Introduction: Experiments

Computational DNA nanotechnology

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Context

Unconventional computation

Explore unconventional computation.

Substrate : DNA.

Main goals:

1. Better understand the underlying processes.
2. Design nanoscale structures.
   - for biophysics, medicine, etc.

Current status

- Familiarized with the basic experimental protocol.
- Negotiated a lab bench.
- Negotiating AFM access : *in progress*.

Coming up next: Run our first experiment in Évry.

DNA computing

Unconventional computing

1. Compute with processes different from those which underlie conventional computers.
2. Get an unusual take on the real-world processes.

Adleman experiment

Hamiltonian path = a path going through all n vertices of a graph exactly once.

1. Generate DNA strands representing random paths.
2. Keep the strands representing paths containing exactly n vertices.
3. Keep the strands representing paths visiting every single vertex.

Adleman, L. M. (1994). Molecular computation of solutions to combinatorial problems. Science. 266 (5187): 1021–1024. *available on eCampus*

DNA self-assembly

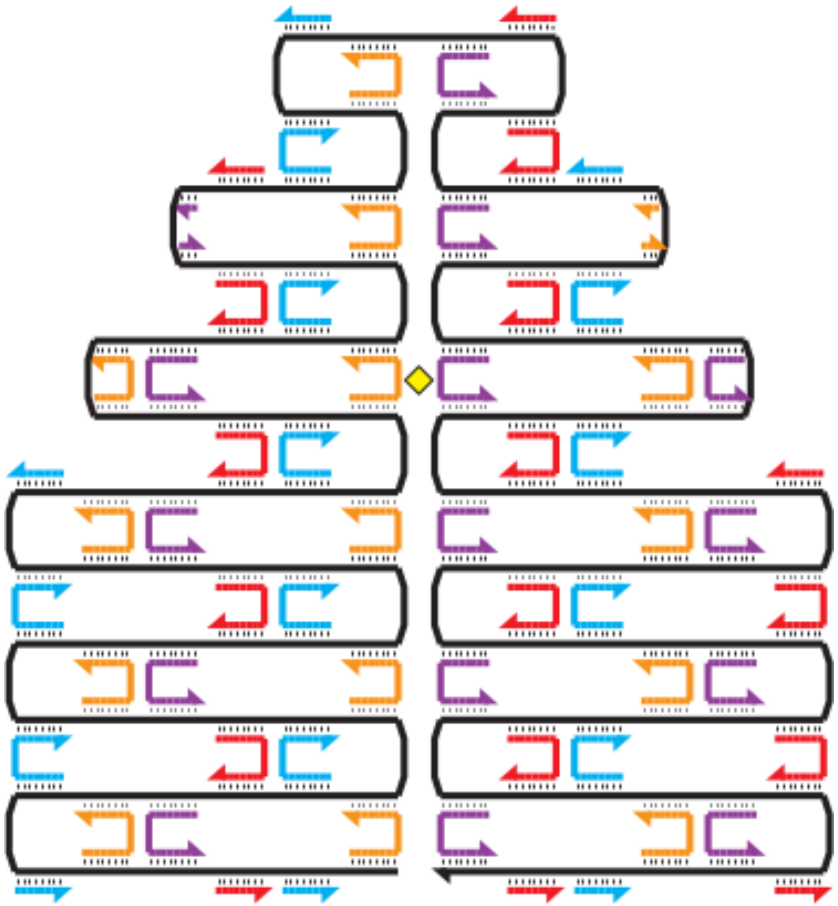
Build nanoscale structures of DNA by abusing Watson-Crick complementarity.

Generally shorter 40–60bp sequences are easier/cheaper to synthesize.

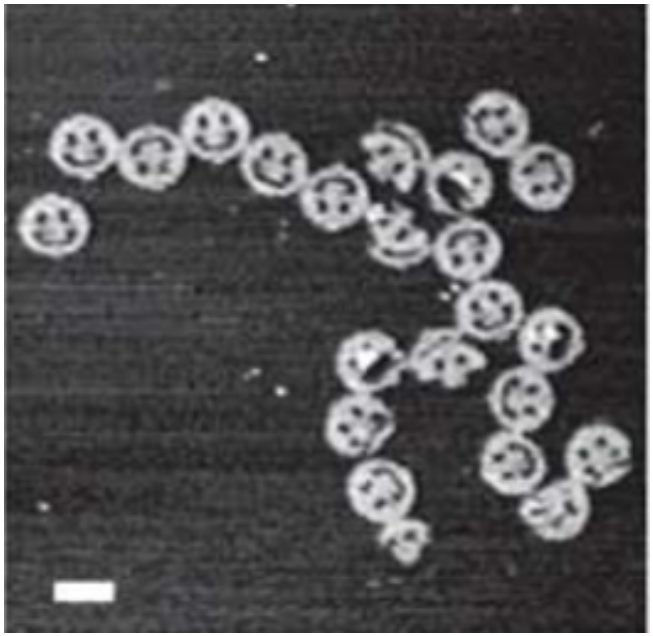
DNA origami

1. Take a long DNA sequence, e.g. a phage,
   - scaffold
2. Apply shorter synthetic sequences.
   - staples
3. Scaffold is bent into shape by the staples.

