

Molecules that compute and assemble nano-objects

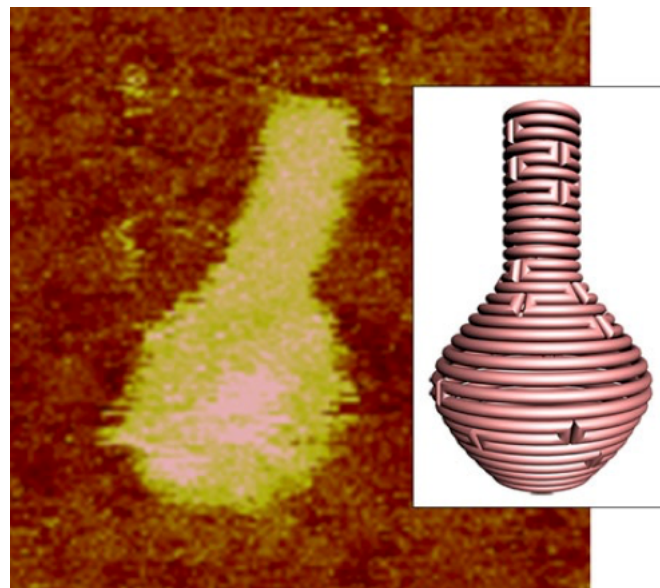
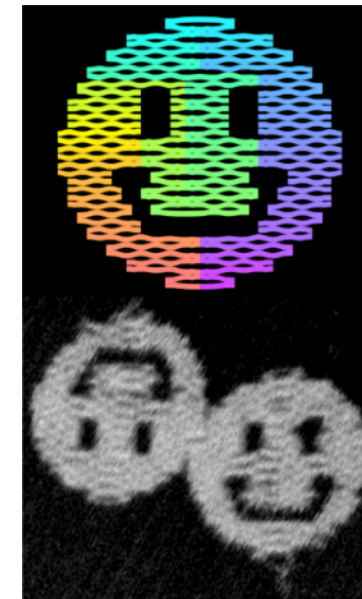
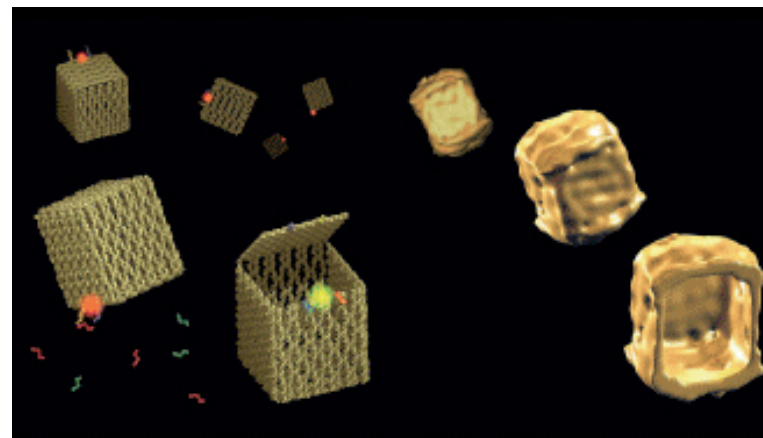
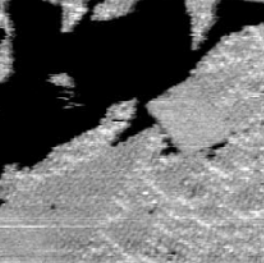
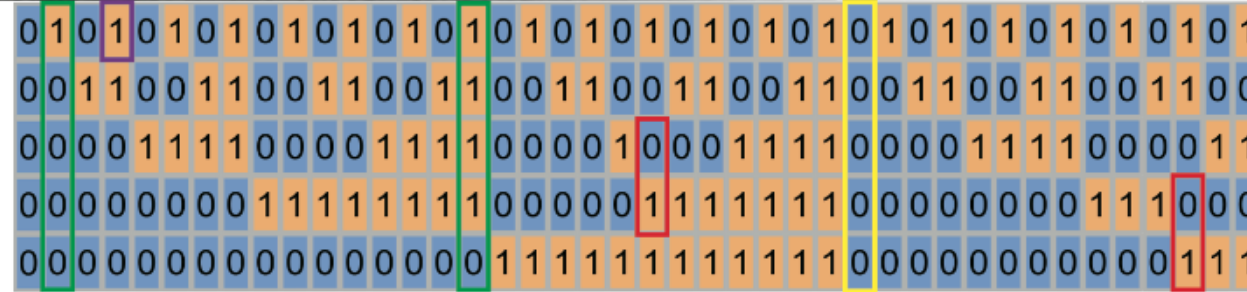
Nicolas Schabanel

Directeur de Recherches CNRS

IXXI - ÉNS Lyon

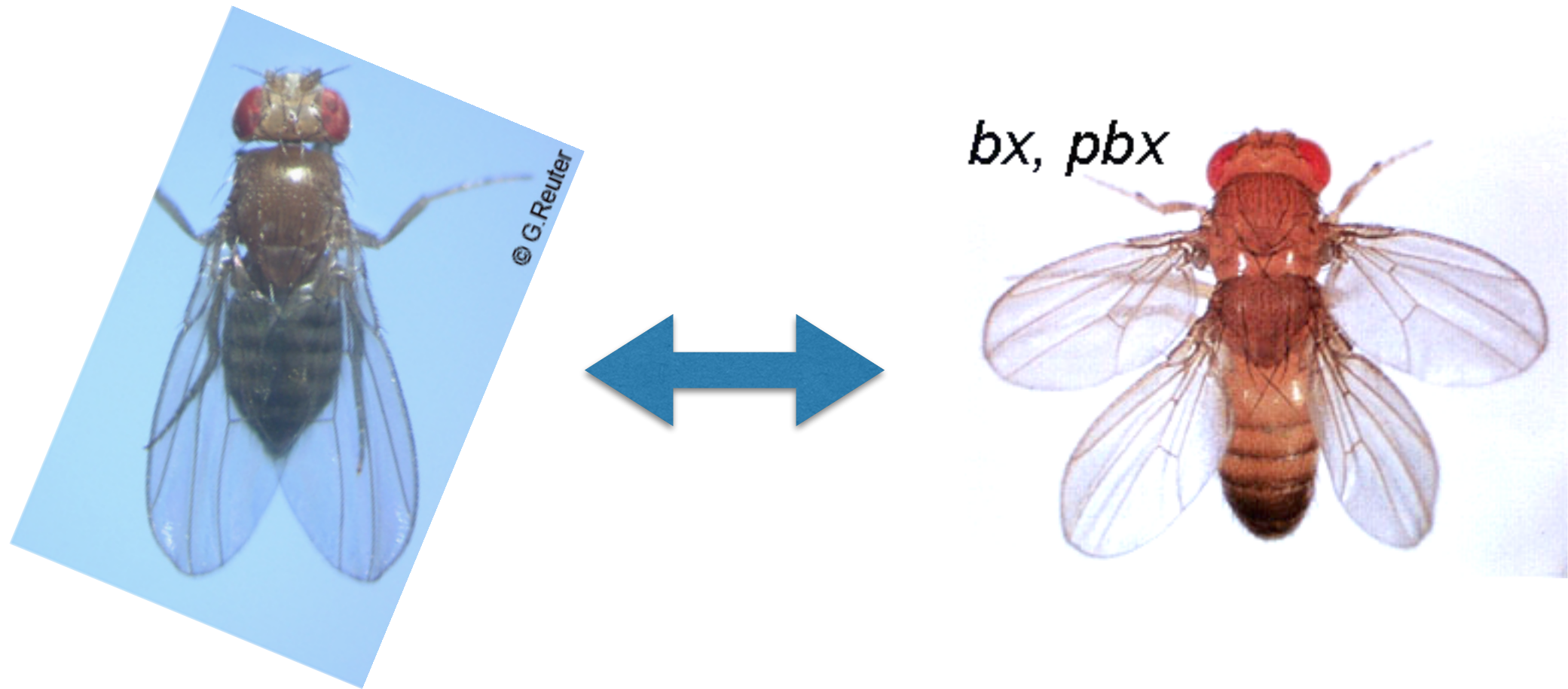
`nicolas.schabanel@ens-lyon.fr`

A grayscale image of a long, narrow, textured object, possibly a piece of fabric or paper, with two green rectangular boxes highlighting specific regions of interest. The object is oriented horizontally and shows a dense pattern of small, light-colored spots or fibers. The background is dark and noisy. The two green boxes are positioned on the left and right sides of the object, each enclosing a small, elongated region.

[illegible]

