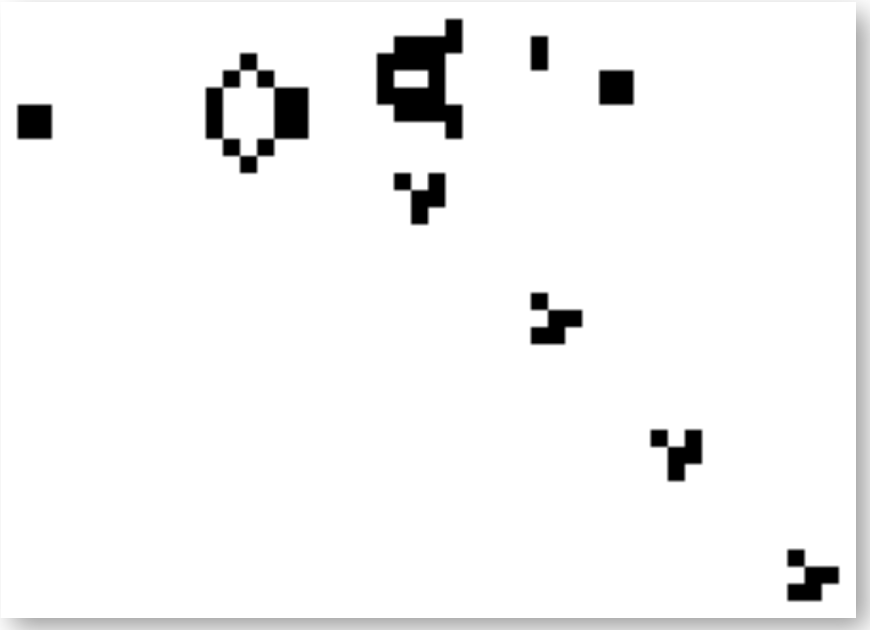
GAME OF LIFE

Game of Life

The **Game of Life**, also known simply as **Life**, was devised by the British mathematician John Horton Conway in 1970, and is an example of a ***cellular automaton***

The "game" is a **zero-player** game, meaning that its evolution is determined by its **initial state**, requiring no further input from humans.

One interacts with the Game of Life by creating an initial configuration and observing how it evolves.



Gosper's Glider Gun creating "gliders"

image after
http://en.wikipedia.org/wiki/Conway's_Game_of_Life#cite_note-0

game of life is a kind of **cellular automata**

- A **cellular automaton** is a collection of "colored" cells on a grid of a specified shape that evolves through a number of discrete time steps according to a set of rules based on the states of neighboring cells.

a digression into **cellular automata**

- **complex systems** consisting of many and similar parts
- behavior of any single part is clearly understood but the behavior of the whole **defies** simple explanation
- real phenomena

complex systems

- autocatalytic chemical sets
- cellular regulation - gene excitation and inhibition
- **statistical mechanical** systems
- multi-cellular animals
- super organism collectives:
    - ant colony, bee hives, flock of birds, school of fish, oceanic reef
    - ecosystems, economies, societies

cellular automata CA

- dynamic system that is discrete in space and time
- CA exhibit a range of behavior from
- order

