DNA: The Secret of Life

James D. Watson

DNA: Not Merely the Secret of Life

Nadrian Seeman

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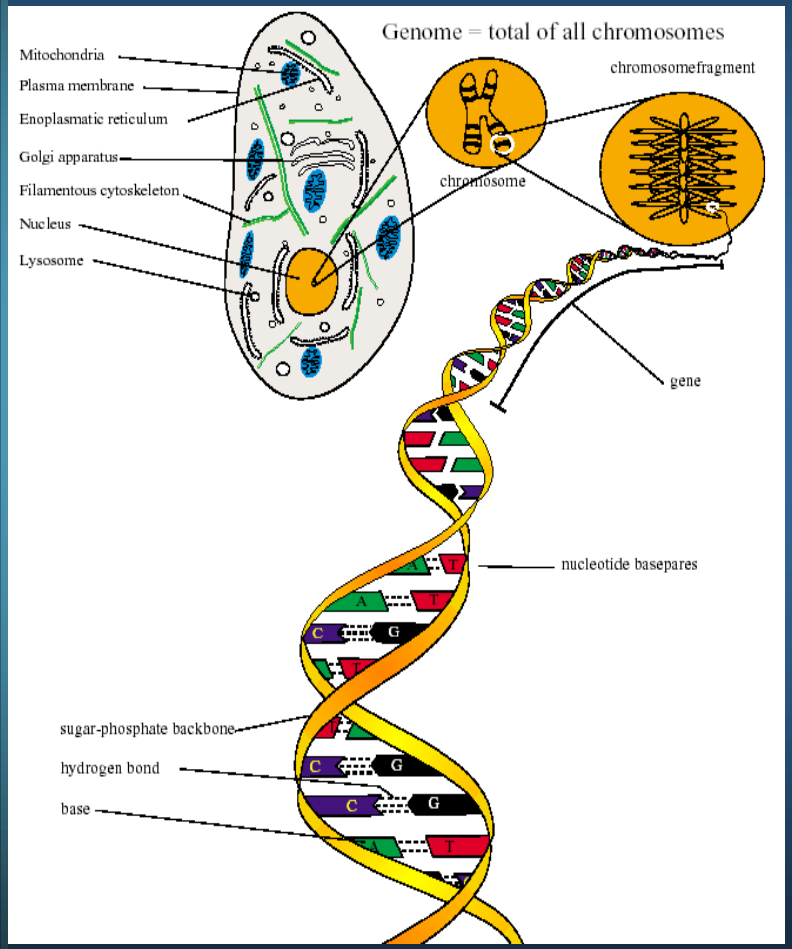


DNA: Not Merely The Secret of Life

DNA Nanotechnology

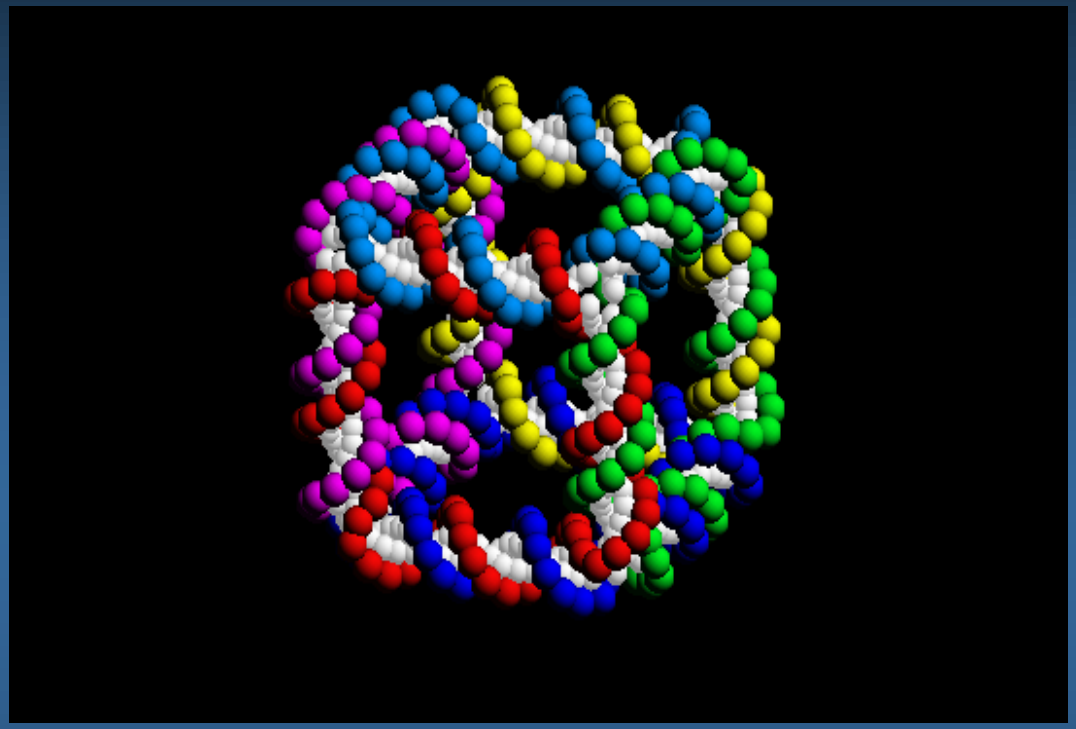
- **Nadrian Seeman at New York University**

  http://seemanlab4.chem.nyu.edu/nanotech.html

- **Ref: Nanobiotechnology, Chapter 20**

- **Ultimate goals for this approach**
  - **the rational synthesis of periodic matter**
  - **the assembly of a biochip computer**

