

Nanofabrication with 3D DNA Origami

 DANA-FARBER
CANCER INSTITUTE

WYSS  INSTITUTE

 HARVARD MEDICAL
SCHOOL

William Shih

Thursday, 2009 August 20

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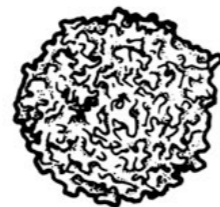
 HARVARD MEDICAL
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flea
1 mm



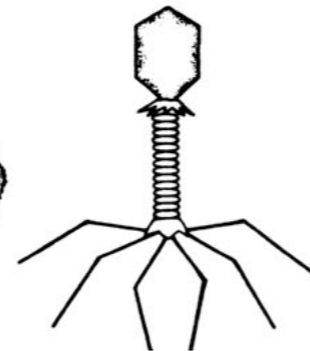
protozoan
0.1 mm



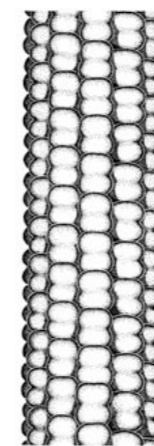
white blood
cell
0.01 mm



E. coli
1 μm



T2 phage
0.1 μm



microtubule
25 nm



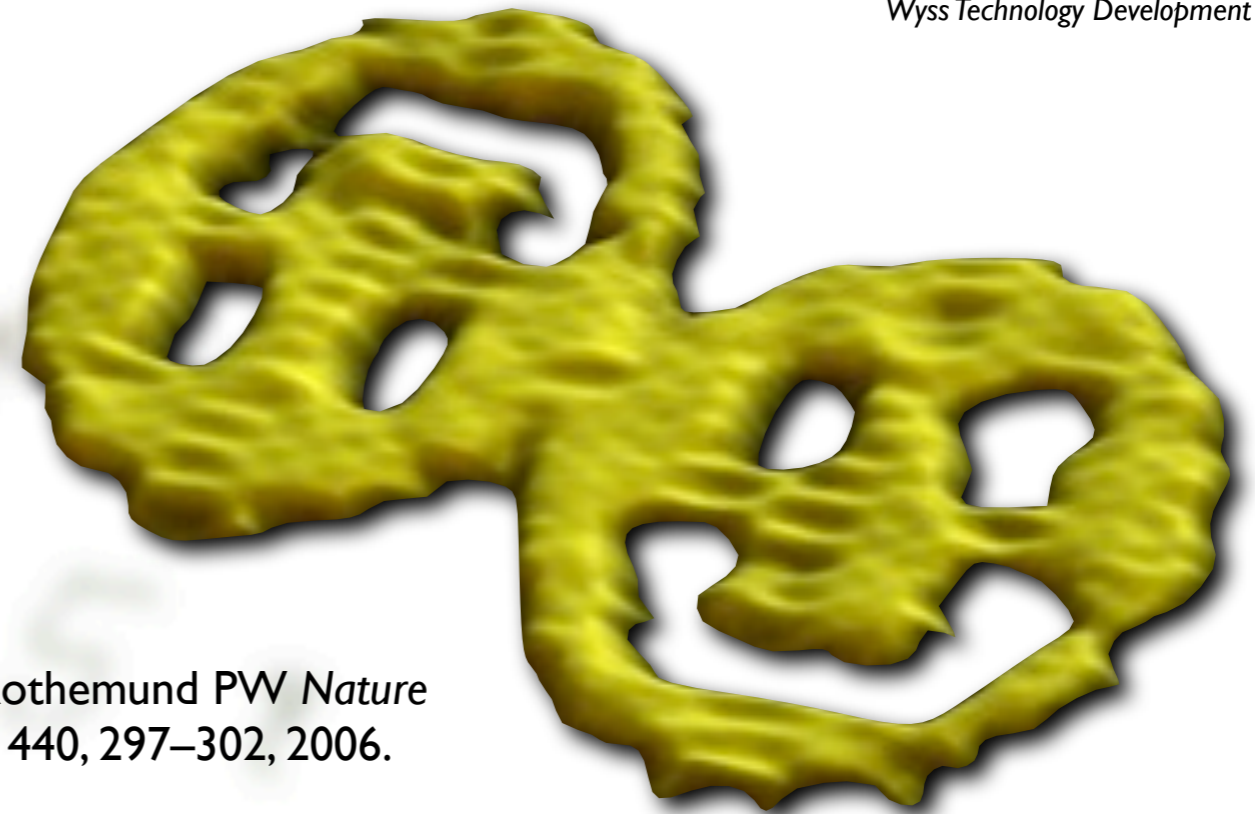
DNA
2 nm



atoms in
DNA
0.2 nm

Shawn Douglas

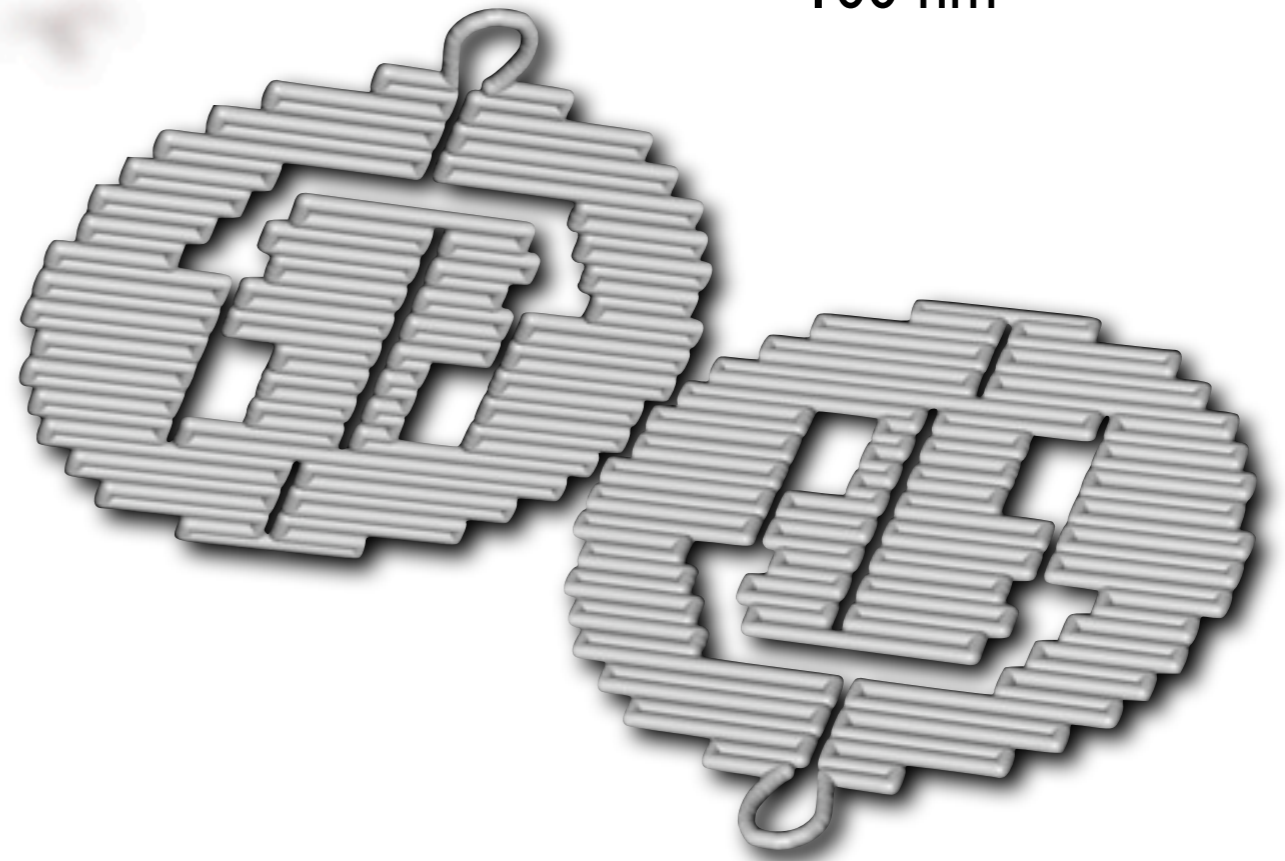
Wyss Technology Development Fellow

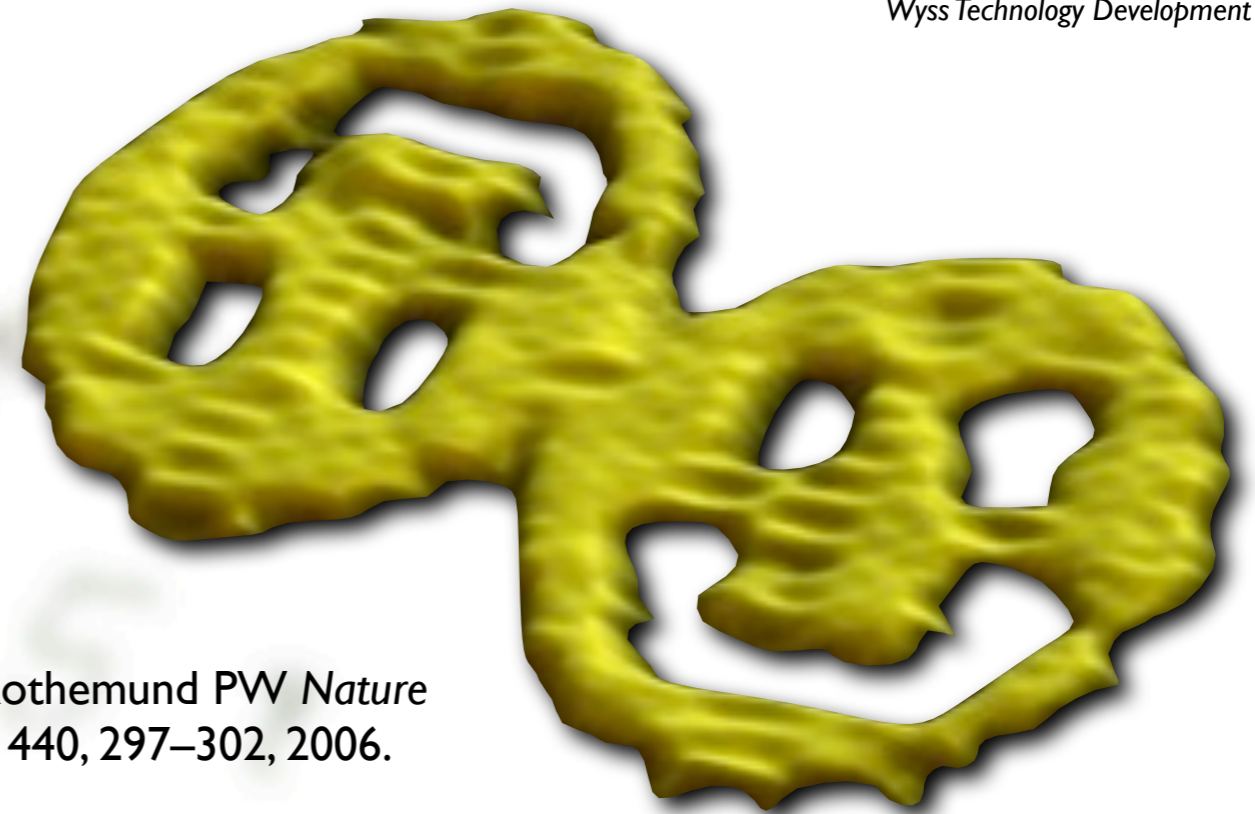


Rothemund PW *Nature*
440, 297–302, 2006.



100 nm

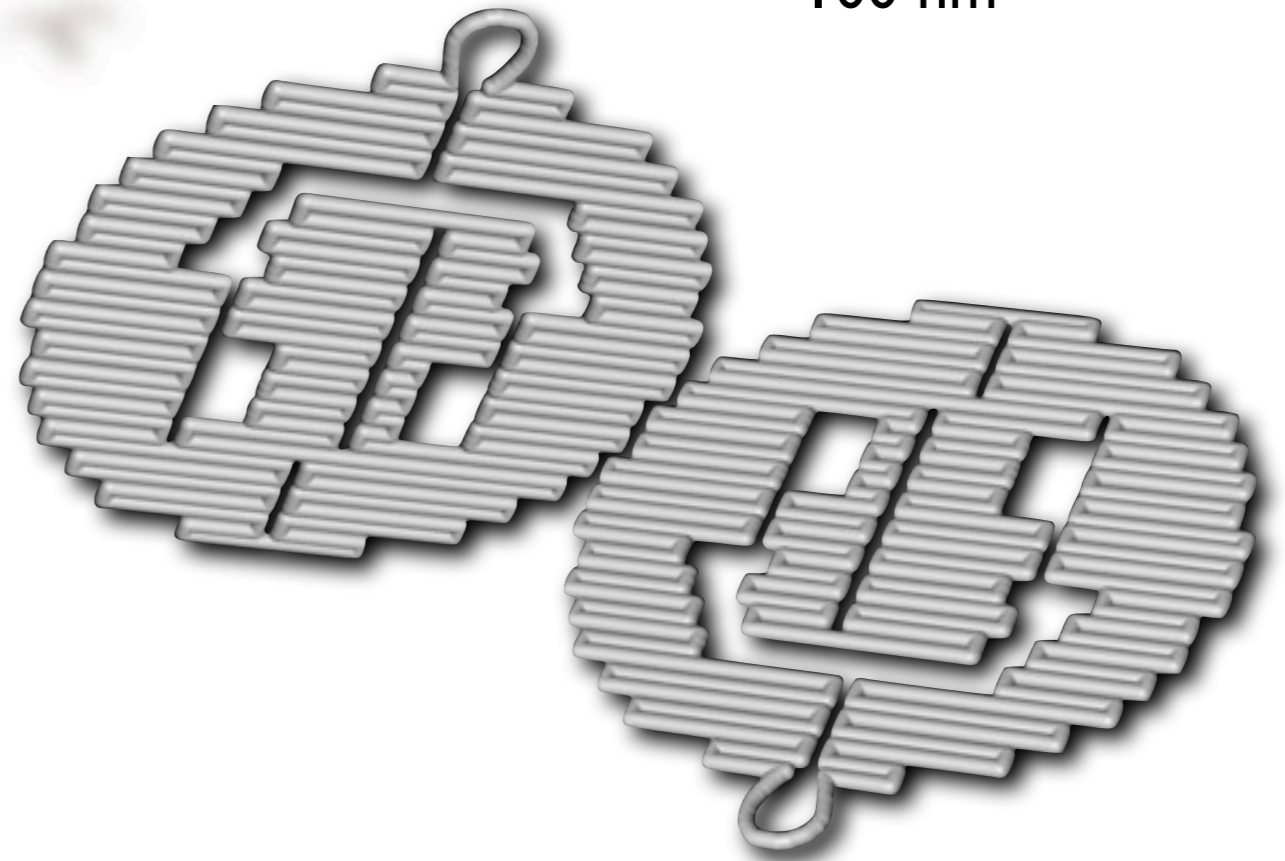


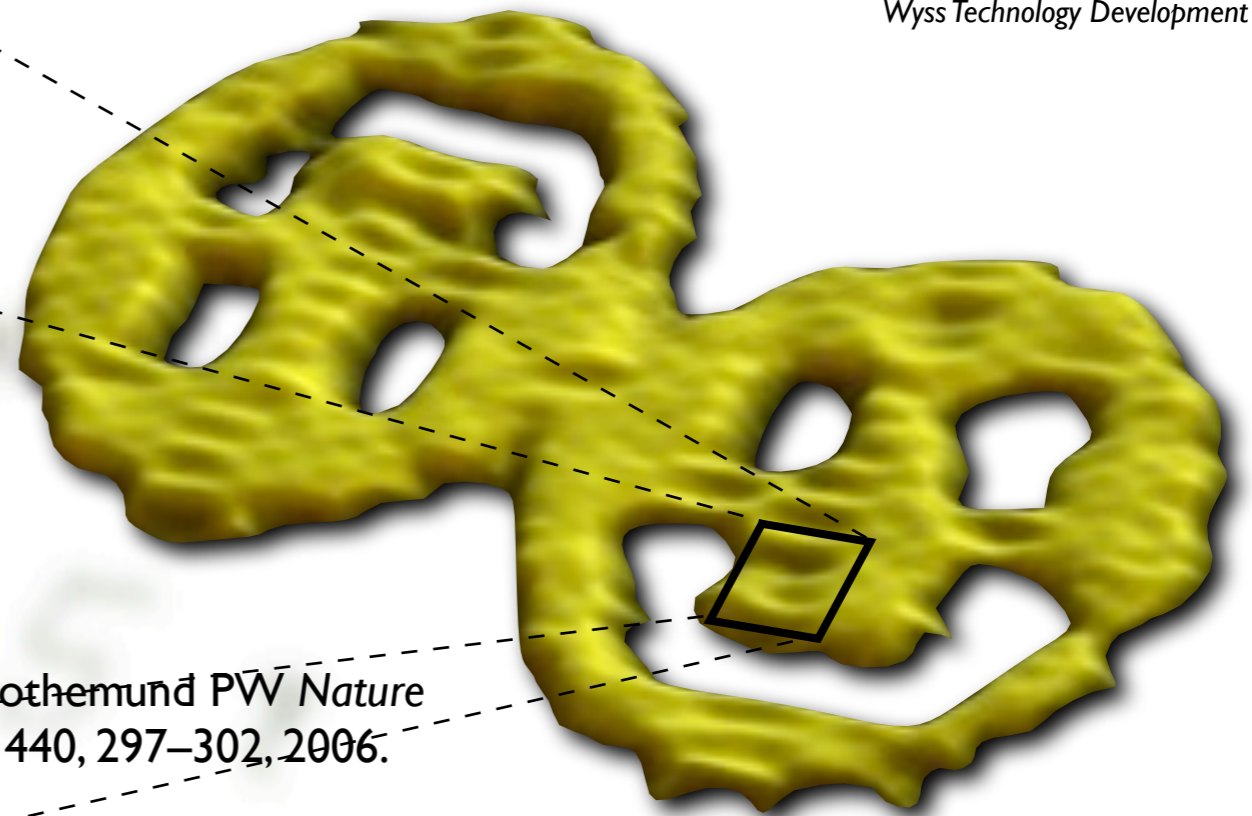
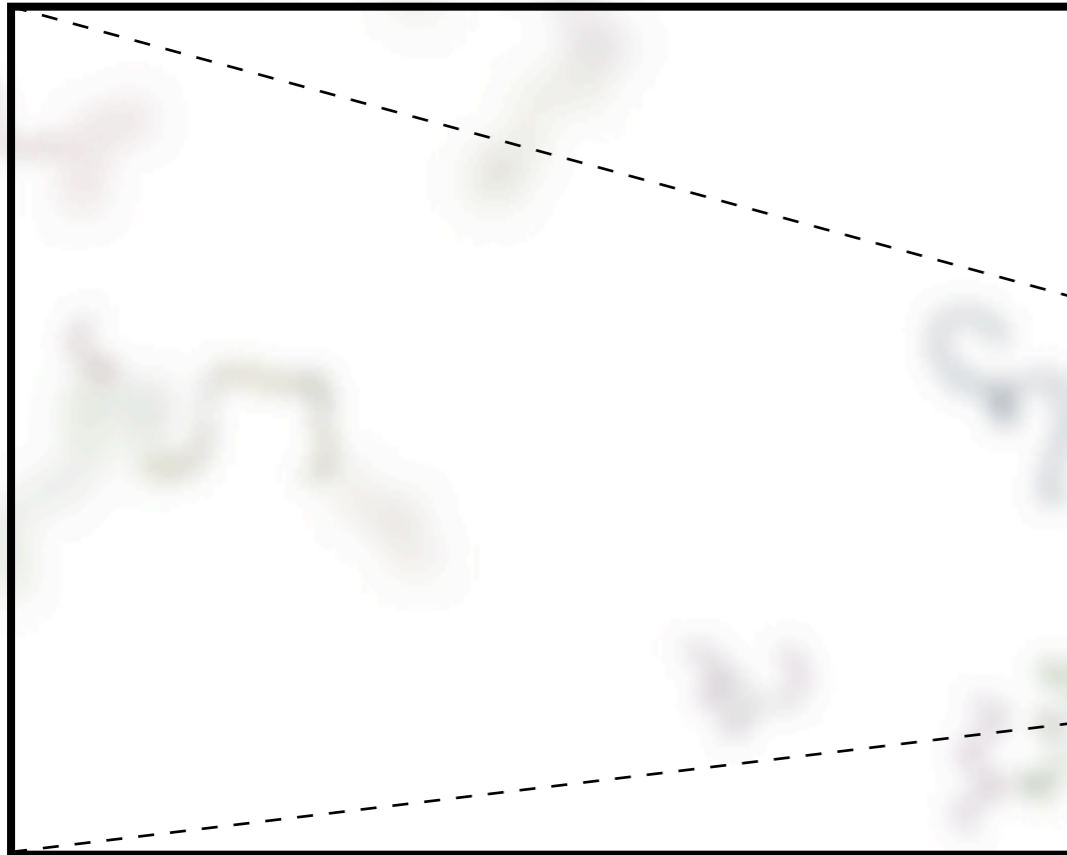


Rothmund PW *Nature*
440, 297–302, 2006.