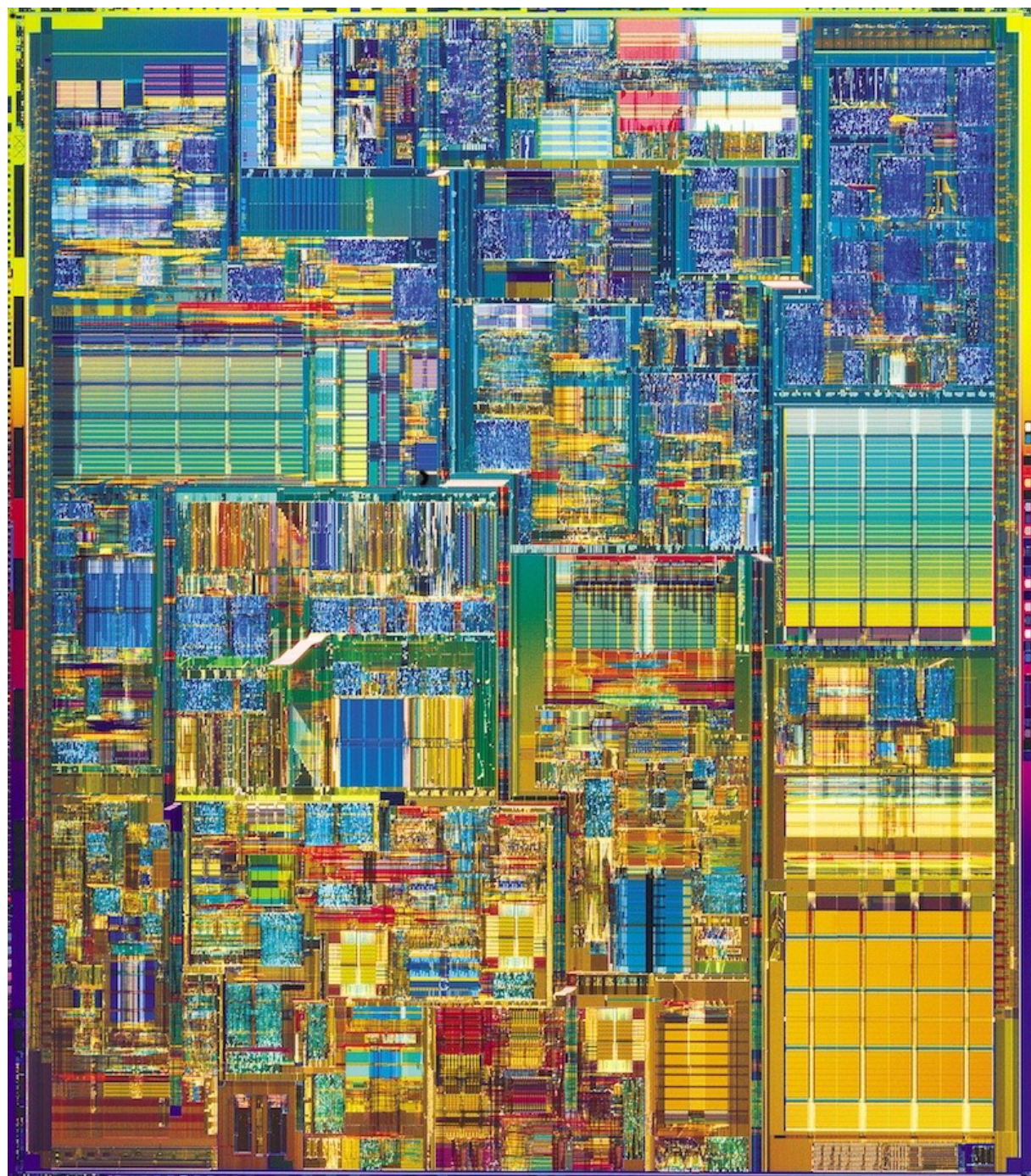
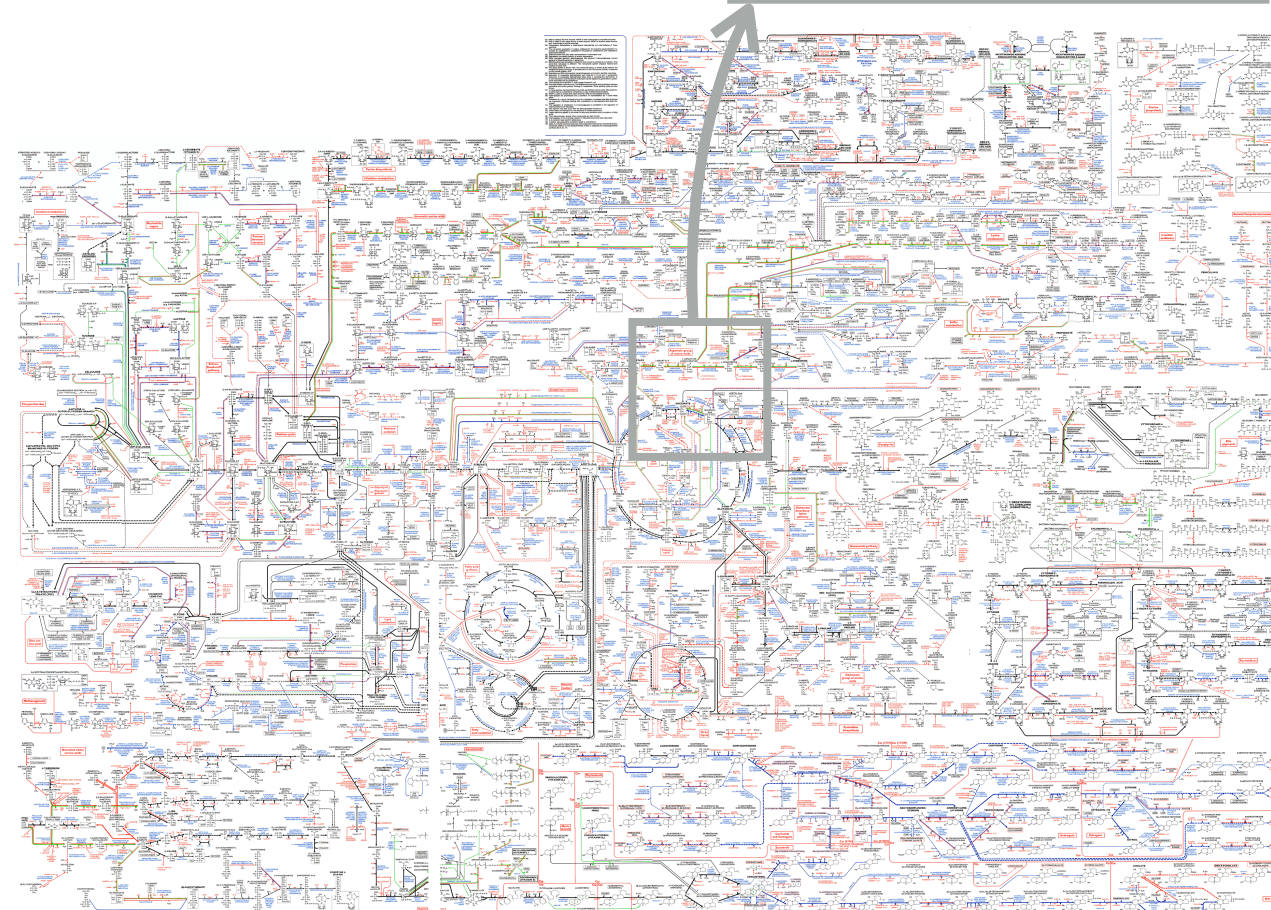
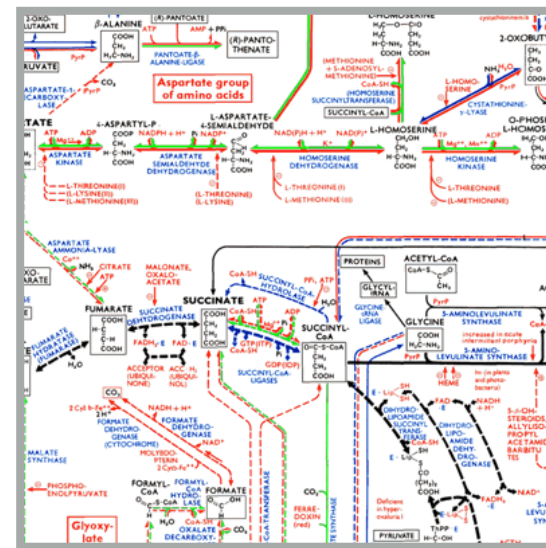
Fujibayashi et al, 2007