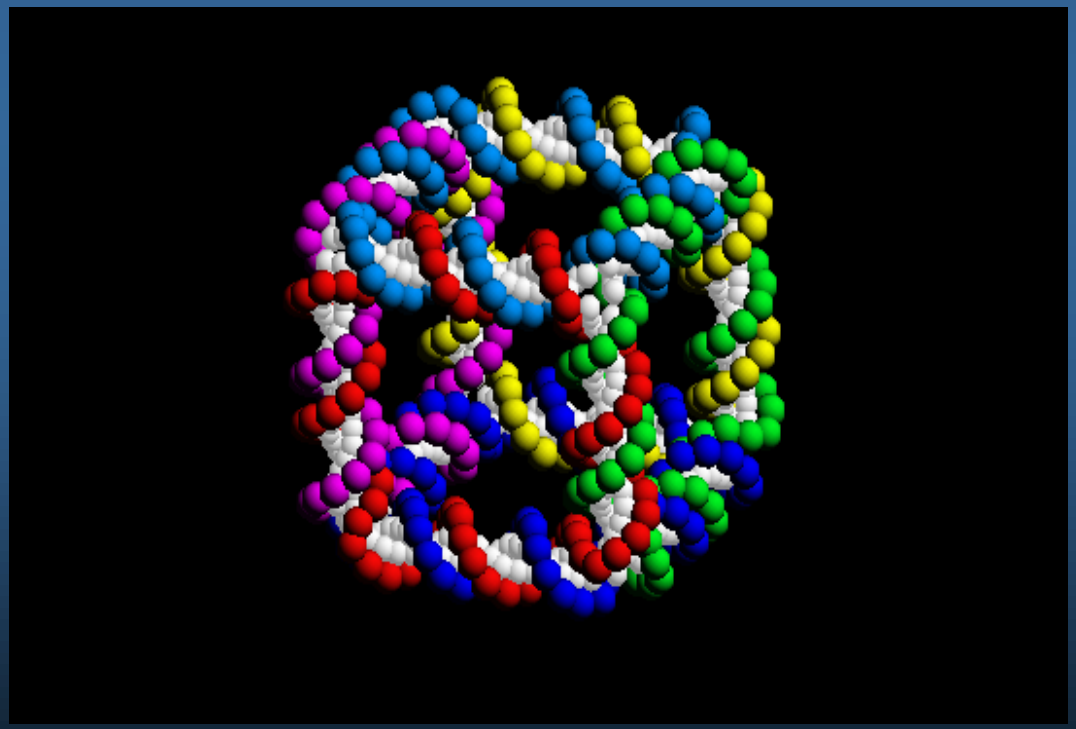
DNA Cube



- Cube contains six different cyclic strands
- Backbones : red (front), green (right), yellow (back), magenta (left), cyan (top), and dark blue (bottom)
- Base : a single white dot

DNA Cube

- **Each edge of the cube**
  - **a piece of double helical DNA, containing two turns of the double helix.**

