5

Artificial Life

Technical definitions and adaptions of the living

Prof. Ursula Damm

The term artificial life was first established by Christopher Langton 1987 at the conference in Los Alamos. A-Life looks at nature as an arrangement of dynamic material processes, comprising all kinds of life forms. Langton considers al these material things as the condiments of life.
The definition neglects all possible spiritual essences contributed to life beyond the material conditions.
He proposes an understanding of life as an activity which emerges out of the interplay of distinctive parts of an organizational process.
This attitude made it possible to make something like „artificial life“ by implementing „life“ as a self-organizational process on computers.

Already John von Neumann (1903 – 1957), a pioneer of the computer as we know it today, developed this machine out of game theory with the aim to build a self-reproducing machine.
If information is regarded as a foundation of life, then a dynamic system is complex enough to reproduce and to bring forth offspring which is more complex than their parents.
Von Neumann described a method to use mathematical models to imitate the functions of a nervous system: an artificial neural net.

Together with Turings claim to imitate every calculable system with a universal calculating machine –the Turing machine – von Neumann layed the foundation for the development of the computer how we know it today and for the much later upcoming artificial life.

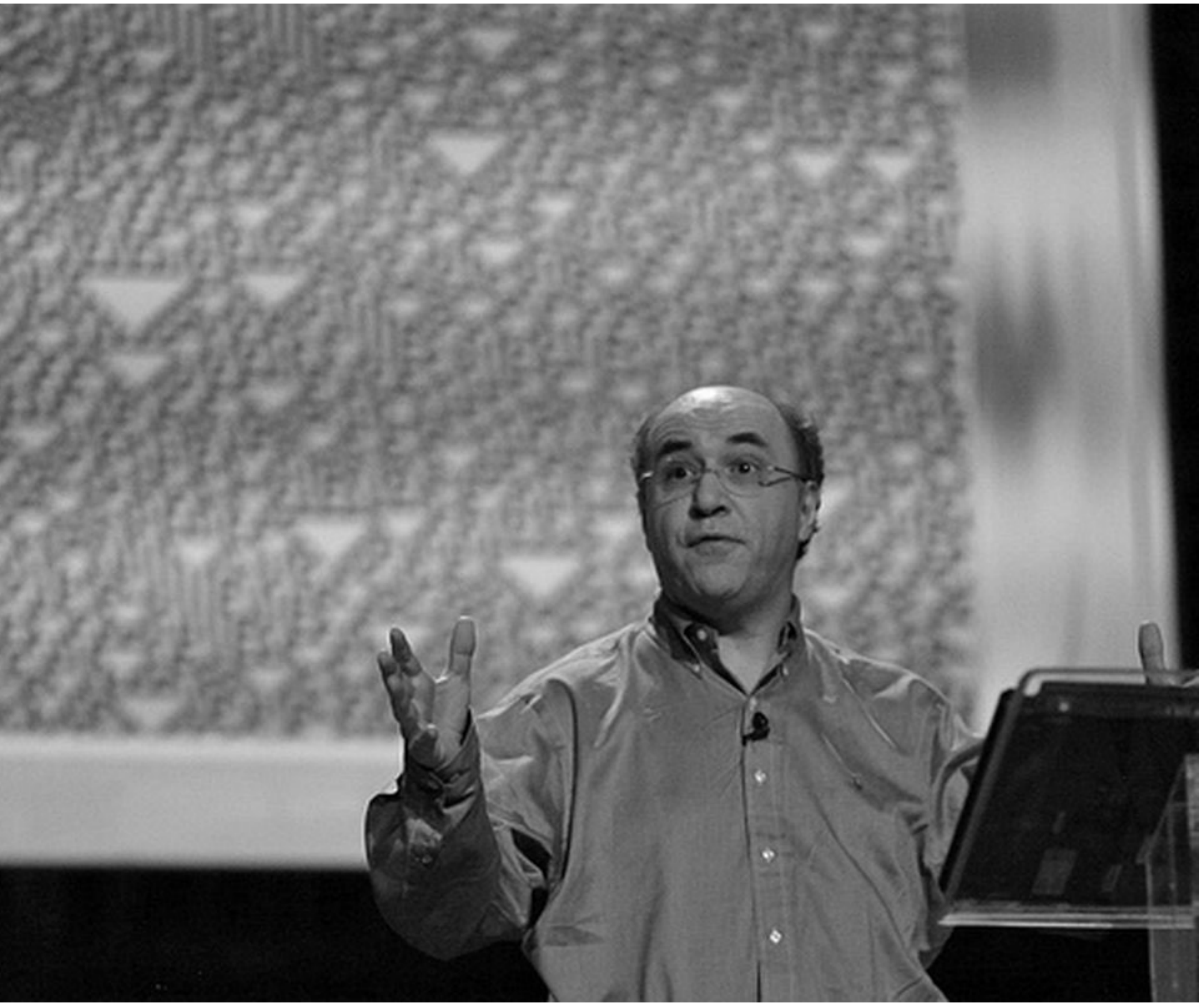
Game of Live

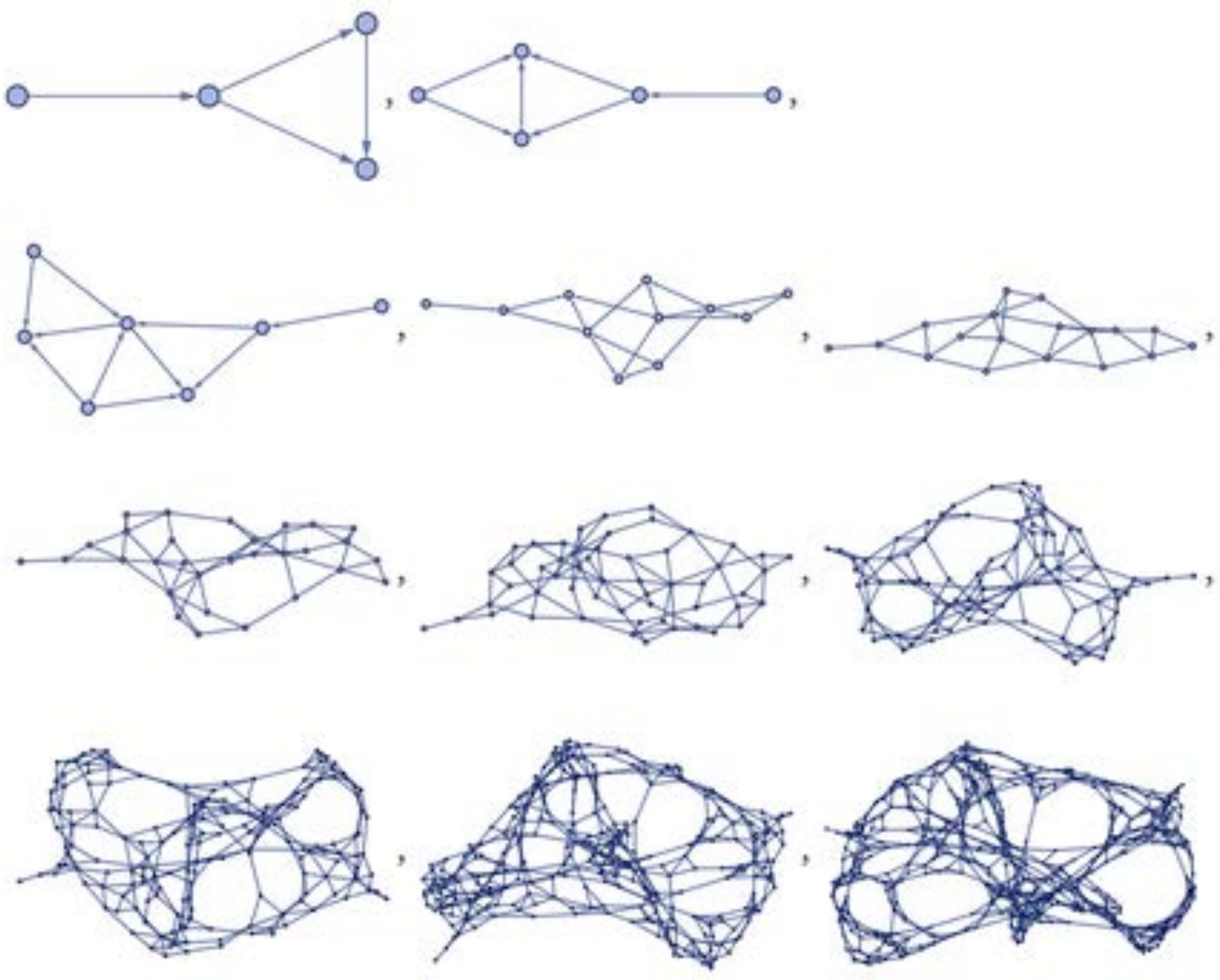
John Conway developed in the late 60ies the game life, (description) a step-stone in the development of the cellular automata.
The basic idea is it to start with a simple constellation of so called von blinkers.
You develop a matrix with pixels which can be black or white.
Then you apply to each cell neighborhood rules, which are described as follows:

1. Any live cell with fewer than two live neighbors dies, as if caused by underpopulation.
2. Any live cell with two or three live neighbors lives on to the next generation.
3. Any live cell with more than three live neighbors dies, as if by overpopulation.
4. Any dead cell with exactly three live neighbors becomes a live cell, as if by reproduction.

The initial pattern constitutes the seed of the system. The first generation is created by applying the above rules simultaneously to every cell in the seed—births and deaths occur simultaneously, and the discrete moment at which this happens is sometimes called a tick (in other words, each generation is a pure function of the preceding one). The rules continue to be applied repeatedly to create further generations.
In short: the rules shall make the behavior of the automaton unpredictable
Info
another applets

Stephen Wolfram





A new kind of Science by Stephen Wolfram
https://writings.stephenwolfram.com/2020/04/finally-we-may-have-a-path-to-the-fundamental-theory-of-physics-and-its-beautiful/

