Implications for Everyday Systems

A New Kind of Science
(S. Wolfram)
(Chapter 8)

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Implications for Everyday Systems

- Systems familiar from everyday life:
  - Are thought to be mysterious in the origins of their behavior,
  - But according to the author, not so mysterious in terms of simple programs:
    - By identifying the basic mechanisms (which are responsible for the most obvious features of the behavior of each kind of system);
    - Constructing simplest possible model for each system.

Implications for Everyday Systems

- The author's repetitive, repetitive, (… boring?...) discovery:
  - Forget about the traditional mathematical equations,
  - Extremely simple underlying rules yield behavior of great complexity.

Implications for Everyday Systems

- Modeling issues:
  - Whether the model be CA, or anything else, the model is to provide an abstract representation of the *effects* in determining system behavior;
  - Below the level of effects, there is *no reason* that the model should operate like the system itself.

Implications for Everyday Systems

- Modeling issues:
  - Go beyond mathematical equations, which is the reason why traditional modeling has become so complicated…;
  - Consider models based on programs with rules of any kind.

Implications for Everyday Systems

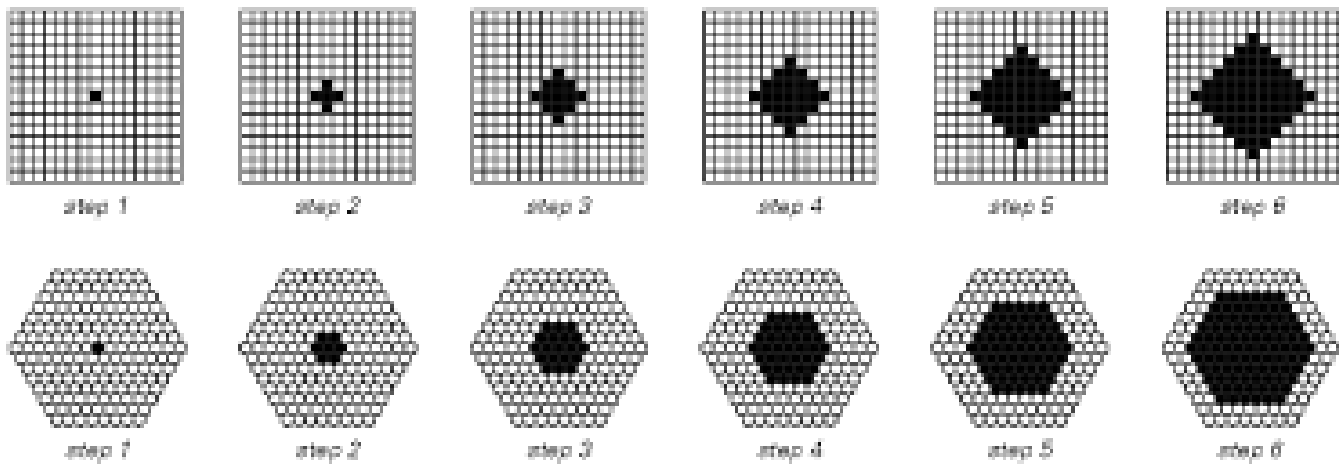
- Modeling of everyday systems:
  - The growth of crystals,
  - The breaking of materials,
  - Fluid flow,
  - Fundamental issues in biology,
  - Growth of plants and animals,
  - Biological pigmentation patterns, and
  - Financial systems.

The Growth of Crystals

- Crystals:
  - At microscopic level: arrays of atoms laid out like the cells in a CA;
  - Start from a seed (often a foreign object), and grow by progressively adding more atoms.

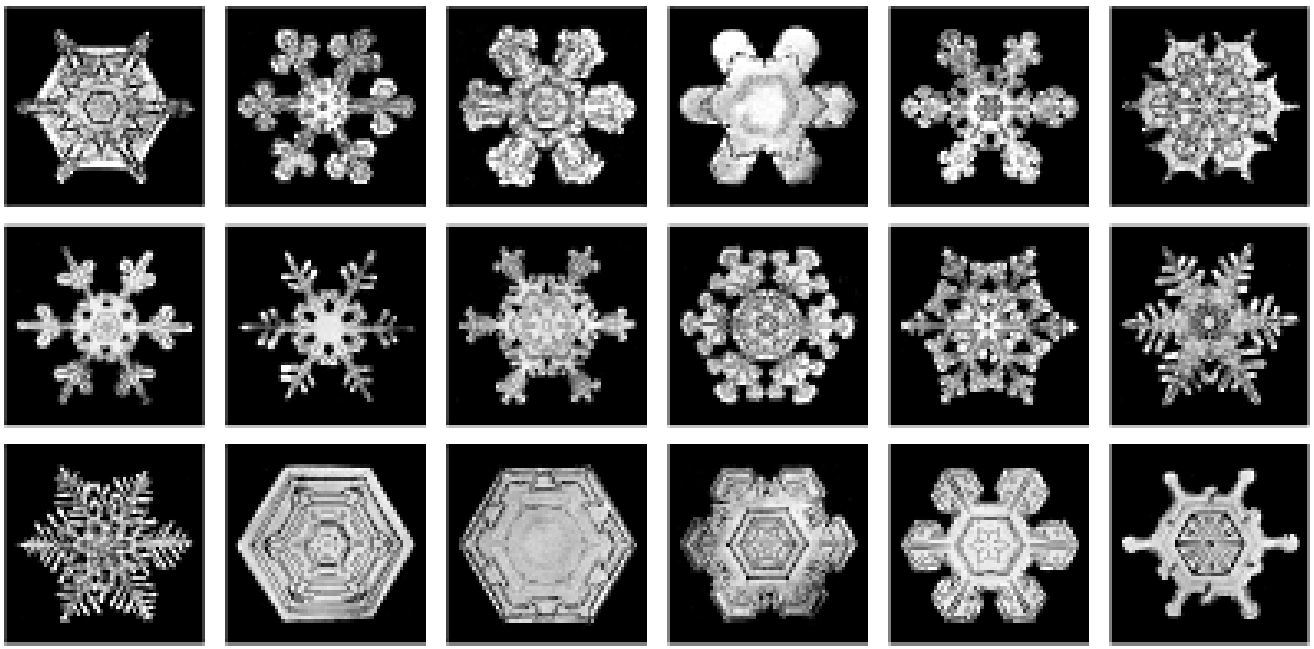
The Growth of Crystals

- CA modeling:
  - Black—solid, white—liquid or gas.
  - Rule: cell adjacent to a black cell becomes black.



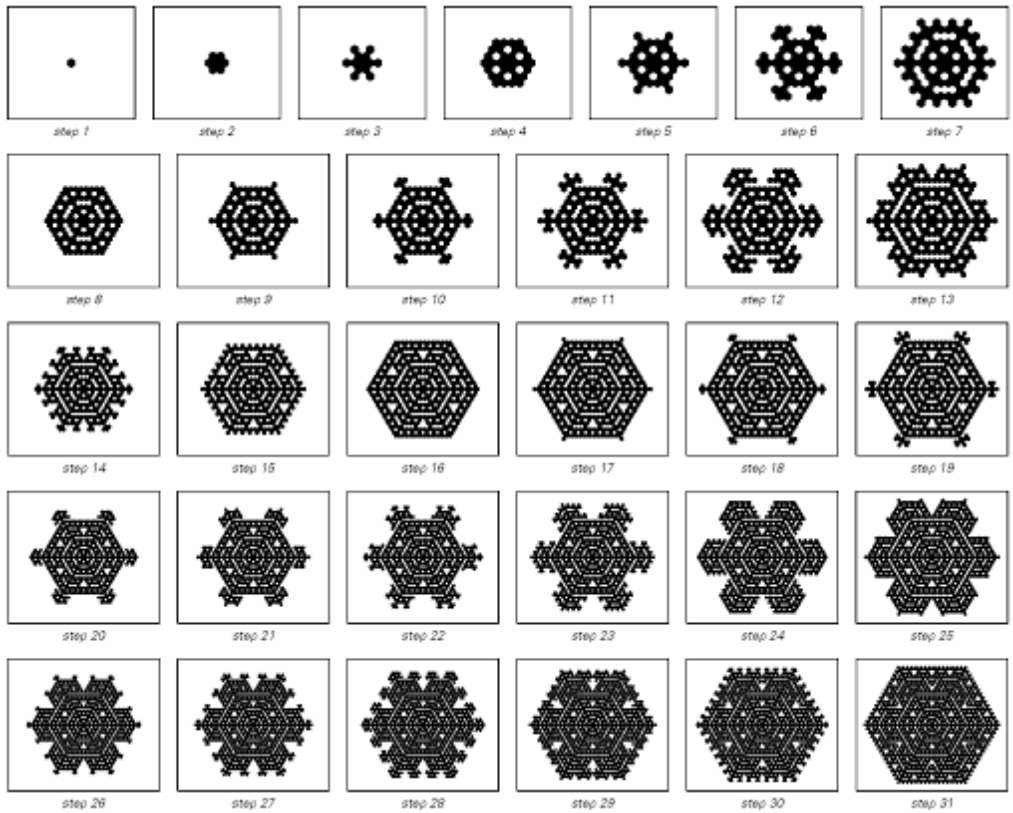
The Growth of Crystals

- Snowflakes have intricate forms:



