The molecular force is with this team

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Xiaohui "Frank" Zhang is integrating physics, immunology and biology to develop a "nanodevice" that could provide a new treatment for stroke, thrombosis and atherosclerosis.

Zhang, assistant professor of mechanical engineering and mechanics and faculty member in the bioengineering program, leads an interdisciplinary research team seeking to deliver medication to targeted regions of the human body.

Their device measures tens of nanometers in size.

The researchers study mechanosensing—how cells sense and respond to mechanical stimuli. Mechanosensing is crucial in the development of tissues and the progression of cardiovascular diseases.

"Of the three basic ways that cells communicate with each other—chemical, electrical and mechanical—the last is by far the least understood," says Zhang.

One reason mechanosensing is not studied extensively is because the mechanical forces imposed on cells occur on a molecular level, he says.

"It's very hard to measure and exert force on molecules."

A nanodevice with a mechanical switch

Zhang uses single molecule force spectroscopy to monitor, manipulate and measure mechanical forces. With optical tweezers, he exerts minute forces onto samples and records the dynamics of protein conformation and mechanical response in real time.

His team studies integrin, a protein molecule that serves as a mechanical sensor to transmit signals across the cell membrane. The hypothesis is that integrin will alter its shape in response to mechanical stimuli, thereby acting as a “switch” to transmit a signal.

The team also studies the transmission of mechanical signals across the cell membrane and monitors the interplay between mechanical signals and biochemical activities. The goal is to develop a mechanically switchable nanodevice for targeted drug therapy.

“When you put a drug in the bloodstream, it disperses throughout the body,” says Zhang. “A nanodevice would be able to carry a drug through the bloodstream to a specific location. When activated by mechanical stimuli, it would undergo a shape change and release its preloaded drug.”

Nanodevices could be used in biosensing and diagnosis, and could help achieve low-cost, low-side-effect treatment of thrombosis, stroke and atherosclerosis.

Zhang’s team is designing a polymer that mimics a blood-clotting molecule called the von Willebrand Factor (vWF), which binds with platelets during rapid blood flow.

Out of diverse interests, a single purpose

Zhang earned a B.S. in physics, studied physiology and biophysics in medical school, and trained in immunology before joining the faculty.

This diverse background led him to mechanobiology, which incorporates techniques from physics, biology, chemistry, computer simulation and polymer synthesis.

His team at Lehigh includes a postdoctoral fellow in physics, a research associate with a medical education, and undergraduate students in biology, engineering and physics.

“Everyone brings something different to the table,” he says.

Lehigh’s emphasis on interdisciplinary study, says Zhang, aligns with his research focus.

“The real excitement of this project is that we’re trying to understand nature. That requires an interdisciplinary approach to determine how the molecule works. There’s no better place to do this than at Lehigh.”

Provided by Lehigh University

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