Genetic algorithms

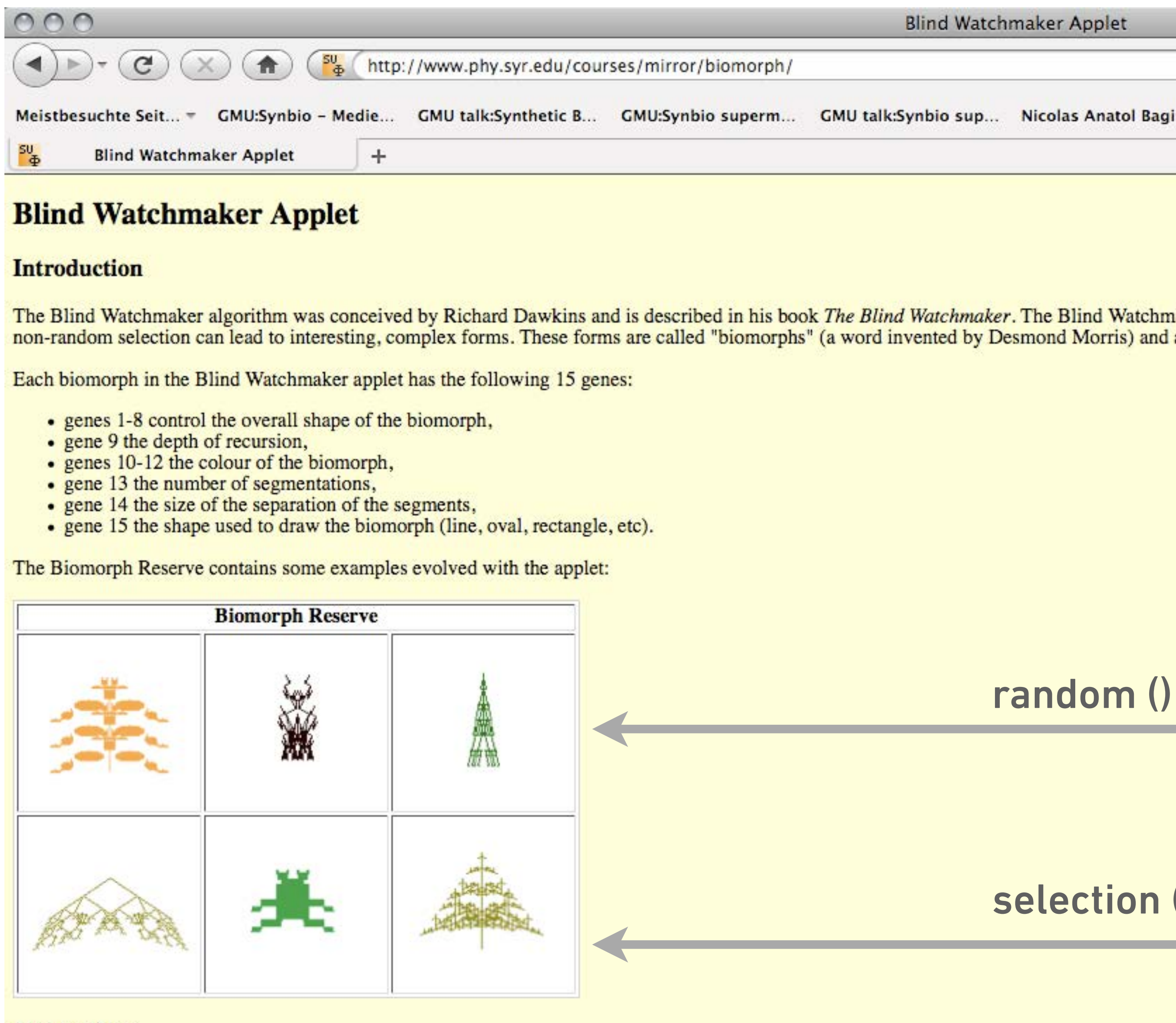
Let’s look at Richard Dawkins, an Evolutionary Biologist.
He regarded artificial life as a generator for insight into the rules of life in nature. In his book „the blind watchmaker" he shows, how one can achieve by applying certain organisational rules order and complexity of todays life forms. He wrote a program, which was made to develop treelike structures.
The parameters generating them were branches, outlines and symmetries. The proposed structures were created by mutation and combination in a computer program. The resulting structures were subjected to a selection, which in his case was an observer who evaluated them from the outside. The proposed solutions were developed in a simulated natural environment, so that the results are conditionally dependent on the conditions of the environment and, due to their functional coupling to it, in their form their product.

Biomorphe Biomorphgenerator

further reading:
http://www.medienkunstnetz.de/themen/cyborg_bodies/transgene_koerper/18/

Genetic algorithms

Form follows function - freely adapted from Richard Dawkins



Blind Watchmaker Applet

Introduction

The Blind Watchmaker algorithm was conceived by Richard Dawkins and is described in his book *The Blind Watchmaker*. The Blind Watchma
non-random selection can lead to interesting, complex forms. These forms are called "biomorphs" (a word invented by Desmond Morris) and a

Each biomorph in the Blind Watchmaker applet has the following 15 genes:

- genes 1-8 control the overall shape of the biomorph,
- gene 9 the depth of recursion,
- genes 10-12 the colour of the biomorph,
- gene 13 the number of segmentations,
- gene 14 the size of the separation of the segments,
- gene 15 the shape used to draw the biomorph (line, oval, rectangle, etc).

The Biomorph Reserve contains some examples evolved with the applet:

Biomorph Reserve

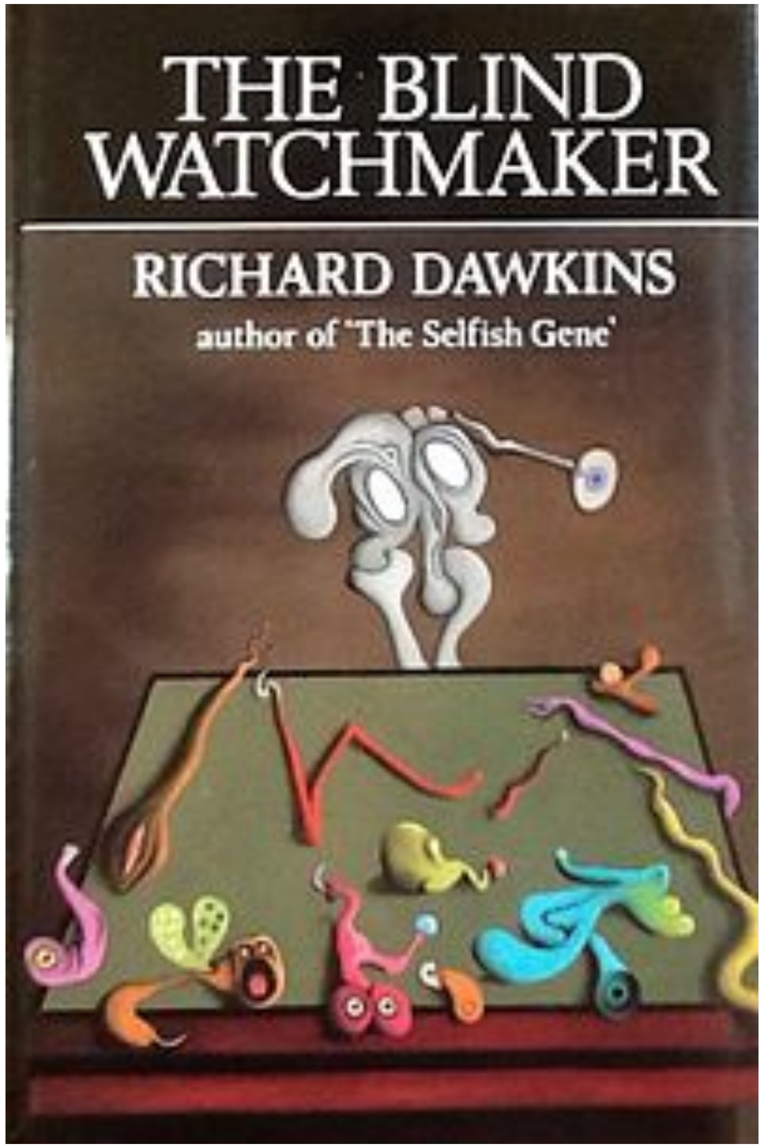
Instructions

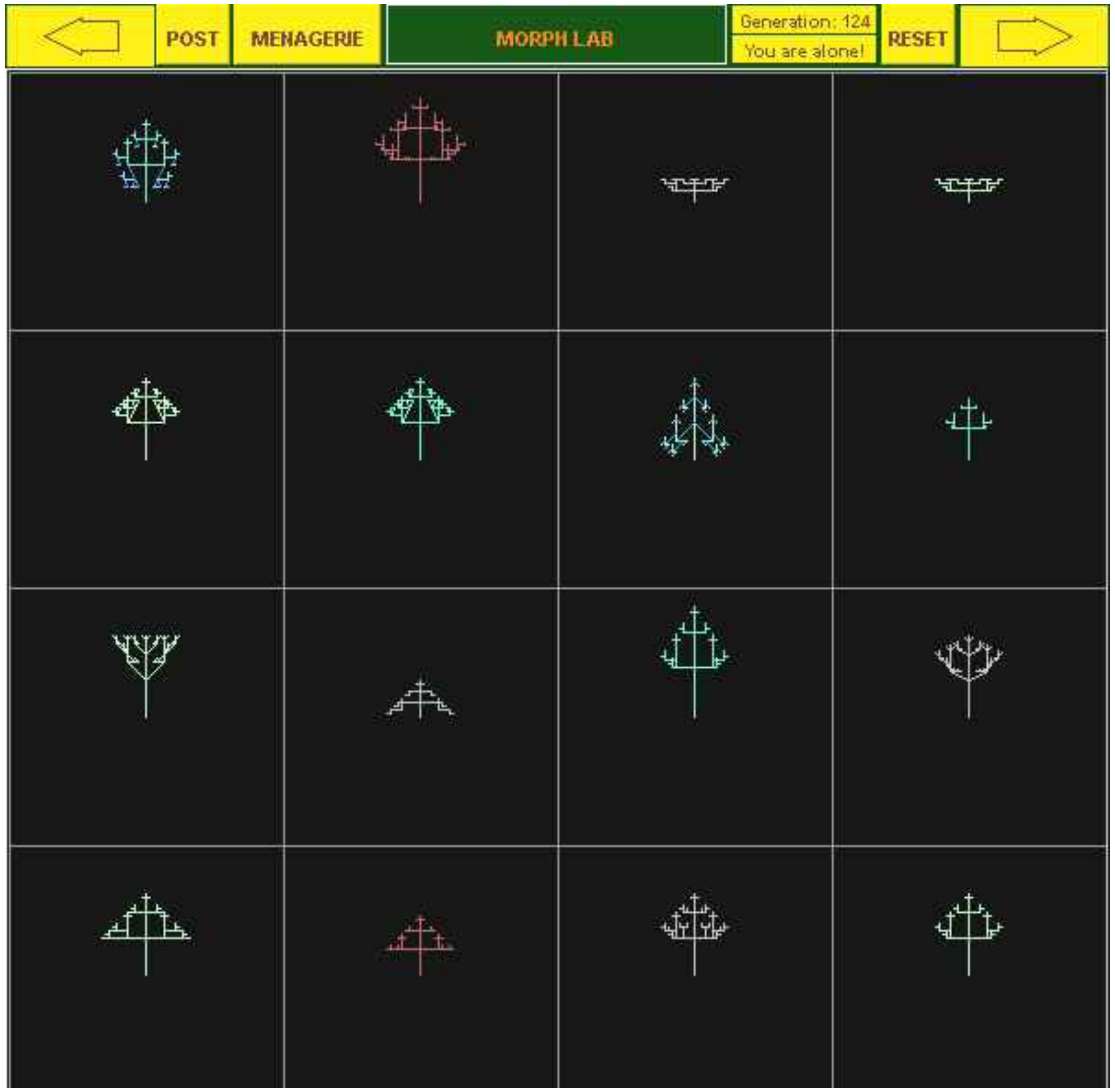
random () -> complexity

selection (by the visitor)

Richard Dawkins

The blind watchmaker 1986





Video - please look at it!

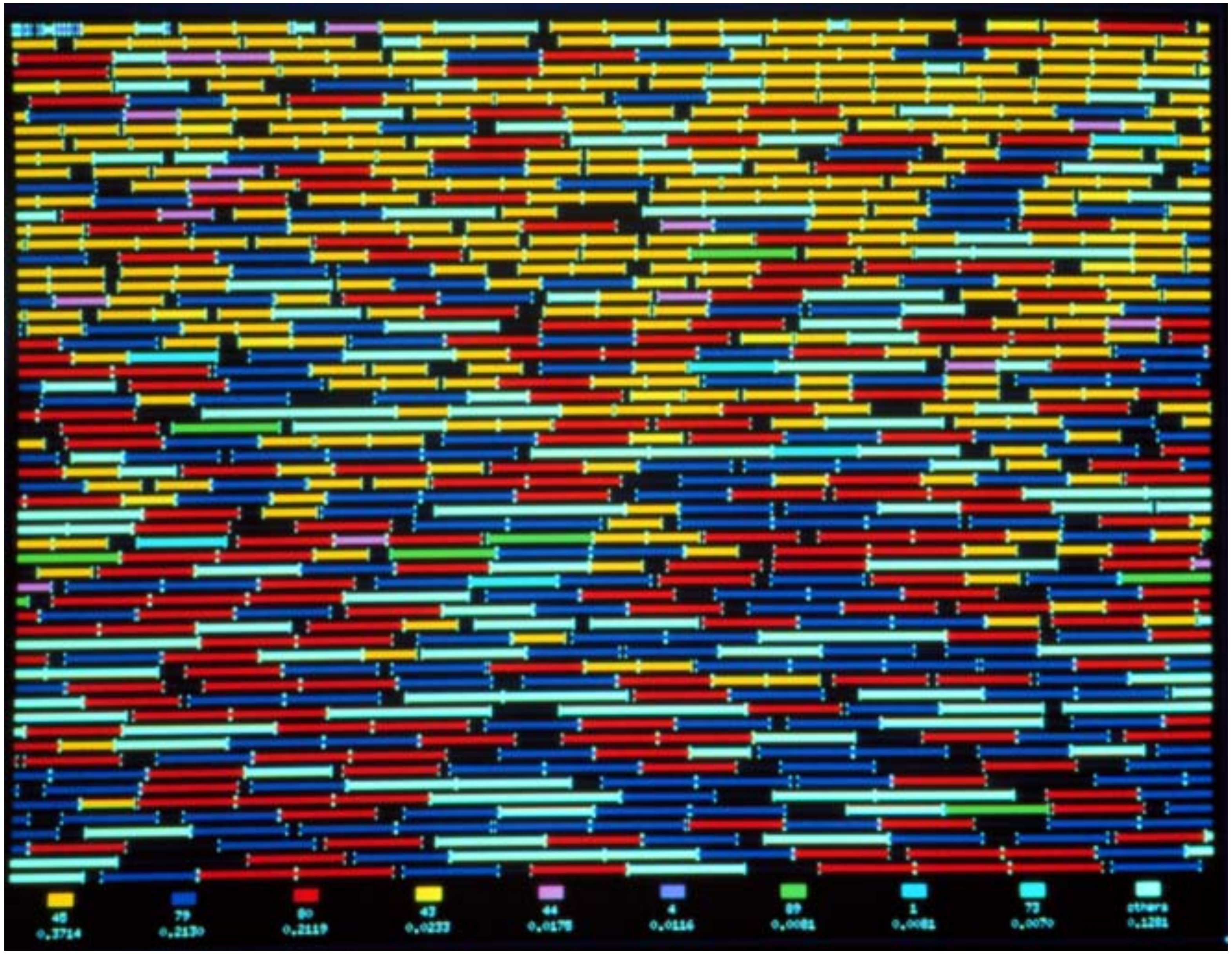
https://en.wikipedia.org/wiki/The_Blind_Watchmaker

