



Lecture 1b  
*An Introduction to Artificial Life*

Alan Dorin

FIT3094 Artificial Life, Artificial Intelligence and Virtual Environments

By ERWIN SCHRÖDINGER

★  
WHAT  
IS  
LIFE?  
★

★  
The Physicist's approach to the  
Subject—With an Epilogue on  
Determinism and Free Will

CAMBRIDGE UNIVERSITY PRESS  
THE MACMILLAN COMPANY



Life Explained

Michel Morange

# Artificial Life

...is a scientific field that studies biological processes by producing models of them and exploring the properties of the models. Many A-Life models are computer models.

*Synthesis* and *Emergence* are common themes of Artificial Life.

Local interactions between simple elements are said to facilitate the *emergence* of complex behaviours at a global level. The *synthesis* of complex behaviour “from the bottom up” is a goal of A-Life research\*.



\*Contrast this with the approach of AI

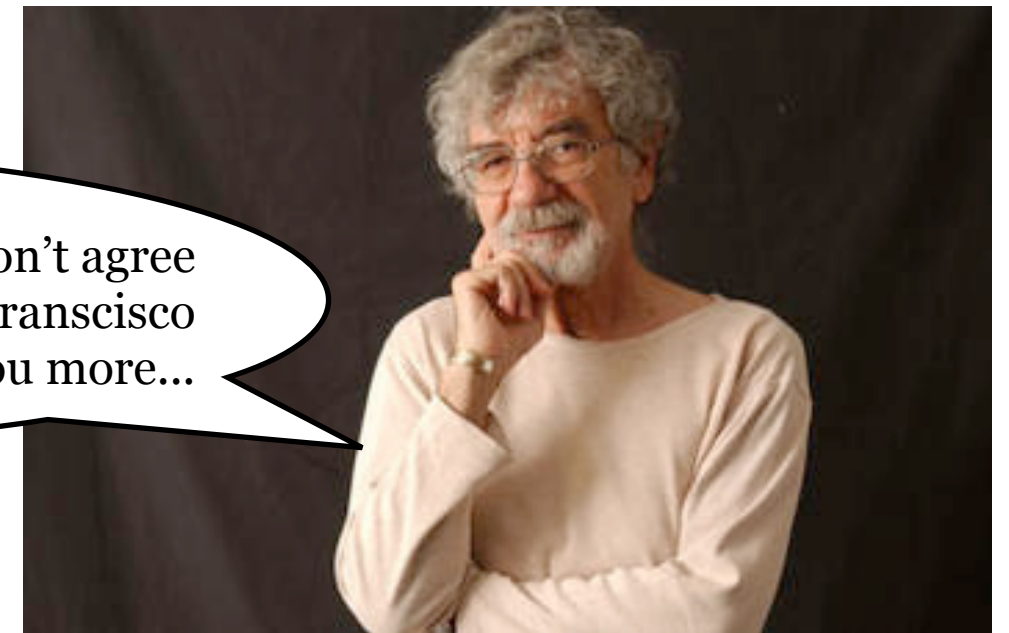




A-Life is the study of *life as it could be*.  
Life is a property of form, independent of matter.

**Chris Langton\***, organiser of the first Artificial Life conference (1987)

I've not had much to do with A-Life, but I don't agree with your second statement. My student Francisco Varela will tell you more...



**Humberto Maturana**, a Chilean Biologist famous for introducing the concept of *autopoiesis*.



Langton's ant

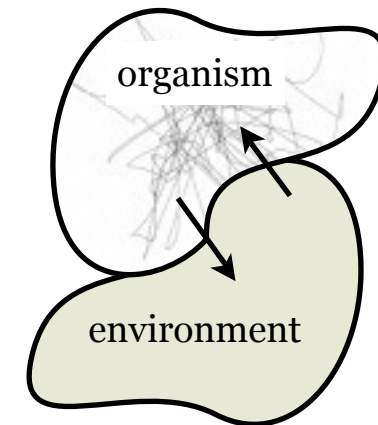
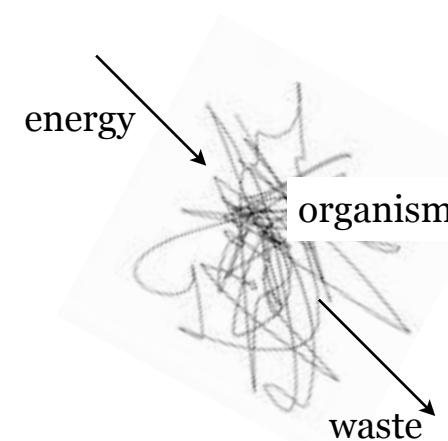
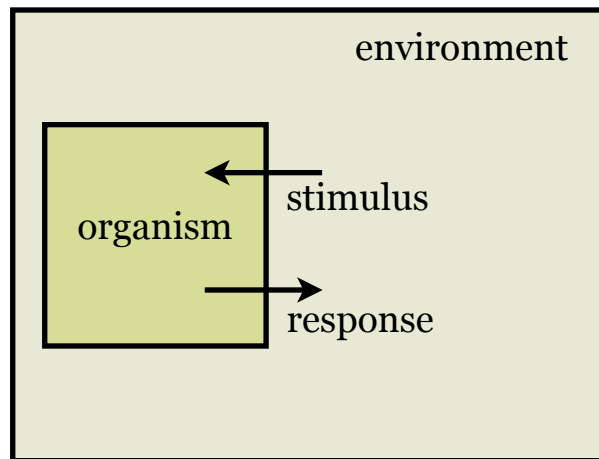
\* Image digitised by Jon McCormack, 2002.



## Langton et. al. 1991, Alife (USA) II...

"Artificial Life is a field of study devoted to understanding life by attempting to abstract the fundamental dynamical principles underlying biological phenomena, and recreating these dynamics in other media - such as computers - making them accessible to new kinds of experimental manipulation and testing"

*A living system can be viewed as having an input (stimulus), an output (response) and some internal control acting on the input to produce the output.*



**Chris Langton**

## Bourgine & Varela 1992, Alife (Europe) I...

"Artificial Life can be better defined as a research program concerned with autonomous systems, their characterization and specific modes of viability."

