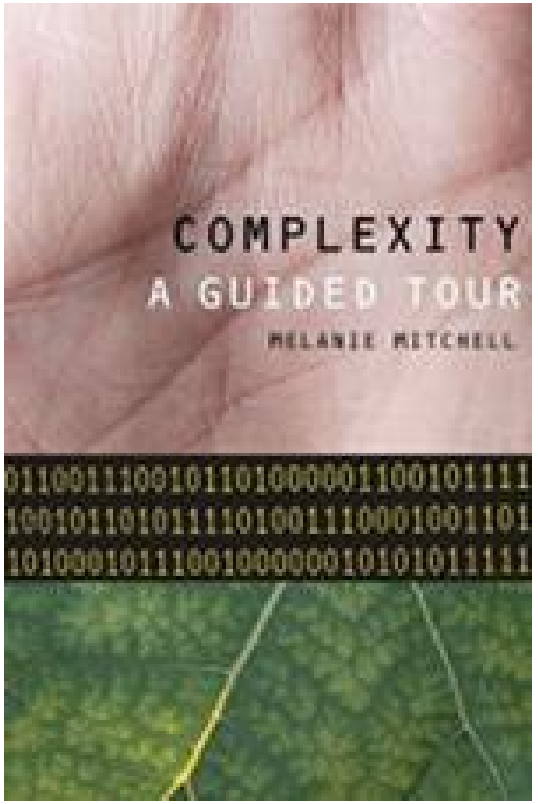
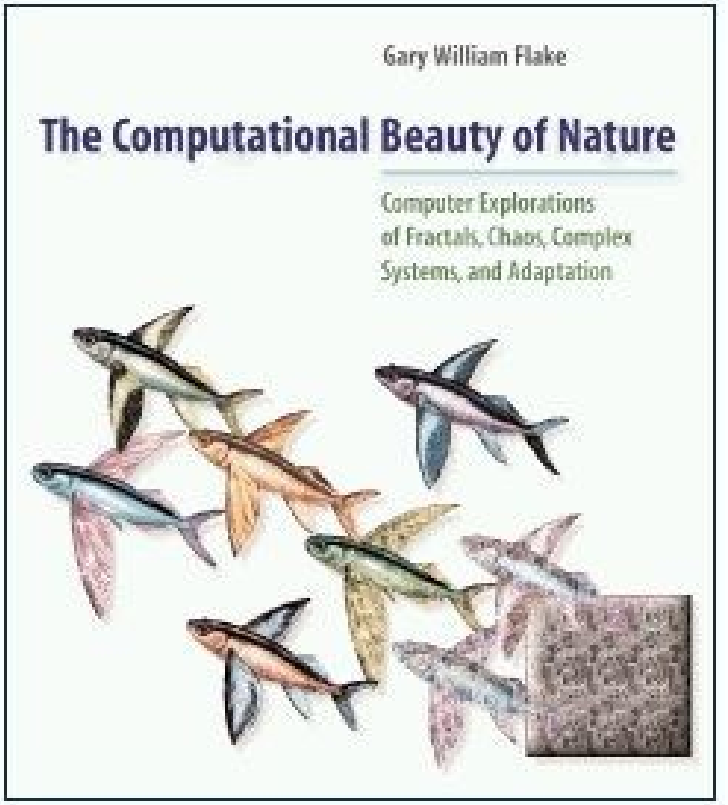
# Cellular Automata

# Reading




**Chapter 10** (pp. 145-159)




**Chapter 15** (pp. 231-259)

# Cellular Automata

- Singular: “cellular automaton” (CA)
- Plural: “cellular automata” (CAs)
- Pronunciation: “uh-TAH-muh-tuh/n”