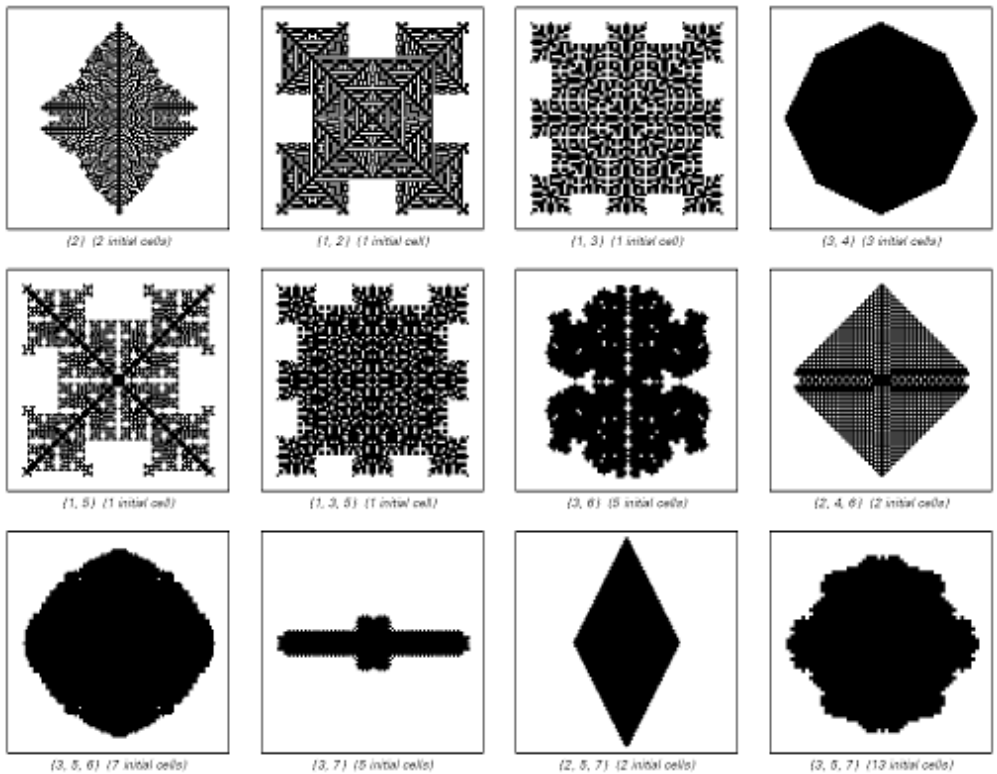
The Growth of Crystals

- Snowflakes CA modeling:
  - Become black with exactly one black neighbor.



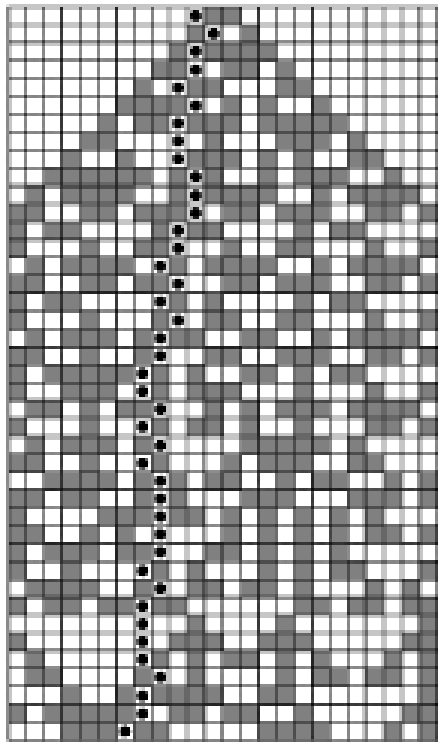
The Growth of Crystals

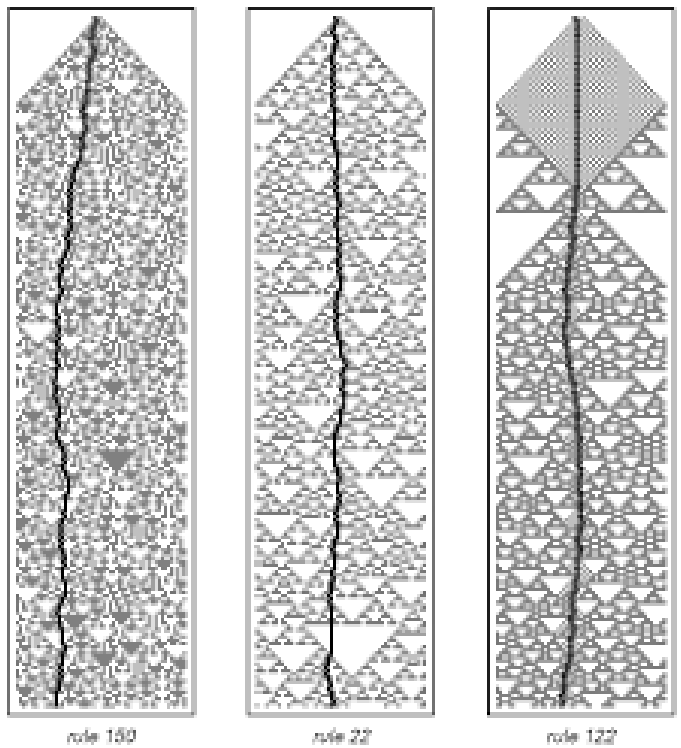
- Other CA crystal modeling:
  - Number of black neighbors (including diagonal ones).



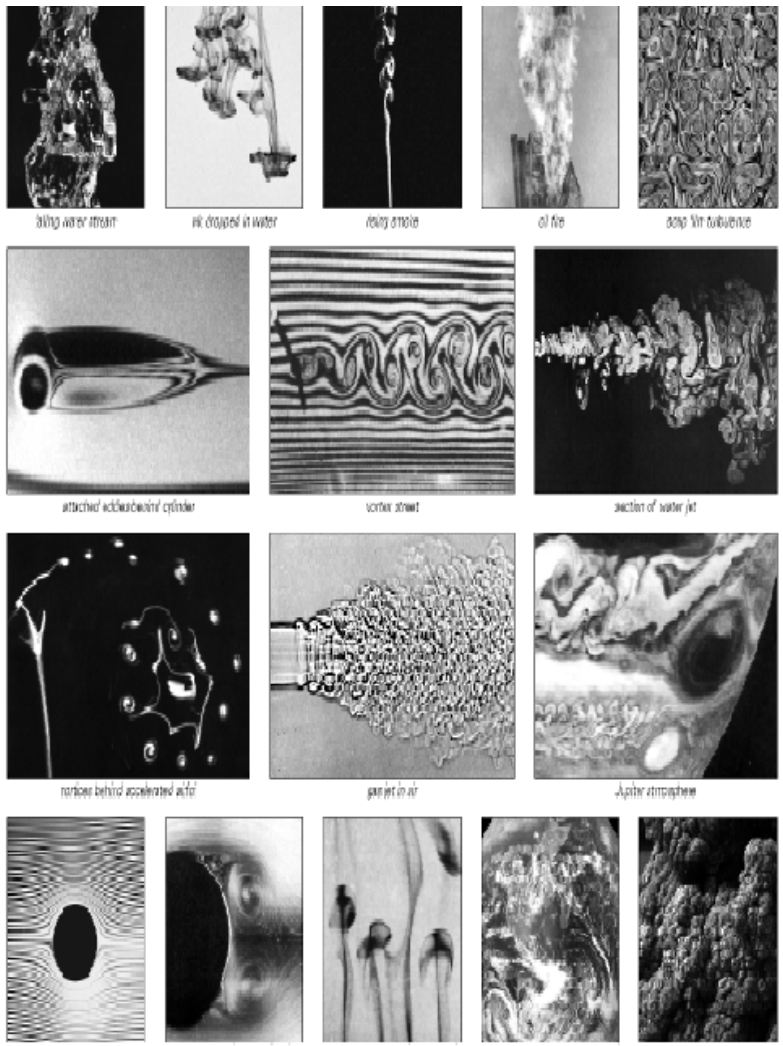
The Breaking of Materials

- Randomness from simple model:
  - Based on displacement of neighboring cells.