*A living system can be viewed as an autonomous device with its autonomy / viability arising through internal self-organizing processes which are responsible for its behaviour.*



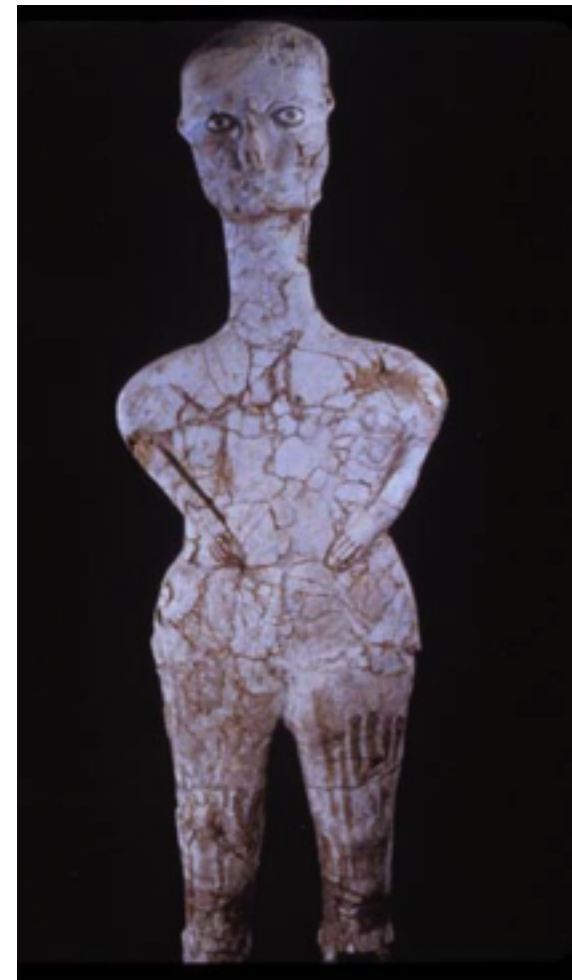
**Francisco Varela**  
(1946-2001)

# So, are these artefacts *alive*?

- ▶ Cave painting
- ▶ Earthen sculpture
- ▶ Puppets
- ▶ Pneumatic sculpture
- ▶ Clockwork automata
- ▶ Electrical robots
- ▶ Computer models

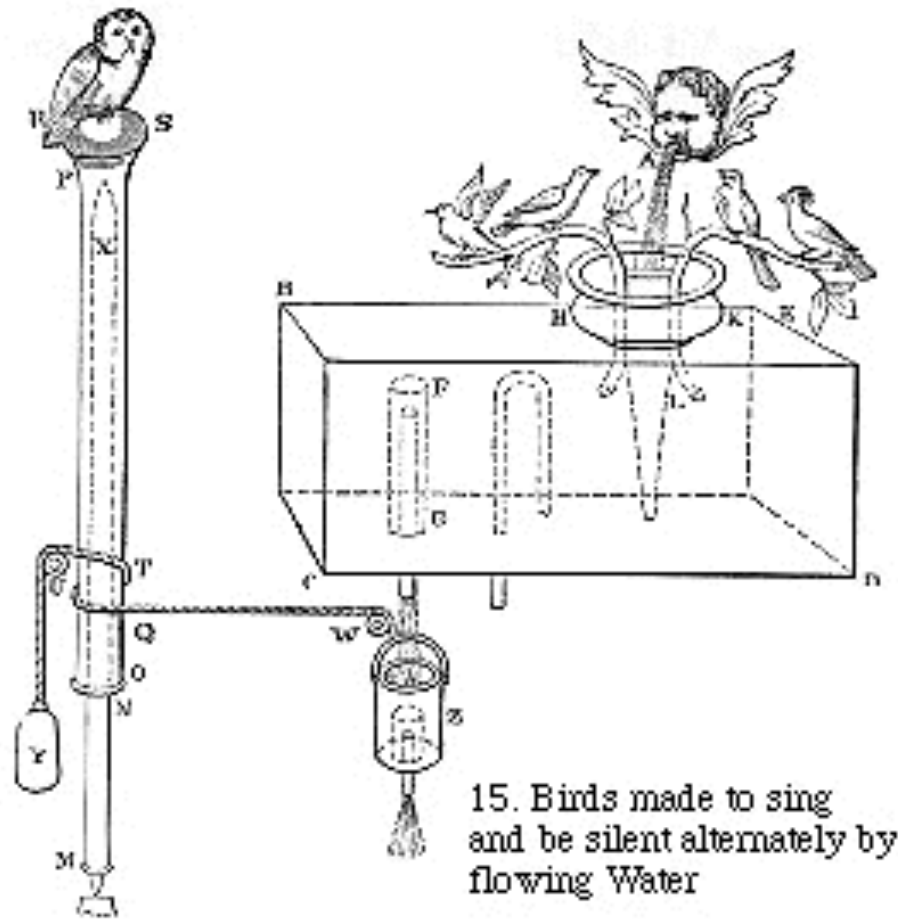


Lascaux Caves, France  
c. 15,000 BCE.

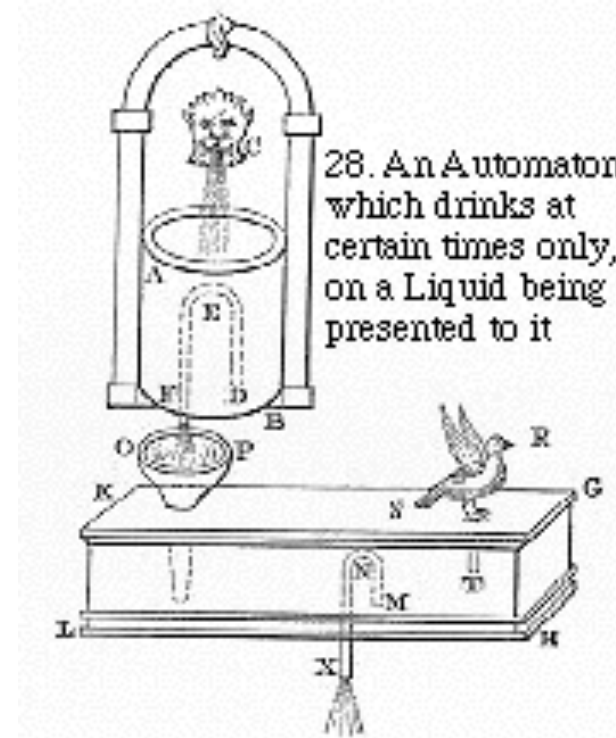


Ain Ghazal, Jordan  
c. 7000-6000 BCE.





