

Celebration of Mind talk: October 2023

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Martin Gardner (1914-2010)

Scientific American – Mathematical Games column

- 1956-1981 (297 monthly columns)

Books:

- Mathematical Games
- Word puzzles
- Annotated Alice
- Books on pseudoscience and skepticism



Today's presentation:

“The Game of Life”

An interesting “computer game”

Devised by Prof. John Horton Conway in 1970

- Lecturer at Cambridge (1964-1986)
- Professor at Princeton (1986-2010)

In the Game of Life, you have a 2-dimensional grid...
and you choose a “starting pattern” of Live cells:

```
- - - - -  
- - * * - -  
- * - - * -  
- * - - * -  
- - * * - -  
- - - - -
```

And there is a simple set of rules
to explain how the pattern
evolves over time

(No shooting, no characters, no
levels, no computer gaming
culture)

At each “turn,” new live cells are created, existing live cells either survive or are deleted, according to three rules:

1. Creating new live cells in empty spaces (Birth rule)

- An empty cell with precisely three “live” neighbors becomes live

2. Live cells can continue to live from one turn to the next (Survival rule)

- A live cell with two or three live neighbors remains alive

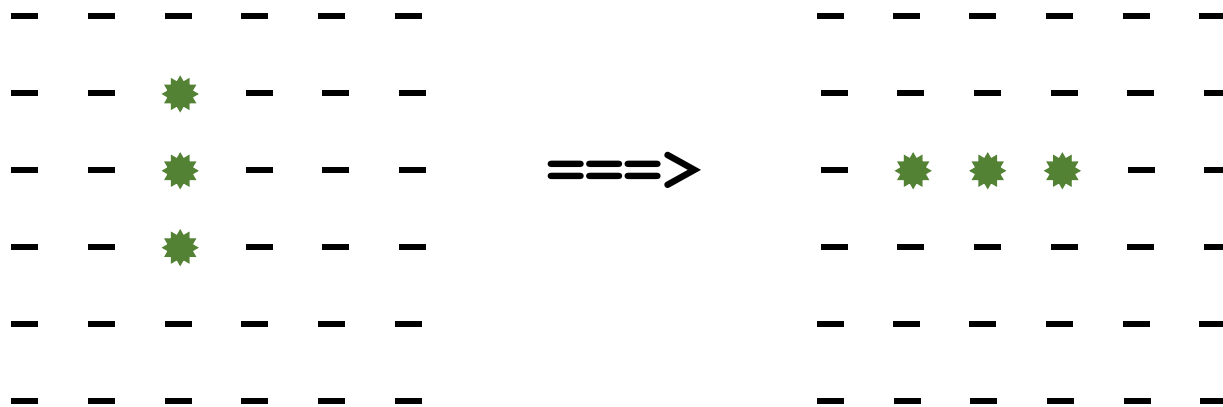
3. Live cells can be deleted (Death rule)

- A live cell with zero or one neighbors dies of isolation; a live cell with four or more neighbors dies of overcrowding

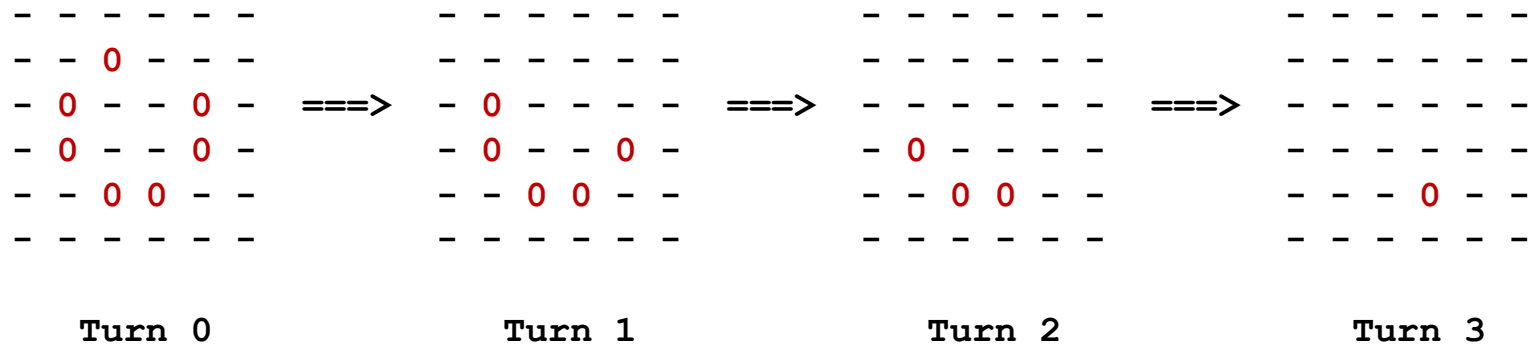
An empty cell with 3 live neighbors becomes live (birth)

