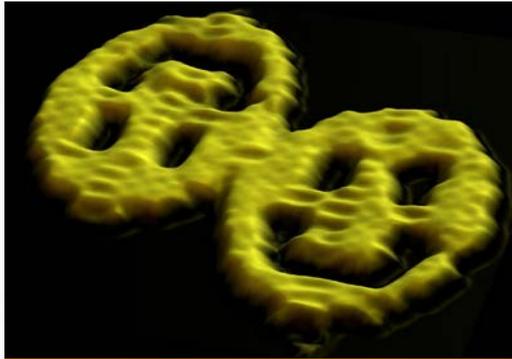


A little proposal



Scott's Seafood
on the River
Sacramento, CA
Oct 25, 2019



UC Davis

Caltech





Acknowledgments



Pierre-Etienne Meunier

Damien Woods



Chris Thachuk



Constantine Evans



Namita Sarraf



Anya Mitskovets



Paul Rothemund





Ljubljana Marshes Wheel. 5k years old

Building things



Newgrange, Ireland. 5.2k years old

Building things by hand: use tools! Great for scale of $10^{\pm 2} \times$ 



Ljubljana Marshes Wheel. 5k years old

Building things



Newgrange, Ireland. 5.2k years old

Building things by hand: use tools! Great for scale of $10^{\pm 2} \times$ 

Building tools that build things:





Ljubljana Marshes Wheel. 5k years old

Building things



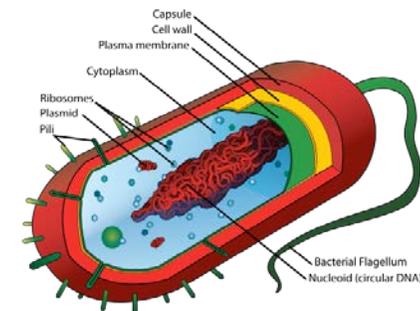
Newgrange, Ireland. 5.2k years old

Building things by hand: use tools! Great for scale of $10^{\pm 2} \times$ 

Building tools that build things:



Programming things to build themselves: for building in small wet places where our hands or tools can't reach

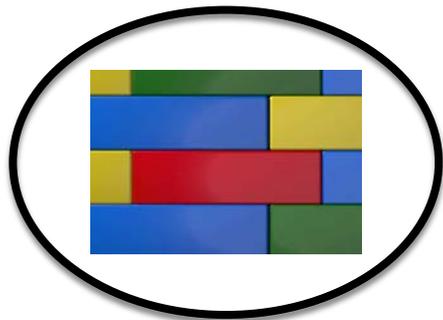


Mariana Ruiz Villarreal

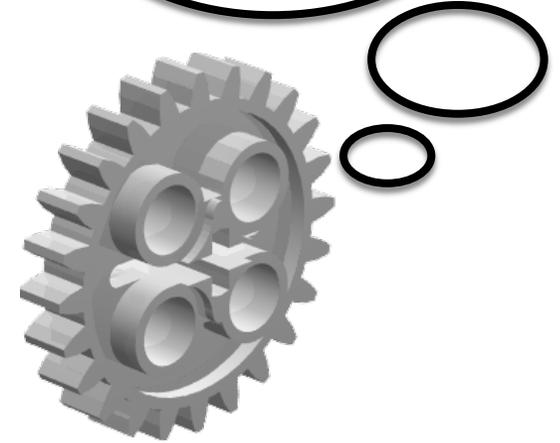
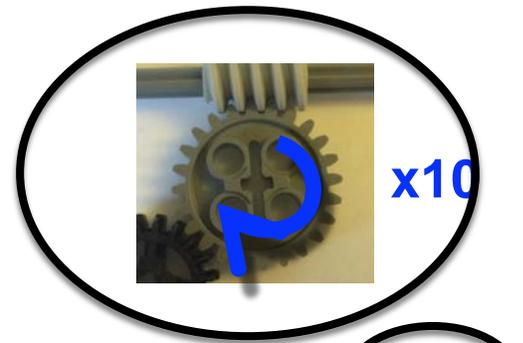
[slide credit: Damien Woods]



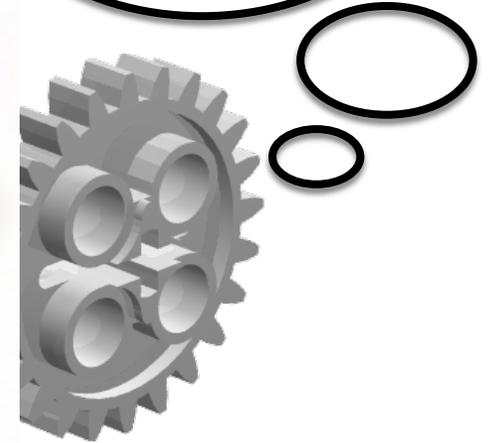
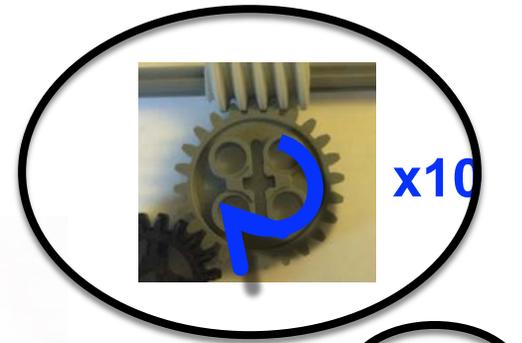
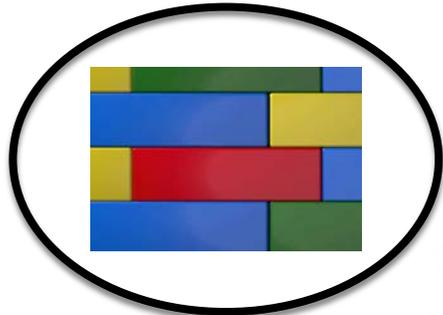
Things that build themselves



I want to stick below blue & yellow and above blue & green

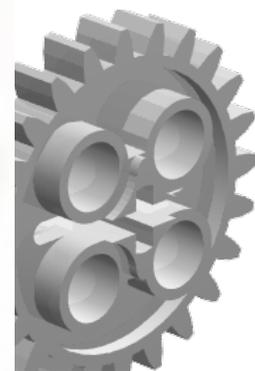
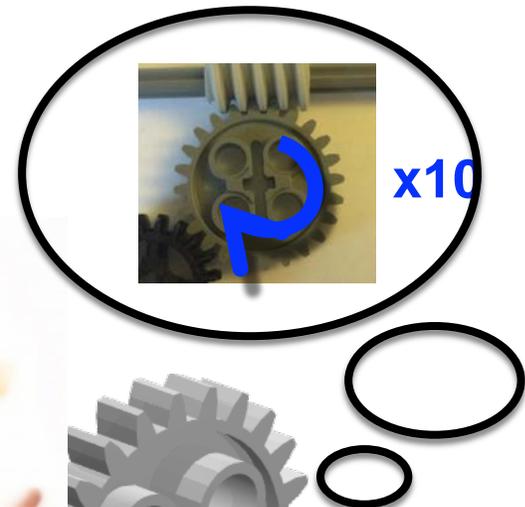
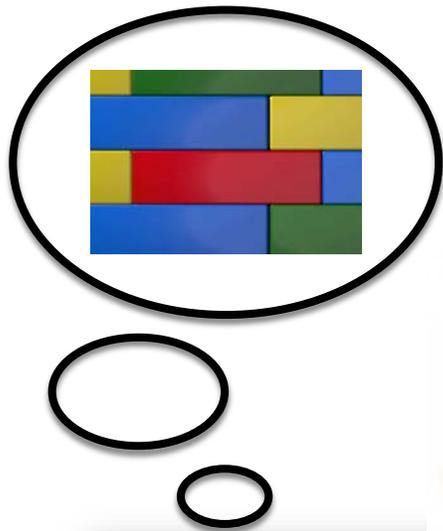