App on Google Play

Thomas Ray

Project Tierra, aesthetically developed virtual PETS

Thomas S. Ray moved his job as evolutionary biologist from the jungle to the computer lab. He uses artificial life as a process in which he learns to understand carbon-based life on Earth through computer simulation.

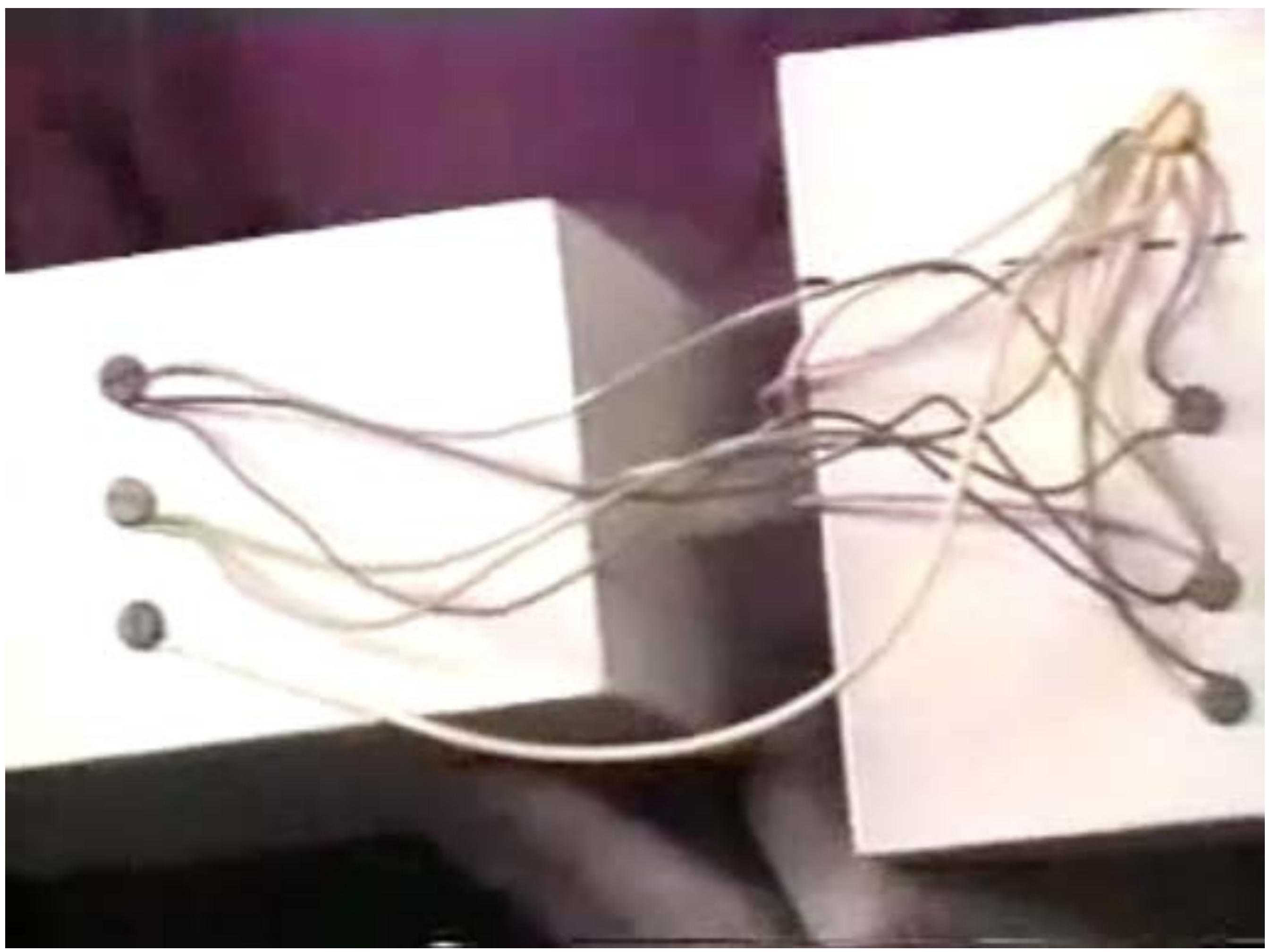


Video - please look at it!
https://en.wikipedia.org/wiki/Tierra_(computer_simulation)

Karl Sims

his first work was an installation with different monitors, on which synthetic, with genetic algorithms developed images were presented. A visitor could select and judge these images. Based on this selection, the images have been further developed with the synthetic genetics.
Installation table

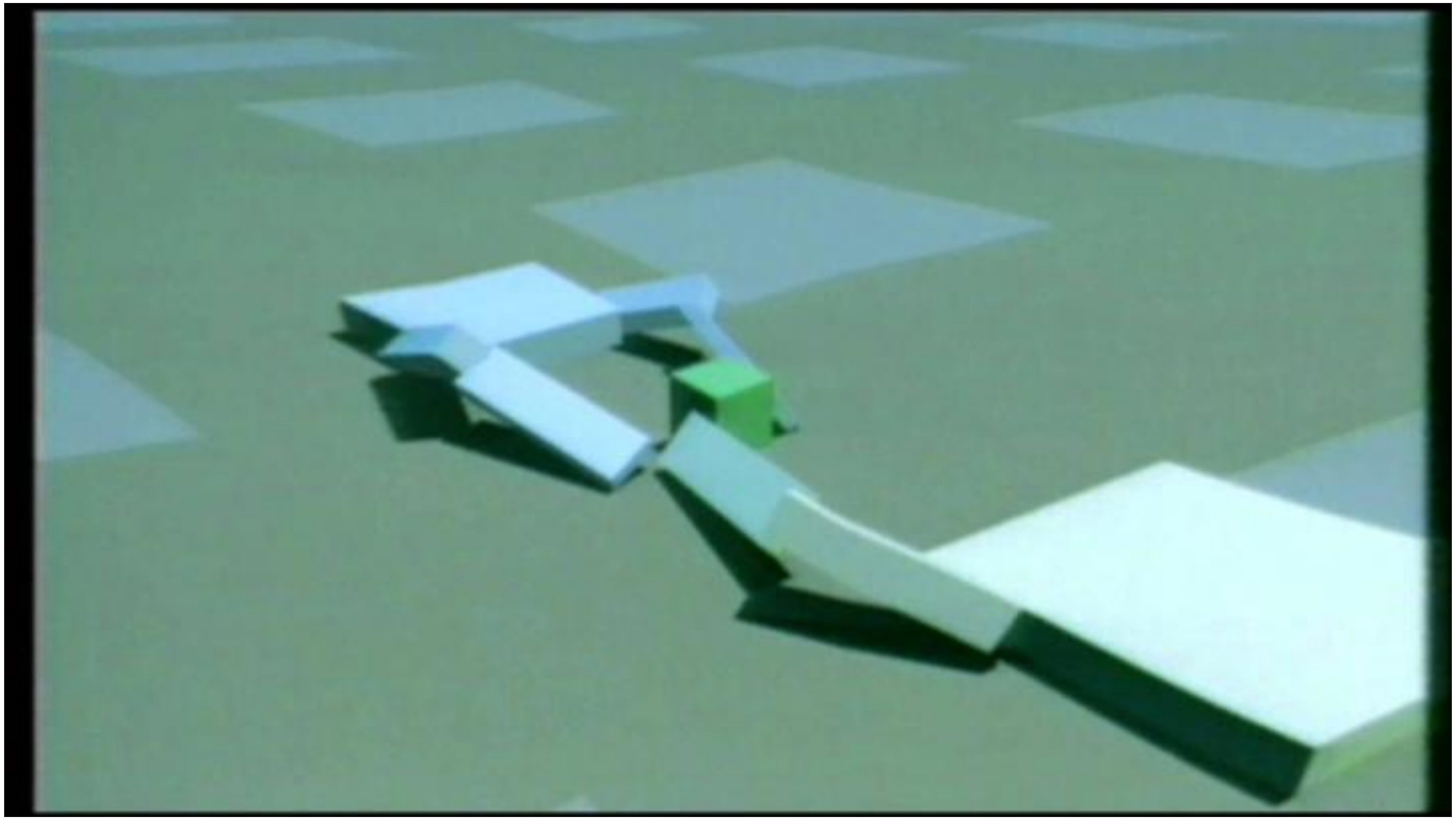
Karl Sims developed virtual creatures in reference to Richard Dawkins, simulating a physical environment on a computer and submitting simple „creatures“ to a selection and reproduction process.



Daniel Dennett - Is Evolution an Algorithmic Process? Part 4 - on Karl Sims creatures

