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Hybrid nanomaterials from proteins, peptides, and DNA

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Abstract

The ability to design materials that mimic the complexity and functionality of biological systems is a long-standing goal of nanotechnology, with applications in medicine, energy, and fundamental science. Biological molecules such as proteins, peptides, and DNA possess a rich palette of self-assembly motifs and chemical functional diversity, and are attractive building blocks for the synthesis of such nanomaterials. The ultimate goal of our work is to enable multi-step, "supramolecular synthesis" of complex nanostructures that combine multiple different types of biological molecules. In this talk, we will describe research in creating hybrid materials that incorporate proteins and peptides with DNA nanotechnology to create cages [1], nanofibers [2], and 3D crystals [3] with a high degree of programmability and nanoscale resolution. Key to these endeavors will be (bio)molecular design, organic chemistry for linking components in a site-specific fashion, and the tuning of multiple self-assembly "modes" to create hybrid structures [4]. Although the talk will focus on the fundamental chemistry and self-assembly of these systems, we will also discuss potential applications in areas such as targeted cargo delivery, biomaterials for regenerative medicine, and synthesis of virus- and antibody-mimetic nanostructures.

[1] Y. Xu, S. Jiang, C. Simmons, R.P. Narayanan, F. Zhang, A.-M. Aziz, H. Yan, N. Stephanopoulos*, ACS Nano 2019, 13, 3545–3554.
[2] A. Buchberger, C.R. Simmons, N.E. Fahmi, R. Freeman, N. Stephanopoulos*, "Hierarchical assembly of nucleic acid/coiled-coil peptide nanostructures" J. Am. Chem. Soc. 2020, 142, 1406-1416.
[3] C.R. Simmons‡, T. MacCulloch‡, F. Zhang, Y. Liu, N. Stephanopoulos*, H. Yan*, Angew. Chem. Int. Ed. 2020, 59, 18619-18626.
[4] N. Stephanopoulos*, Chem 2020, 6, 364-405.