DNA origami experiments



$\Rightarrow$



Rothemund P.W. Folding DNA to create nanoscale shapes and patterns. Nature. 2006 Mar 16;440(7082):297-302.

Not biology yet

Forget about most of the DNA-related biological processes.

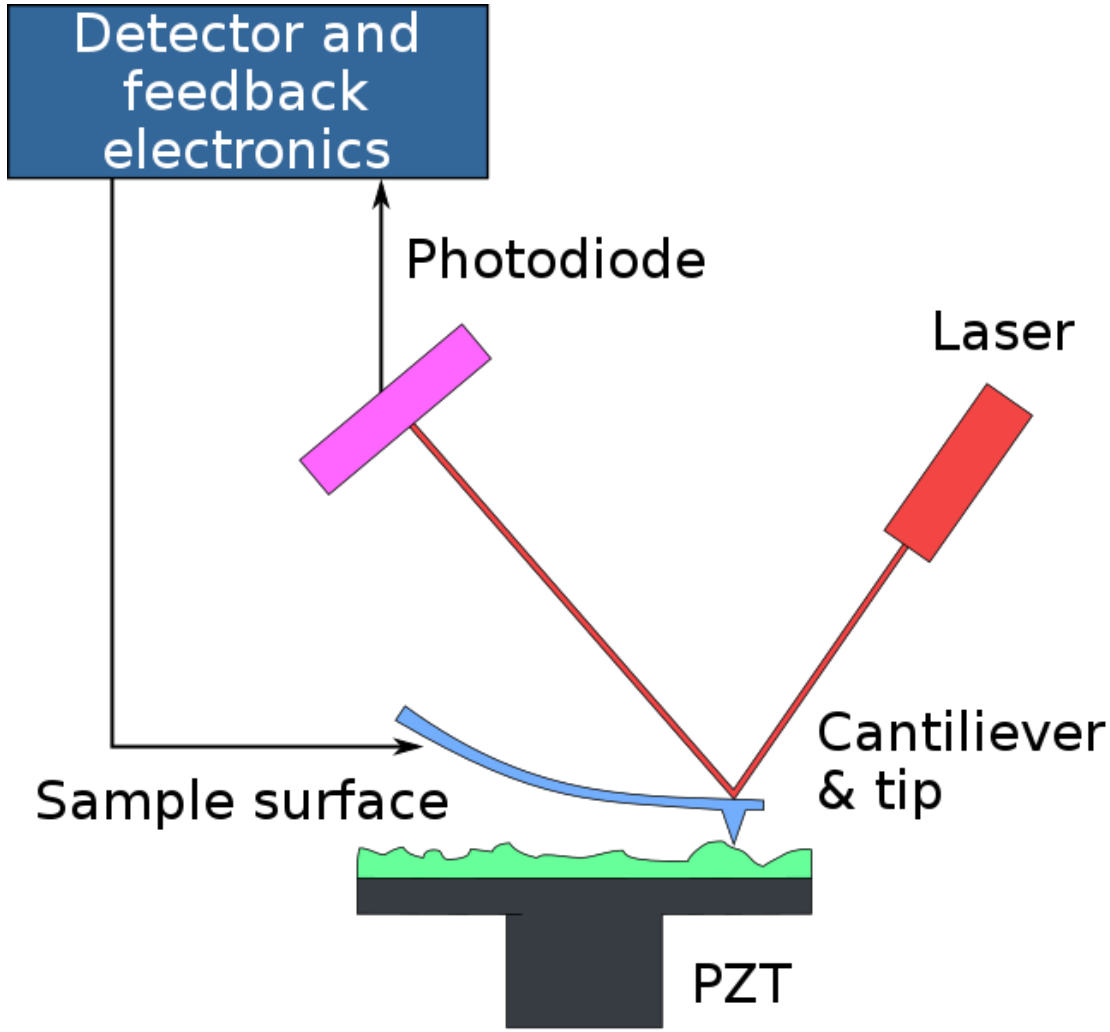
- no ribosomes
- no proteins
- no RNA
- ...

