

Game of life in E coli

Conway's Game of Life in E coli

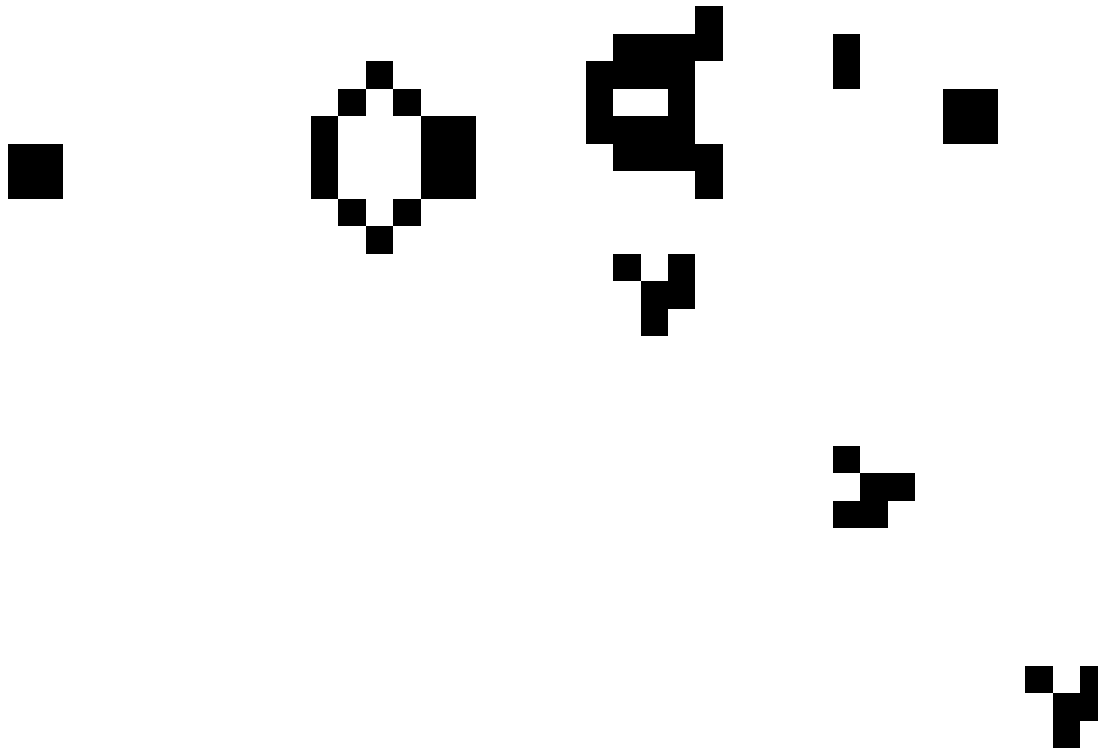
Principles of Synthetic Biology

David Joy

December 7th 2015

Game of life in E coli

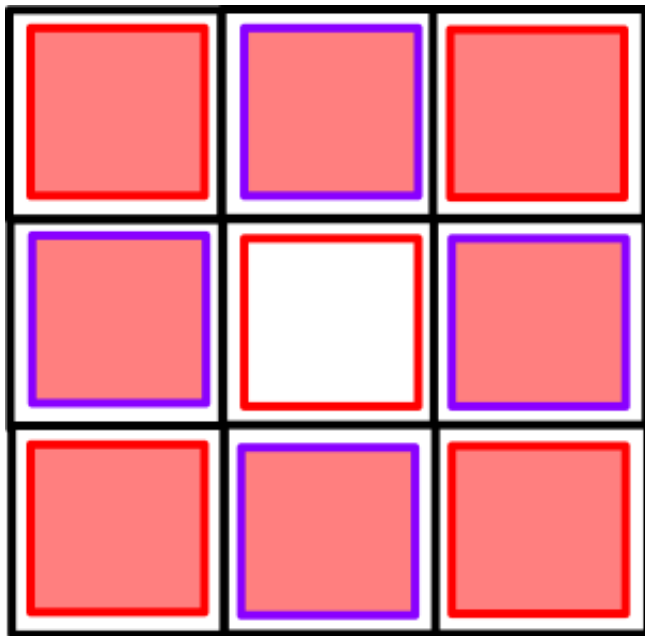
- What is Conway's Game of Life?



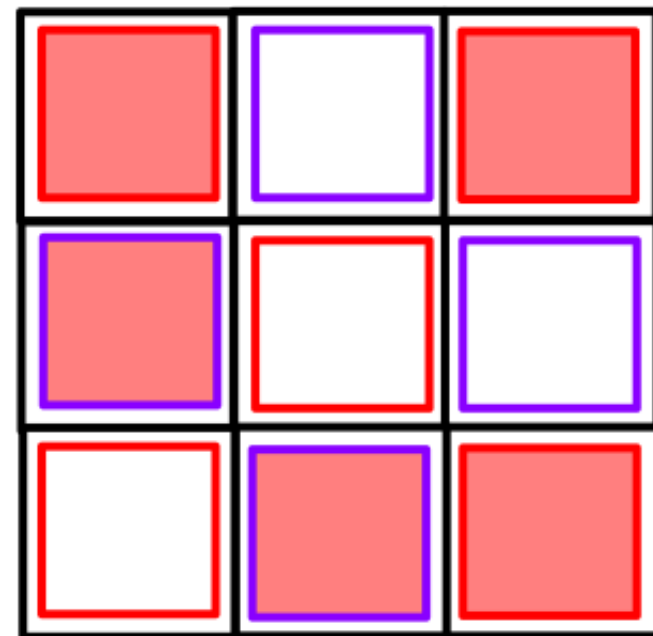
"Gospers glider gun" by Kieff - Own work. Licensed under CC BY-SA 3.0 via Commons - https://commons.wikimedia.org/wiki/File:Gospers_glider_gun.gif#/media/File:Gospers_glider_gun.gif