  simple fixed point dynamics

  periodic limit cycles
- edge of chaos

  where true computation is possible
- chaos

history

invented by **von Neumann** with help from **Stanislaw Ulam**

– further developed by **Stephen Wolfram**

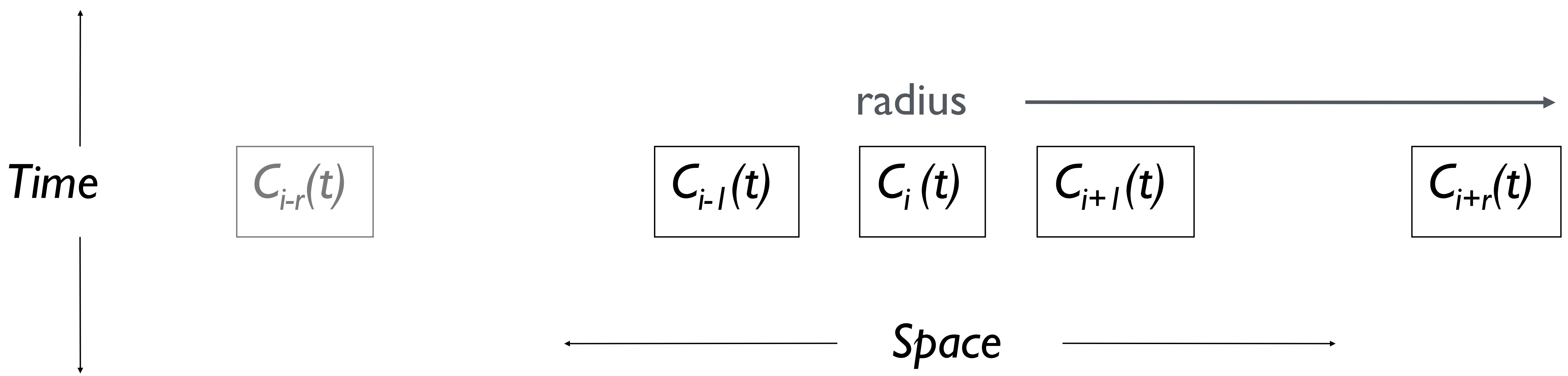
a two-dimensional CA is equivalent to a

Turing machine and hence capable of

universal computation

one dimensional CA

Linear grid of cells extending to the left and right, where each cell is in one of a finite number of states and at each time step, the next state of the cell is a function of the states of its local neighborhood in space



ca rule

Radius r=1, States k=2

k^{2r+1}

States

$C_{i-1}(t)$	$C_i(t)$	$C_{i+1}(t)$	$C_i(t+1)$
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