15. Birds made to sing and be silent alternately by flowing Water

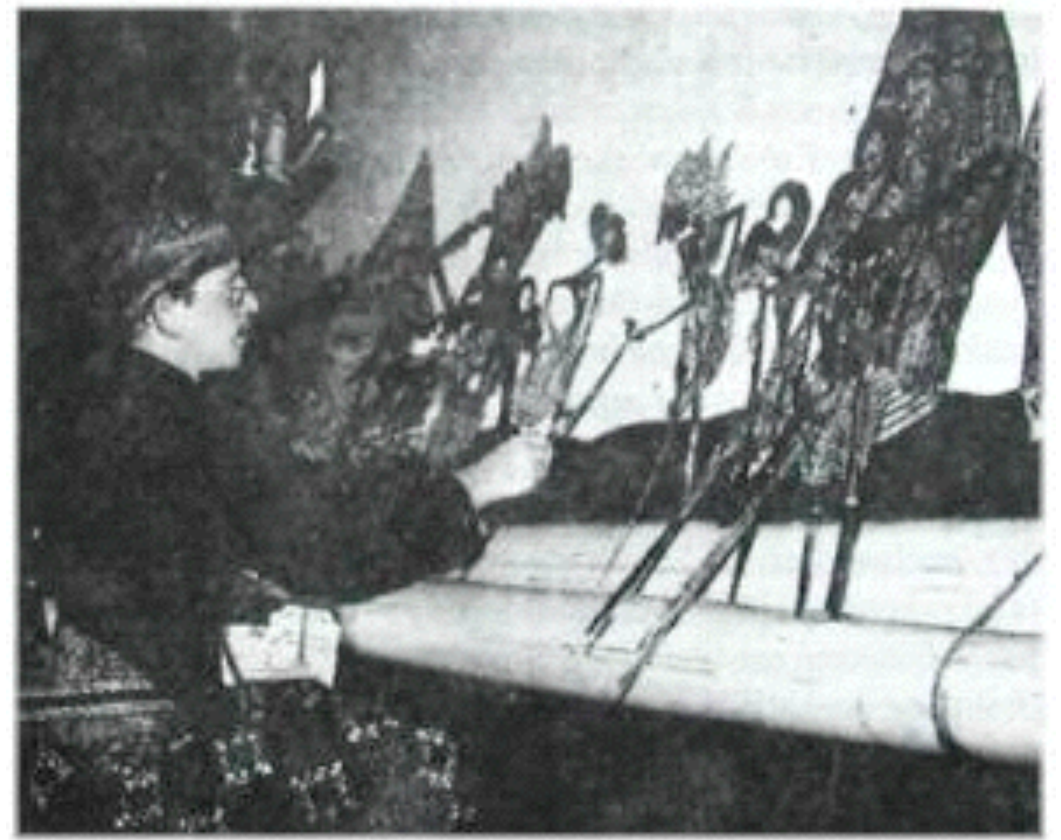


28. An Automaton which drinks at certain times only, on a Liquid being presented to it

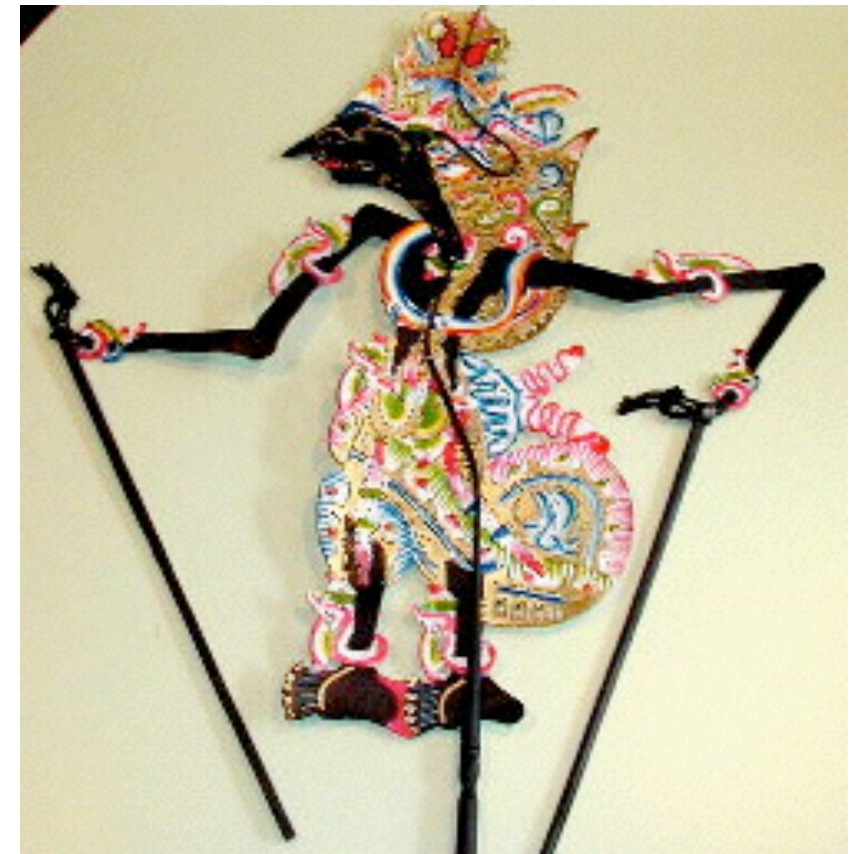
Designs of Hero of Alexandria (1st century A.D.)







Puppets (very old & very new)







The *Golem* is a character from Jewish folklore This artificial life form was raised from inanimate clay by Rabbi Juddah Loew, an expert Kabbalist. Its purpose was to guard over the Jews of the Prague ghetto who were often subject to anti-Semitic violence.

The golem has spawned numerous clones in modern mythology and makes many (mostly tacky) appearances around Prague. There was even an X-files episode about the creature living still in suburban USA!

X-Files, *Kaddish*

**Scully** "You think it's some kind of a ghost?"

**Mulder** "No...a ghost is spirit without form...what we're seeing here is form without spirit. Something called a golem."

**Scully** "A golem?"

**Mulder** "Yeah, it's a...a kind of man-made monster described in Jewish folklore...it's fashioned from mud and then animated through mystical incantation."

**Scully** "Mud?"







Gog and Magog, two of Melbourne's lesser-known features menacingly gaze upon the visitors to the Royal Arcade (off Bourke St.)



Jacks, clockwork armoured figures (~1400 -> present)

The famous astronomical clock in Prague's old square.





Writing Automaton... why writing?