Genetic code behaves as a program

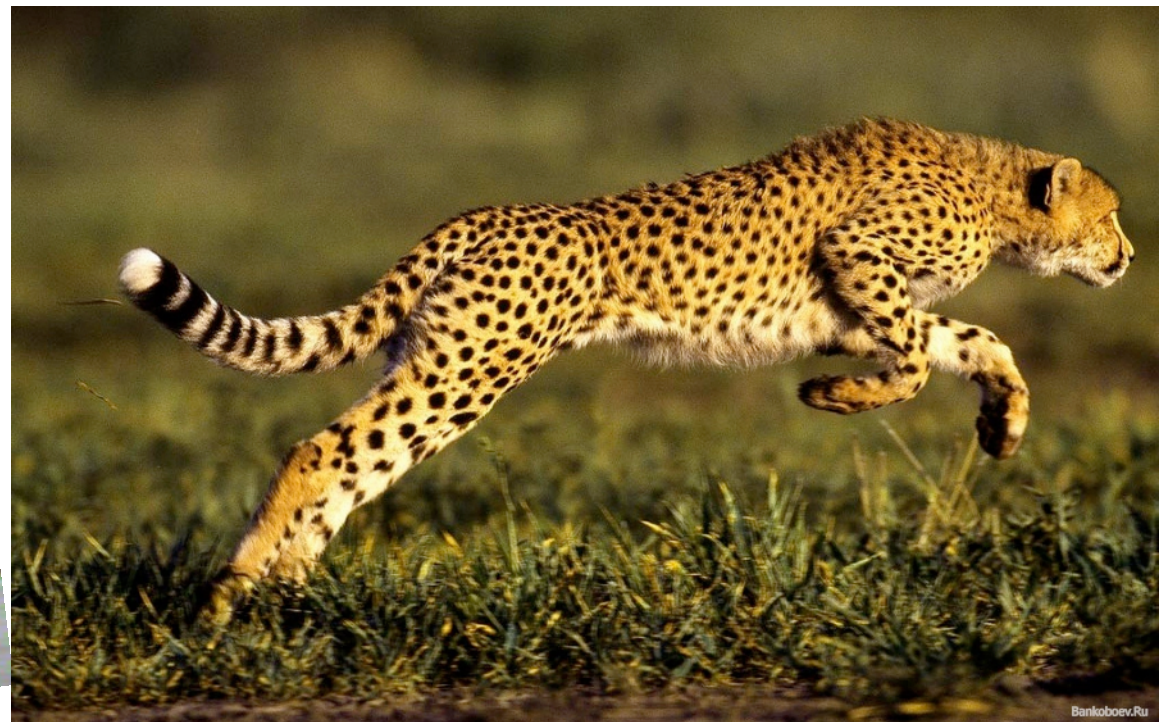


For instance, small changes in the code
imply big differences

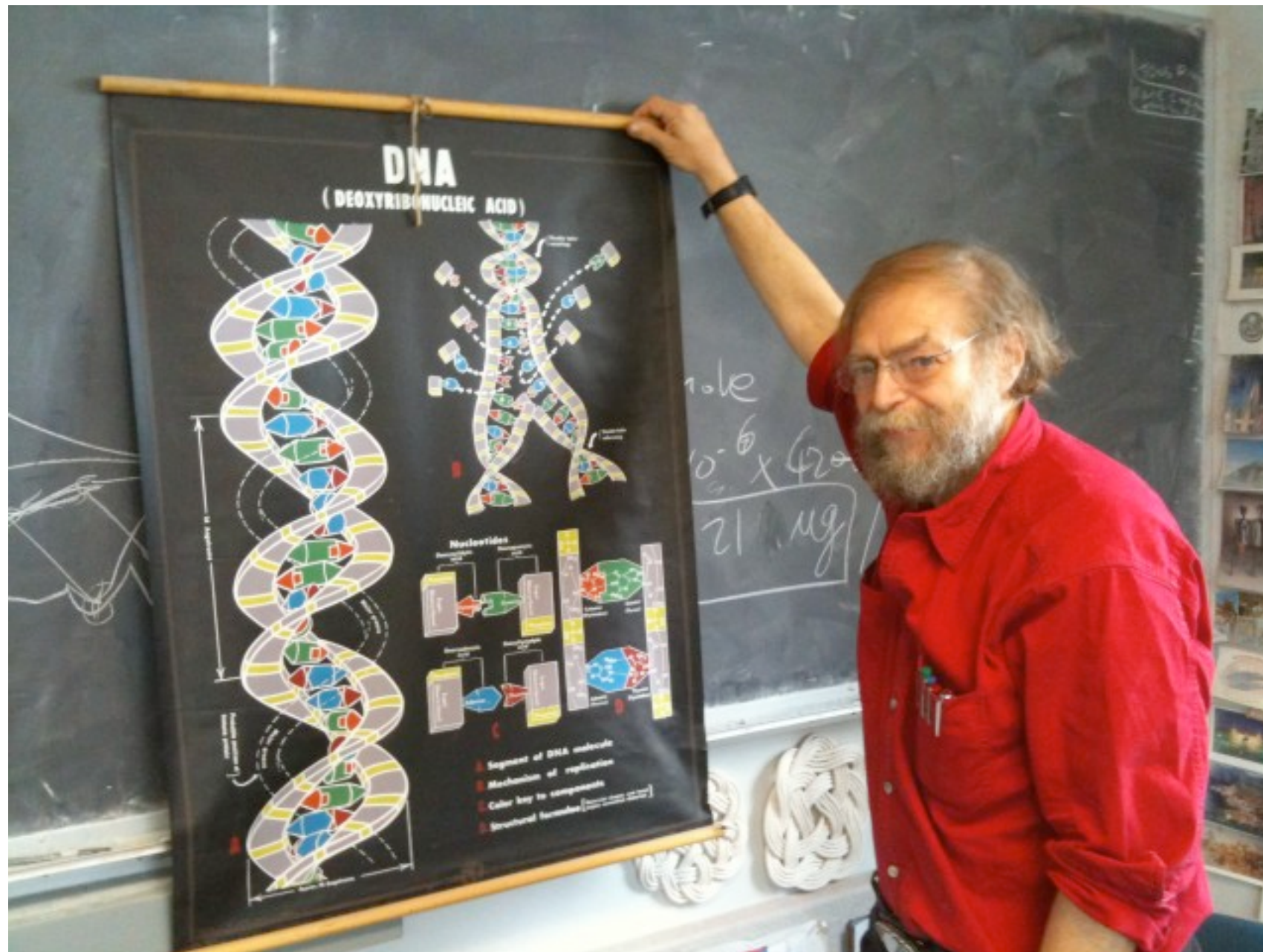
Nature is very complicated



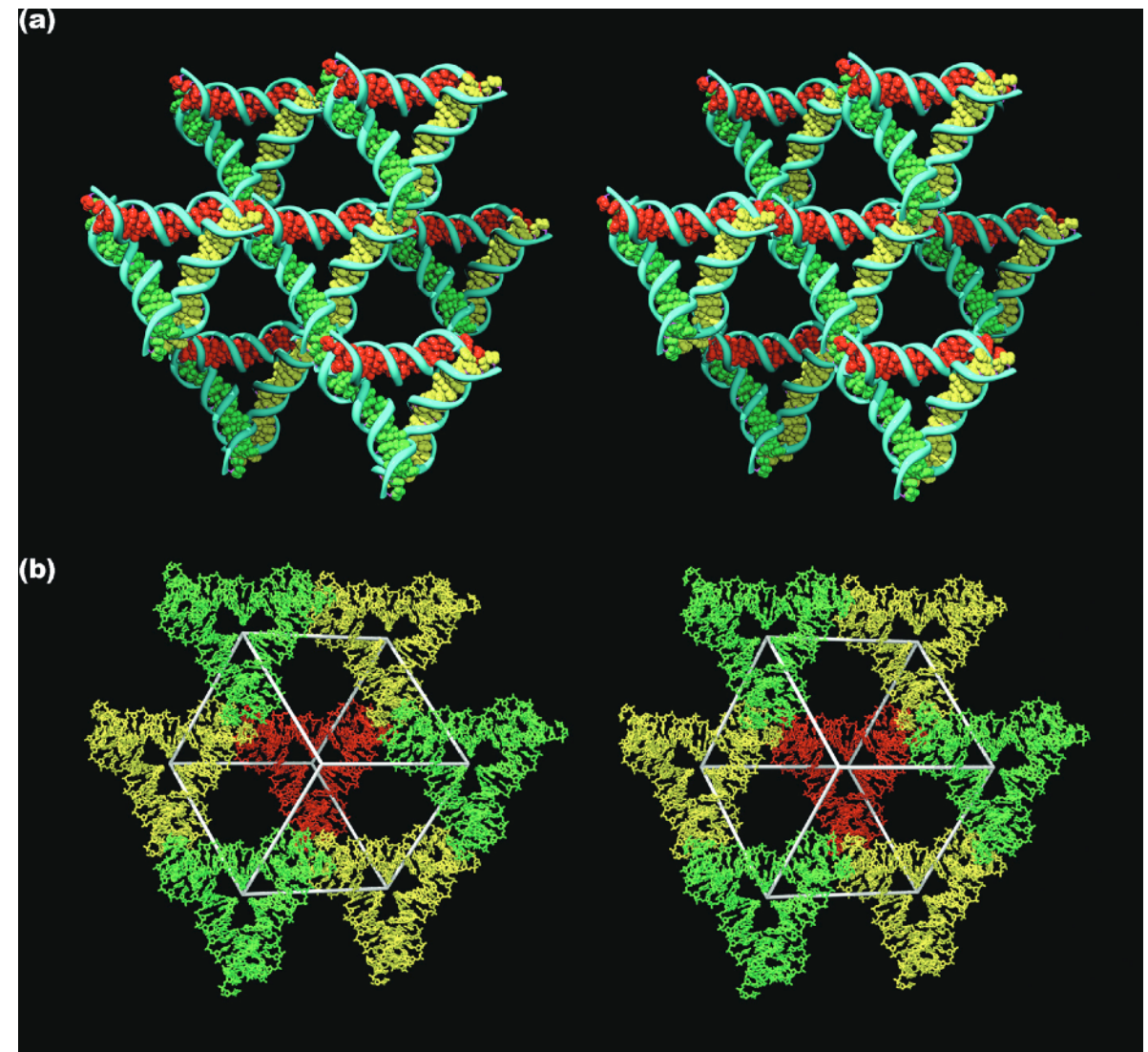
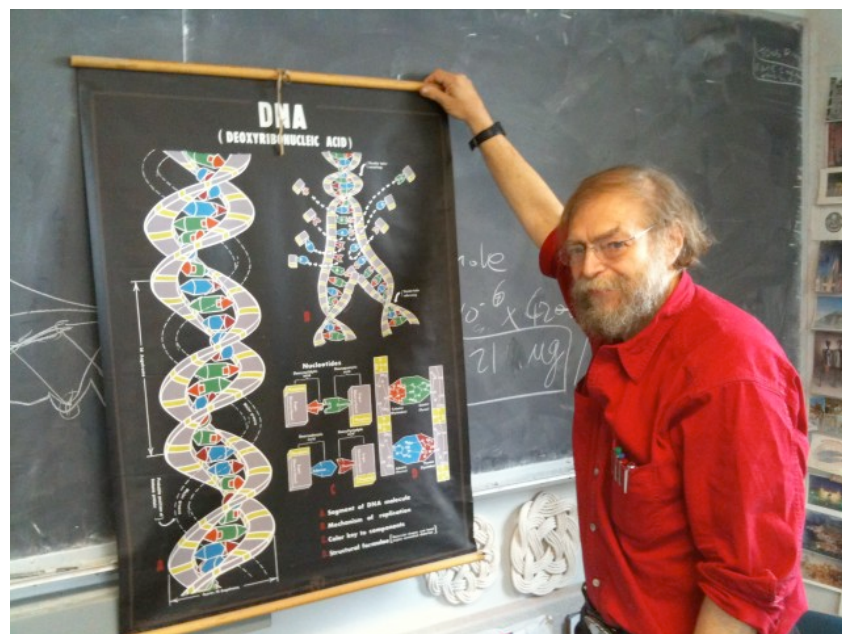
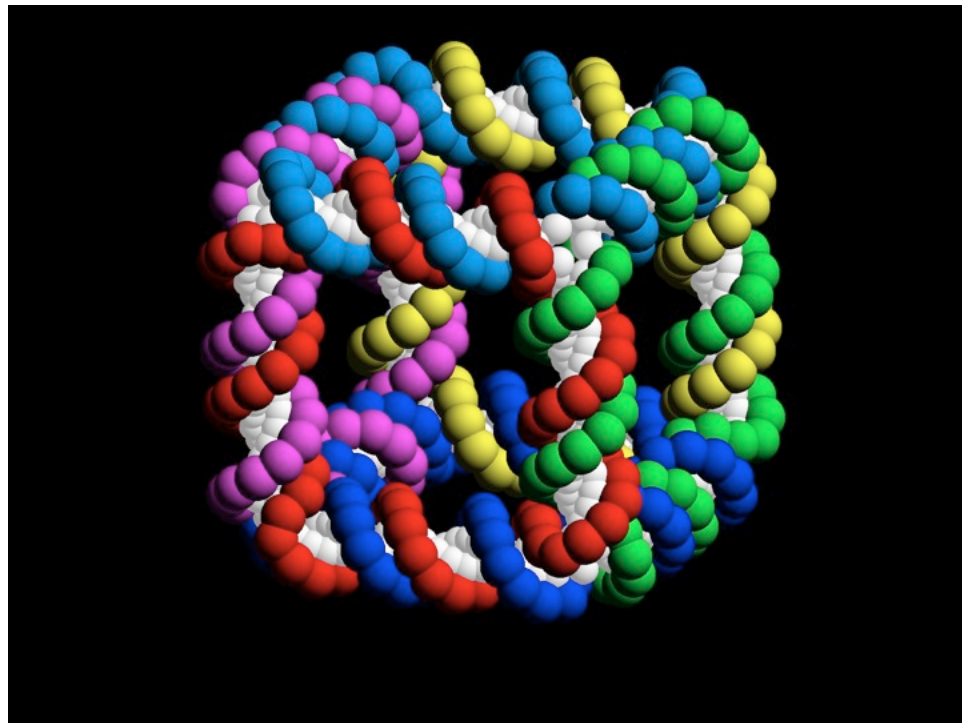
However we can try
doing differently