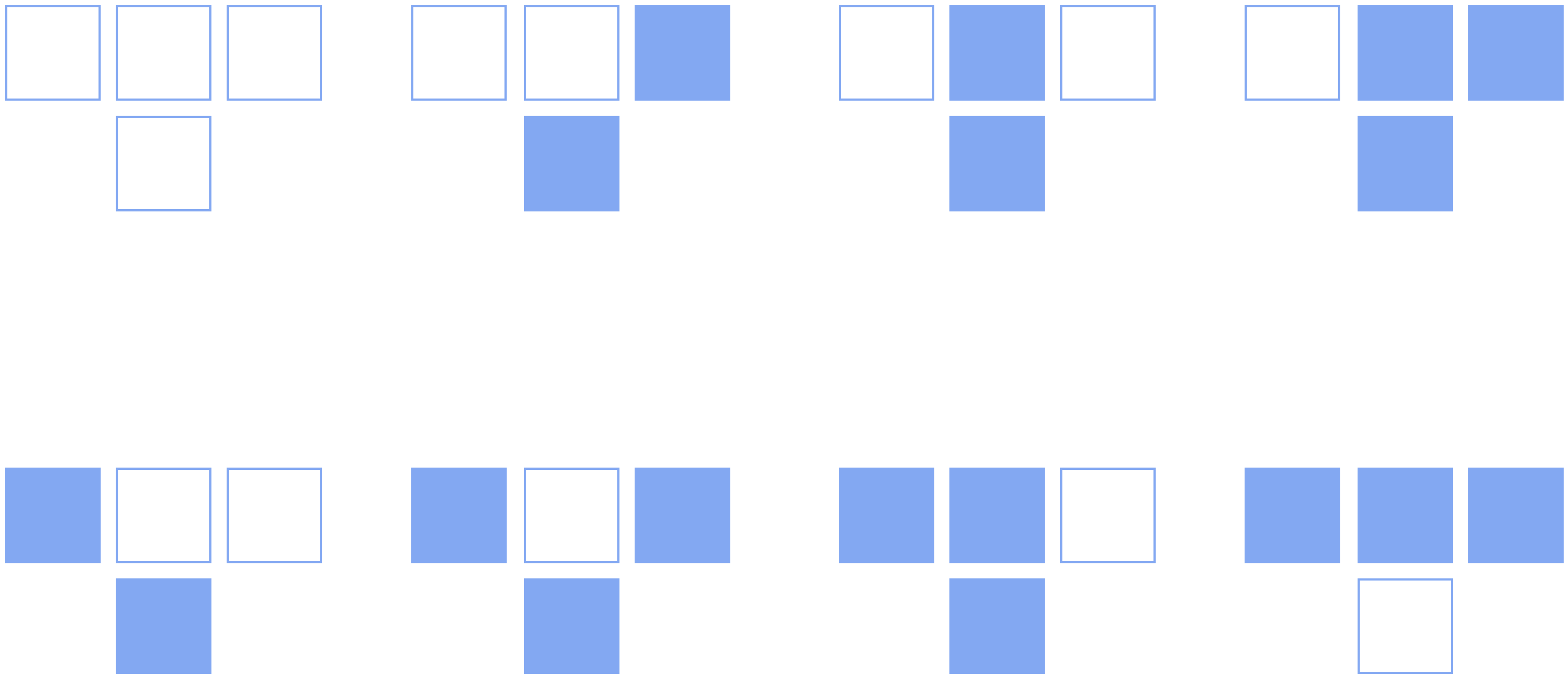
simplifying a ca rule

- as ***r*** and ***k*** get larger the number of entries in a rule get exponentially larger
- "If neighborhood cells are all off or all on, next state is off, otherwise next state is on"
- The next state is 1 iff the sum of the states in a neighborhood is 1 or 2
- representing all states using $k^{(2r+1)}$ digits 0110
- easier to implement on a machine

Initial state

- usually has a starting pattern, which can be randomly assigned
- what happens at the boundary?
- common convention is wrap the ca about the boundary

graphical view of a ca rule

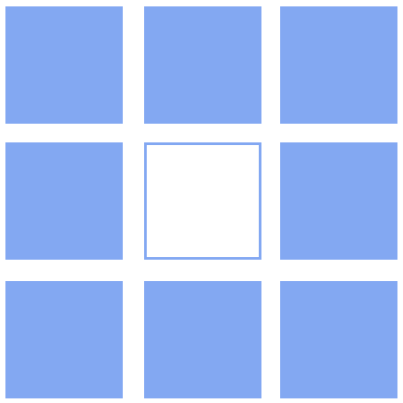


BACK TO THE GAME OF LIFE

conway's game of life

The universe of the **Game of Life** is an infinite **two-dimensional orthogonal grid** of square cells,

- ✳ each cell is in a binary state (**life** or **death**)
- ✳ each cell has **eight** neighbors



- ✳ **Rules** of Life deal with - **loneliness • overcrowding • reproduction • stasis**

to go from **this state** to the **next** state is a function of a cell's neighbors

