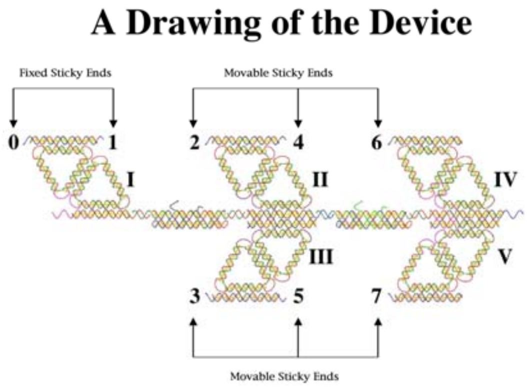
Programmable Nanoscale Machines Achieved by DNA Self-Assembly

The goal is to build programmable devices and polymeric structures using DNA. In one example, a DNA nanomechanical translation device has been build in the laboratory (a schematic is shown in the figure).



The device contains a series of sticky ends, indicated by numbers [1, 2]. The sticky ends ride on DNA diamonds or double diamonds, which are connected by PX-JX_2 devices. There are 2-state devices [3] that rotate a half-turn and can be addressed individually. By changing the states of the two devices, the numbers that flank an interval can be changed. Thus, the interval flanked by 1 and 2 would be flanked by 1 and 3 if the state of the device separating the diamond on the left were to be switched. There are 4 states available to the translation device. The advent of translation was a watershed event in the evolution of life. The putative RNA world was freed from dependence on transcriptional construction of polymers, and was able to generate much greater chemical diversity by adding translation to its capabilities. We expect to be able to use the same capabilities in DNA nanotechnology to be able to construct diverse, predesigned polymers. Furthermore, the translational capability of this device will enable it to function as a variable input device to a finite-state machine. The DX molecules are the equivalents of aminoacyl tRNA molecules.

In another example, researchers have created a two-armed nanorobotic device that can manipulate molecules within a device made of DNA. Nadrian Seeman of New York University and colleagues have found that the programmable unit provides an unprecedented ability to capture and maneuver DNA components. The creation builds on the single nanorobotic arm Seeman completed in 2006—the first time researchers had used a functional nanotechnology device within a DNA array. The new nanorobotic device uses its two arms to practice DNA origami, a method where short DNA components direct a very long DNA strand to form structures in a desired shape. These shapes can be larger and more complex than those possible within a simple crystalline DNA array. Atomic force microscopy has shown that the nanorobotic device captures targeted molecules with 100 percent accuracy. Such nanorobotic devices may one day act as a factory for synthesizing chemicals. They also have the potential to advance the encryption of information and the assembly of computer devices using DNA scaffolds.

Gu, H., J. Chao, S.-J. Xiao, N. C. Seeman. Dynamic patterning programmed by DNA tiles captured on a DNA origami substrate. *Nature Nanotechnology*, 15 February, 2009; advance online publication, DOI: 10.1038/nnano.2009.5

Liao, S., and N.C. Seeman, Translation of DNA Signals into Polymer Assembly Instructions, *Science* **306**, 2072-2074 (2004). A provisional patent has been filed:

Liao, S., & N.C. Seeman, A Polynucleotide Nanomechanical Device that Acts as an Artificial Ribosome and Translates DNA Signals into Polymer Assembly Instructions, #60/592,402, Filed, 08/02/04. NYU has licensed the patents from this work to Nanoscience Technologies, Inc.

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