Things that build themselves



[slide credit: Damien Woods]

Things that build themselves

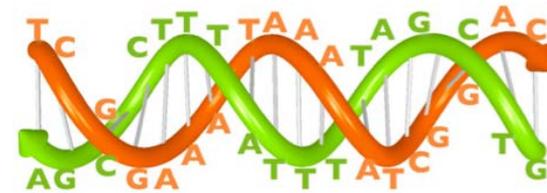
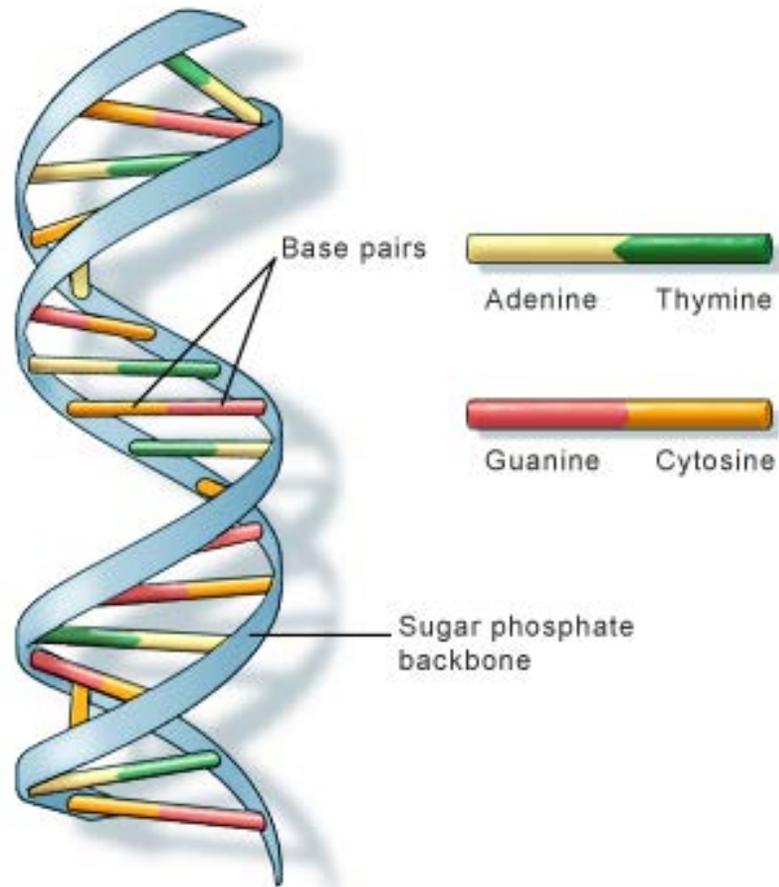




DNA nanotechnology

a.k.a. DNA carpentry

DNA as a building material

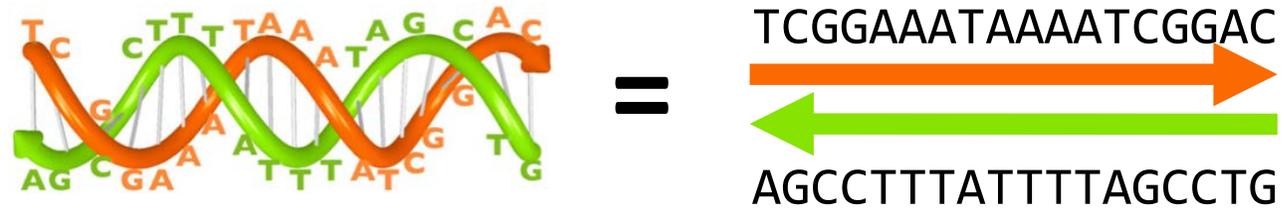
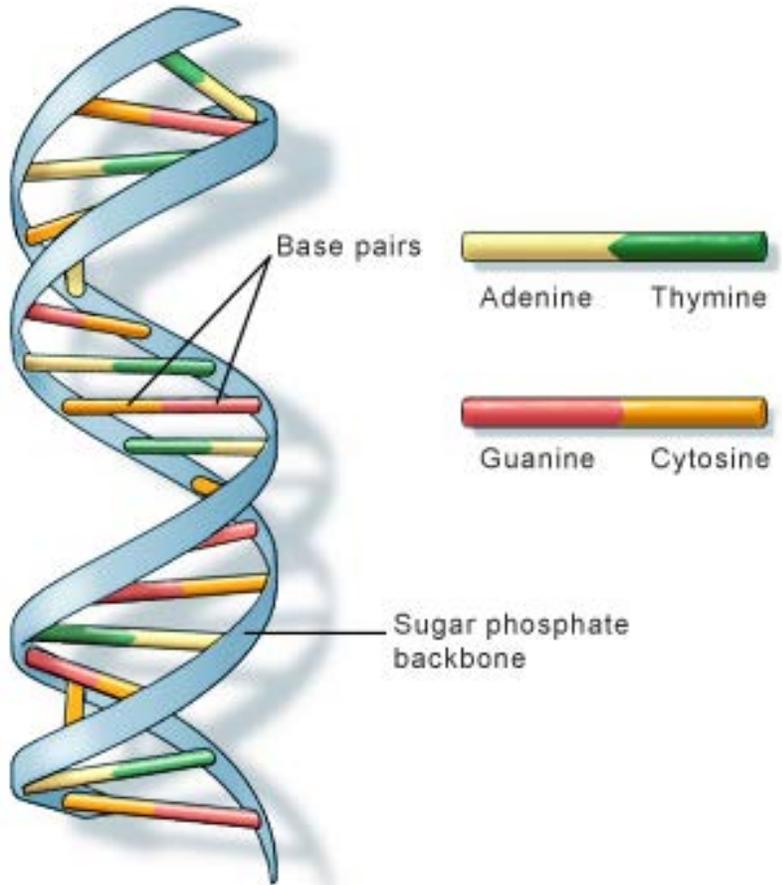