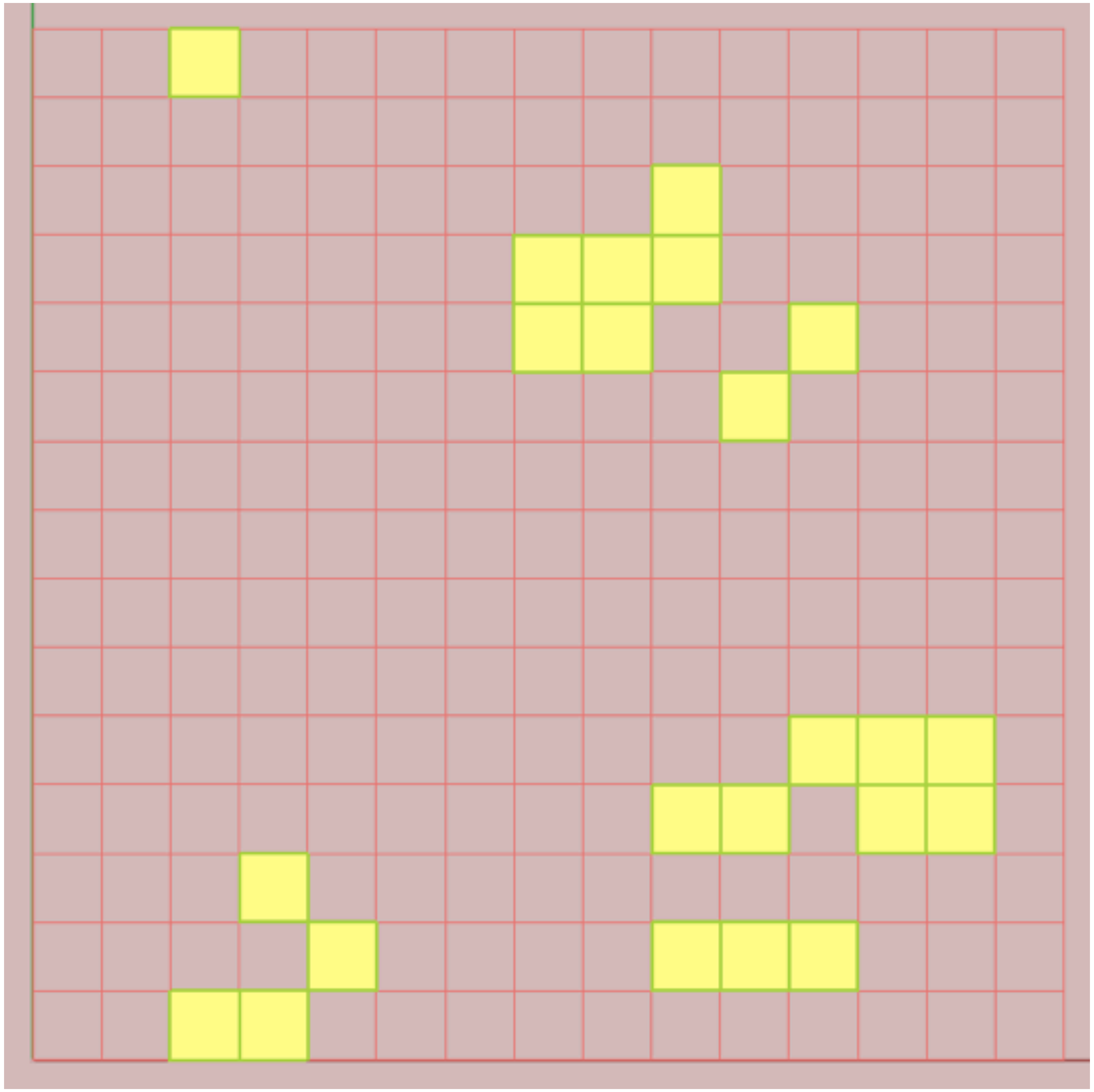
Rules of Life

At **each step** in **time**, the following **transitions** occur:

1. Any **live** cell with fewer **than two** live neighbors **dies**, as if caused by ***loneliness***.
2. Any **live** cell with **more than three** live neighbors **dies**, as if by ***overcrowding***.
3. Any **live** cell with **two or three live neighbors** remains **live** for the next generation (***stasis***)
4. Any **dead** cell with **exactly three live neighbors** becomes a **live** cell, as if by ***reproduction***
5. For every other condition a **dead** cell remains **dead** for the next generation (***stasis***)