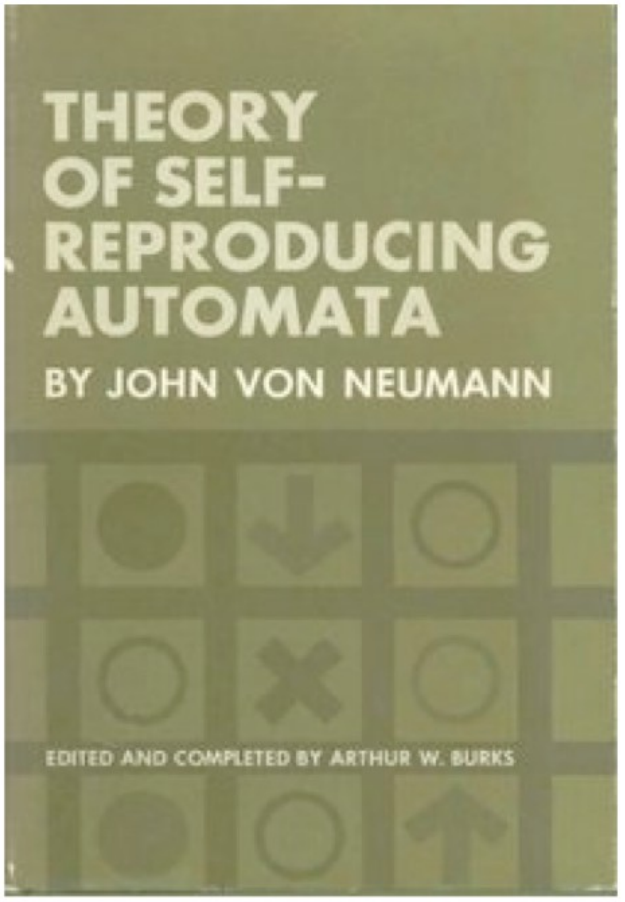
# Cellular Automata

- Idealized models of **physical systems**
- The “Universe” consists of a large array of **grid cells**
- Each cell can be in one of a small number of **states**
- Time flows **discretely**, from step to step
- All cells follow the **same rules** (the “laws of physics”)
- No centralized control (only **local** communication allowed)

# Cellular Automata

- Invented in the 1940s by **John von Neumann** and **Stanislaw Ulam** to study the concept of self-reproduction in organisms and machines

John von Neumann
1903 - 1957




Stanislaw Ulam
1909 - 1984

# Applications of Cellular Automata

- **Computer Science**
  - Massively parallel computation
  - Molecular scale computation

- **Complex Systems**
  - Modeling processes in biology, physics, geology, chemistry, economics, sociology, etc.
  - Studying abstract notions of **self-organization** and **emergent computation**

# Our Plan

- Today: **The Game of Life**
  - Best-known example of a CA
  - 2-dimensional
  - Complex behaviors

- Thursday: **"Elementary" CAs**
  - Simpler to analyze
  - 1-dimensional
  - Easier to study in detail

# The Game of Life

- The world's most famous cellular automaton
- Not really a game
- Inspired by John von Neumann's models of CAs
- Invented by the British mathematician **John Conway** in 1970

1937 – 2020
R.I.P.

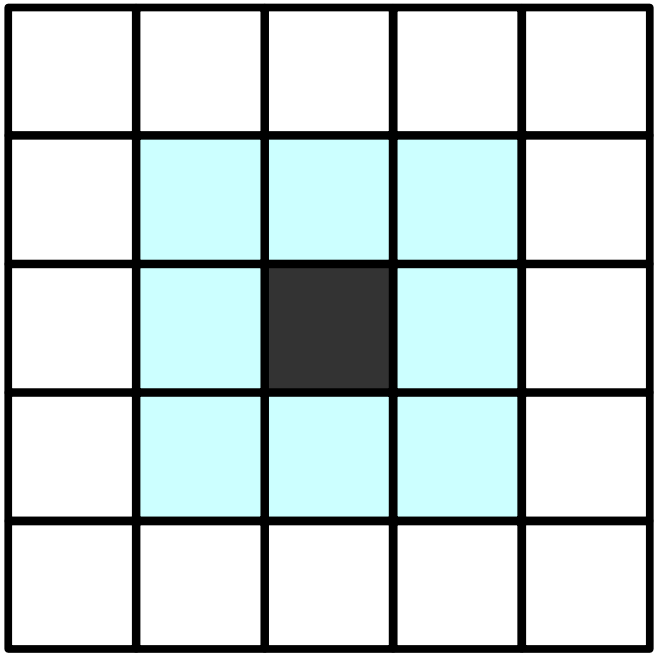

Princeton, 1993

https://www.nytimes.com/2020/04/15/technology/john-horton-conway-dead-coronavirus.html

