



Bacterial Logic Gates

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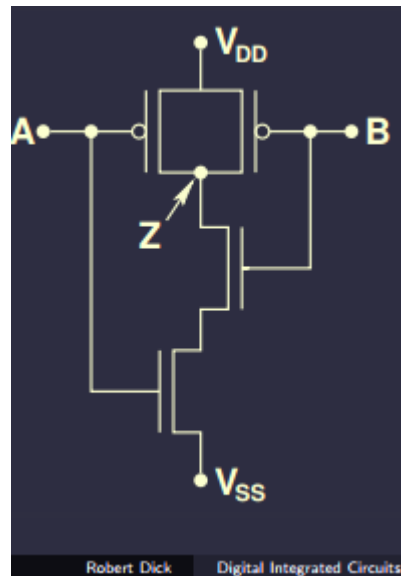
Arjun Khurana

Logic Gates

- Elementary Building Blocks for Digital Circuits
- Implement Boolean Functions
 - Two binary conditions (Low or High)
 - Typically 2 input and 1 output
- 7 Basic types
 - AND, OR, XOR, NOT, NAND, NOR, and XNOR

General Notion about Logic Gates

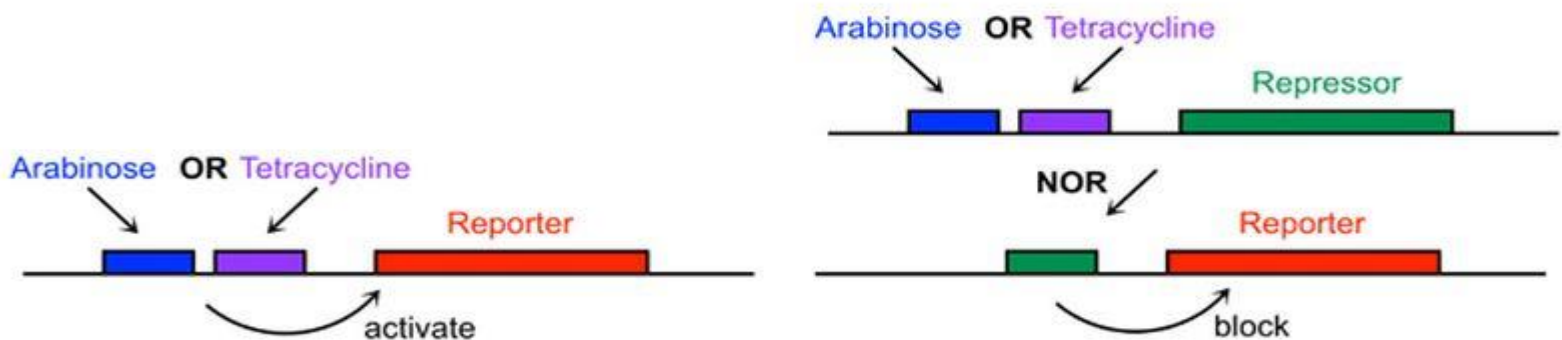
- Uses Electronic switches
 - Diodes
 - Transistors
- Primarily Used in Computing



NAND Gate

Logic Gates based off DNA Sequencing

- Stretches of DNA known as “promoters” act as logical OR and NOR functions
 - Promoters activate nearby genes in response to simple chemicals
 - Putting two promoters next to a Reporter gene creates an OR gate
 - Putting a Repressor gene between the Reporter and Promoters creates a NOR gate

