Generative art

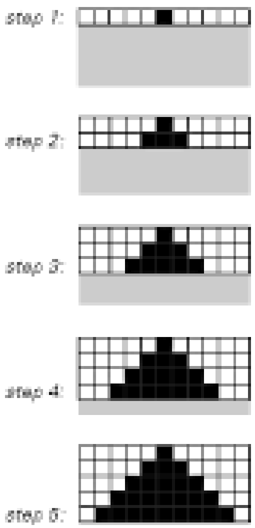
Cellular Automata
Genetic Algorithms

Cellular Automata

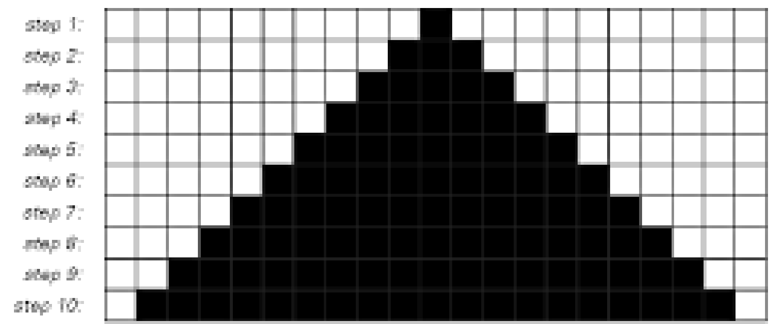
Stephen Wolfram: A New Kind of Science,
Chapter 2 The Crucial Experiment

http://www.wolframscience.com/nksonline/toc.html

An important feature of cellular automata is that their behavior can readily be presented in a visual way. And so the picture below shows what one cellular automaton does over the course of ten steps.

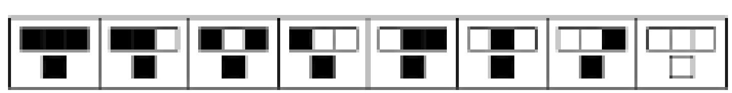


A visual representation of the behavior of a cellular automaton, with each row of cells corresponding to one step. At the first step the cell in the center is black and all other cells are white. Then on each successive step, a particular cell is made black whenever it or either of its neighbors were black on the step before. As the picture shows, this leads to a simple expanding pattern uniformly filled with black.

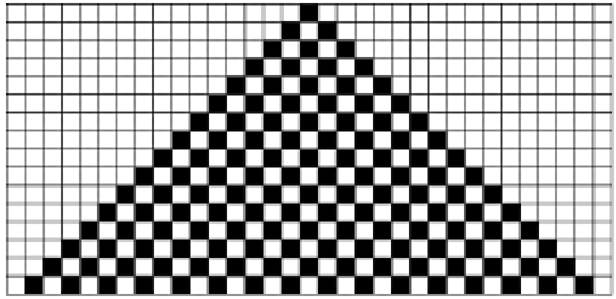


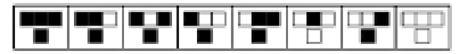
The cellular automaton consists of a line of cells, each colored either black or white. At every step there is then a definite rule that determines the color of a given cell from the color of that cell and its immediate left and right neighbors on the step before.

For the particular cellular automaton shown here the rule specifies—as in the picture below—that a cell should be black in all cases where it or either of its neighbors were black on the step before.



A representation of the rule for the cellular automaton shown above. The top row in each box gives one of the possible combinations of colors for a cell and its immediate neighbors. The bottom row then specifies what color the center cell should be on the next step in each of these cases. In the numbering scheme described in Chapter 3, this is cellular automaton rule 254.

