Highlighted Topics series: Cellular Responses to Mechanical Stress

This issue of the Journal of Applied Physiology introduces a new Highlighted Topics series on “Cellular Responses to Mechanical Stress.” The breathtaking advances in molecular biology during the past few decades have given physiologists powerful tools with which to characterize the molecular basis of cell, tissue, and organ function. Because many of these tools were developed in biochemistry laboratories, initial efforts were often directed toward sequencing and quantifying proteins and nucleotides with less attention to structure and function. With the maturing of the field and the dissemination of molecular technology across disciplines, structural biology has come of age, and there is an increasing number of investigators who are now asking questions about the physical regulation of cell behavior. Nanotechnology has helped reduce the scale on which these investigations are being carried out, and it is once again becoming “fashionable” to profess an interest in biomechanics.

The October issue includes the second “Controversies in Physiology” article, with Drs. Donald E. Ingber and Steven R. Heidemann debating the usefulness of tensegrity as a structural framework for understanding cell mechanics. In the tensegrity paradigm, the cytoskeleton is viewed as a network of biopolymers, which, by virtue of their interconnectedness, transfer force (i.e., biological information) more or less instantaneously throughout the cell. The tensegrity proponent, Dr. Ingber, argues that this information transfer is fundamental to such basic biological functions as cell growth and differentiation. Dr. Heidemann questions the usefulness of the tensegrity paradigm, pointing to real and perceived inconsistencies in the “tensegrity story.” Specifically, he argues that distant signaling, i.e., deformation distant from the site of applied stress, is not always seen. Along the way, these two opponents on the issue of tensegrity treat the readership of the Journal to a discourse on a topic that should concern scientists interested in tissue engineering, organ development, cell signal transduction, and tissue remodeling alike.

Also in the October issue, Drs. Claudia dos Santos and Arthur Slutsky provide a mini-review titled “Mechanisms of ventilator-induced lung injury: a perspective.” Dr. Slutsky is a pioneer in the field of lung deformation injury, and his work has contributed in many respects to the shift in treatment emphasis away from managing gas exchange to providing physical therapy to the injured lung. Their review underscores the intimate link between cell deformation and tissue inflammation and points to the many recent advances in our understanding of immune responses of the lung.

In the November issue, Drs. Mingyao Liu and Martin Post expand on the lung deformation theme in a mini-review titled “Mechanochemical signal transduction in the fetal lung.” These investigators were among the first to detail the interactions between humoral and physical factors involved in the regulation of lung growth and maturation. They give an extensive account of molecular networks and pathways that respond to physical stress and review opportunities and challenges to future research in this field. Also in the November issue, Drs. Dimitrije Stamenovic and Ning Wang take readers back to the tensegrity debate in their mini-review and discuss “Engineering approaches to cytoskeletal mechanics.” Their review underscores how the fast pace of technology has allowed investigators to ask bold and fundamental questions such as “how much force does a cell exert on its surroundings?”

In the December issue, Dr. John B. West provides a mini-review of “Pulmonary capillary stress failure.” This investigator was among the first to draw attention to the profound cytopathological changes associated with pulmonary microvascular hypertension, a condition experienced by both patients with heart failure and racehorses near the finish line. In the same issue, Drs. Nicholas Vlahakis and Rolf Hubmayr examine “Plasma membrane stress failure in alveolar epithelial cells.” Like Drs. dos Santos and Slutsky, these authors are also concerned with the consequences of alveolar overdistension but examine the problem from a different perspective; i.e., they focus on the mechanics and deformation responses of plasma membranes.

The next three issues of the Journal focus on recent advances in technology and molecular biology that have provided tools with which to explore “Cellular Responses to Mechanical Stress.” Although this Highlighted Topics series focuses primarily on cellular responses of the lung to mechanical stress, it should be emphasized that the central principles of...
mechanotransduction, as modeled by tensegrity, are relevant to cellular responses throughout the body. Therefore, this series presents issues and problems common to a number of biological fields. Certainly, these are issues of great importance in applied physiology, and it is the hope of the Associate Editors and myself that this series will promote further research in this exciting new area.

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