A live cell with 2 or 3 neighbors stays alive (survival)

A live cell with 0, 1, or 4 or more neighbors dies (death)

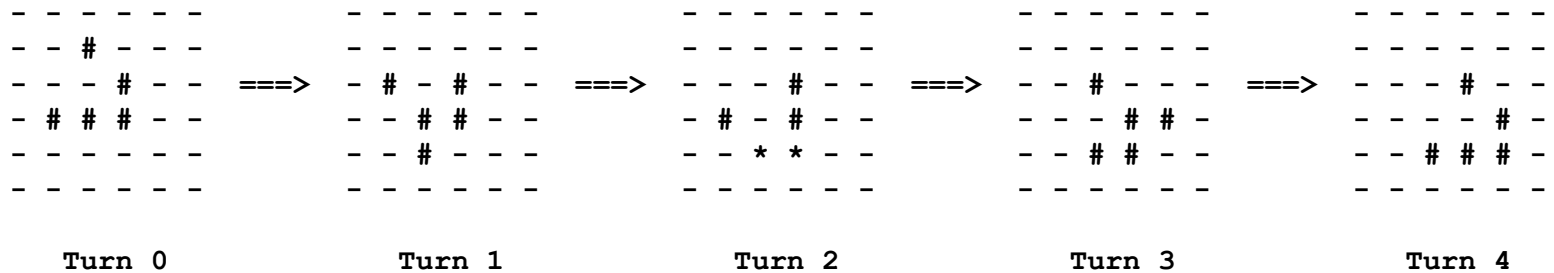


Some patterns just “disappear” – here is a simple example



The cells “at the ends” die because there is only one neighbor, the cells in the middle of the chain keep living because they have two neighbors

Some patterns are “gliders” – they regenerate the original pattern (but displaced)



After turn 4, the glider has moved down and to the right by one cell.

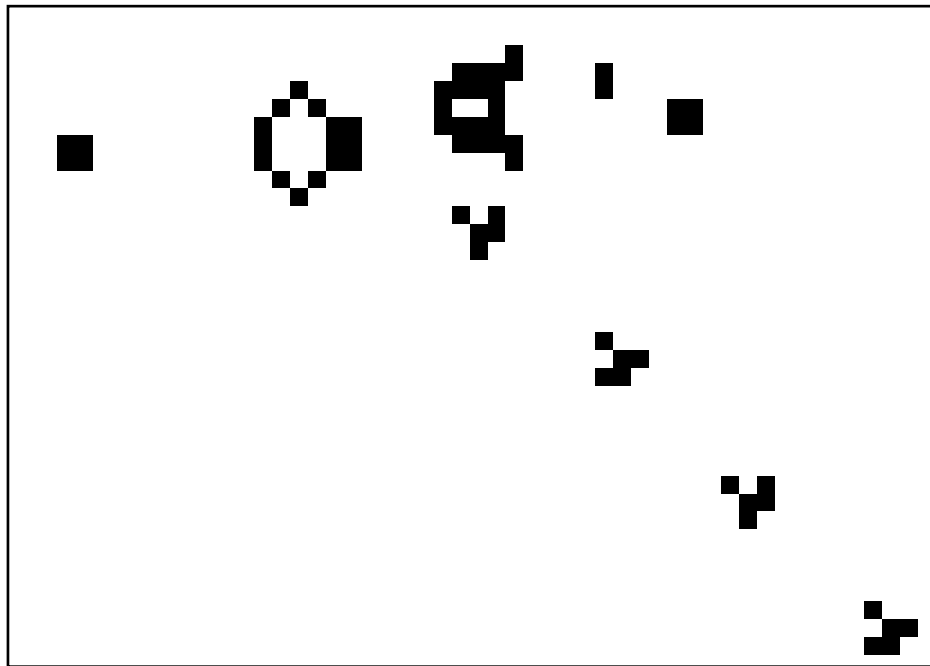
So what is the “game?”

It is a game of exploration – looking for “cool patterns”

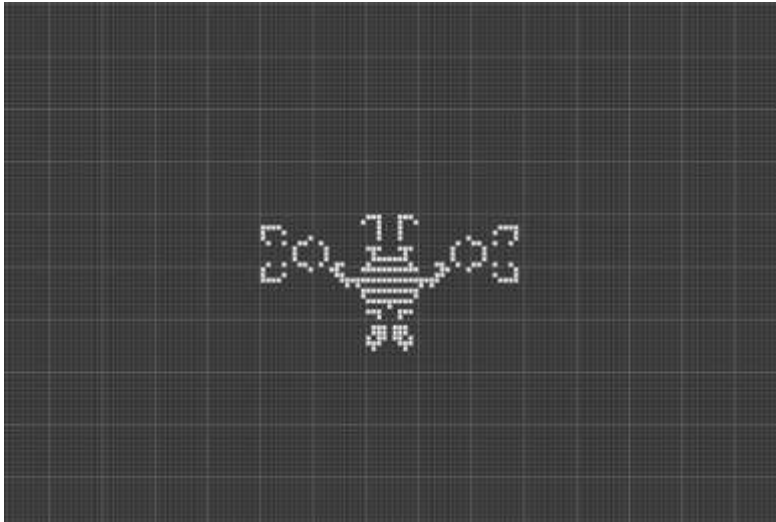
- Stable patterns
- Oscillations
- Gliders and Spaceships
- “Guns”
- “Space fillers”

What is a “gun?”