Using DNA to create shapes, Ned Seeman (1990-)



Using DNA to create shapes, Ned Seeman (1990-)

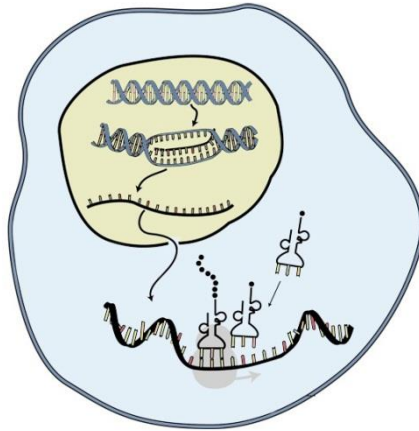


Create complementary strands
inducing particular shapes

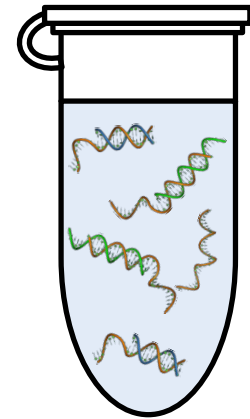
A tour of achievements

Why do we want to use nucleic acids to build structures, motors and circuits?

natural
biological
interface



easy
chemical
synthesis



combinatorial design space

S1 = ATCGAATTCCGTAGGCC

S2 = CCCGATCGTTACGTCAT

S3 = GGCATTTTGTGGAACCA

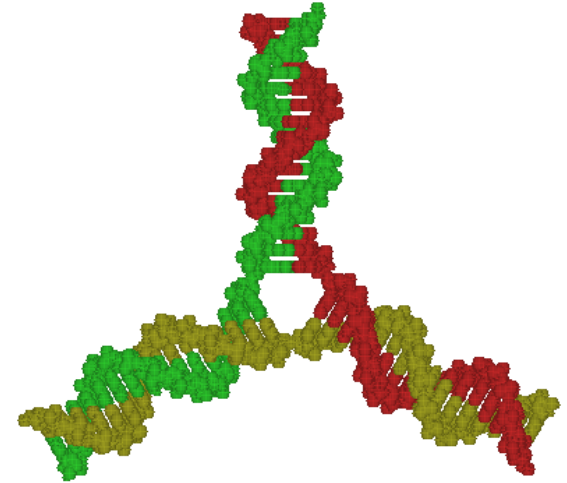
S4 = TTAGAATCCACAGTTAG

 4^n

predictable
behavior



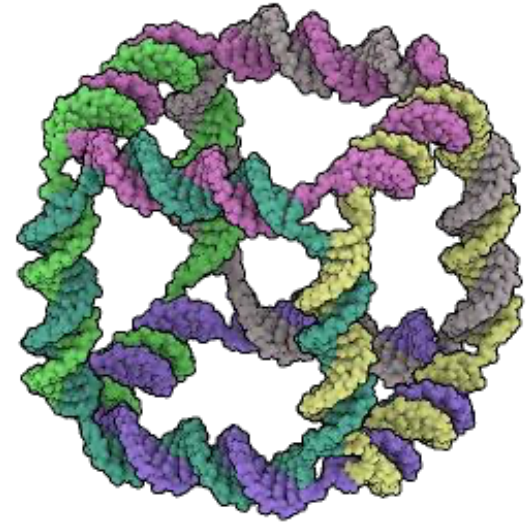
Molecular programming



Seeman, *J. Theor. Biol.* 1982

self-assembly of
nanostructures

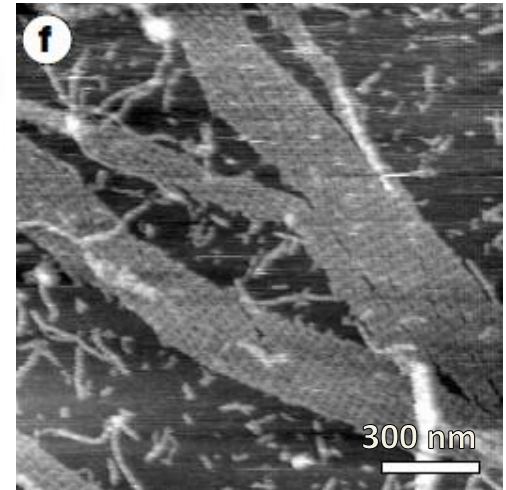
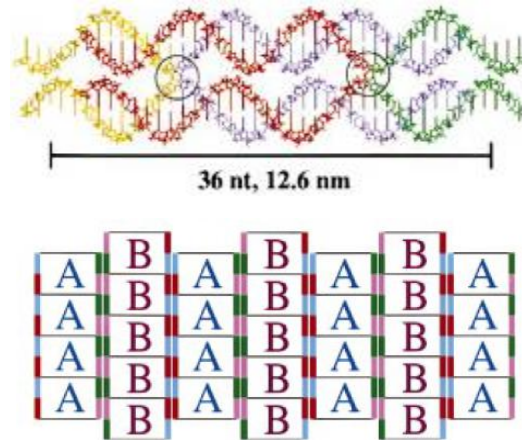
Molecular programming



Chen & Seeman, *Nature* 1991

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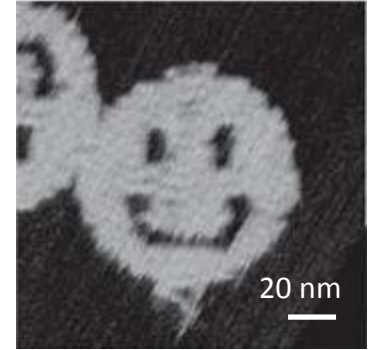
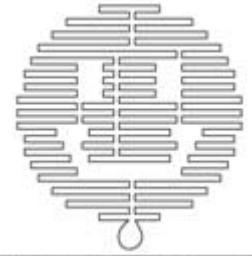
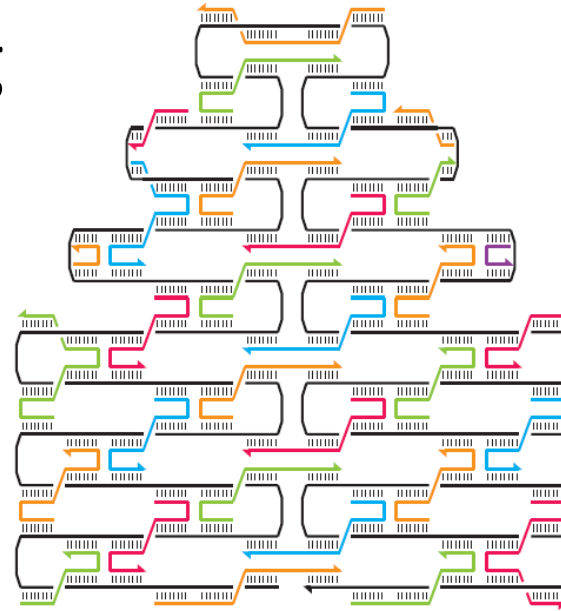
Molecular programming



Winfrey et al, *Nature* 1998

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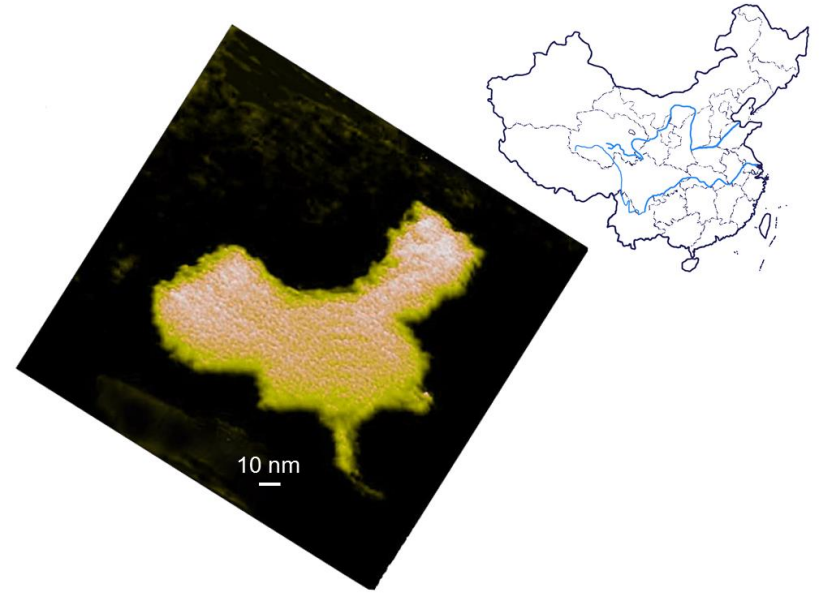
Molecular programming



Rothemund, *Nature* 2006

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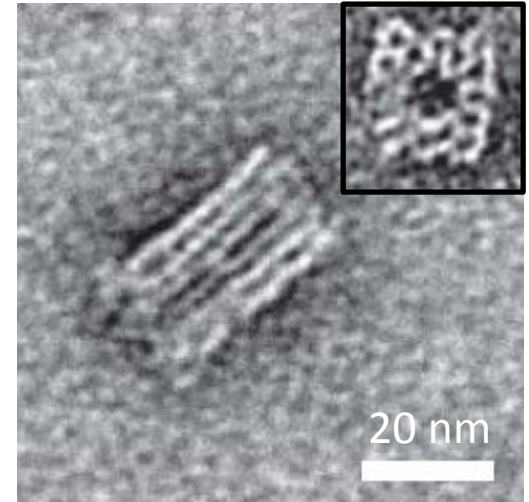
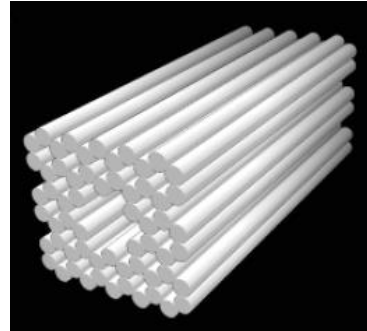
Molecular programming