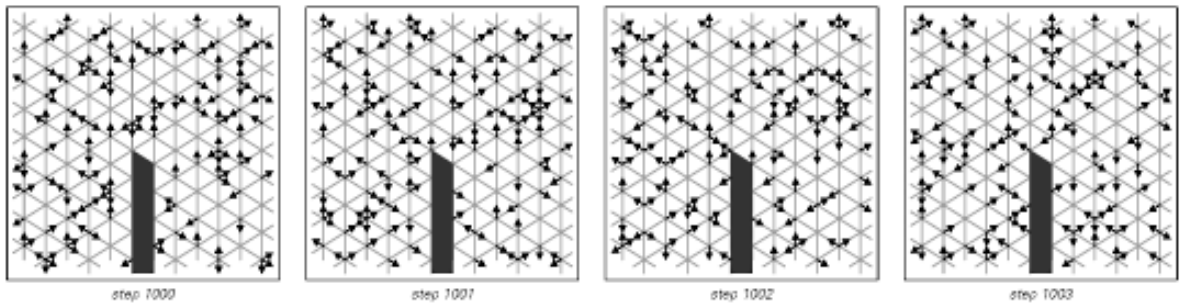


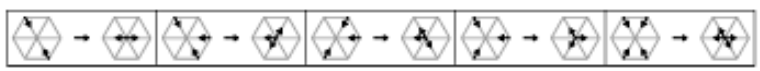
Fluid Flow



Fluid Flow

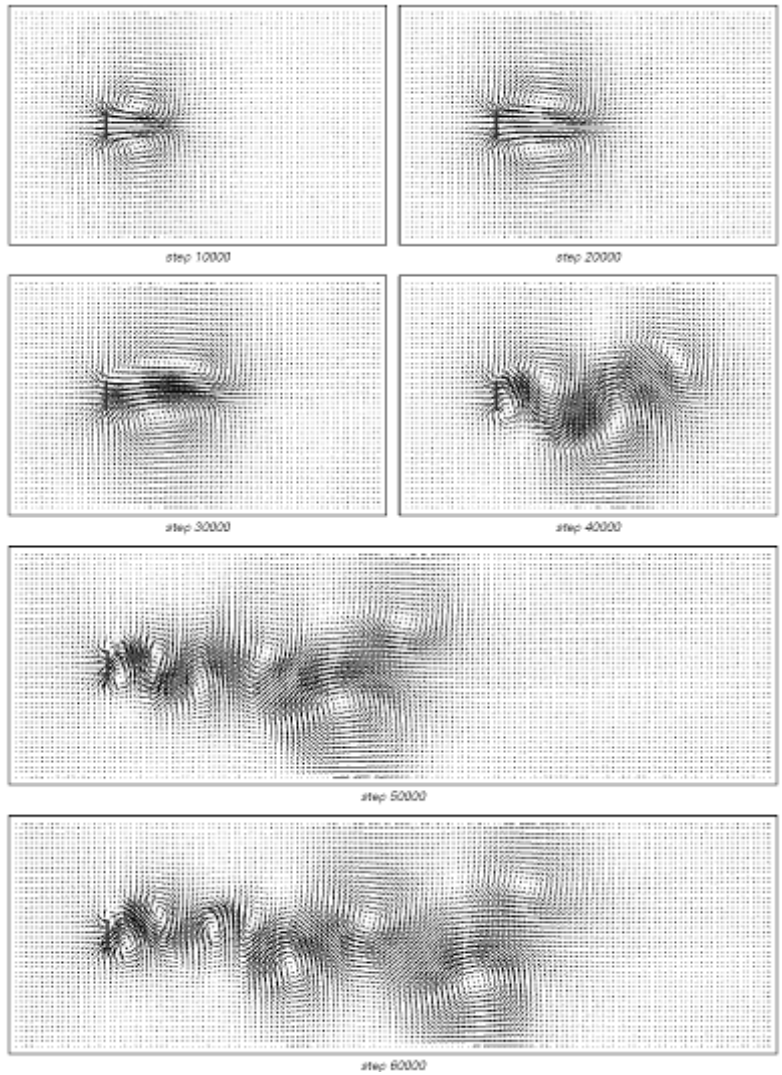
- CA modeling:
  - Updating according to simple collision rules.



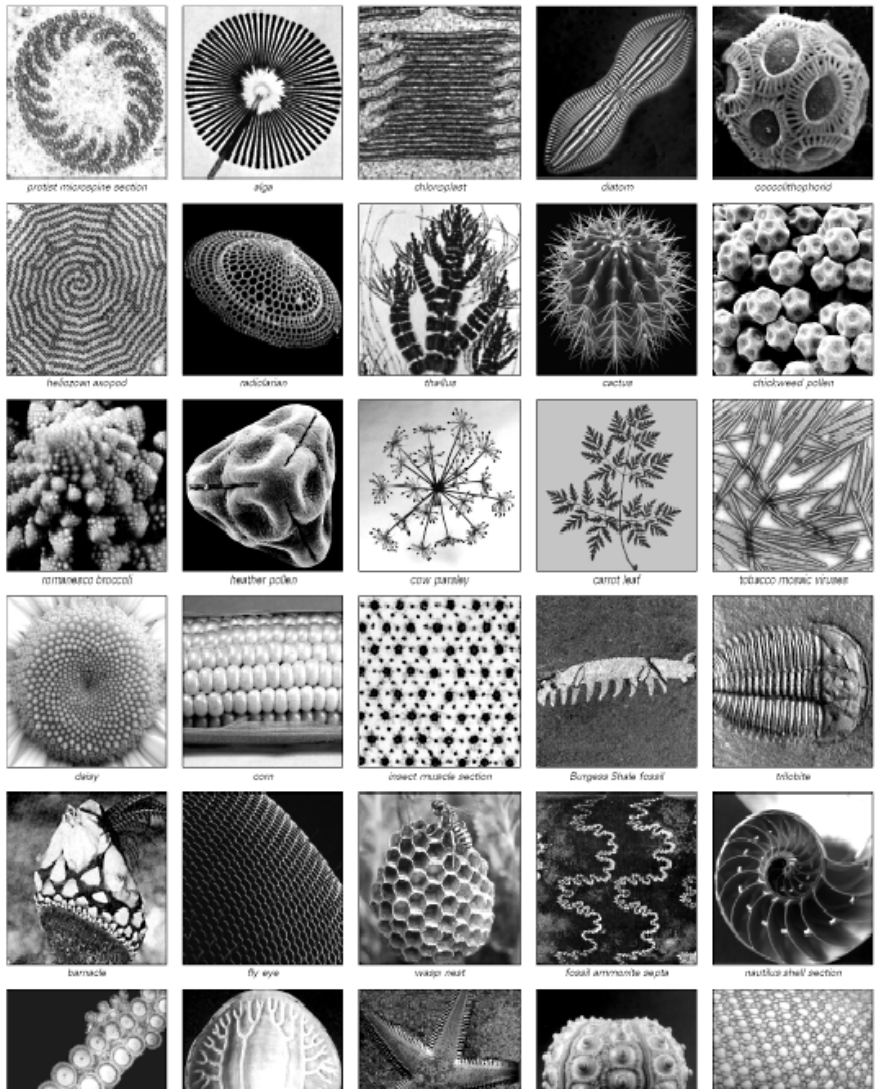


Fluid Flow

- CA modeling:
  - Array of eddies shown random irregularities (like turbulence in real fluid).



Fundamental Issues in Biology

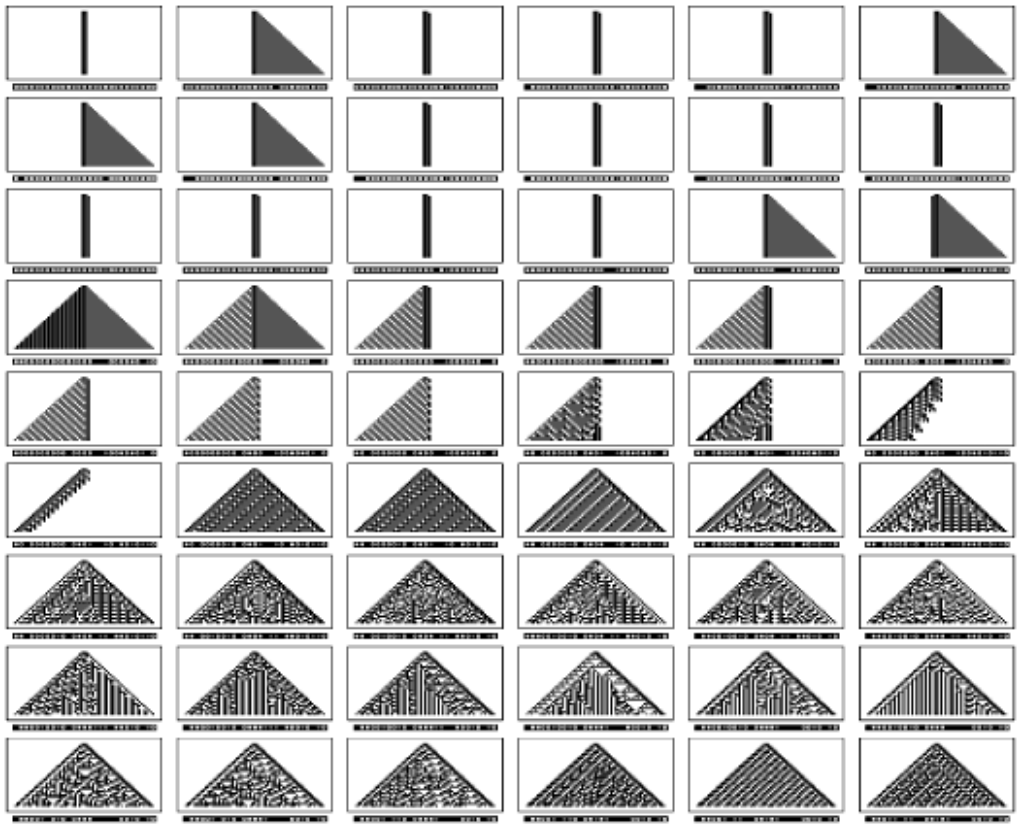


Fundamental Issues in Biology

- Supreme examples of complexity in nature.
  - According to the author:
    - very little to do with adaptation or natural selection;
    - They are consequences of very basic phenomena in the context of simple programs;
    - Choices of underlying rules lead to behavior of great complexity.

Fundamental Issues in Biology

- CA sequence obtained by successive random mutations:



Fundamental Issues in Biology

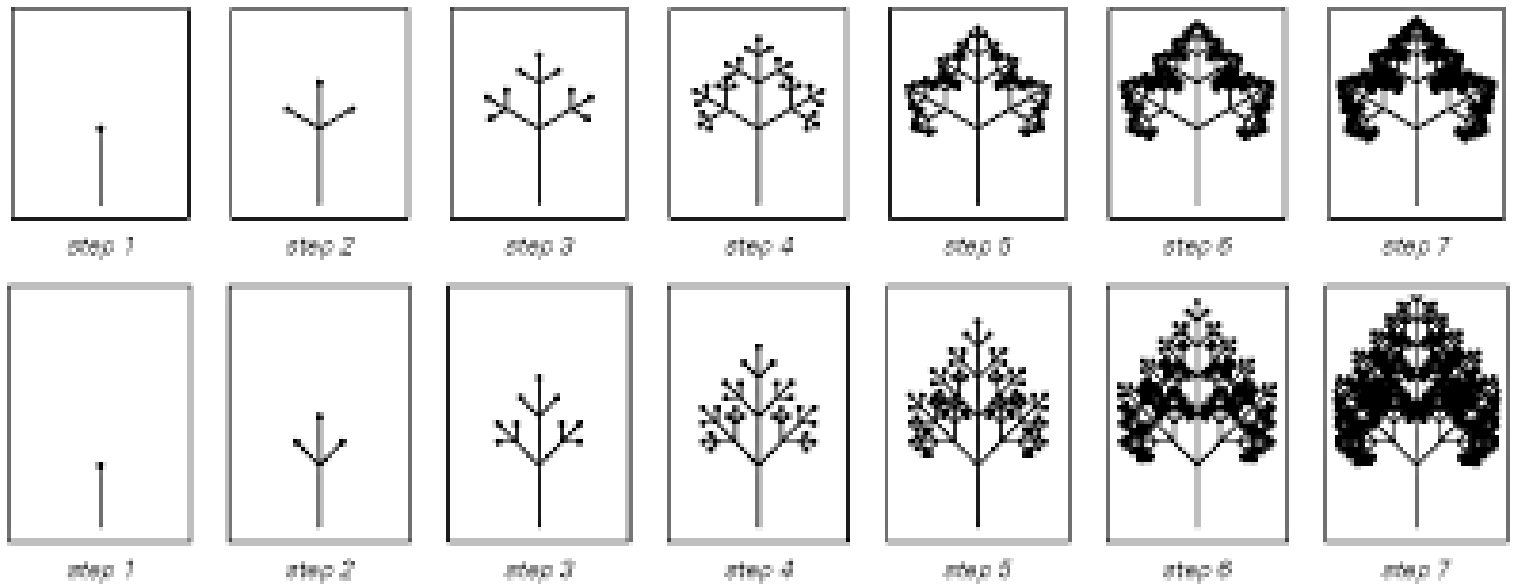
- Issues around a central topic:
  - Natural selection will normally be able to explain the development of living organism.
  -
  - (I tried to find what those fundamental issues are, but I got lost in the author's plethora of subjective descriptions.)

