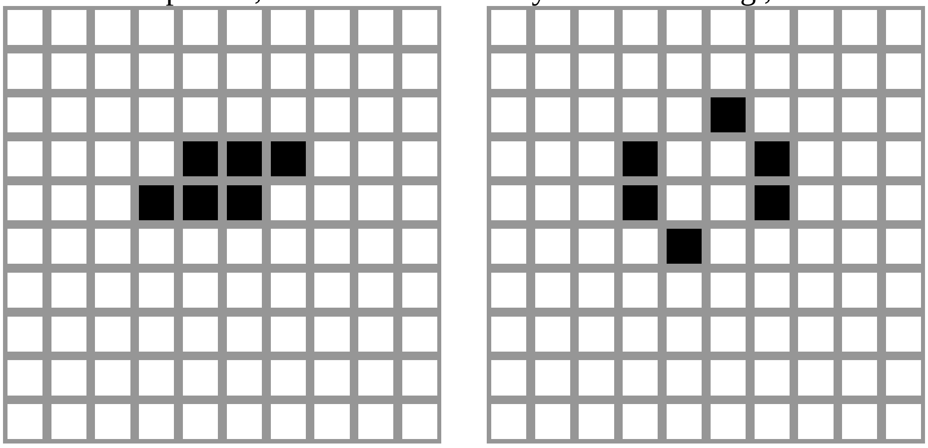
Conway's Game of Life

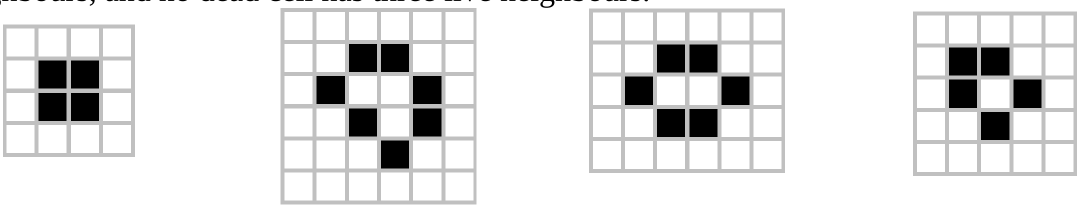
The rules:

1. Start with a square grid of “cells”, each of which is “alive” or “dead”.
2. At each step, we count the number of each cells neighbours that are alive, and
    1. any live cell with fewer than 2 live neighbours dies
    2. any live cell with more than three neighbours dies
    3. any live cell with 2 or 3 live neighbours lives on
    4. any dead cell with exactly three live neighbours becomes alive, and otherwise stays dead

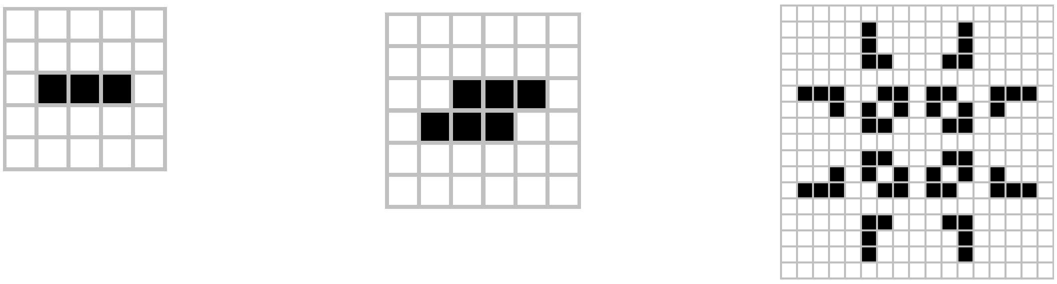
We start with some initial pattern, and then watch the system evolve: e.g.,



The interesting thing is how much variety such simple rules can create. For instance, the following are “still lives” that don't change once formed. We can see that each of the live cells has 2 or 3 live neighbours, and no dead cell has three live neighbours.



These are “oscillators” – they go through a series of steps, and get back to the starting pattern, and then repeat:



We can't (easily) see them oscillate on paper, so we will use some software to simulate life. There are various choices. Today we are using

GameOfLife – http://www.bitstorm.org/gameoflife/standalone/

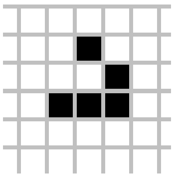
golly – http://golly.sourceforge.net/

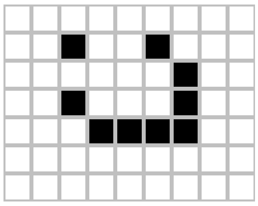
Another good one is

Winlife32 – http://www.winlife32.com/

Try out the examples above to see that they work. Then play around and create some of your own patterns. Some patterns die out, some settle down to oscillate, and some evolve forever.

Some of the more remarkable patterns are the “gliders”and “spaceships” that move along. Try these two:

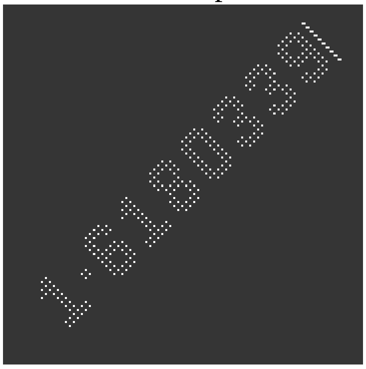




There are many amazing patterns that can be created, e.g.,
1. the F-pentomino – a simple pattern that creates great complexity;
2. glider guns – a pattern that creates gliders repeatedly;
3. logic-gates, for instance to simulate binary logic such as used in computers;
4. self-replications – much as in real “life” where organisms reproduce.

Its now known that the game of life can be used to replicate all the functions of a general computing device called a Turing machine, although it might not be very efficient. So we can do anything with this simple game that you can do on a computer, if you are clever enough.

Perhaps the most amazing pattern to date is one that prints out the value of π or the golden ratio ϕ.



Why study “life”?

Apart from being fun, the game of life is a special case of a cellular automaton. They illustrate a basic principle that complex, large-scale behaviour (e.g., life) can arise from simple local rules. The behaviour isn't random, but it isn't easy to predict either. These automata have been used to study
1. crystal formation
2. pattern formation, for instance on sea shells
3. insect colonies
4. economic systems

and anything else that can be modelled as a large number of simple “agents” that interact to create complex results.

People have even suggested that the fundamental physics of the Universe might be based on a cellular automaton.

There are many variations, and a huge literature on the Game of Life and its relatives. More information can be found in many places, but here are some starting points:

http://www.conwaylife.com/wiki/Conways_Game_of_Life
http://www.radicaleye.com/lifepage/
http://www.conwaysgameoflife.net/
http://www.ibiblio.org/lifepatterns/