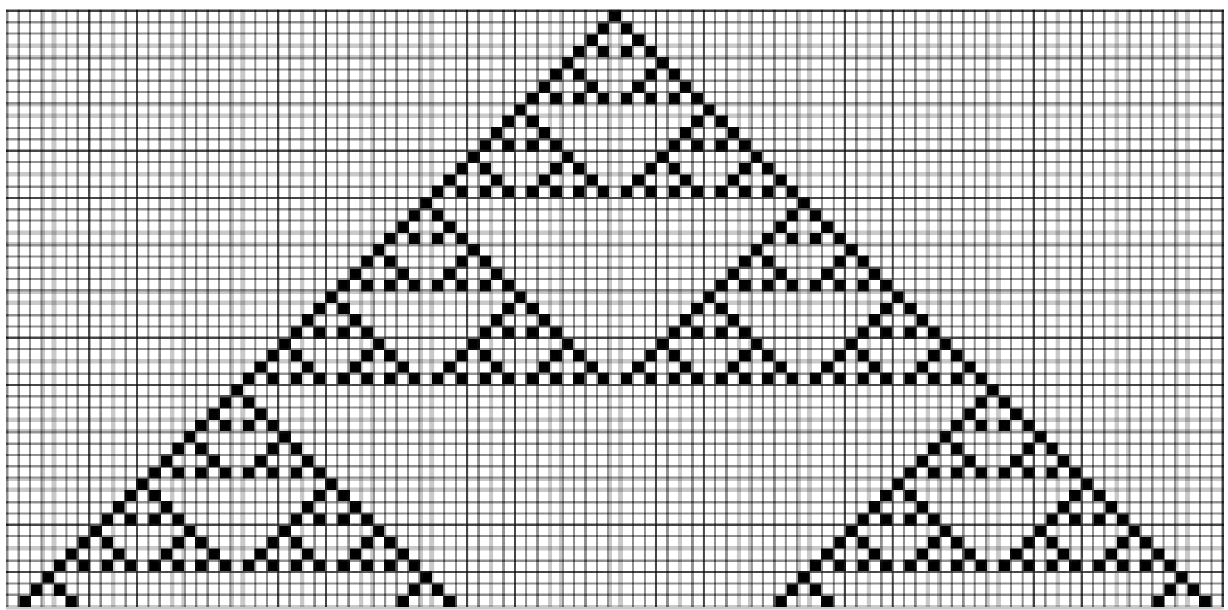




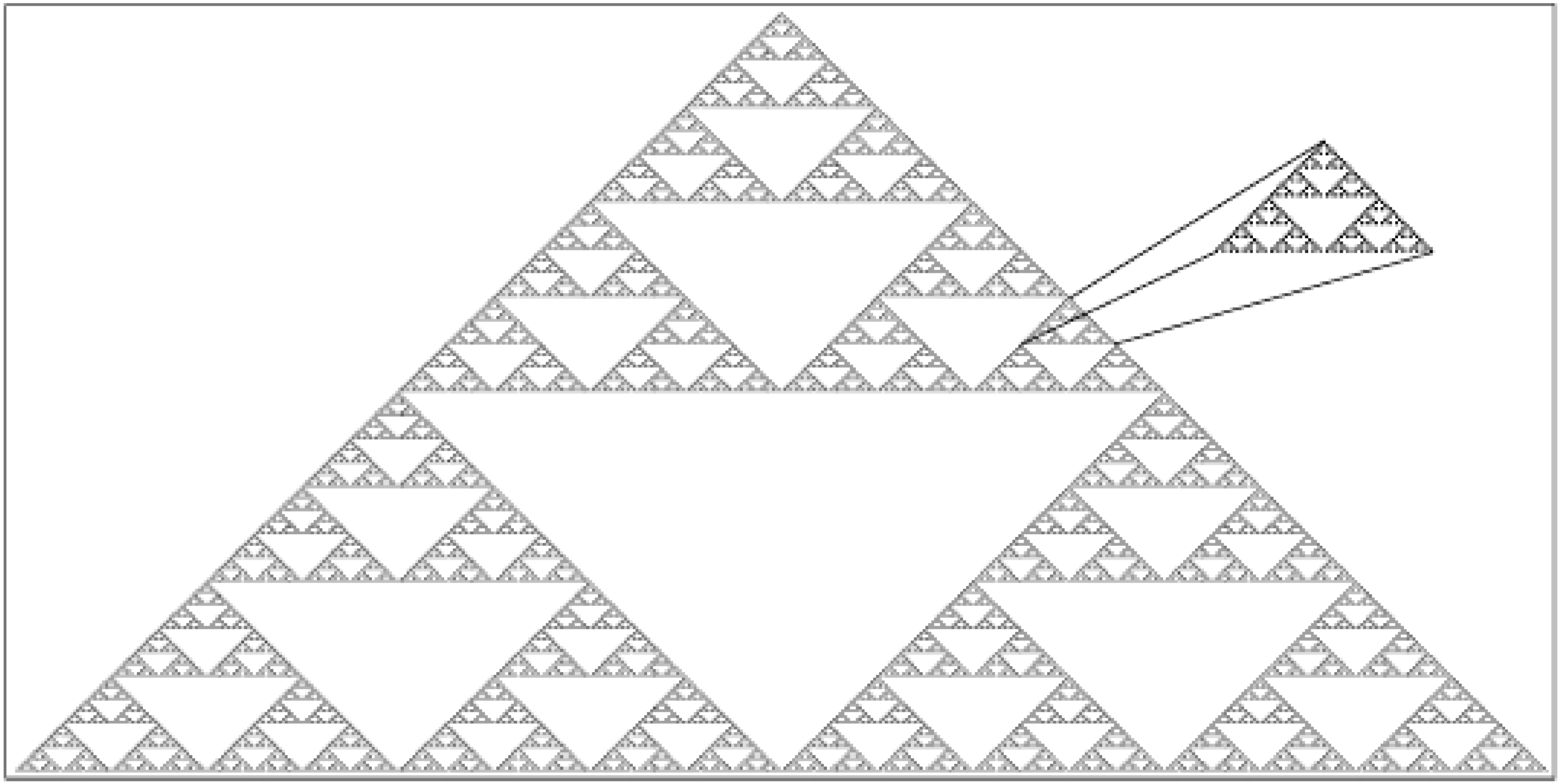
A cellular automaton with a slightly different rule. The rule makes a particular cell black if either of its neighbors was black on the step before, and makes the cell white if both its neighbors were white. Starting from a single black cell, this rule leads to a checkerboard pattern. In the numbering scheme of Chapter 3, this is cellular automaton rule 250.

This pattern is however again fairly simple. And we might assume that at least with the type of cellular automata that we are considering, any rule we might choose would always give a pattern that is quite simple. But now we are in for our first surprise.