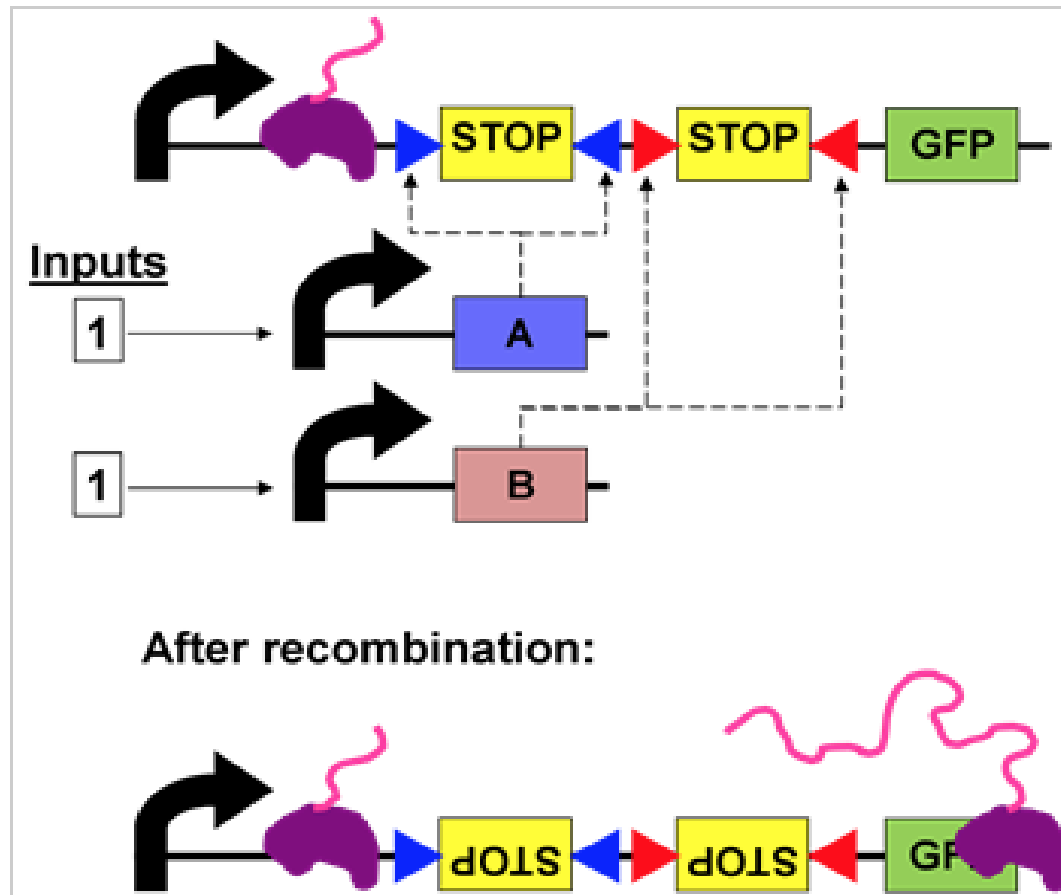


Promoters that are regulated by chemicals can be used to create an OR gate (left) or, with an extra step, a NOR gate.

Imperial College of London Research

- E. Coli
 - Grown Easily
 - Inexpensive
- “Rewire” Communication Between Cells
- Reprogram E. Coli using Modified DNA
- Make more complex Logic Gates

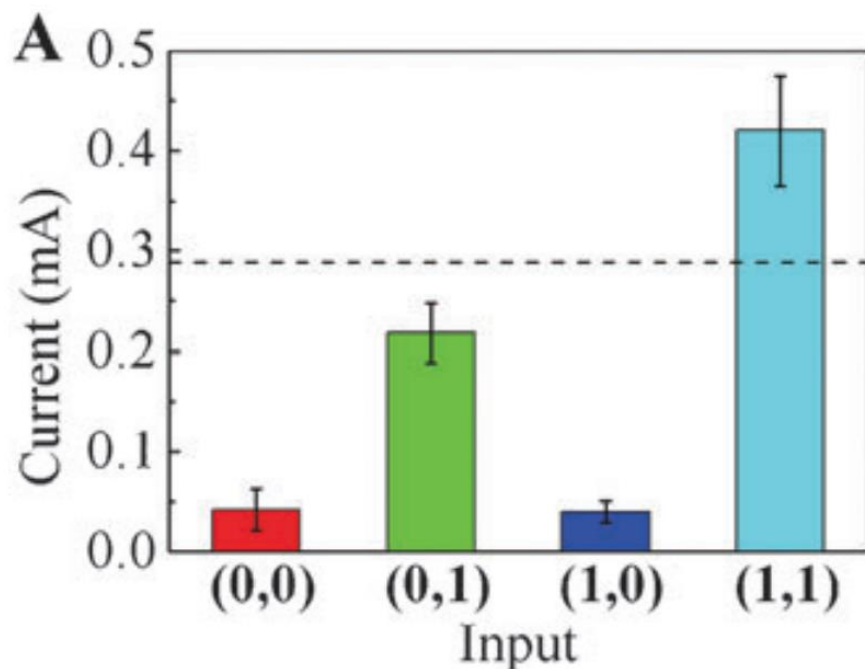
Sequencing of DNA in E. Coli Logic Gate



AND gate Operation

- Use chemicals to monitor Electric Potential
- Input (C4-HSL & 3-oxo-C12-HSL)
 - Present considered logic **1** (true)
 - Absent considered logic **0** (false)
- Output
 - Current $> .29\text{mA}$ \Rightarrow Logic **1** (true)
 - Current $< .29\text{mA}$ \Rightarrow Logic **0** (false)

Actual Data (Chemical Communications journal)



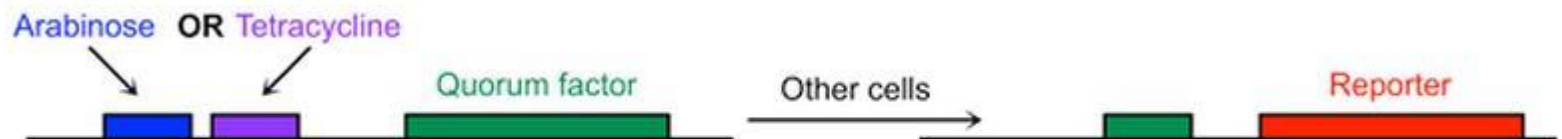
Input A 3-oxo- C12-HSL	Input B C4-HSL	Output AND Gate
0	0	0
0	1	0
1	0	0
1	1	1

Issues with Bacterial Logic Gates

- Limit on how many logic gates can be fit into one bacterium
 - Potential breakthrough has occurred by using a small population of bacteria
- Gates are slow
- Cell cycle coordination

Capacity and Cycle Coordination Issue

- Solution: Wire bacteria together
 - Using genes that bacteria use to signal each other
 - These signals diffuse into neighboring cells and act like the chemicals used to control the initial logic gates
- Been demonstrated in lab environment
 - Researchers created an XOR gate using NOR, NOT, and OR logic gates



Genetic logic gates can be used to regulate genes for quorum factors, which act as wires to transmit the logic results to other cells.

Future

- Circuitry comprised of bacterial logic gates
 - Currently, engineered bacteria are used for production of biofuels, pharmaceuticals, and various other products
- Biological Processors
- Microscopic Biological Computers
- Bacterium that swim inside arteries and target specific issues
- Bacterium that detect/destroy cancer cells

Sources

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