tissues can be understood as hierarchical materials with mechanical instabilities that can be harnessed to engineer morphogenetic events.

ABOUT THE SPEAKER

Dr. Nimesh Chahare is a postdoctoral researcher at the Institute of Bioengineering of Catalonia in Barcelona, specializing in epithelial mechanics. He began his academic journey at VNIT Nagpur, where he studied Mechanical Engineering. Subsequently, he secured his master's degree in mechanical engineering from IISc Bengaluru, where he worked with Prof. Namrata Gundiah on various aspects of biomechanics. This experience motivated him to pursue a PhD in tissue mechanics within the Faculty of Applied Mathematics at Universitat Politècnica de Catalunya, under the guidance of Prof. Xavier Trepat and Prof. Marino Arroyo. His research primarily concentrates on understanding how biological and mechanical forces influence tissues. He has designed experimental tools to examine the mechanics of cells and tissues using microfluidic devices. Furthermore, he is eager to explore emergent mechanical phenomena in living systems.

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