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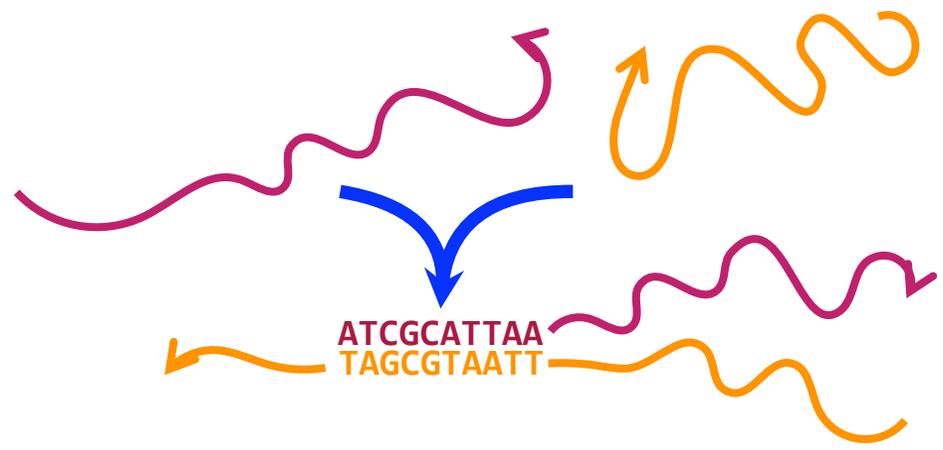
TCGGAAATAAAATCGGAC
AGCCTTTATTTTAGCCTG

The text shows two DNA sequences. The top sequence, TCGGAAATAAAATCGGAC, is written above an orange arrow pointing to the right. The bottom sequence, AGCCTTTATTTTAGCCTG, is written below a green arrow pointing to the left.

DNA as a building material



DNA strands can bind even if only part of strands are complementary:





DNA origami

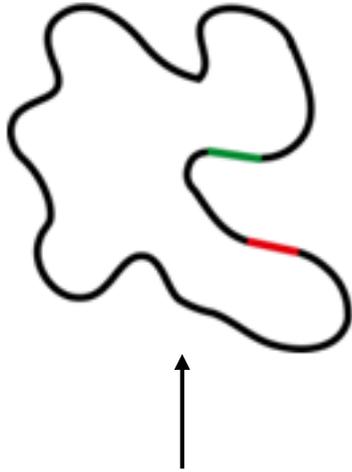


Paul Rothemund

Folding DNA to create nanoscale shapes and patterns

Nature 2006

DNA origami

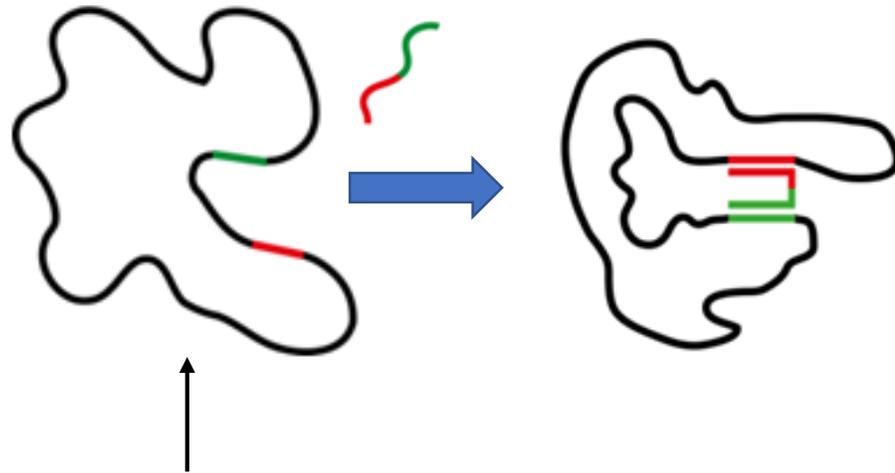


↑
scaffold DNA strand
(M13mp18 bacteriophage virus)



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Folding DNA to create nanoscale shapes and patterns
Nature 2006

DNA origami

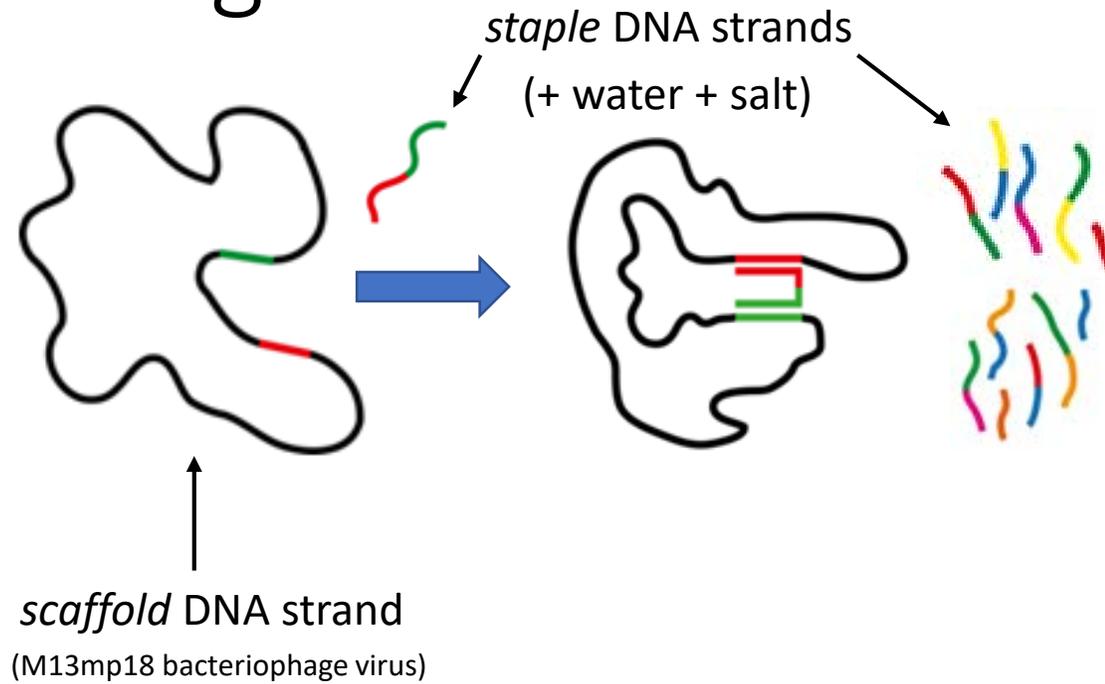


scaffold DNA strand
(M13mp18 bacteriophage virus)