# The Game of Life

**Universe:**

- Infinite 2-dimensional grid of cells
- Each cell is either “alive” or “dead” (ON or OFF)
- Each cell has 8 surrounding neighbor cells

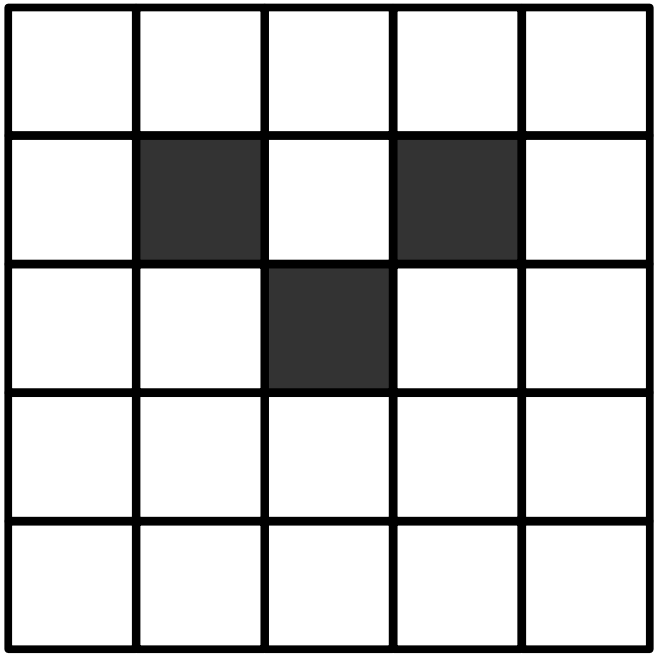


# The Game of Life

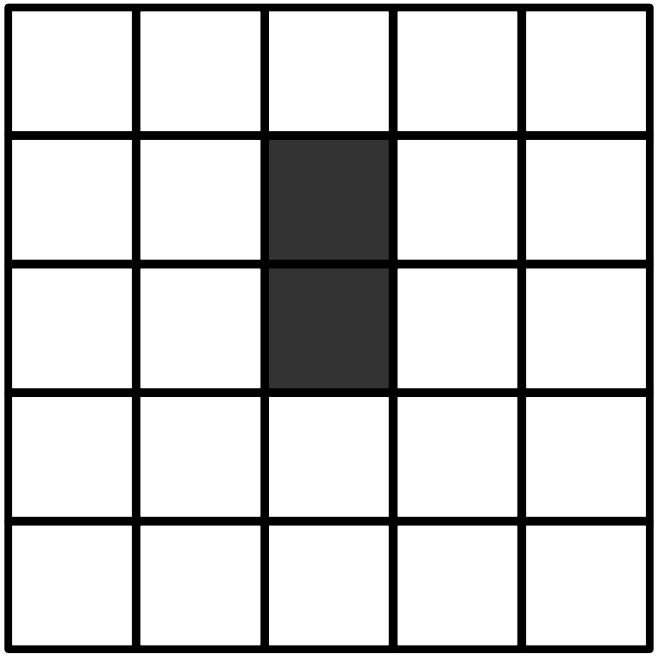
**Rules:**

- A live cell with < 2 live neighbors dies (loneliness)
- A live cell with > 3 live neighbors dies (overcrowding)
- A live cell with 2 or 3 live neighbors stays the same (survival)
- A dead cell with 3 live neighbors becomes alive (birth)

