Media contact Jordan Reese 215-573-6604 jreese@pobox.upenn.edu

Bioengineers at University of Pennsylvania Devise Nanoscale System to Measure Cellular Forces

August 27, 2007

PHILADELPHIA -- University of Pennsylvania researchers have designed a nanoscale system to observe and measure how individual cells react to external forces.

By combining microfabricated cantilevers and magnetic nanowire technology to create independent, nanoscale sensors, the study showed that cells respond to outside forces and demonstrated a dynamic biological relationship between cells and their environment.

The study also revealed that cells sense force at a single adhesion point that leads not to a local response but to a remote response from the cell's internal forces, akin to tickling the cell's elbow and watching the knee kick.

"The cell senses the force that we apply and adjusts its own internal forces to compensate," Chris Chen, an associate professor in the Department of Bioengineering in the School of Engineering and Applied Science at Penn, said. "This suggests that either the cell's cytoskeleton dictates the reaction or the cell organizes a biochemical response. In either instance, cells are adapting at the microscale."

The findings, published in the September issue of the Proceedings of the National Academy of Sciences prove useful to more than just an understanding of the mechanics of single cells. Physical forces play a strong role in how whole tissue grows and functions. Using the Penn system, researchers could monitor for differences in how forces are sensed or generated in normal and diseased cells. This could lead to new therapeutic drug targets and to methods for modifying how cells interact with each other.

To study the cell's biomechanical response to forces, Chen and his team applied force to each cell using microfabricated arrays of magnetic posts containing cobalt nanowires interspersed amongst an array of non-magnetic posts. In the magnetic field, the posts with nanowires applied an external force to cells cultured on the tops of the posts. Nonmagnetic posts acted as sensors in which traction forces in each cell were measured. Recording the traction forces in response to such force stimulation revealed two responses: a sudden loss in contractility that occurred within the first minute of stimulation or a gradual decay in contractility over several minutes.

For both types of responses, the subcellular distribution of loss in traction forces was not confined to locations near the actuated micropost or uniformly across the whole cell but instead occurred at discrete locations along the cell periphery. Together, these data suggest that cells actively adjust their internal tension to mechanical forces arising in their microenvironment and reveal an important dynamic biological relationship between external and internal forces.

Mechanical forces contribute to many cellular functions, including changes in gene expression, proliferation and differentiation. Applying shear or tensile stresses to cells in culture, for example, can induce changes in adhesion regulation, intracellular signaling and cell function much like internal forces do. The similarities in cellular responses to external and internal forces have led to the suggestion that both types of forces may use shared mechanotransduction pathways to convert mechanical stimuli into biochemical signals. While externally applied and internally generated forces may act independently on cells, the University of Pennsylvania team postulated and then showed that they are coupled.

The study was conducted by Chen, Nathan J. Sniadecki, Michael T. Yang and Zhijun Liu of the Department of Bioengineering as well as Alexandre Anguelouch, Corinne M. Lamb, Stuart B. Kirschner, Yaohua Liu and Daniel H. Reich of Johns Hopkins University.

The research was funded by grants from the National Institutes of Health, an Army Research Office Multidisciplinary University Research Initiative, the Material Research Science and Engineering Center of Hopkins and Penn's Nano/Bio Interface Center.

« previous | next »

News at a Glance for
» Natural Science