https://youtu.be/b1rHS3R0llU

Karl Sims

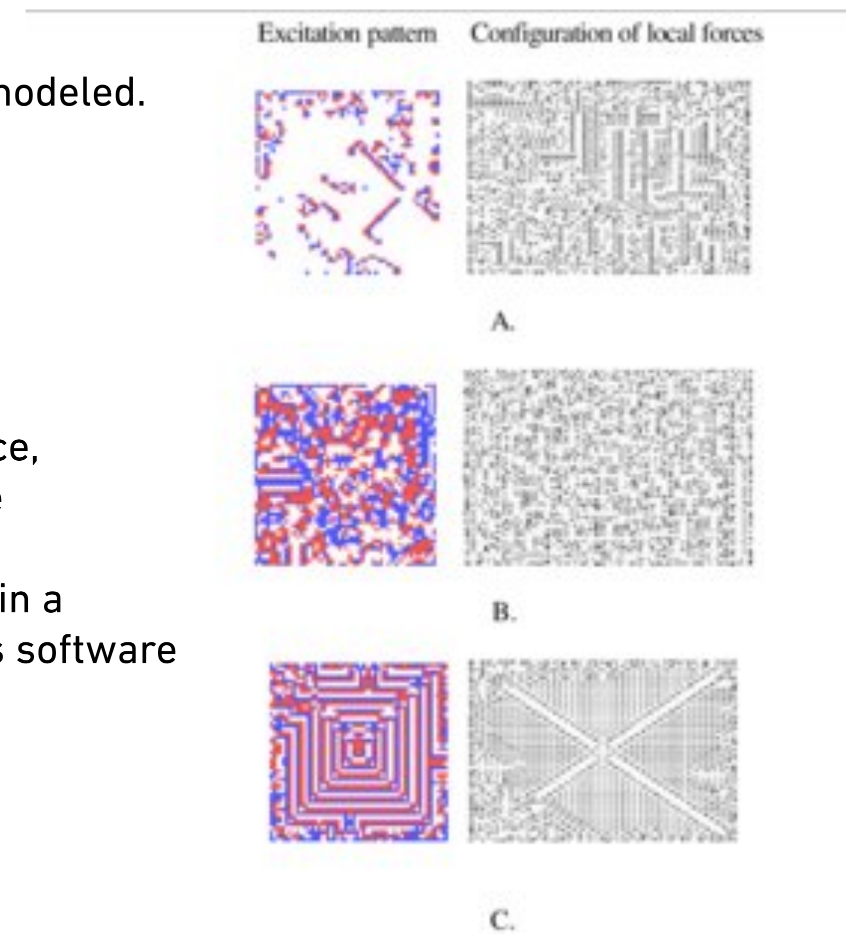


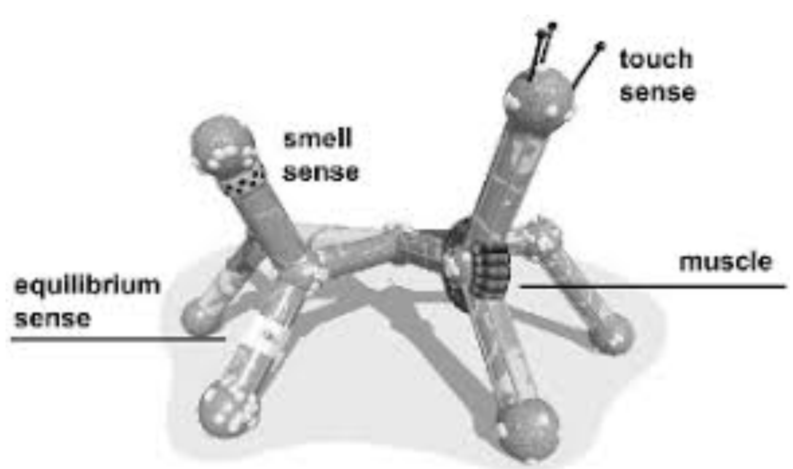
Karl Sims on his virtual creatures

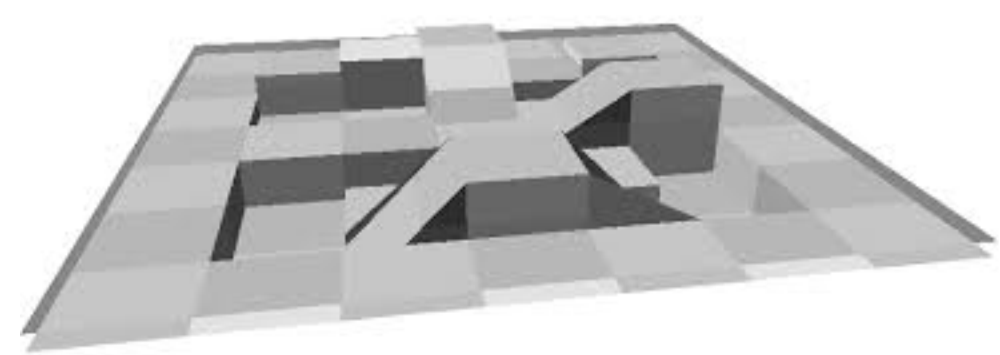
https://youtu.be/WmrTNrtE-Lk
[a more recent approach]()

Framsticks

Framsticks is a three–dimensional life simulation project.
Both mechanical structures (“bodies”) and control systems (“brains”) of creatures are modeled.
It is possible to design various kinds of experiments, including simple optimization
(by evolutionary algorithms), coevolution, open–ended
and spontaneous evolution, distinct gene pools and populations, diverse
genotype/phenotype mappings, and species/ecosystems modeling.
You are welcome to try our program! Current Framsticks users work on evolutionary
computation,
artificial intelligence, neural networks, biology, robotics and simulation, cognitive science,
neuroscience, medicine, philosophy, virtual reality, graphics, and art. The system can be
interesting
for experimenters who would like to evolve their own artificial creatures and see them in a
three–dimensional, virtual world. You can also manually design and test creatures. This software
is a
versatile tool for research and education.

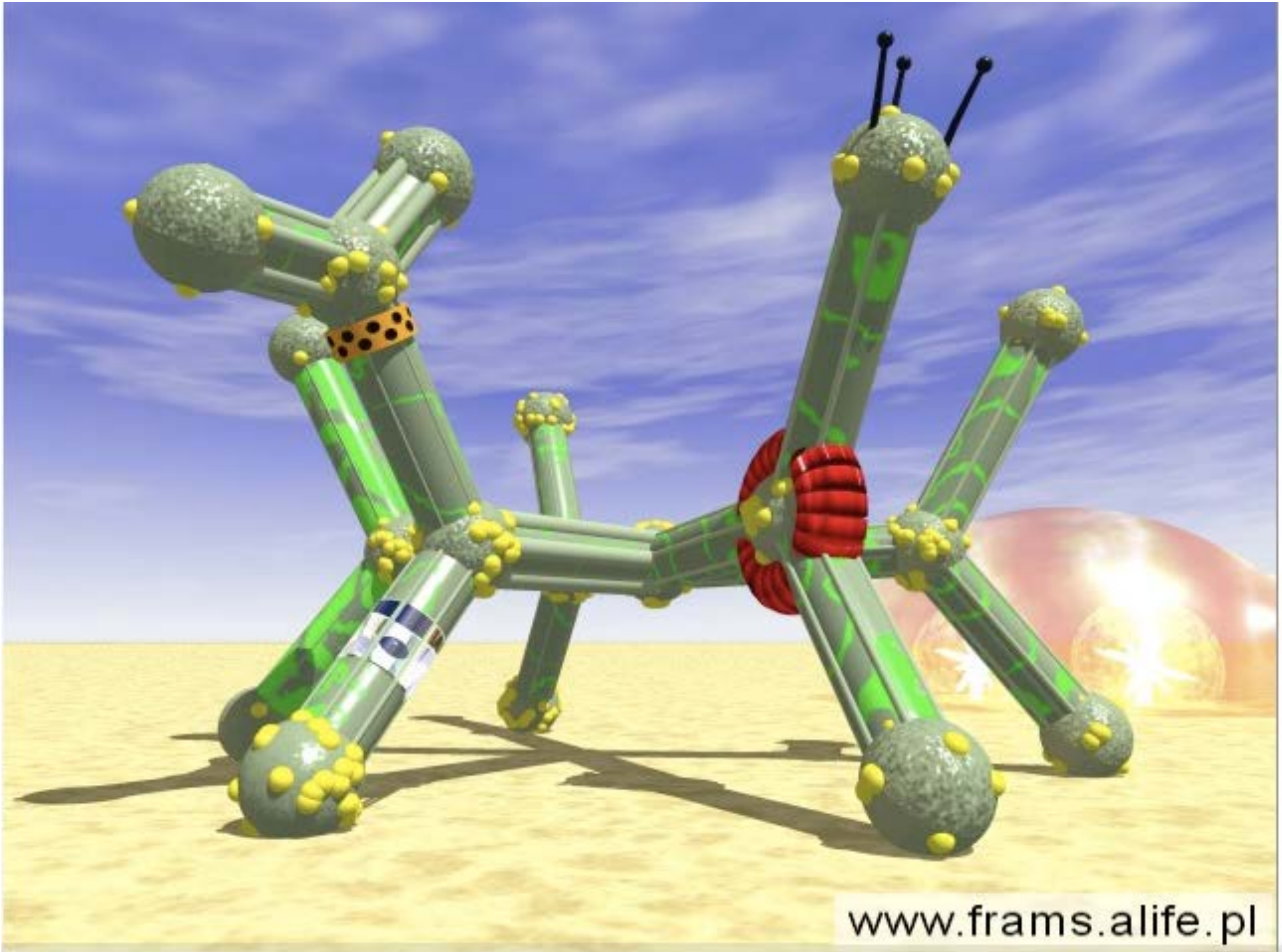






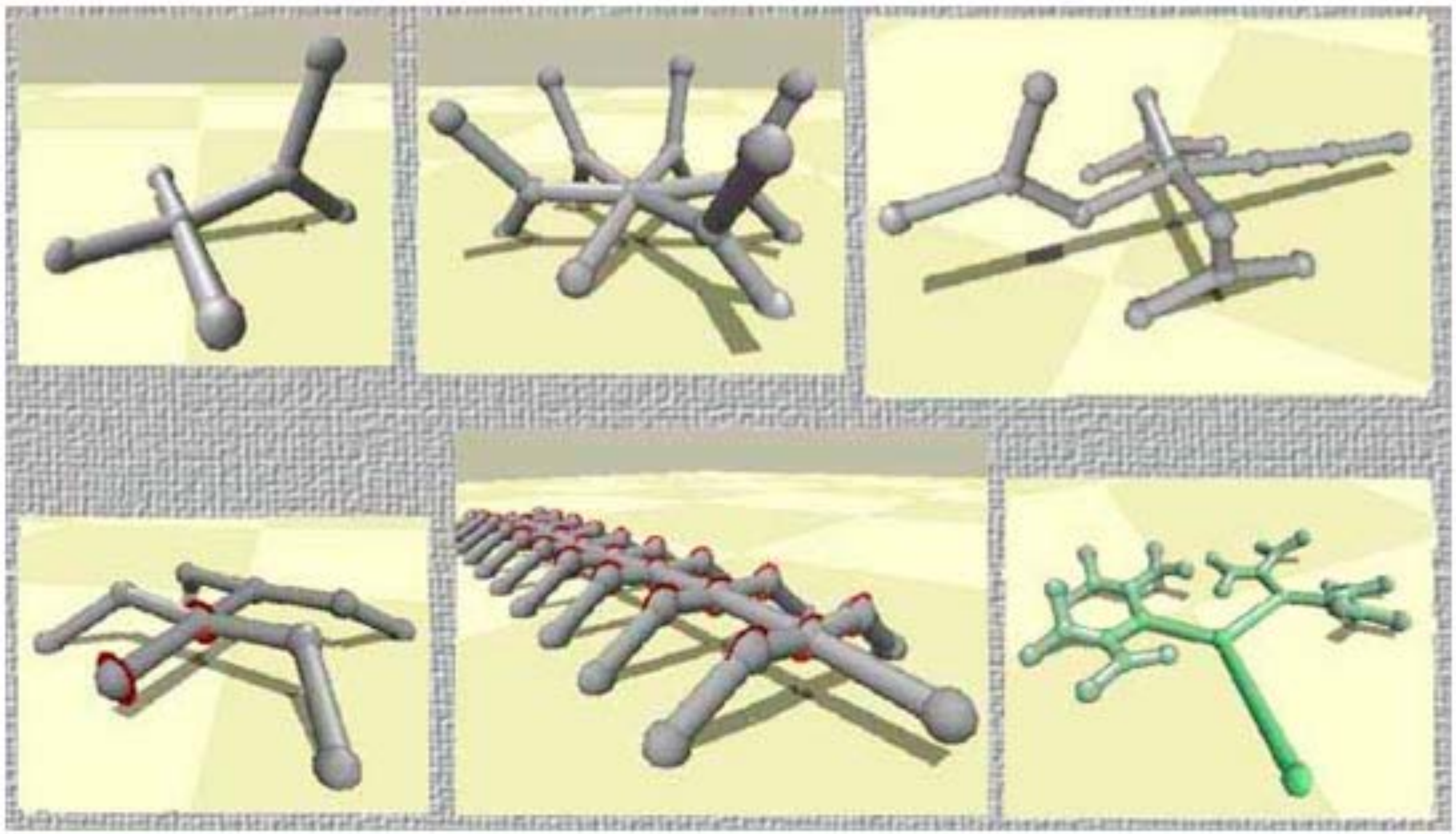
http://www.framsticks.com/

framsticks



A creature made of sticks, each is specialized in some function. You can see three receptors – touch, smell, equilibrium, and a red muscle.