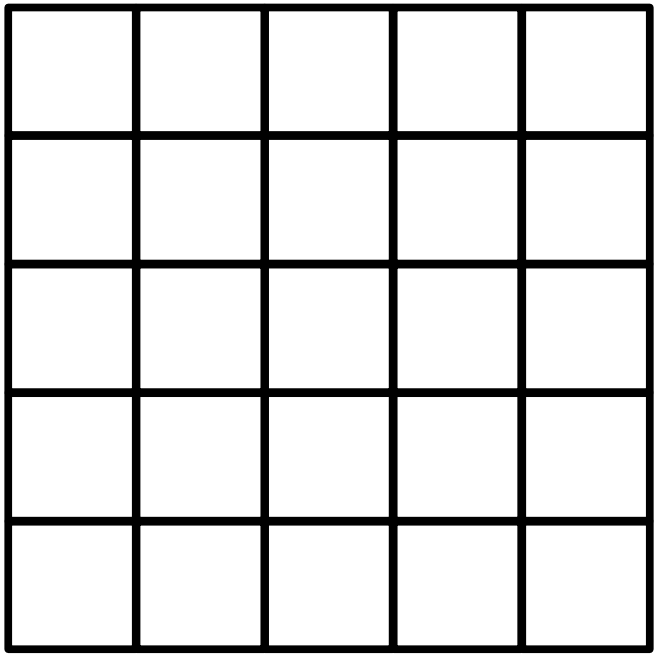
# Example 1: time step 0



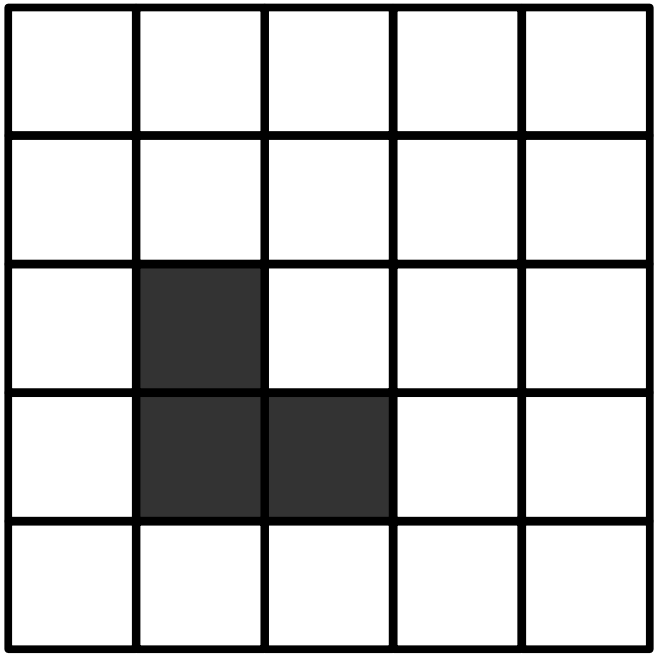
# Example 1: time step 1



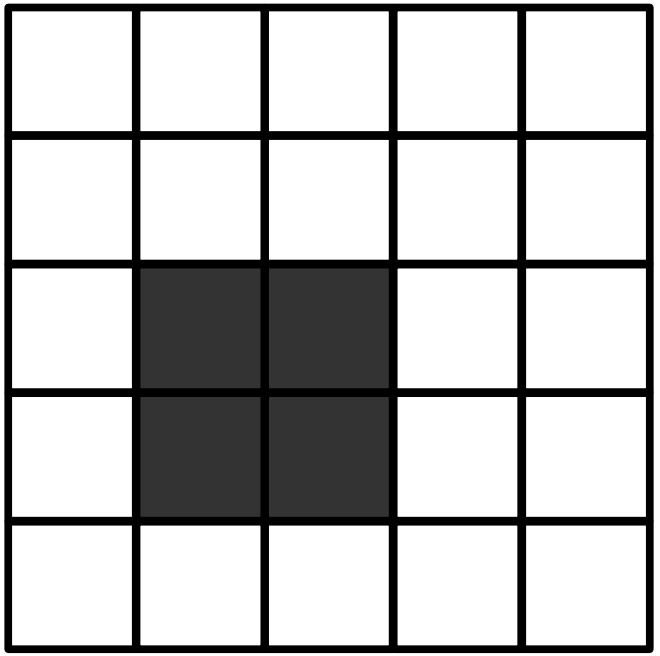
# Example 1: time step 2



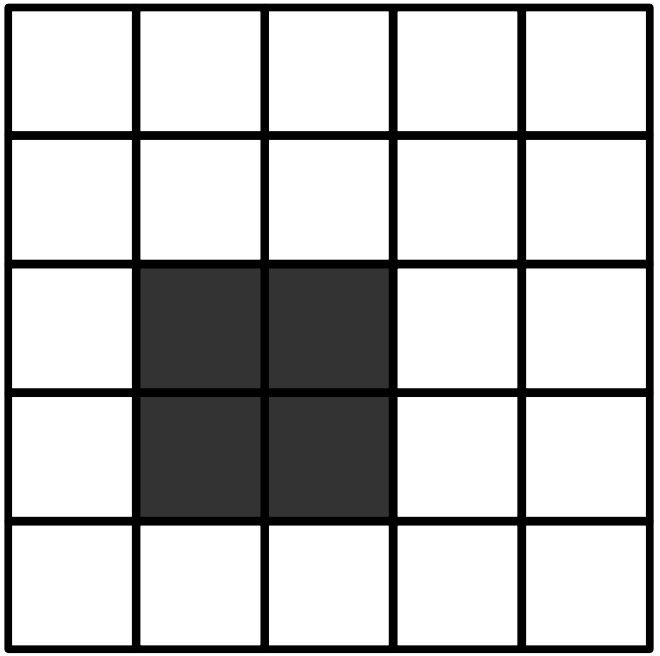