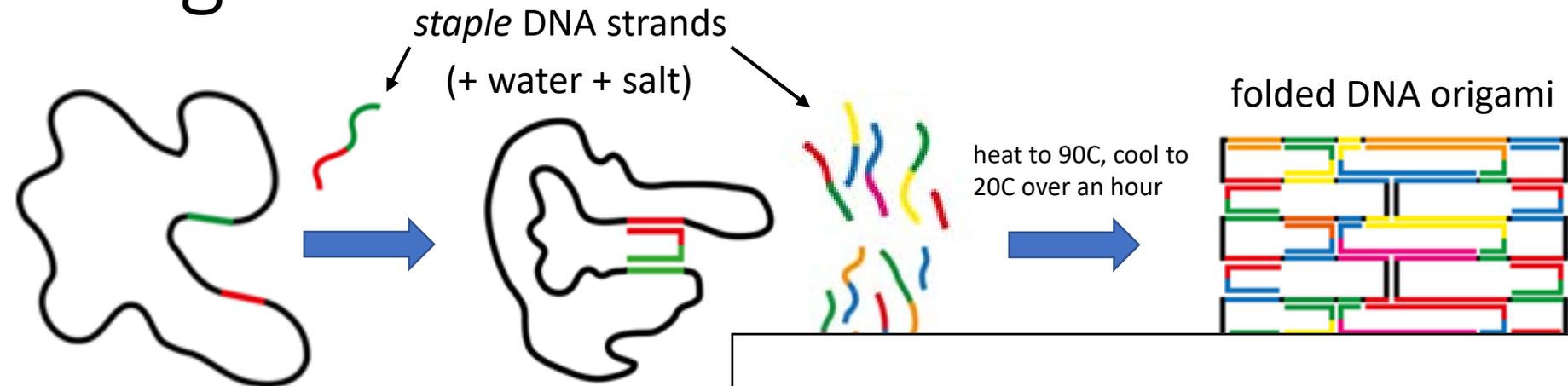
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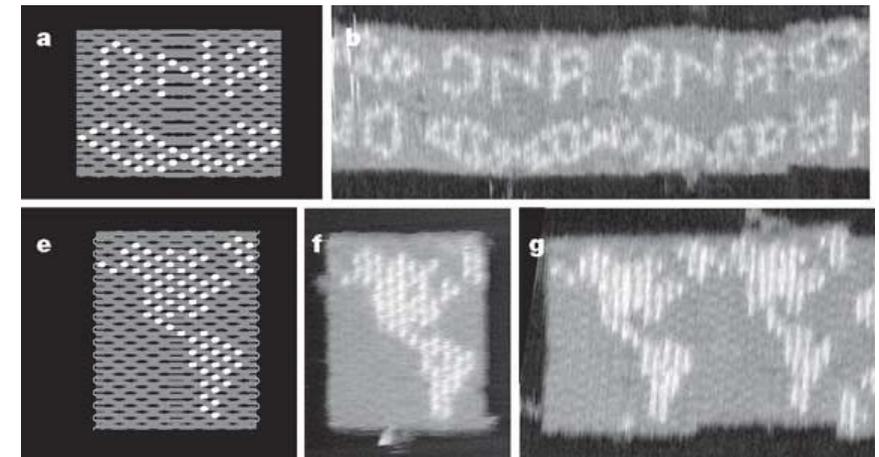
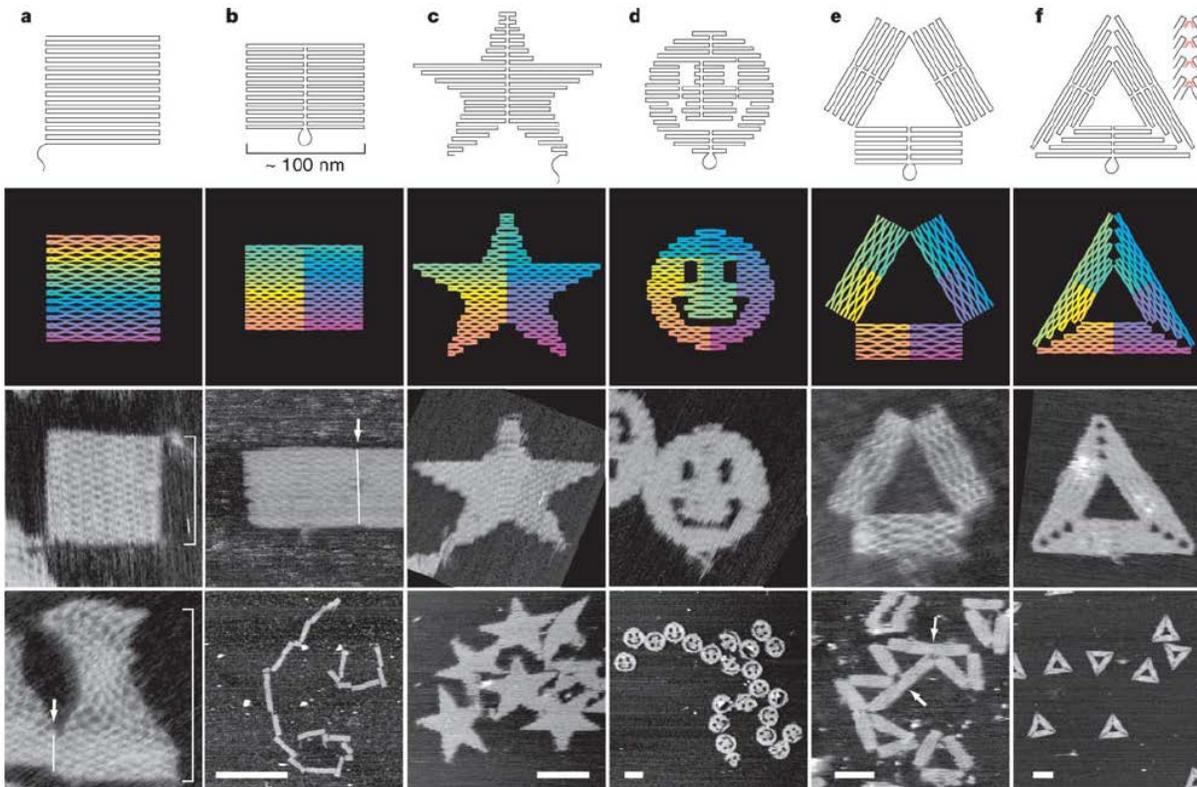
DNA origami

Paul Rothemund

Folding DNA to create nanoscale shapes and patterns

Nature 2006

Atomic force microscope images



100 nm



DNA nanotechnology applications

nonbiological:

- nanoscale resolution surface placement
- X-ray crystallization scaffolding
- molecular motors
- super-resolution imaging
- molecular circuits

biological:

- smart drugs
- mRNA detection
- cell surface marker detection
- genetically encoded structures

DNA nanotechnology applications

nonbiological:

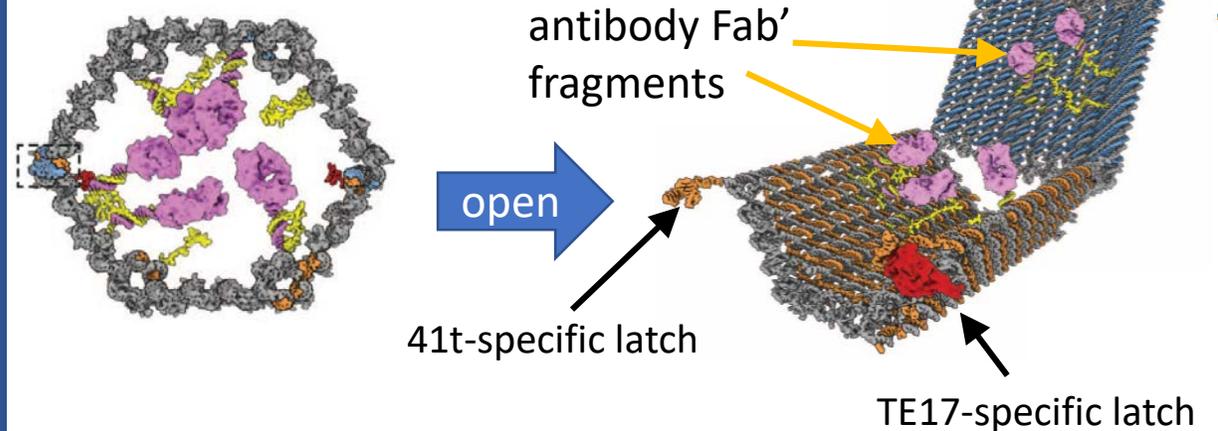
- nanoscale resolution surface placement
- X-ray crystallization scaffolding
- molecular motors
- super-resolution imaging
- molecular circuits

biological:

- smart drugs
- mRNA detection
- cell surface marker detection
- genetically encoded structures

example

DNA origami opens to deliver antibody only in presence of two protein antigens

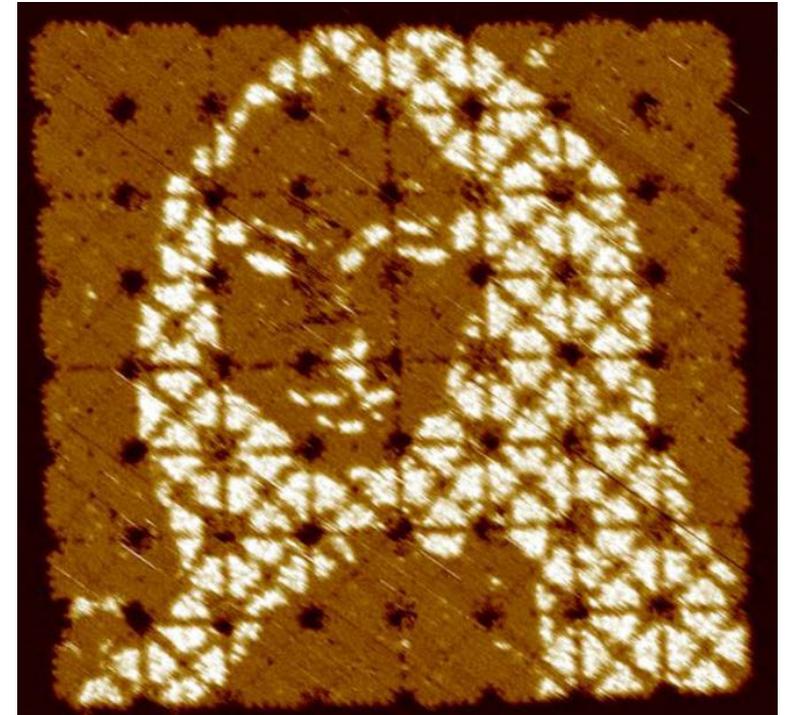
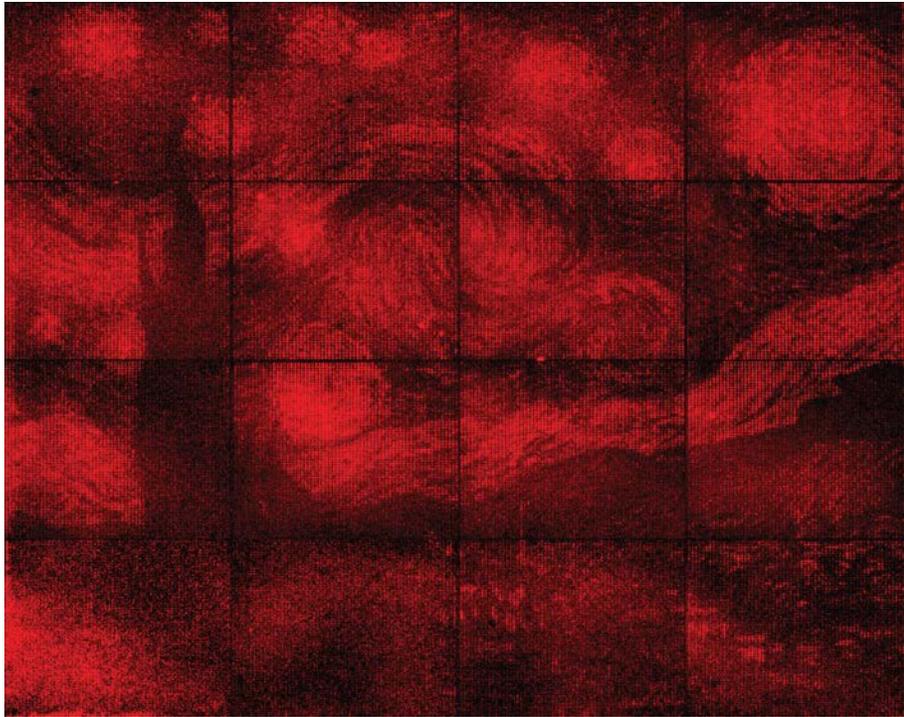


Shawn Douglas, Ido Bachelet, George Church, *A logic-gated nanorobot for targeted transport of molecular payloads*, Science 2012

DNA nanotechnology applications

nonbiological:

- **art**

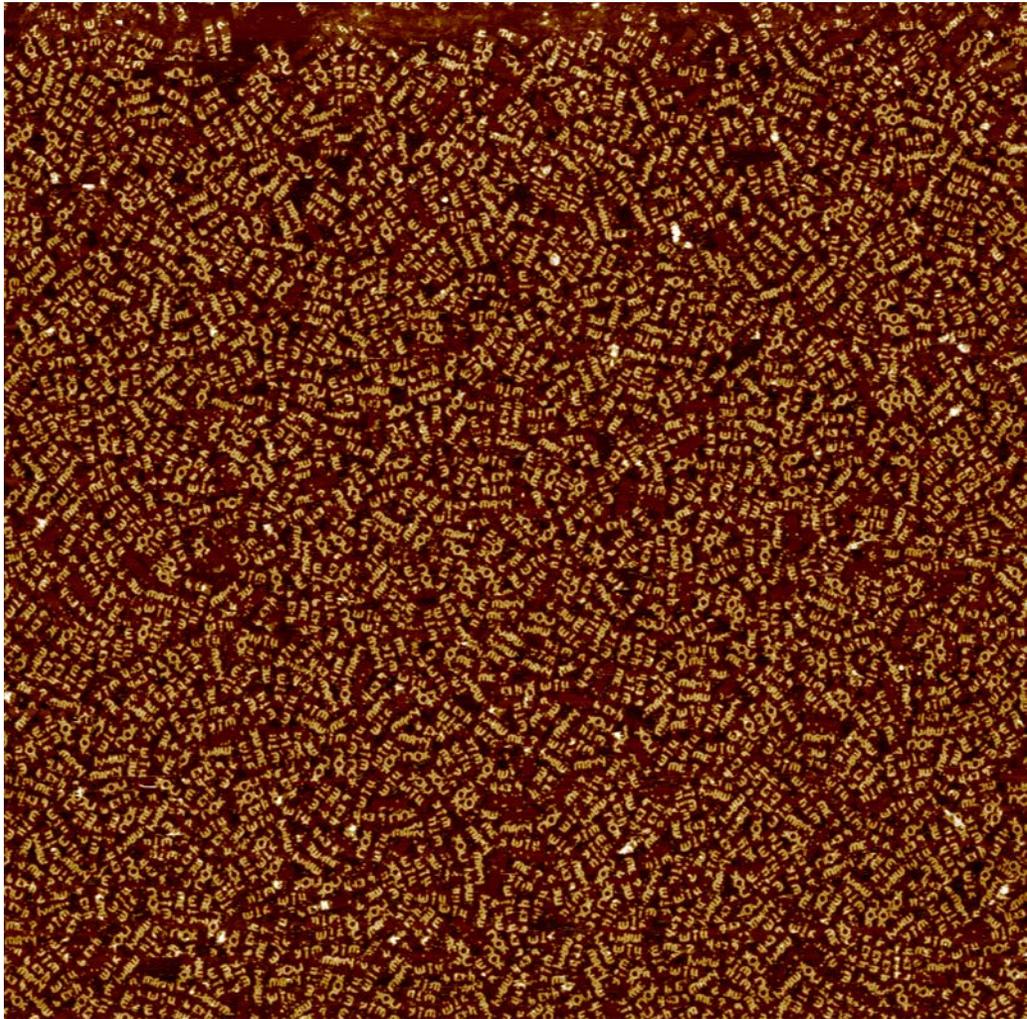


Ashwin Gopinath, Evan Miyazono, Andrei Faraon, Paul Rothemund, *Engineering and mapping nanocavity emission via precision placement of DNA origami*, Nature 2016

Grigory Tikhomirov, Philip Petersen, and Lulu Qian. *Fractal assembly of micrometre-scale DNA origami arrays with arbitrary patterns*. Nature 2017.

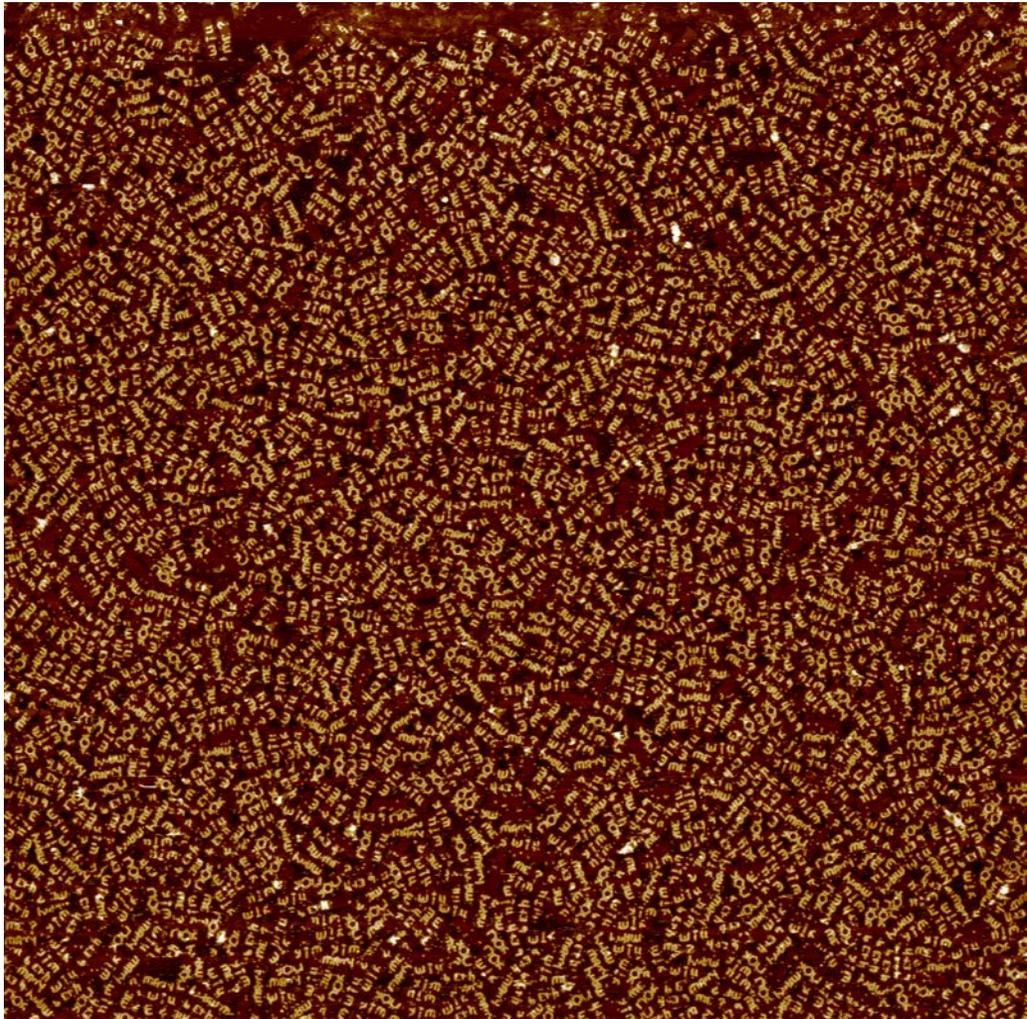
IMPORTANT application of DNA nanotechnology