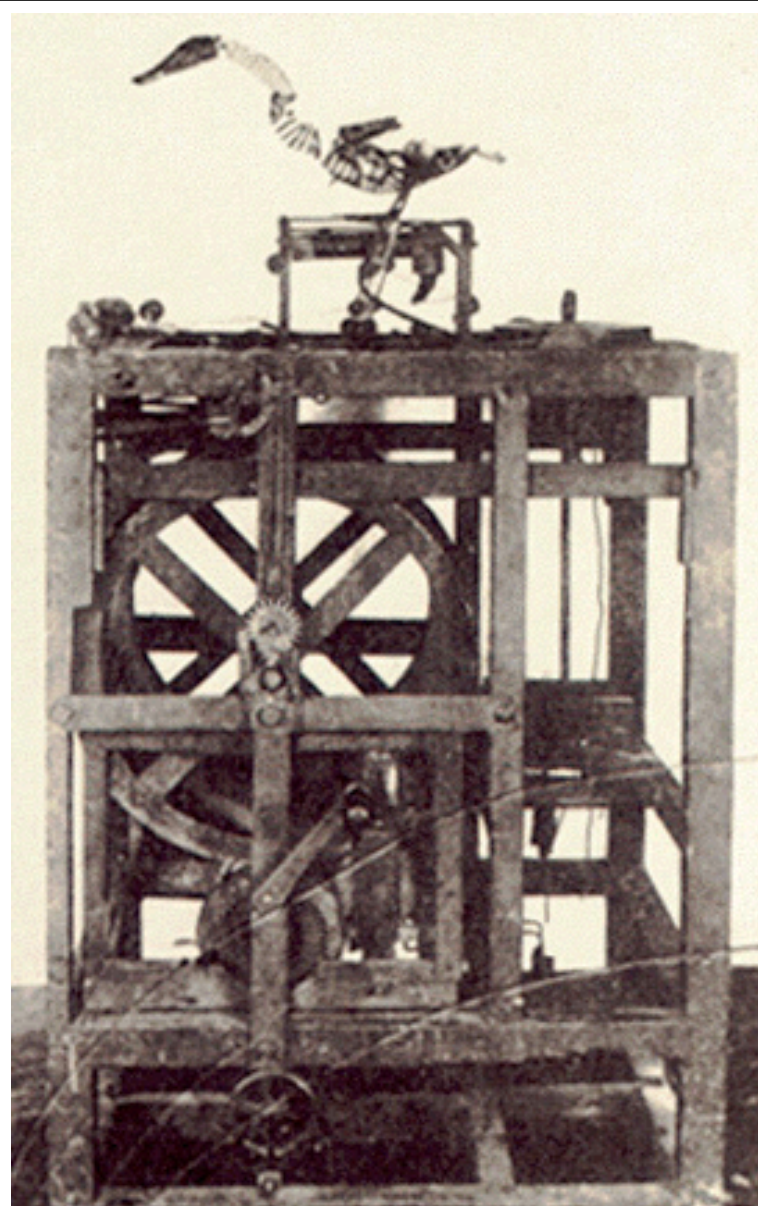
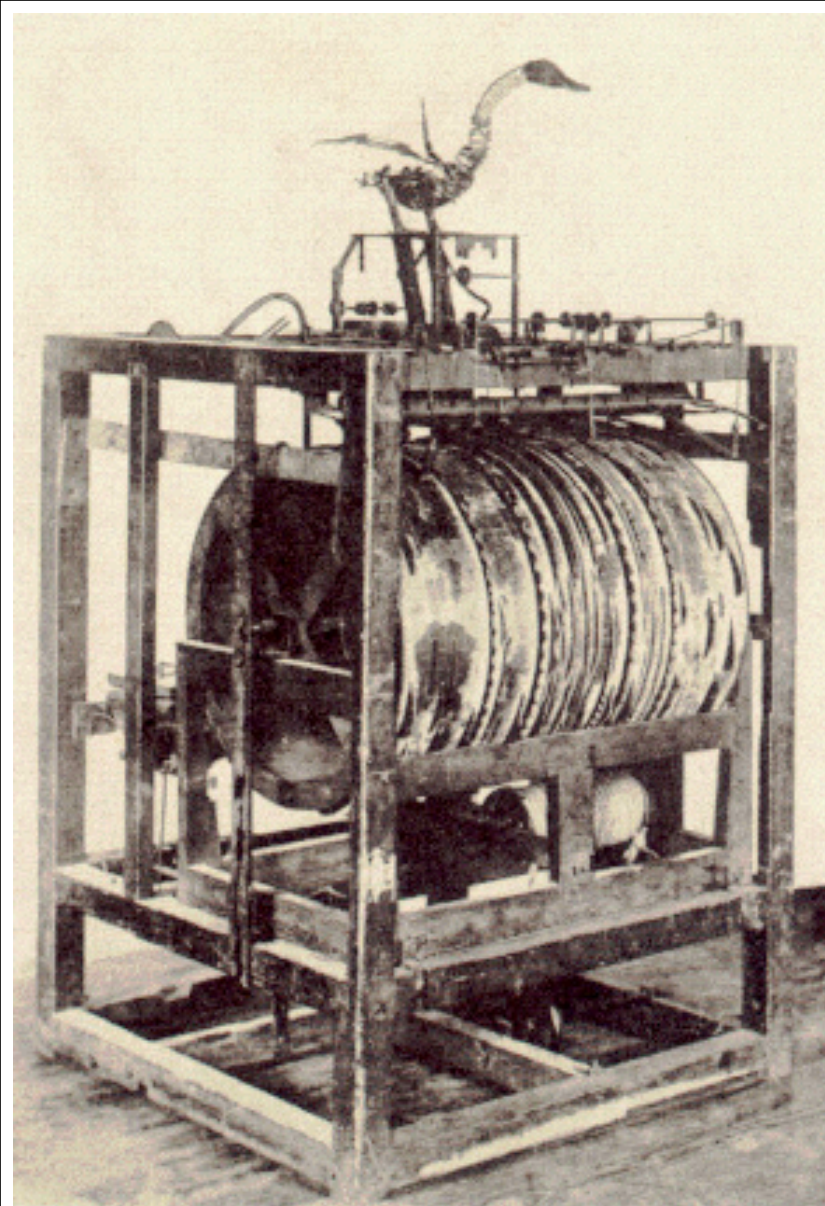
*Le Mano che Scrive*, Friedrich von Knaus (1764)  
(Museo di Storia della Scienza, Florence, Italy)





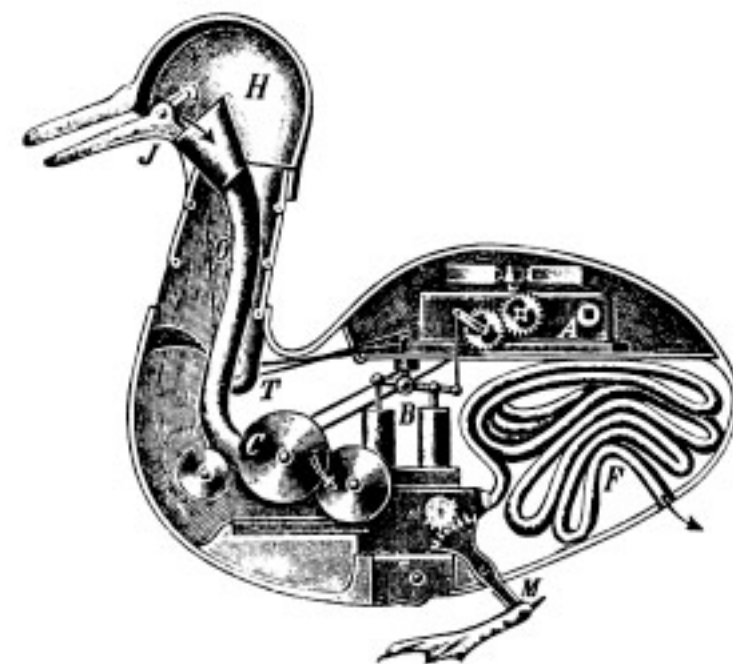
"This devil was made by taking a sixteenth-century torso — possibly a Christ at the Column — and applying a clockwork mechanism to turn the head and the eyes, and to stick out the tongue and make an inarticulate sound. A seventeenth-century description mentions horns and a collar that are now lost." (Castello Sforzesco, Milan, Italy)





Three views of the mechanical duck attributed to Vaucanson (1735)