Start with a **random** configuration

example-Game of Life



rules

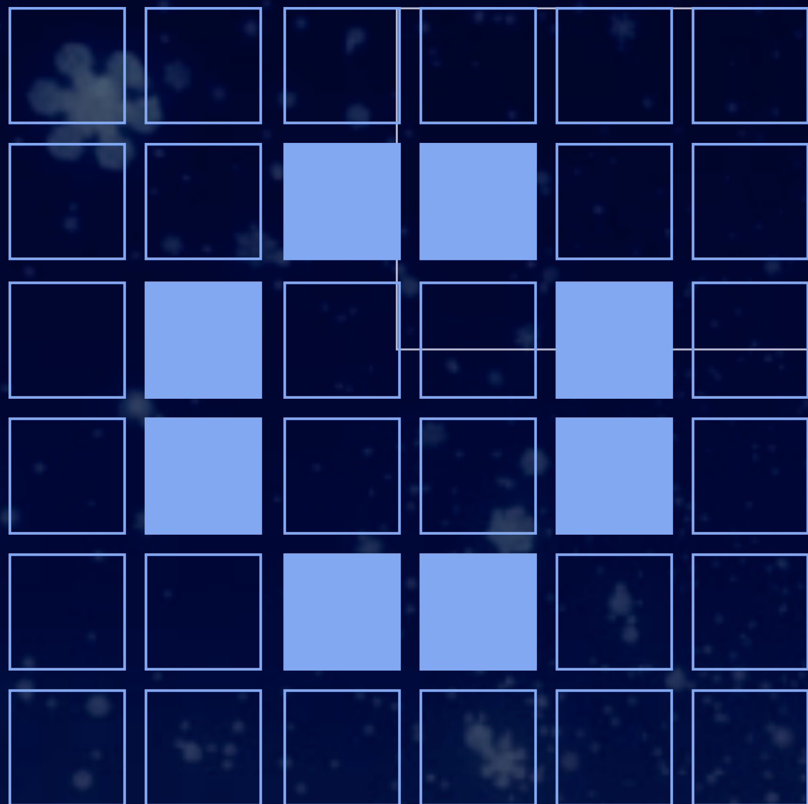
cell c • n live neighbors

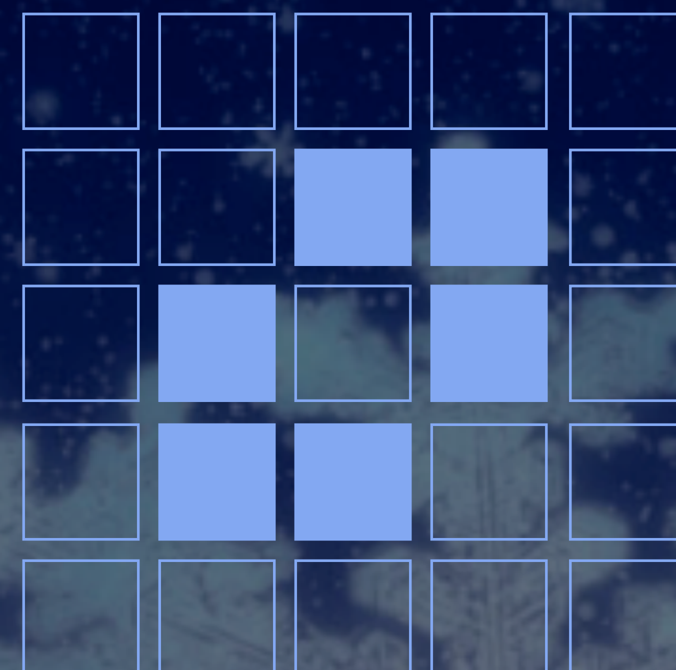
- if live c & n< 2 - c dies (loneliness)
- if live c & n > 3 - c dies (overcrowding)
  - if empty c & n = 3 - c comes alive (reproduction)
  - otherwise (n=2) - c stays as is (stasis)

