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Smart Mechanics and Biological Selectivity in Engineered Protein Hydrogels

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Artificially engineered protein hydrogels provide an attractive platform for biomedical materials due to their similarity to components of the native extracellular matrix and ability to be easily biofunctionalized to promote desired cellular responses. Despite a great deal of research in this field and the discovery of many engineered protein sequences, the physical and mechanical performance of protein materials is often limited when compared to synthetic counterparts. A better understanding of the polymer science underlying their structure and mechanical response can also help to extend the range of mechanical properties achievable with such systems, including producing materials that are tough, adhesive, highly extensible, and have an extremely high stiffness.

This talk will discuss three engineering design concepts in protein hydrogels that can be exploited to improve their mechanical performance: hierarchical structuring, topological entanglement, and chain folding/aggregation. Using these strategies, we demonstrate the ability to produce stiff, tough, adhesive, and extensible gels, and also to modulate all of these advanced mechanical properties in response to stimuli such as temperature or mild oxidation. Theories of polymer physics can be applied to explain the structural and molecular origins of the mechanical response, and the promise of many of the materials is demonstrated for cell culture and tissue toughening. Finally, we show that the incorporation of biofunctional protein sequences into such artificial gels can recapture the biological specificity and interactions of the nuclear pore gel.