Programmable self-assembly of DNA into nanoscale three-dimensional shapes

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Molecular self-assembly offers a 'bottom-up' route to fabrication with subnanometre precision of complex structures from simple components. DNA is an attractive building block for programmable construction of such objects. Templated self-assembly of DNA into custom two-dimensional shapes on the megadalton scale has been demonstrated previously with a multiple-kilobase ‘scaffold strand’ that is folded into a flat array of antiparallel helices by interactions with hundreds of oligonucleotide 'staple strands'. We have extended this method to building custom three-dimensional shapes formed as pleated layers of helices constrained to a honeycomb lattice. We demonstrated the design and assembly of nanostructures approximating six shapes — monolith, square nut, railed bridge, double gear, stacked cross, slotted cross — with precisely controlled dimensions ranging from 10 to 100 nm. Proper assembly requires week-long folding times and calibrated monovalent and divalent cation concentrations. We also showed hierarchical assembly of structures such as homomultimeric linear tracks and of heterotrimeric wireframe icosahedra.