Growth of Plants and Animals

- Forms of plants and animals:
  - Underlying rules for their growth are complex?
  - No, highly complex forms can be obtained from simple rules,
    - The growth of plants and animals are governed by simple rules.

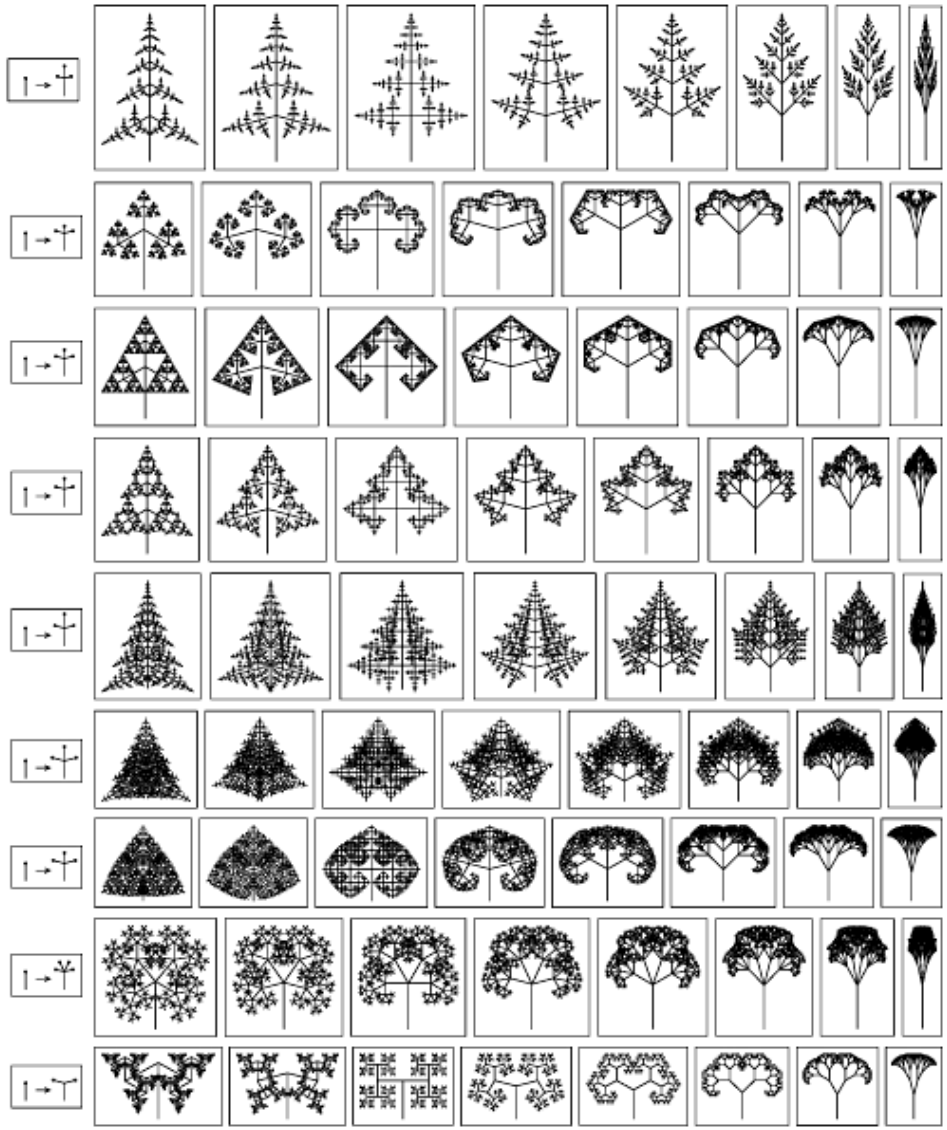
Growth of Plants and Animals

- Simulation: every stem in effect branches into three new stems at each step.



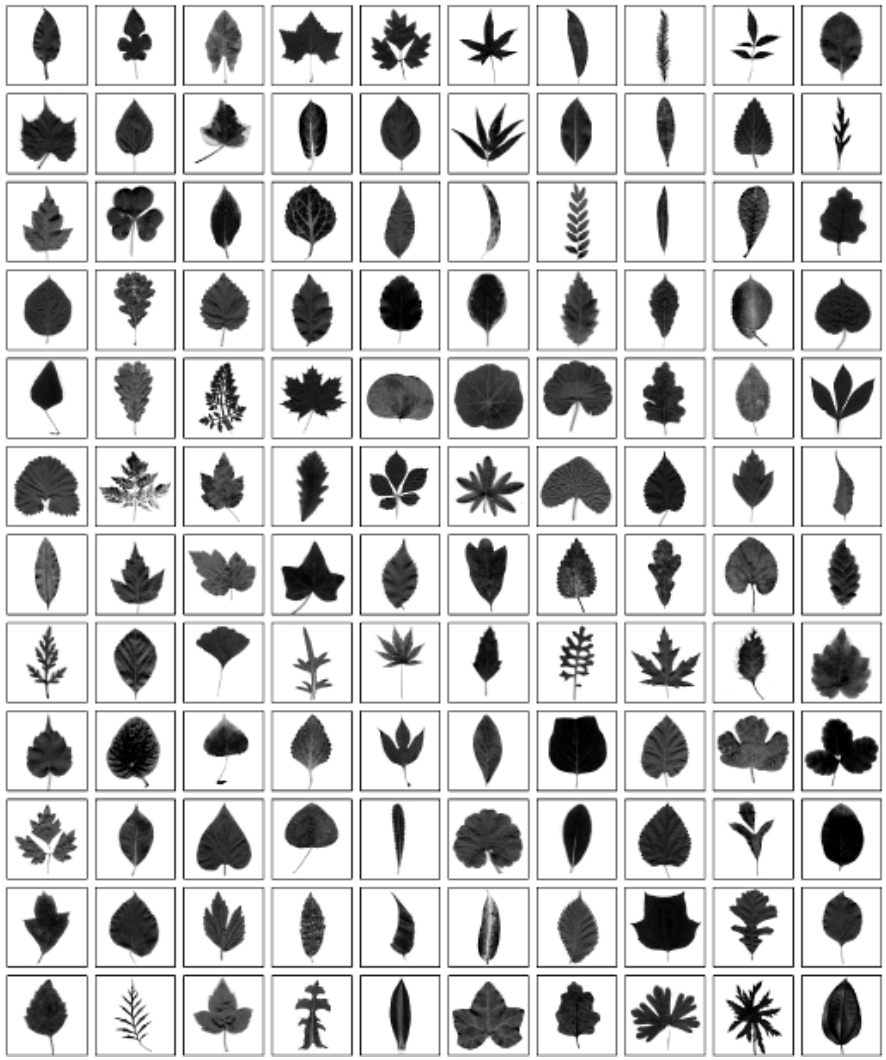
Growth of Plants and Animals

- Branching with varied lengths and angles of new stems.



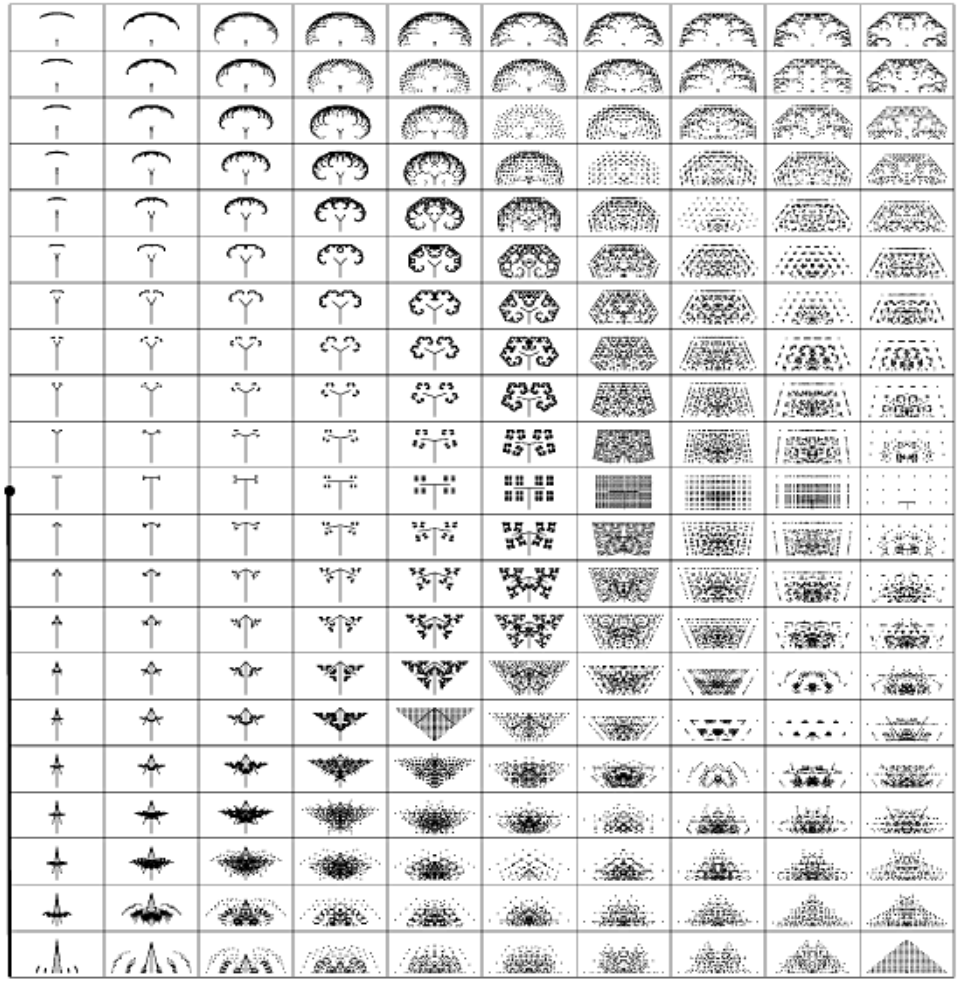
Growth of Plants and Animals

- Diversity in leaf shapes.
  - Traditional concept:
    - The complexity suggests particular purposes in natural selection process.
  - The author:
    - Complexity arises in a sense effortlessly following simple rules of growth.