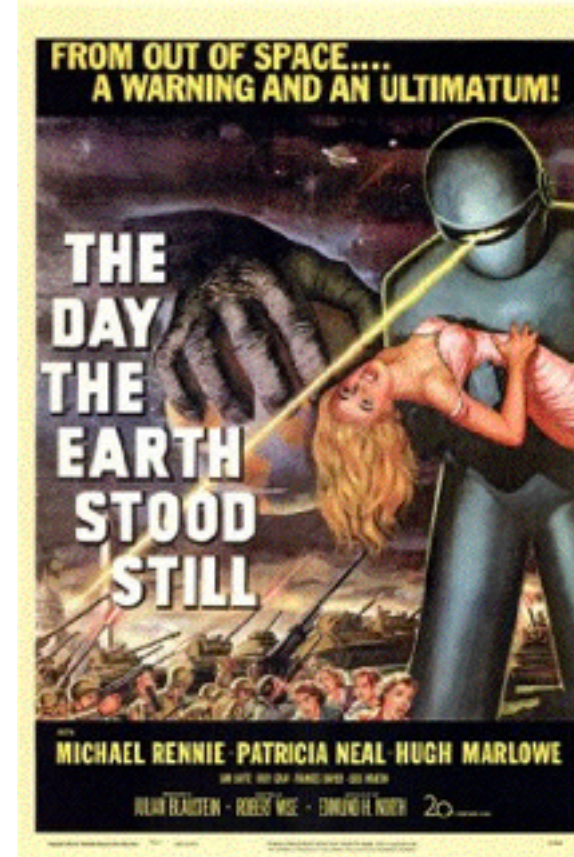
Printed in *Automata: A Historical and Technological Study*  
by Alfred Chapuis & Edmond Droz, published by B.A. Batsford Ltd.







*Robovie*  
ATR research labs, Kyoto 2000



*The Day the Earth Stood Still*  
Robert Wise 1951



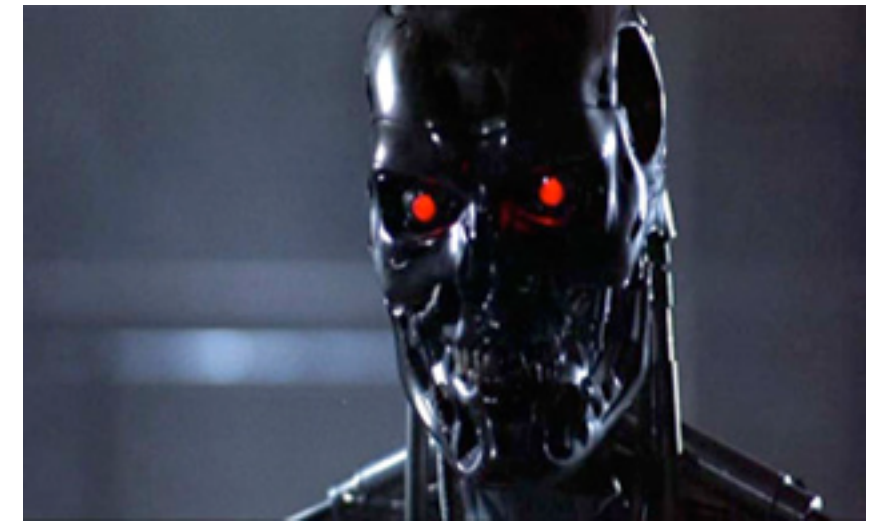
*Frankenstein's monster*  
Mary Shelley 1818



*Metropolis*  
Fritz Lang 1927



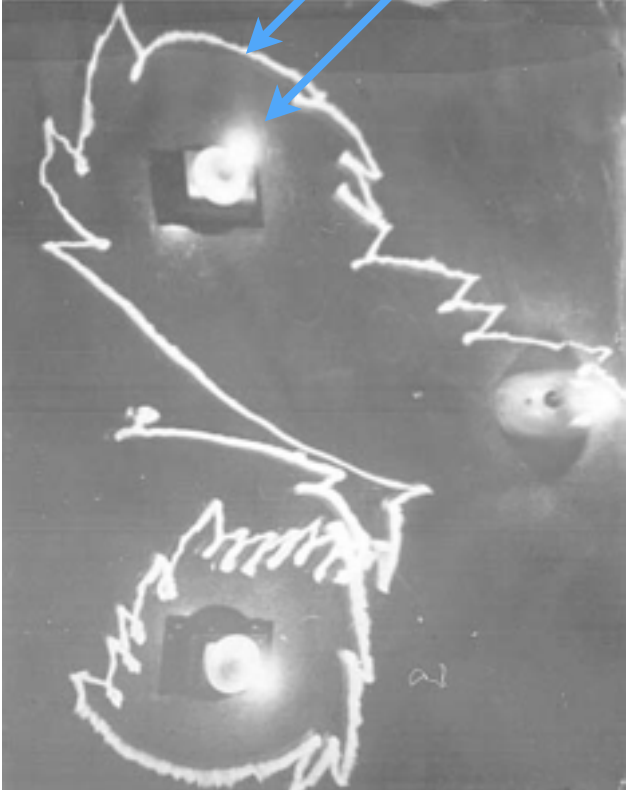
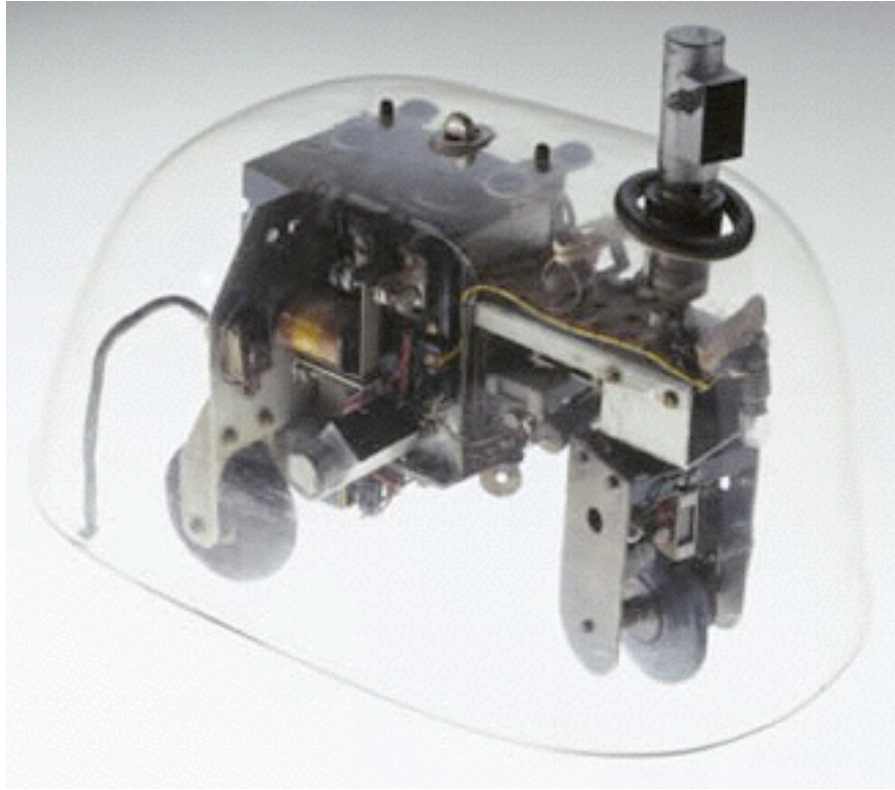
*Ghost In the Shell*  
Masamune Shirow (manga) 1989+