# Example 2: time step 0



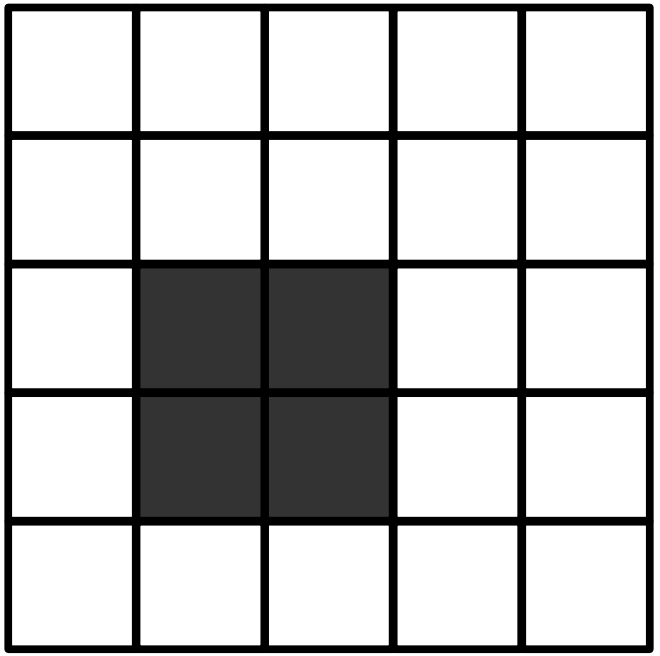
# Example 2: time step 1



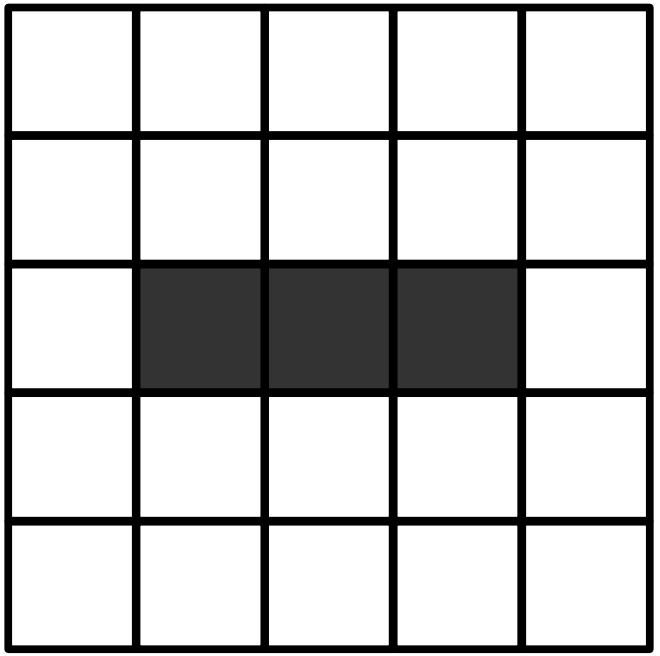
# Example 2: time step 2



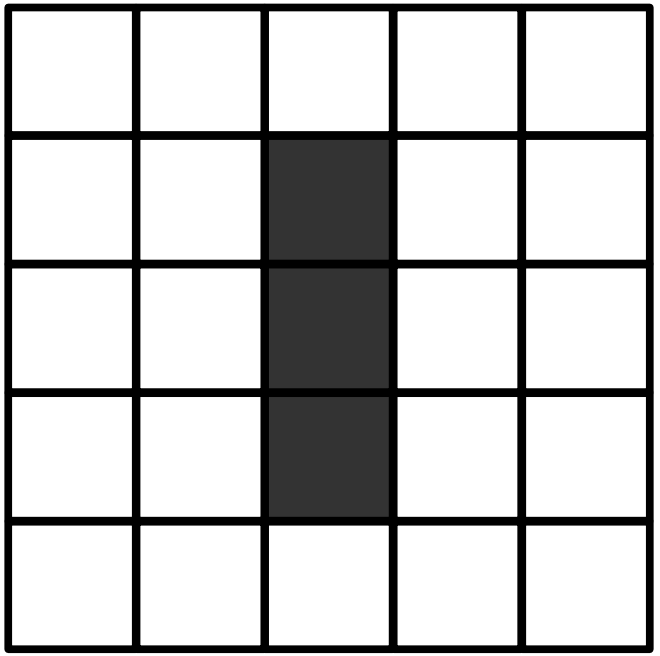