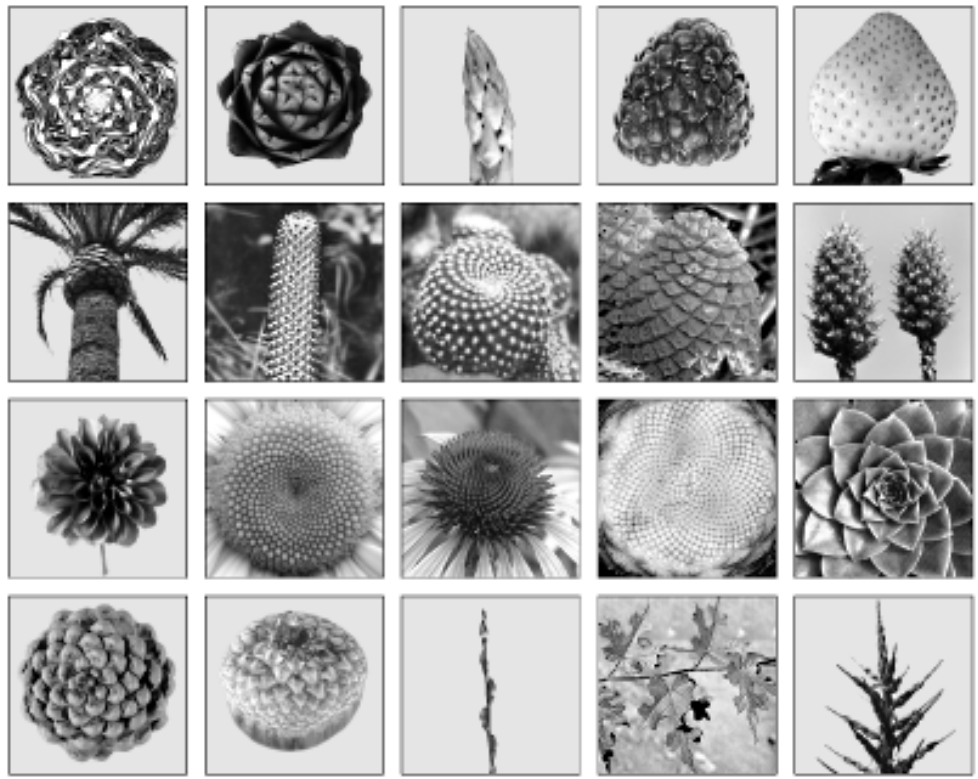
Growth of Plants and Animals

- Each stem splits into two new stems.



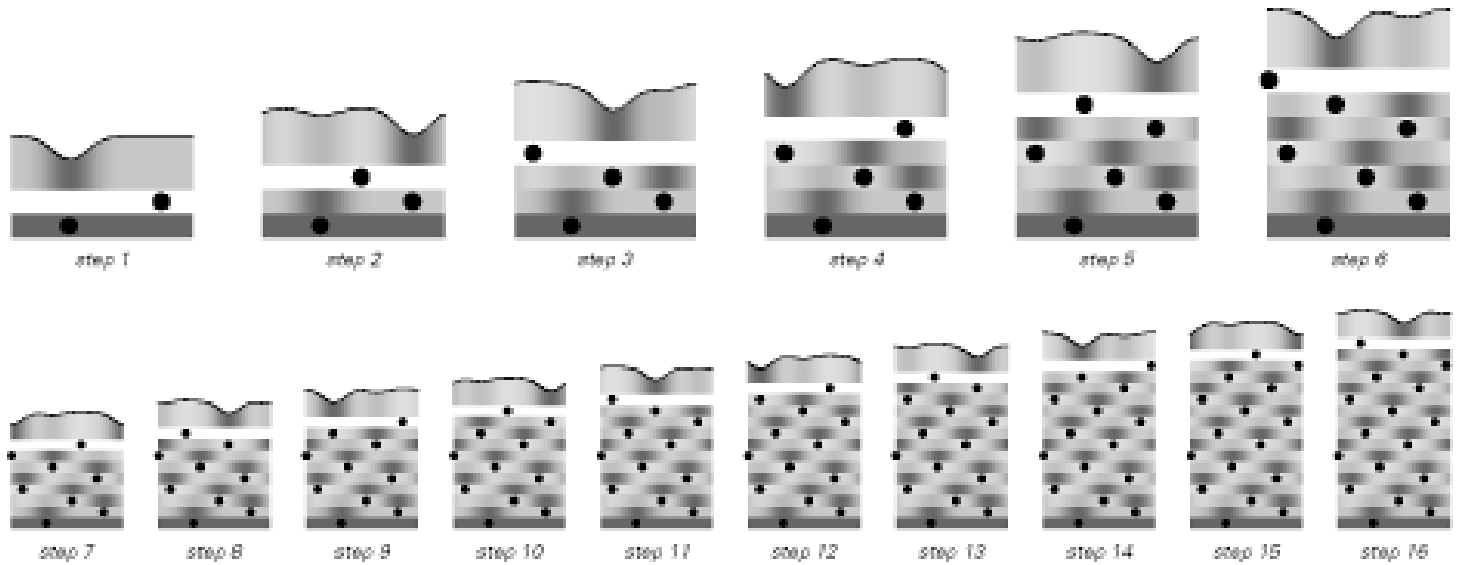
Growth of Plants and Animals

- Examples of spiral arrangements:
  - Details of final geometry are different;
  - But the original angle between successive elements is 137.5^{o}.



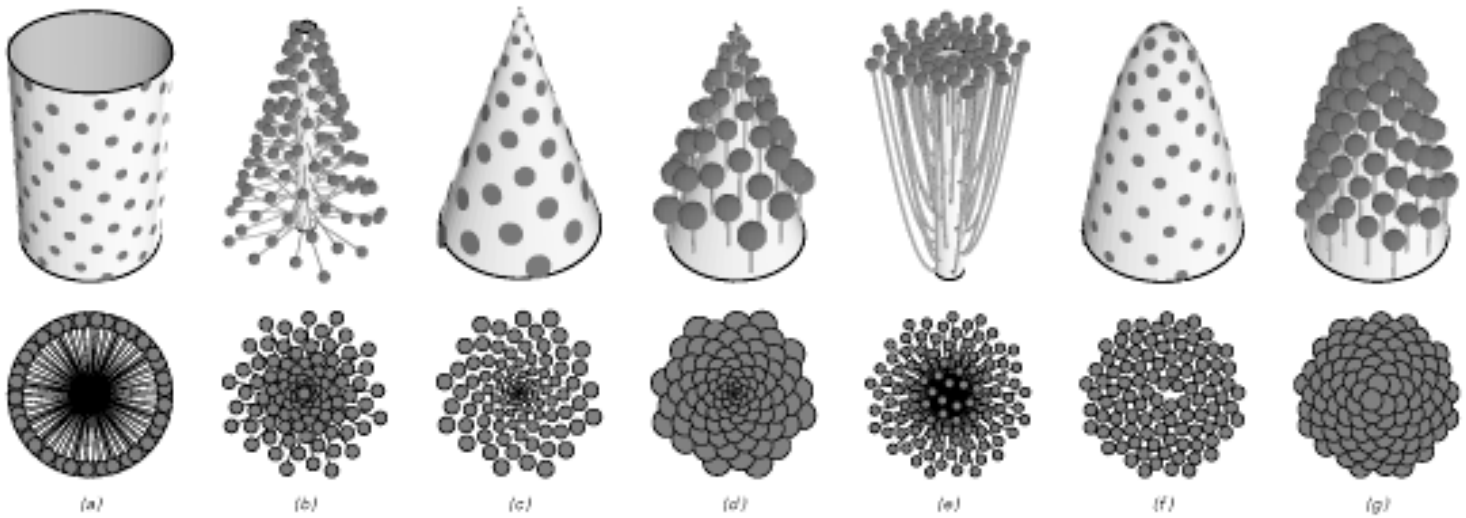
Growth of Plants and Animals

- Simulation, 137.5º??