100 nm

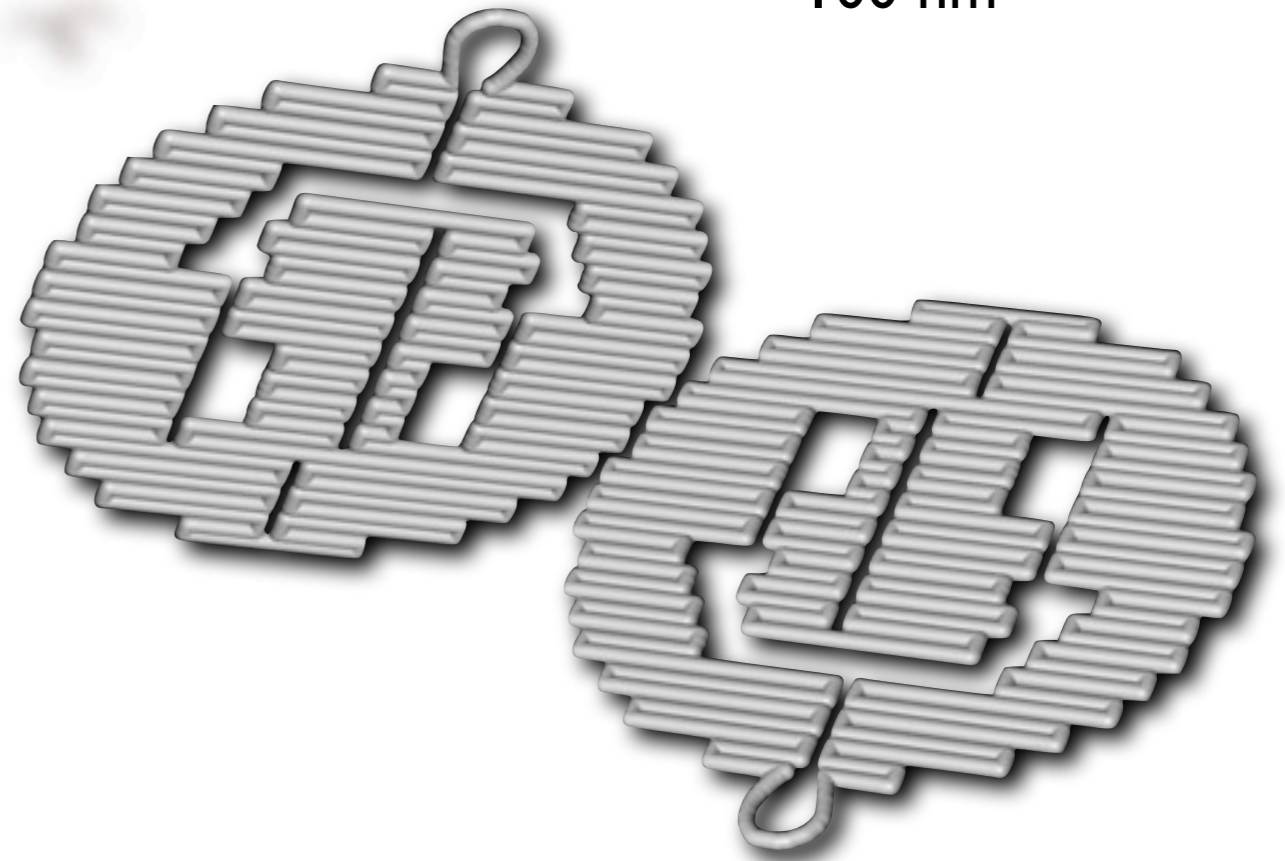




Rothemund PW *Nature*
440, 297–302, 2006.

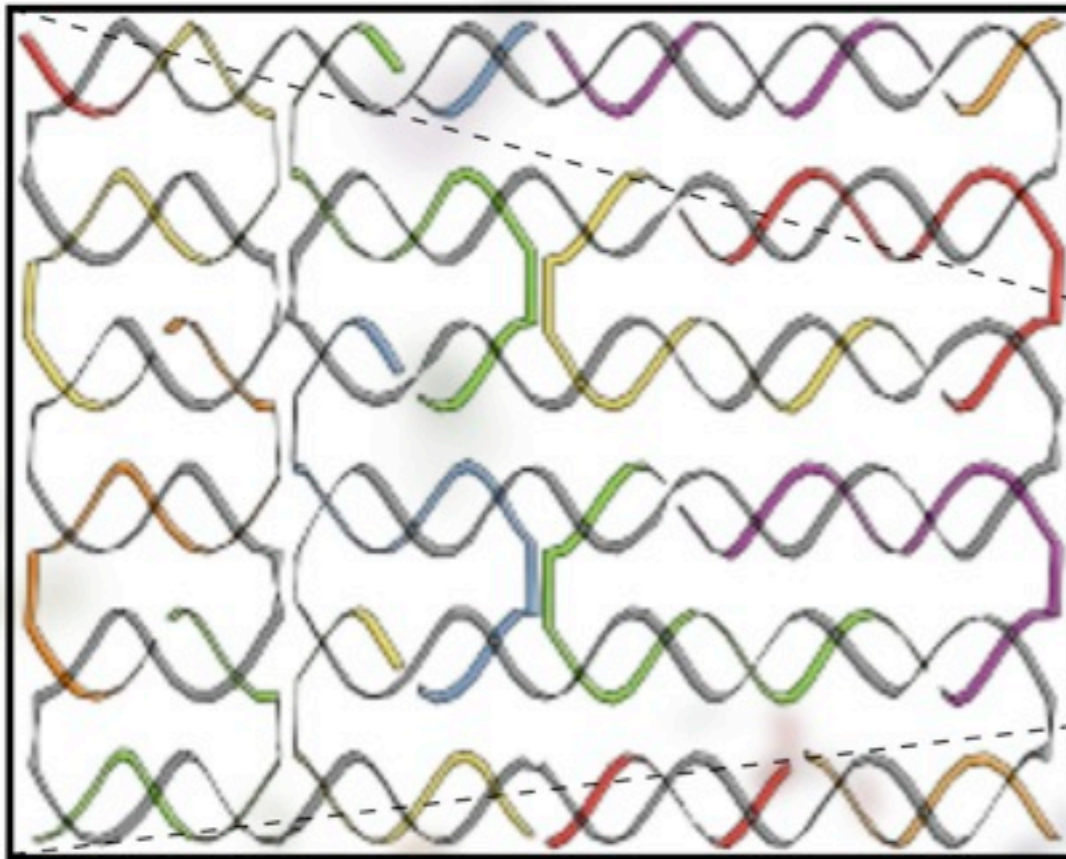


100 nm

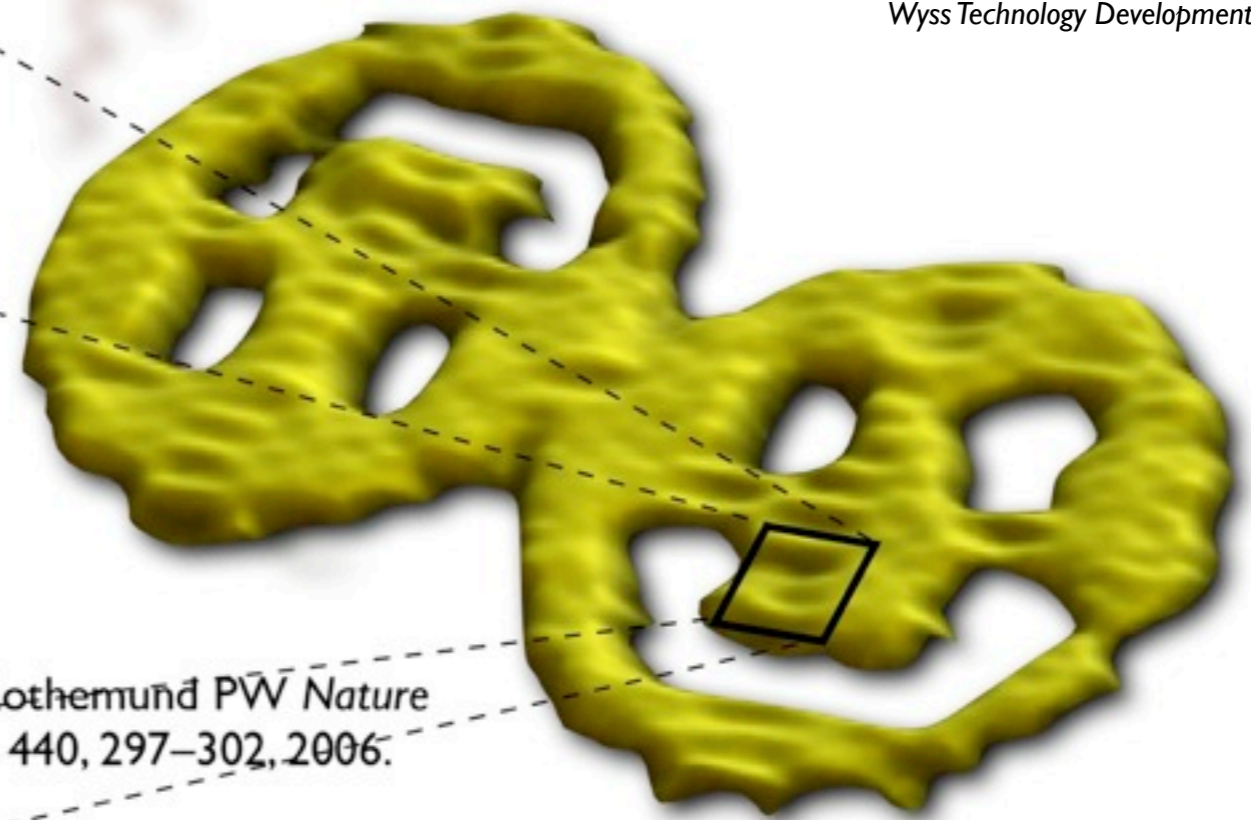


Shawn Douglas

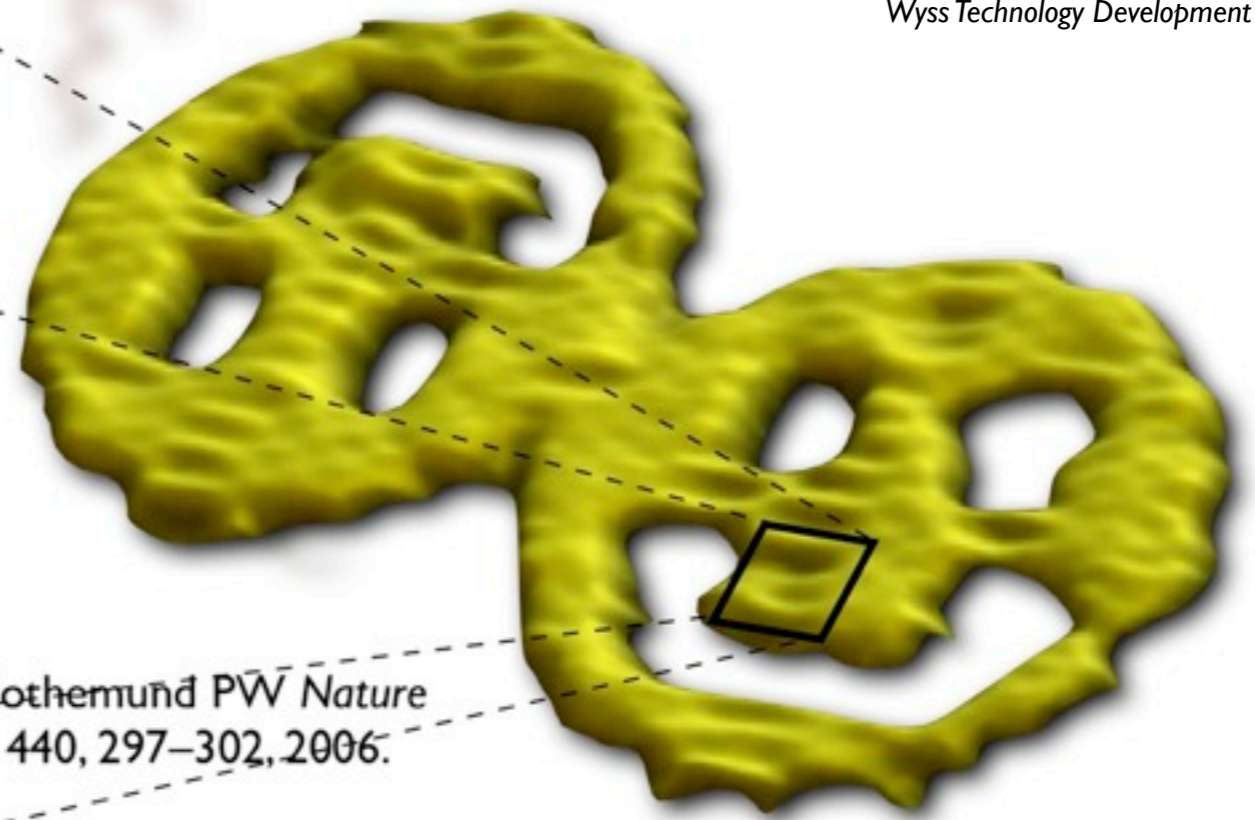
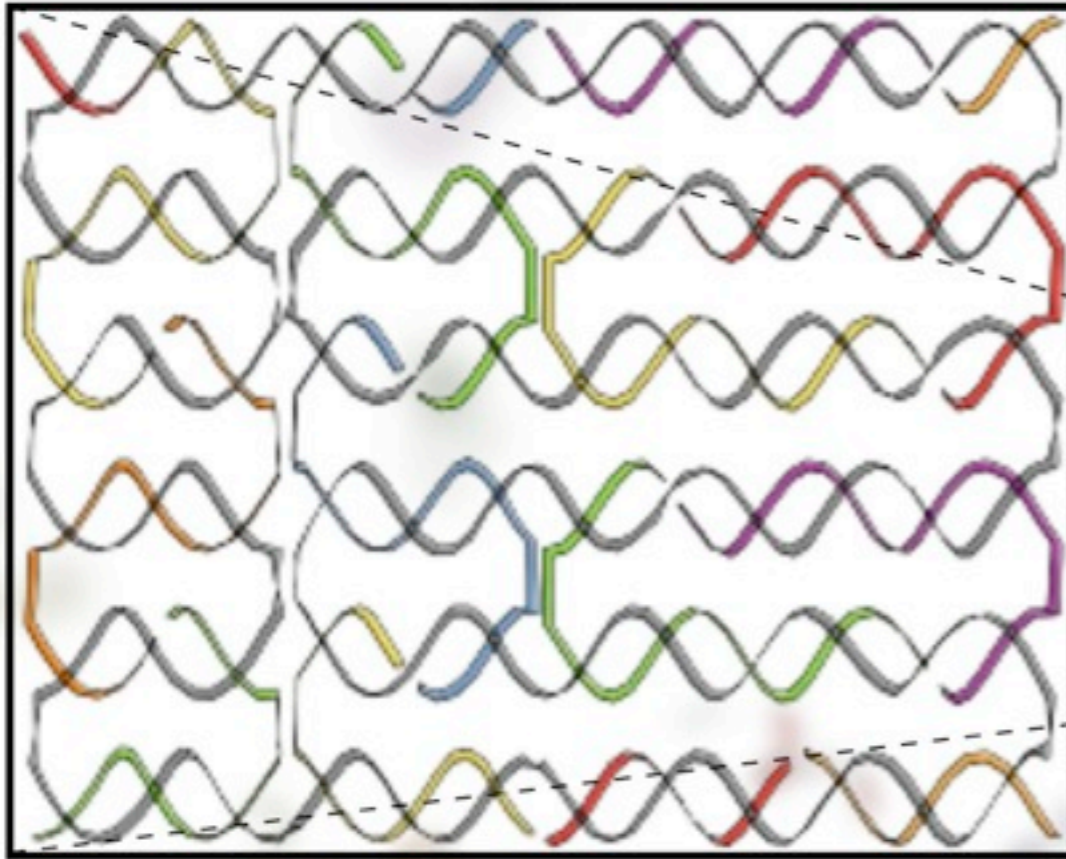
Wyss Technology Development Fellow



Rothemund PW *Nature*
440, 297–302, 2006.



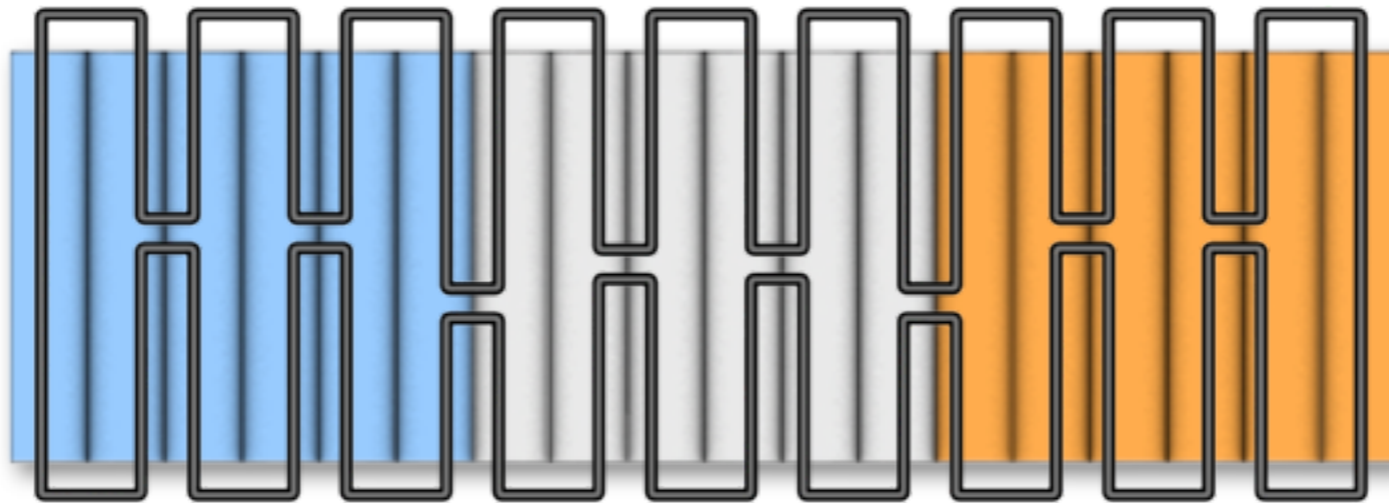
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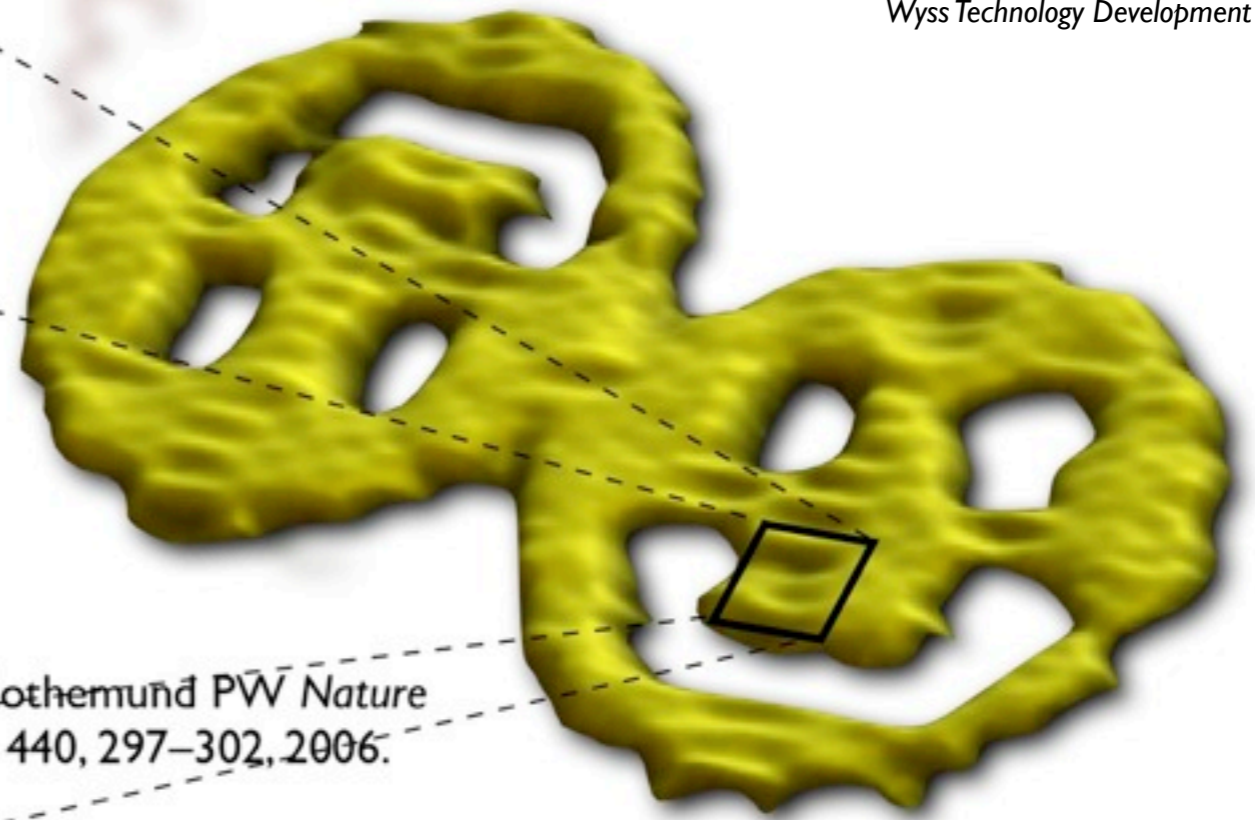
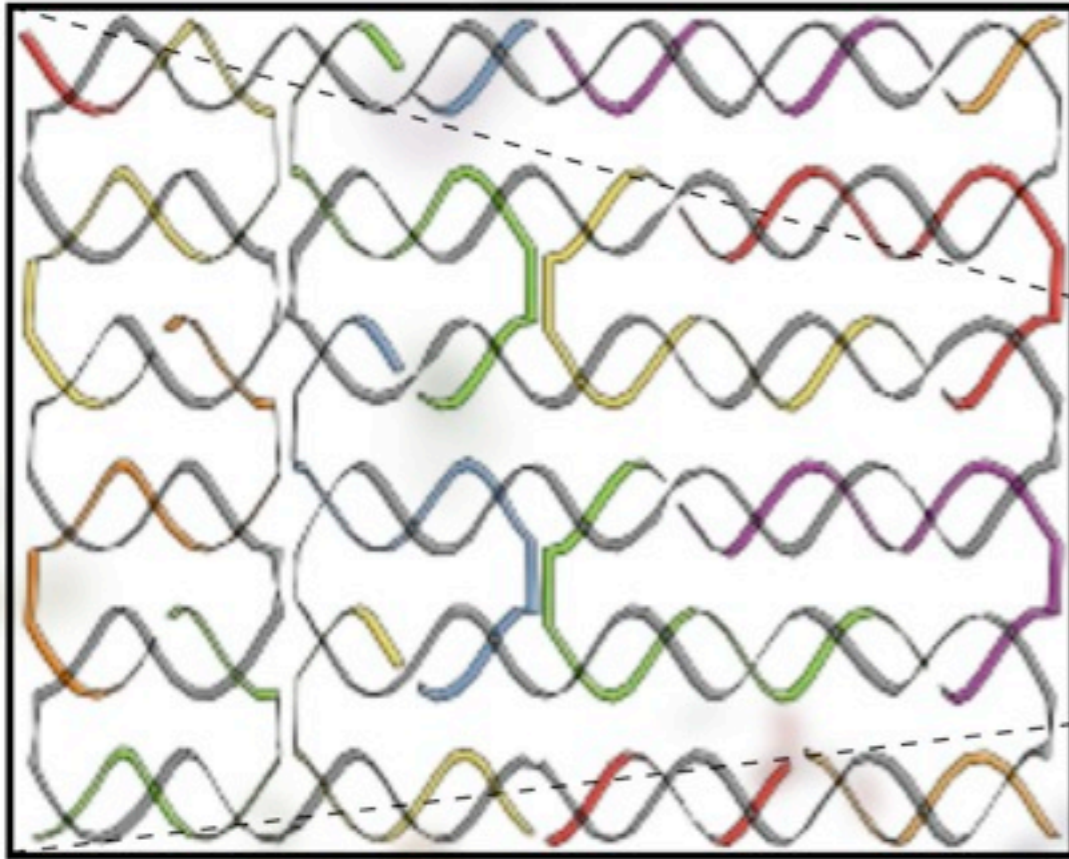


Rothemund PW *Nature*
440, 297–302, 2006.