Game of Life in E coli

- Simple Rules:
 - Count the number of neighbors that are ON



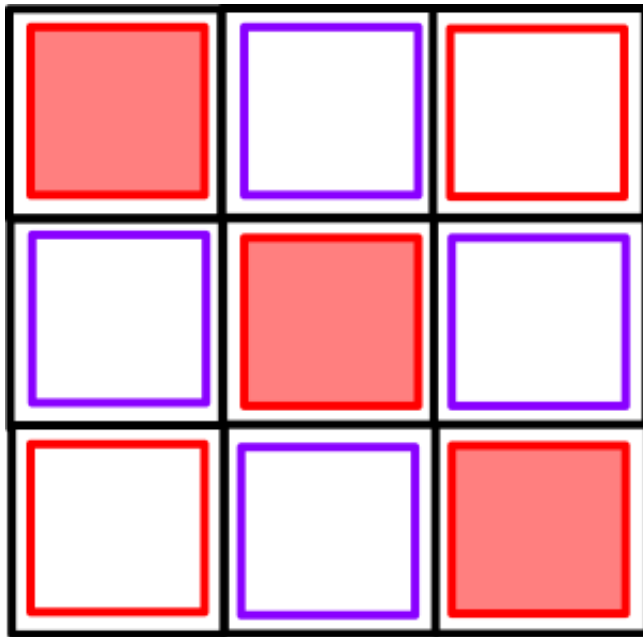
8 Neighbors On



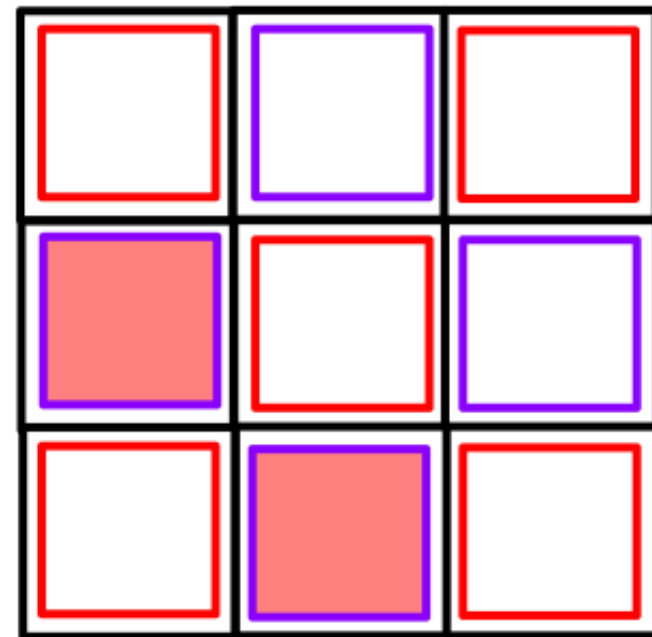
5 Neighbors On

Game of Life in E coli

- Simple Rules:
 - If there are exactly two neighbors, stay the same



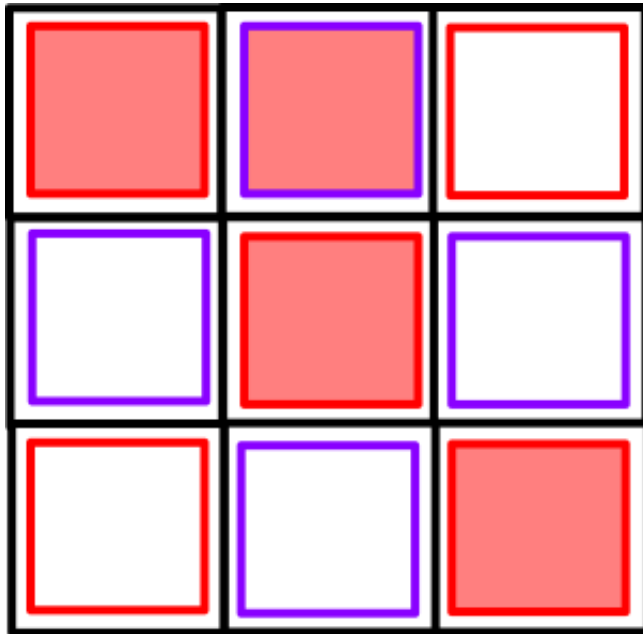
2 Neighbors On



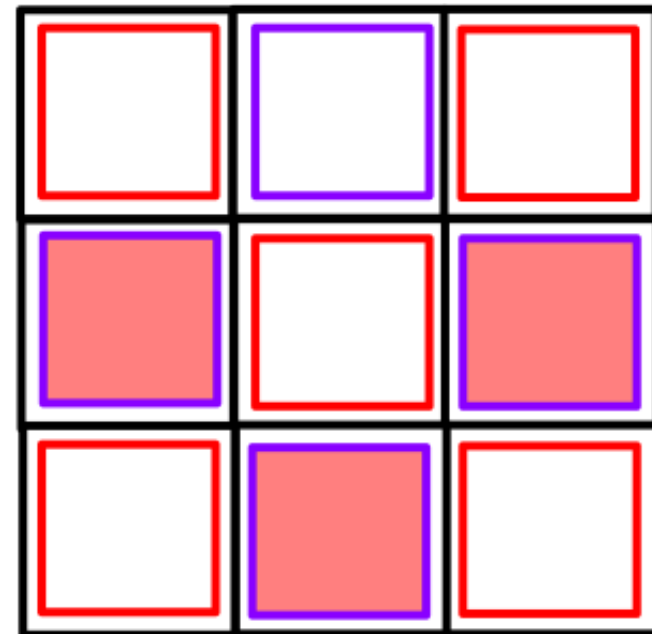
2 Neighbors Off

Game of Life in E coli

- Simple Rules:
 - If there are exactly three neighbors, turn ON



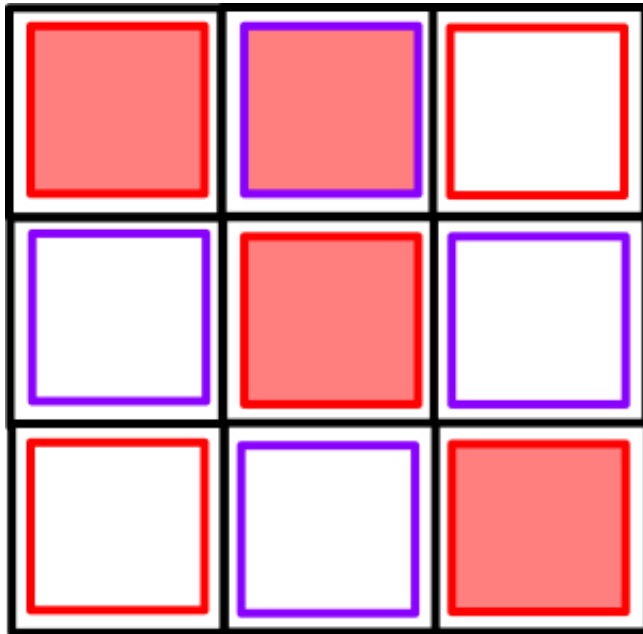
3 Neighbors On



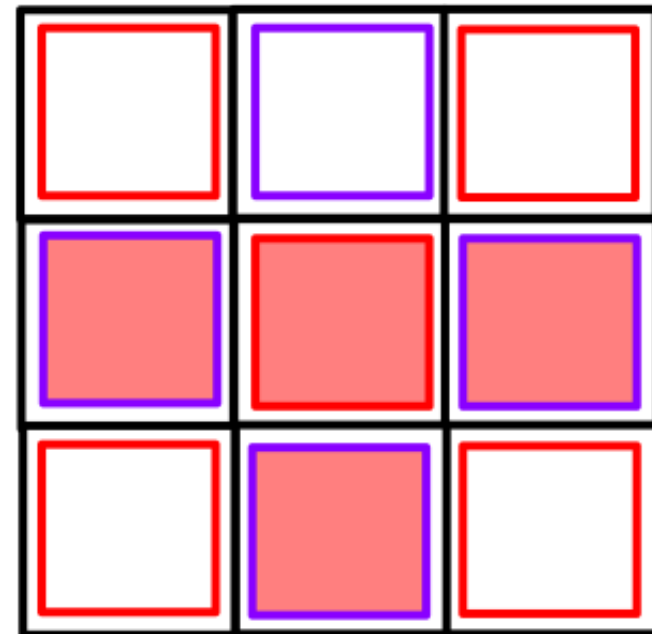
3 Neighbors Off

