Preface

While you are reading this book, comfortably seated in a quiet and relaxing environment, your body is producing dramatic and dynamic mechanical phenomena. Indeed, your heart is beating, your lungs are inflating and deflating, blood courses through your vasculature, your stomach and intestines are moving to digest your last meal and all of these movements generate mechanical forces that have important consequences, even at the cellular level. Furthermore, tissues and organs are composed of a variety of scaffold proteins that are organized in a myriad of ways resulting in a wide range of cellular microenvironments in vivo. Together, scaffolding proteins not only control the biochemistry of the microenvironment but also its mechanical properties, which vary depending on the tissue and organ type. The mechanical forces and properties that arise in the cellular microenvironment play a role not only in mammalian cell biology but also in plants and bacteria, which are well known to possess distinct biochemical mechanisms to sense and respond to the diversity of physical cues in their microenvironment.

For decades, cellular responses to their extracellular environment have been directly understood in terms of their genetics and biochemistry. The development of new technical approaches has facilitated quantitative investigations and insights into how physical cues in the microenvironment regulate cell biology. Integrating these new concepts has prompted many new questions about cell biology, such as: What physical information in the cellular microenvironment affects cell biology? How do cells detect and respond to changes in the physical properties of the microenvironment? Can we re-engineer the purpose of living systems using physical cues? It is now well known that many parameters such as cell differentiation, morphology, and migration, to name only a few, can be controlled and modulated by physical cues. These findings have emphasized the importance of physical phenomena in cell biology in the context of health and disease.

In this book, chapters written by leading experts in their respective research fields provide an overview of how mechanical forces and the physical properties of the microenvironment affect cell and tissue homeostasis. The book addresses current knowledge on how prokaryotic and eukaryotic cells are able to sense and integrate physical signals. In the organism, cells are exposed to a variety of forces, material properties, and topographical features that influence a diversity of biological functions. The chapters in this book detail many of the modern methods that have been utilized to develop a better understanding of how these physical cues influence cell biology. These methods include the development of traction force microscopy, atomic force microscopy, micropost methods, microfluidic devices, deformable membrane arrays, and novel biomaterials at the single cell to whole organism level. All chapters point out future perspectives and limitations of these technologies and discuss the significance or application of the research at hand. In addition to research on animal systems, several chapters highlight and review the approaches that have been employed to shed new light on the importance of physical phenomena in governing bacteria and plant cells.

This review volume is dedicated to a broad range of interdisciplinary scientists (biologists, physiologists, pharmacologists, engineers, physicists, etc.) who are interested in these new and important physical aspects of cell biology. It is intended to provide an extremely broad overview of the role of physical cues in governing diverse aspects of cell biology across kingdoms and in physiological and pathological processes. To conclude, we would like to thank and acknowledge the time and great efforts made by all of the contributors who participated in this enjoyable project.

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