100 nm



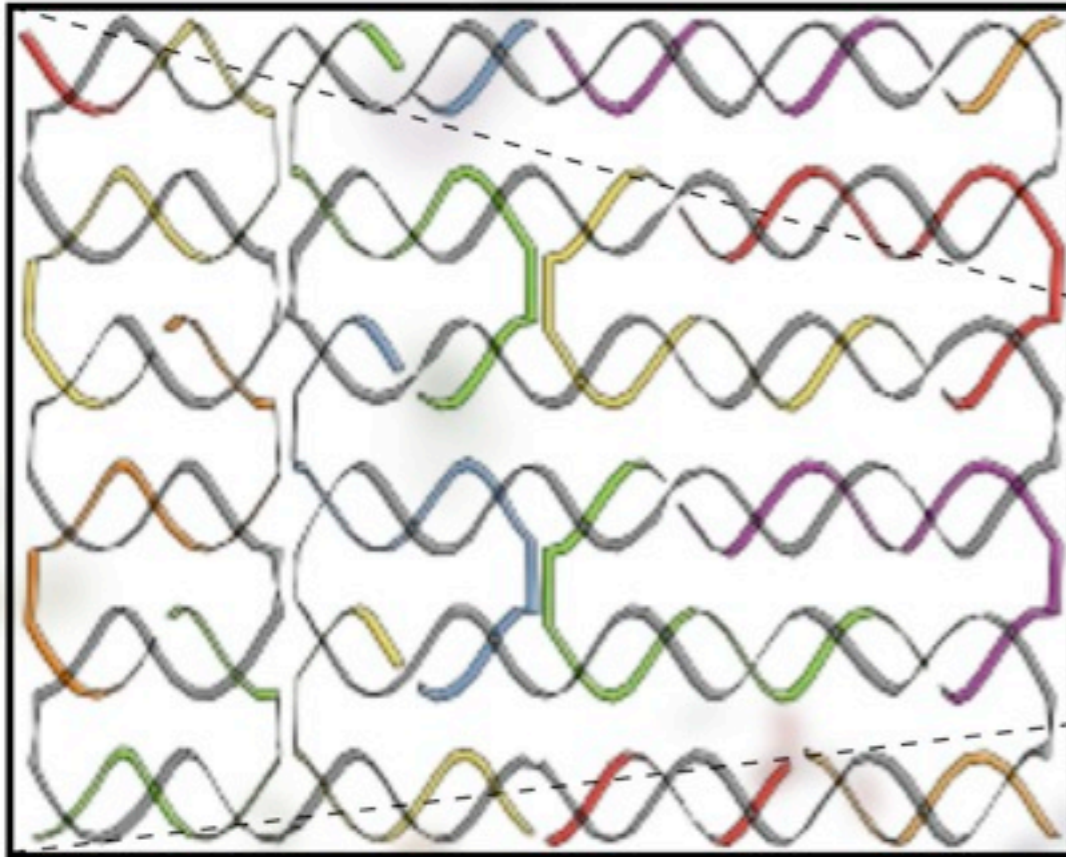


Rothemund PV Nature
440, 297-302, 2006.

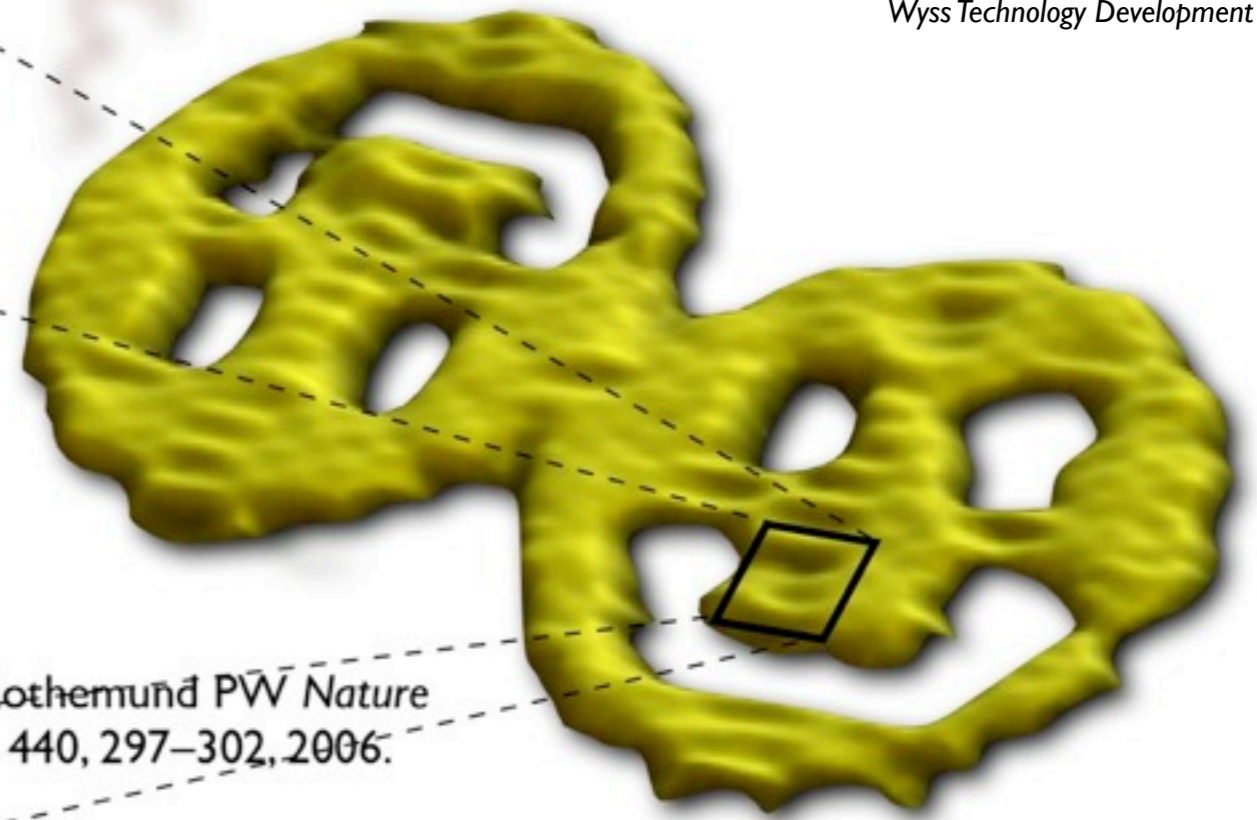


100 nm



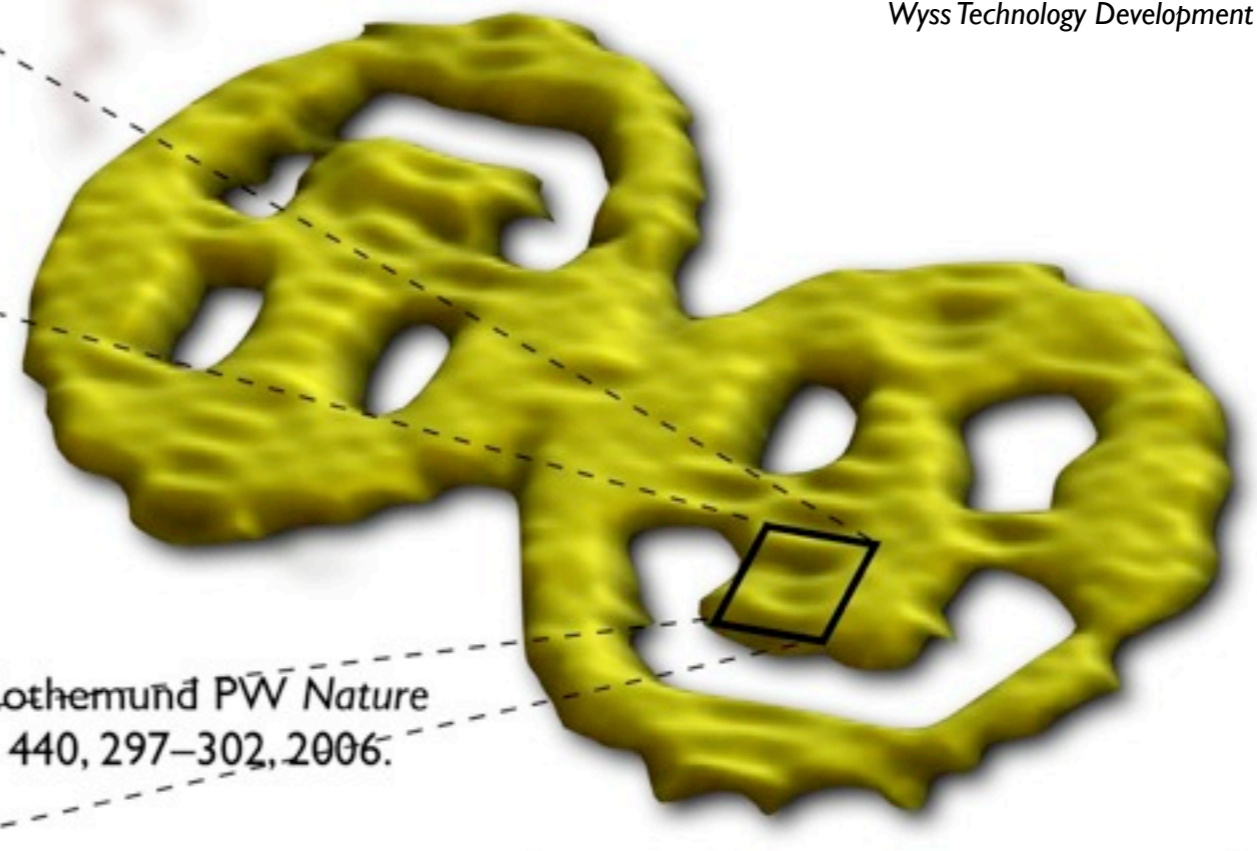
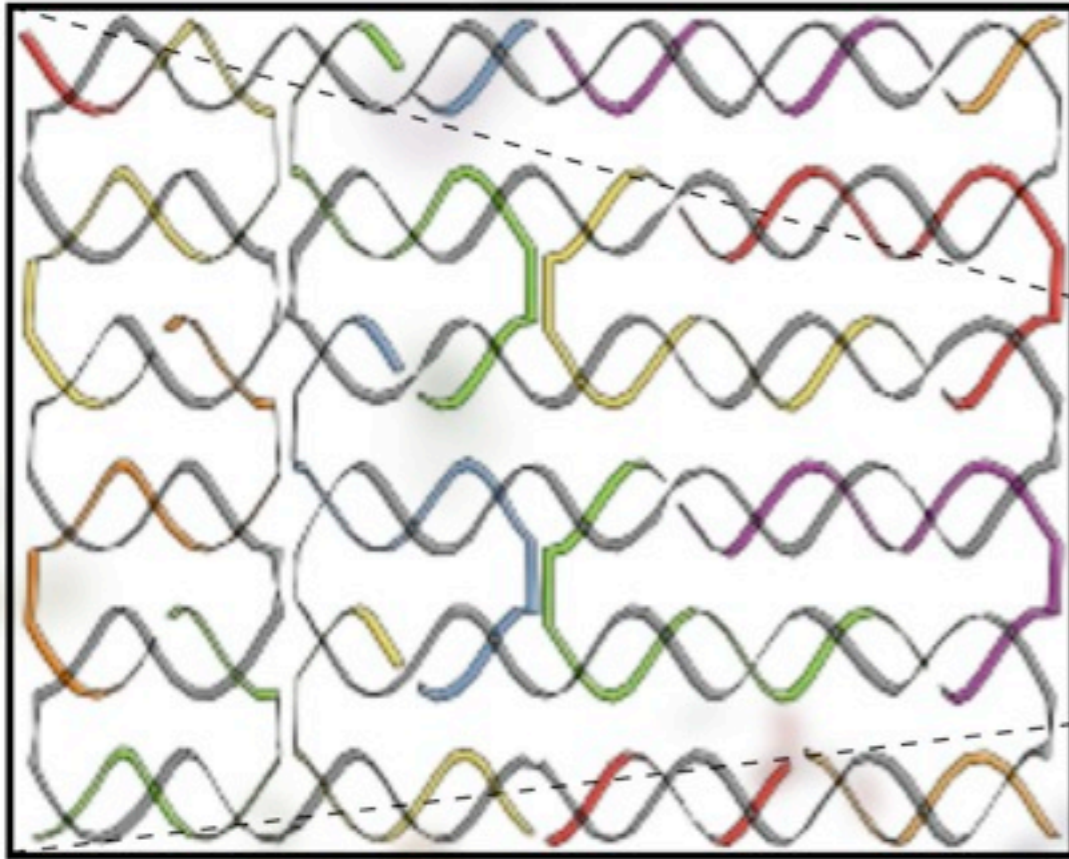


Rothemund PW *Nature*
440, 297–302, 2006.



100 nm



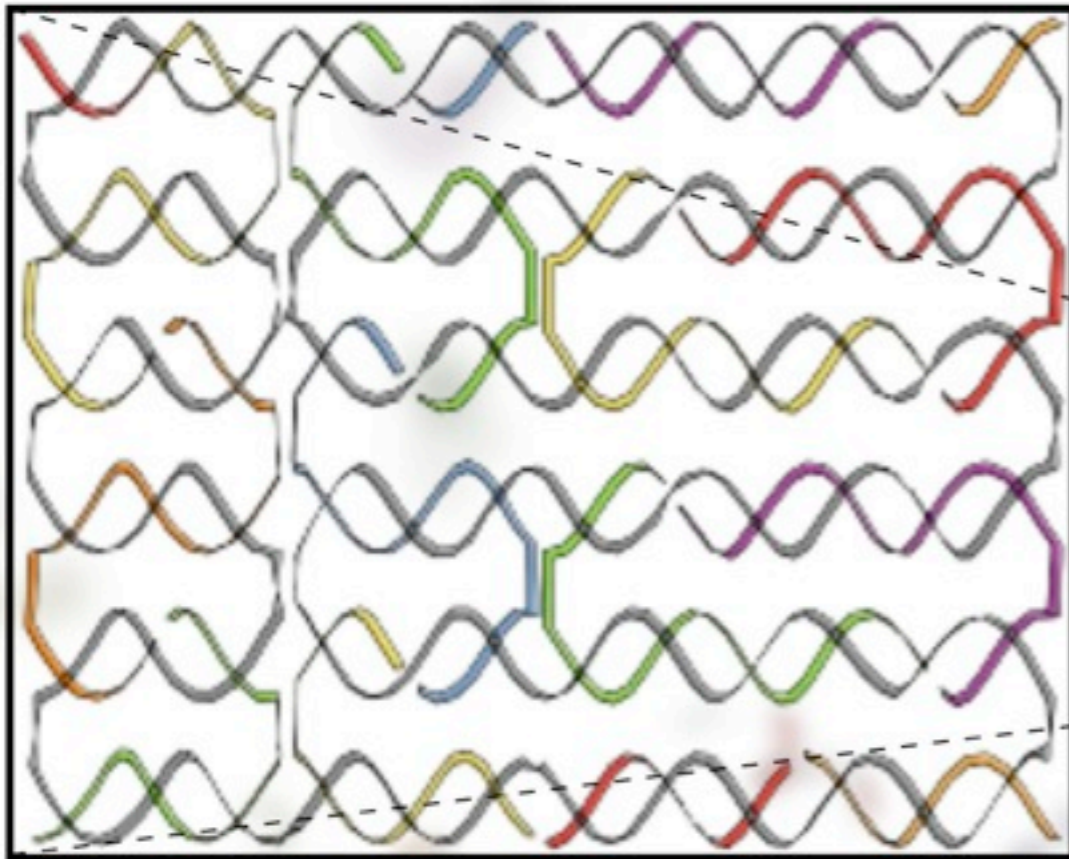


Rothemund PW *Nature*
440, 297–302, 2006.

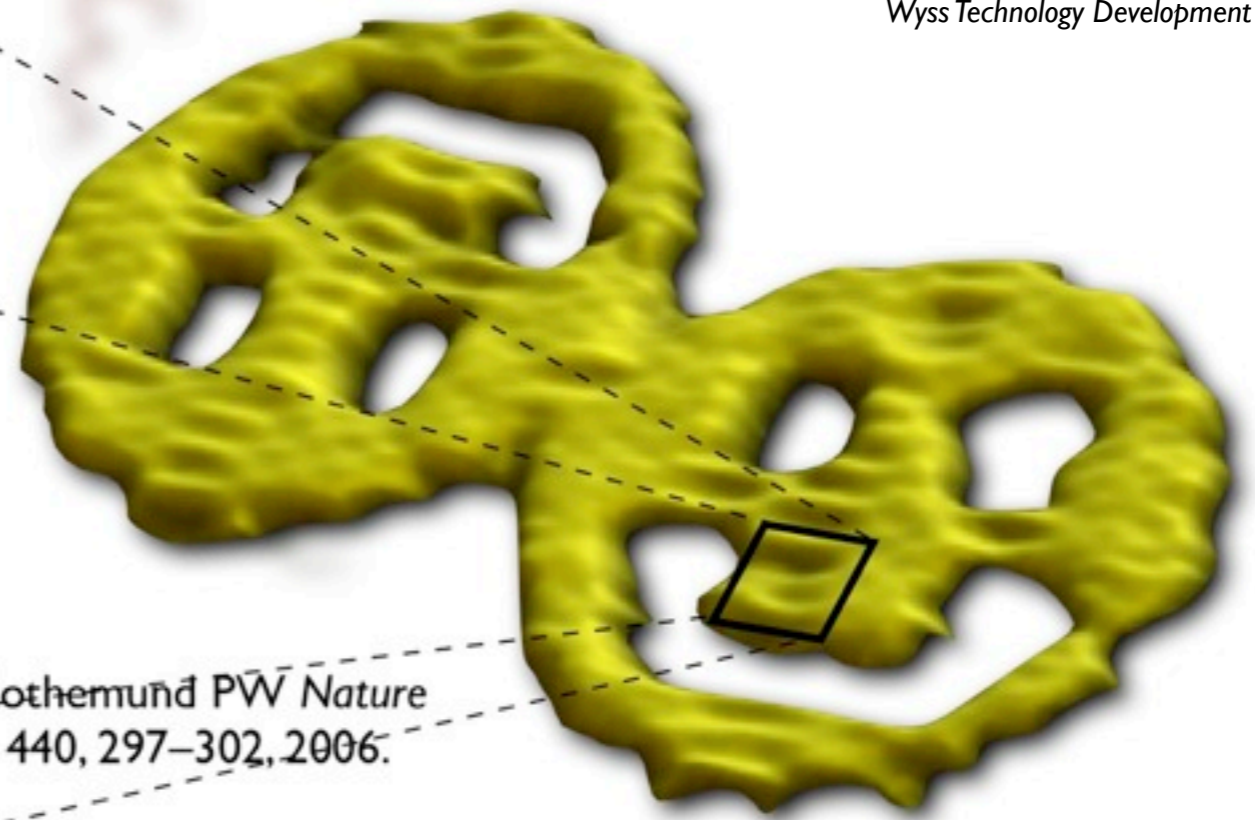


100 nm





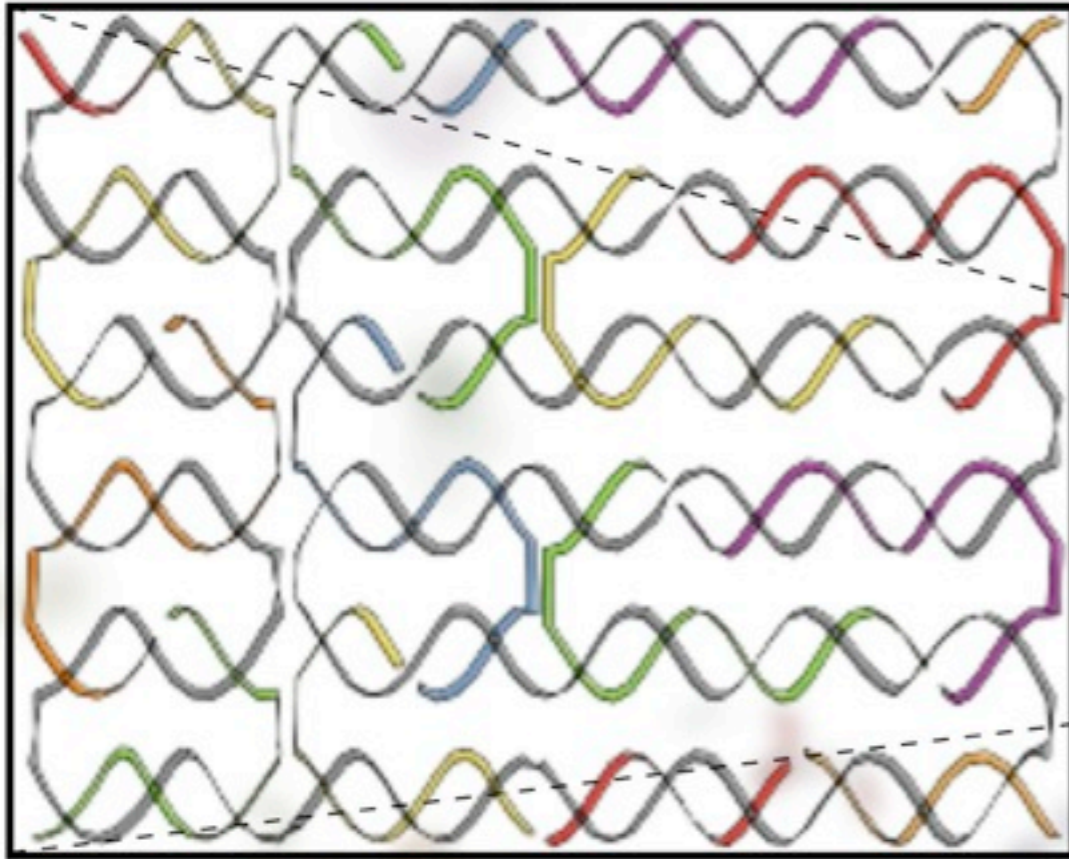
Rothemund PW *Nature*
440, 297–302, 2006.



