Self-Assembly of Nanoscale Architectures with DNA

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Abstract: Nature has evolved to self-assemble complex functional architectures in a sustainable bottom-up way. From bacteria to humans, biological systems arise from a common set of atomically precise nanoscale building blocks such as proteins that give rise to complex functions such as sensing, computation, and actuation. In contrast, most human-made devices are composed of building blocks with much less precision, and are assembled through a top-down process which is highly inflexible and unsustainable. Drawbacks aside, these devices are highly useful and can often surpass their biological counterparts (e.g., computers playing chess). This success is largely due to a systematic and modular engineering approach where simple but well-understood components such as transistors are put together in a programmable way. Is it possible to develop a new approach to building complex devices that combines the strengths of biomolecular self-assembly and systematic engineering? In this talk I will discuss recent work towards this goal using DNA as a nanoscale, programmable building block [1-5]. However, despite being the most programmable molecule for information processing, DNA lacks the basic physical attributes required for building high performance electronic devices. I will discuss ongoing work towards a new type of nanoscale building blocks in which DNA can be flexibly replaced with other materials such as metals and semiconductors. These nanoscale modules can be designed to self-assemble into a variety of plasmonic, photonic, and electronic architectures unattainable with any current nanofabrication techniques. This novel approach integrates the advantages of natural bottom-up assembly and engineered top-down programming and may lead to a host of new intelligent devices for technology and medicine.

References:

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Bio: Greg is a senior postdoctoral scholar in bioengineering at Caltech. He has a longstanding dream to build systems approaching the complexity of life, motivated by the realization that incomprehensible natural complexity arises from comprehensible fundamental laws. He is interested both in understanding the principles required to build such systems as well as in building practical devices using these principles. He received his BSc and Ph.D. in chemistry from Moscow State University and National Institute for Nanotechnology respectively, where he developed approaches to assemble nanometer-precise molecular and supramolecular architectures. In his postdoctoral work, he has worked on DNA nanotechnology, assembling the world's smallest Mona Lisa (which is also the largest uniquely addressable DNA breadboard) and the world's smallest tic-tac-toe game.