Biologic Computing

It can come standard with viruses. Literally.

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Overview

- What is Biological Computing?
- History
- Biological Computing vs Traditional Computing
- Brain based biocomputing
- Noise
- Transcriptors and Boolean Integrase Logic (BIL) gates
- Animal Brains
- Storing Data / Folding
- Current Work
- Future

What is Biological Computing?

- Living organisms performing computations
- Different from computational biology
- Encompasses DNA computing
- Involves storing, retrieving, and processing of data.

History

1958 - Heinz von Foerster, abandoned von Neumann architecture for a decentralized network of interconnect simple components

1994 - Beginning of DNA computing

1997 - Researchers at University of Rochester develop logic gates made of DNA

2002 - Weizmann Institute unveil programmable DNA molecule computer

2013 - Researchers store jpeg and mp3 in biological storage.

2013 - Transcriptors were invented

Biological Computing vs Traditional Computing

Biological Computing	Traditional Computing
Information is represented using genes A (adenine), G (guanine), C (cytosine), and T (thymine)	Information is represented as a collection of bits (0s and 1s).
Information processing is massively parallel, inexact, and ongoing. Information is also continually changing, decentralized, and fundamentally noisy.	Information is processed via logical operations (single type, fixed, centralized, and typically noise-free).

What is Cellular Noise?

Cellular noise - is a generic term designating random fluctuations in the rates of biochemical reactions, which can cause non-deterministic heterogeneity among genetically identical cells. Such fluctuations can either be detrimental to the accuracy of biological function or favourable to the sensitivity or adaptability of biological processes.

Genetic Identical cells will have varying numbers of proteins, and have different shapes and size.

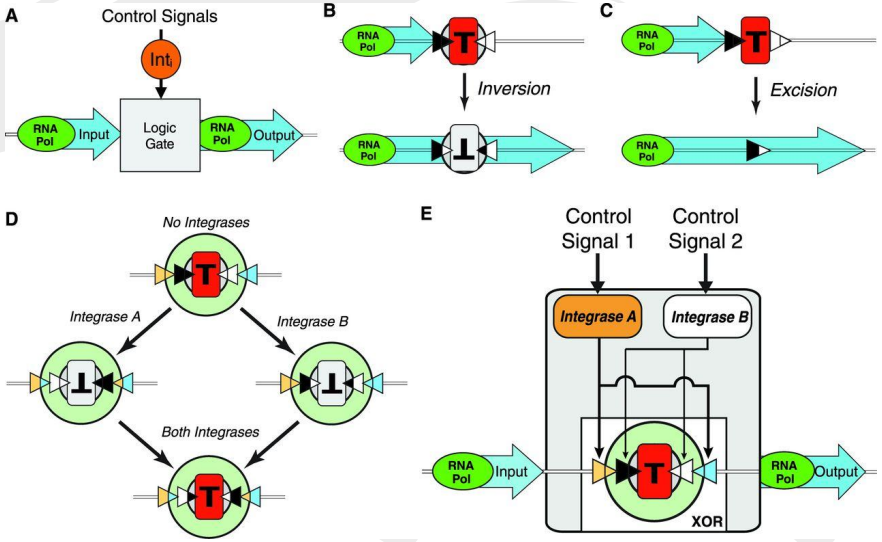
Noise vs No Noise

Noise Interferes with the current clock designed for biological computers making things very difficult to time. Having varying cells also affects precision.

Noise causes variance between cells which drastically increases their survivability and adaptability.

