Programming Nucleic Acids Self-Assembly

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I will discuss my lab's research on engineering synthetic, nucleic acid-based nanostructures and their applications in biosensing, imaging, nanofabrication, and tissue engineering.

We have recently invented a general framework for programming the self-assembly of short synthetic nucleic acid strands into prescribed target shapes or demonstrating their prescribed dynamic behavior. Using short DNA strands, we have demonstrated the modular construction of sophisticated 1D (***Science***, 321:824-826, 2008), 2D (***Nature***, 485:623-626, 2012) and 3D (***Science***, 338:1177-1183, 2012) structures on the 100-nanometer scale with nanometer precision. Using reconfigurable DNA hairpins, we have demonstrated diverse, dynamic behavior such as catalytic circuits, triggered assembly, and autonomous locomotion (***Nature***, 451:318, 2008).

By interfacing these synthetic, nucleic acid nanostructures with functional molecules, we are developing a diverse range of applications. In biosensing, we have constructed robust and ultraspecific probes for detecting single-base changes in a single-stranded DNA/RNA target (***Nature Chemistry***, 4:208-214, 2012). In bioimaging, we have engineered geometrically encoded fluorescent barcodes for highly multiplexed single-molecule imaging (***Nature Chemistry***, 4:832-839, 2012) and dynamic fluorescent probes for super-resolution imaging. In nanofabrication, we have collaboratively developed a versatile framework for producing inorganic materials (e.g. graphene [***Nature Communications***, 4:1663, 2013], silicon dioxides [***JACS***, 135:6778, 2013], silver, gold) with arbitrarily prescribed nanometer scale shapes. In tissue engineering, we have developed a general strategy to engineer DNA directed self-assembly of biocompatible hydrogel bricks into complex architectures (***Nature Communications***, 4:2275, 2013).

I will also discuss my lab's ongoing work on moving the DNA nano-structures from test tubes to RNA based systems living cells, in particular a reconfigurable RNA hairpin system for implementing complex in vivo logic.

See our lab’s work at http://**molsys.net**.