*The Terminator*  
James Cameron 1984



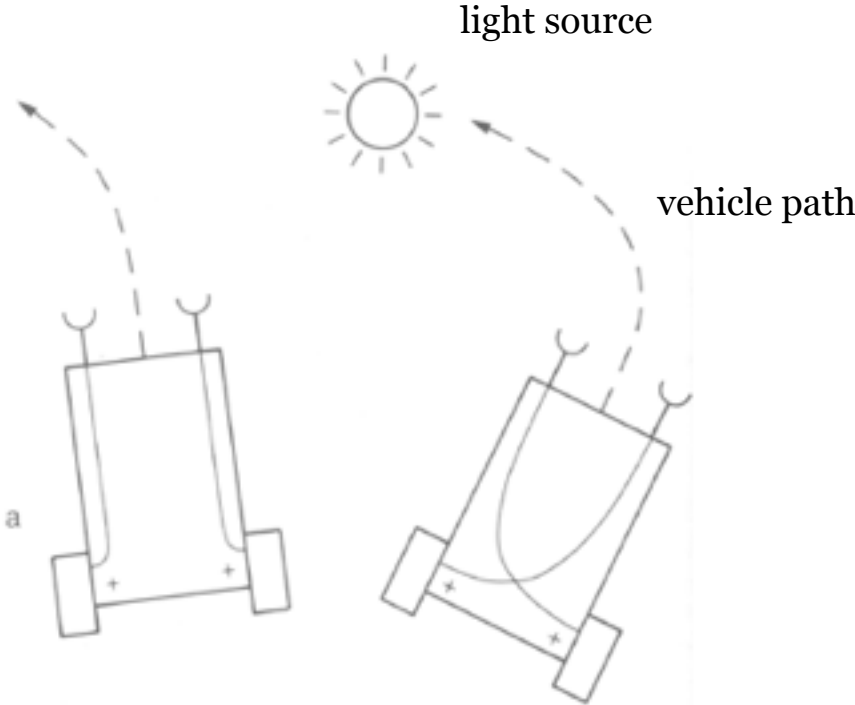
# Grey Walter's cybernetic tortoises (1950s)

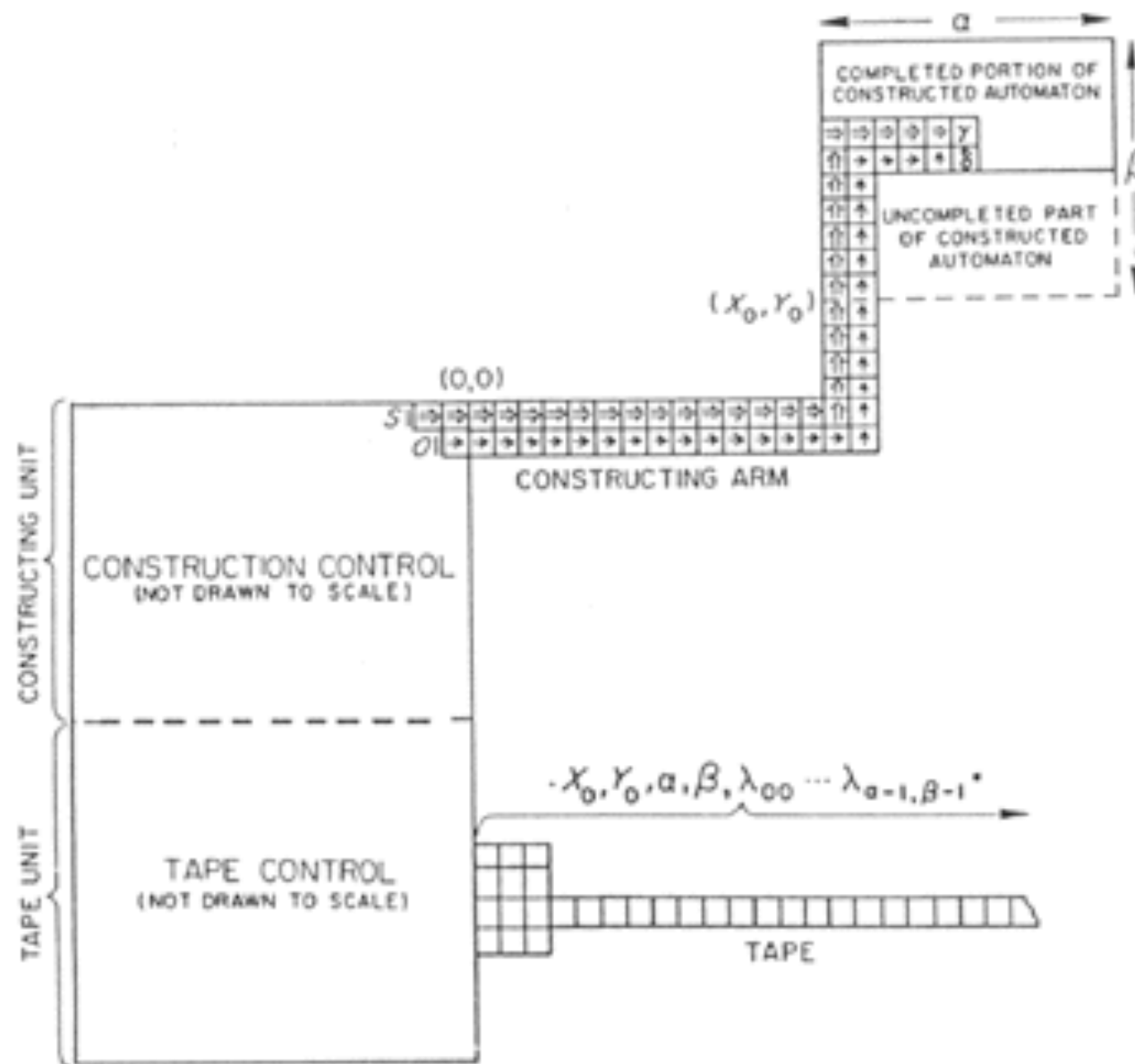


William Grey Walter (1910–1977)



*Vehicles, Experiments in Synthetic Psychology* by Valentino Braitenberg, MIT Press, 1986 (images from 7th printing, 2000)





Schematic diagram of von Neumann's self-reproducing CA configuration (1929).  
 from Burks (Essays on Cellular Automata)



John von Neumann  
 (1903-1957)