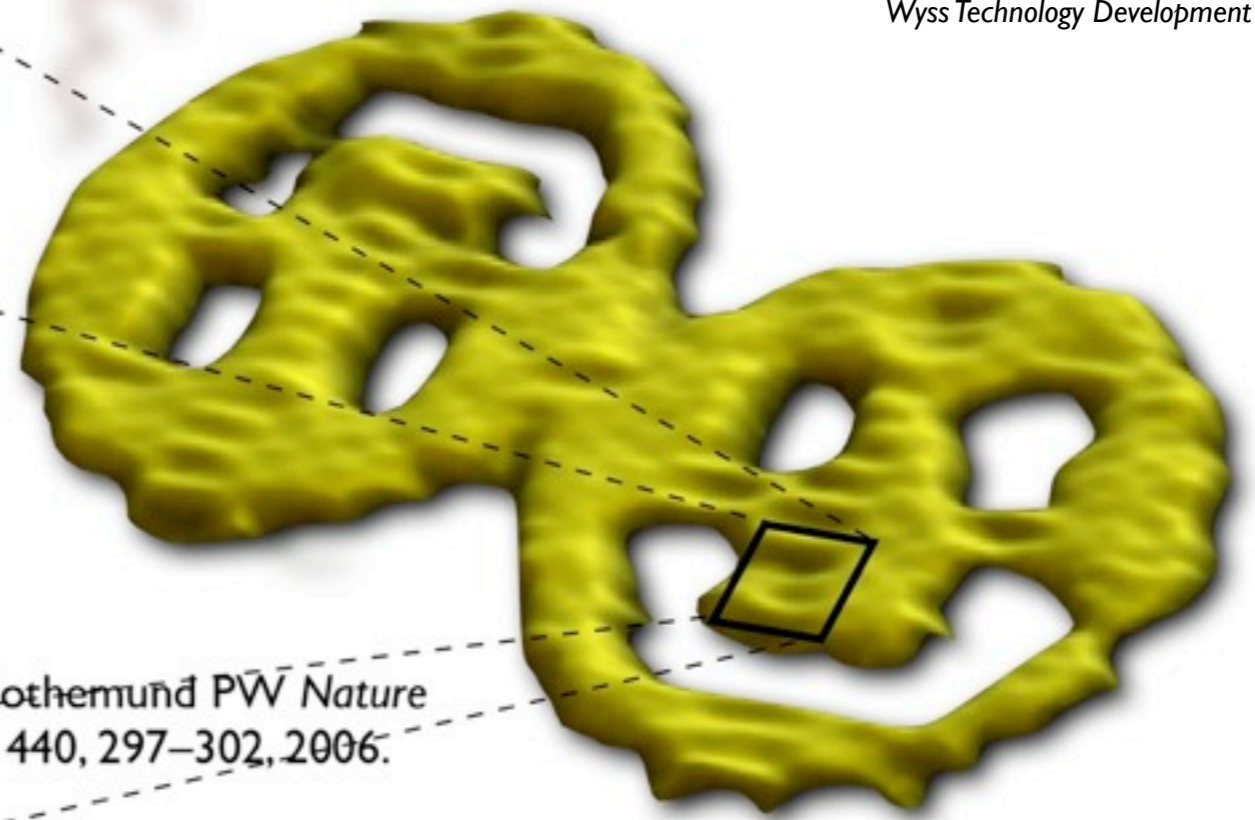
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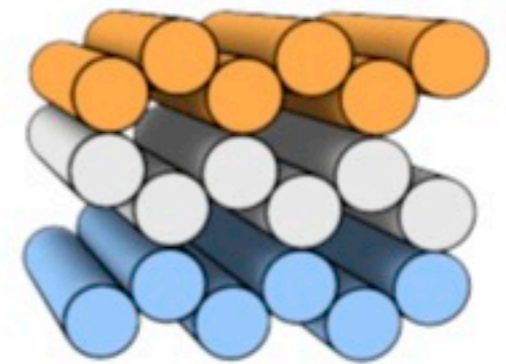
10 nm



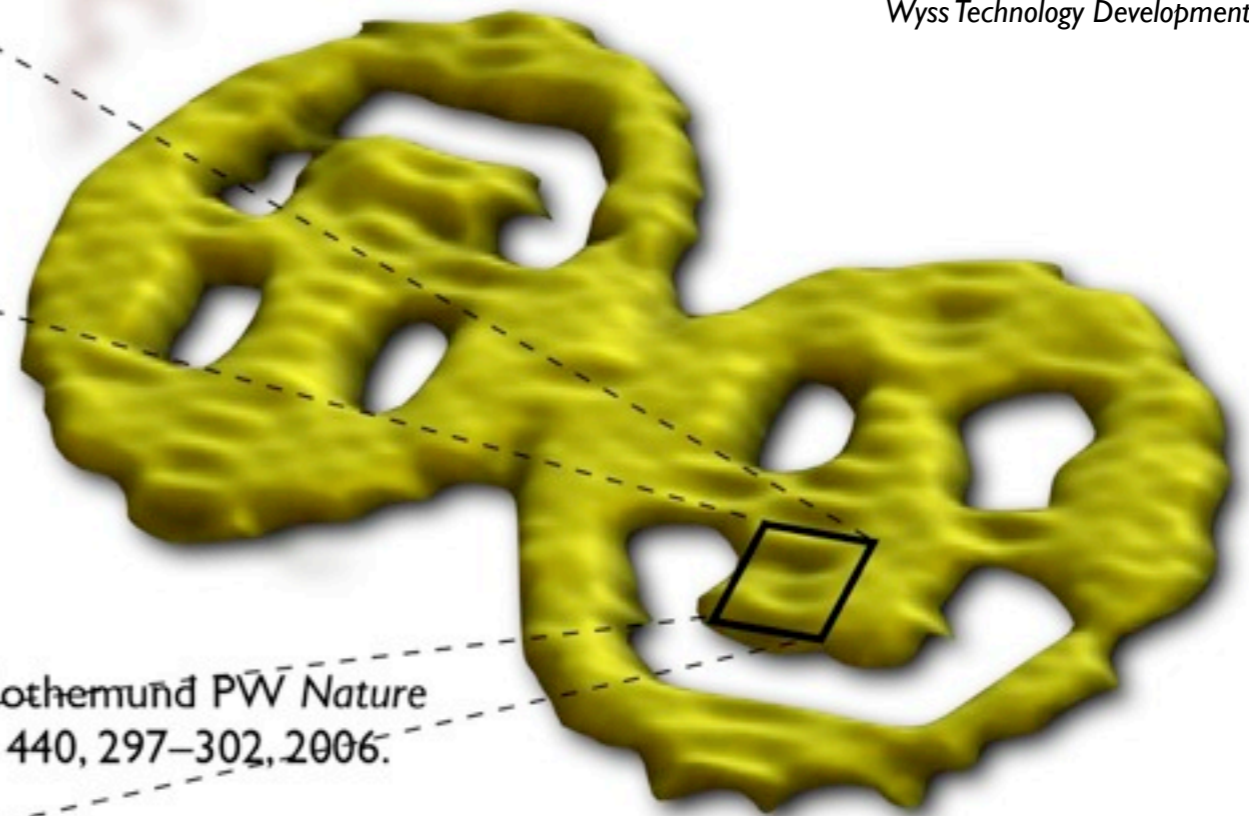
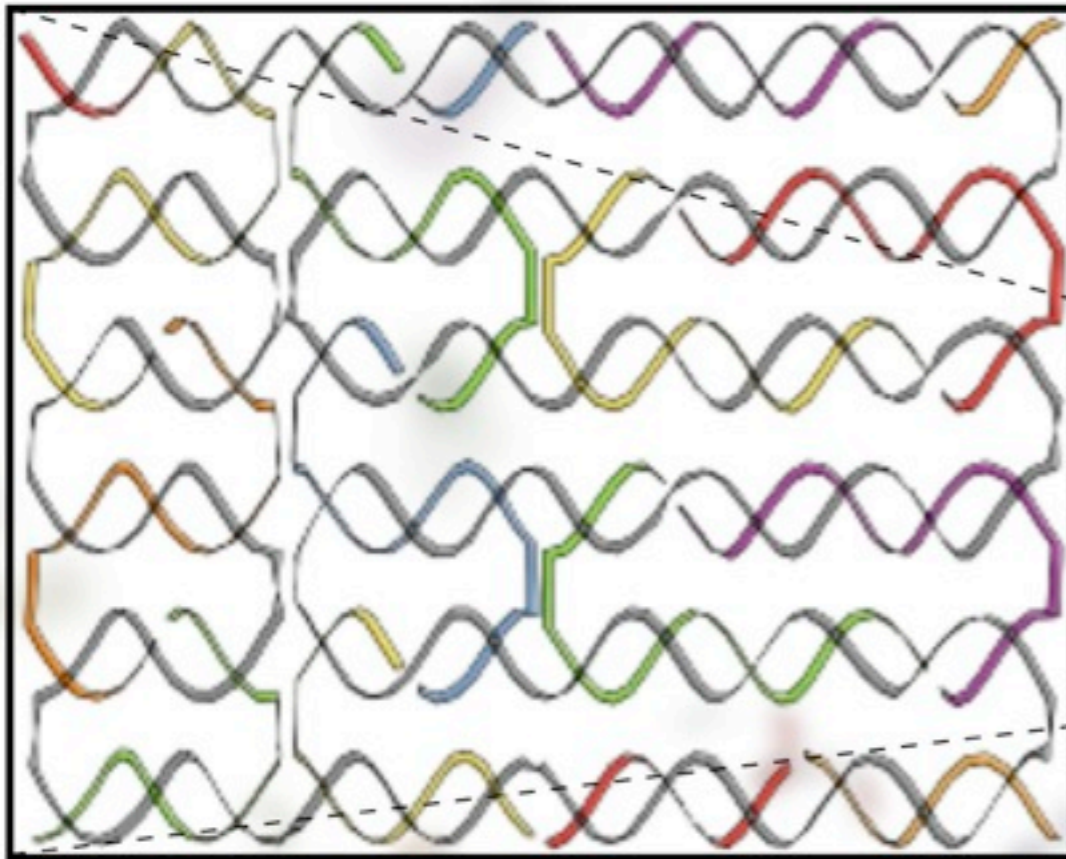
Rothemund PW *Nature*
440, 297–302, 2006.



100 nm

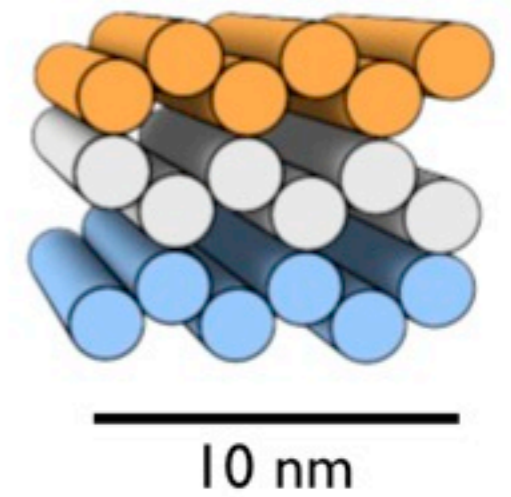
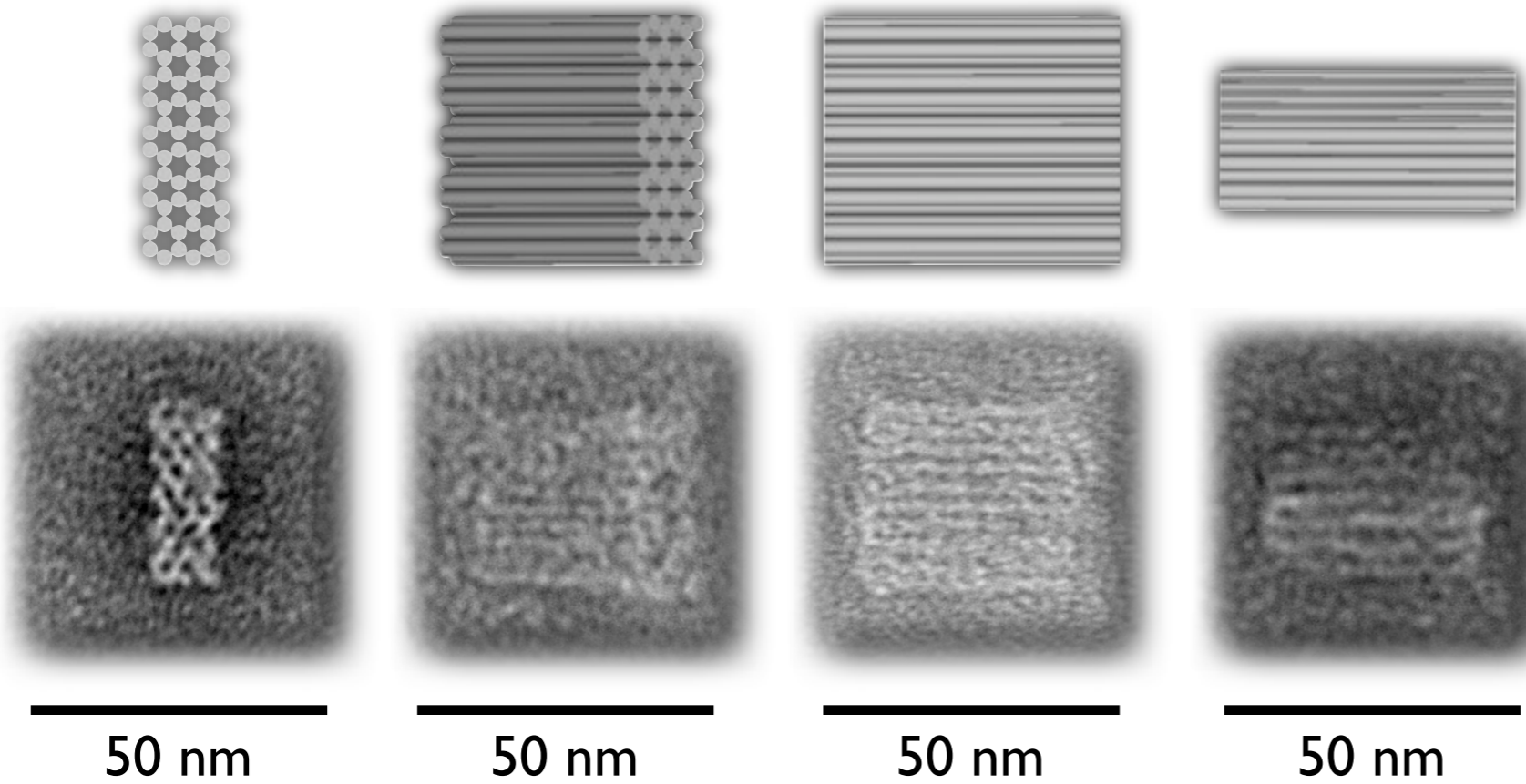


10 nm



Rothemund PW *Nature*
440, 297–302, 2006.

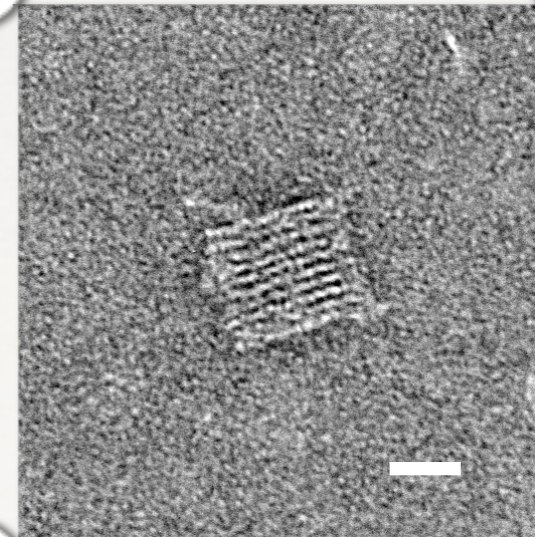
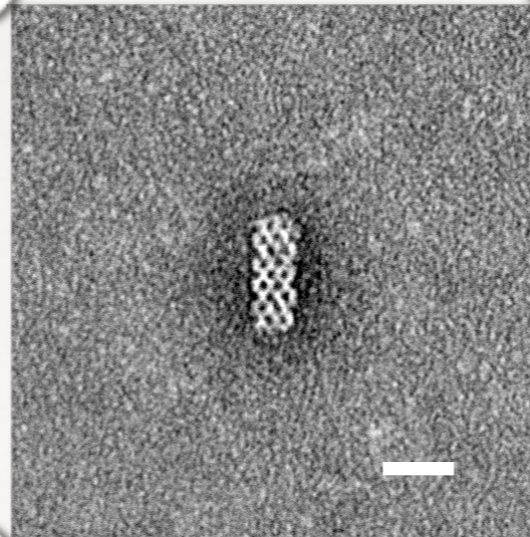
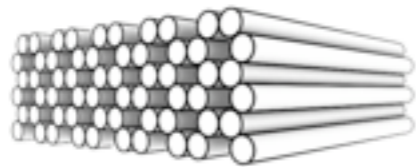
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10 nm

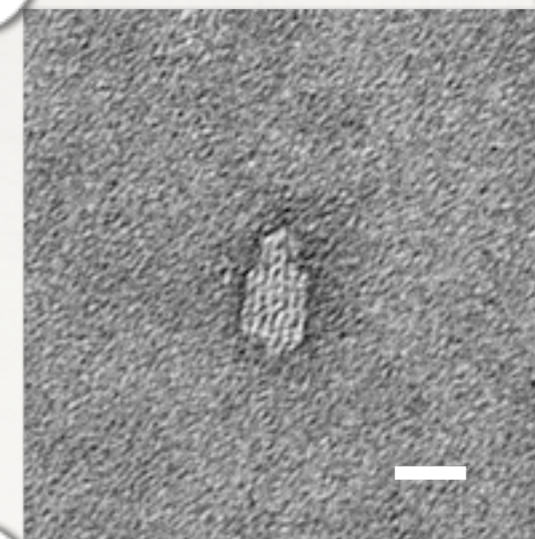
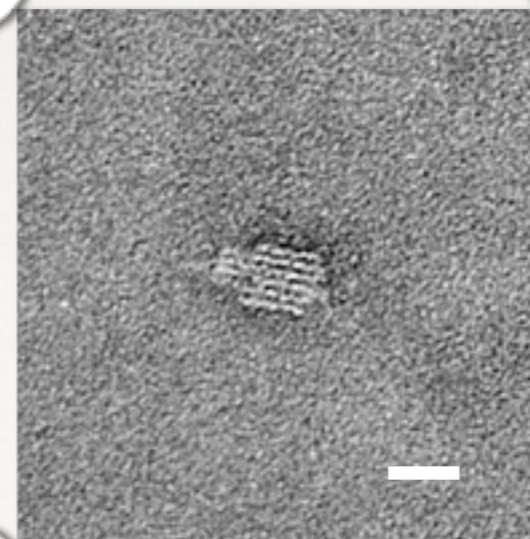
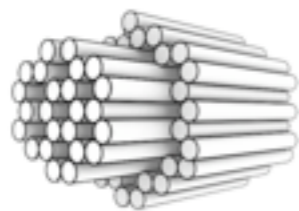
“Monolith”

