BIOGRAPHICAL SKETCH

NAME: **Ashutosh Agrawal**

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
Indian Institute of Technology Bombay, Mumbai, India	B. Tech	08/2001	Civil Engineering
Rice University, Houston	M.S.	08/2003	Civil & Environmental Engineering
University of California, Berkeley	Ph.D.	05/2009	Civil & Environmental Engineering

A. Personal Statement

The focus of my group, 'Life at the Interface', is to uncover the engineering principles at the intersection of mechanics, geometry, and electrostatics. Our aim is to understand how these principles govern the integrity and functionality of 2D structures in biological cells and biomimetic topological materials for diverse engineering applications. Driven by curiosity and imagination, our research focuses on fundamental scientific questions, leveraging a diverse array of methodologies—including mathematical theory, atomistic simulations, Monte Carlo simulations, and finite element modeling to explore complex phenomena and uncover mechanistic insights. These approaches have allowed us to address critical challenges in areas such as cellular transport, organelle dynamics, neuronal signaling, electromechanics of thin films, and the mechanics of plates and shells.

Notable outcomes include the identification of geometric instabilities in cellular transport (*PNAS 2015*), nuclear shaping (*PNAS 2016*), and mitochondrial division (*MBOC 2018*). Additionally, we have discovered a phase transition in lipid membranes triggered by lateral electric fields (*Soft Matter 2022*), developed a new theory of electromechanics for lipid membranes (*Mathematics and Mechanics of Complex Systems 2016*), and created a new class of biomimetic plate and shell structures with complex topology (*Mathematics and Mechanics of Solids 2023*).

B. Positions, Scientific Appointments, and Honors

Positions and Employment

2017-present Associate Professor, University of Houston
2011-2017 Assistant Professor, University of Houston
2010-2011 Research Associate, Caltech
2009-2010 Research Assistant Professor, University of Houston

Other Experience and Professional Memberships

2025-2026 Member, Biophysical Society

Honors

2015 UH Teaching Excellence Award

Other Professional Activities:

2022 Organized a symposium on 'Mechanobiology of Disease' in the Annual Technical Meeting of Society of Engineering Science (College Station, 2022).
2022 Panel reviewer, NSF Mechanics of Materials and Structures program

2018	Organized a symposium on 'Engineering Art' in the Annual Technical Meeting of Society of Engineering Science (Madrid, 2018).
2016	Panel reviewer, NSF Mechanics of Materials and Structures program
2015	Panel reviewer, NSF Biomechanics and Mechanobiology program
2013	Co-organized the Pan American Congress on Applied Mechanics (PACAM XIII, Houston).
2013	Panel reviewer, NSF Mechanics of Materials and Structures program

C. Contributions to Science

I. ***Mechanics of endocytosis.*** We have investigated the role of proteins in driving vesicle formation in high tension environment. My group has computationally discovered an instability-based mechanism of vesicle formation driven by actin and BAR proteins. We have recently identified a mechanism by which tension-sensing endocytic proteins could be sensing the physical state of a membrane. We have developed the generalized theory of membranes to account for asymmetry, heterogeneities and lack of isotropy created by endocytosis-generating lipids and proteins. We were the first one to show that spatial heterogeneity in membrane properties can lead to variable surface tension field in the membrane, which has historically been assumed to be a constant field in membranes.

a) Joseph, J. G., Osorio, C. , Yee, V., Agrawal, A. and Liu, A.P. Complimentary action of structured and unstructured domains of epsin supports clathrin-mediated endocytosis at high tension. ***Communications Biology, 3(1),*** pp.1-16 (2020).
b) N. Walani, and A. Agrawal, Stability of lipid membranes with orthotropic symmetry, **Mathematics and Mechanics of Solids,** p.1081286519872236 (2019).
c) Irajizad, E., Walani, N., Veatch, S.L., Liu, A.P., Agrawal, A., Clathrin polymerization exhibits high mechano-geometric sensitivity, ***Soft Matter***, DOI: 10.1039/C6SM02623K (2017).
d) Walani, N., Torres, J., Agrawal, A., Endocytic proteins drive vesicle growth via instability in high membrane tension environment, ***Proceedings of the National Academy of Sciences***, 112.12: E1423-E1432 (2015).