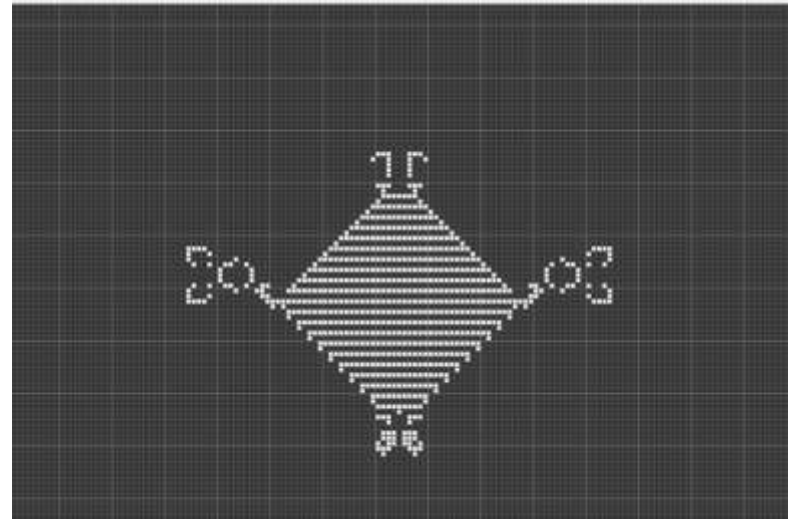
- A gun is a pattern that periodically generates a new glider or spaceship
- The first successful gun pattern: “Gosper’s Glider Gun”
(Bill Gosper, November 1970)



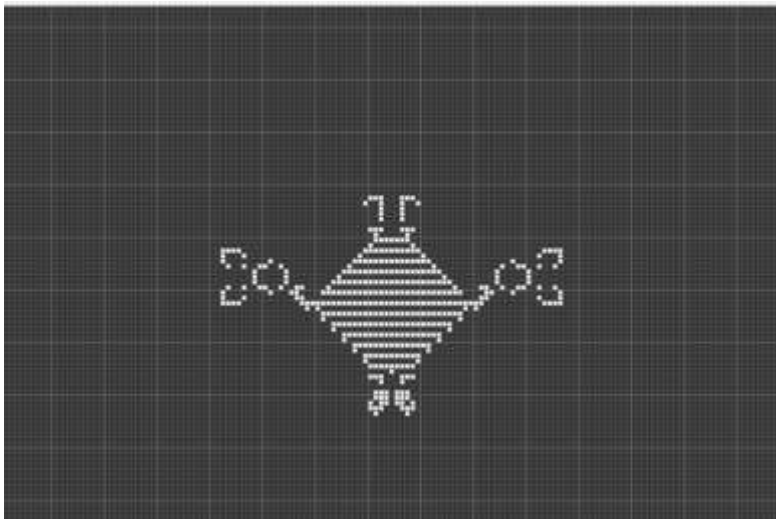
“Space fillers” – they just keep growing...



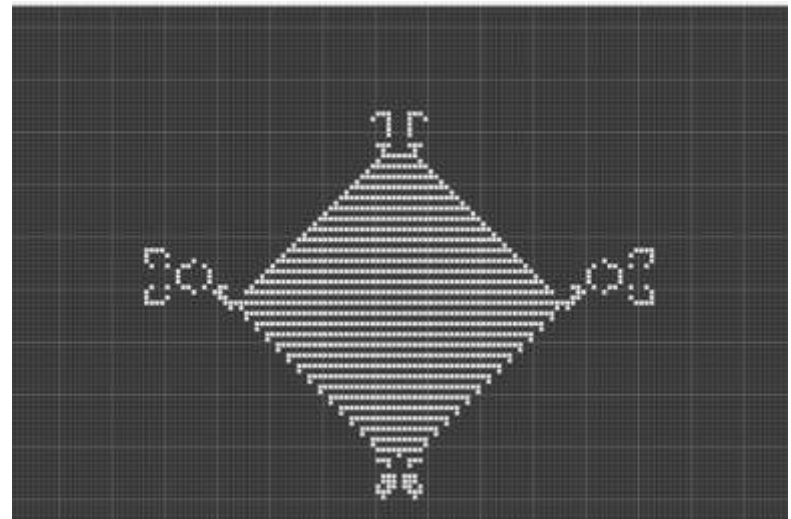
Turn 0



Turn 32



Turn 16



Turn 48

Conway's contribution

A simple set of rules...

