DNA: Not Merely the Secret of Life

Nadrian C. Seeman

Department of Chemistry, New York University, New York, NY 10003, USA

We build branched DNA species that can be joined using sticky ends to produce N-connected objects and lattices. We have used ligation to construct DNA stick-polyhedra and topological targets, such as Borromean rings. Branched junctions with up to 12 arms have been produced.

Nanorobotics is a key area of application. We have made robust 2-state and 3-state sequence-dependent devices that change states by varied hybridization topology. Bipedal walkers, both clocked and autonomous have been built. We have constructed a molecular assembly line by combining a DNA origami layer with three 2-state devices, so that there are eight different states represented by their arrangements. We have demonstrated that all eight products (including the null product) can be built from this system.

A central goal of DNA nanotechnology is the self-assembly of periodic matter. We have constructed 2-dimensional DNA arrays with designed patterns from many different motifs. We have used DNA scaffolding to organize active DNA components. Active DNA components include DNAzymes and DNA nanomechanical devices; both are active when incorporated in 2D DNA lattices. We have used pairs of 2-state devices to capture a variety of different targets. Multi-tile DNA arrays have been used to organize gold nanoparticles in specific arrangements.

Recently, we have self-assembled a 3D crystalline array and have solved its crystal structure to 4 Å resolution, using unbiased crystallographic methods. Many other crystals have been designed following the same principles of sticky-ended cohesion. We can use crystals with two molecules in the crystallographic repeat to control the color of the crystals. Thus, structural DNA nanotechnology has fulfilled its initial goal of controlling the structure of matter in three dimensions. A new era in nanoscale control awaits us.

This research has been supported by the NIGMS, NSF, ARO, ONR and the W.M. Keck Foundation.