Game of Life in E coli

- Simple Rules:
 - If there are exactly three neighbors, turn ON



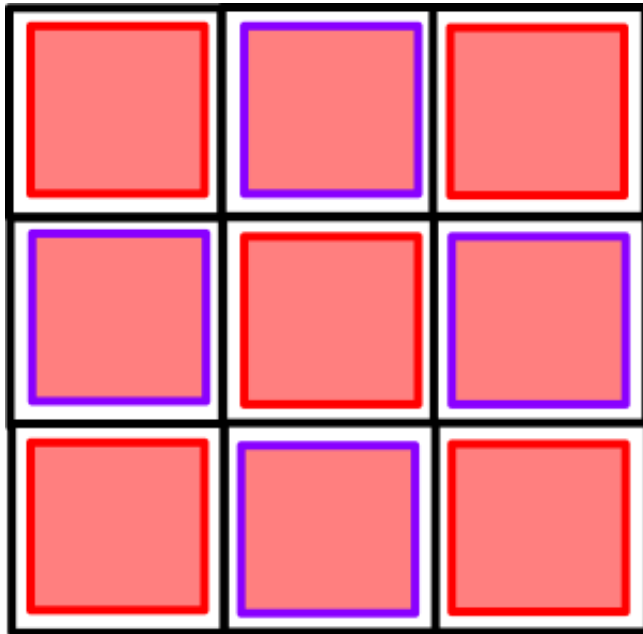
3 Neighbors On



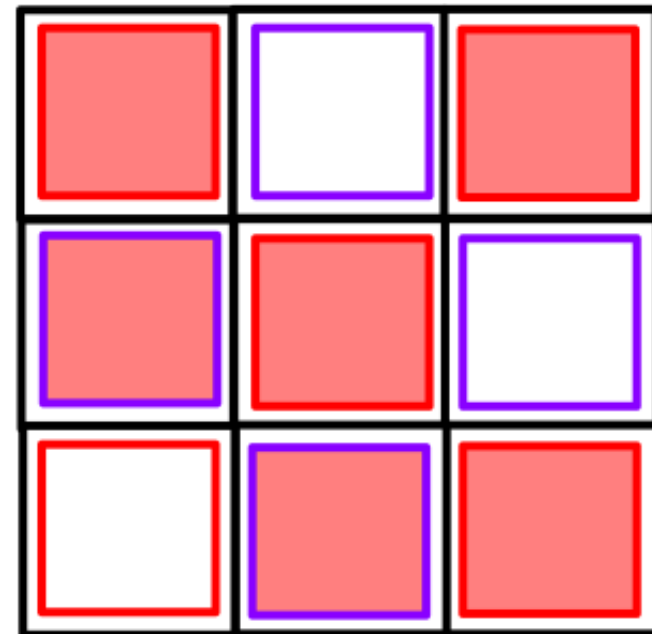
3 Neighbors Off

Game of Life in E coli

- Simple Rules:
 - Otherwise, turn OFF



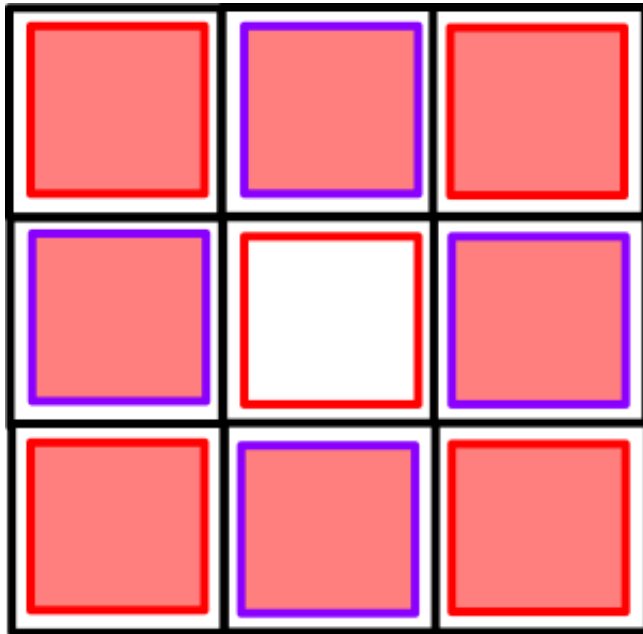
8 Neighbors On



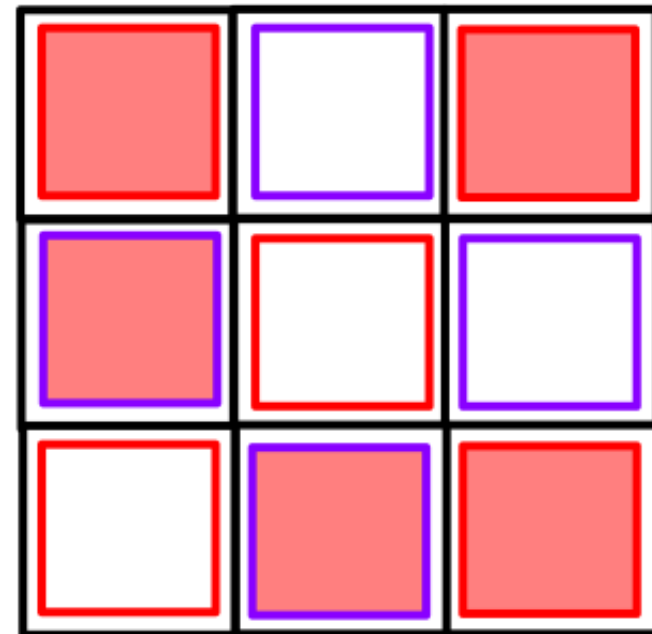
5 Neighbors On

Game of Life in E coli

- Simple Rules:
 - Otherwise, turn OFF



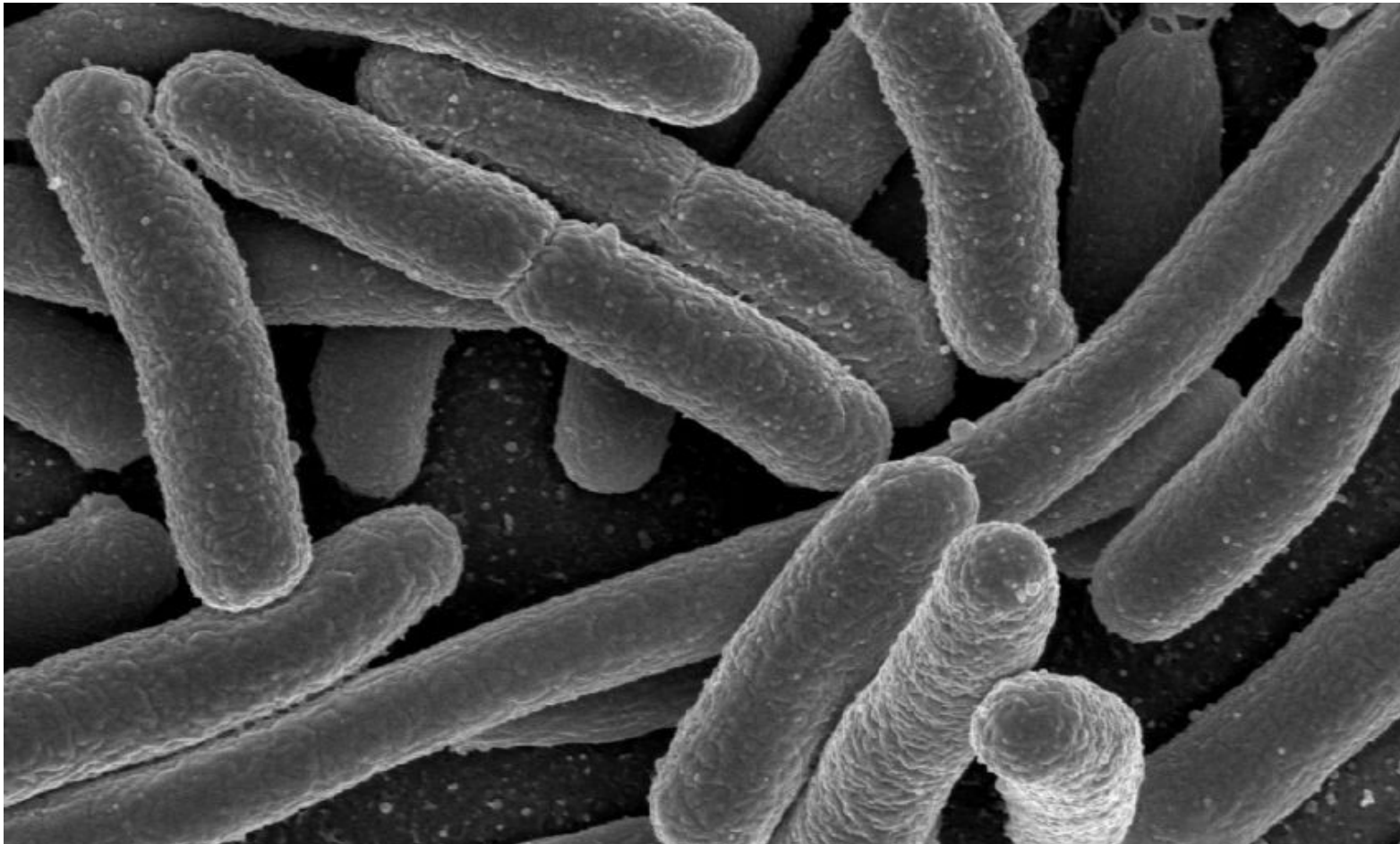
8 Neighbors On



5 Neighbors On

Game of life in E coli

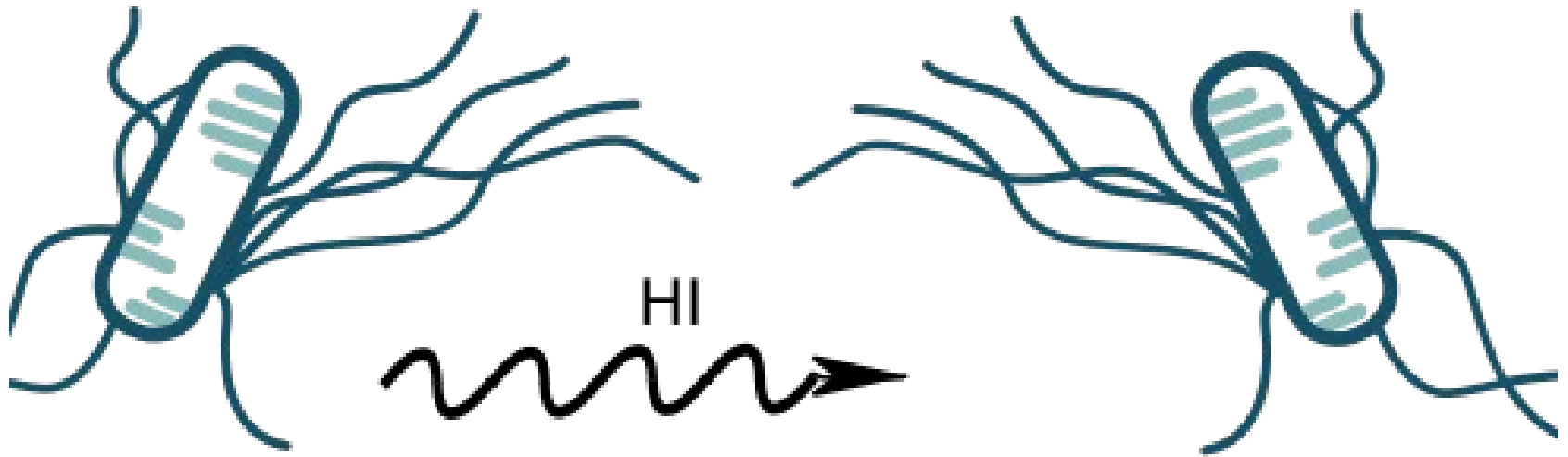
- Why implement the Game of Life in E coli?