Shawn Douglas



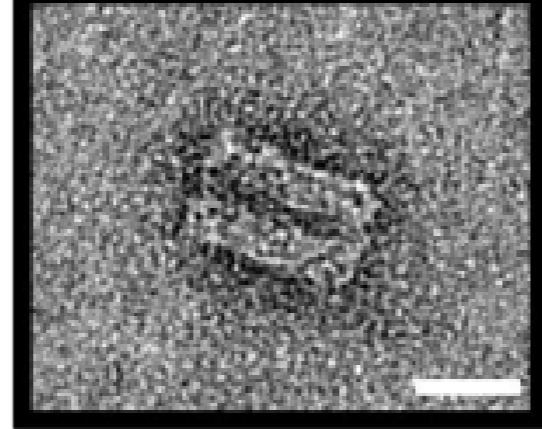
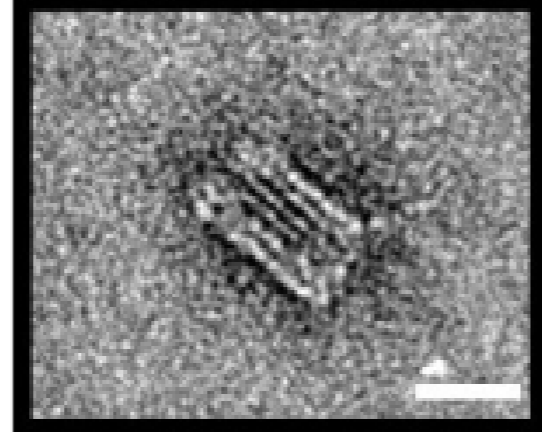
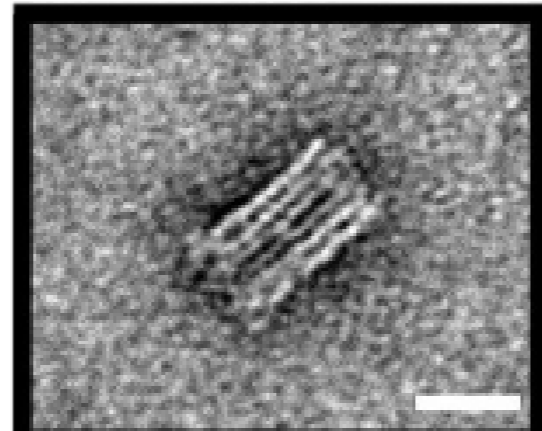
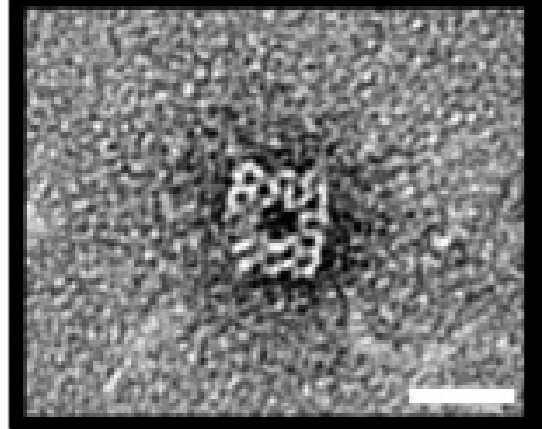
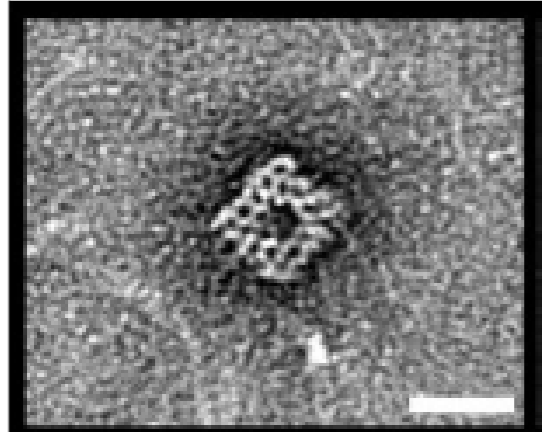
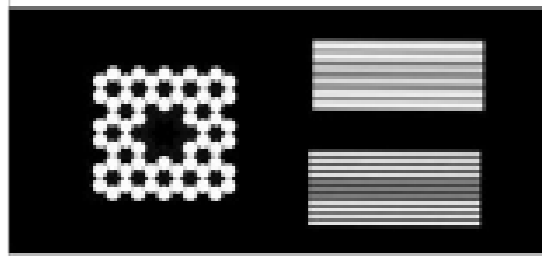
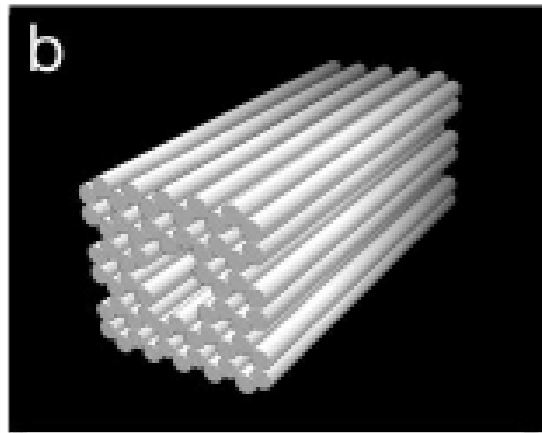
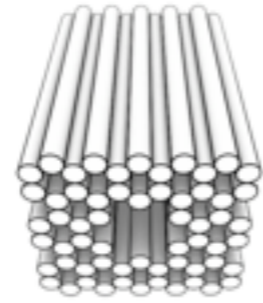
“Genie Bottle”

Franziska Graf



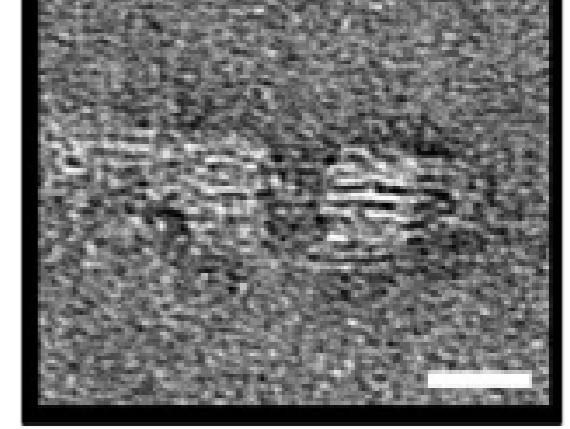
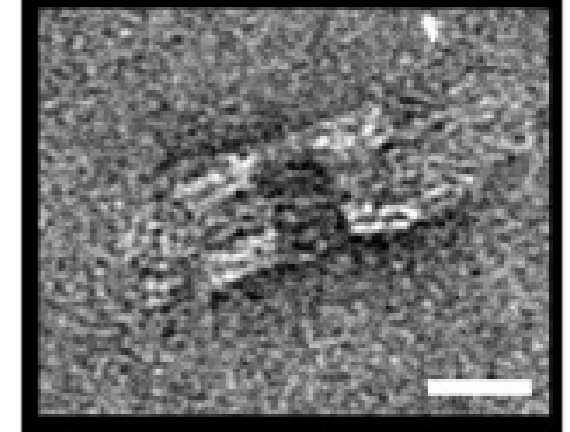
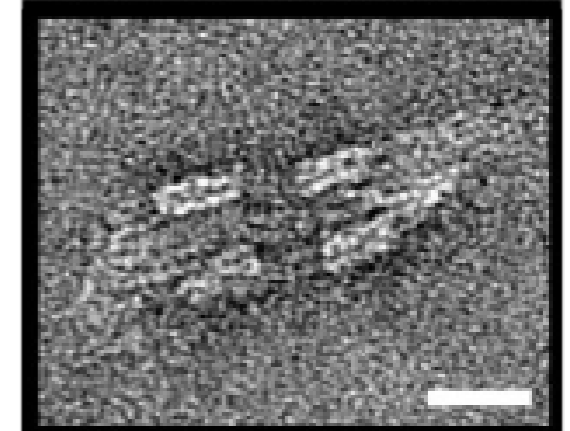
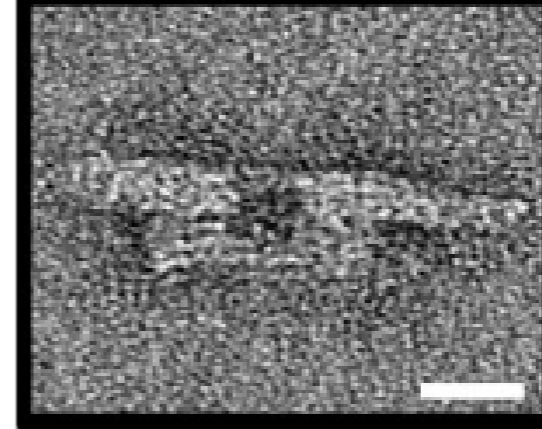
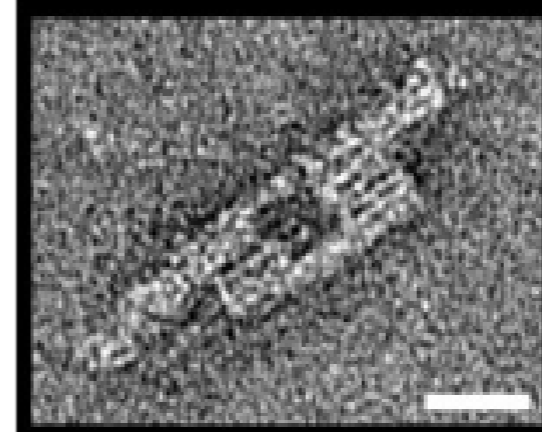
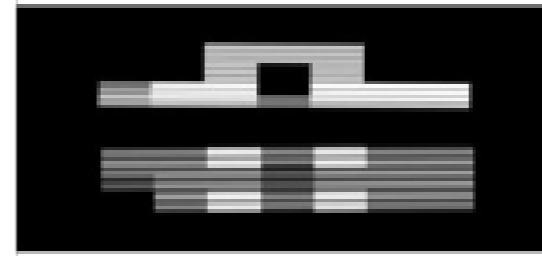
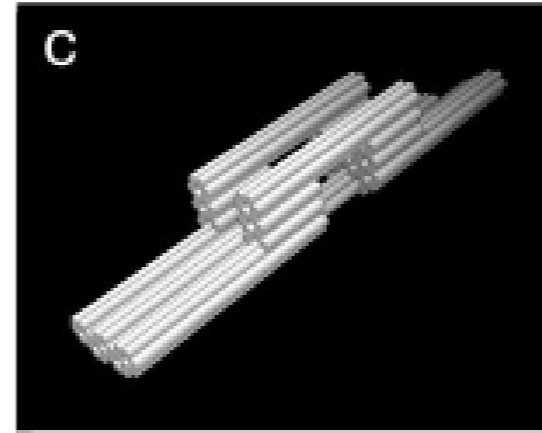
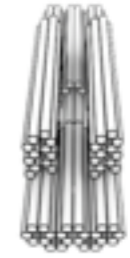
“Square Nut”

Shawn Douglas



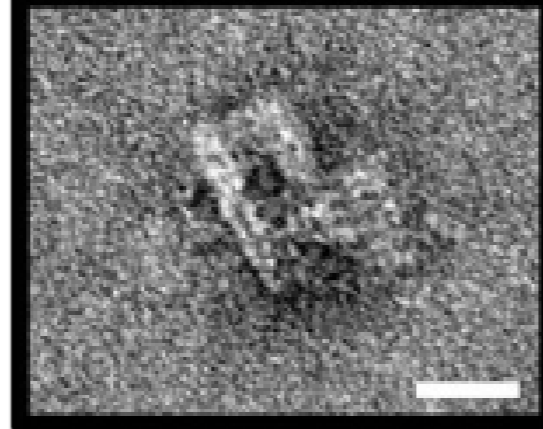
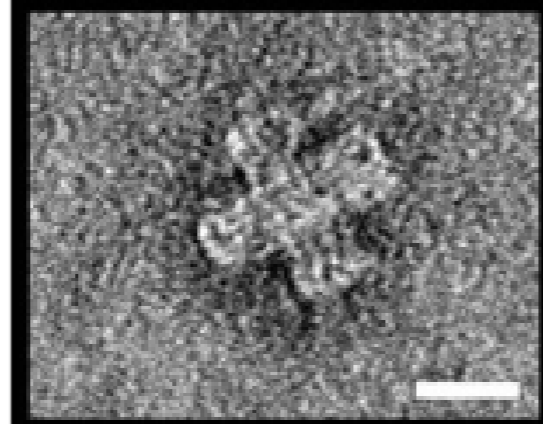
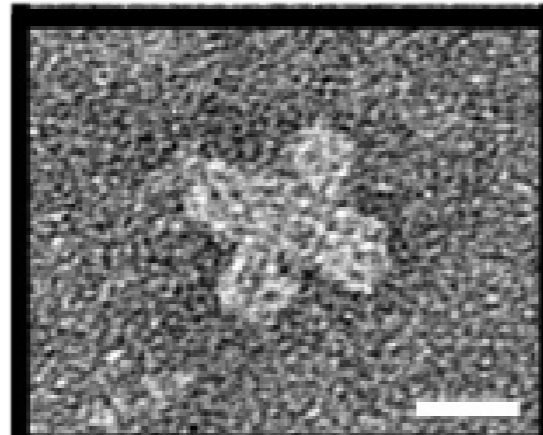
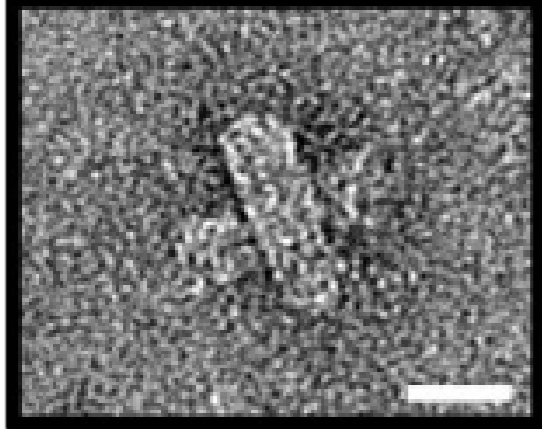
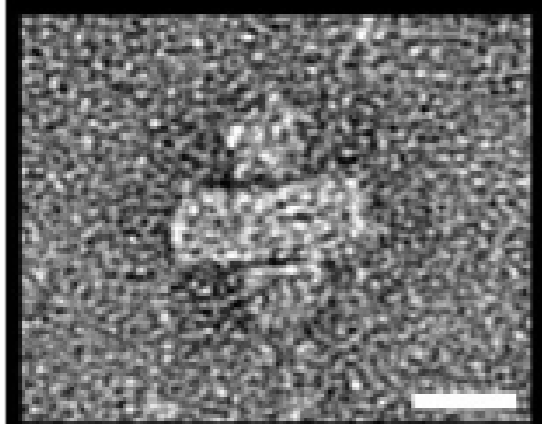
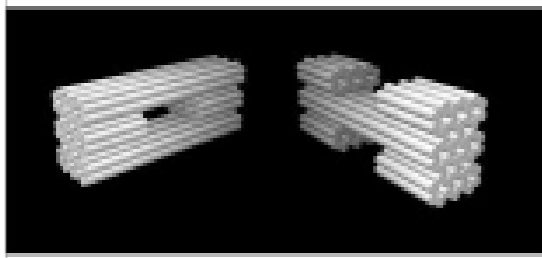
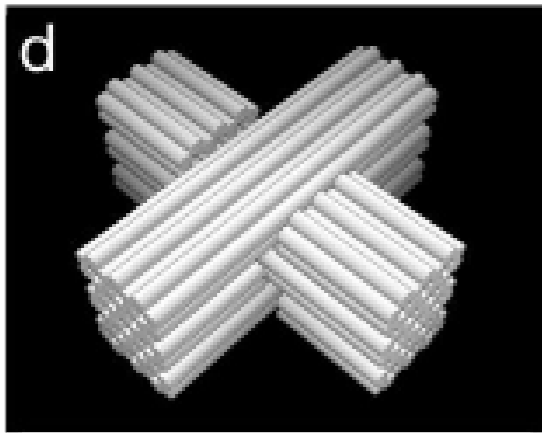
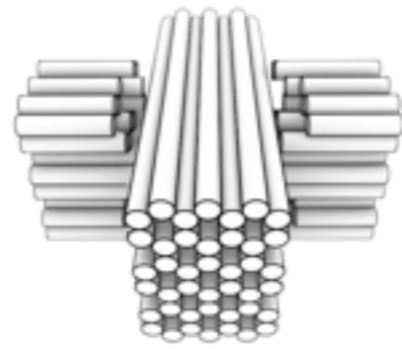
“Railed Bridge”

Tim Liedl



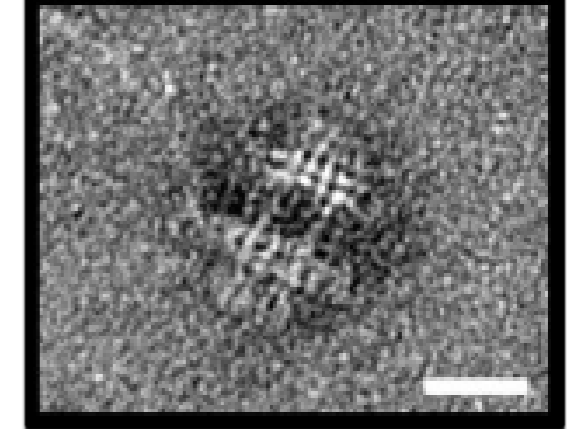
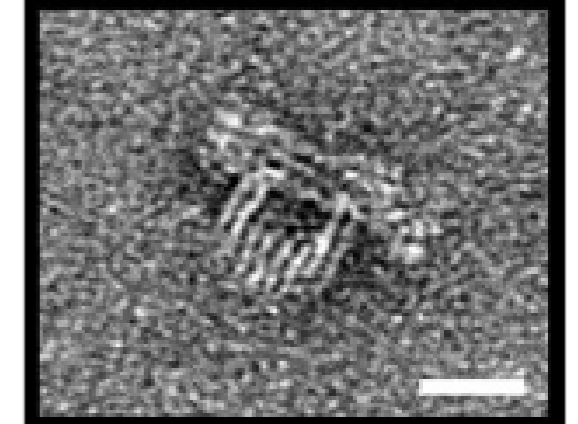
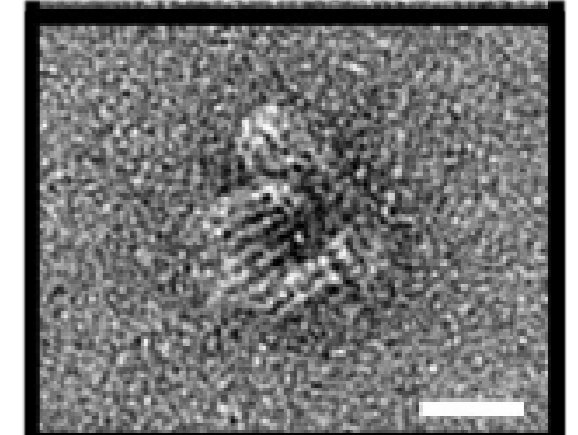
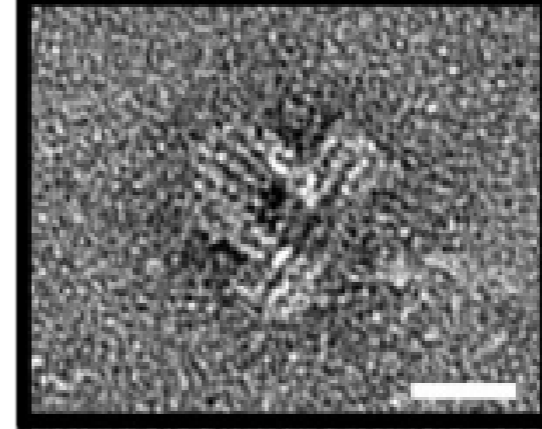
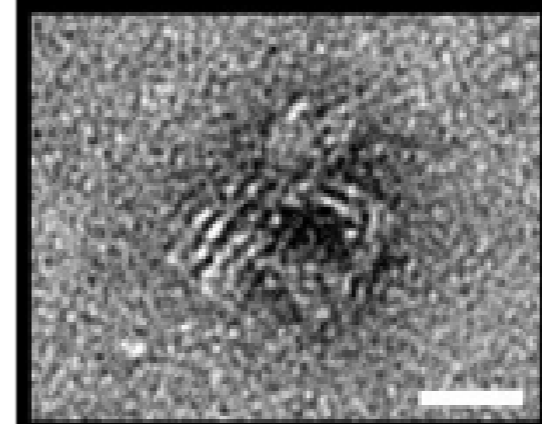
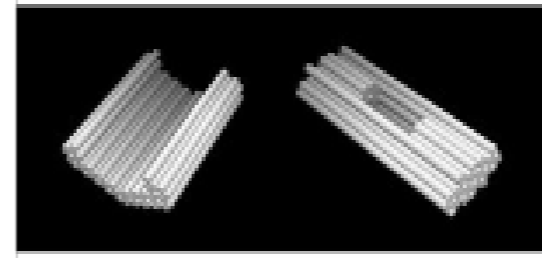
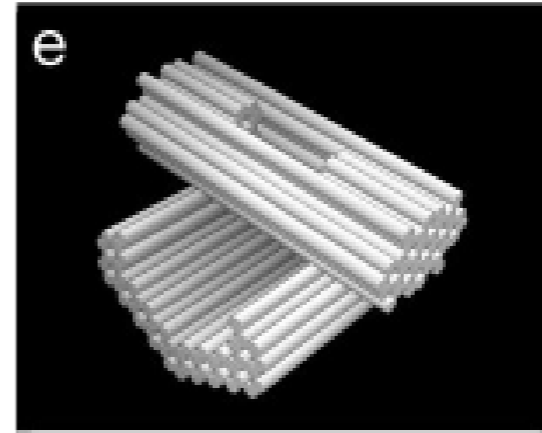
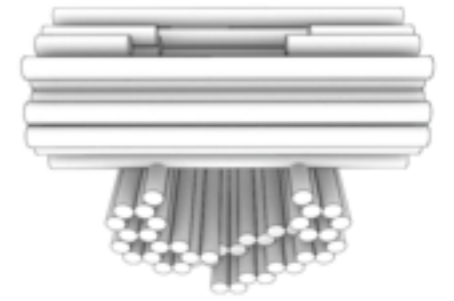
“Slotted Cross”

Björn Högberg



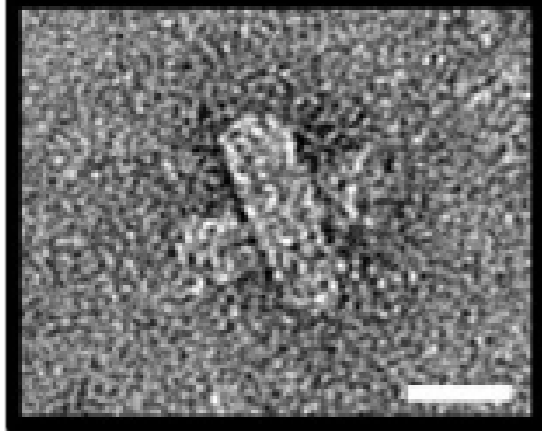
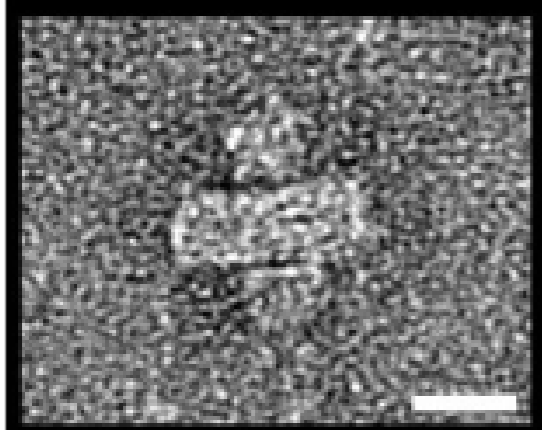
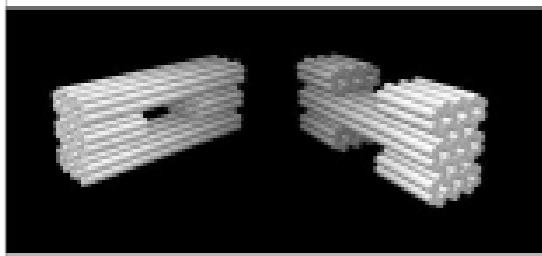
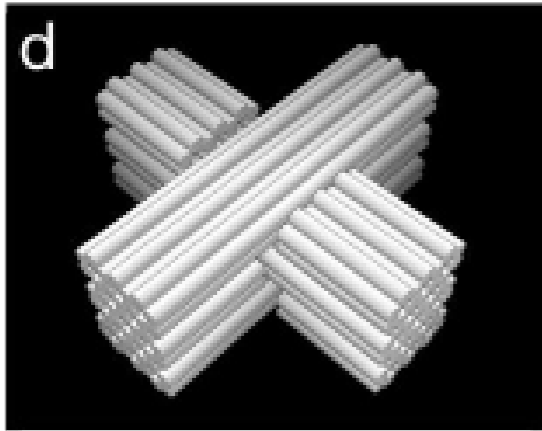
“Stacked Cross”

