

Physics Colloquium

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Soft matter approaches to biology: A tale of mucus hydrogel in human lung defense

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2:30 pm—3:45 pm

210 Robeson Hall

Biological systems are featured by their ability to defend themselves against external challenges. While these defense mechanisms are extensively studied in the context of life sciences, their physical aspects have largely been overlooked, although they are implicated in many important biological processes. Using knowledge and tools in soft matter and physical science, we can not only provide unique insights to biological questions that directly impact healthcare, but also in turn create new directions that broaden the scope of soft matter research. In this talk, I will discuss how soft matter physics can help understand a long-standing question for human lung defense: Why can the human lung fight against numerous inhaled infectious particulates and maintain functional through its lifetime? Contrary to the widely accepted dogma that the epithelium of human airway is lined by a physiological liquid, I discover that it is covered by a gel-like polymer brush. This brush layer protects the epithelium from small, infectious particulates that sneak through mucus hydrogel. Moreover, the brush layer enables efficient clearance of mucus out of lung by stabilizing itself against osmotic compression from the mucus. Furthermore, I will show that chronic osmotic stress from diseased mucus likely affects airway remodeling. It slows down the proliferation of epithelial cells, and more strikingly, directs the differentiation of epithelial cells to mucus producing cells, a hallmark of mucus obstructive lung diseases such as asthma, chronic obstructive pulmonary disease (COPD) and cystic fibrosis. These findings suggest that the osmotic pressure of mucus hydrogel provides a unified measure of pathogenesis of mucus obstructive lung diseases, and open new directions for the development of novel therapeutics to treat these diseases.