"EscherichiaColi NIAID" by Credit: Rocky Mountain Laboratories, NIAID, NIH - NIAID: These high-resolution (300 dpi) images may be downloaded directly from this site All the images, except

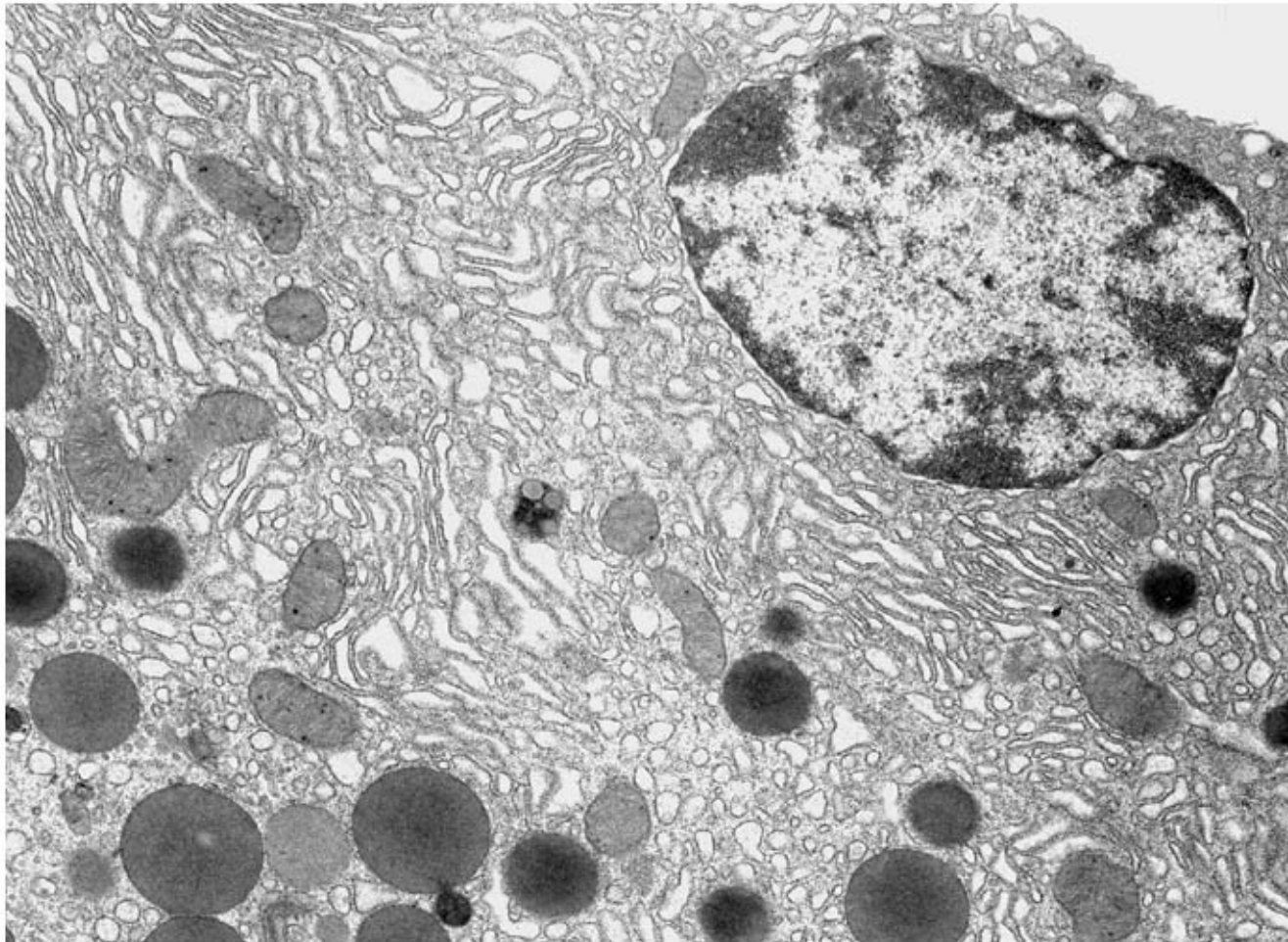
Game of Life in E coli

- Simple example of Cell-to-Cell Communication



Game of Life in E coli

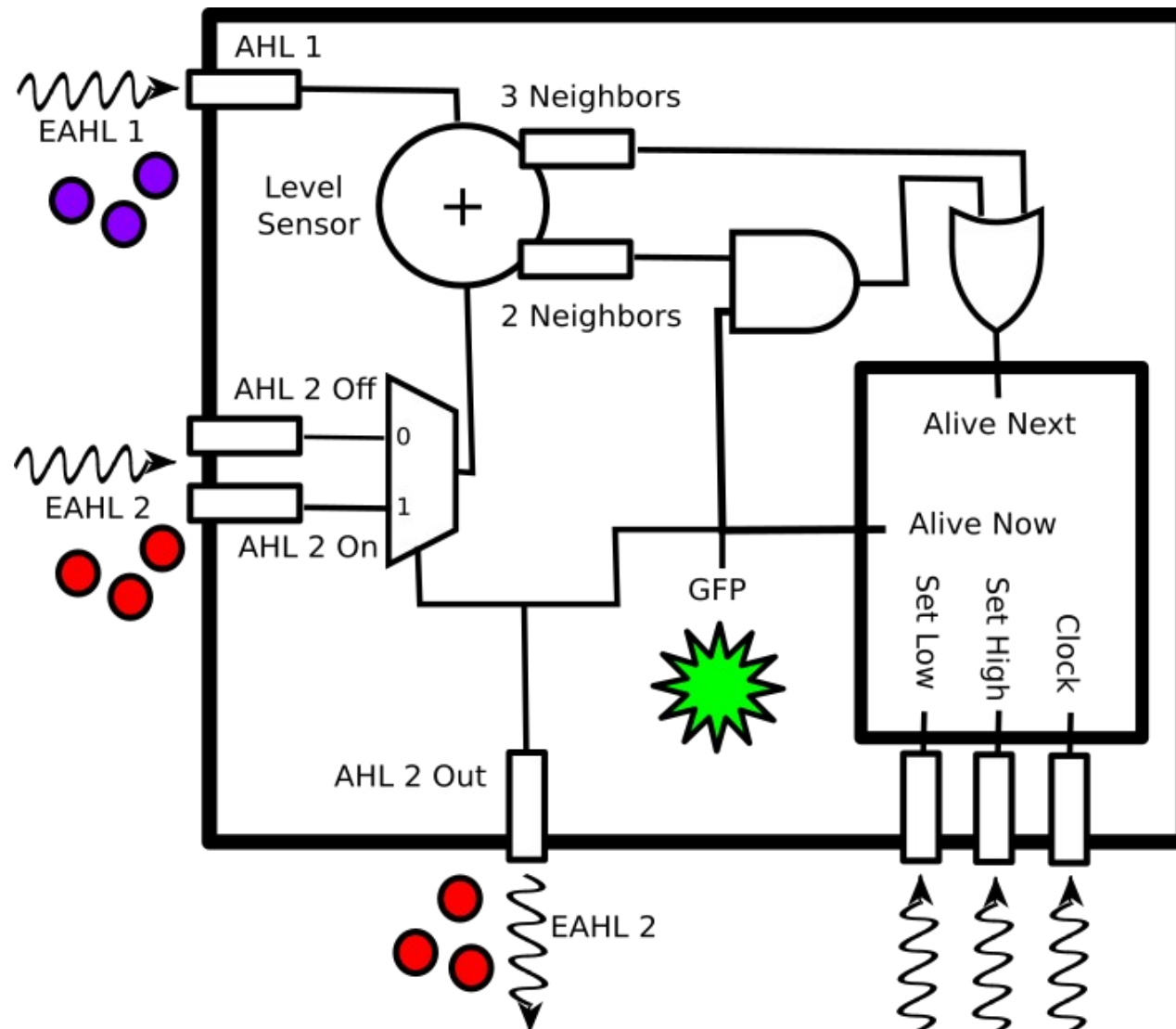
- That can lead to complex behaviors



Courtesy of T. Howard, Cold Spring Harbor. Noncommercial, educational use only.

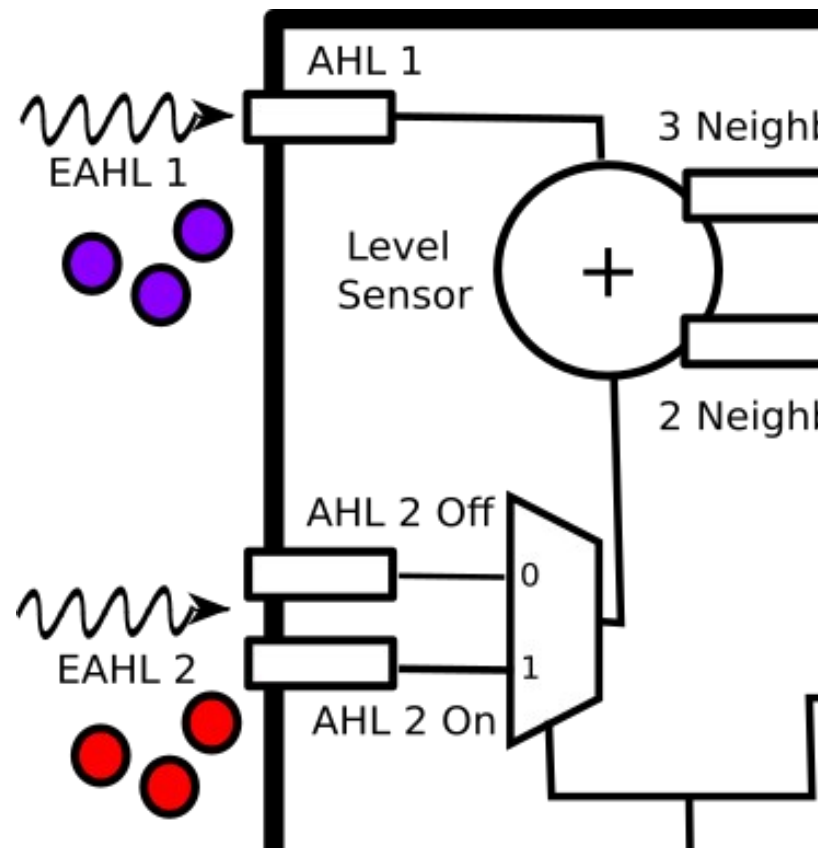
Game of Life in E coli

- How would we implement it in E coli?



