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FROM DYNAMIC STRUCTURES TO FUNCTIONAL MATERIALS

Light-Controlled Intracellular Peptide Assembly

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The ability to control supramolecular peptide assembly with high spatial and temporal precision offers exciting opportunities for engineering adaptive biomaterials and studying dynamic cellular processes. Light is a particularly attractive stimulus owing to its non-invasive nature and excellent spatiotemporal resolution, enabling precise regulation of molecular interactions in complex biological environments. Here, we present complementary strategies for light-controlled intracellular peptide assembly that combine molecular design with programmable supramolecular organization.

At the molecular level, light-responsive peptide building blocks were engineered to regulate peptide conformation and intermolecular interactions through photoactivation.[1,2] By incorporating photoresponsive motifs into self-assembling peptides, light serves as an external trigger to initiate or modulate supramolecular organization, providing dynamic control over structural order and assembly pathways. This molecular toolbox enables reversible access[2] to distinct supramolecular states and highlights how subtle changes in peptide conformation can dictate the architecture of higher-order assemblies.

Building on these design principles, light-triggered peptide assembly was translated into living cells, where visible-light activation initiates the formation of intracellular nanostructures with high spatial and temporal precision.[1] The controlled emergence of peptide assemblies within the cellular environment demonstrates how external optical stimuli can direct the formation of functional supramolecular materials while minimizing off-target effects. Combining molecular-level control with intracellular assembly further enables investigation of the relationship between supramolecular structure, assembly kinetics, and cellular responses.

Together, these studies establish a versatile platform for programming peptide self-assembly through light-responsive molecular design. By integrating precise optical control with intracellular supramolecular engineering, this work provides new opportunities to investigate dynamic biological processes and develop responsive peptide-based materials. Beyond fundamental studies of self-assembly, light-controlled peptide systems hold considerable promise for applications in chemical biology, synthetic biomaterials, intracellular engineering, and targeted therapeutic strategies, where precise regulation of material formation in space and time is essential.

This poster will be presented together with Yong Ren.

[1]Y. Ren, *et al.*, *Nature Synthesis.* **4**, 673–683 (2025).
[2]J. Link, *et al.*, *Angewandte Chemie. International Edition.* **65**, e14781 (2026).