- start with a random configuration

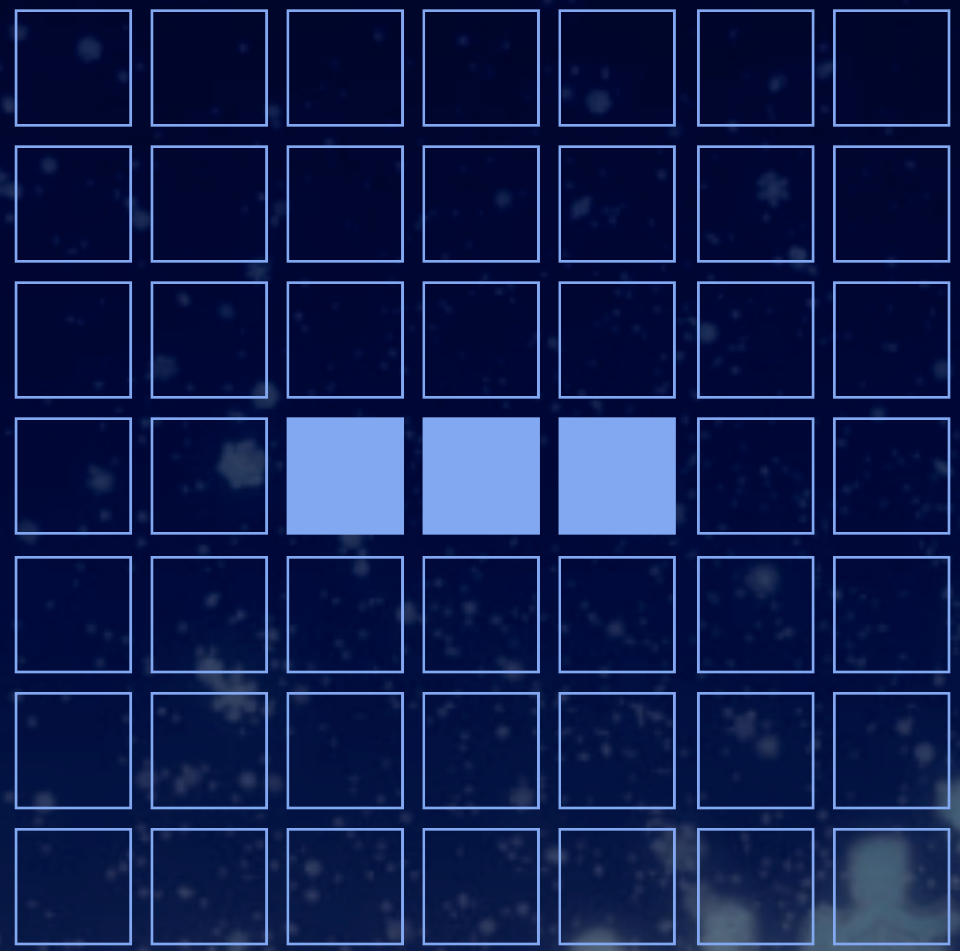
static objects

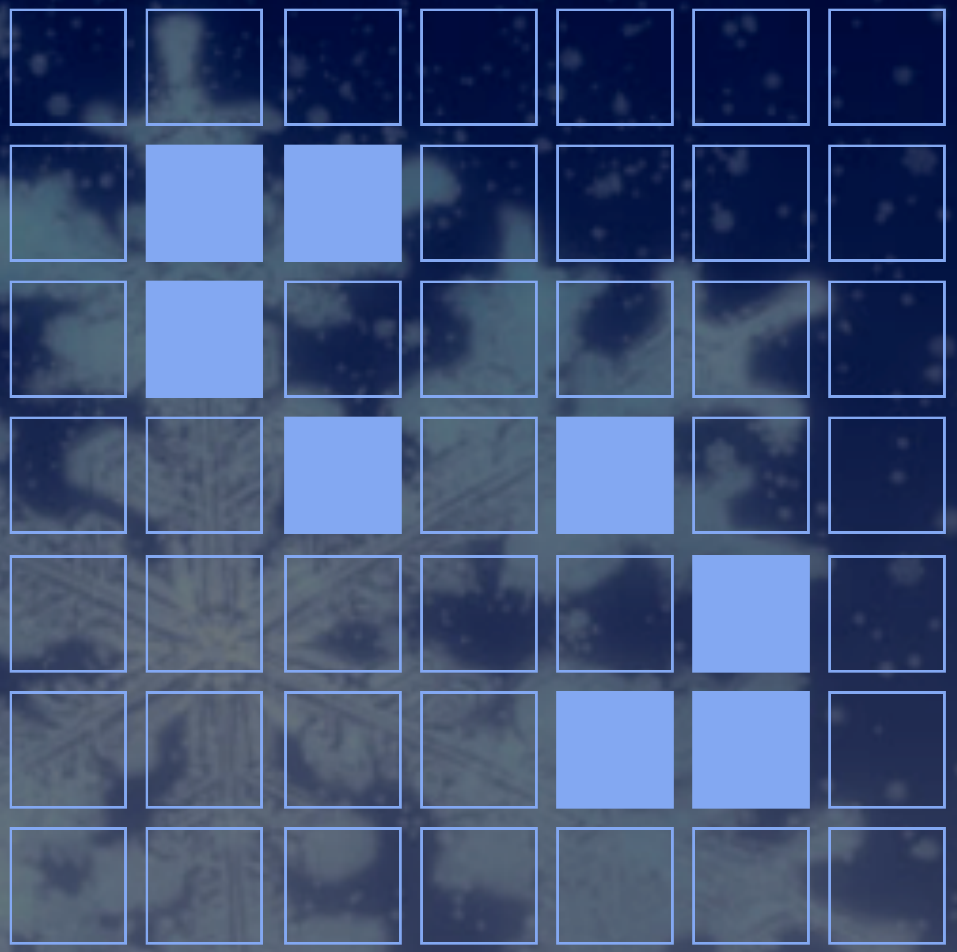
in the game of life





periodic objects