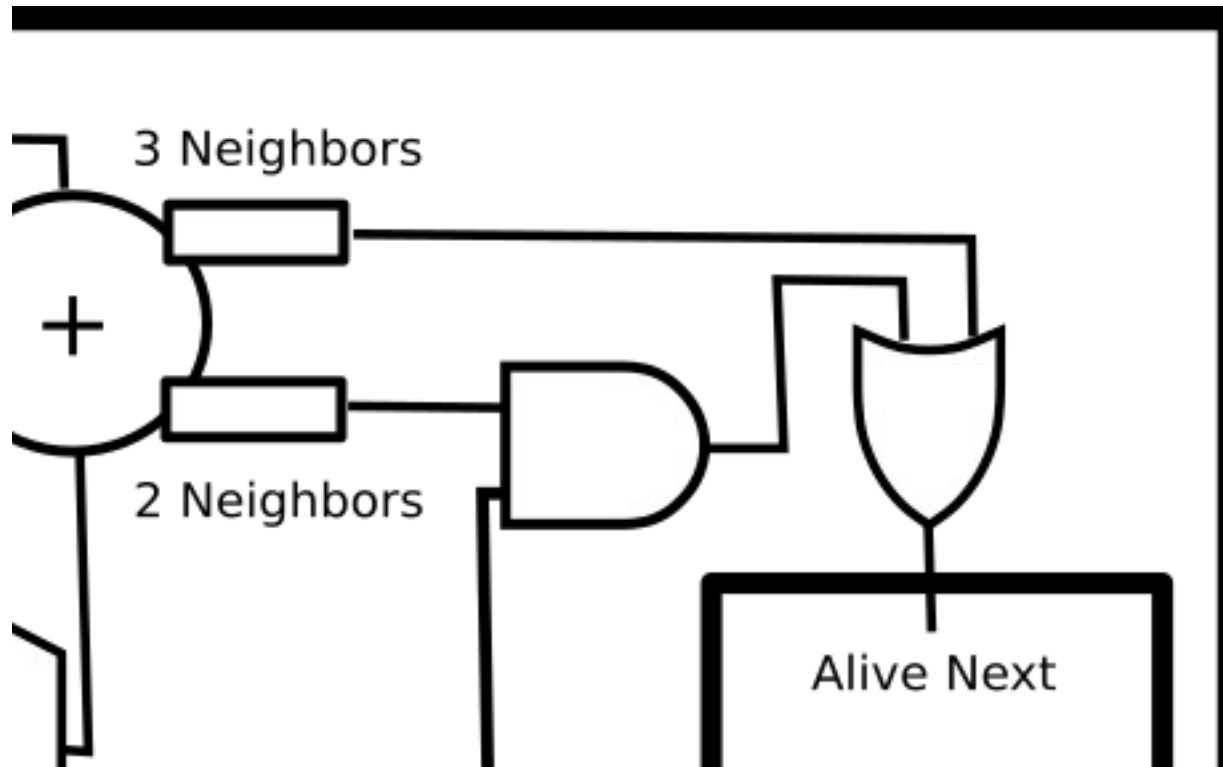
Game of Life in E coli

- Level sensor to count our neighbors



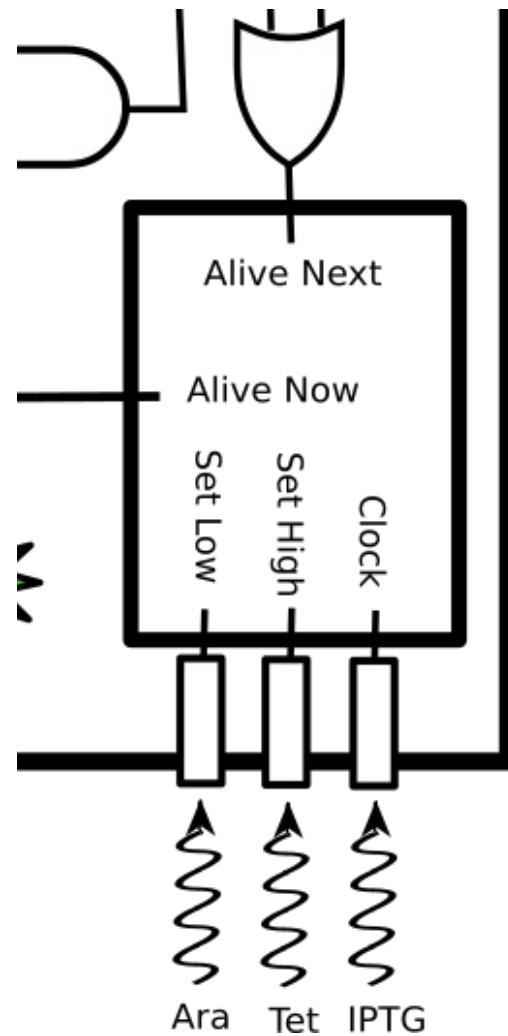
Game of Life in E coli

- Logic Gates to apply the rules of the game



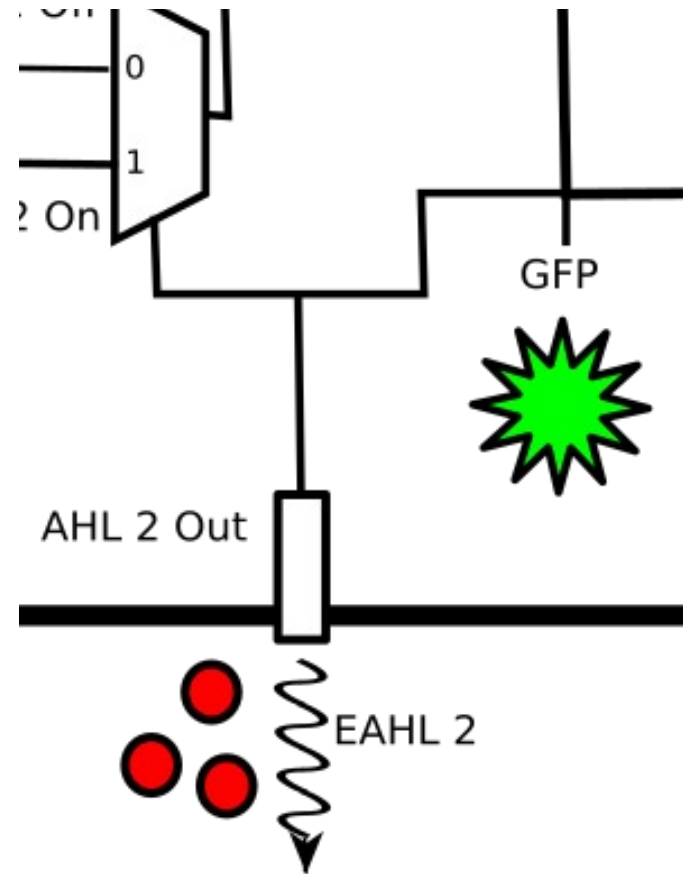
Game of Life in E coli

- Memory to remember our current state



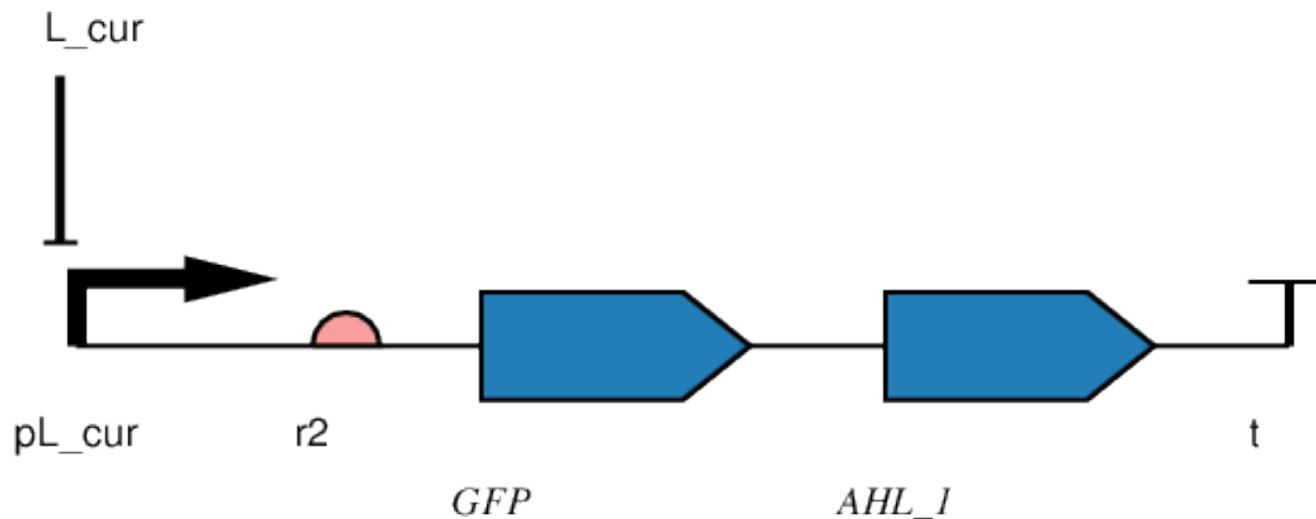