Hendrik Dietz



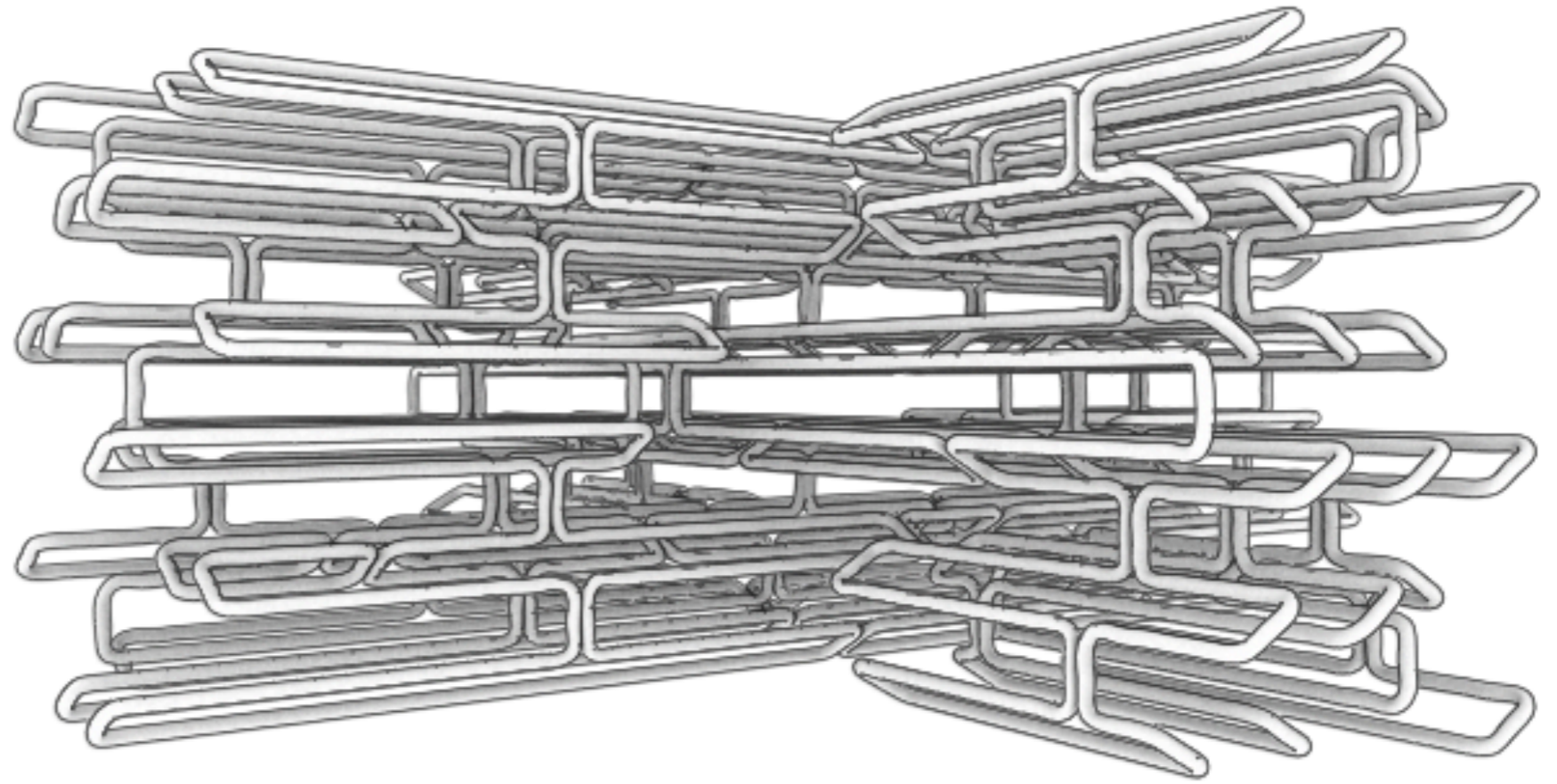
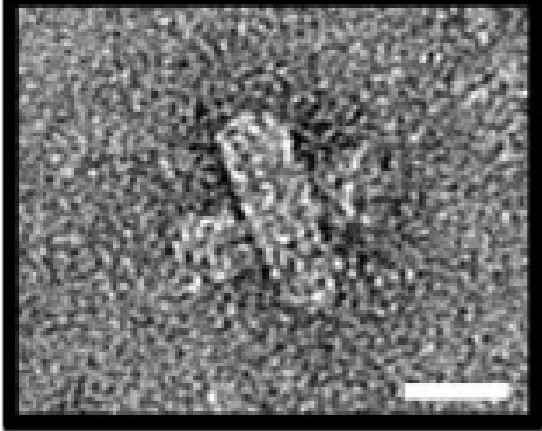
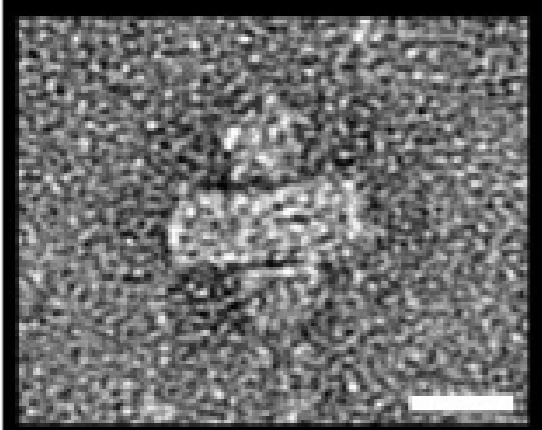
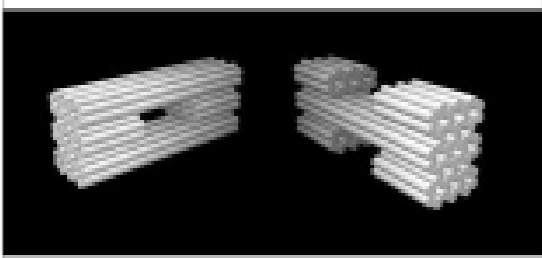
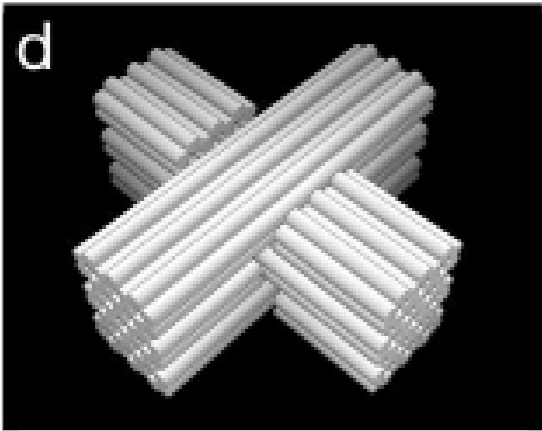
“Slotted Cross”

Björn Högberg



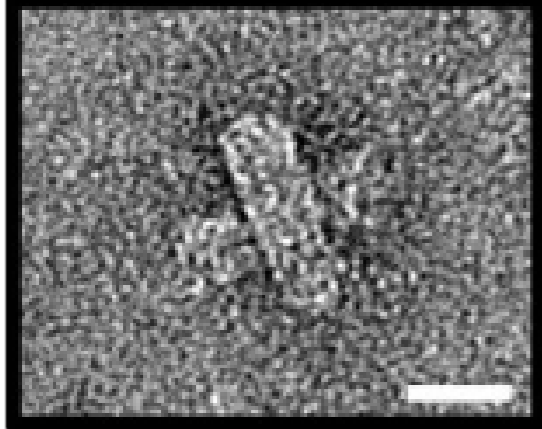
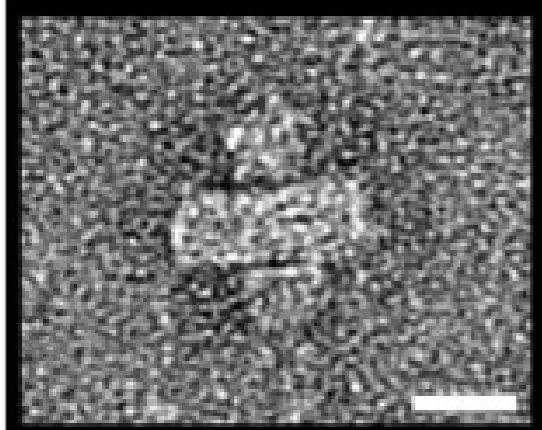
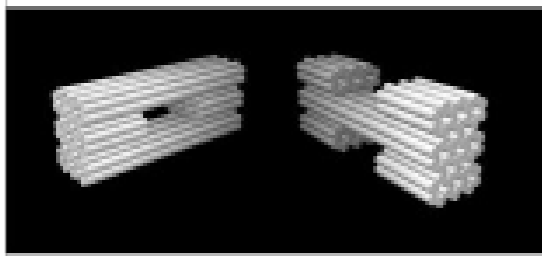
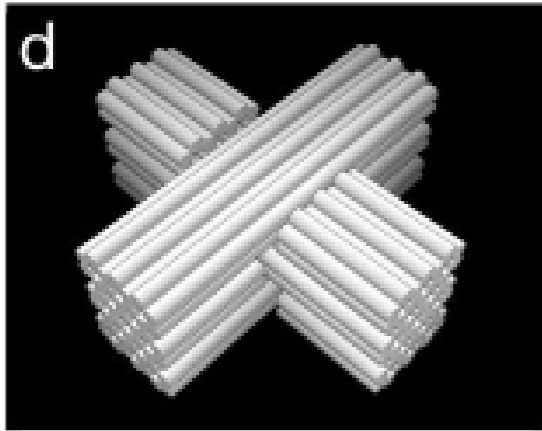
“Slotted Cross”

Björn Högberg



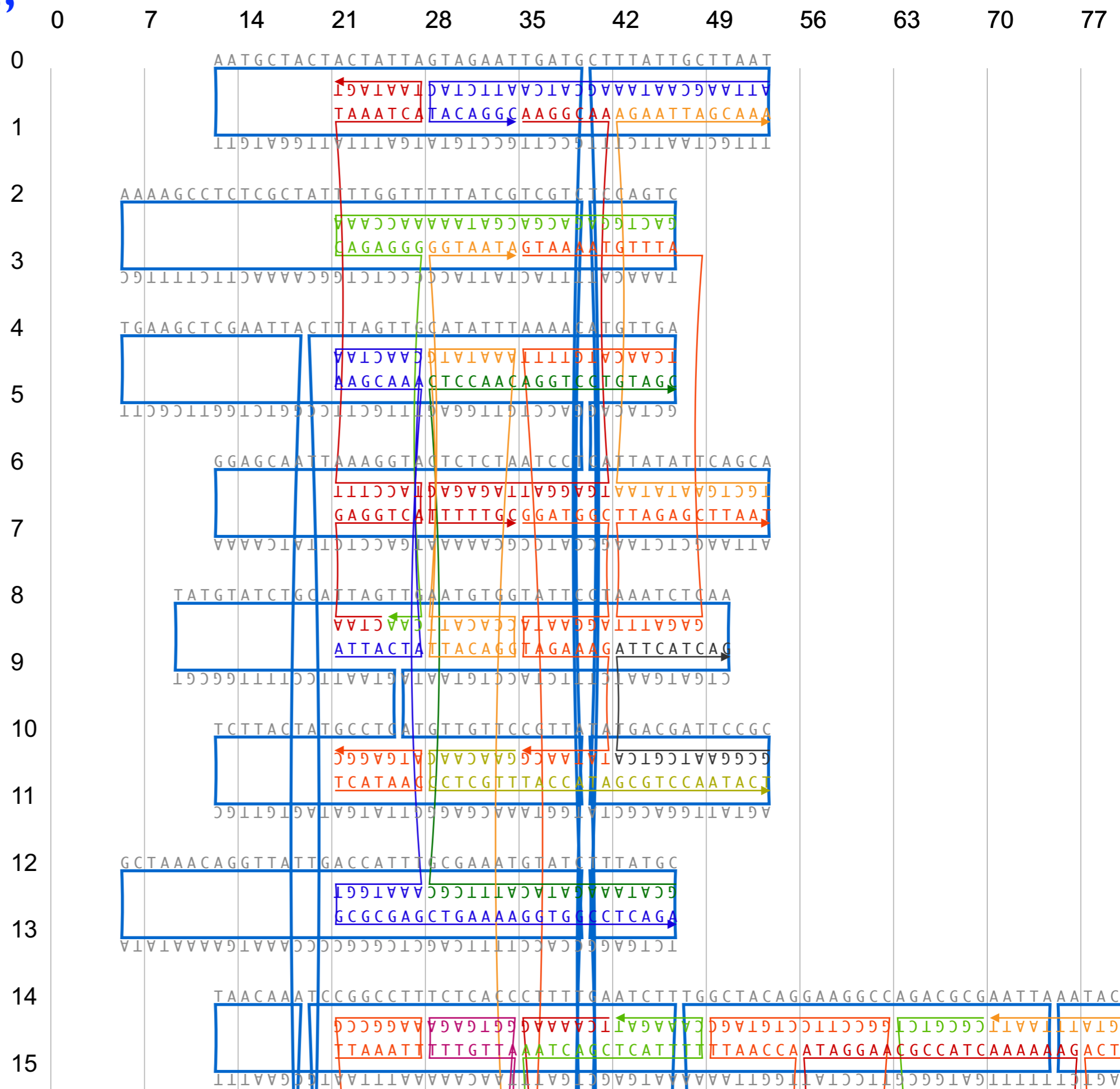
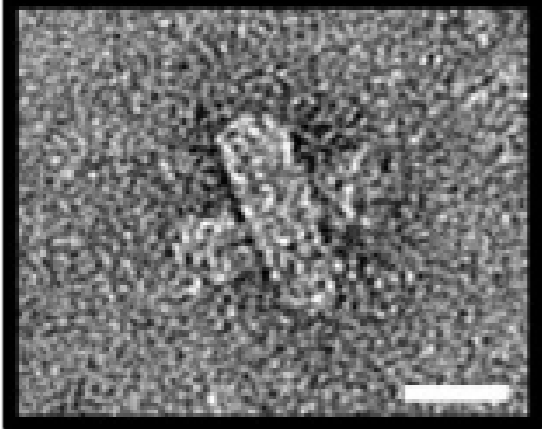
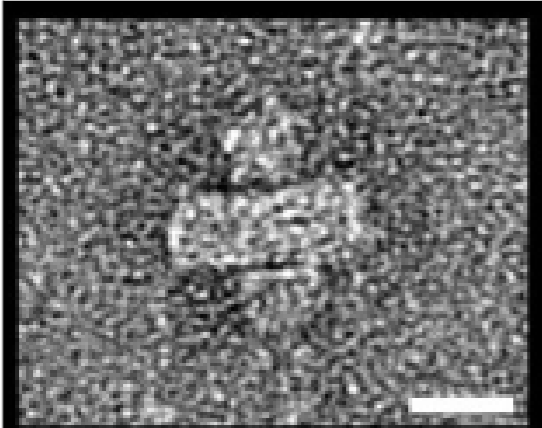
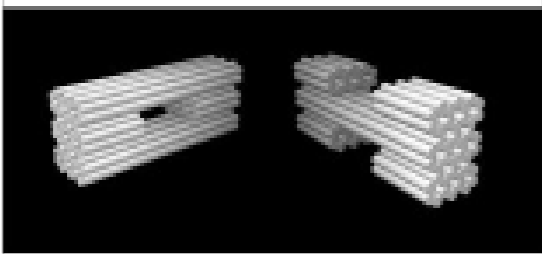
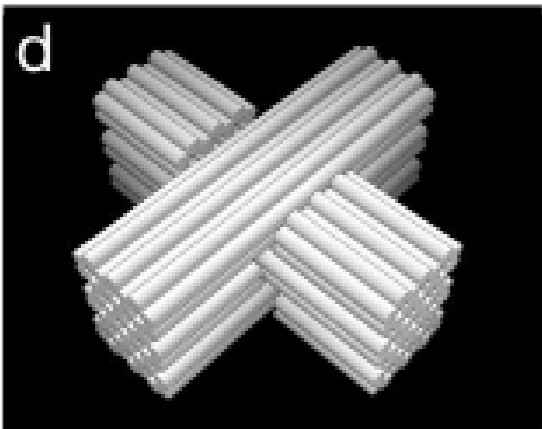
“Slotted Cross”

Björn Högberg



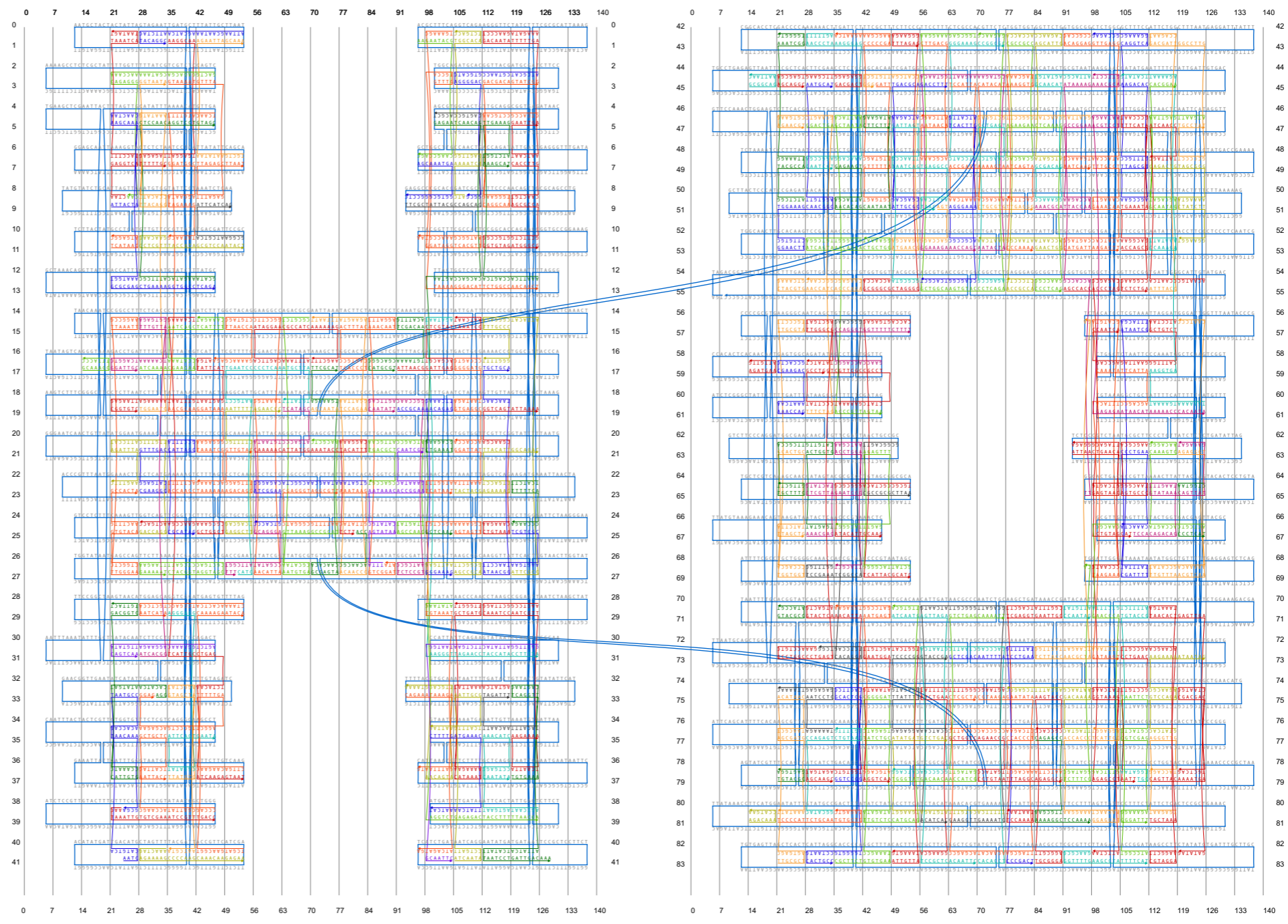
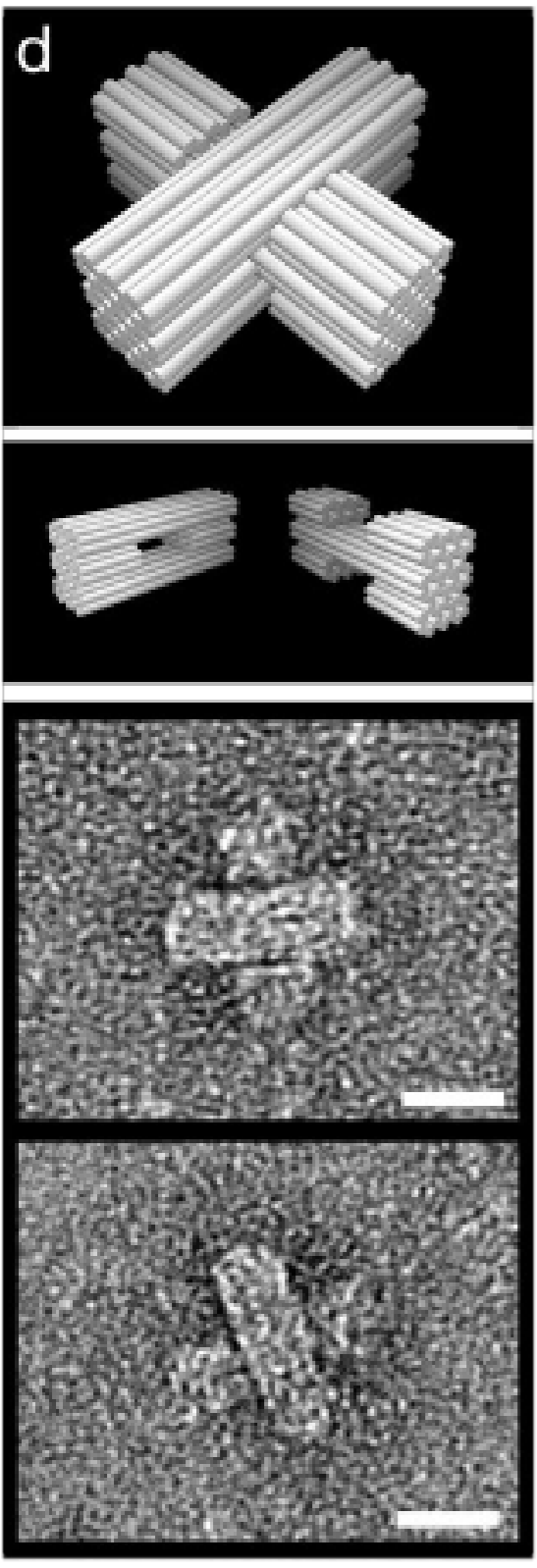
“Slotted Cross”