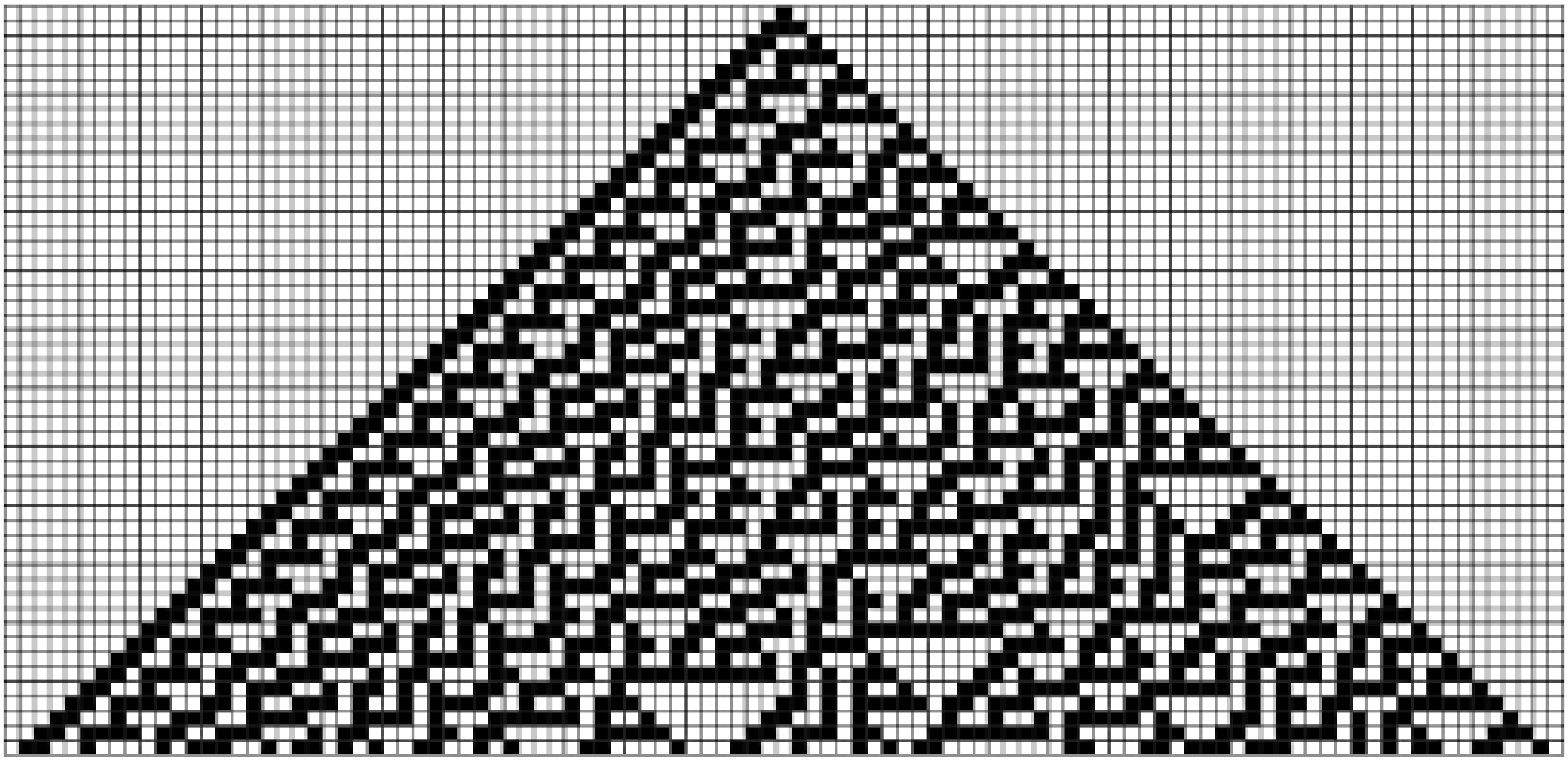
The picture below shows the pattern produced by a cellular automaton of the same type as before, but with a slightly different rule.

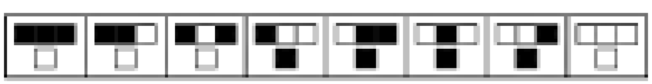


A cellular automaton that produces an intricate nested pattern. The rule in this case is that a cell should be black whenever one or the other, but not both, of its neighbors were black on the step before. Even though the rule is very simple, the picture shows that the overall pattern obtained over the course of 50 steps starting from a single black cell is not so simple. The particular rule used here can be described by the formula $a_i' = Mod[a_{i-1} + a_{i+1}, 2]$. In the numbering scheme of Chapter 3, it is cellular automaton rule 90.