image: 4×10^{-6} m wide

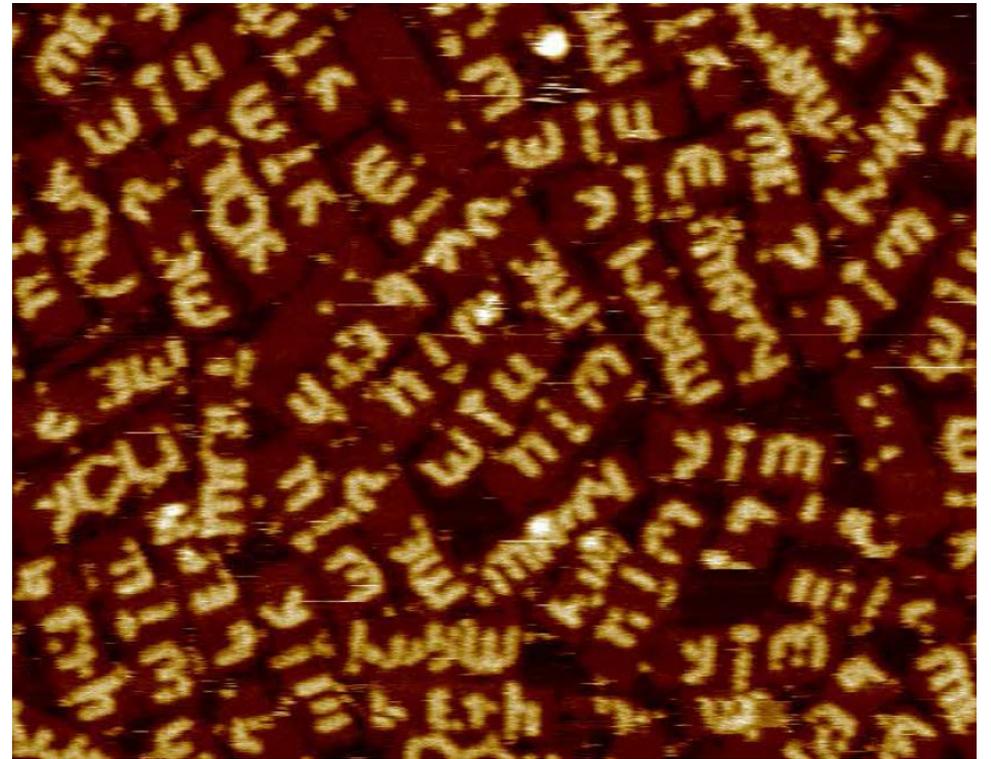


IMPORTANT application of DNA nanotechnology

image: 4×10^{-6} m wide



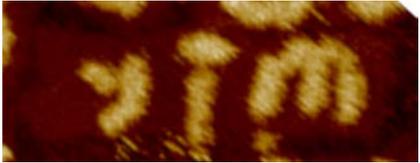
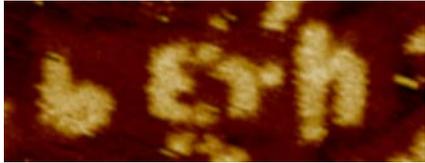
zoom in



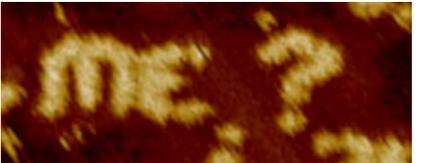
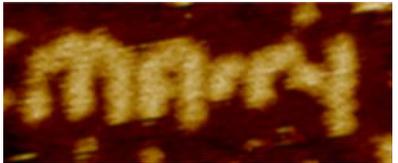
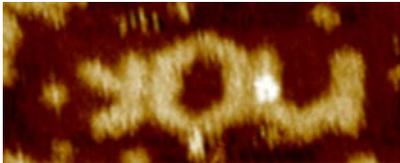
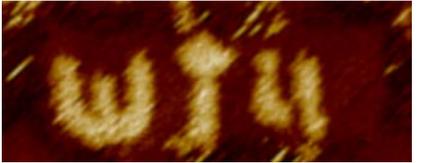
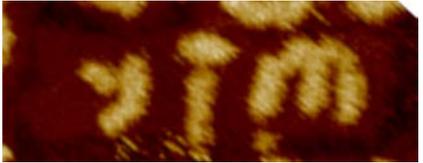
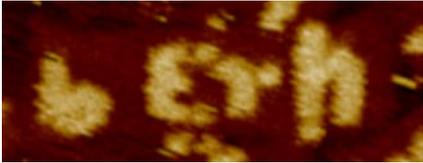


A little proposal

100 nm



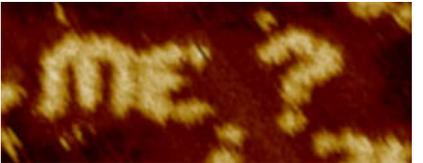
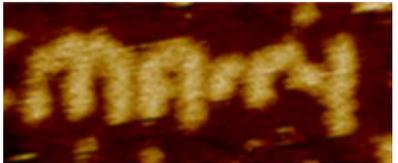
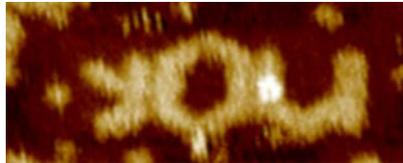
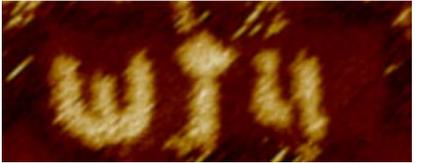
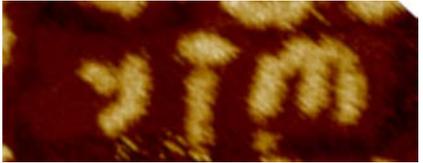
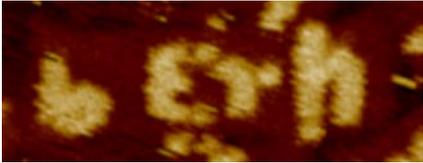
A little proposal



100 nm



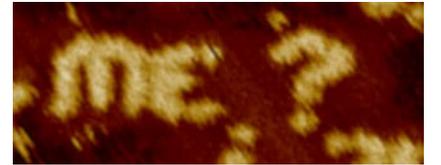
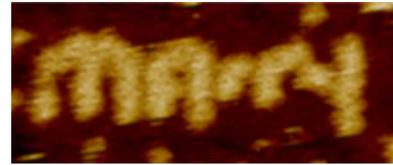
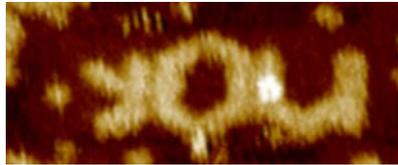
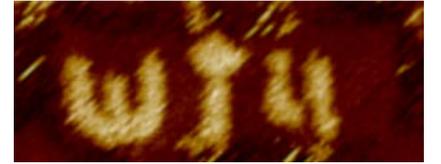
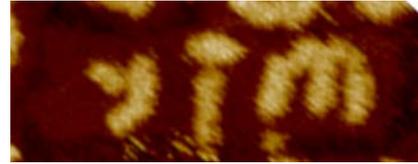
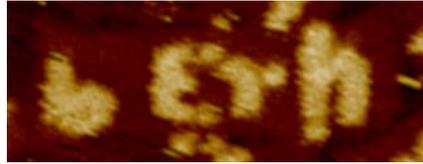
A little proposal