Björn Högberg



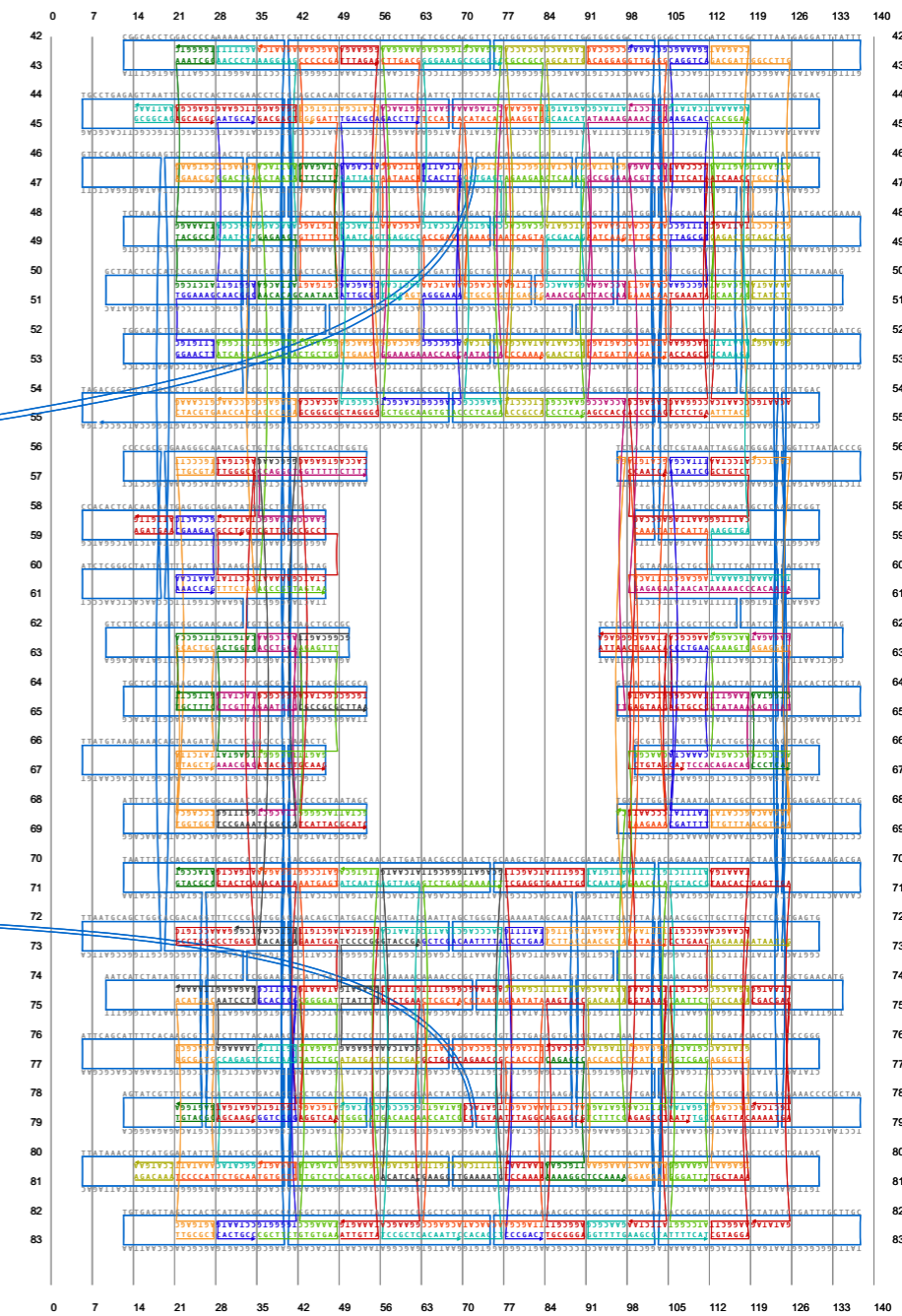
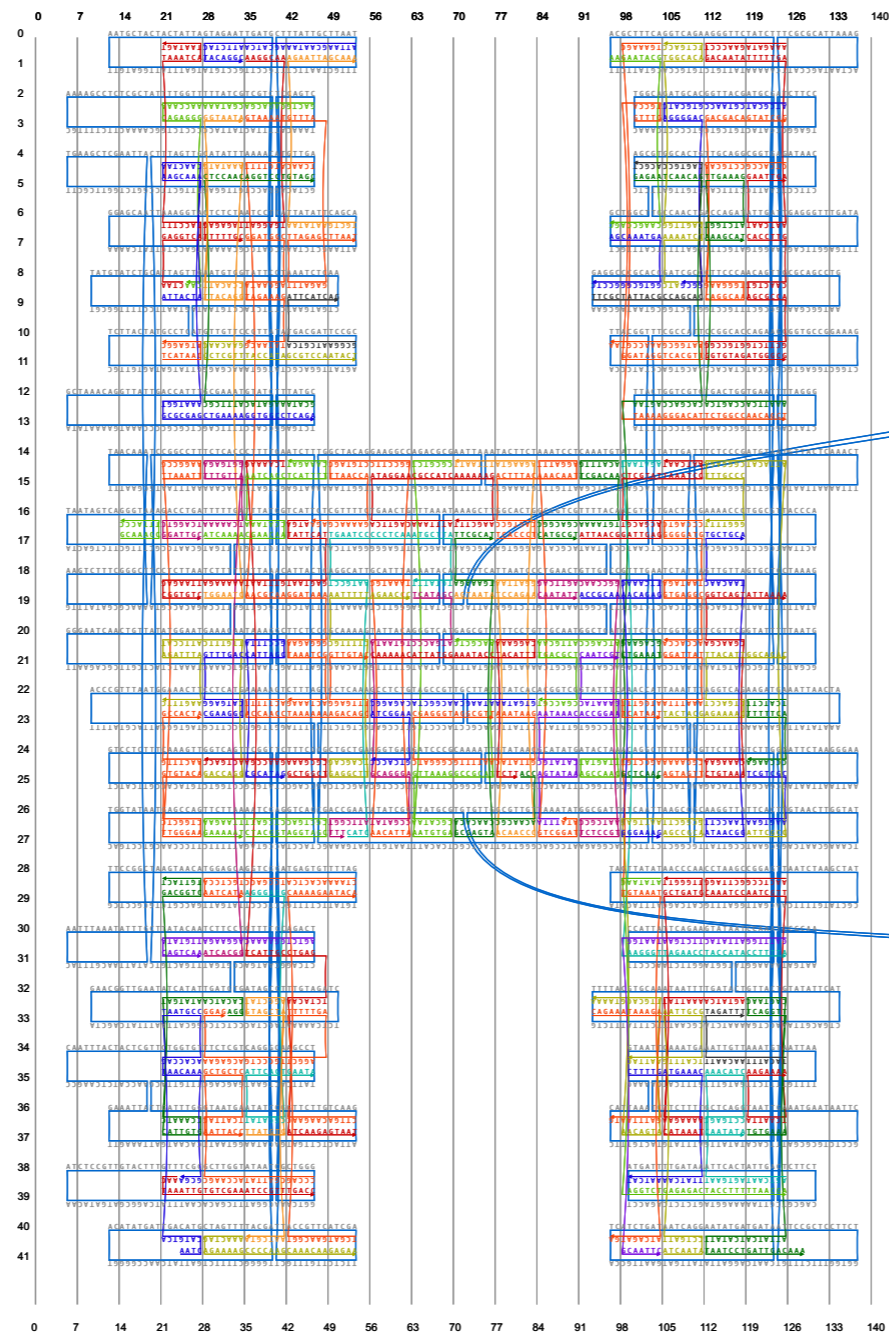
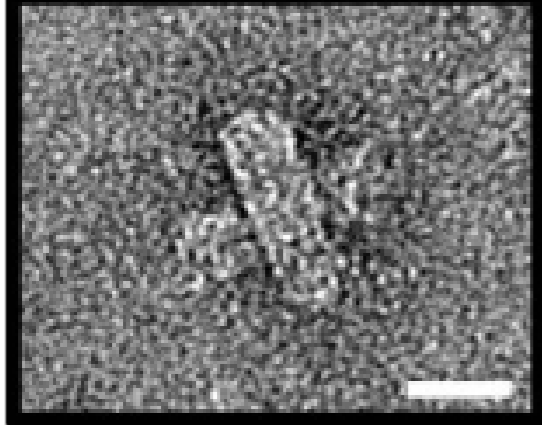
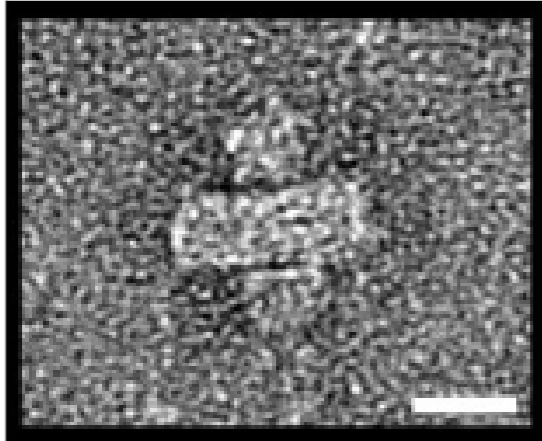
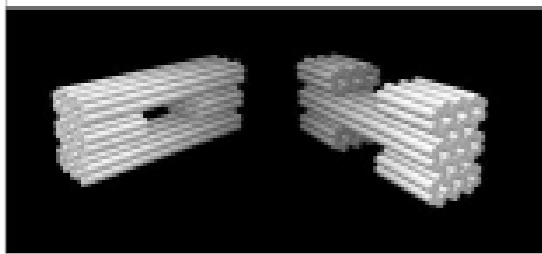
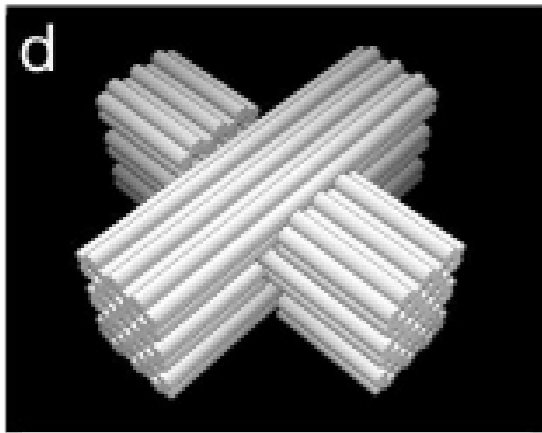
“Slotted Cross”

Björn Högberg



“Slotted Cross”

Björn Högberg



Design challenges

Steep learning curve

Ad hoc methods are tedious and error prone

New shapes can require days or weeks of effort



caDNAno

open-source software for design of
three-dimensional DNA origami

[Intro](#)[Tutorials](#)[Gallery](#)[Source](#)[Links](#)[Contact](#)

1. Download & Install



ADOBE AIR™

2. Get caDNAno



caDNAno

what is caDNAno?

caDNAno is software for design of three-dimensional [DNA origami](#) nanostructures. It was written with the goal of providing a simple and user-friendly interface to facilitate a process that can be complex and error-prone.

caDNAno features:

- No programming required
- Integrated 2D and 3D interfaces
- Visual cues to aid design process
- Export formats: [SVG](#), [X3D](#), [JSON](#)
- Platform independent
- Open source (MIT license)

Featured design



slotted cross

[view full gallery](#)

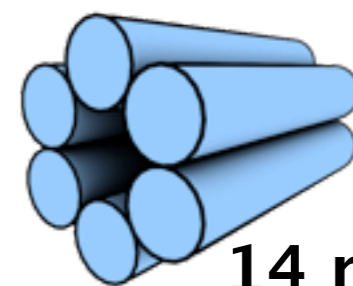
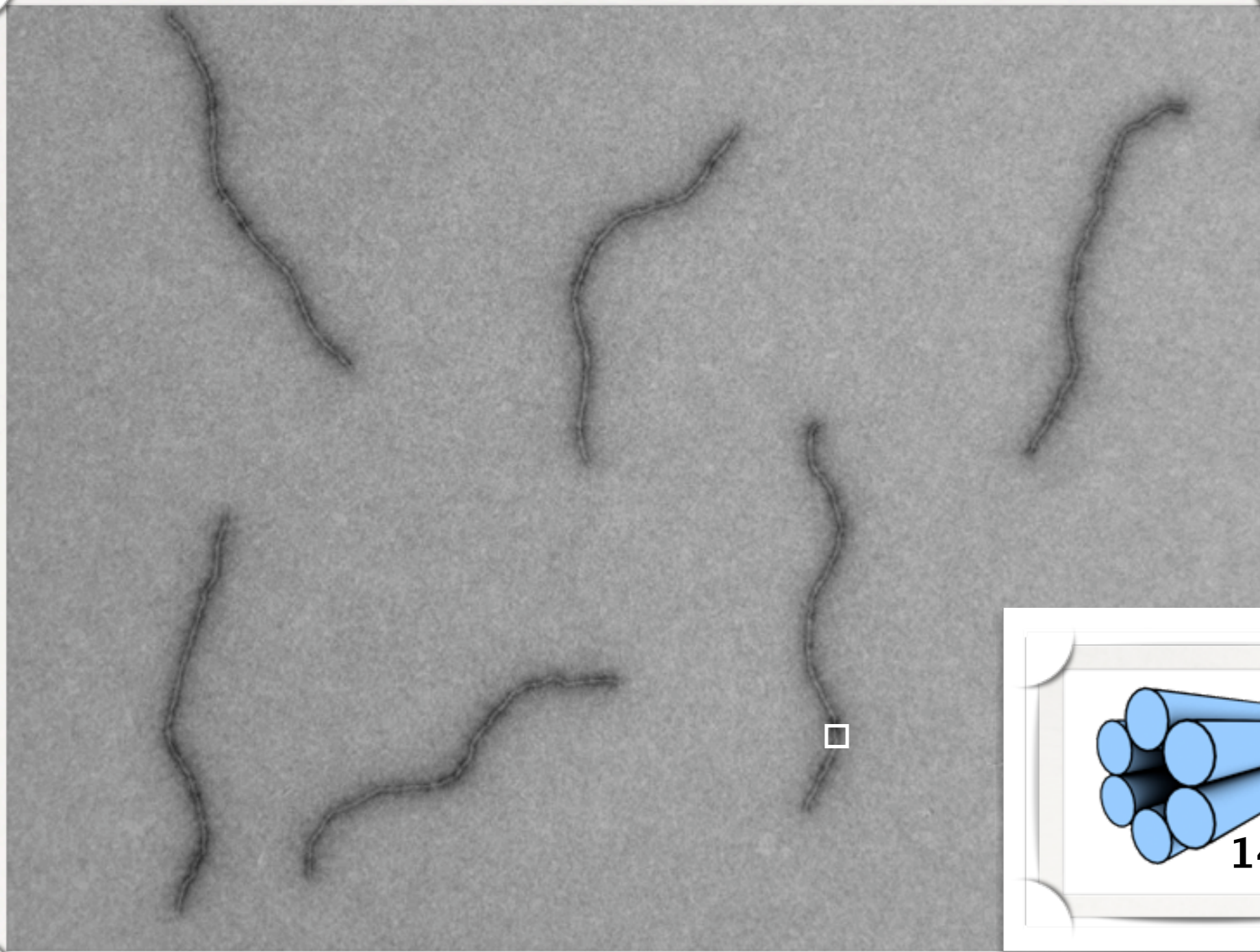
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[Shih Lab](#)

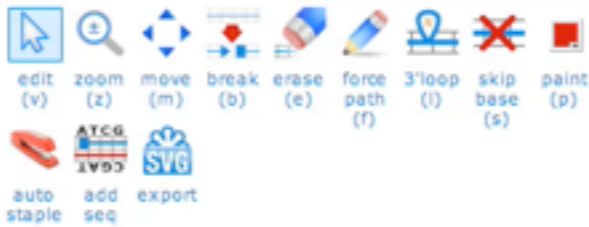
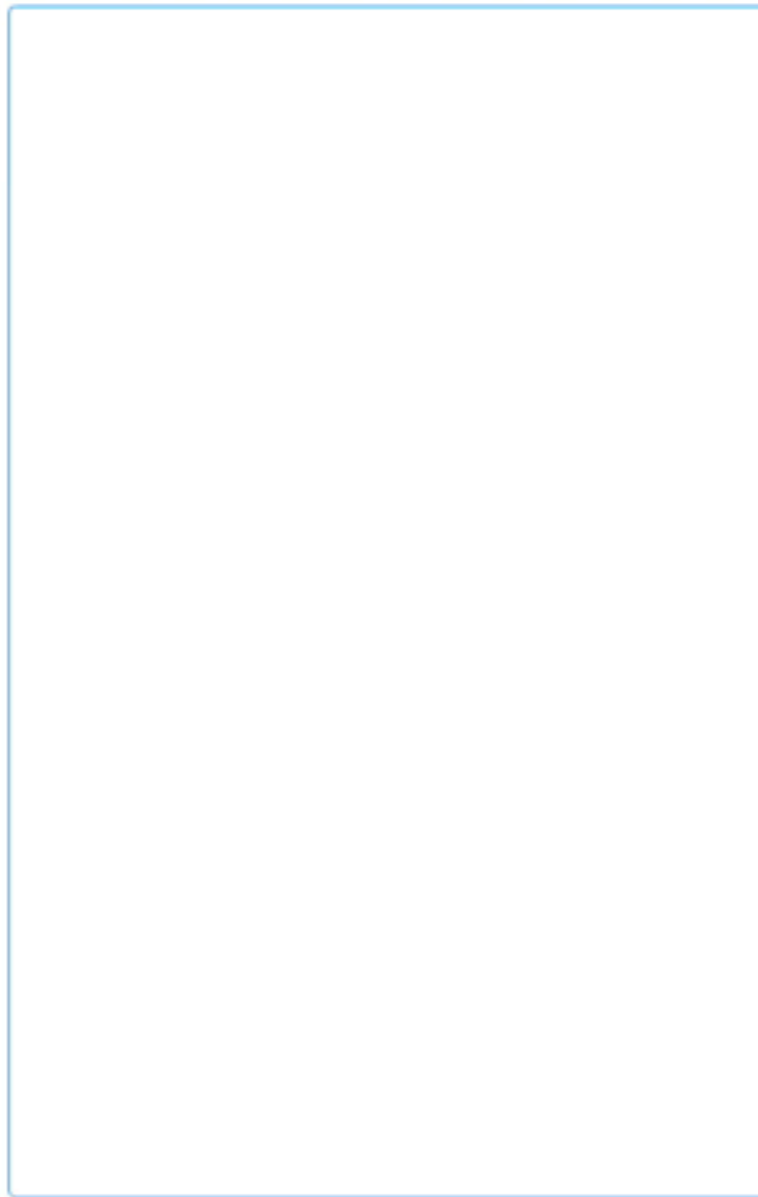
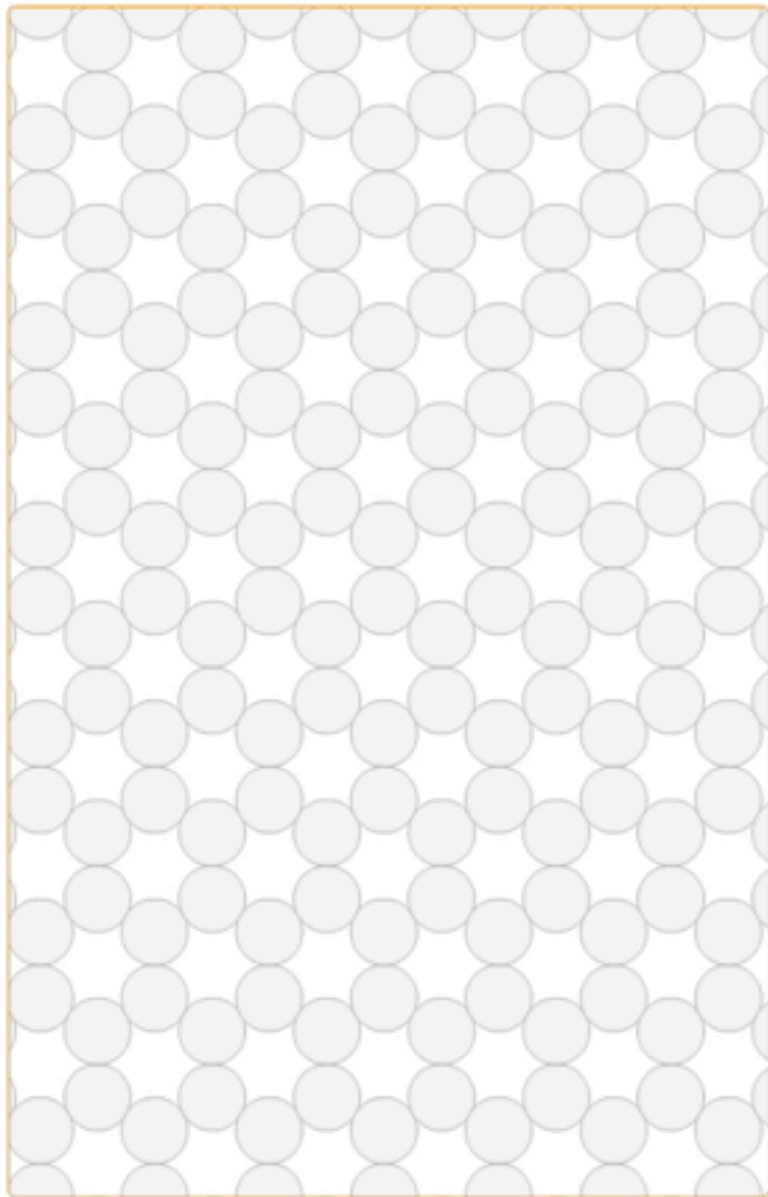
[Church Lab](#)