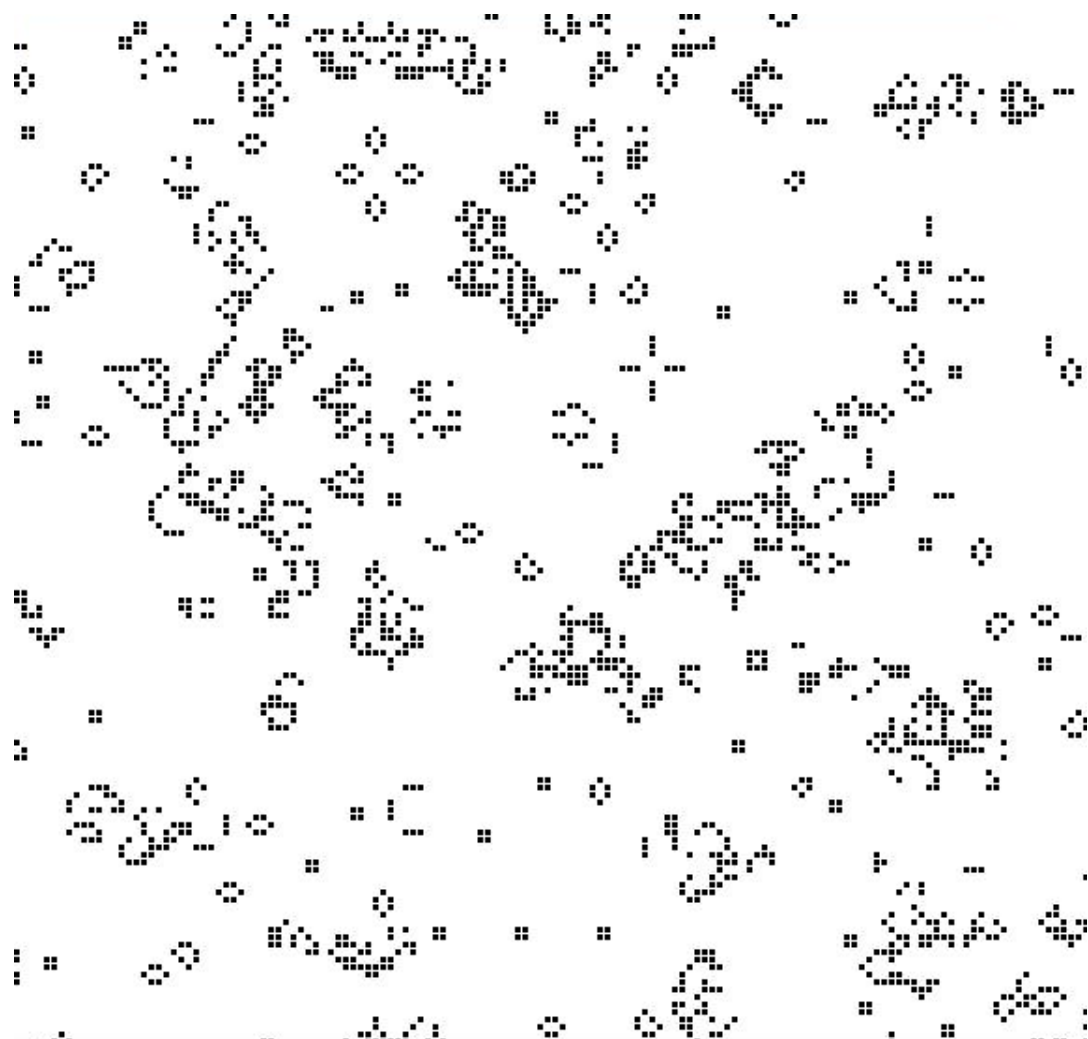
# The Game of Life (by John H. Conway c.1970)

This is a mathematical “game” that unfolds according to strict rules.  
The elements of the system are known as “Cellular Automata”.



Photo by Peter Murphy

Board



Rules

```
if (cell is OFF)
{
    if(exactly 3 neighbours are ON) cell turns ON
    else cell stays OFF
}

if (cell is ON)
{
    if (2 or 3 neighbours are ON) cell stays ON
    else cell turns OFF
}
```

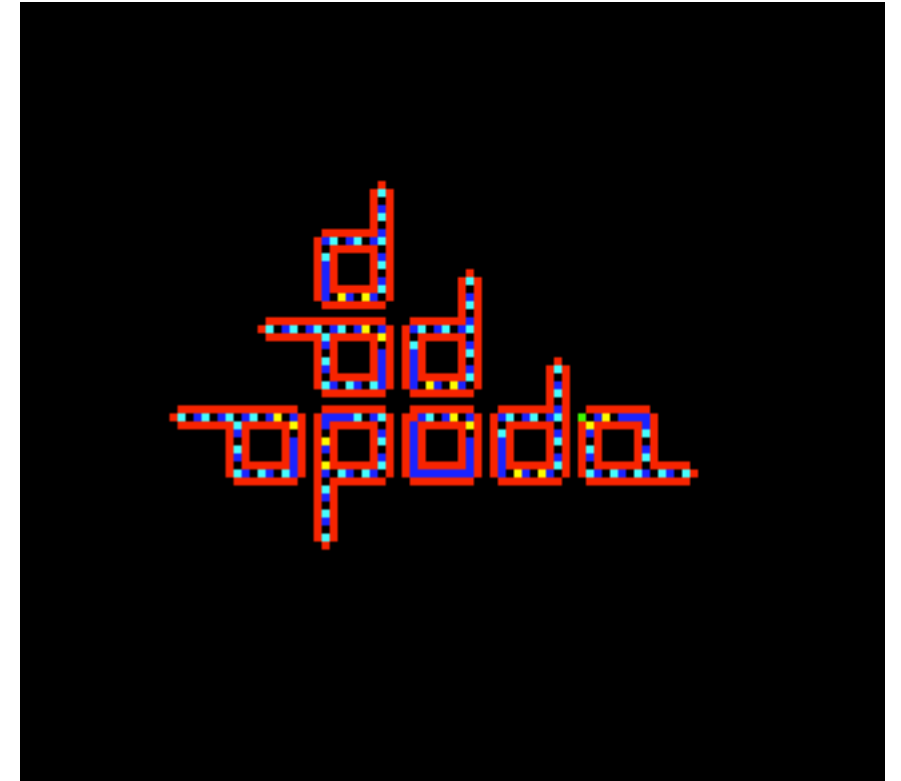
Why are Cellular Automata interesting?

The rules are simple.

The behaviour of the system is complex.