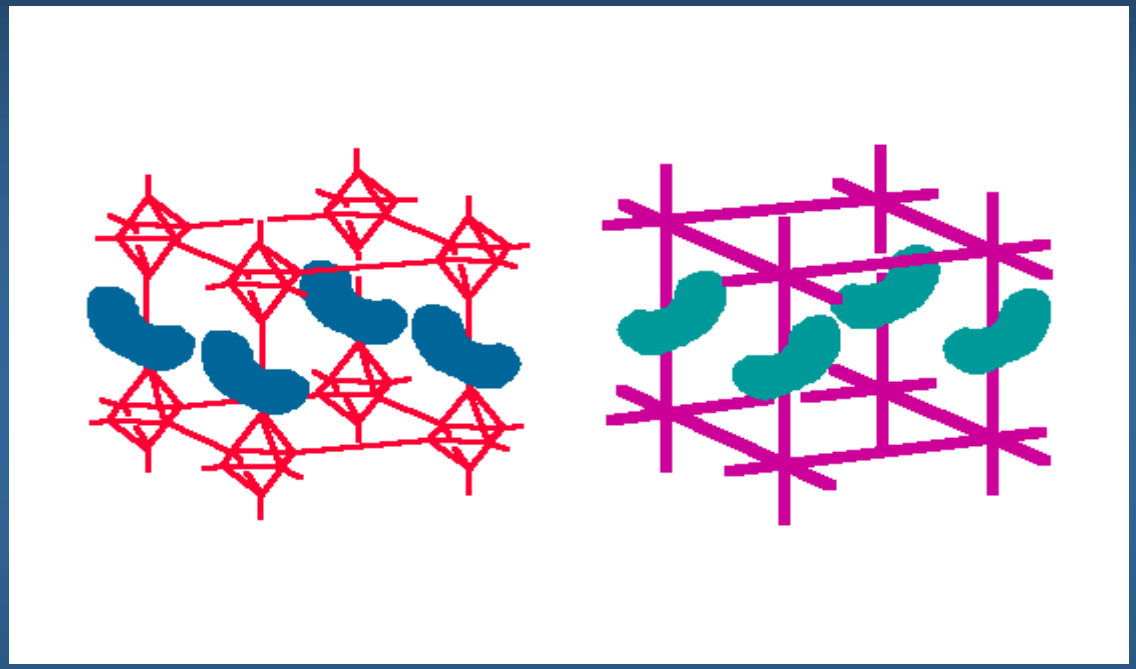


Truncated Octahedron

--- contains six squares and eight hexagons.

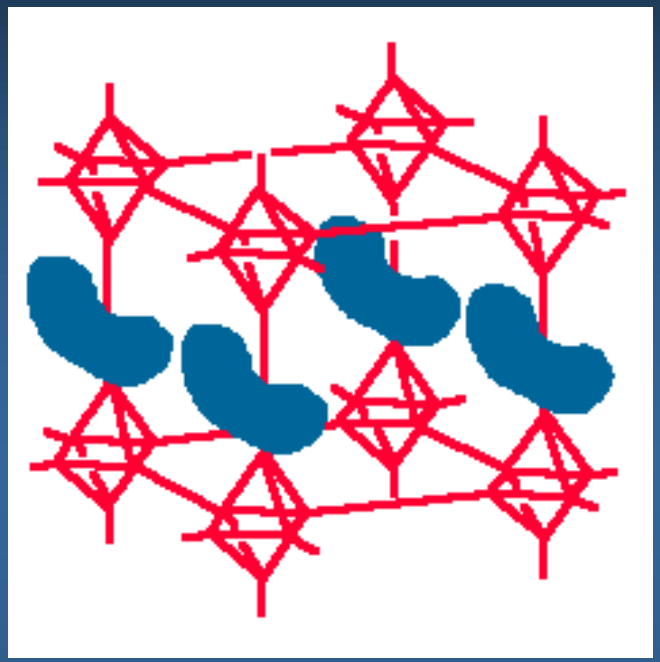
--- molecular weight: about 790,000 Daltons.

DNA Cages Containing Oriented Guests



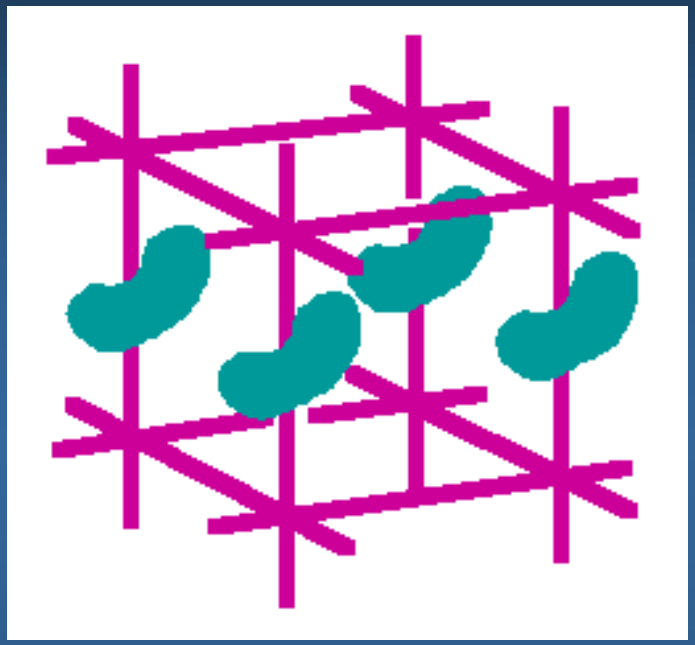
- **Both networks contain kidney-shaped objects that are oriented in a parallel fashion within each network.**

5-connected network



- Each vertex is connected to five other vertices.
- It contains octahedra and a truncated cube.

6-connected network



- Each vertex is connected to six different networks.
- It contains only cubes

Ultimate goals for this approach

--- the rational synthesis of periodic matter

--- the assembly of a biochip computer

DNA Nanomechanical Devices (DNA Motor)

The goals of nanotechnology include nanorobotics.

