

# **iBiology.org Teaching Tools**

## **William Shih's Lecture Part 1:**

### **Nanofabrication through DNA origami**

Teaching Tools were prepared by Karen Cheng and William Shih.

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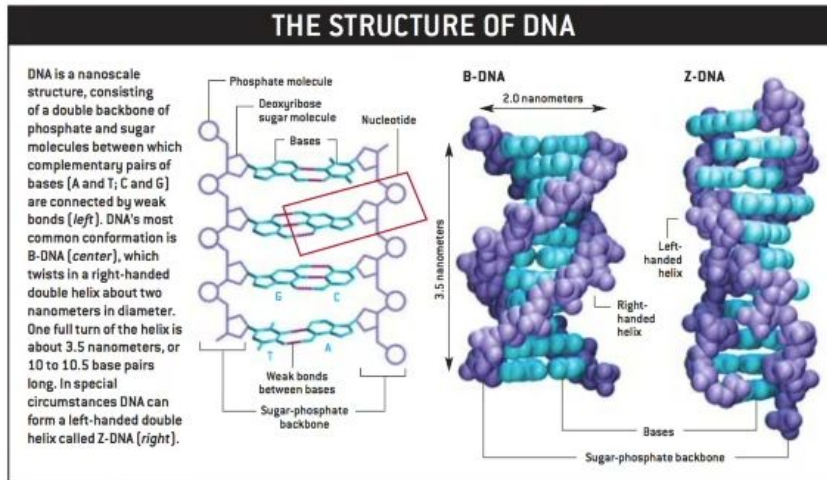
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#### **1. Keywords and Terms**

DNA origami, Holliday junctions, DNA tiles, DNA nanostructure tools

#### **2. Lecture Notes**



Seeman NC, *Sci.Am.* 290, 64-75, 2004.

Ladder with antiparallel strands.  
 Right-handed twist with 10.5 basepairs per turn.  
 A pairs with T, C pairs with G.



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### 5:14 min

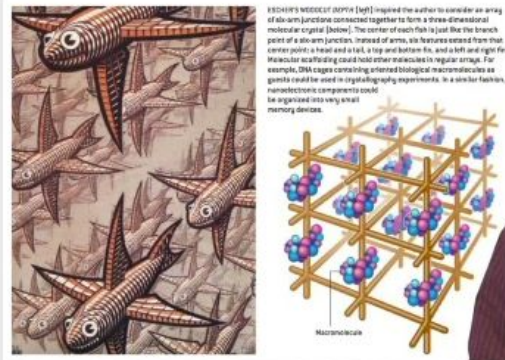
The structure of DNA lends itself to being a useful building block for nano-construction for 3 reasons:

1. ladder with antiparallel strands
2. right handed twists
3. predictable AT/CG

Watson-Crick base pairing



Seeman NC, *Sci.Am.* 290, 64–75, 2004.



7:35 min

Ned Seeman envisioned Holliday junctions to be used to impose order upon crystal lattice formation for protein xray crystallography