Experimental protocol

Overview

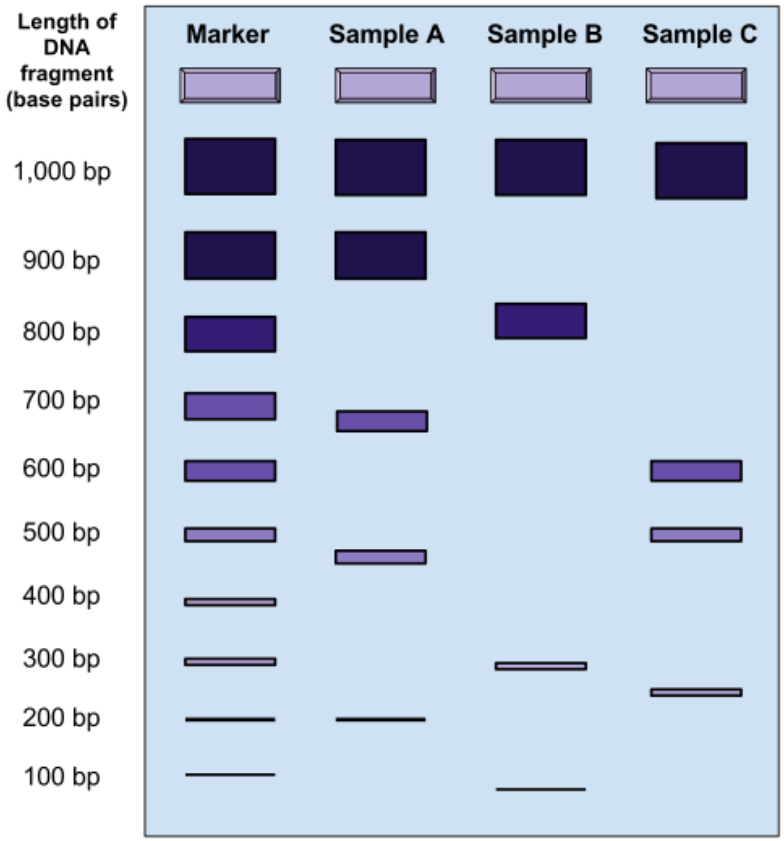
1. Grab a scaffold.
2. Design the staples.
   - hard
3. Order the staples.
   - expensive
4. Mix everything.
5. Heat to ~95° C.
6. Cool down.
   - Anneal: first to 48℃, then slowly to 45℃, then to room temperature.
7. Imaging / gel electrophoresis / etc.

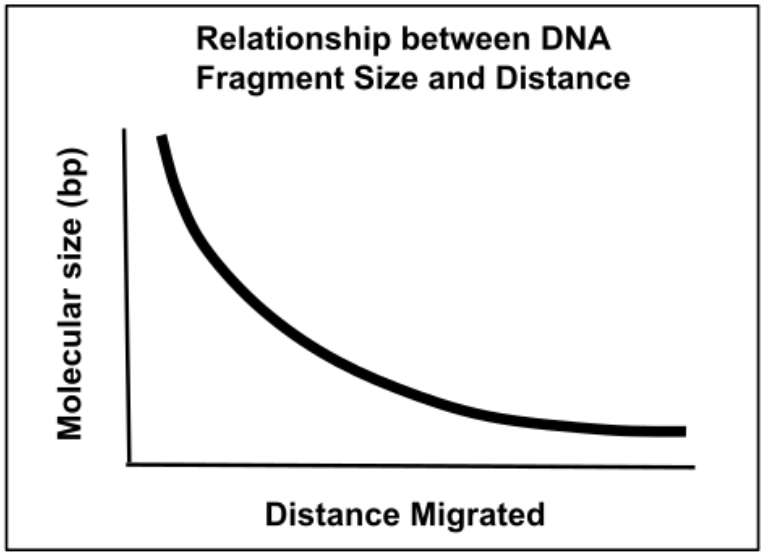
Atomic Force Microscopy



https://en.wikipedia.org/wiki/Atomic_force_microscopy

Gel electrophoresis





https://en.wikipedia.org/wiki/Gel_electrophoresis

Perspectives

Perspectives

- DNA breadboards
- Biosensors
- Molecular computers
- Intelligent biomachines duh

Not biology?

DNA self-assembly can be used in non-biological contexts.

The DNA substrate makes it look promising for biomedical applications.

To make those work, we need biology ♥