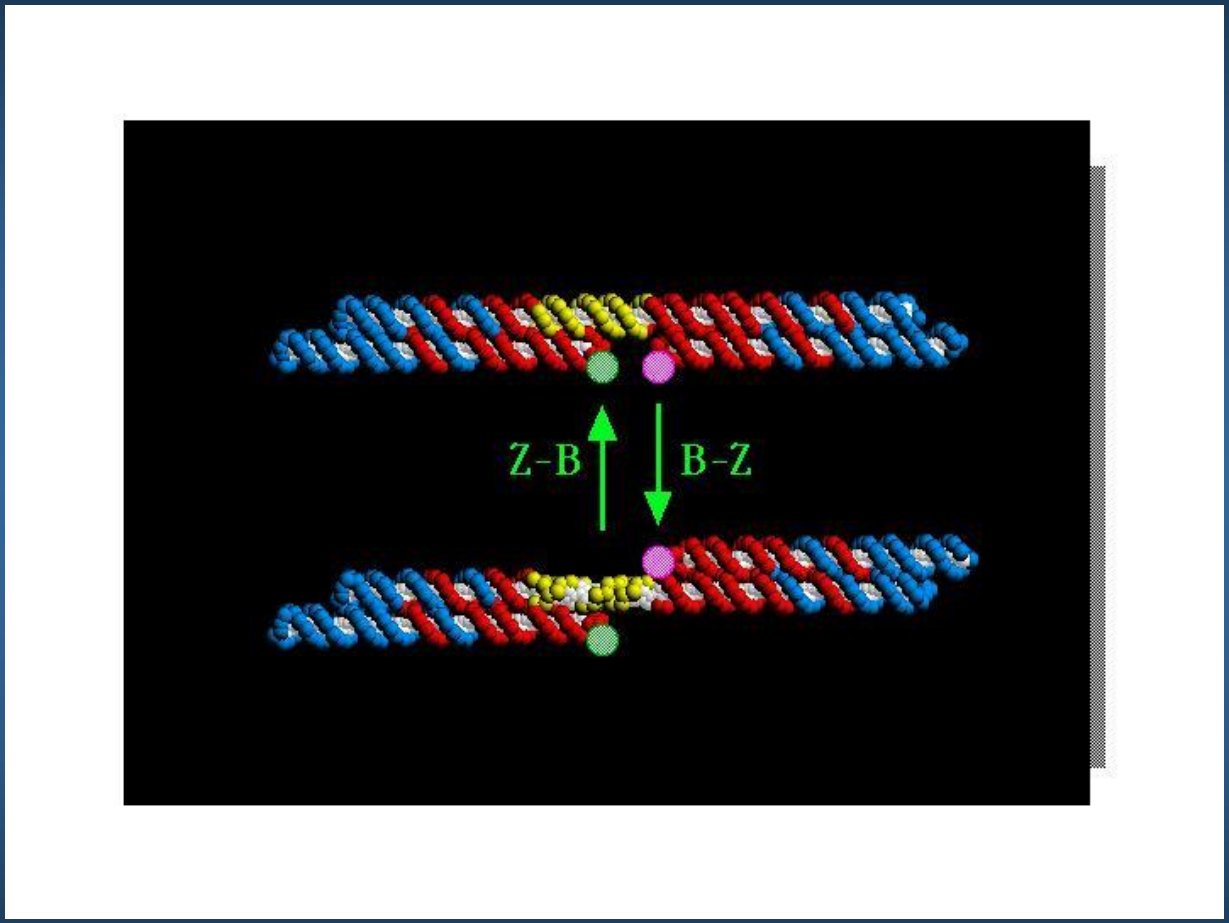
(1) Based on the B-Z transition of DNA

(2) Based on hybridization topology

(3) Bipedal walking device

--- The rise and fall of each foot of the biped is controlled by introducing DNA strands with specific sequences into the solution.