Qian et al, *Chinese Sci. Bull.* 2006

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Molecular programming

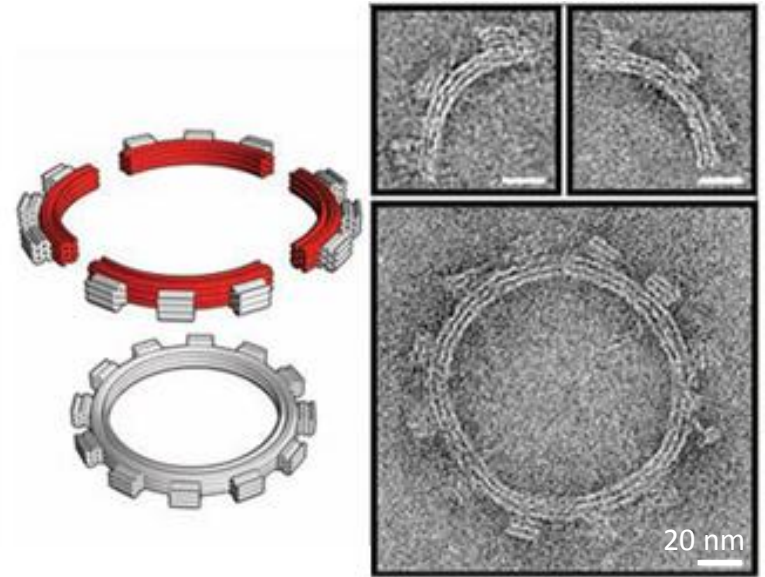


Douglas et al, *Nature* 2009

self-assembly of
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Molecular programming

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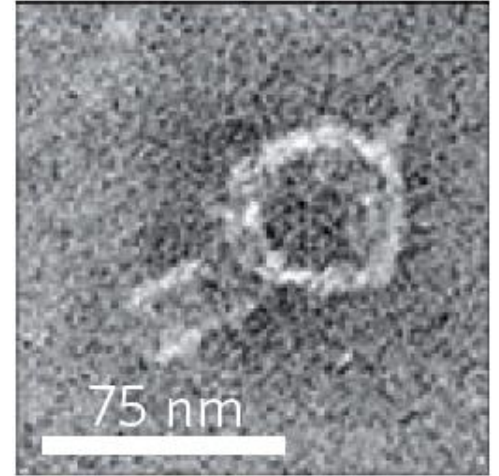


Dietz et al, *Science* 2009

Molecular programming

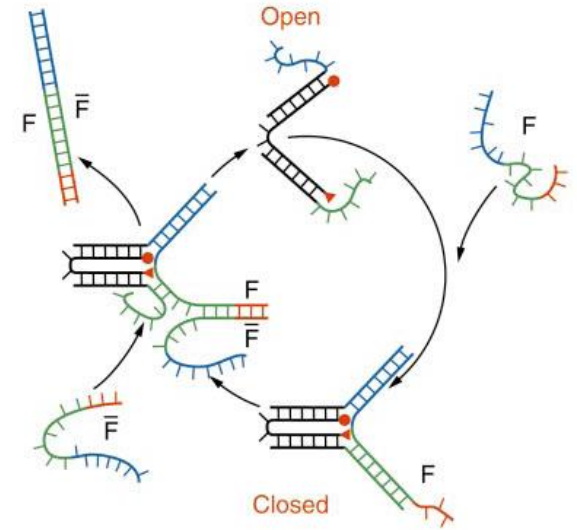


self-assembly of
nanostructures



Han et al, *Science* 2011

Molecular programming

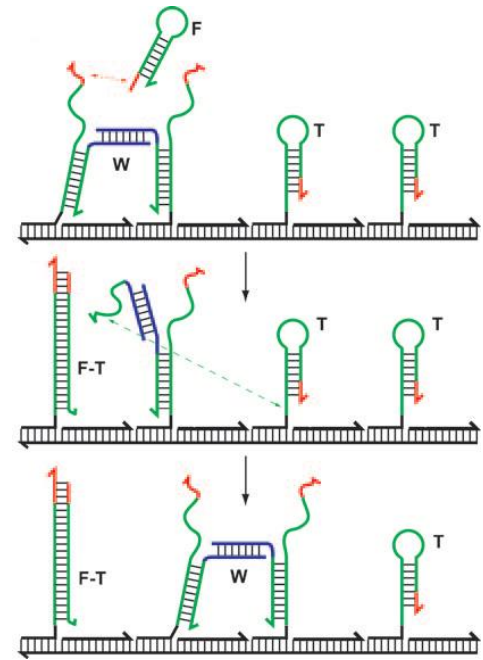


Yurke et al, *Nature* 2000

nanomechanical
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Molecular programming

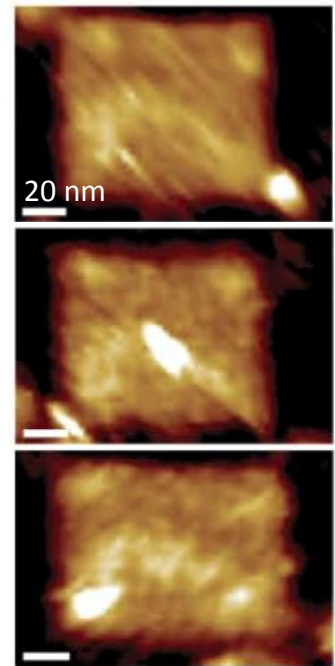
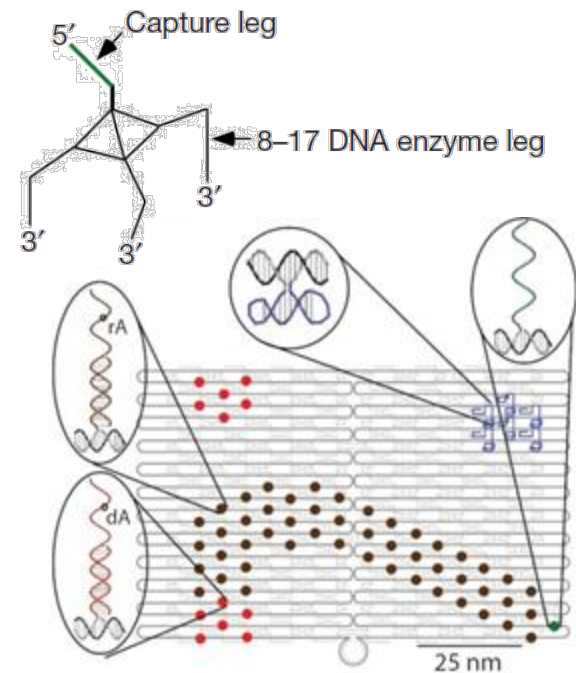


Yin et al, *Nature* 2008

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Molecular programming

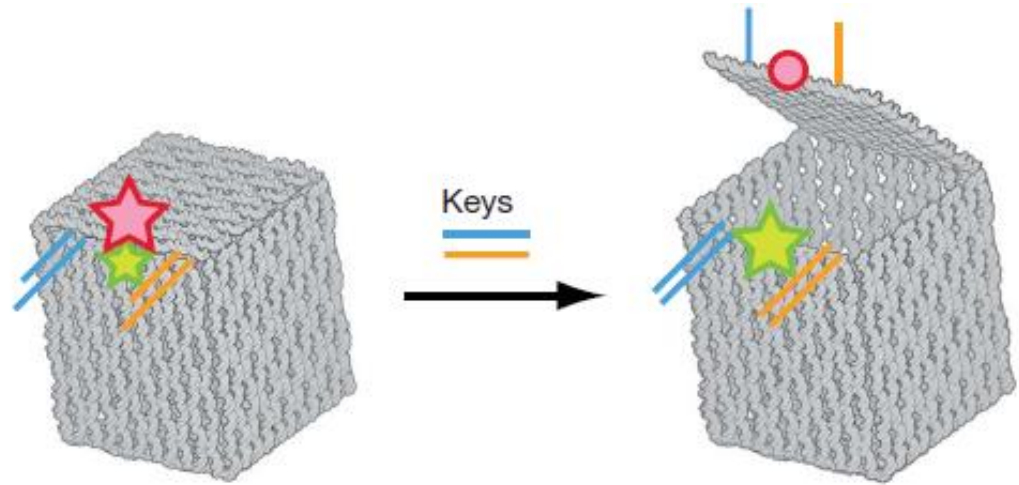


Lund et al, *Nature* 2010

nanomechanical
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Molecular programming



Andersen et al, *Nature* 2009

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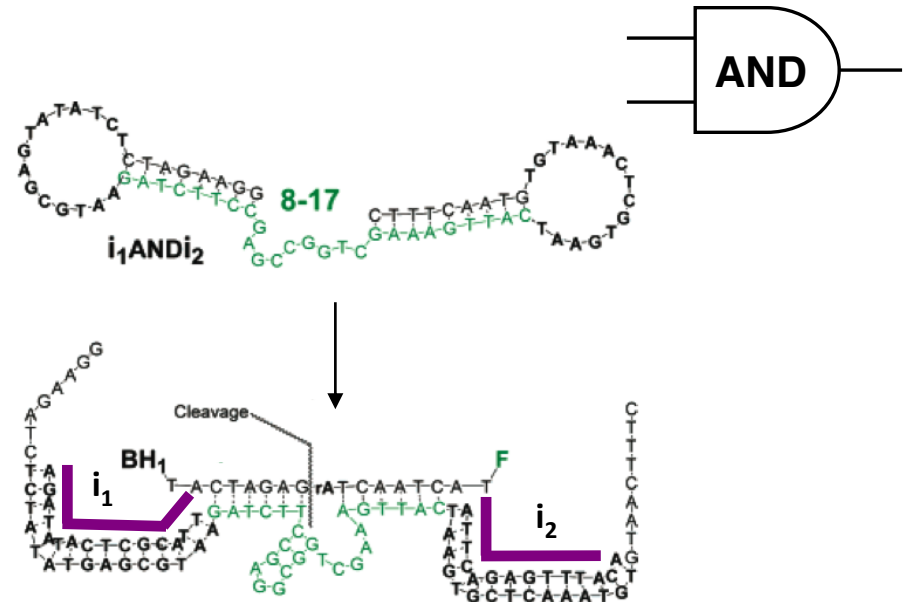
self-assembly of
nanostructures