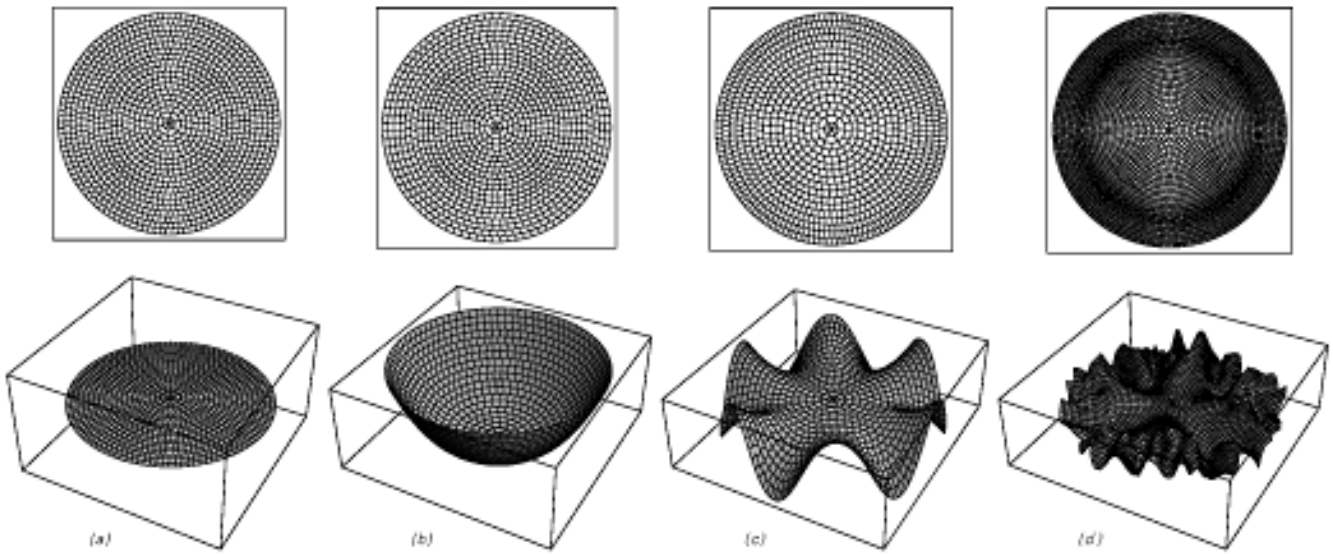
Growth of Plants and Animals

- Structures formed in various geometries by successively adding elements at 137.5^{o}.



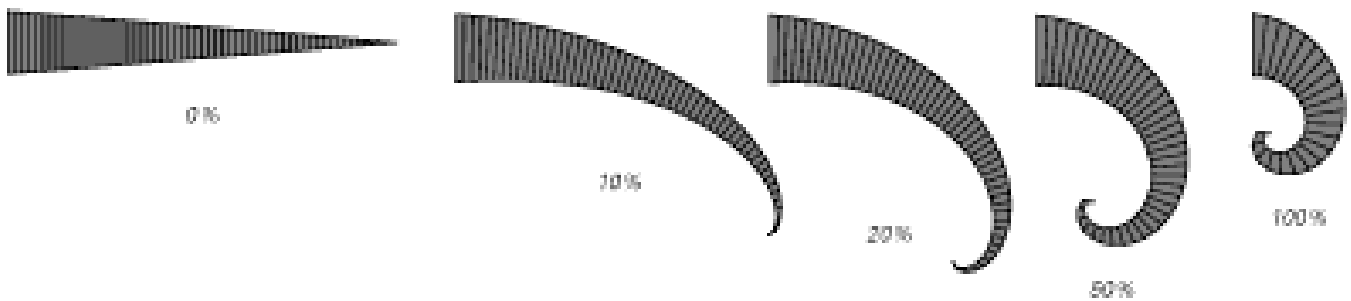
Growth of Plants and Animals

- Ex: start with a flat disk and add different amounts of materials in different places:



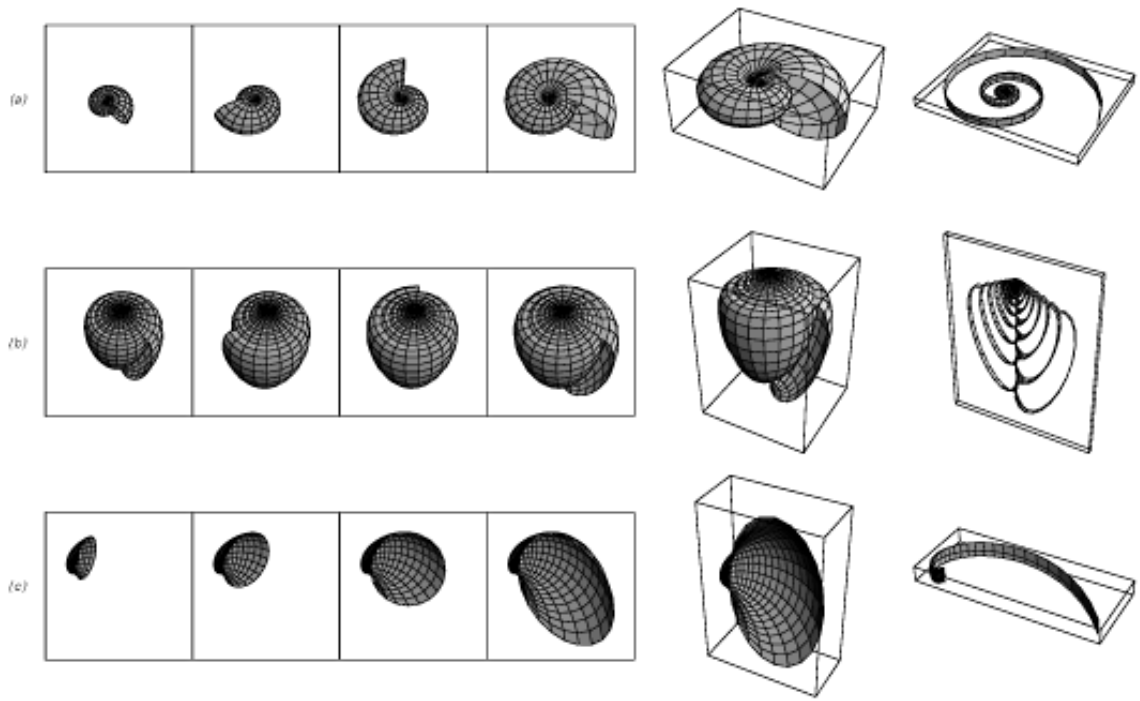
Growth of Plants and Animals

- Animals (horn/coiling): adding materials exactly same on each side (for the first), and there is difference for others:



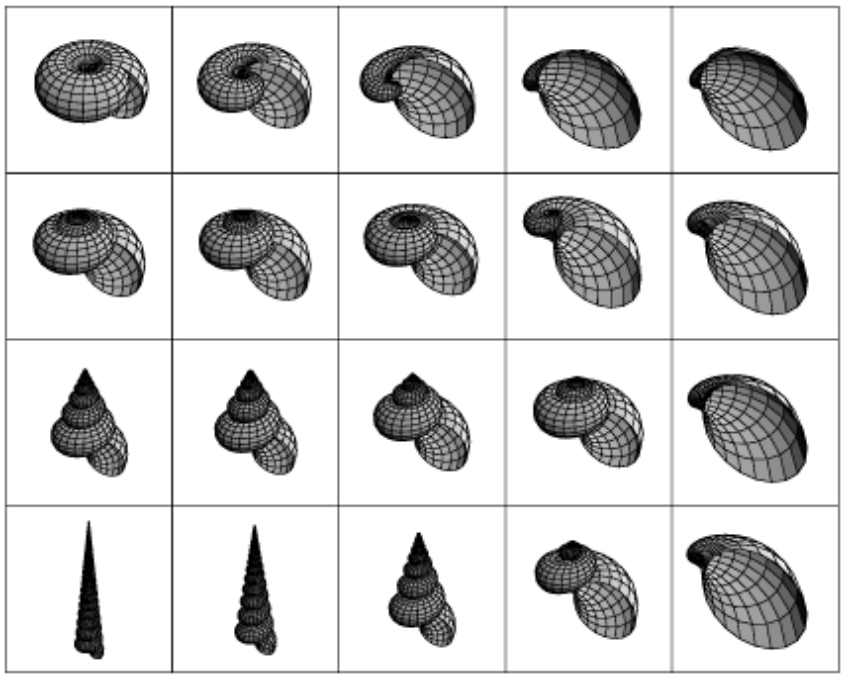
Growth of Plants and Animals

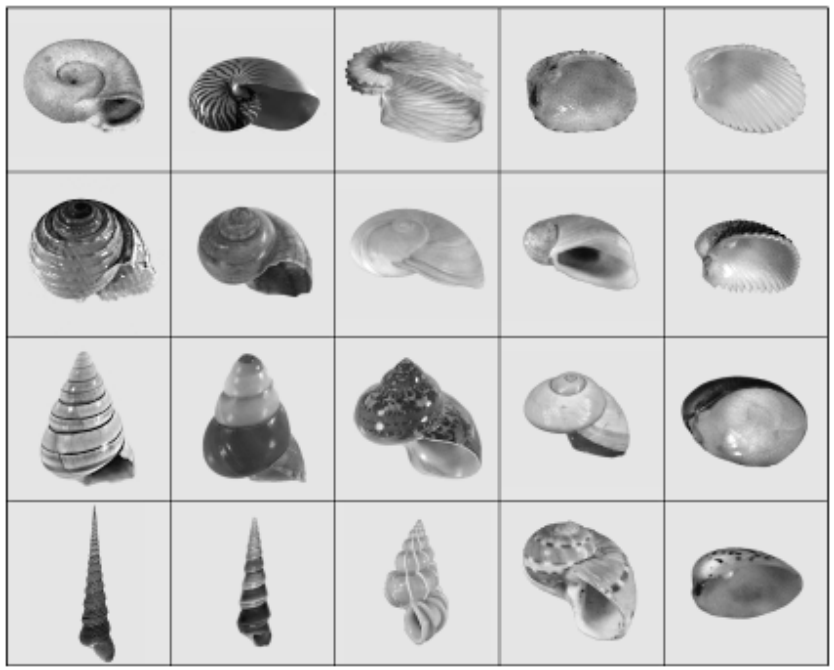
- Model for the growth of mollusk shells: new material is progressively added at the open end:



Growth of Plants and Animals

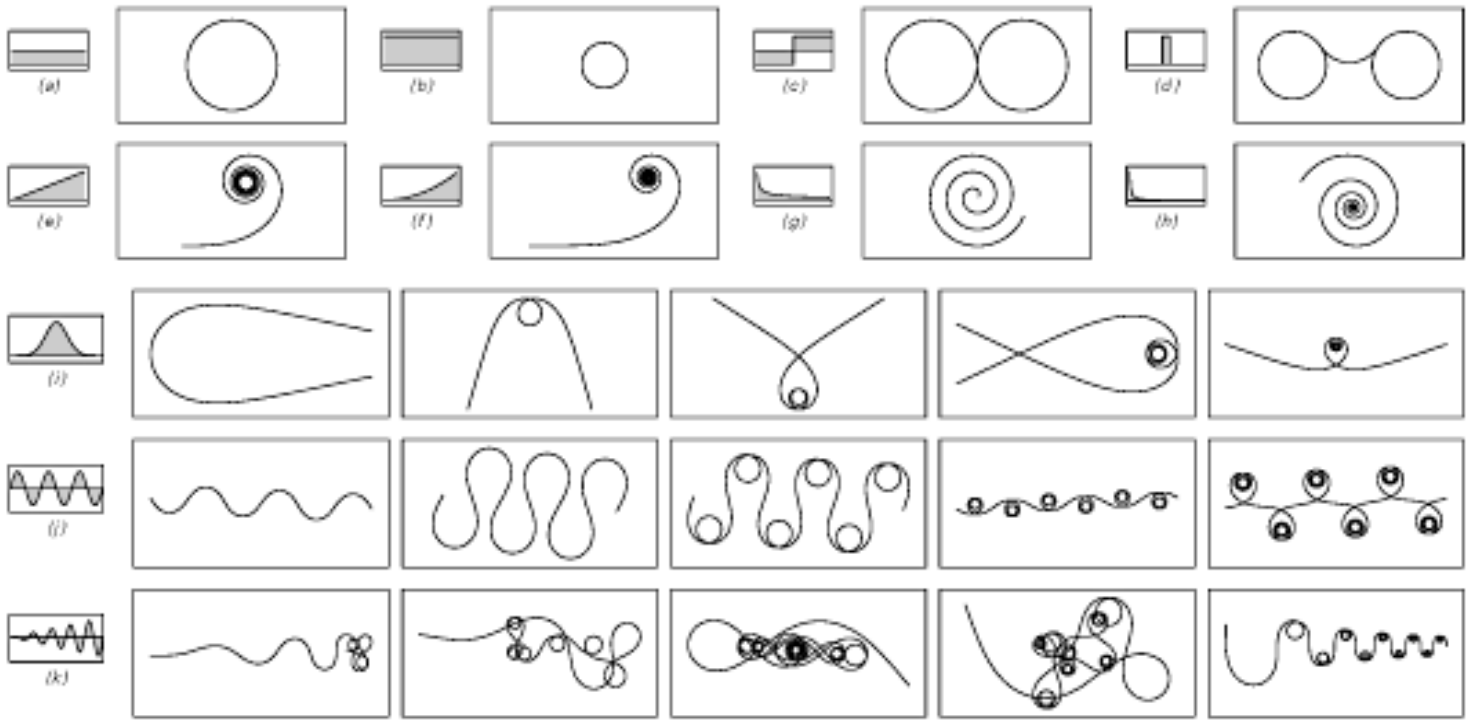
- Shell shapes:





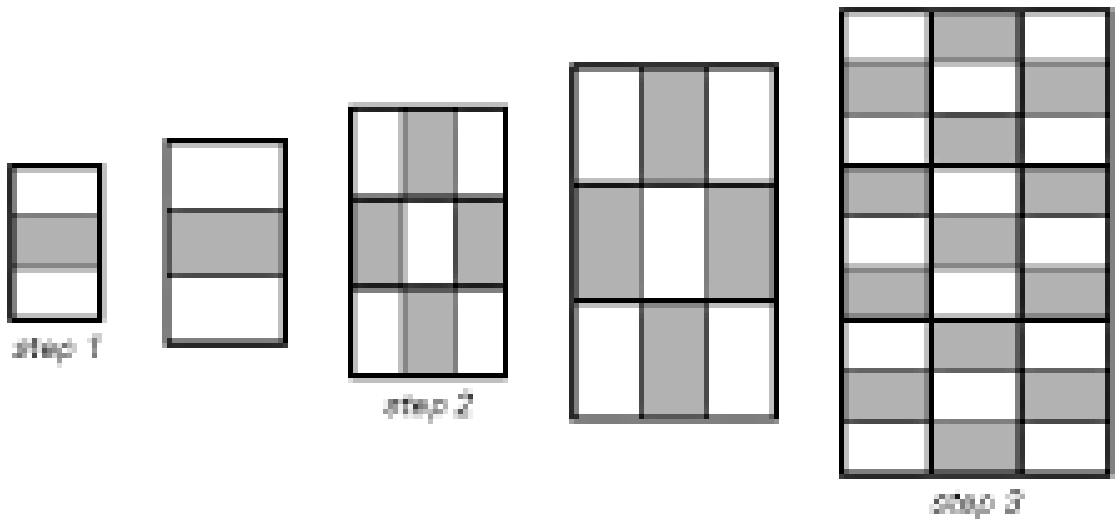
Growth of Plants and Animals

- Folding: important in teeth surfaces, ear bones, tissues, tubes…



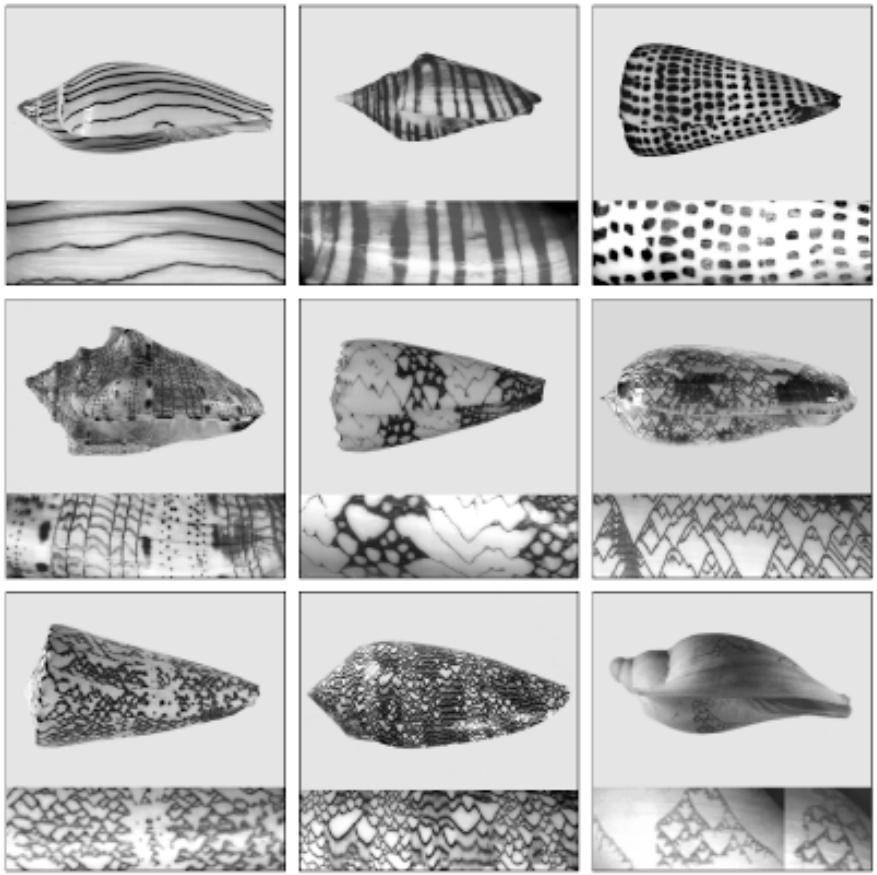
Growth of Plants and Animals

- Subdivision occurs in the growth of animals (embryo development):



Biological Pigmentation Patterns

- Pigmentation patterns on mollusk shells.

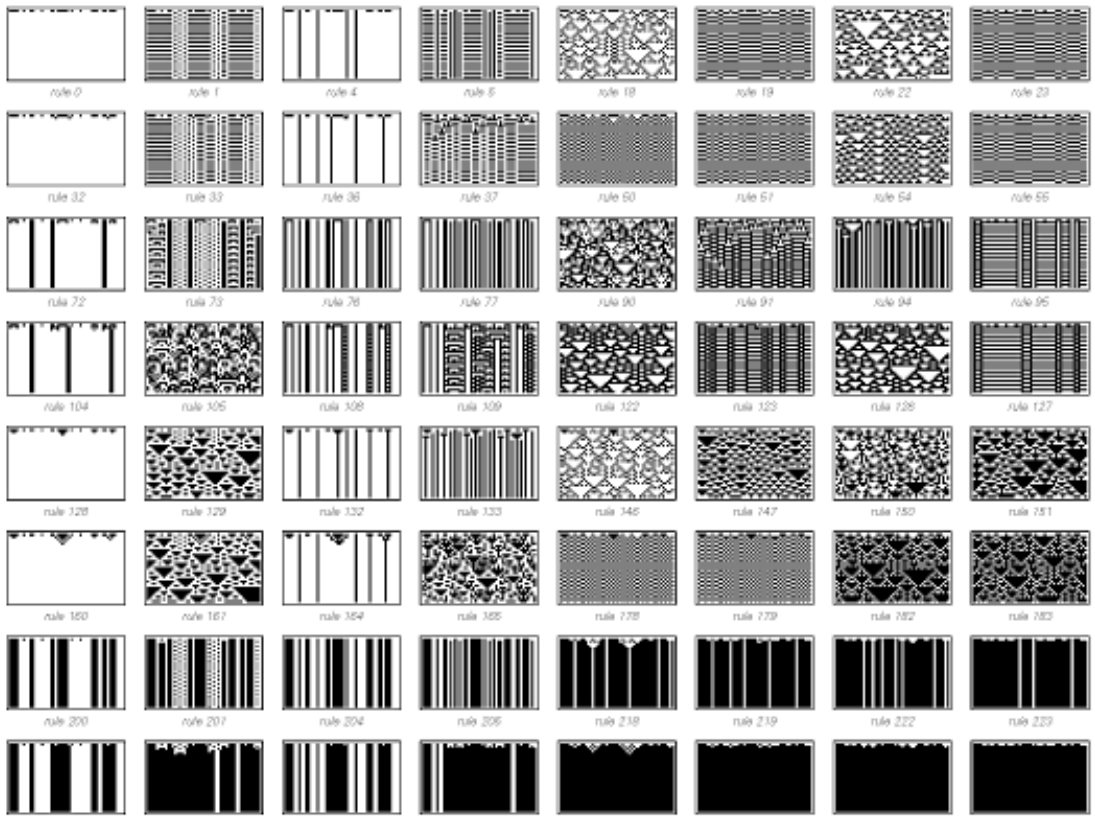


Biological Pigmentation Patterns

- Again, the author announces:
  - Not through the natural selection,
  - But generated by processes with simple basic rules and at random.