(1) Based on the B-Z Transition of DNA



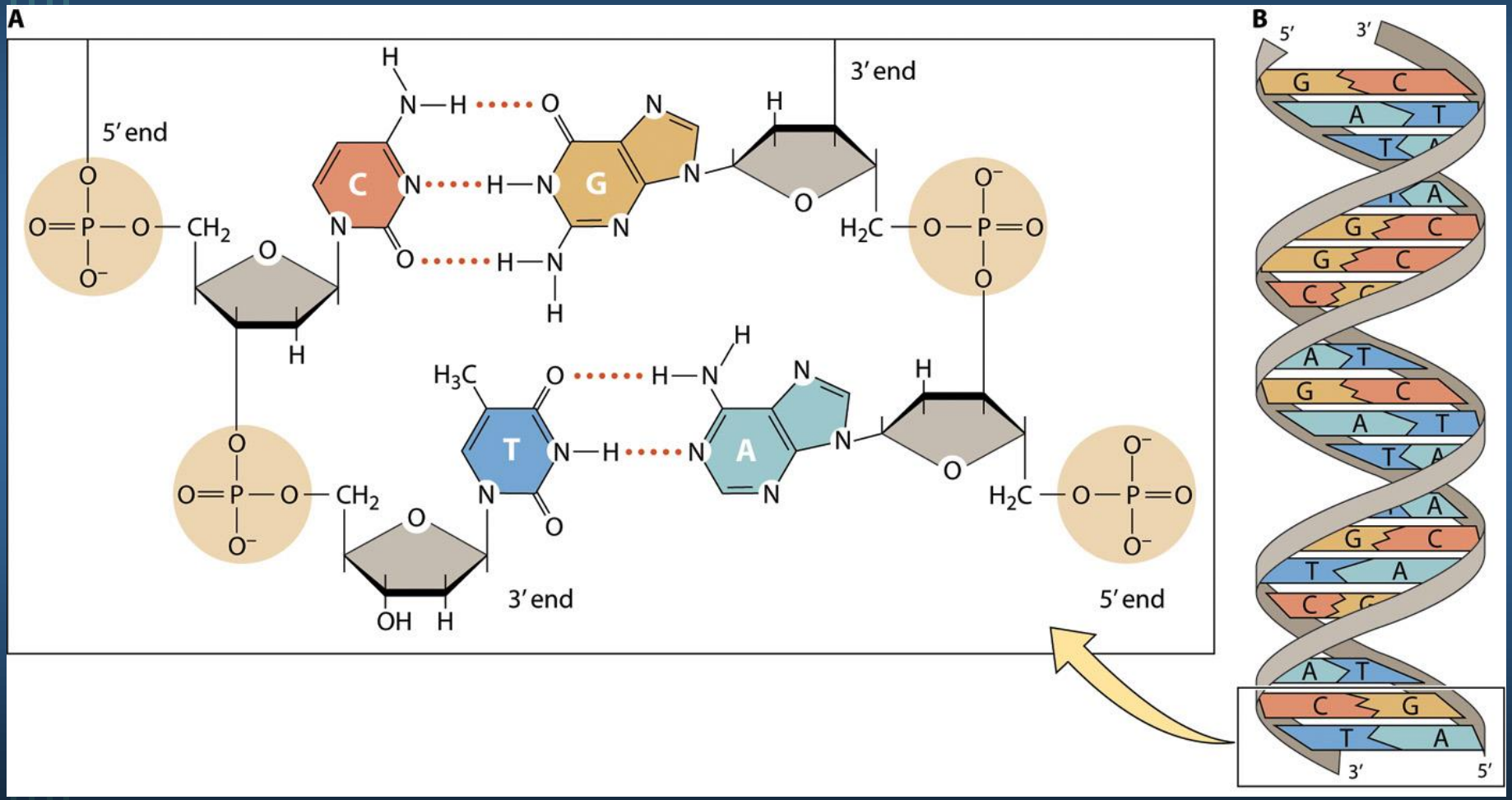
B-DNA (right-handed DNA) Z-DNA (left-handed DNA)

(1) Based on the B-Z Transition of DNA

- Two double crossover molecules (red and blue regions) were connected by a bridge segment (yellow region).

- The rigidity of the antiparallel **double crossover molecule** has allowed us to use it as a component of a DNA nanomechanical device.

* **Right-handed helix**
  --- **When an observer looks down the axis of the helix in either direction, each strand follows a clockwise path as it moves away from the observer.**
  --- **Naturally occurring DNA molecules are generally right-handed helices.**


A
5′ end
3′ end
C
G
T
A
3′ end
5′ end
B
5′
3′
3′
5′

* The change from B-DNA to Z-DNA :