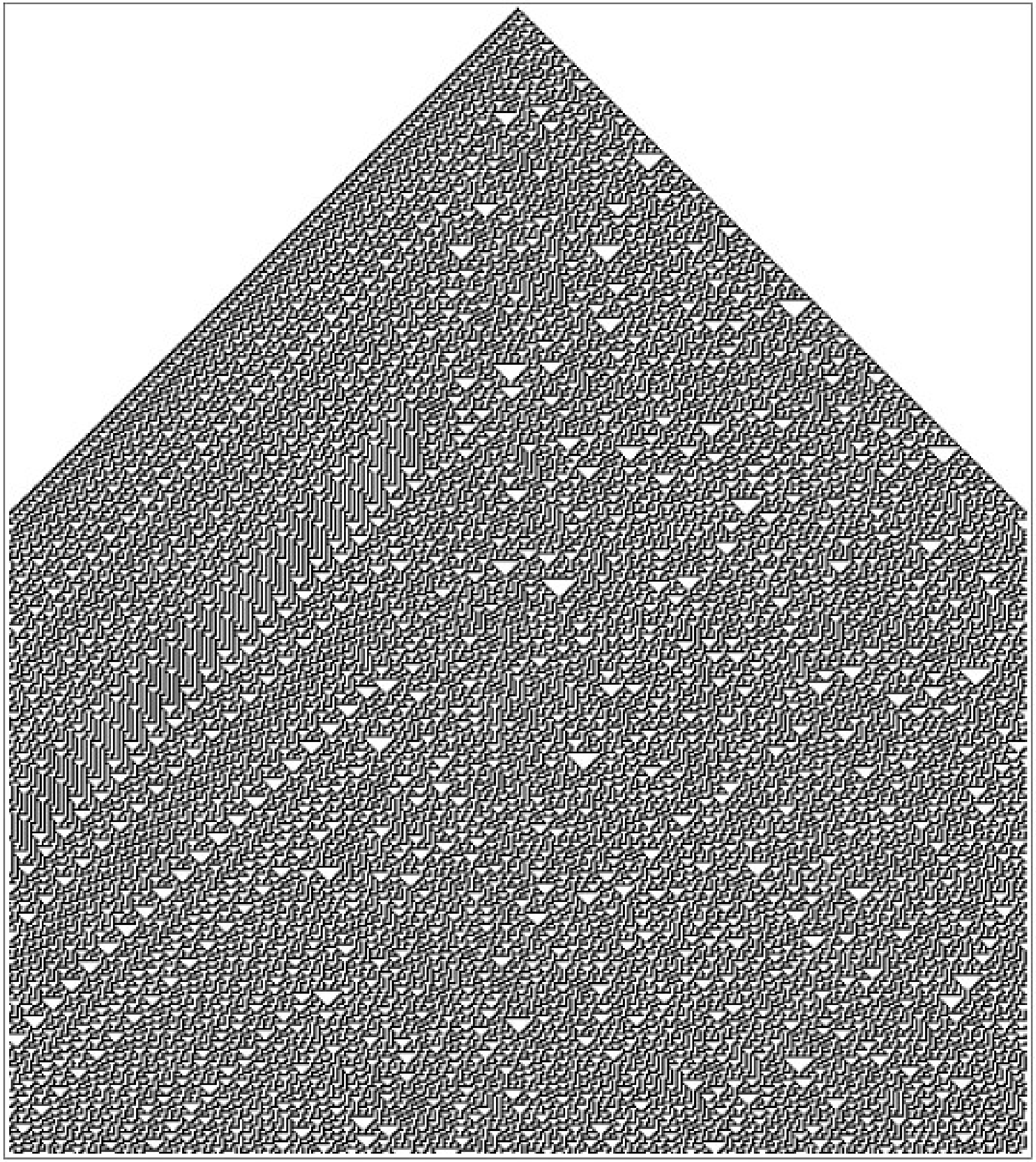


A larger version of the pattern from the previous page, now shown without a grid explicitly indicating each cell. The picture shows five hundred steps of cellular automaton evolution. The pattern obtained is intricate, but has a definite nested structure. Indeed, as the picture illustrates, each triangular section is essentially just a smaller copy of the whole pattern, with still smaller copies nested inside it. Patterns with nested structure of this kind are often called "fractal" or "self-similar".