Molecular programming

biochemical
circuits

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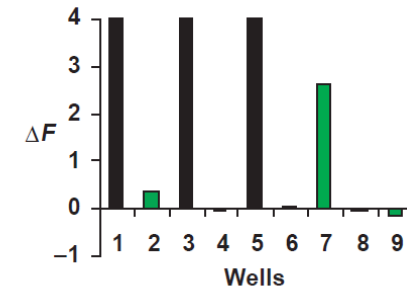
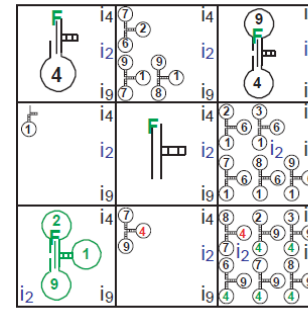
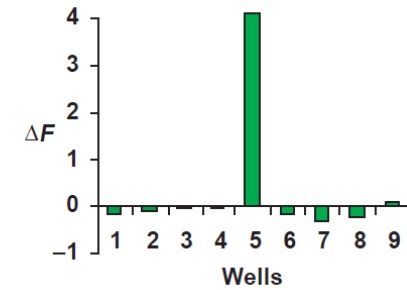
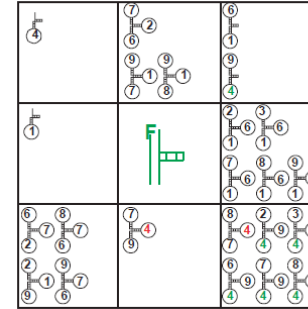
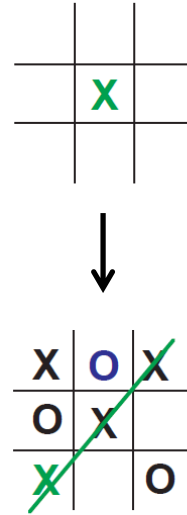
Stojanovic & Stefanovic, *JACS* 2002

Molecular programming

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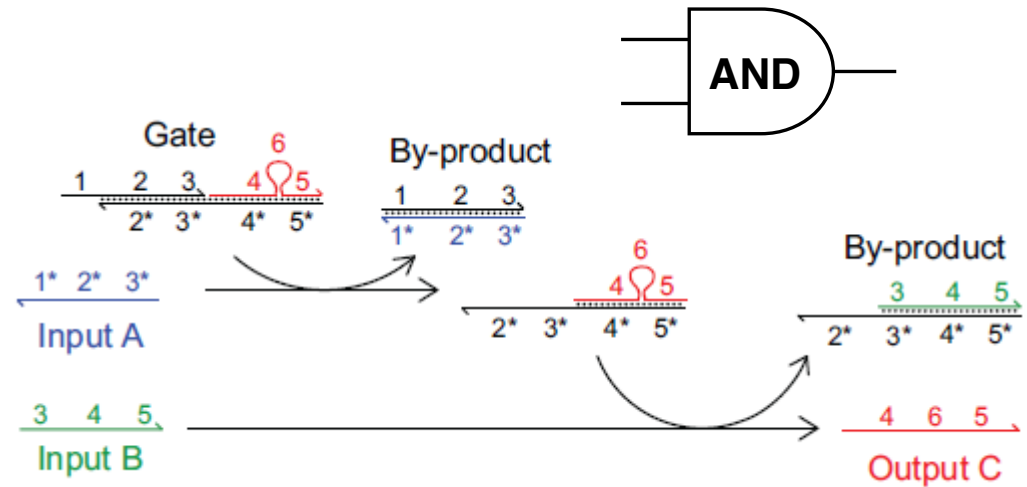
Stojanovic & Stefanovic, *Nat. Biotech.* 2003

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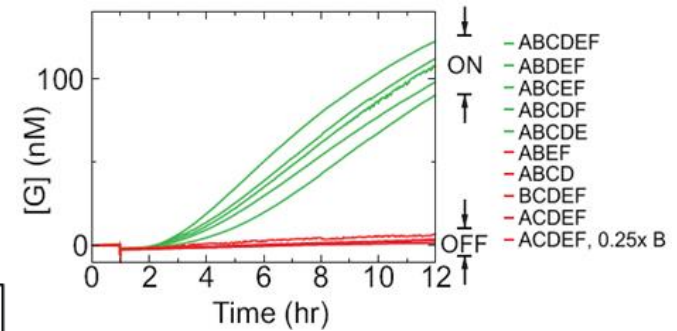
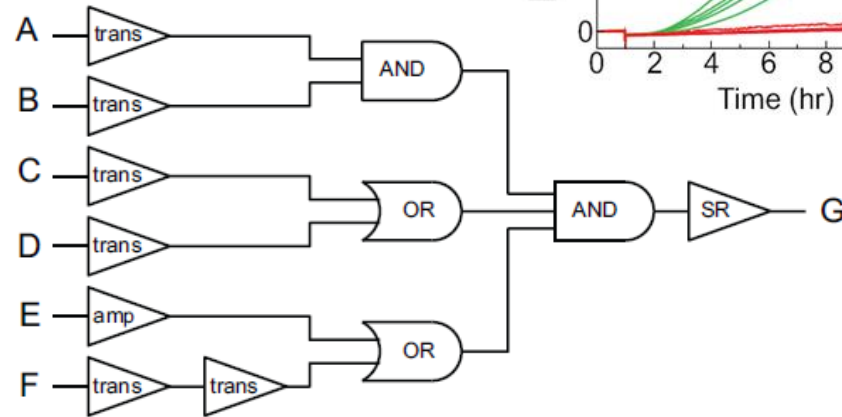
Seelig et al, *Science* 2006

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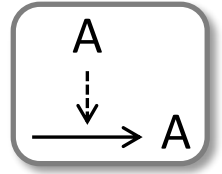
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Seelig et al, *Science* 2006

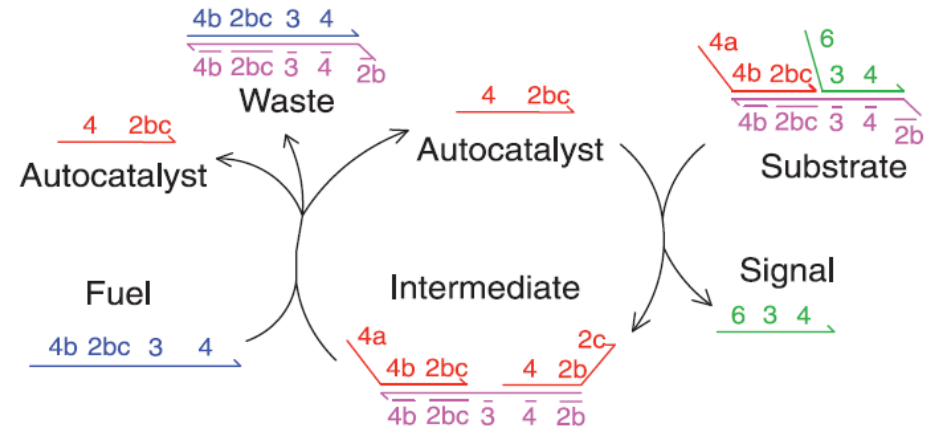
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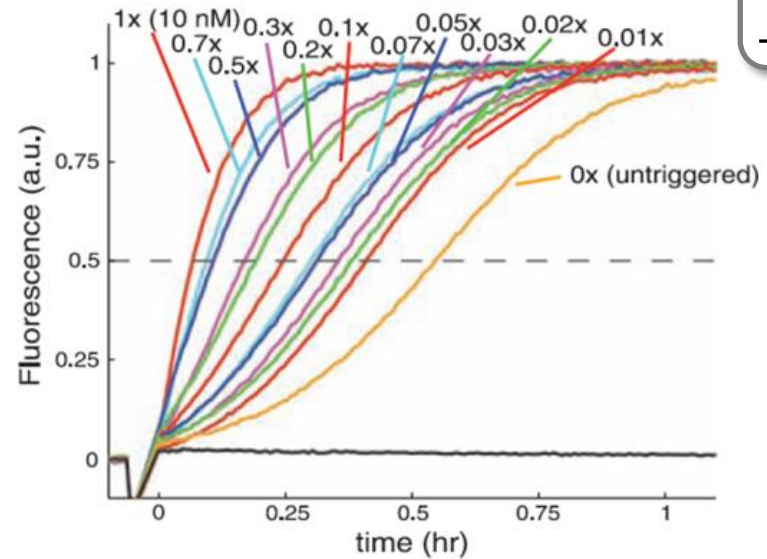
Zhang et al, *Science* 2007