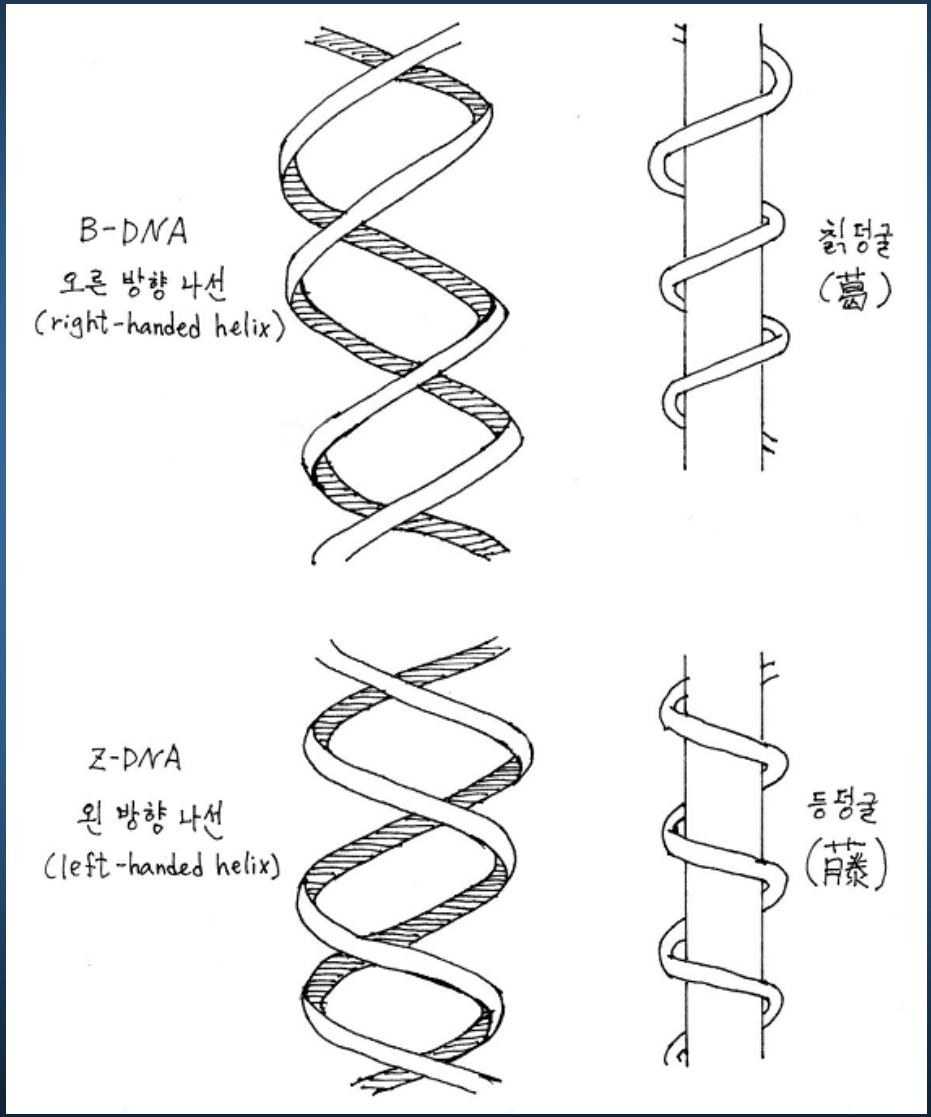
---- by the addition of Hexaamminecobalt(III) chloride to the solution.

* The change back:

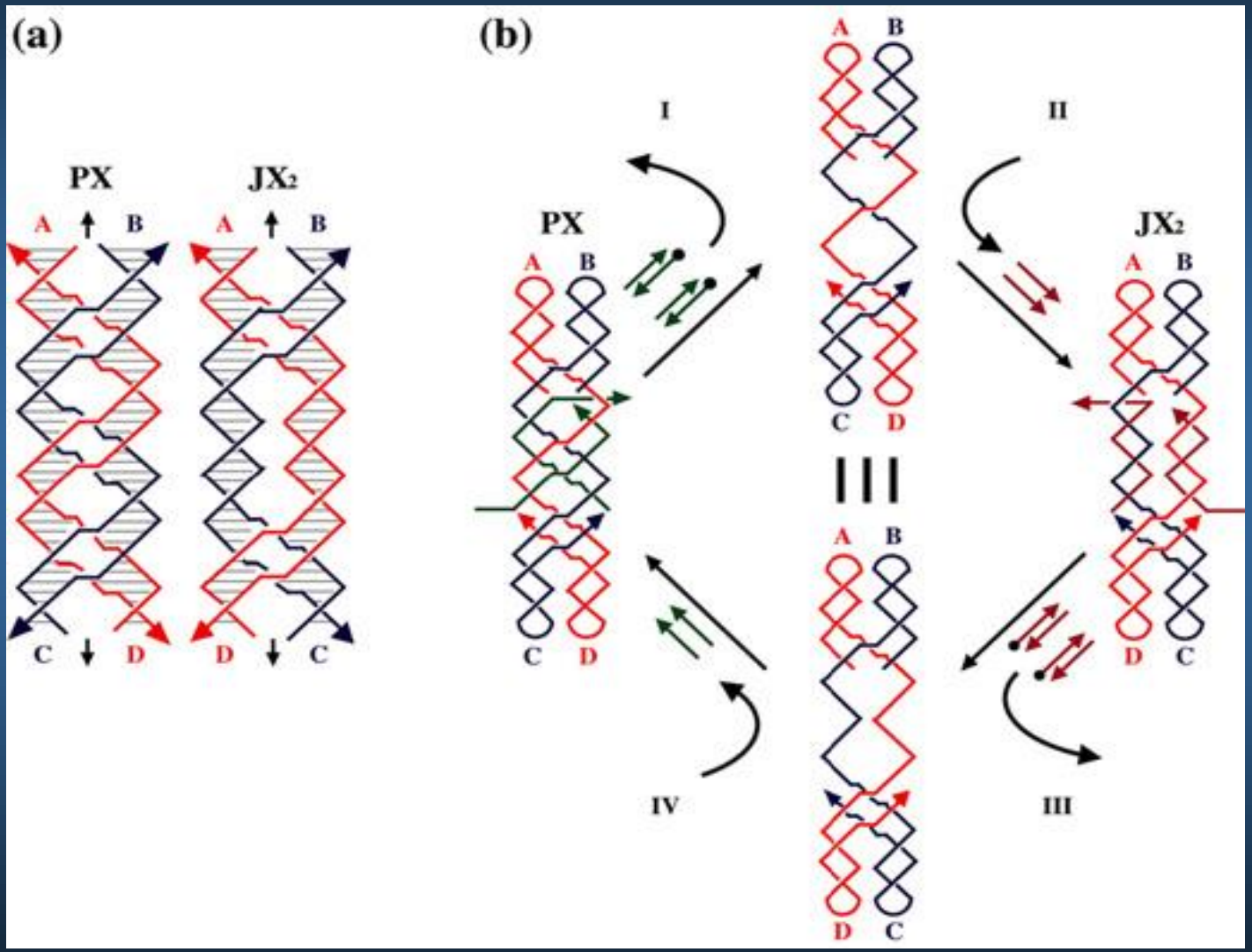
---- by removal of this reagent.