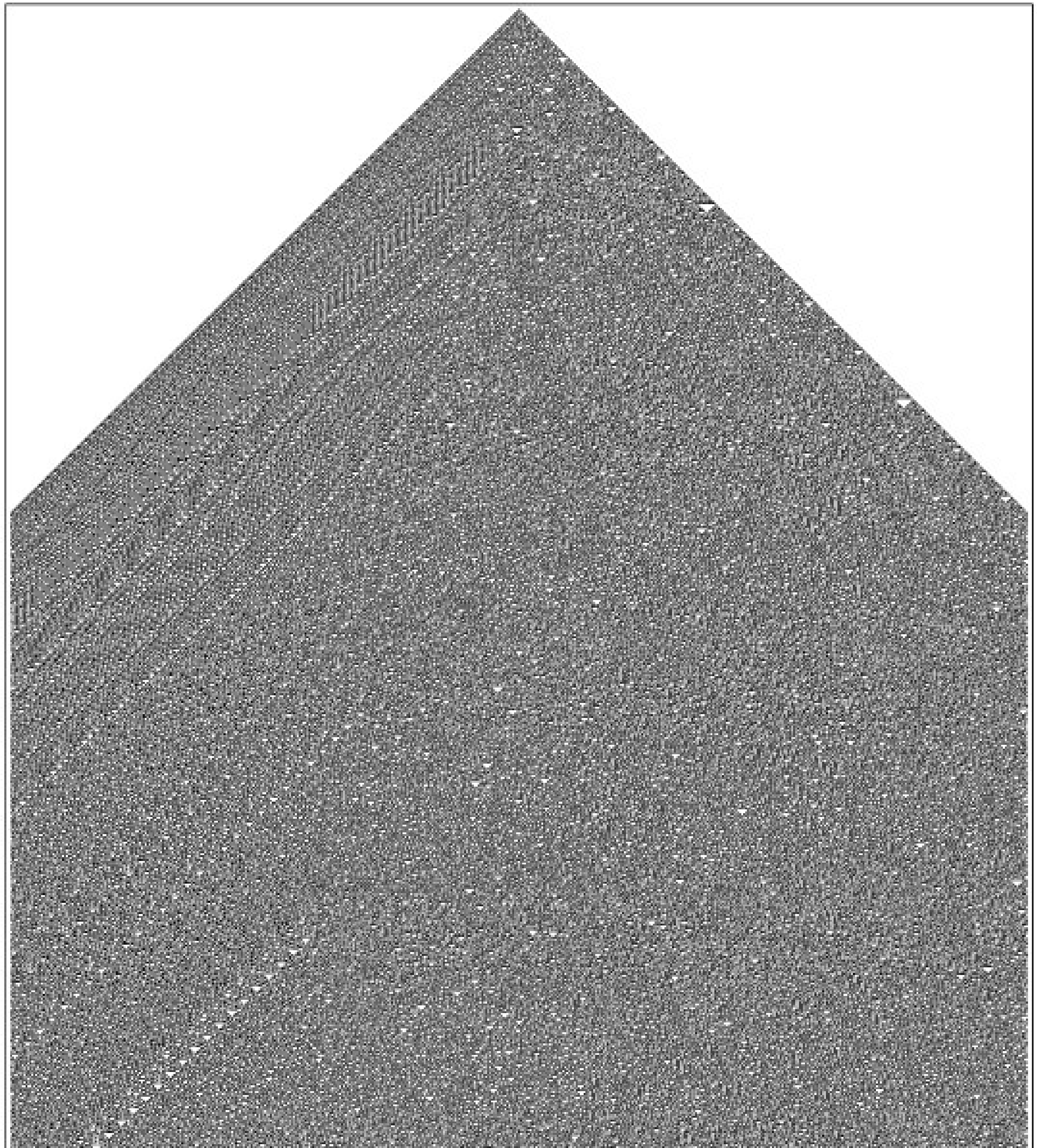




A cellular automaton with a simple rule that generates a pattern which seems in many respects random. The rule used is of the same type as in the previous examples, and the cellular automaton is again started from a single black cell. But now the pattern that is obtained is highly complex, and shows almost no overall regularity. This picture is our first example of the fundamental phenomenon that even with simple underlying rules and simple initial conditions, it is possible to produce behavior of great complexity. In the numbering scheme of Chapter 3, the cellular automaton shown here is rule 30.



Five hundred steps in the evolution of the rule 30 cellular automaton from page 27. The pattern produced continues to expand on both left and right, but only the part that fits across the page is shown here. The asymmetry between the left and right-hand sides is a direct consequence of asymmetry that exists in the particular underlying cellular automaton rule used.