Some more samples of possible structures:



4 Simulation Details

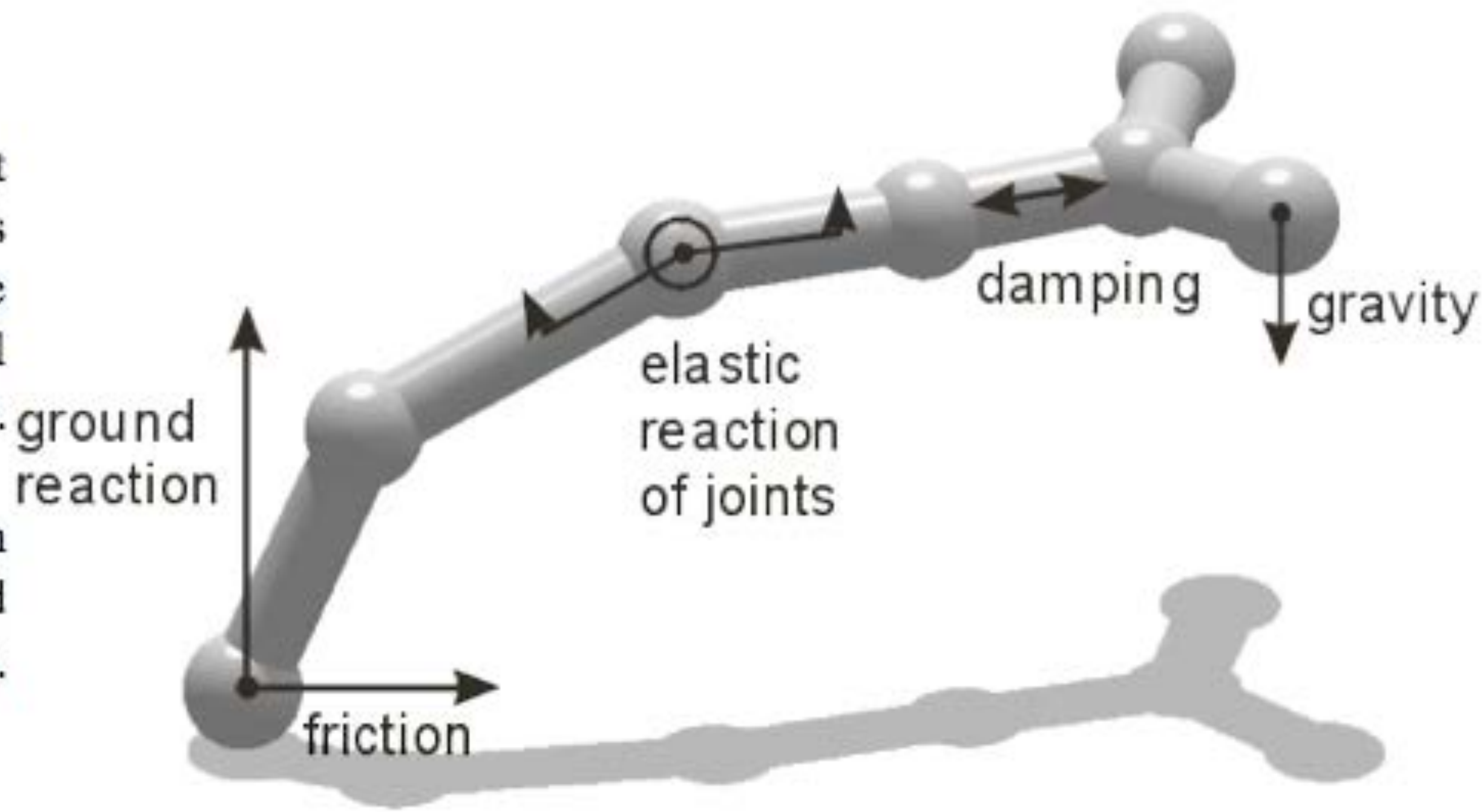
4.1 Physical (creature's body) simulation

Bodies of creatures are divided into small pieces (at sticks' ends) which are ideal material points. This approach is called "finite element method": not every point of a material body is simulated – only a finite number of points, representing small volumes in the body. The simulator calculates all the forces affecting a given point: gravity, elastic reaction when joined with other points, ground reaction and friction when touching the ground, etc.

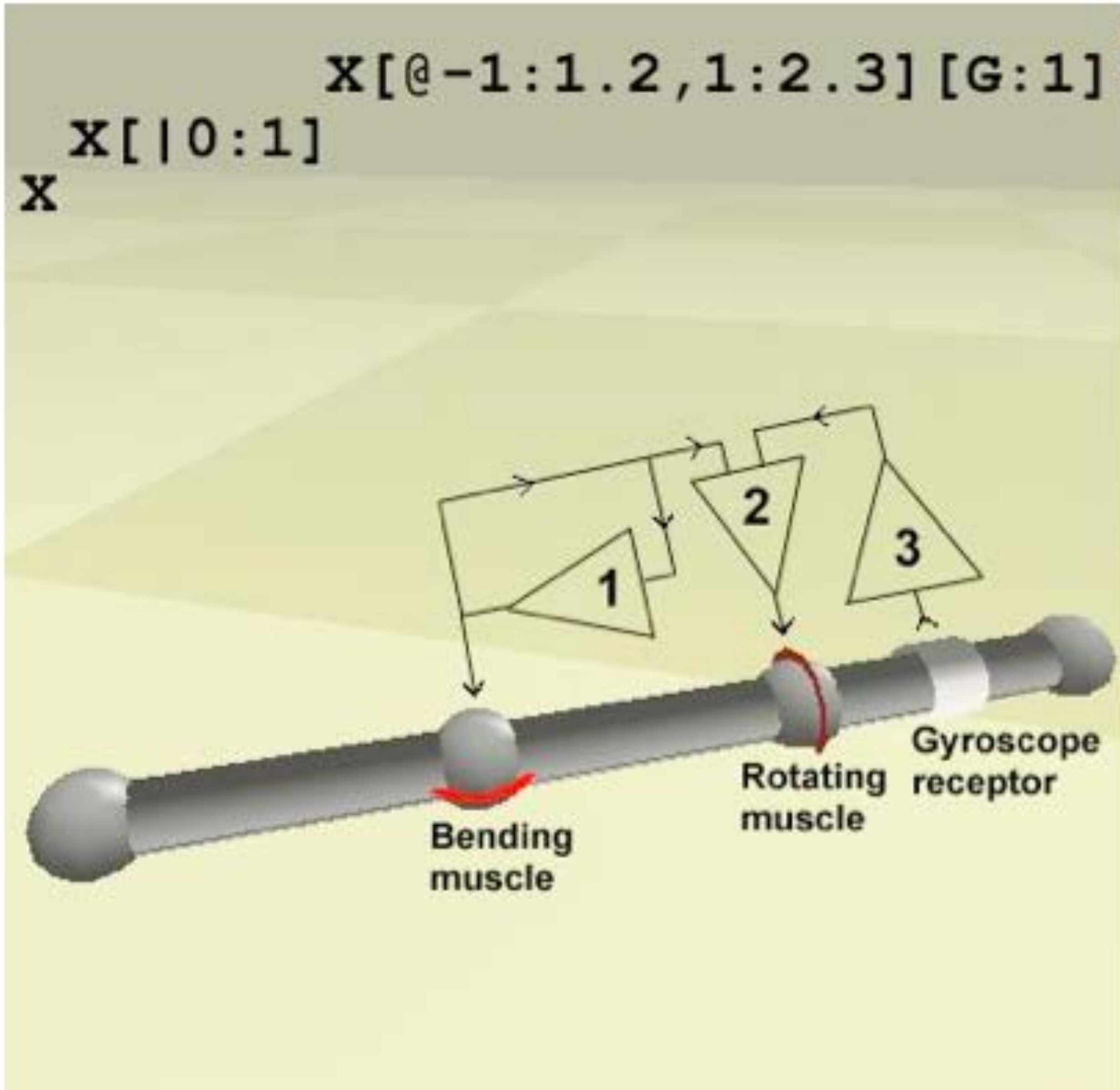
In our model some assumptions are taken to simplify calculations. A primitive but fast numeric integration method is used, so the results are not very exact when dealing with big forces.

The picture on the right shows sample forces calculated in the Framsticks physical simulator, *Mechastick*.

The body is made from **parts** (points) and **joints** (sticks, rods).



One stick can have many neurons – X[.....][.....][.....]



Example:

X X[|0:1] X[@−1:1.2,1:2.3][G:1]

- neuron (1) affects stick's bend and is looped recursively
- neuron (2) affects stick's rotation, and receives signals from neurons (1) and (3)
- neuron (3) has one input: gyroscope (equilibrium sense of the last stick)

https://youtu.be/CrWj_l-UrN4

Virtual Fish Tank 2001

http://musemediapedia.pbworks.com/w/page/65312496/VirtualFishtank-%20Create%20Virtual%20Fish%20at%20Home%20and%20Release%20Them%20at%20the%20Museum

http://tcm.computerhistory.org/exhibits/VirtualFishTank.html
https://www.youtube.com/watch?v=BPEt2BNHEdk

...just a predator-prey simulation online

...and here a nice video from a simulation

Craig Reynolds Boids
Craig Reynolds on Evolutionary Computation
Contemporary applications

Karin Ohlenschläger (curator) presents VIDA

https://youtu.be/yuqmdXakWTo

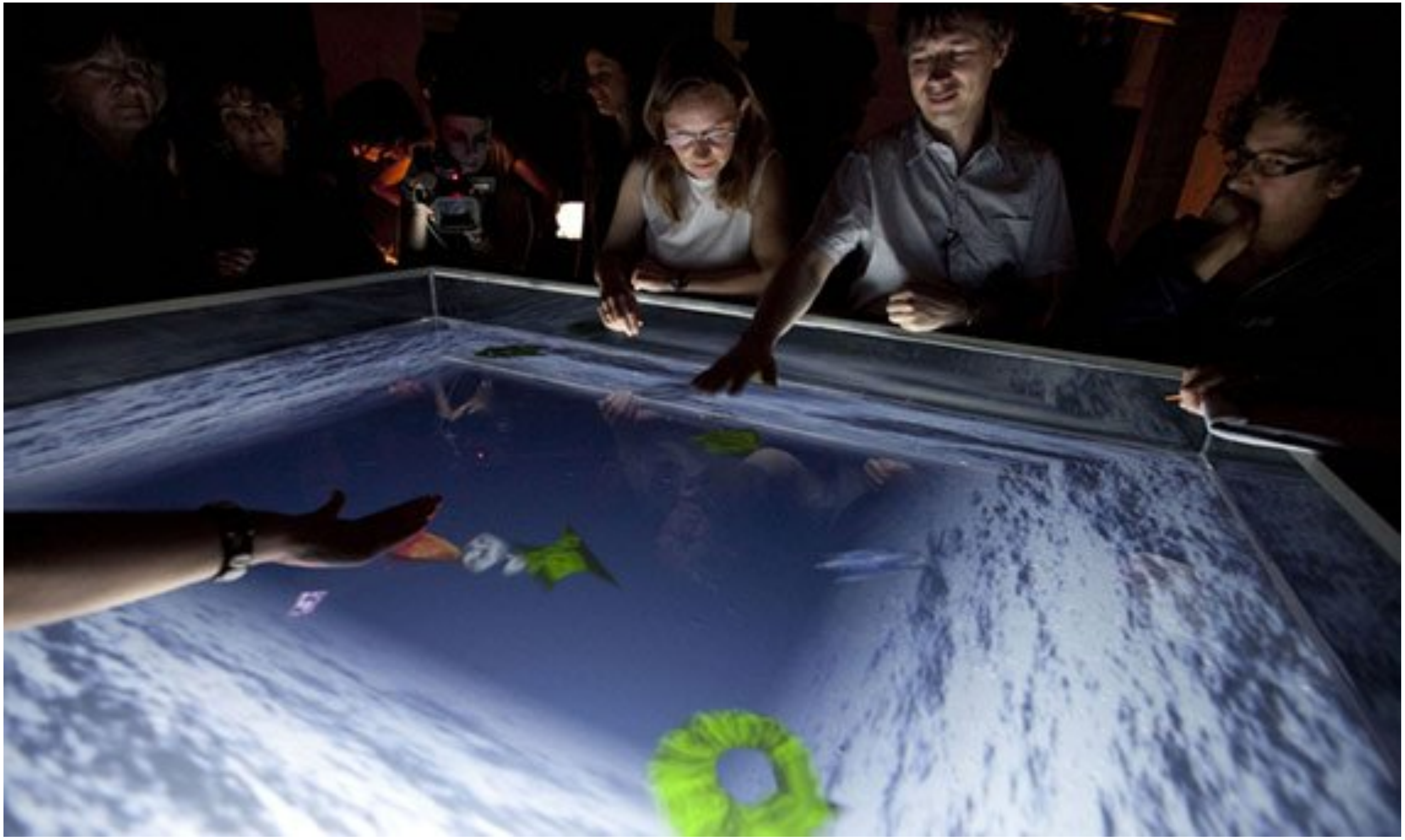
Christa Sommerer, Laurent Mignoneau

Interactive Plant Growing, 1993

https://artelectronicmedia.com/artwork/interactive-plant-growing/
https://vimeo.com/7723181