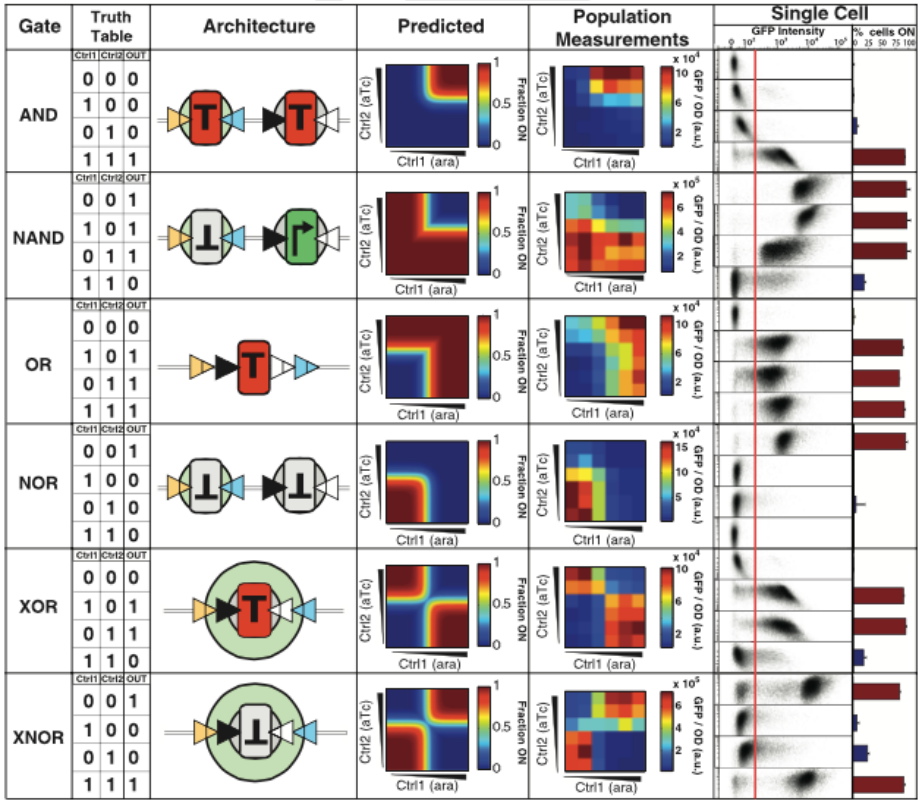
Transcriptors and Boolean Integrase (BIL) gates

- A transcriptor controls the flow of RNA polymerase molecules along a strand of DNA.
- Previous versions regulated messenger RNA levels. They were difficult to scale because of problems associated with reusing regulator molecules with the self-mixing environments of individual cells. .
- Current version changes the state of double stranded DNA.



BIL Gates

$65 a gate



Brain based Biocomputers

Ideally would link signals produced from brains to create a non-centralised cloud computing.

Two rats have been linked from North America to South America(encoder-decoder). Achieved successful Transmission 70% of the time.

Encoding Methods for Data in DNA

- Genetic Code
- Church’s Method
- Goldmans Method

Genetic Code

Originated in 1967

Uses 20 Amino Acids to represent letters.

Does not support letters and all lowercase.

Church's Method

Developed 2012

Used G-T = 1 A-C = 0

Had problem of repetitive G's

Achieved 5.5 petabits per mm

Sequential Access

Goldmans Method

Current Method (Developed 2013)

Converts ascii to ternary.

Used huffman tree to reduce ternary to GATC

No repetition, please

A DNA coding scheme

Previous base written	Digit to be encoded		
	0	*1*	*2*
A	C	G	T
C	G	T	A
G	T	A	C
T	A	C	G