Molecular programming

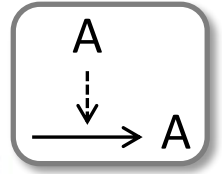
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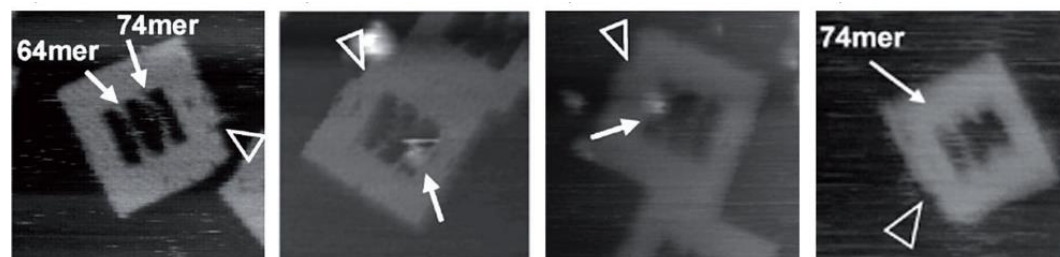
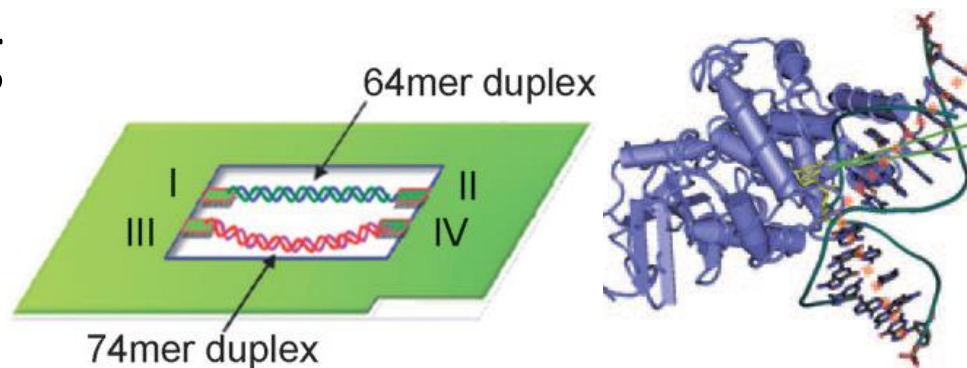


Zhang et al, *Science* 2007



Molecular programming

fundamental architectures



Endo et al, *JACS* 2010

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Molecular programming

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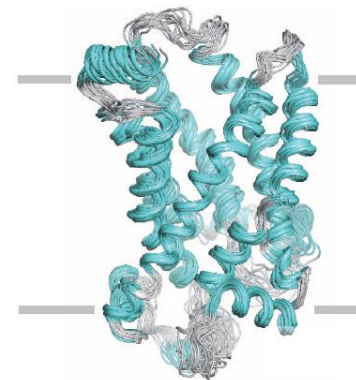
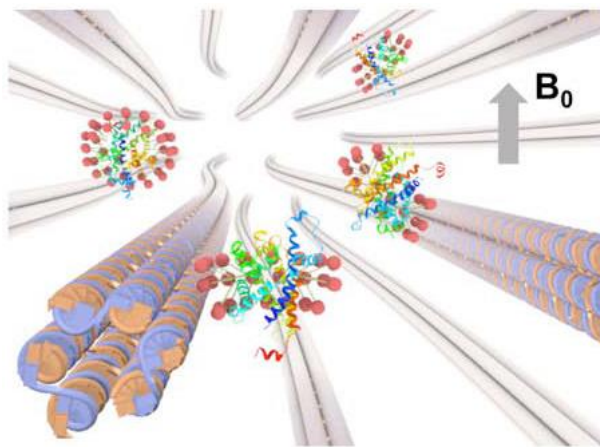
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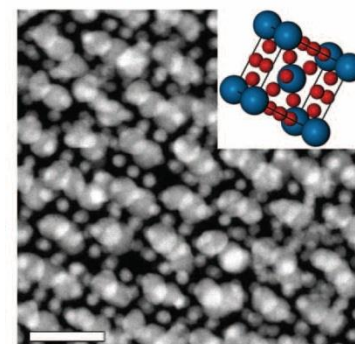
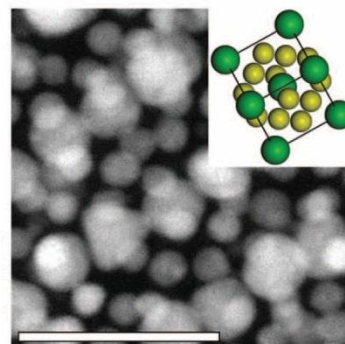
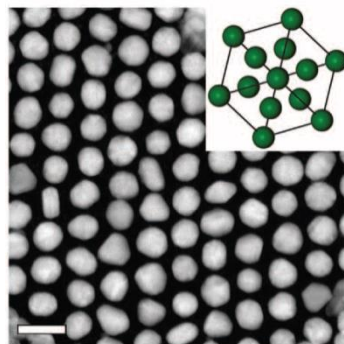
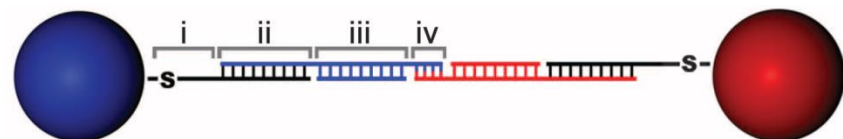


Berardi et al, *Nature* 2011

real-world applications

Molecular programming

fundamental architectures



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Macfarlane et al, *Science* 2011

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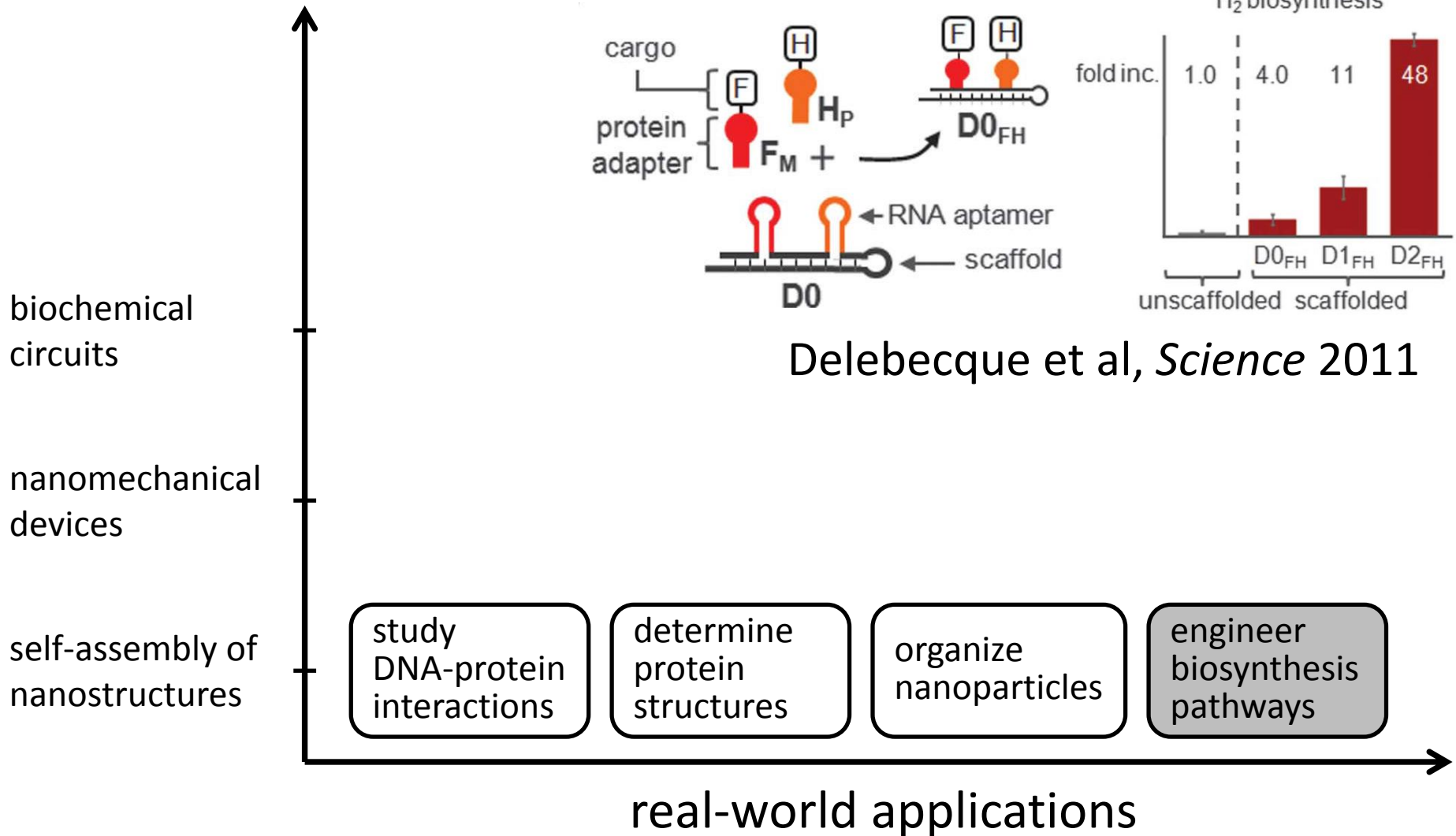
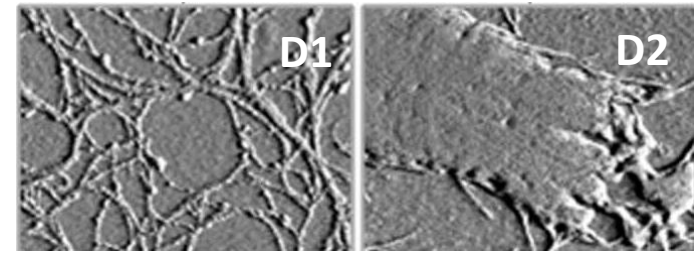
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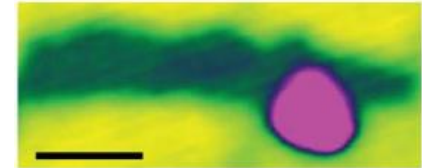
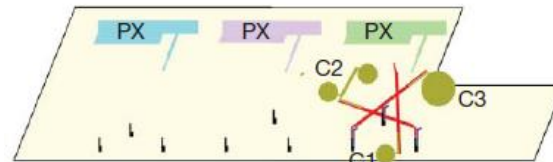
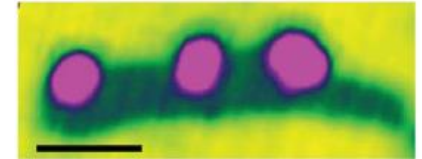
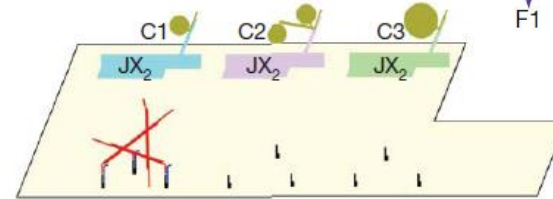
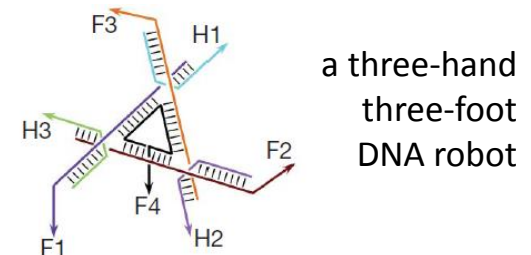
Molecular programming