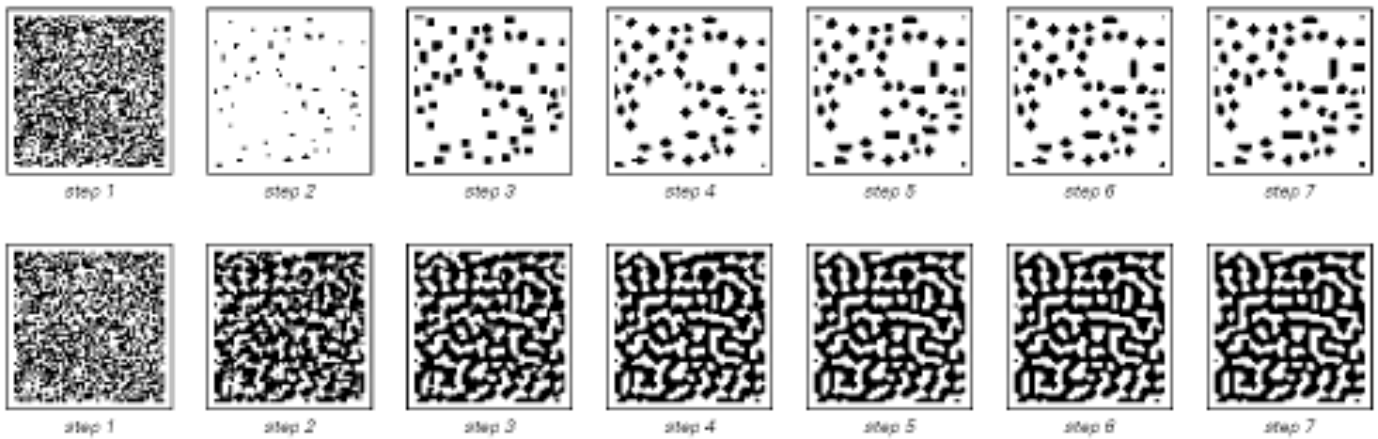
Biological Pigmentation Patterns

- Patterns produced by the evolution of symmetrical 1-D cellular solution.



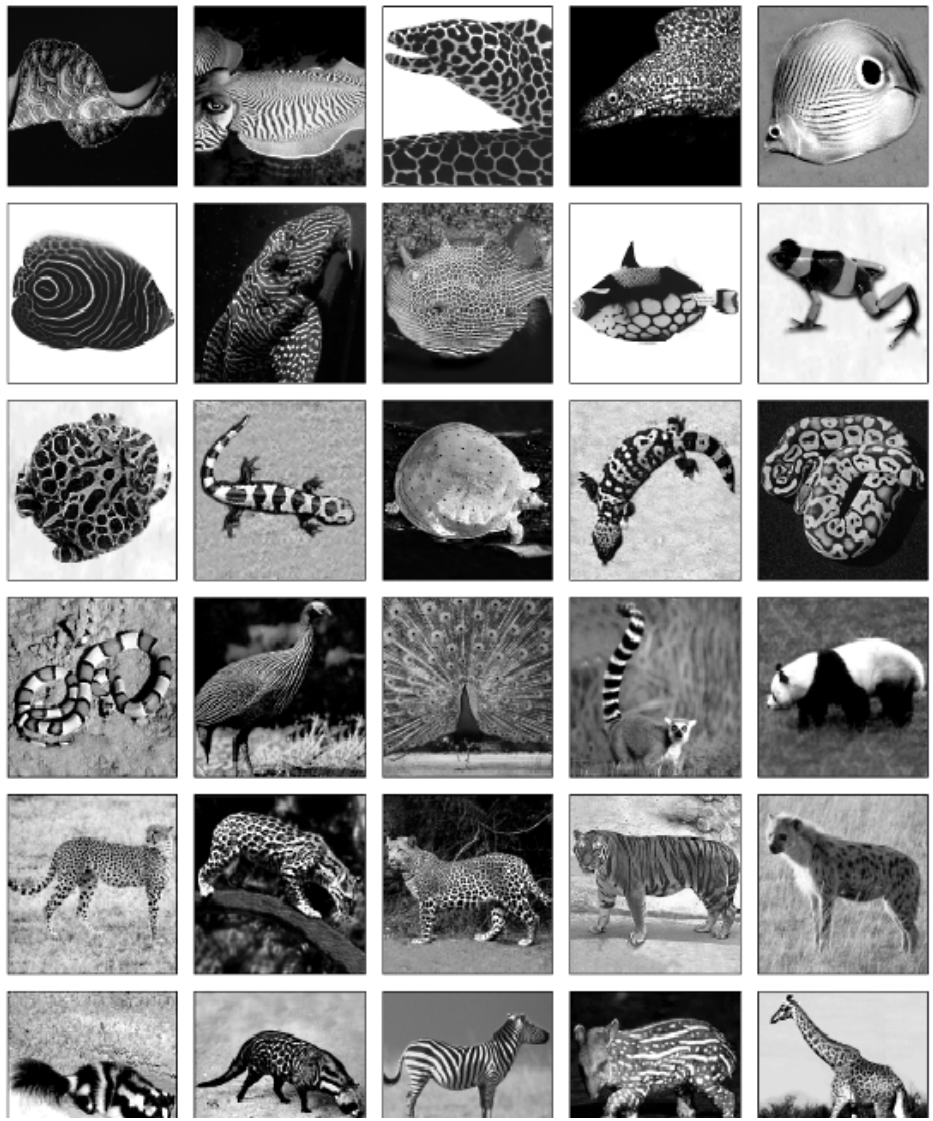
Biological Pigmentation Patterns

- Patterns produced by the evolution of simple 2-D cellular automata.



Biological Pigmentation Patterns

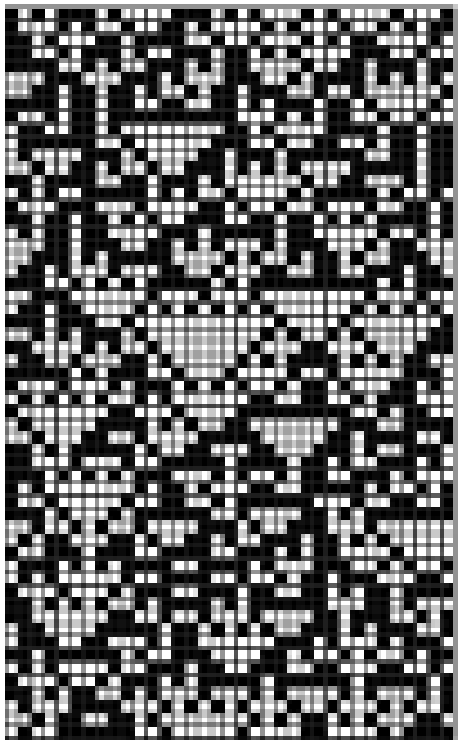
- Pigmentation patterns on animals.
  - Different animals have similar patterns.

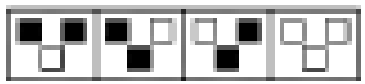


Financial Systems

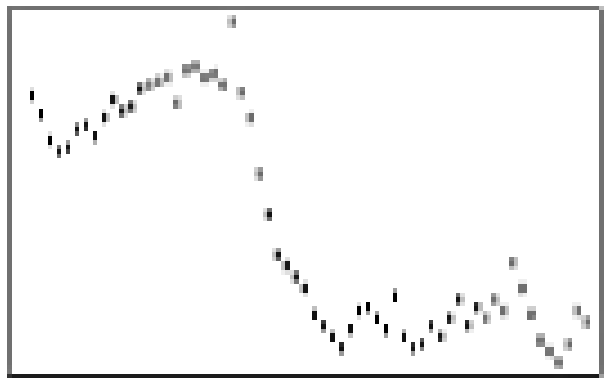
- Randomness in all financial markets: stocks, bonds, currencies, …
- Why is there randomness in the markets?
  - On short timescales, a consequence of internal dynamics.
    - Traditional mathematics cannot provide a good model.
    - CA seems more promising with simple rules.

Financial Systems





An example of a very simple idealized model of a market. Each cell corresponds to an entity that either buys or sells on each step. The behavior of a given cell is determined by looking at the behavior of its two neighbors on the step before according to the rule shown. The plot below gives as a rough analog of a market price the running difference of the total numbers of black and white cells at successive steps. And although there are patches of predictability that can be seen in the complete behavior of the system the plot on the right looks in many respects random.



Comments

- A book with many interesting examples and illustrations (the only POSITIVE part) but with lengthy boring descriptions from which:
  - You are reminded of some political doctrines of some political parties/dictators (if you have such experience);
  - You can tell the author is a genius, a braggart, some type of maniac, crank, psycho…

Comments

- I will 99% agree with one of the book's reviewers comments:
  - *What is true is not new,*
  - *What is new is not true.*
- I will NOT read this book anymore, except the illustrations.
  - Spent two days on only chapter 8:
    - I suffered loss of eyesight,
    - Spoiled my reading habit.

Comments

- But I did get some confidence:
  - Except for the English (the author's native language), I could write a better (nontechnic) book than this "world-class scientist" did.

- I'll give two stars (out of five) for this book.

Q&A

Thanks