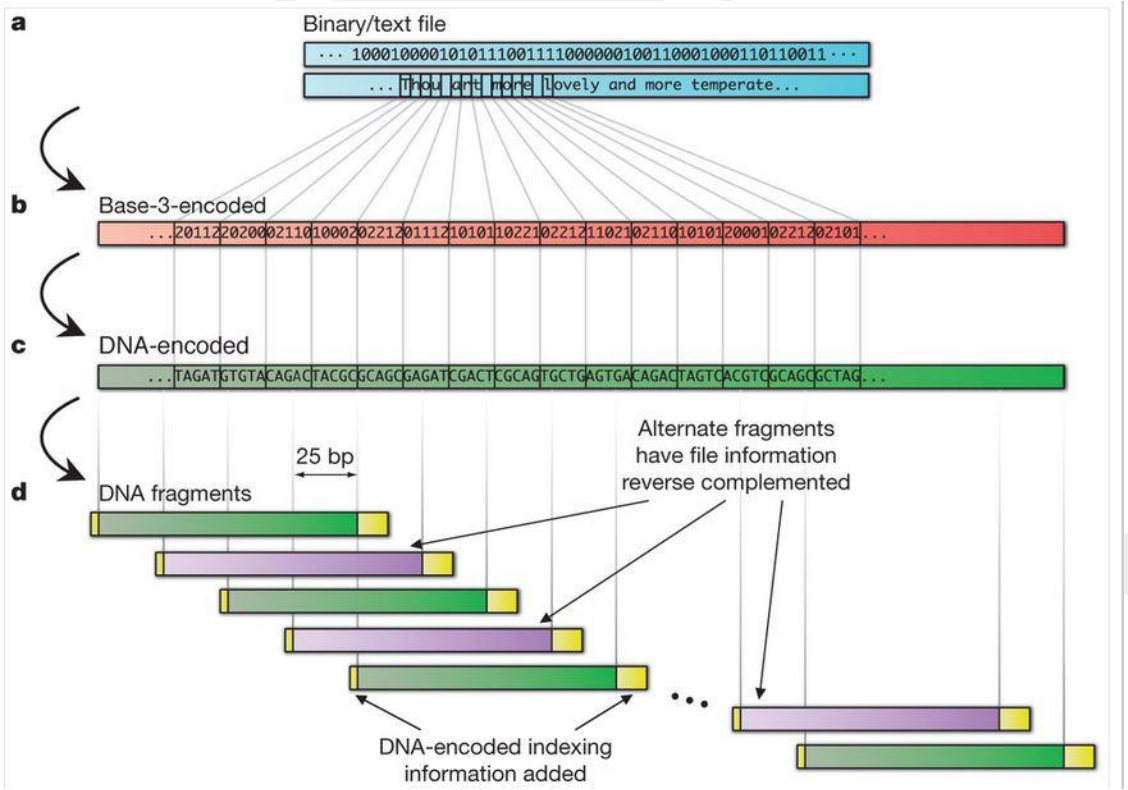
Source: Nick Goldman *et al*, *Nature*

Goldmans Method

Like Page Table

5 redundant copies:
1 original
2 forward
2 backwards

Achieved 90 petabytes
per 41 grams in test.



Examples

Universal Genetic Code

start	H	E	L	L	Q	W	Q	R	L	D	stop	
ATG	CAC	GAG	UUG	UUG	CAG	UGG	CAG	CGA	CUA	GAC	TGA	36 genetic characters