The change of conformation from B-DNA to Z-DNA is monitored by fluorescence resonance energy transfer (FRET) spectroscopy involving these two dyes.

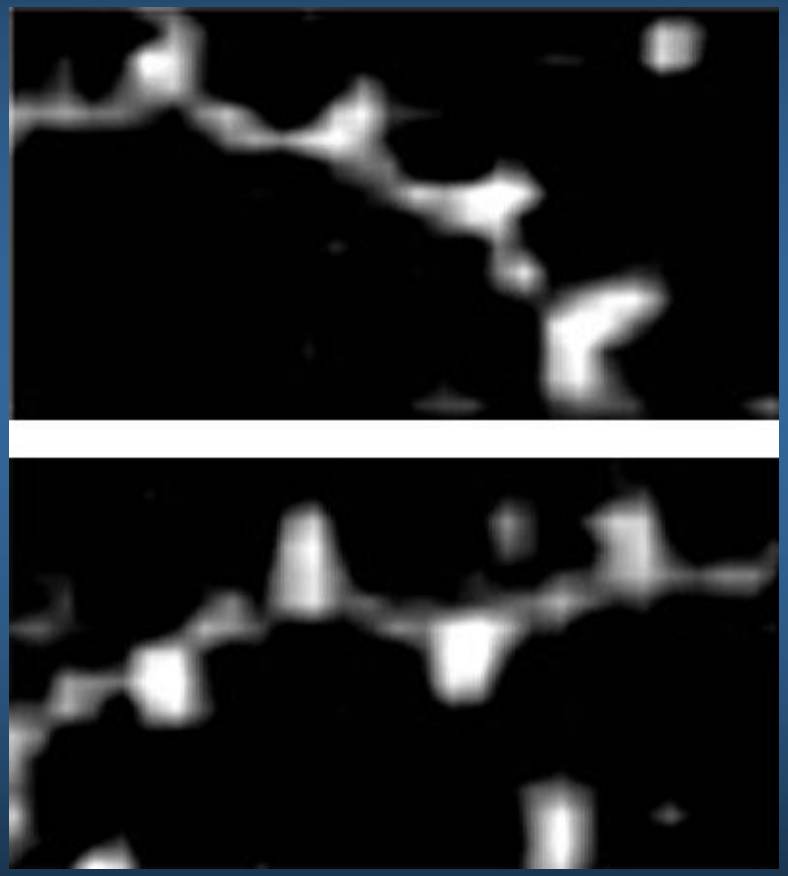
DNA와 갈등


B-DNA
오른 방향 나선
(right-handed helix)
칡덩굴
(葛)
Z-DNA
왼 방향 나선
(left-handed helix)
등덩굴
(藤)

..... (2) Based on Hybridization Topology .....