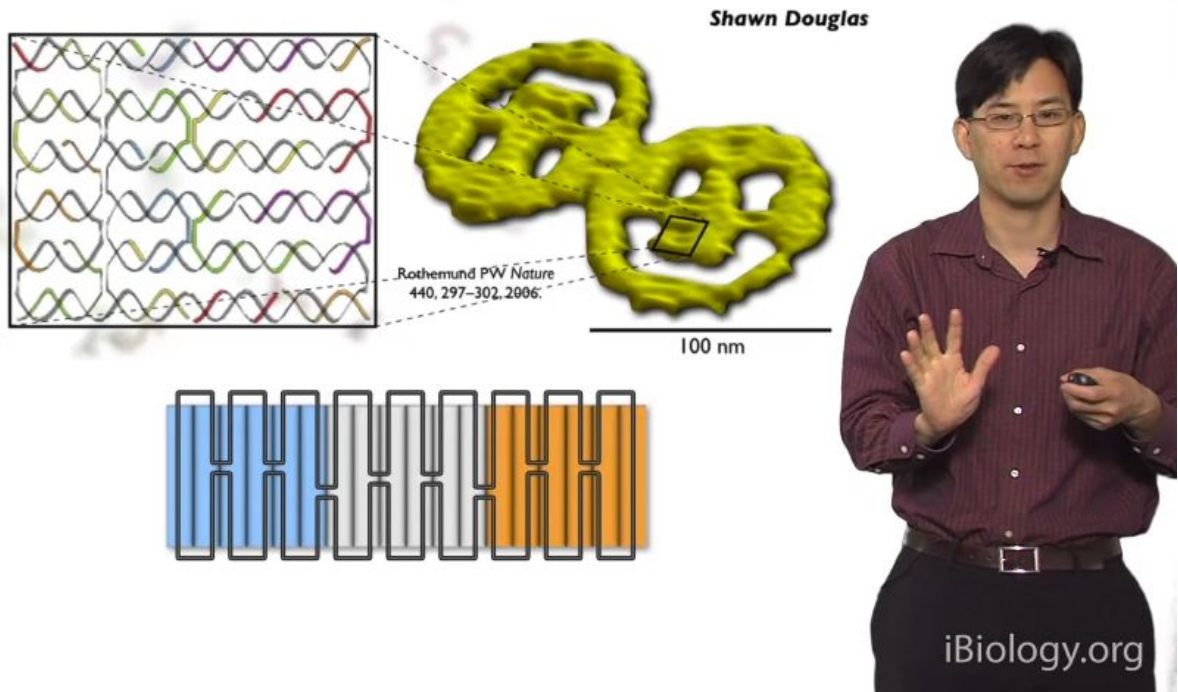


Seeman NC, *Sci.Am.* 290, 64–75, 2004.



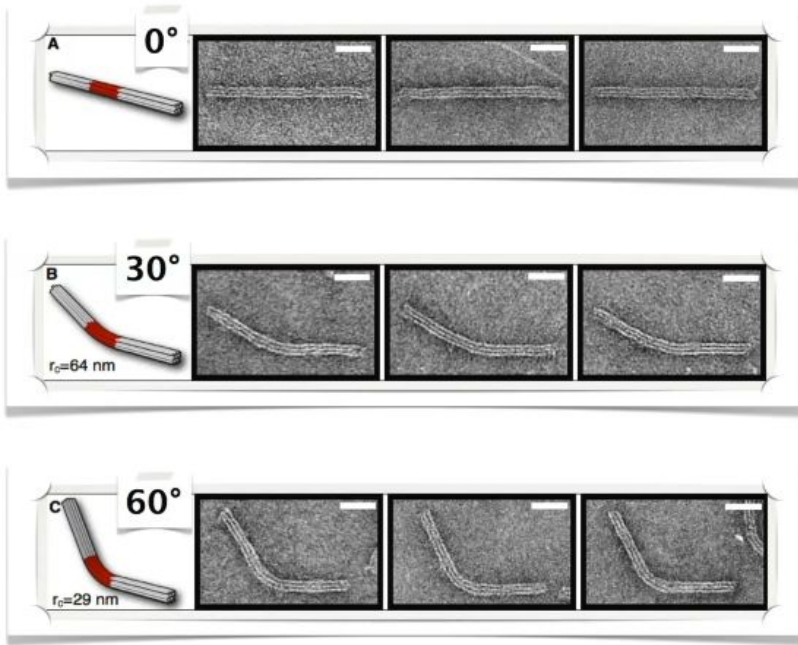
**8:54 min**

Double crossover Holliday junctions are used to stabilize the DNA origami building block. These DNA bricks can self-assemble into 2D DNA tiles.



**17:27 min**

The double helix crossover events can be designed so that the DNA tiles are no longer planar (2D) and can fold into complex 3D structures (DNA origami).



**34:37 min**

Introducing more/less base pairs/turn can induce bending of DNA origami structure.

## Conclusions

We can self-assemble arbitrary 3D-origami DNA nanostructures twice the mass of a ribosome.

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38:04 min

### 3. Review Questions

1. What are Holliday Junctions?
2. What are Holliday Junctions used for in DNA nanotechnology?
3. True/False: DNA adopts a right-handed twist with 10.5 base pairs/turn and cannot deviate from this predicted nucleic acid structure.

### 4. Answers to Review Questions

1. It is a four-way branched nucleic acid junction and is a key intermediate in recombination events.
2. In DNA nanotechnology, they are used to create rigid DNA tiles that can be used to assemble into larger flat arrays. The HJ used to assemble DNA nanostructures differ from the HJ found in biology in that the Holliday Junctions are immobile, i.e. no branch migration occurs.

3. False. DNA is often found as 10.5 bp/turn but importantly, the # bp/turn can adopt 6-15 bp/turn (under and overwound) to create curvature in the DNA twist, which is essential in achieving higher complexity 3D designs.

## 5. Discussion Questions

What are advantages and disadvantages of DNA origami vs. DNA tiles?

## 6. Answers to Discussion Questions

1. DNA origami:

- a. Has a master template (due to continuous connectivity) that guides folding of the structure.
- b. Thermodynamically more stable because it uses a long strand with more linkages
- c. Greater mechanical strength because covalent bonds have to be broken to disrupt the DNA structure

2. DNA tiles:

- a. More modular in design (analogy to legos)
- b. Each domain has a unique sequence so stereospecific assembly can be achieved
- c. Conceptually simpler
- d. Synthetic diversity because all elements are short strands that are accessible to synthesis. In contrast, DNA origami is long so it can only be synthesized enzymatically so DNA origami is only limited to dNTPs that are recognized by polymerases.
- e. Good for building periodic structures