Christa Sommerer, Laurent Mignoneau

A-Volve, 1994-97

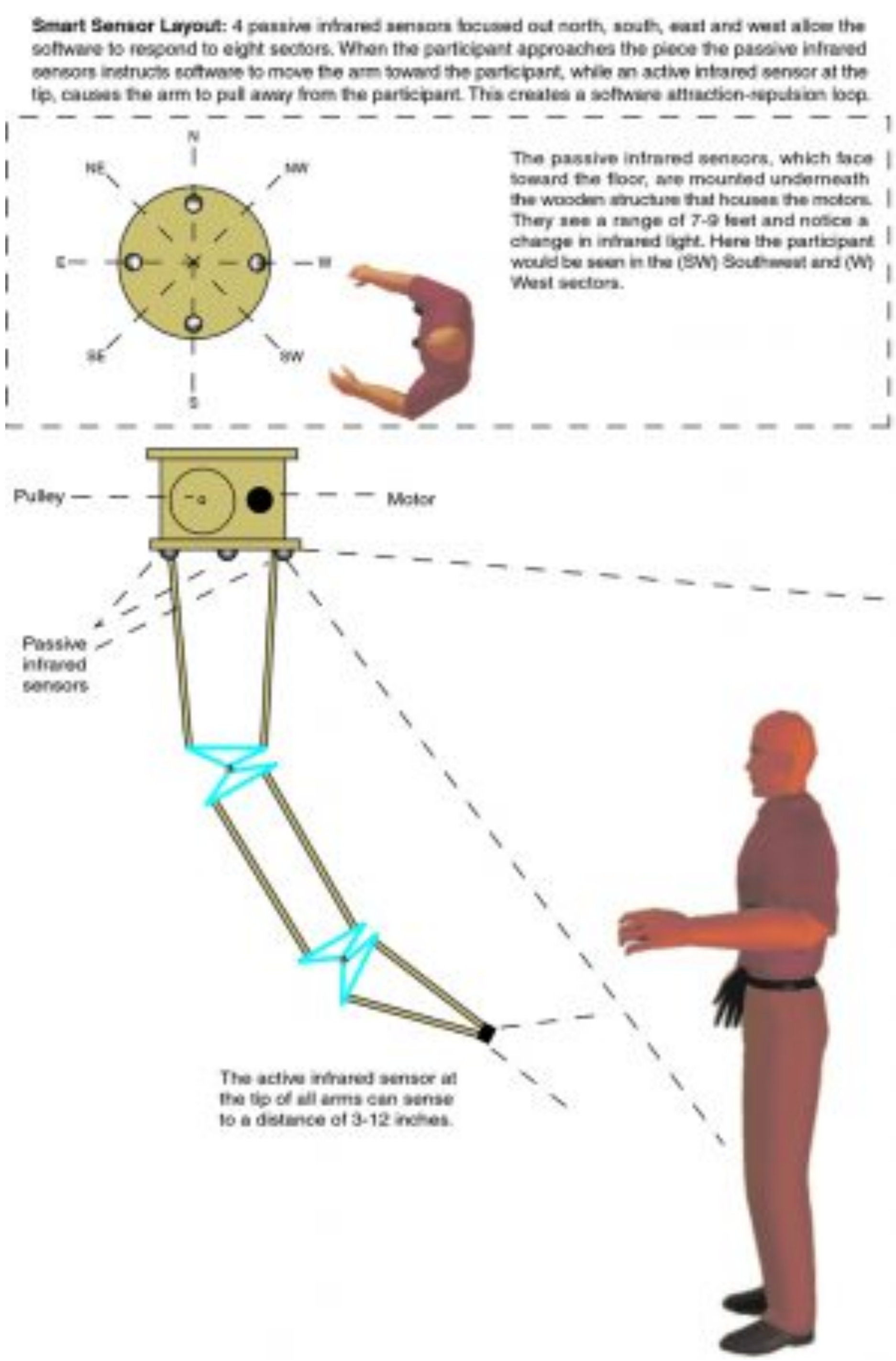


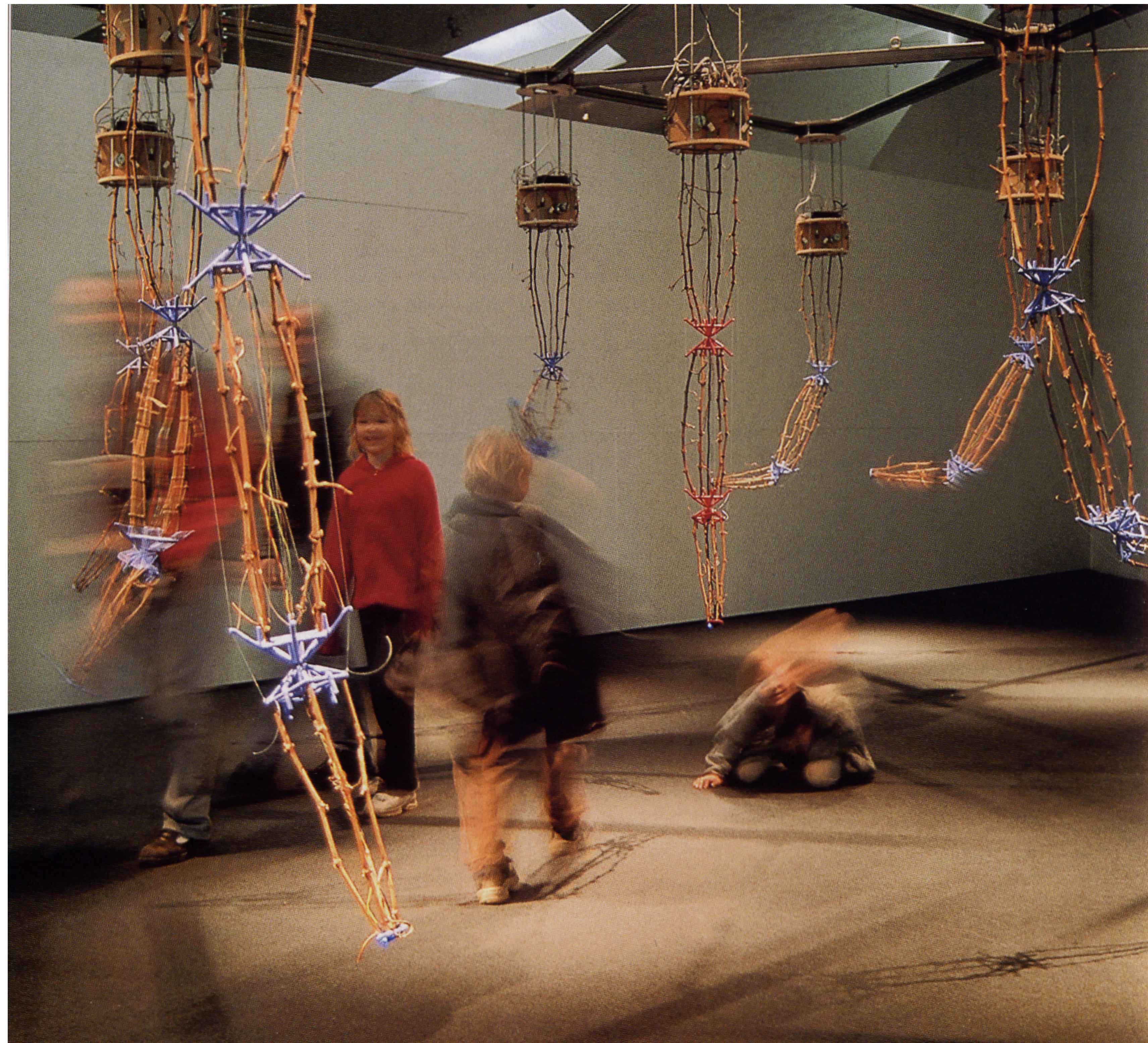
[*Video*](http://www.interface.ufg.ac.at/christa-laurent/WORKS/CONCEPTS/A-VolveConcept.html)

http://www.interface.ufg.ac.at/christa-laurent/WORKS/CONCEPTS/A-VolveConcept.html

Kenneth Rinaldo

Autopoiesis + The Flock, 2000





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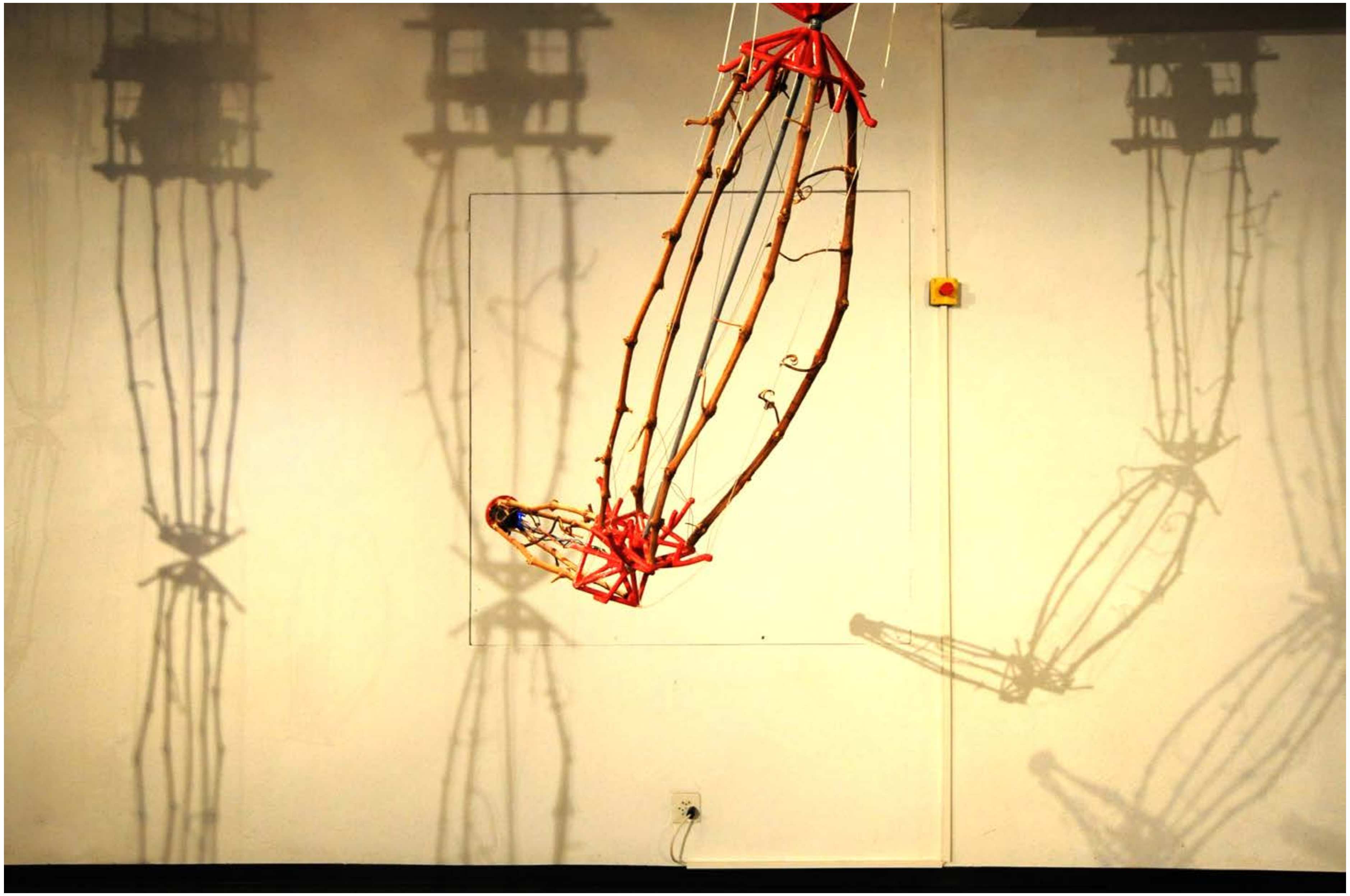


https://www.kenrinaldo.com/portfolio/autopoiesis/
https://www.kenrinaldo.com/wp-content/uploads/2015/08/Autopoiesis-web.mp4?id=0
https://www.kenrinaldo.com/portfolio/the-flock-2000-finland/

