Special Issue: Cell Mechanics and Signaling: From Micro to Nano

Mechanical forces play an increasingly recognized role in guiding cell function. Cell-generated forces allow active traversal of both matrix and other cells in the extracellular space, an essential element of tissue development and key to multiple pathologies. Moreover, the response of the environment to these forces conveys information back to the cell, casting mechanics as a cell signaling factor. Determining the factors that guide cell mechanics is a major contemporary challenge across multiple disciplines, for which bioengineering provides a particularly powerful set of concepts and methods. Cells use a collection of physical and chemical cues to produce motion, in many ways similar to how automobiles depend on mechanical, electrical, and hydraulic elements for proper function, and full understanding of either system requires a systems-level integration of these components. In the case of cells, these systems include molecular receptors that sense the extracellular environment, biochemical processing of the various inputs through intricate cell signaling network, and finally transduction of biochemical signals into coordinated mechanical forces. Since these events are orchestrated in a precise spatiotemporal fashion, there is a need to study biochemical and biomechanical processes in cells at both spatially- and temporally-resolved details. Contemporary engineering approaches are well suited for integrating multiple conceptual components and embracing spatially complex processes, particularly at micrometer and nanometer scales between those of tissues and individual protein molecules. The papers in this Special Issue provide a collective snapshot of contemporary progress in this field, highlighting specific, underlying areas of research.

NUMERICAL MODELING

Computational models are a key engineering approach for investigating complex, physiologically relevant systems. The articles by Ma *et al.*,³ and Su and Schmid-Schonbein⁶ provide elegant demonstrations of this approach. At sub-cellular scales, Welf and Haugh⁸ provide a new framework for applying chemical regulatory motifs to local dynamics of cell protrusion.

MATERIALS

Several materials, particularly polyacrylamide and polydimethylsiloxane, have been developed in the context of cell biomechanics, allowing the study of cell response to materials of more physiological stiffness than traditional cell-culture plastic or glass. In this Issue, Mann and Leckband⁴ continue the development of these materials for longer-term measurement of cellular forces, allowing analysis of these forces over the course of cell differentiation. Zhou and Petroll⁹ examine cell behavior within an advanced, nested collagen matrix.

CELLULAR BIOMECHANICS

Understanding the regulatory mechanisms of force generation and rigidity sensing by cells is a major contemporary challenge. Moving beyond the analysis of individual cells, the works in this Issue by Liu and Chen,² Saunders and Hammer,⁵ and Califano and Reinhart-King¹ present new advances into this field, focusing on the roles of cell-generated forces in coordinating heterotypic and homotypic cell–cell interactions. In addition, Mann and Leckband⁴ provide a new glimpse into the dynamics of forces over the course of cell differentiation.

CELL SIGNALING AND BIOPHYSICS

Proteins, including those with interface and intracellular signaling roles, are the links between mechanics and cell function. In this issue, Welf and Haugh,⁸ Zhou and Petroll,⁹ and Tsai and Kam⁷ provide elegant, engineering-based studies into the roles of specific proteins, and the biophysical presentation of such molecules, in modulating cell function.

We look forward to the bright future of bioengineering research that utilizes interdisciplinary concepts and improved methods for analyzing spatial complexity of cells, and hence continues to reveal new rules explaining integration of mechanics and signaling at cellular and molecular levels. We also celebrate the first two years of Cellular and Molecular Bioengineering, an important venue for this increasingly interdisciplinary field. We thank the editors David Odde and Edward Guo as well as Springer for their vision and commitment in this field.

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