100 nm



A little proposal



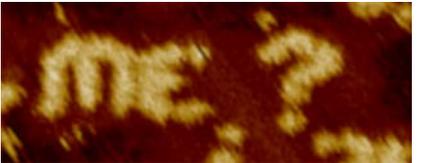
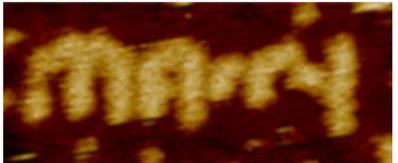
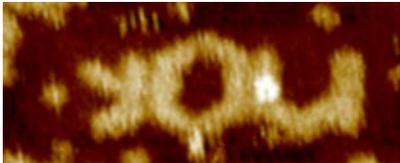
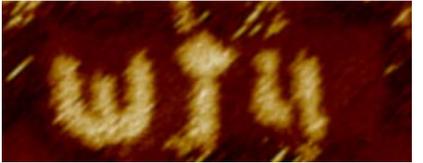
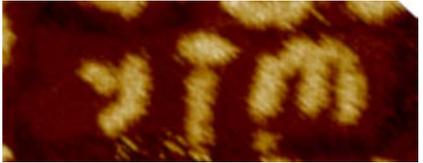
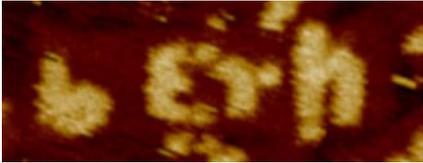
100 nm



total number of proposals in 50 μ L test tube:
 \approx 100 billion



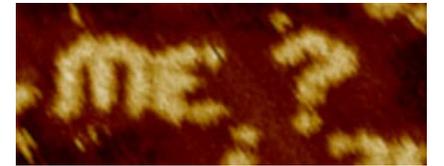
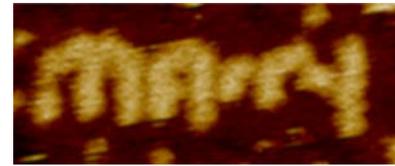
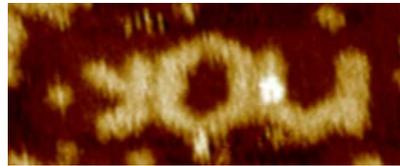
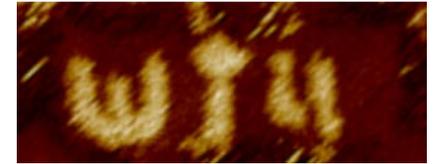
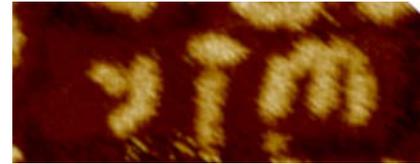
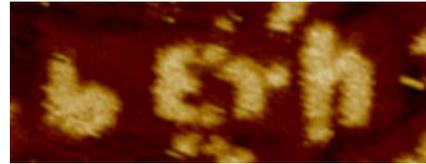
A little proposal



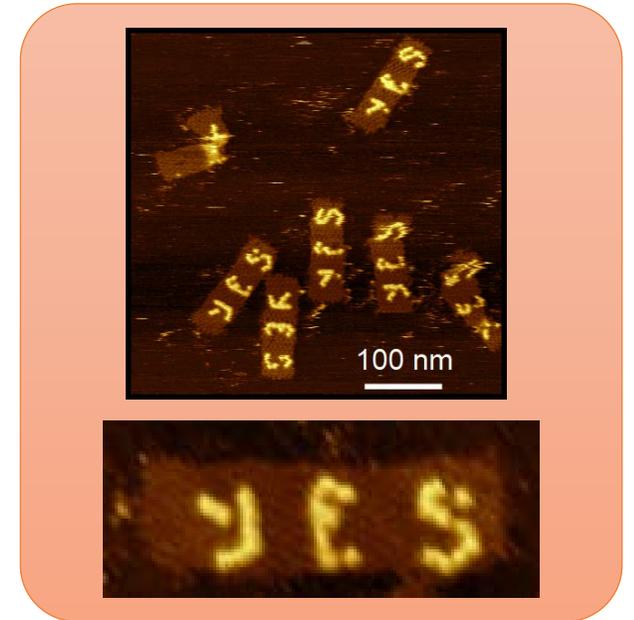
100 nm



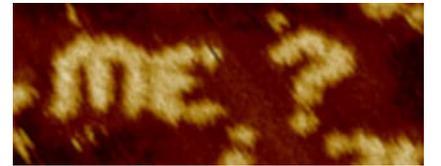
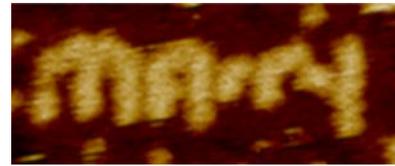
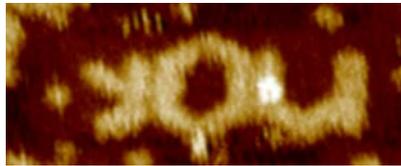
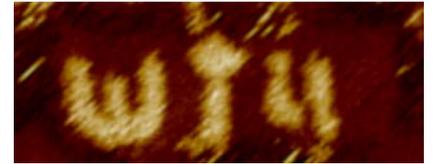
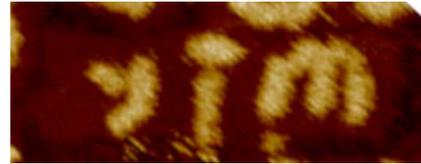
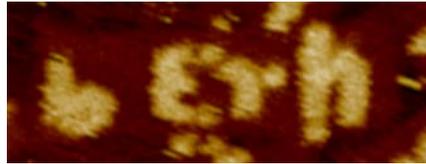
A little proposal and a little reply



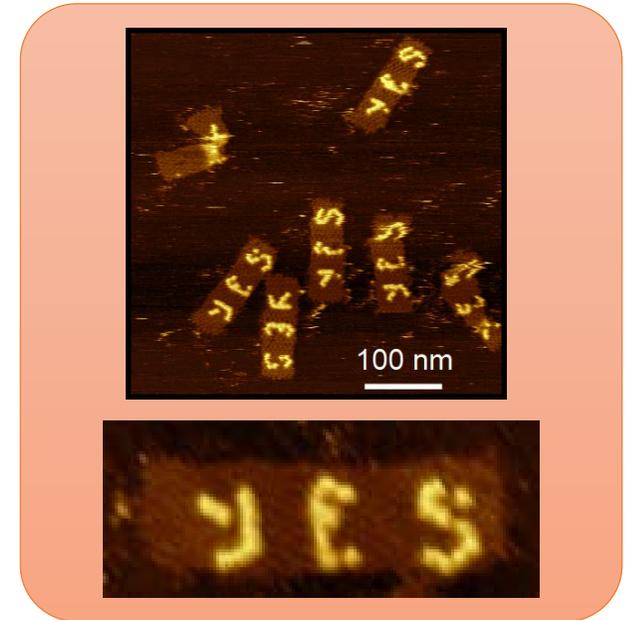
100 nm



A little proposal and a little reply



100 nm



Thank you!