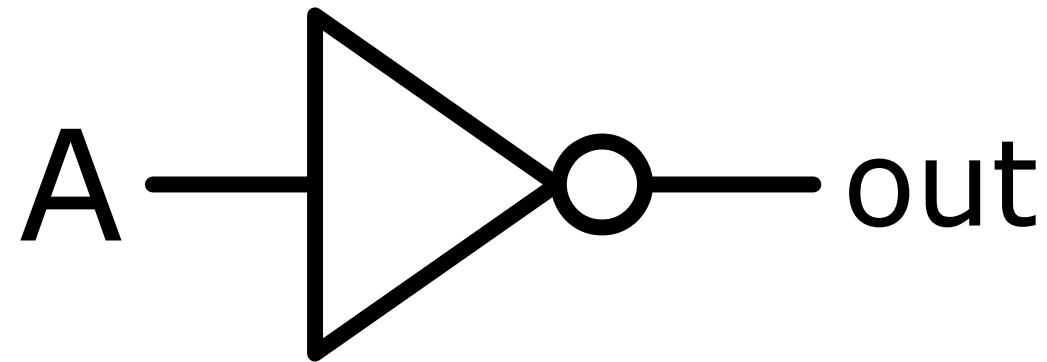
Game of Life in E coli

- And an output system to signal other cells



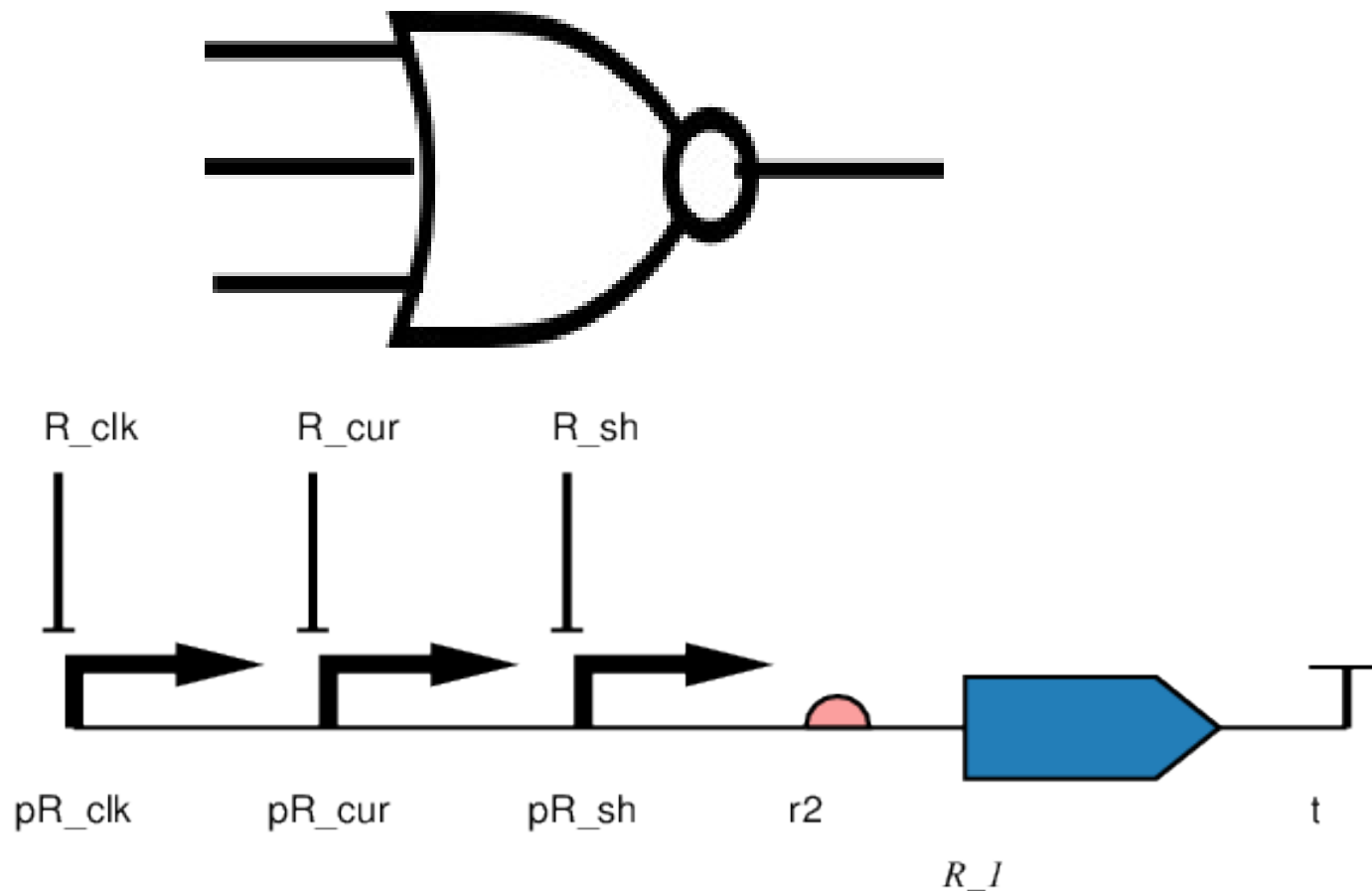
Game of Life in E coli

- Converting logic gates to biological circuits



Game of Life in E coli

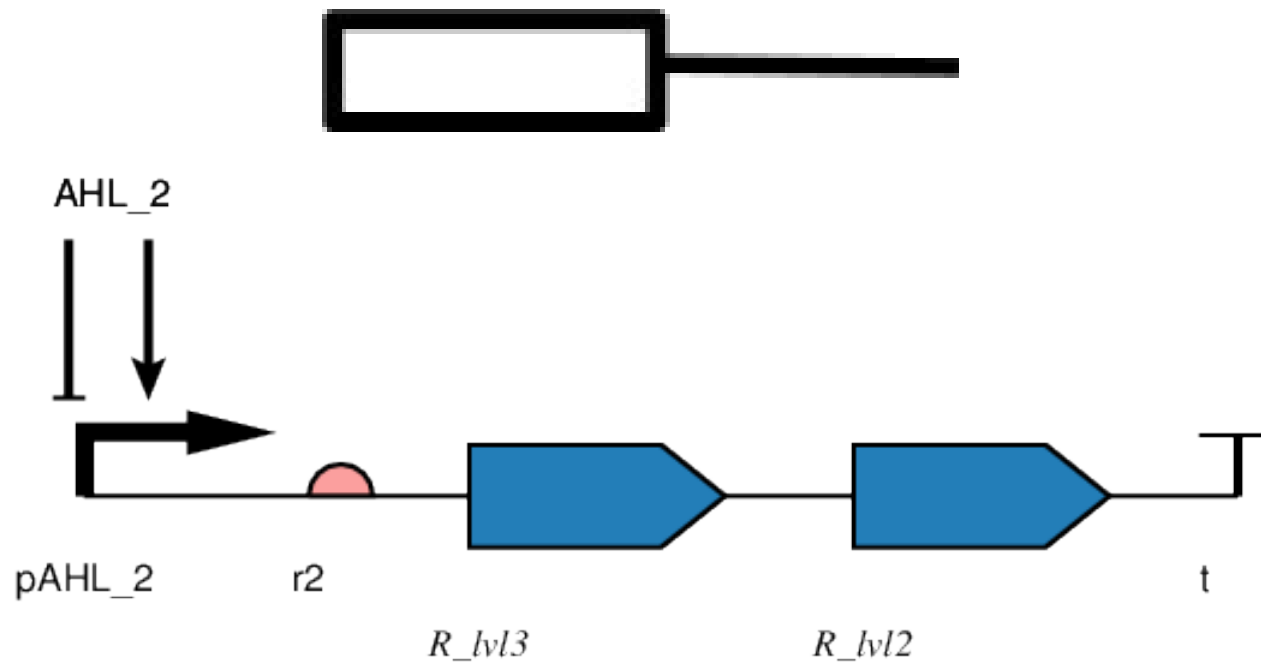
- Converting logic gates to biological circuits