fundamental architectures



Molecular programming

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Gu et al, *Nature* 2010

biochemical
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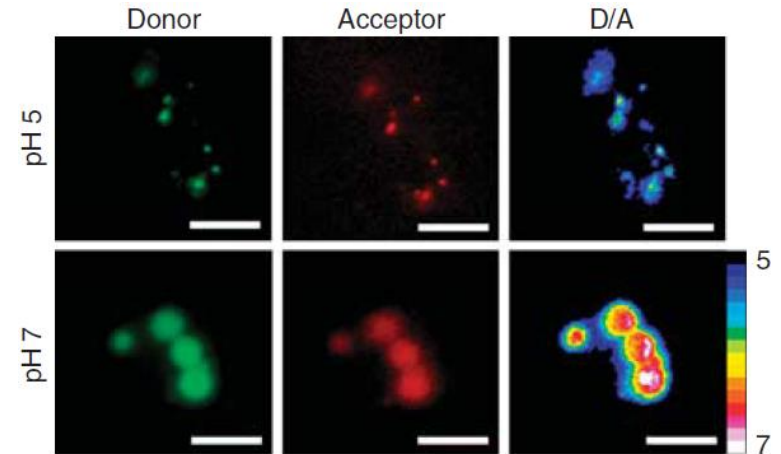
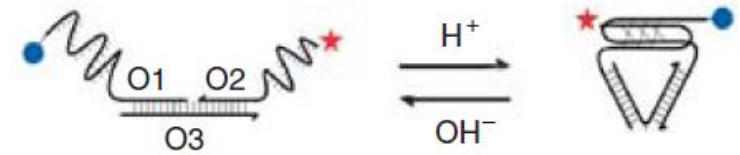
organize
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Molecular programming

fundamental architectures



Surana et al, *Nat. Commun.* 2011

biochemical
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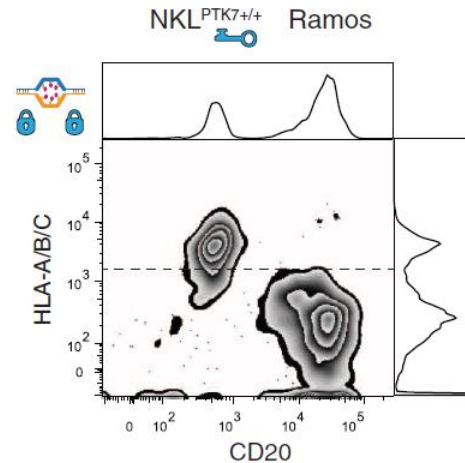
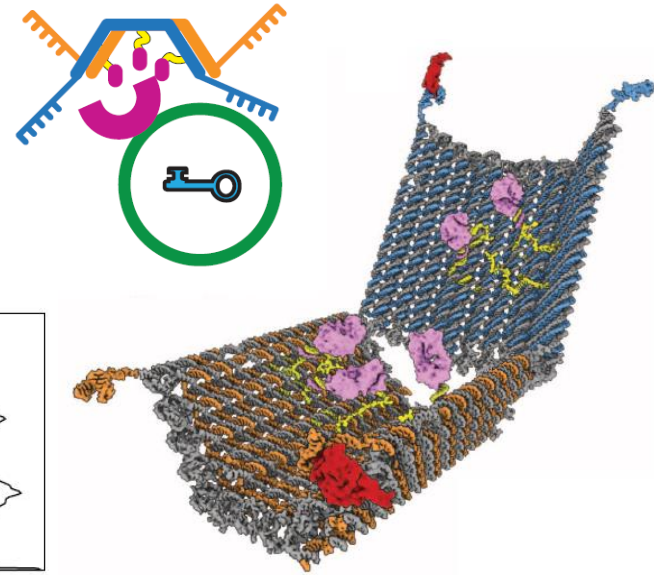
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Molecular programming

fundamental architectures



Douglas et al, *Science* 2012

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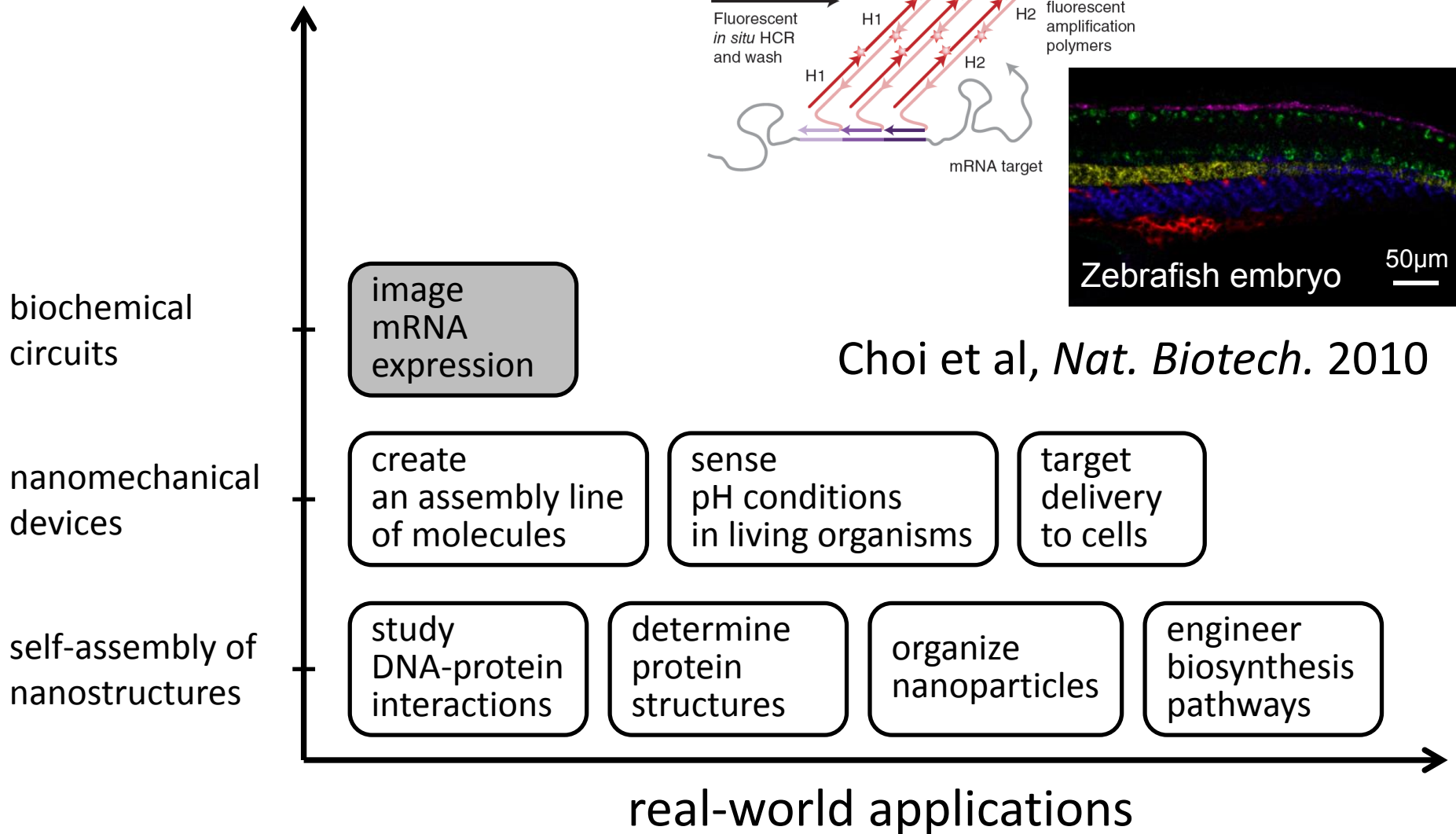
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real-world applications

Molecular programming

fundamental architectures



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image
mRNA
expression

identify
cancer
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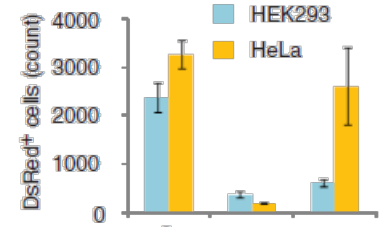
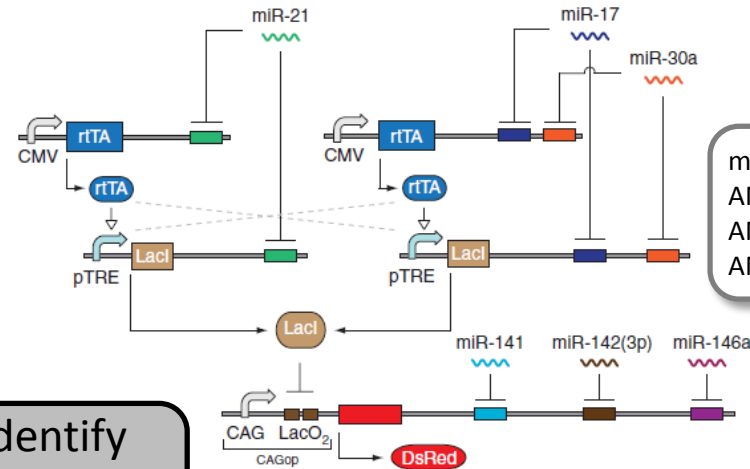
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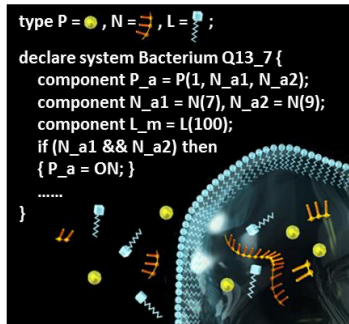


miR-21 AND miR-17-30a
AND NOT (miR-141)
AND NOT (miR-142(3p))
AND NOT (miR-146a)

Xie et al, *Science* 2011

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