# Example 2: time step 3



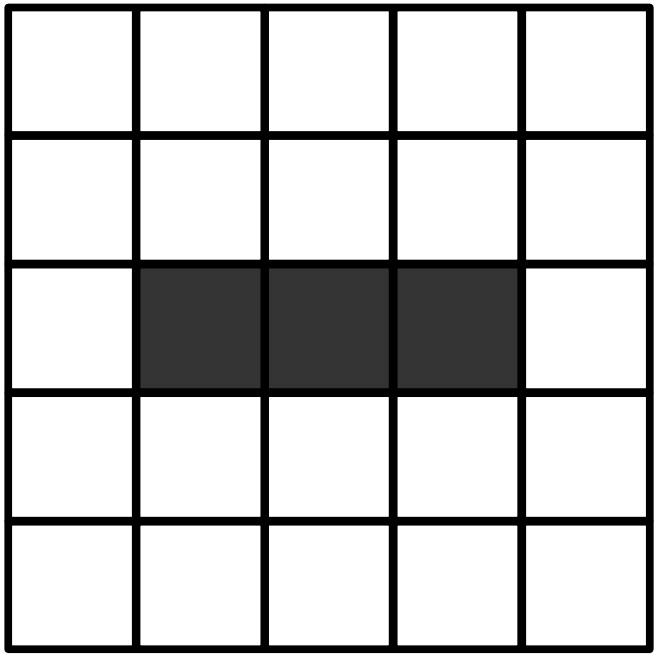
# Example 3: time step 0



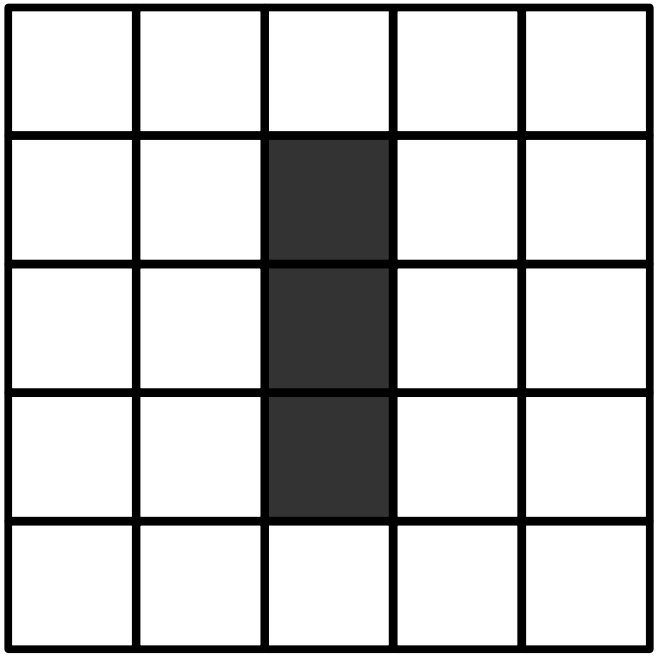
# Example 3: time step 1



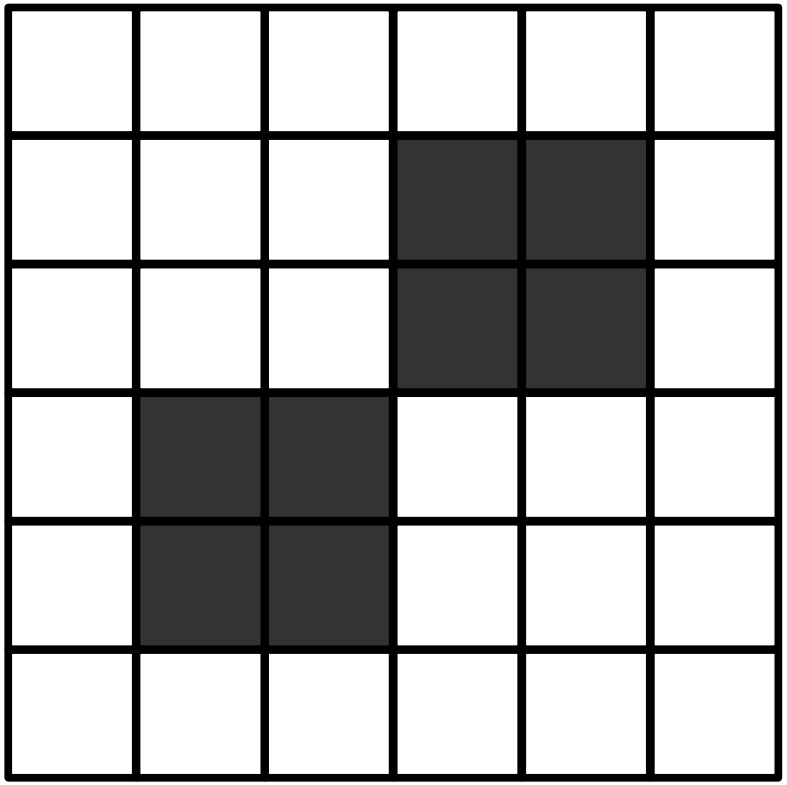