Ursula Damm

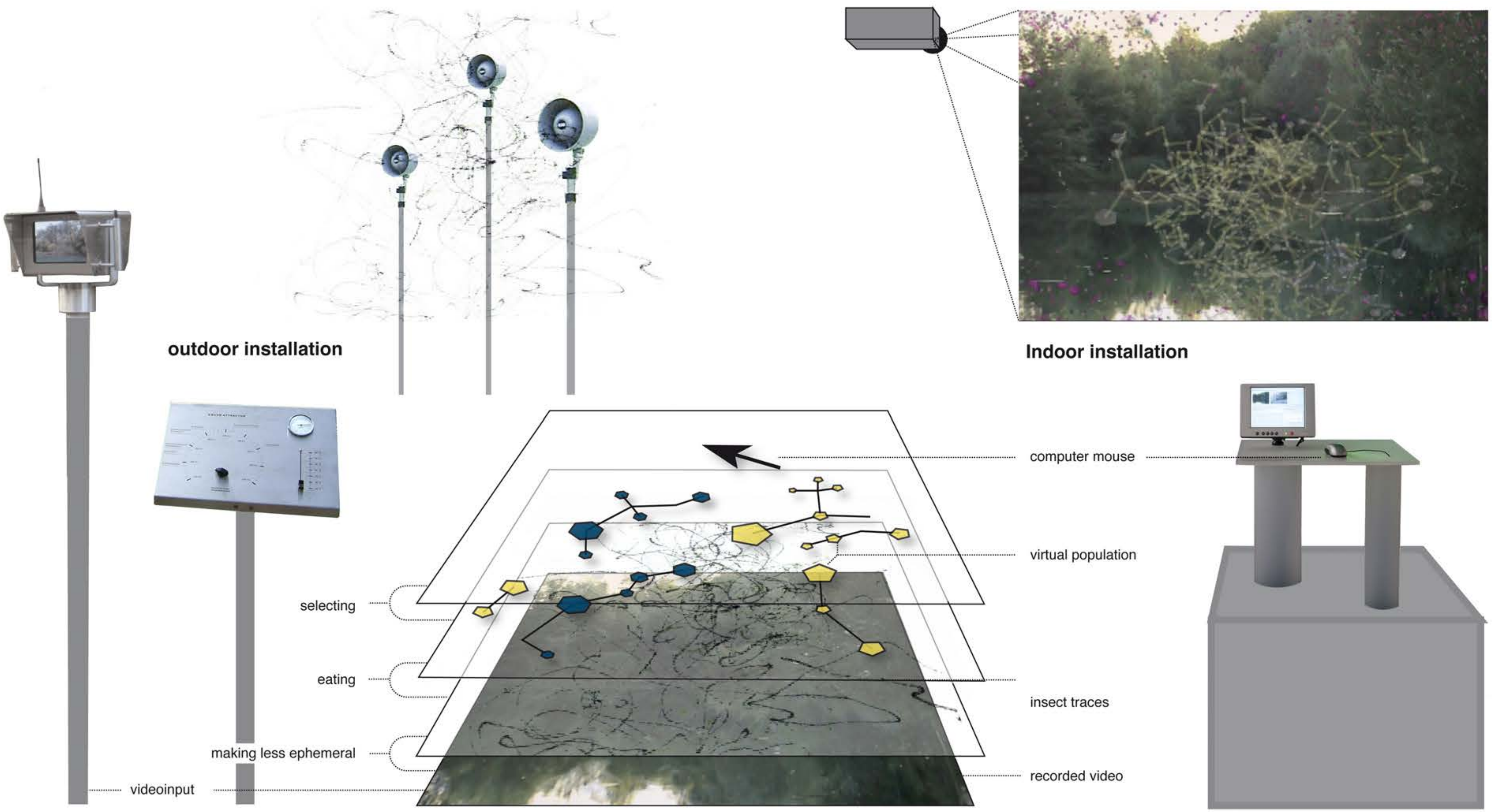
Double Helix Swing 2004-2006

http://ursuladamm.de/double-helix-swing-2006/

a PDF documentation on the art work

Ursula Damm

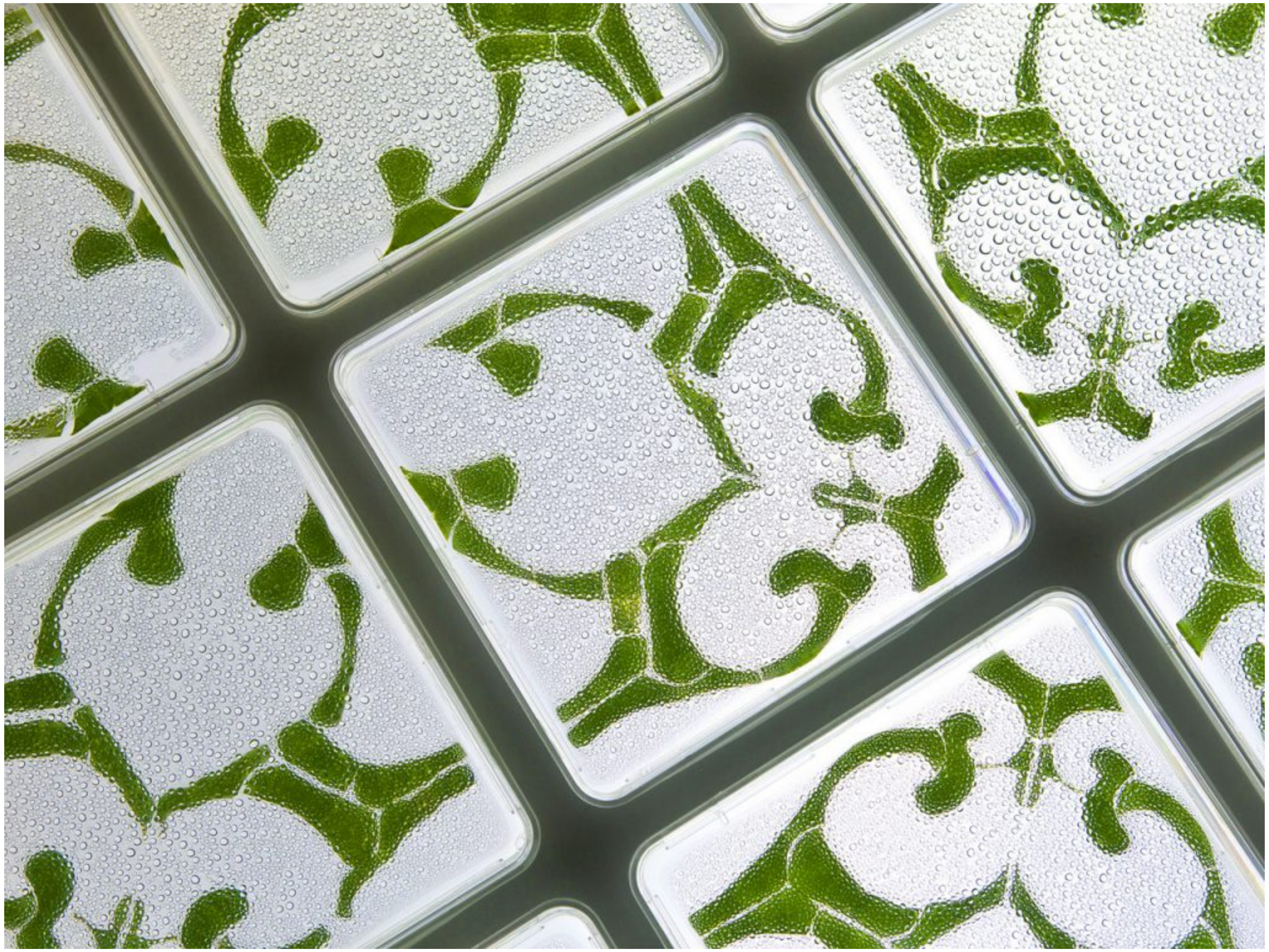
Double Helix Swing 2004-2006



[Video Animation](#)
[Video Outdoor Installation](#)