II. ***Electromechanics of membranes.*** We have investigated the role of lipids in regulating the gating of potassium channels. Using long-timescale atomistic simulations, we identified the mechanisms by which POPA and cholesterol preferentially solvate Kv channels. We have recently obtained the first molecular proof of in-plane flexoelectricity in bilayers. Also, we have recently shown that lateral electric fields can induce changes in phase transitions temperatures of bilayer. This finding offers a new mechanism to interpret electrosensitivity in cells.

a) N. Thomas and A. Agrawal, A lateral electric field inhibits gel-to-fluid transition in lipid bilayers, Soft Matter, 18(34):6437-42 (2022).
b) N. Thomas, K.K. Mandadapu, and A. Agrawal, Electromechanics of lipid-modulated gating of potassium channels. Mathematics and Mechanics of Solids, Jul;27(7):1284-300 (2022).
c) N. Thomas, A. Agrawal. Quantification of in-plane flexoelectricity in lipid bilayers. Europhysics Letters, 134.6 (2021): 68003 (2021).

III. ***Mechanics of nuclear envelope.*** My group has identified a potential biophysical mechanism that leads to the ultradonut topology of the nuclear envelope with thousands of holes. We have also shown that the ultradonut topology can lead to significantly enhance the flexural stiffness of the nuclear envelope. We have written a review article to discuss the open physics issues associated with the nuclear envelope.

a) A. Agrawal and T. Lele, Geometry of the nuclear envelope determines its flexural stiffness. ***Molecular Biology of the Cell***, 31(16), pp.1815-1821 (2020).
b) A. Agrawal and T. Lele, Mechanics of nuclear membranes, ***Journal of Cell Science***, *132*(14), p.jcs229245 (2019).
c) Q. Zhang, A.C. Tamashunas, A. Agrawal, M. Torbati, A. Katiyar, R.B. Dickinson, J. Lammerding, and T.P. Lele, Local, transient tensile stress on the nuclear membrane causes membrane rupture, ***Molecular Biology of the Cell,*** 30(7):899-906 (2019).
d) Torbati, M., Lele, T.P., Agrawal, A., Ultradonut topology of the nuclear envelope, ***Proceedings of the National Academy of Sciences***, 113 (40), 11094-11099 (2016).

IV. ***Mechanics of voltage-sensitive ion channels.*** My group has uncovered strong electrostatic interactions between phosphatidic acid and arginine residues in potassium channels. We have also developed a mathematical model to elucidate the potential role of these lipids in the gating mechanisms of voltage-sensitive ion channels.

a) N. Thomas, W. Combs, K.K. Mandadapu, A. Agrawal. Preferential electrostatic interactions of phosphatidic acid with arginines. ***Soft Matter***, 20 (13), 2998-3006 (2024).
b) N. Thomas, K.K. Mandadapu, A. Agrawal. Electromechanics of lipid-modulated gating of potassium channels. ***Mathematics and Mechanics of Solids***, 27 (7), 1284-1300 (2022).

V. ***Mechanics of mitochondrial dynamics.*** My group has identified a lipid-mediated buckling instability that promotes mitochondrial fission. We have written a review article to discuss the potential role of lipids in mitochondrial dynamics.

a) A. Agrawal and R. Ramachandran, Exploring the links between lipid geometry and mitochondrial fission: Emerging concepts. ***Mitochondrion*** (2019).
b) E. Irajizad, R. Ramachandran, and A. Agrawal, Geometric instability catalyzes mitochondrial fission, ***Molecular Biology of the Cell***, 30(1):160-168 (2019).

VI. ***Mechanics of biomimetic torene plates and shells.*** My group has pioneered a new class of plate and shell structures with ultra-high mathematical genus, exhibiting exceptional flexural stiffness.

a) M. Bazmara, R.A. Sauer, A. Agrawal. Biomimetic torene shells. *Mathematics and Mechanics of Solids*, 28 (8), 1926-1935 (2023).