Game of Life in E coli

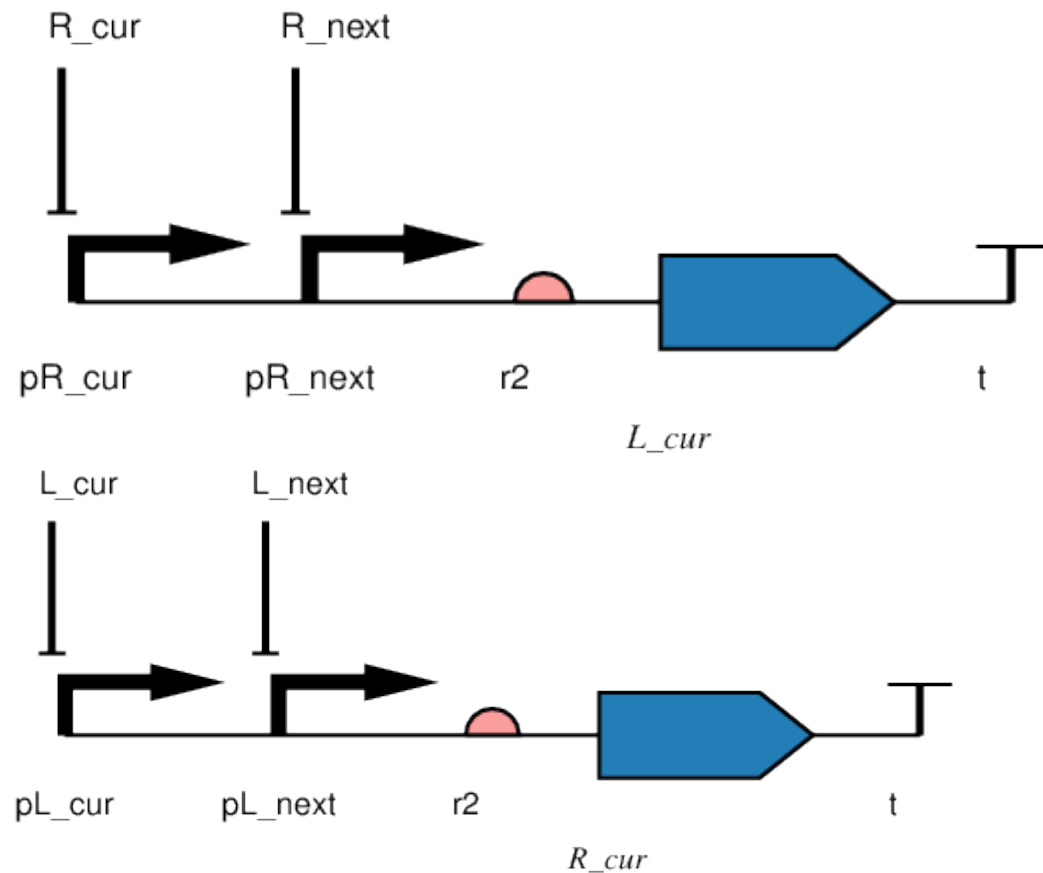
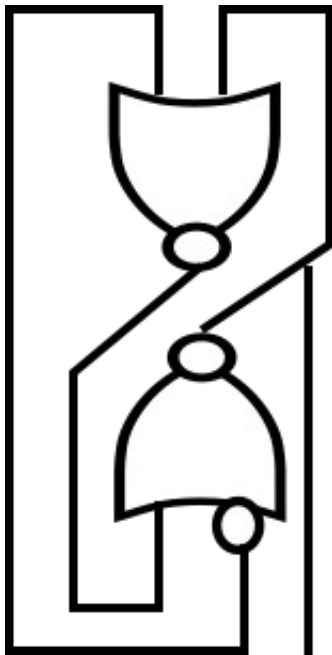
- Converting logic gates to biological circuits