Alison Kudla

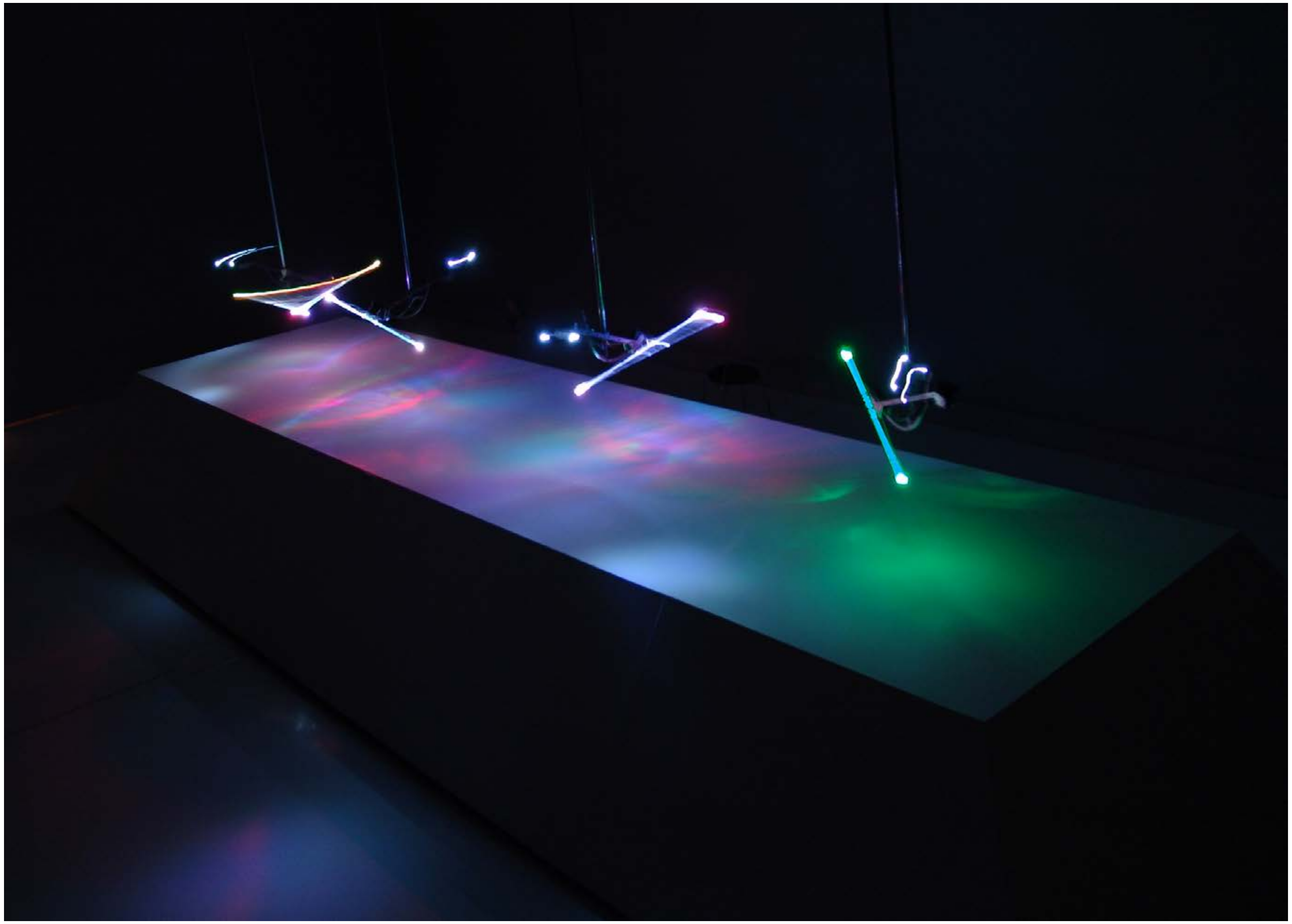
Growth Pattern 2012



http://allisonx.com/project/growth-pattern/
https://vimeo.com/79462371

Ruairy Glynn

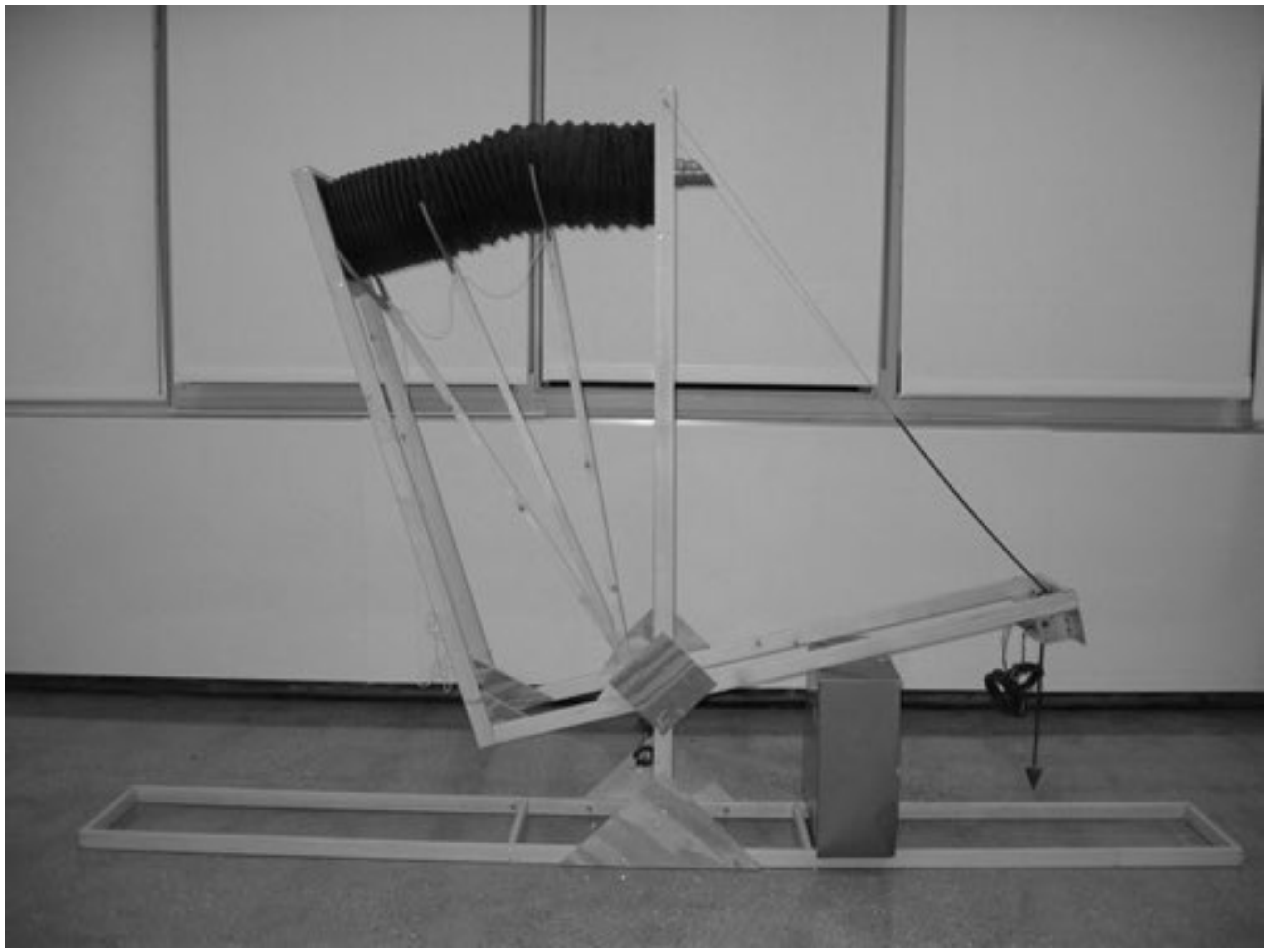
Performative Ecologies, 2012



http://www.ruairiglynn.co.uk/portfolio/performative-ecologies/
https://vimeo.com/3337399

Simon Penny

Phatus 2010



https://youtu.be/HmRIbVm83BQ
http://www.simonpenny.net/works/phatus.html

Teo Jansen

Strandbeetsen since 1990

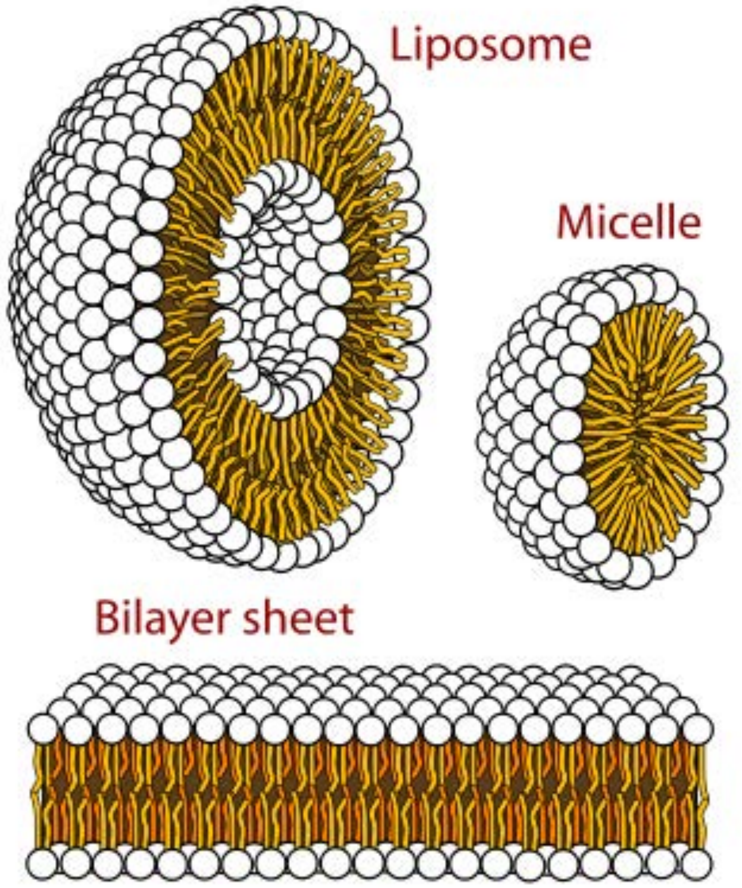
https://youtu.be/LewVEF2B_pM
https://www.strandbeest.com/

Rachel Armstrong
Protocells 2011

A protocell (or protobiont) is a self-organized, endogenously ordered, spherical collection of lipids proposed as a stepping-stone to the origin of life. A central question in evolution is how simple protocells first arose and how they could differ in reproductive output, thus enabling the accumulation of novel biological emergences over time, i.e. biological evolution. Although a functional protocell has not yet been achieved in a laboratory setting, the goal to understand the process appears well within reach.

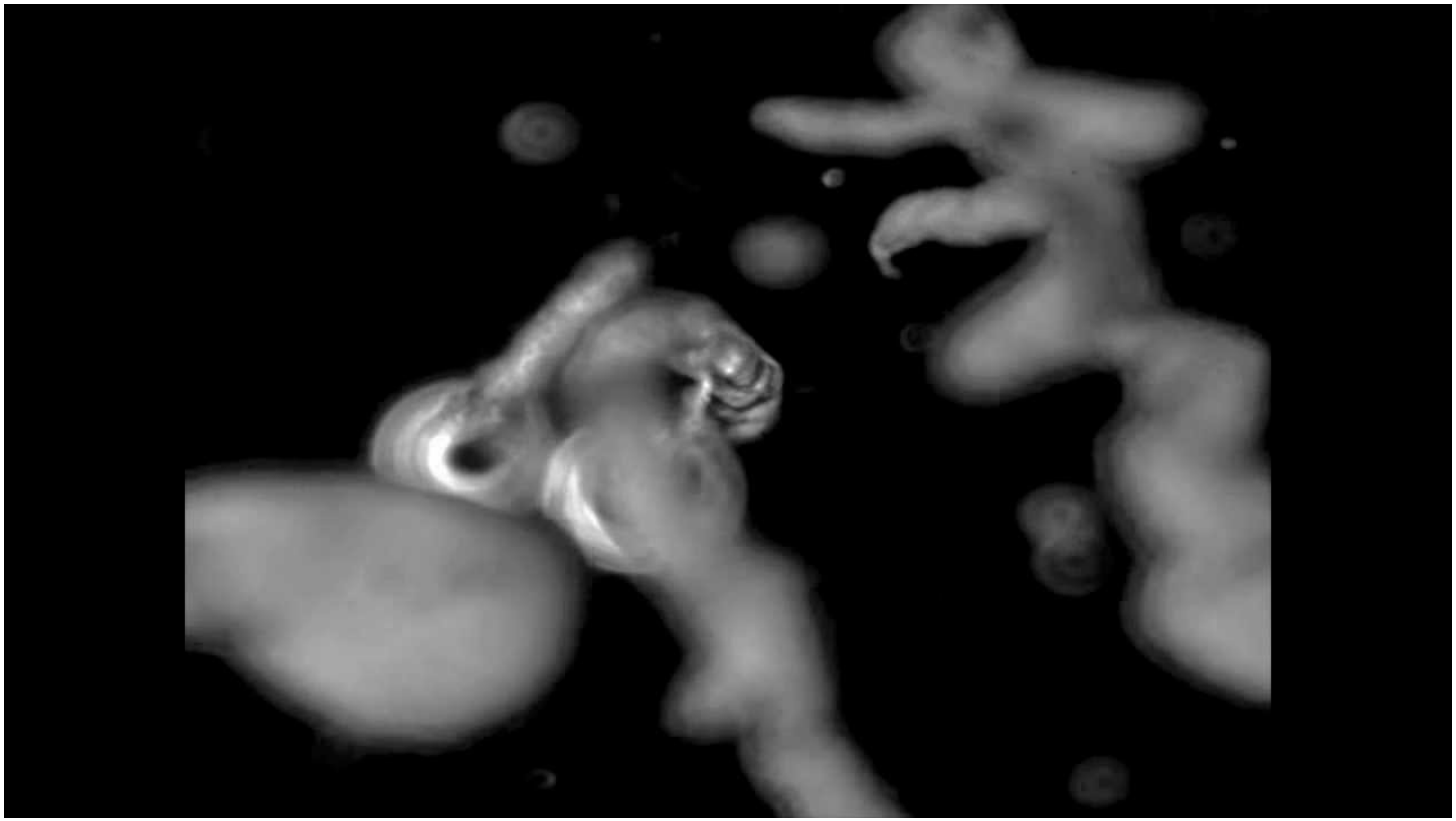
Self-assembled vesicles are essential components of primitive cells. The second law of thermodynamics requires that the universe move in a direction in which disorder (or entropy) increases, yet life is distinguished by its great degree of organization. Therefore, a boundary is needed to separate life processes from non-living matter.The cell membrane is the only cellular structure that is found in all of the cells of all of the organisms on Earth.

Source: Wikipedia



Rachel Armstrong

Protocells 2011



https://vimeo.com/22115996