A completely deterministic game (following the rules)

And... it isn't easy to analyze what happens to each pattern

It's a fun way to waste time...

- Back in the 1970s, we didn't have the Internet... couldn't waste time shopping or checking stock prices...
- But you could set up a Game of Life simulator on your fancy graphics terminal (if you were lucky enough to have one)

Young computer programmers learn to write a Game of Life simulator program

- A relatively easy program, but it uses 2-dimensional arrays
- Example: Coding the Game of Life in JavaScript:
 - A tutorial by Daniel Shiffman (Coding Train YouTube channel)
 - https://www.youtube.com/watch?v=FWSR_7kZuYg

Of course, there are many of good “open source” tools

LifeWiki

- https://conwaylife.com/wiki/Main_Page

Conway's Game of Life (2022 book by Nathaniel Johnston and Dave Greene)

- <https://conwaylife.com/book/>

Alan Zucconi's documentary on the 50th anniversary of the Game of Life

- <https://www.youtube.com/watch?v=Kk2MH9O4pXY>

Thoughts on Life – a film in progress by Will Cavendish (documentary about John Conway)

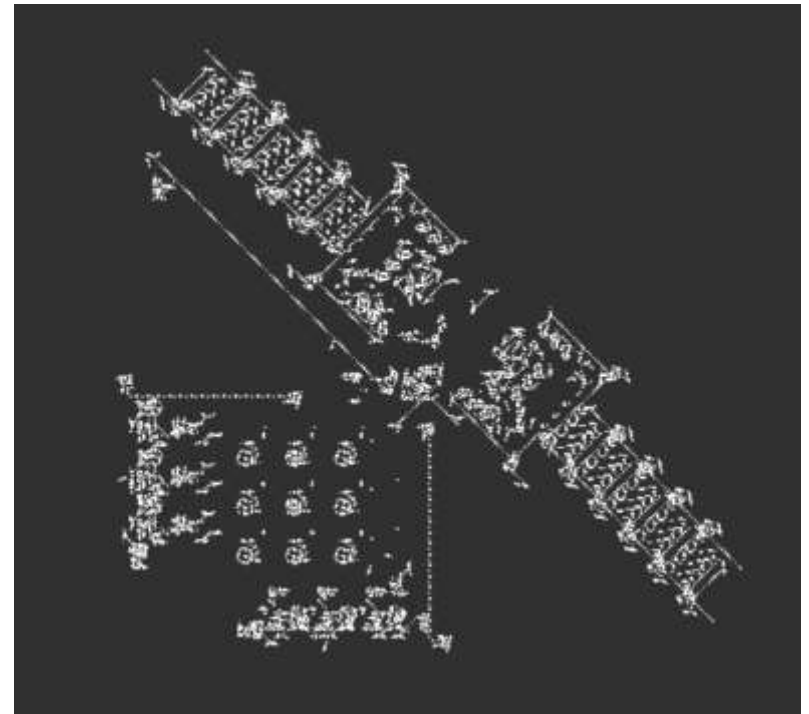
- <https://www.thoughtsonlifefilm.com>

What is going on today?

- “Game of Life research” has defined a way to build “a computer” within the Game of Life environment
- Glider guns are used to transmit a stream of data...
- Other Game of Life elements implement “gates” and “latches” – basic elements of computer logic

Yes, someone has implemented a full Turing Machine implementation within the Game of Life!

And... the Turing Machine can run a program that simulates the Game of Life...



More about John Horton Conway

Conway was involved in much more serious research in mathematics

- Many results in “group theory” (algebra)
- Knots
- Combinatorial game theory

Also, some interesting recreational math results

- Penrose tiles
- Surreal numbers (see the book by Donald Knuth)
- Doomsday algorithm

And... he said he hated the Game of Life for years... (he just thought people paid too much attention to it)

A good short interview with Conway:

- <https://www.youtube.com/watch?v=E8kUJL04ELA>

More information

- Martin Gardner wrote about The Game of Life in one of his regular Scientific American columns:
 - “Mathematical Games,” *Scientific American*, October 1970.
- Gardner’s articles on The Game of Life have reprinted and extended in other books:
 - *Wheels, Life, and Other Mathematical Amusements* (W. H. Freeman & Co., 1983)
 - https://maa.org/sites/default/files/pdf/pubs/focus/Gardner_GameofLife10-1970.pdf
- Conway biography:
 - *Genius at Play* by Siobhan Roberts (Bloomsbury USA, 2015)



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