in the game of life

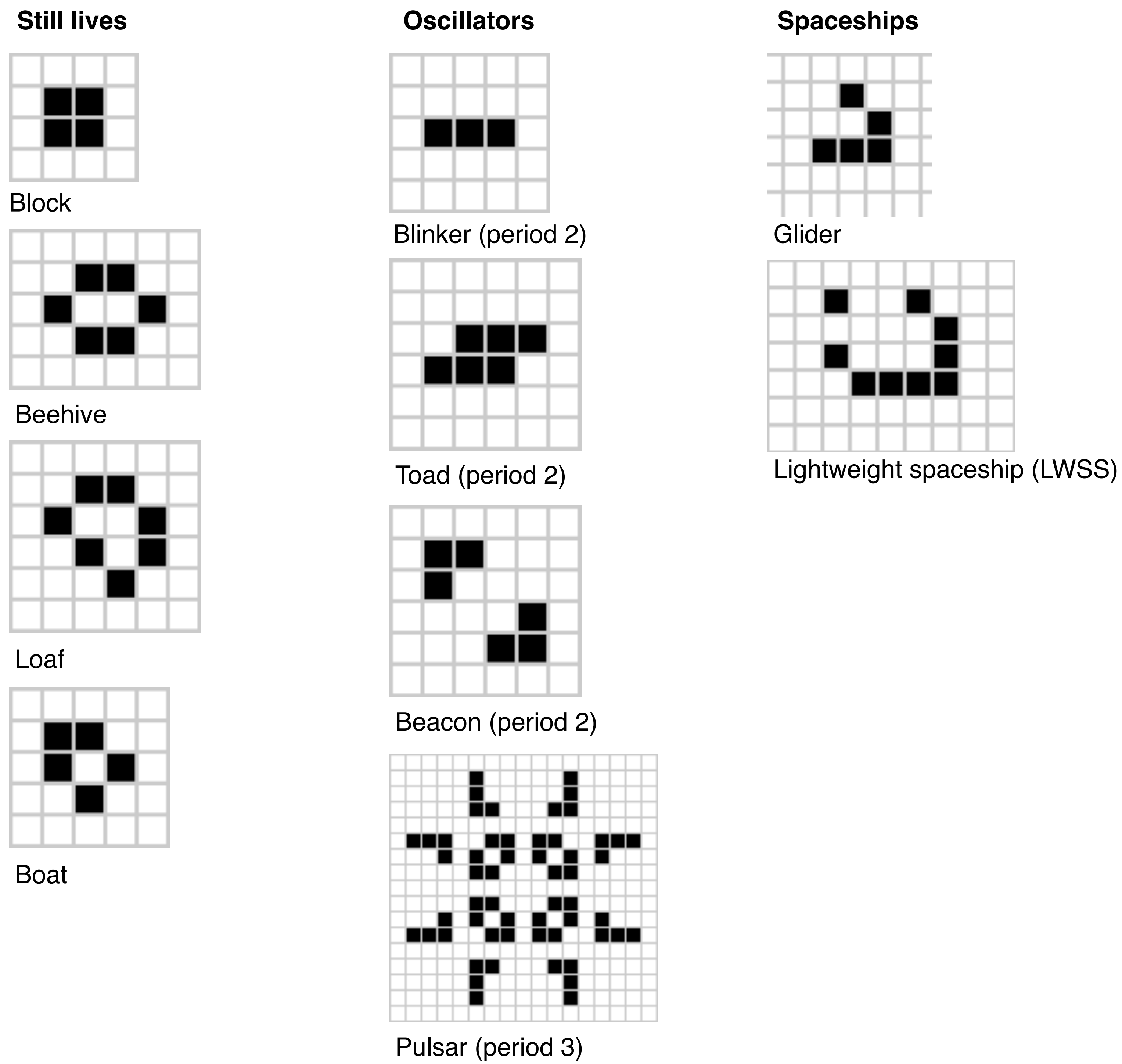




moving objects

in the game of life

patterns of Life



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