3 Neighbors



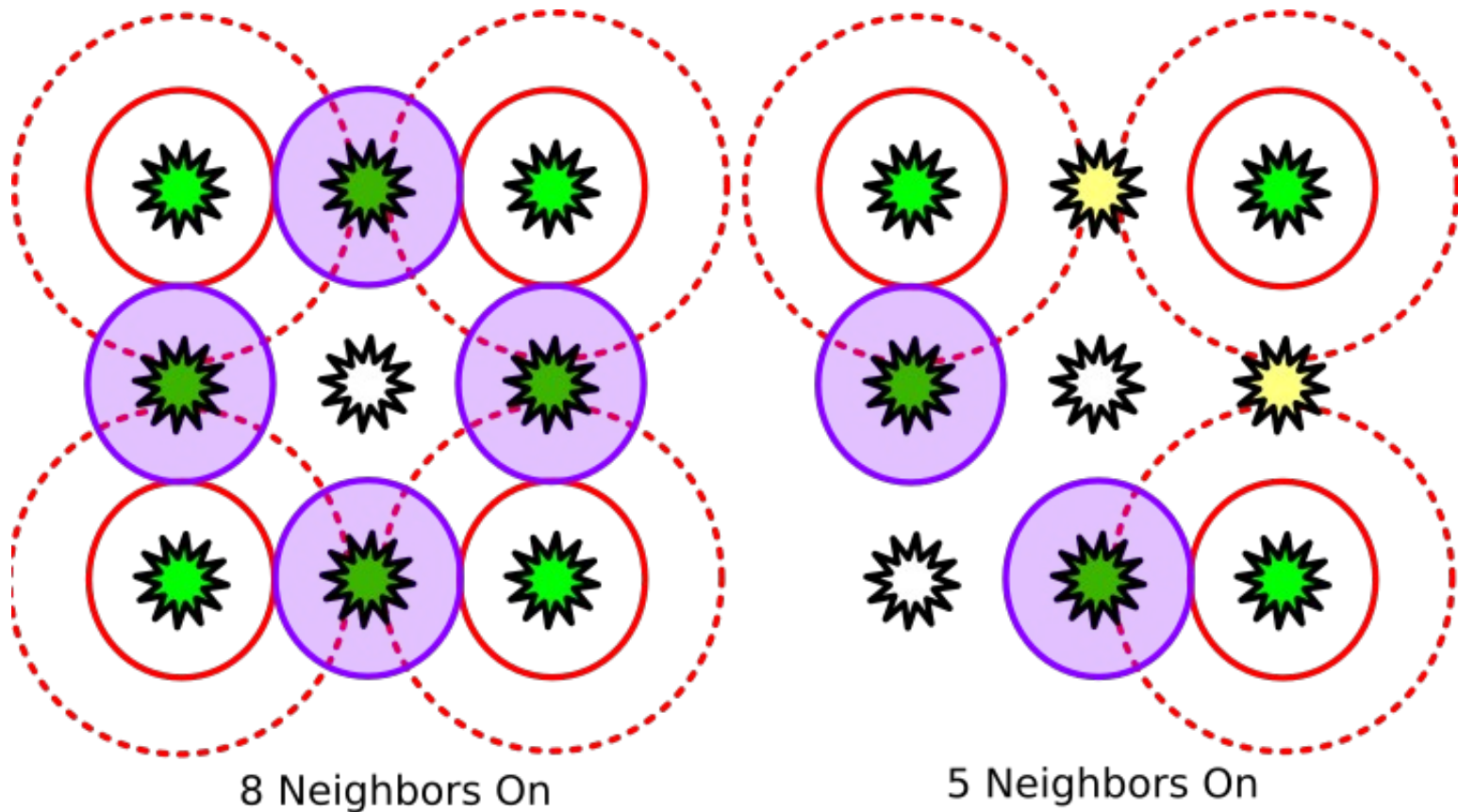
Game of Life in E coli

- Converting logic gates to biological circuits



Game of Life in E coli

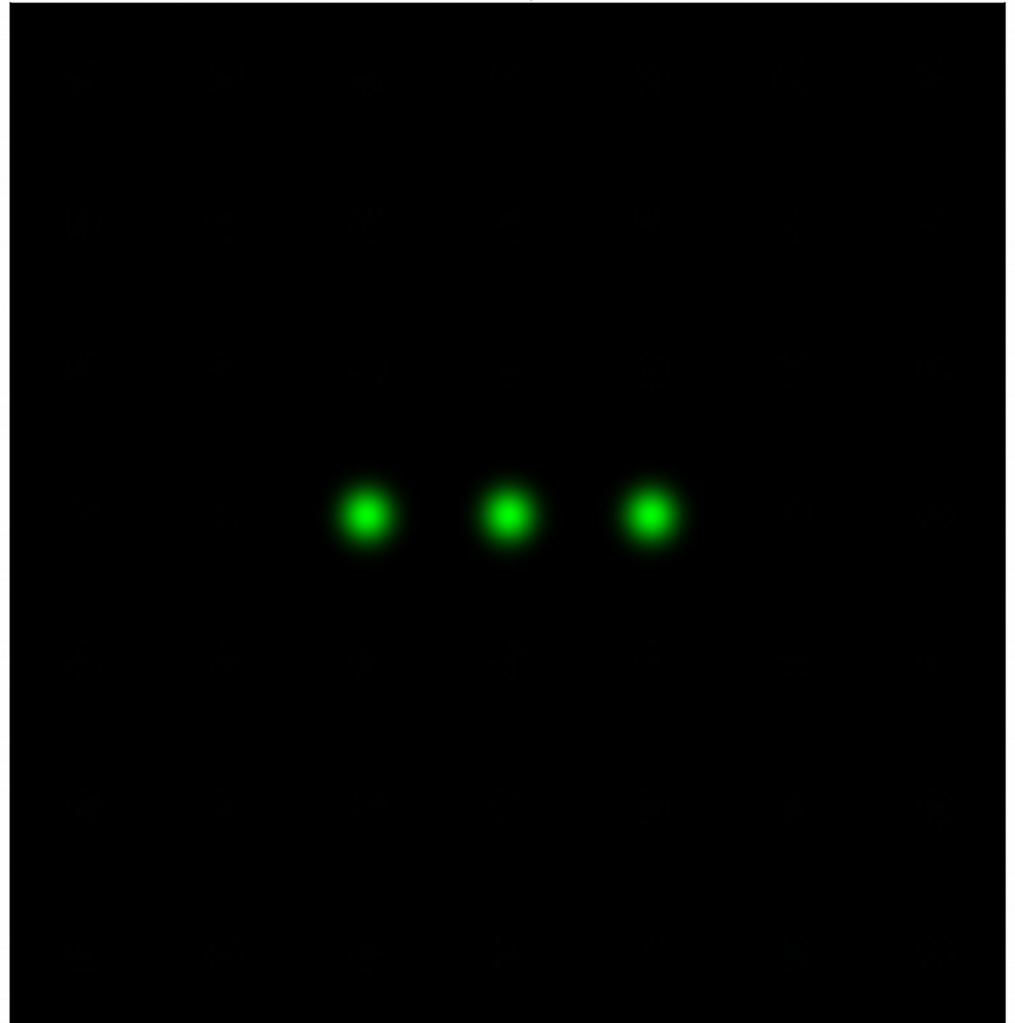
- Spatial Arrangement



Game of Life in E coli

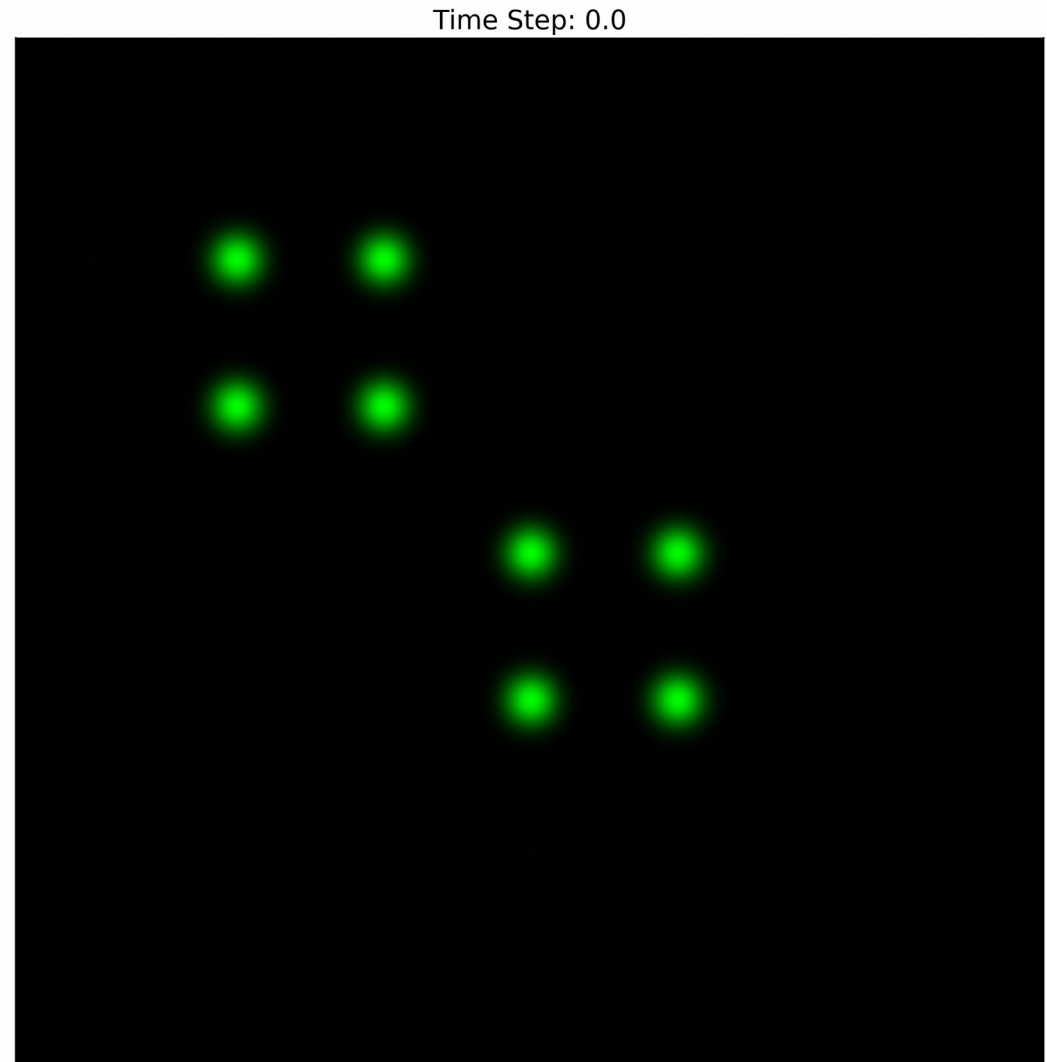
- Simulation:
Blinker

Time Step: 0.0



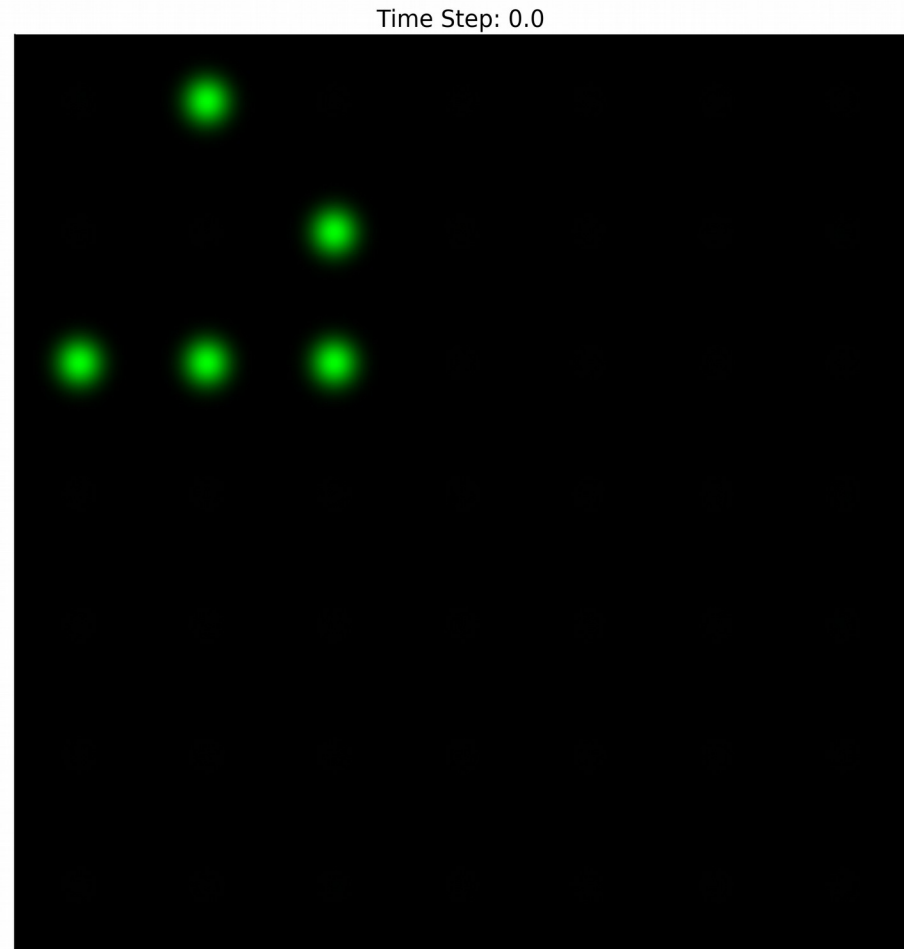
Game of Life in E coli

- Simulation:
Beacon



Game of Life in E coli

- Simulation:
Spaceship



Game of Life in E coli

- Discussion
 - The logic gate network works
 - Most of the constants are biologically reasonable
 - It's a big circuit, but not the biggest
 - The level sensors are finicky
 - Need really precisely tuned constants
 - Need really high cooperativity
 - Probably need to implement this as multiple components

Game of Life in E coli

- Conclusions:
 - Cell-to-cell communication is a powerful tool for creating programmable biological systems
 - Modeling can show the strengths, and weaknesses of trying to program biology as a logic system