Fifteen hundred steps of rule 30 evolution. Some regularities are evident, particularly on the left. But even after all these steps there are no signs of overall regularity—and indeed even continuing for a million steps many aspects of the pattern obtained seem perfectly random according to standard mathematical and statistical tests. The picture here shows a total of just under two million individual cells.

Genetic Algorthims

Richard Dawkins' weasel program

HTML/Javascript version of weasel

Biomorphs applet

The Blind Watchmaker

http://en.wikipedia.org/wiki/The_Blind_Watchmaker

Weasel Program

The Dawkins' weasel is a thought experiment and a variety of computer simulations illustrating it.

They clarify that the process that drives evolutionary systems

— random variation combined with non-random cumulative selection —

is different from pure chance.

In chapter 3 of his book 'The Blind Watchmaker'

“I don't know who it was first pointed out that, given enough time, a monkey bashing away at random on a typewriter could produce all the works of Shakespeare. The operative phrase is, of course, given enough time. Let us limit the task facing our monkey somewhat. Suppose that he has to produce, not the complete works of Shakespeare but just the short sentence 'Methinks it is like a weasel', and we shall make it relatively easy by giving him a typewriter with a restricted keyboard, one with just the 26 (capital) letters, and a space bar. How long will he take to write this one little sentence?” – Richard Dawkins

Weasel Scenerio

Staged to produce a string of gibberish letters, assuming that the selection of each letter in a sequence of 28 characters will be random.

The number of possible combinations in this random sequence is 2728, or about 1040, so the probability that the monkey will produce a given sequence is extremely low.

Any particular sequence of 28 characters could be selected as a "target" phrase, all equally as improbable as Dawkins's chosen target, "METHINKS IT IS LIKE A WEASEL".

Weasel Scenerio

A computer program could be written to carry out the actions of Dawkins's hypothetical monkey, continuously generating combinations of 26 letters and spaces at high speed.

Even at the rate of millions of combinations per second, ***it is unlikely, even given the entire lifetime of the universe to run*****,** that the program would ever produce the phrase "METHINKS IT IS LIKE A WEASEL".

Weasel Scenerio

Illustrates a common misunderstanding of evolutionary change, i.e.. DNA sequences are not the result of atoms “randomly” combining.

Cumulative selection can take far fewer steps to reach it's target.

Weasel Scenerio

- Begins by choosing a random sequence of 28 letters
- It duplicates it repeatedly, but with a certain chance of random error – 'mutation' – in the copying.
- The computer examines the mutant nonsense phrases, and chooses the one which, however slightly, most resembles the target phrase, METHINKS IT IS LIKE A WEASEL.”

Weasel Scenerio

Generation 01: WDLTMNLT DTJBKWIRZREZLMQCO P

Generation 02: WDLTMNLT DTJBSWIRZREZLMQCO P

Generation 10: MDLDMNLS ITJISWHRZREZ MECS P

Generation 20: MELDINLS IT ISWPRKE Z WECSEL

Generation 30: METHINGS IT ISWLIKE B WECSEL

Generation 40: METHINKS IT IS LIKE I WEASEL

Generation 43: METHINKS IT IS LIKE A WEASEL

Weasel Scenerio

“The exact time taken by the computer to reach the target doesn't matter. […] What matters is the difference between the time taken by cumulative selection, and the time which the same computer, working flat out at the same rate, would take to reach the target phrase if it were forced to use the other procedure of single-step selection: about a million million million million million years.

This is more than a million million million times as long as the universe has so far existed.”

– Richard Dawkins

HTML/Javascript Weasel Program

https://s3.amazonaws.com/files.nice/weasel2.html

Wikipedia

https://en.wikipedia.org/wiki/Weasel_program#Example_algorithm

Biomorphs Applet

http://www.emergentmind.com/biomorphs

Biomorph evolution is a random "evolution", without component of selection.

Demonstrates the development of complexity of pure randomness as opposed to that of randomness coupled with cumulative selection.

Biomorph shows what a wide variety of forms is possible even with a very limited genome - it is possible to see forms that look like insects, trees, letters and so on.