

## **DNA: Not Merely the Secret of Life**

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DNA is well-known as the genetic material of living organisms. Its most prominent feature is that it contains information that enables it to replicate itself. This information is contained in the well-known Watson-Crick base pairing interactions, adenine with thymine and guanine with cytosine. The double helical structure that results from this complementarity has become a cultural icon of our era. To produce species more diverse than the DNA double helix, we use the notion of reciprocal exchange, which leads to branched molecules. The topologies of these species are readily programmed through sequence selection; in many cases, it is also possible to program their structures. Branched species can be connected to one another using the same interactions that genetic engineers use to produce their constructs, cohesion by molecules tailed in complementary single-stranded overhangs, known as 'sticky ends.' Such sticky-ended cohesion is used to produce N-connected objects and lattices.

Structural DNA nanotechnology is based on using stable branched DNA motifs, like the 4-arm Holliday junction, or related structures, such as double crossover (DX), triple crossover (TX), and paranemic crossover (PX) motifs. We have been working since the early 1980's to combine these DNA motifs to produce target species. From branched junctions, 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. We have also built DNA nanotubes with lateral interactions.

Nanorobotics is a key area of application. PX DNA has been used to produce a robust 2-state sequence-dependent device that changes states by varied hybridization topology. We have used this device to make a translational device that prototypes the simplest features of the ribosome. A protein-activated device that can be used to measure the ability of the protein to do work, and bipedal walkers, both clocked and autonomous have been built. We have also assembled a robust 3-state device.

A central goal of DNA nanotechnology is the self-assembly of periodic matter. We have constructed 2-dimensional DNA arrays from many different motifs. We can produce specific designed patterns visible in the AFM. We can change the patterns by changing the components, and by modification after assembly. Recently, we have used DNA scaffolding to organize active DNA components, as well as other materials. Active DNA components include DNAzymes and DNA nanomechanical devices; both are active when incorporated in 2D DNA lattices. We have used pairs of PX-based devices to capture a variety of different targets. Multi-tile DNA arrays have also been used to organize gold nanoparticles in specific arrangements. We have self-assembled a 3D crystalline array and have solved its crystal structure.

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