# Example 3: time step 2



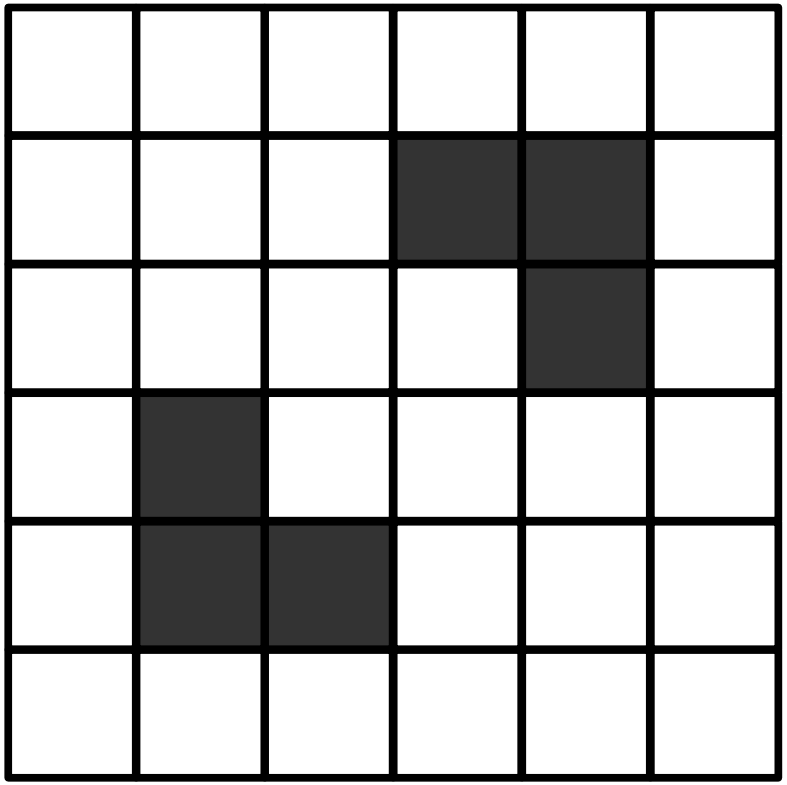
# Example 3: time step 3



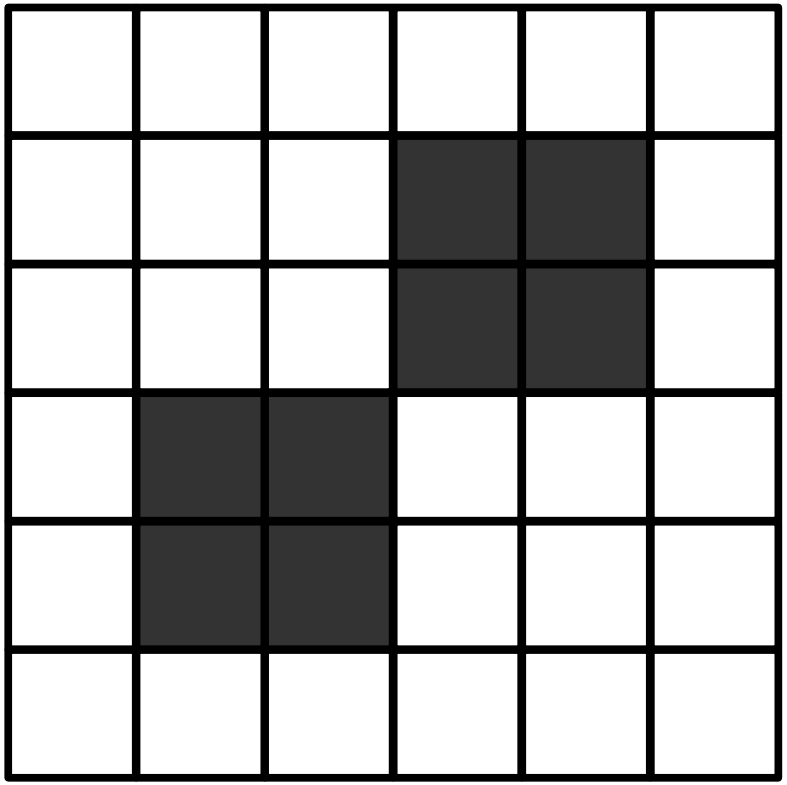
# Example 4: time step 0



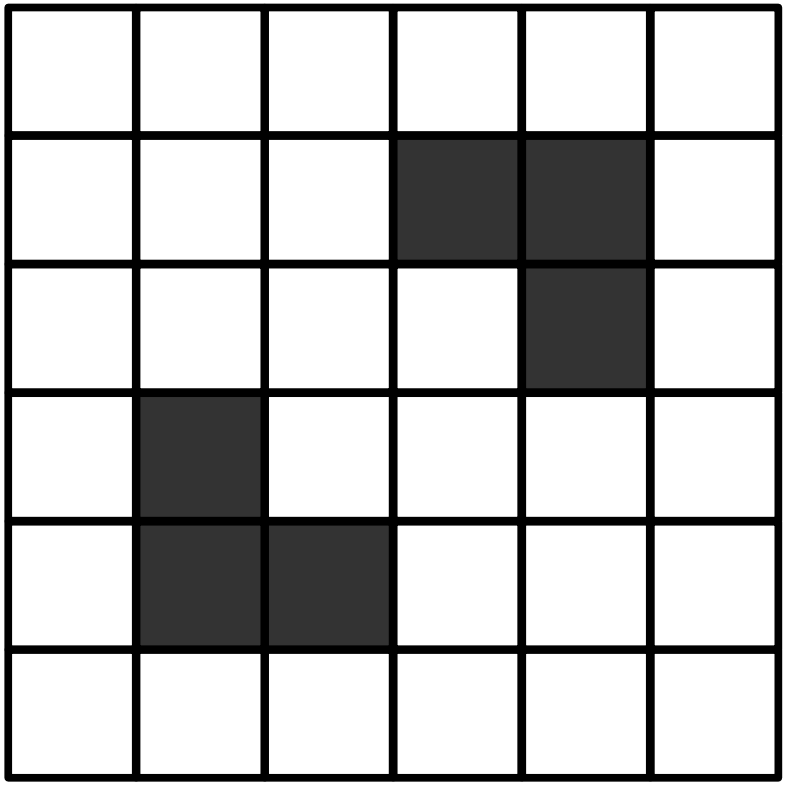
# Example 4: time step 1



# Example 4: time step 2



# Example 4: time step 3



# In Preparation for Lab Tomorrow

Download **Golly** simulator from

**http://golly.sourceforge.net**

Latest version is 3.3

My version is 2.8