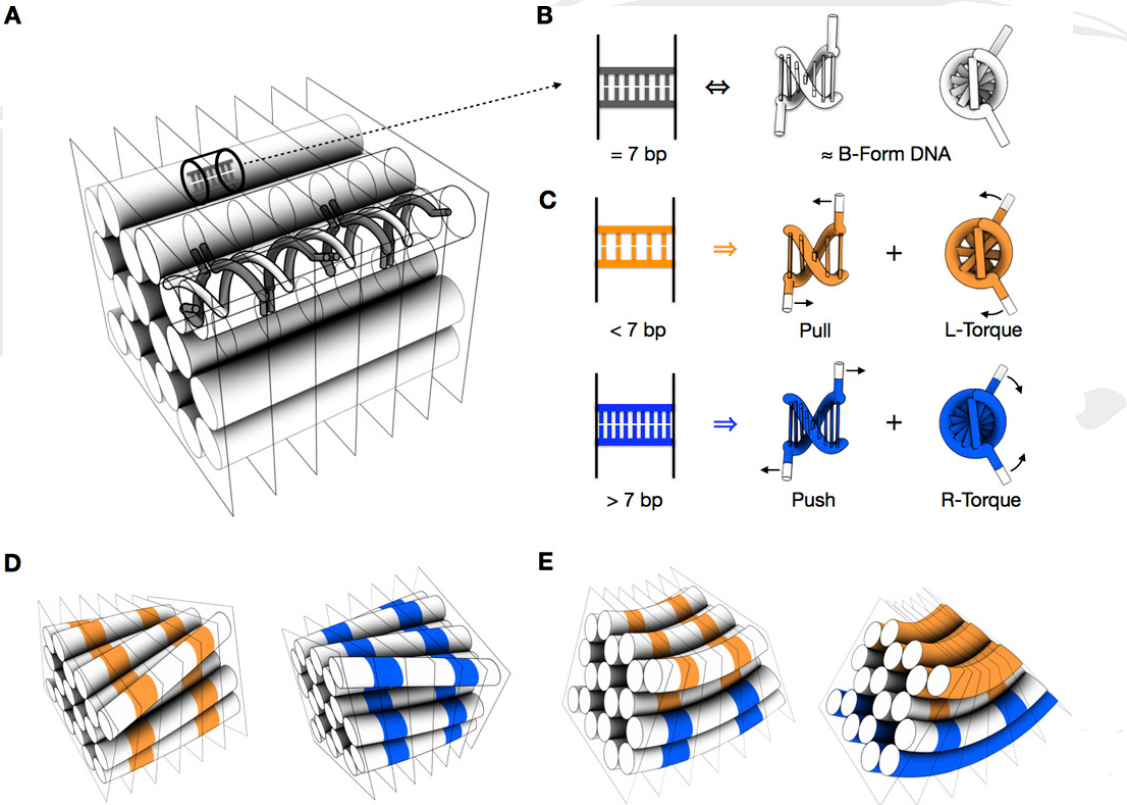
Church's Method

H	E	L	L	0	
0110 1000	0110 0101	0110 1100	0110 1100	0110 1111	
AGTA GACA	AGTA AGAG	AGTA GTAC	AGTA GTAC	AGTA GTGT	40 genetic characters

Goldman's Method with indexes

H	i	W	o	r	l	d	
02200 10220	01012	10020	11010	11020	11000	10201	
CATAC TATGT	AGTCA	GTAGT	AGTAC	TACAC	GTACG	ACACT	40 genetic characters

Shrinking the space DNA takes



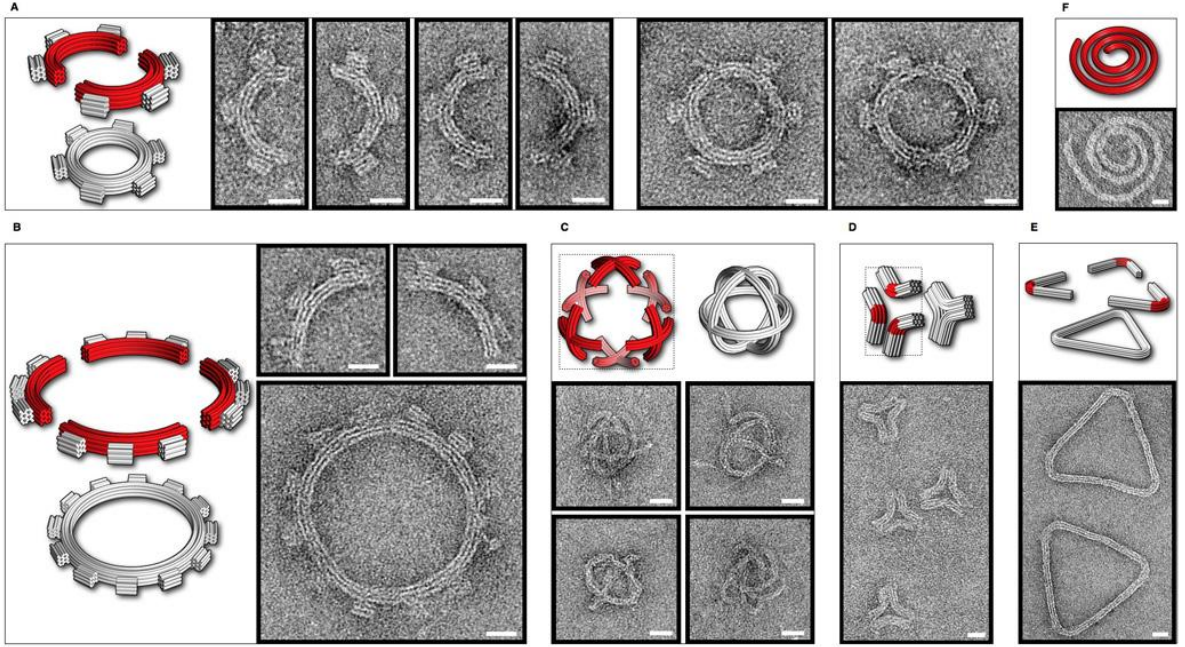
Shrinking the space DNA takes

Harvard Scientists

DNA origami

Wind DNA tighter

Bend into less space



Current work

Establishing a reliable clock.

Shrinking data storage methods.

Using Bil gates in complex systems.

Future

- Medicine
- Warfare(Hopefully Not)
- Within 10 years price the of dna encoding and decoding could reach feasible production levels.

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