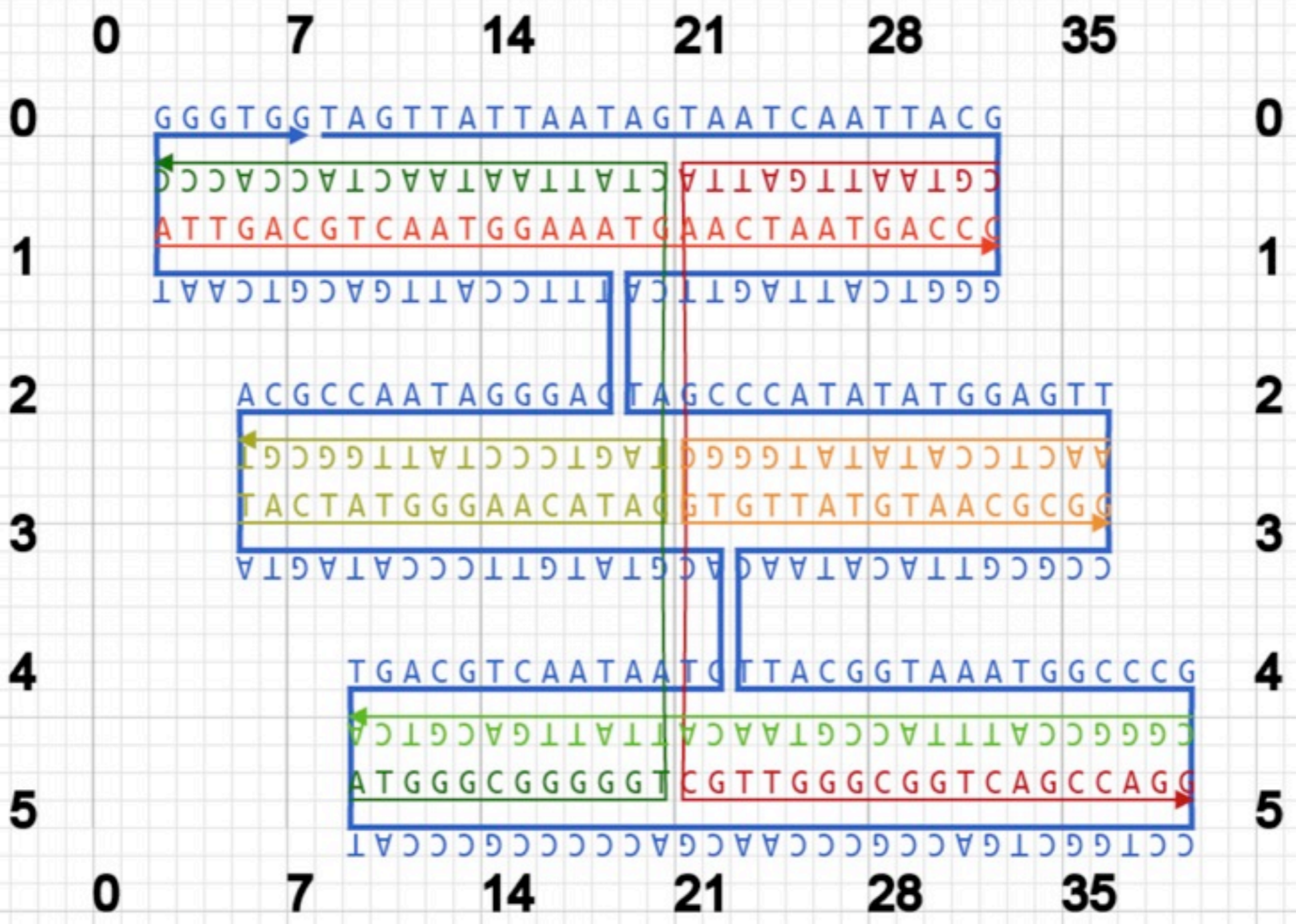
<http://cadnano.org/>

Douglas SM, Marblestone AM, Teerapittayanon S, Vazquez A, Church GM, Shih WM. *Nucleic Acids Res.* In press, 2009.



14 nm





Exploring shape dependence of DNA-particle cellular uptake

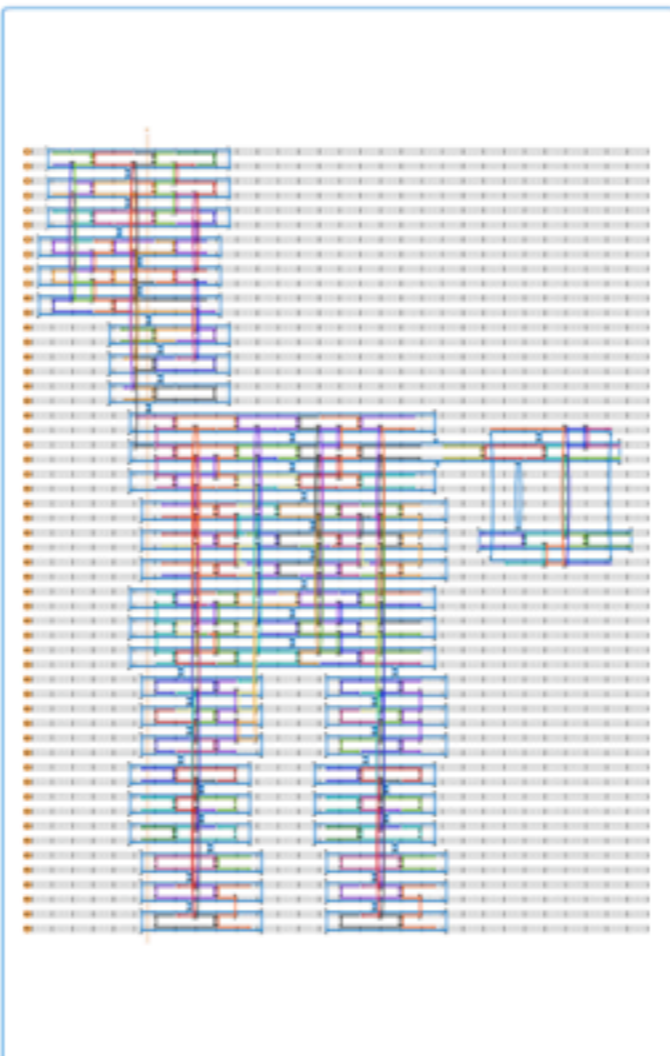
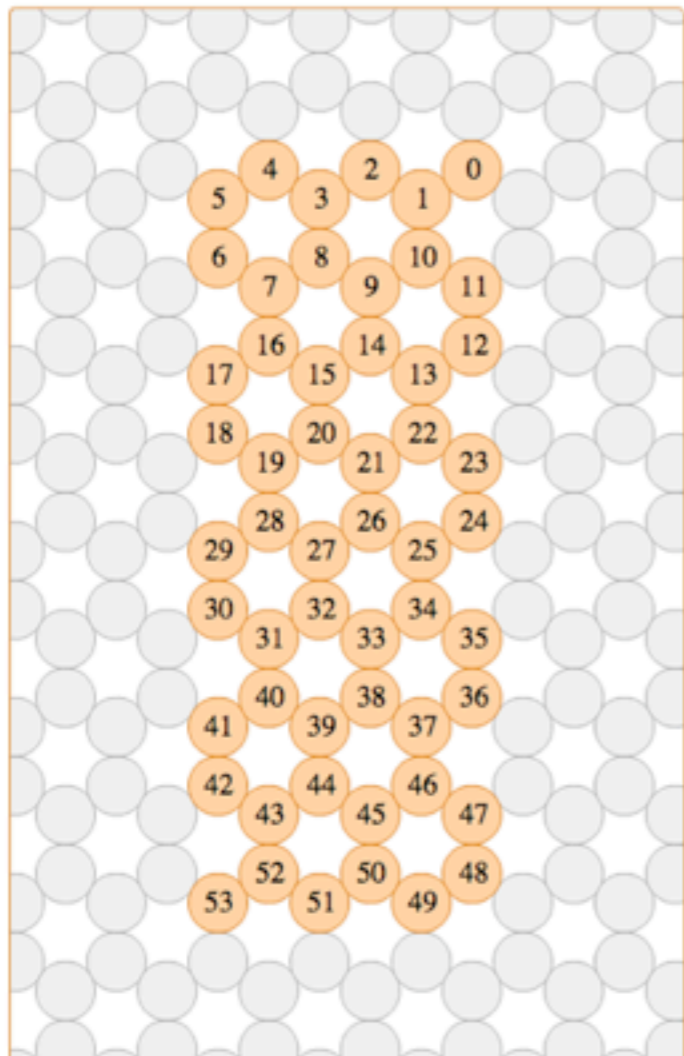


Franziska Graf

Katrina Galkina



caDNAno



edit zoom move first prev next last

edit (v) zoom (z) move (m) break (b) erase (e) force path (f) 3'loop (l) skip base (s) paint (p)

auto staple add seq export

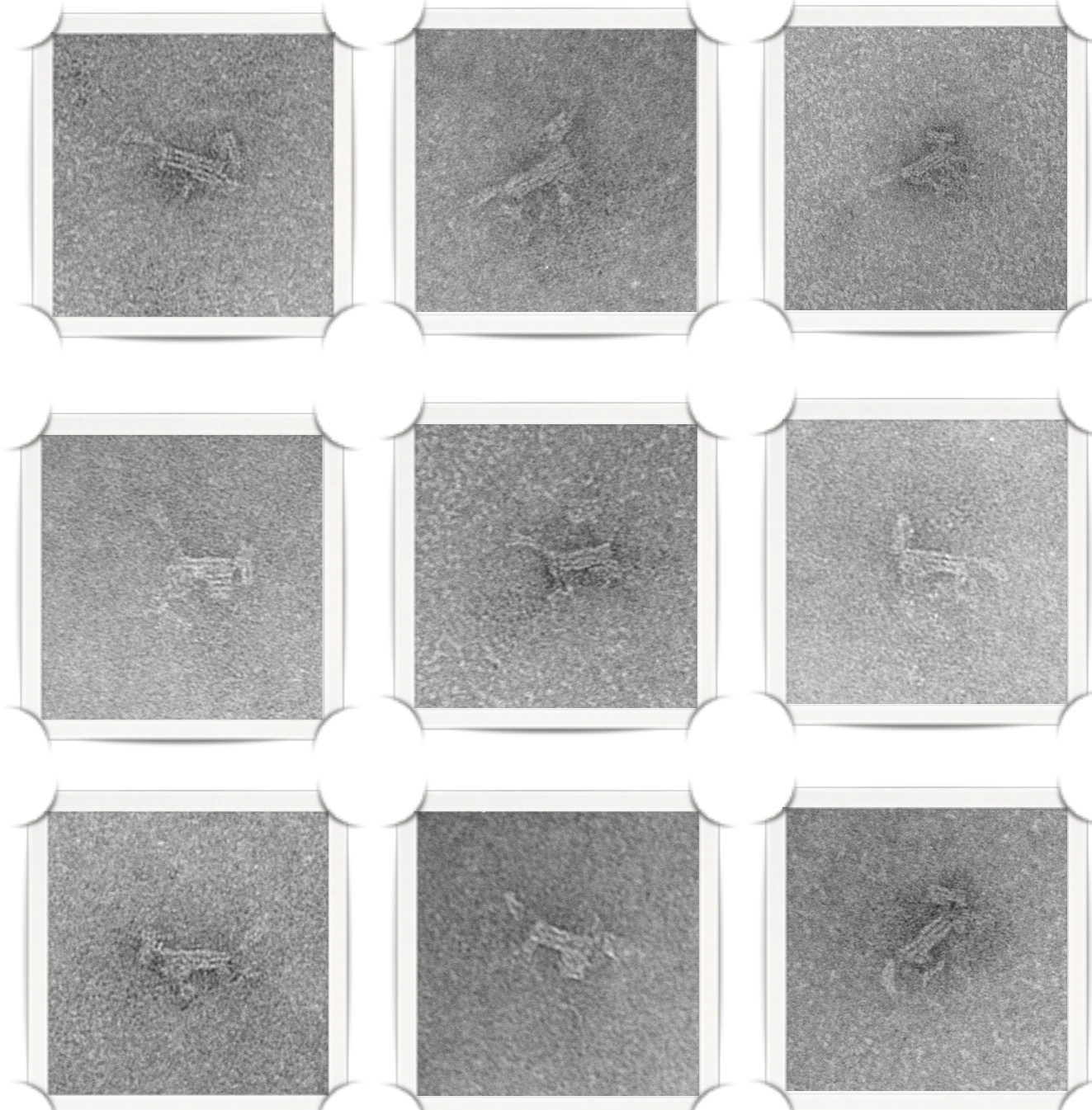
zoom move export

open save save as use server

DOCK

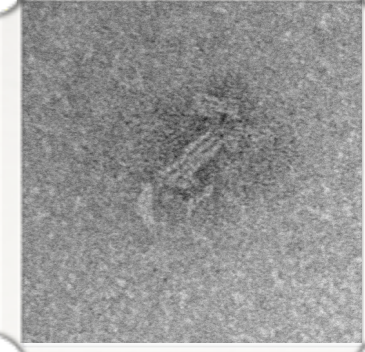
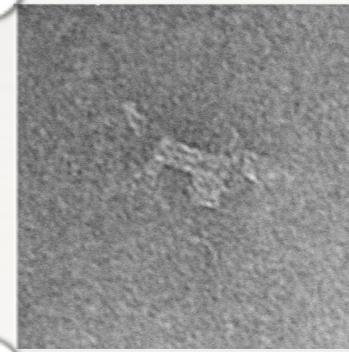
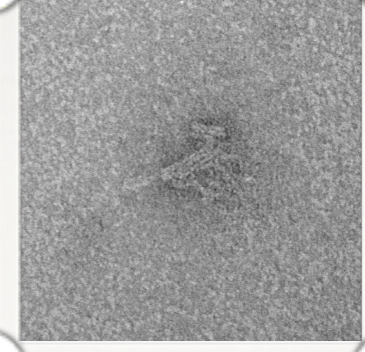
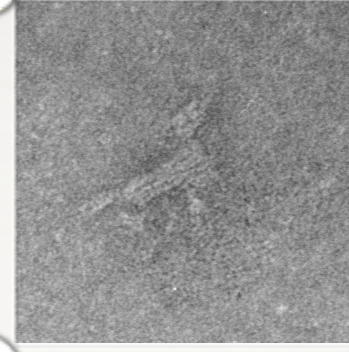
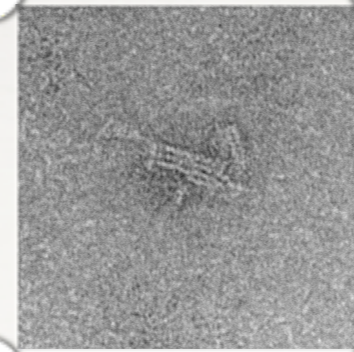
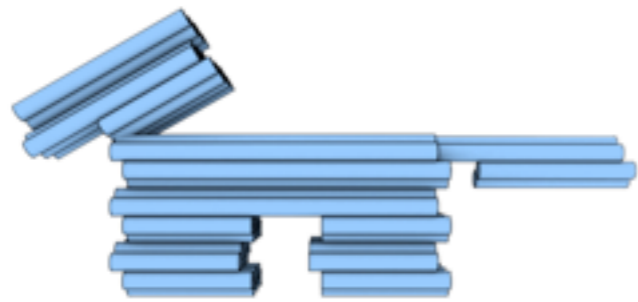
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22:45:13

TEM



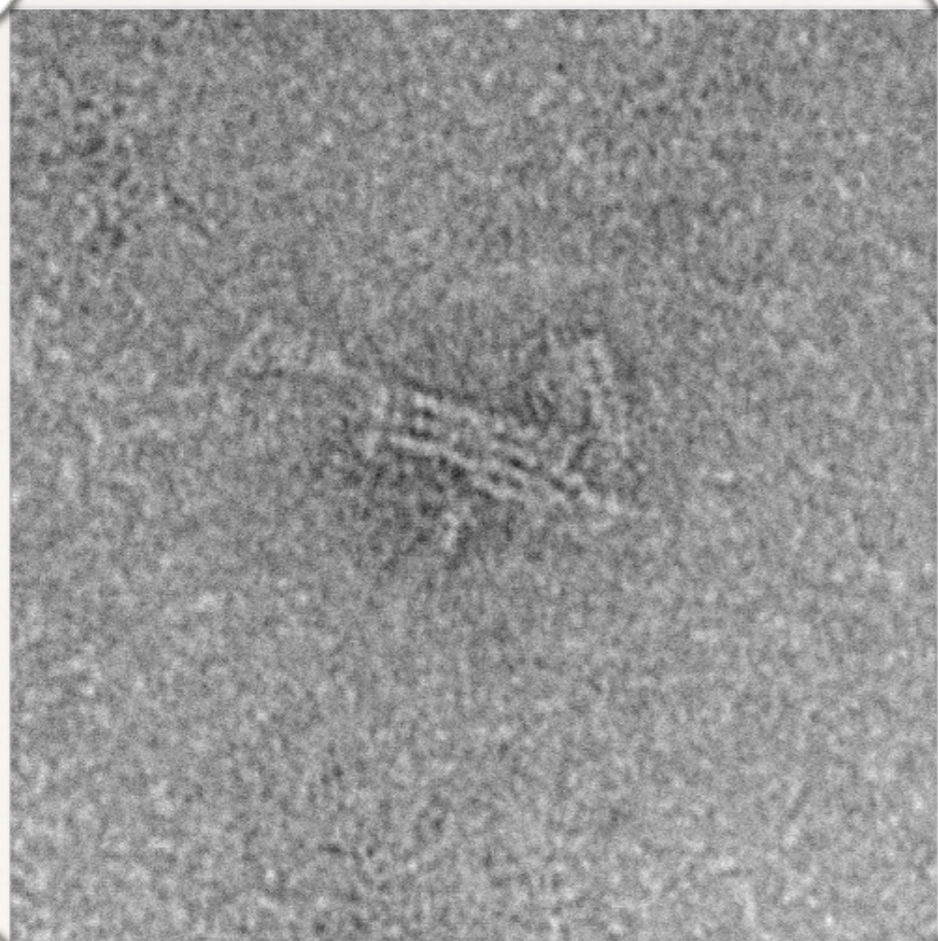
100 nm

TEM



100 nm

Closeups



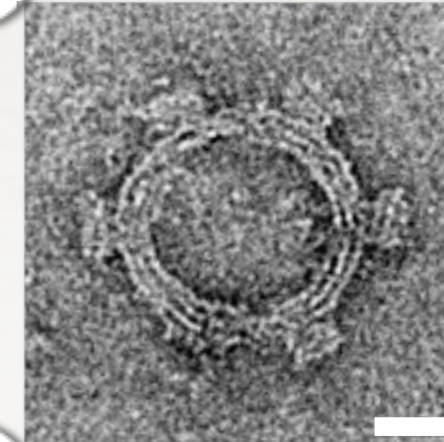
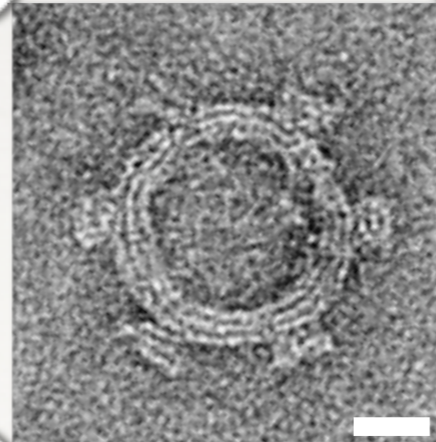
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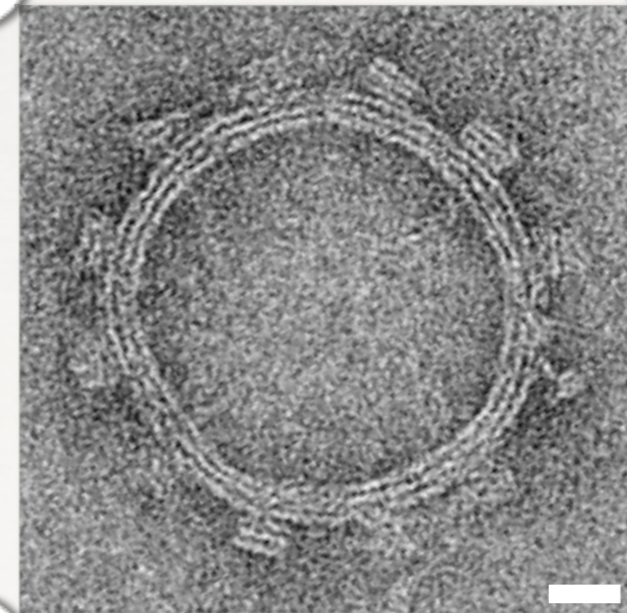
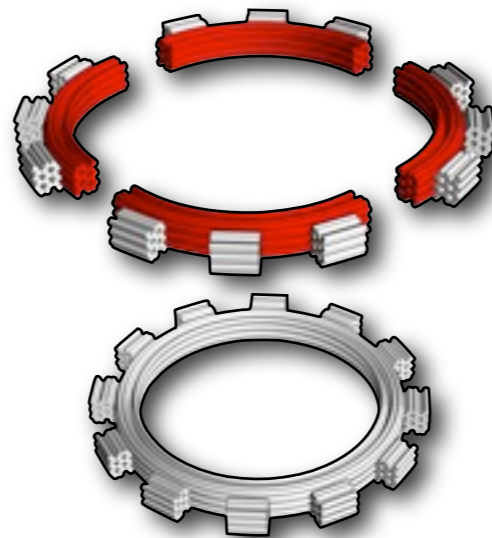
Dietz H, Douglas SM, Shih WM. **Science** 325, 725–730, 2009.



**6-tooth
gear**



**12-tooth
gear**



Conclusions

We can self-assemble arbitrary 3D-origami DNA nanostructures.

Precise control over self-assembly of 3D DNA nanostructures will be useful.



Support

NIH New Innovator Award
DFCI Barr Award in Innovative
Basic Cancer Research
Wyss Institute for Biologically
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