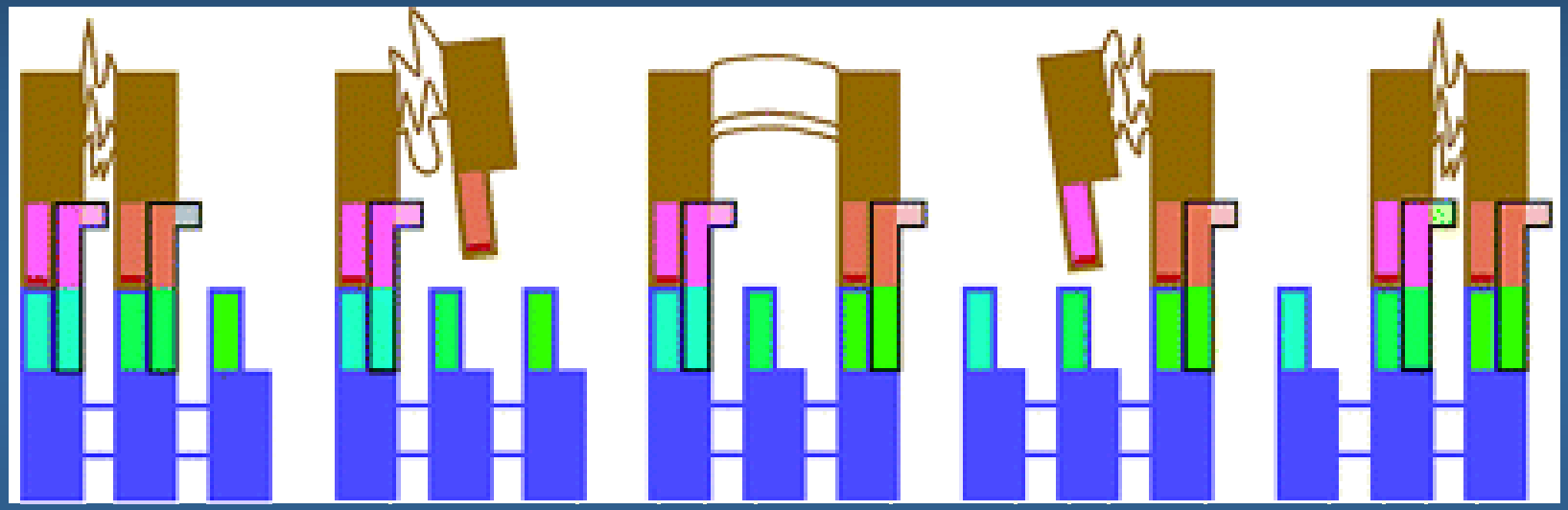
"A Robust DNA Mechanical Device Controlled by Hybridization Topology," Nature, January 3, 2002.



- The bumps on this DNA motor each consist of three joined DNA tiles.
  - Top: bumps aligned with each other
  - Bottom: bumps alternating directions

(3) Bipedal Walking Device (Walking DNA)

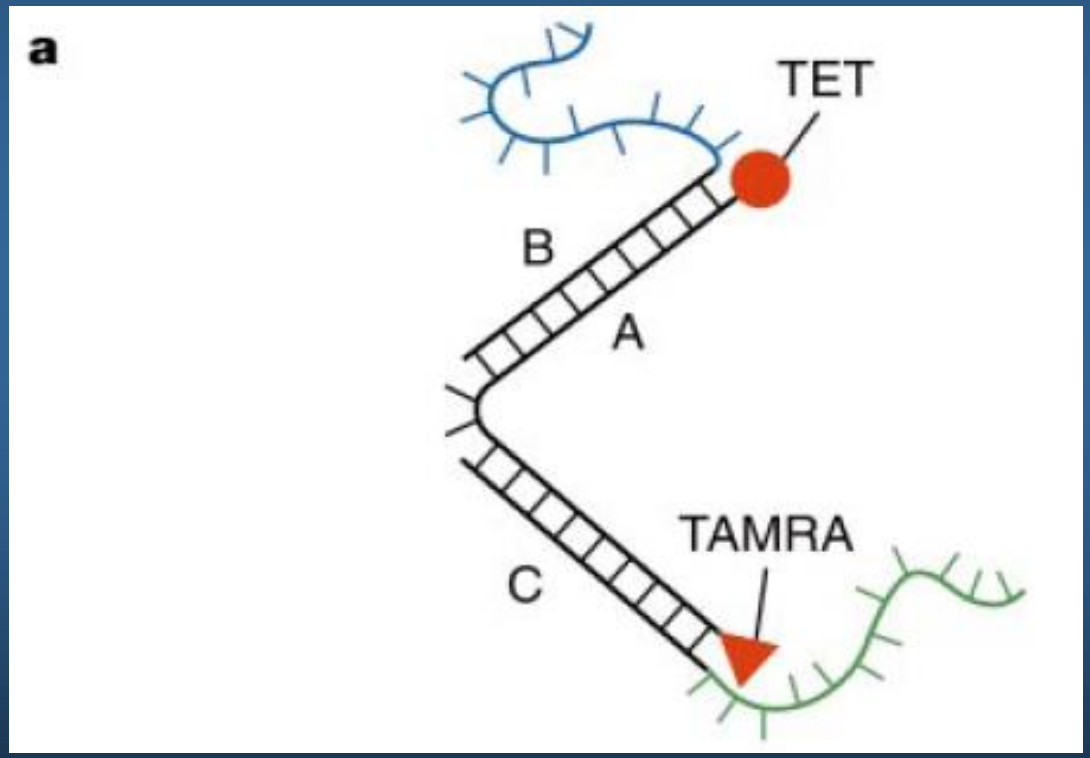
W. B. Sherman and N. C. Seeman, Nano Lett.; 2004; *4*(7) pp 1203 - 1207



The rise and fall of each foot of the biped is controlled by introducing DNA strands with specific sequences into the solution.

DNA Tweezers

(Nature, 406, p605, 2000)



DNA Tweezers

(Nature, 406, p605, 2000)