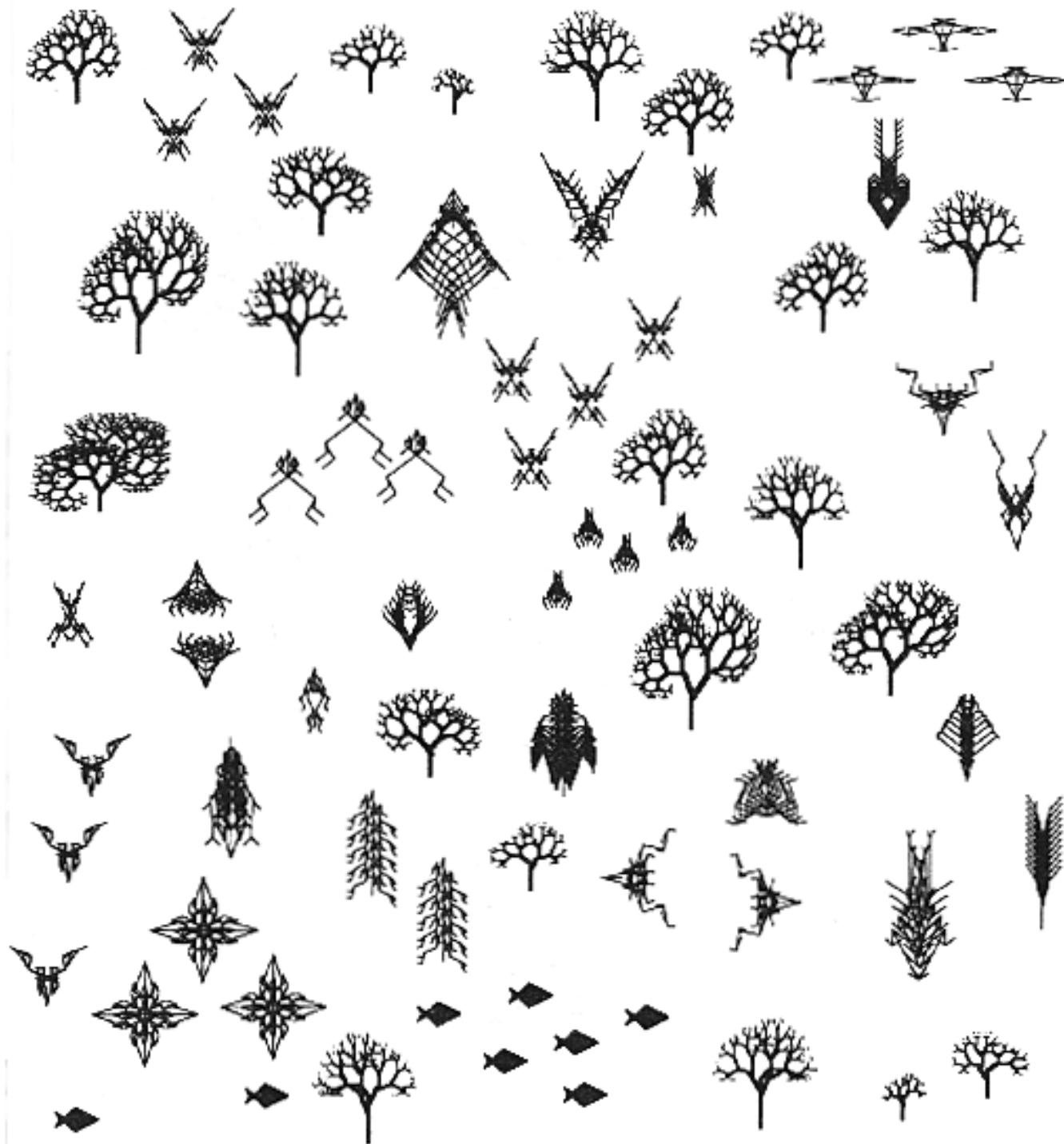
Rules only dictate interactions between neighbouring cells but give rise to recognisable groups of stable static, cyclic and mobile patterns.

The system therefore exhibits *emergence* of recognisable dynamic forms and *synthesises* their behaviour “from the bottom up”.



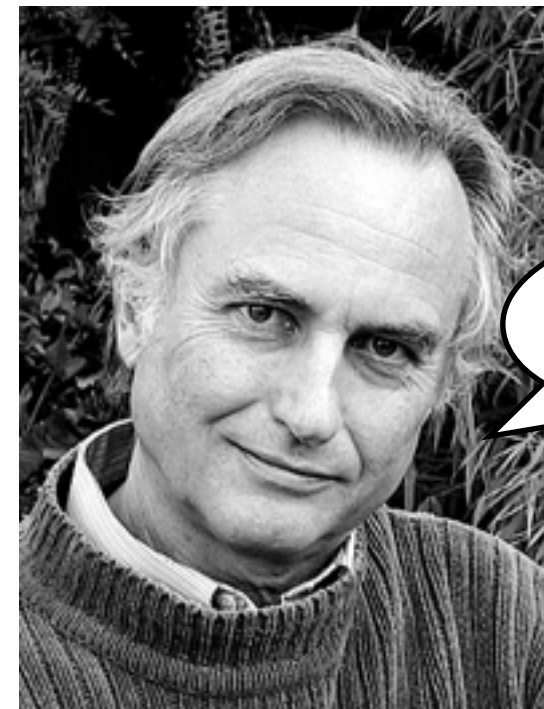
Langton's loop

# The Blind Watchmaker (by Richard Dawkins 1986)



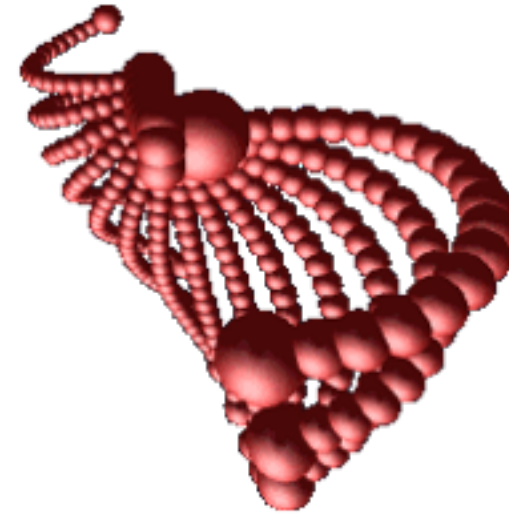
This is computer software that allows humans to selectively breed stick figures by selecting an aesthetic parent from which to generate new generations of offspring.

This process is called *artificial evolution*.

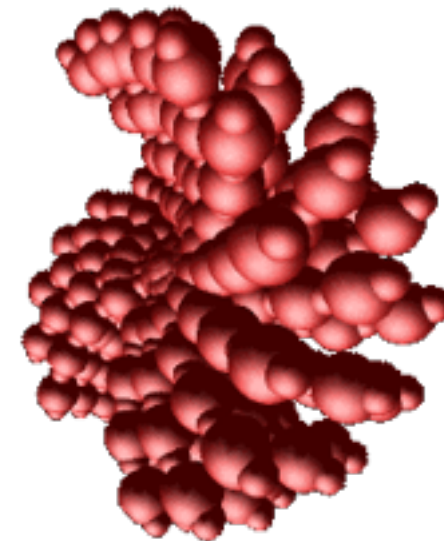
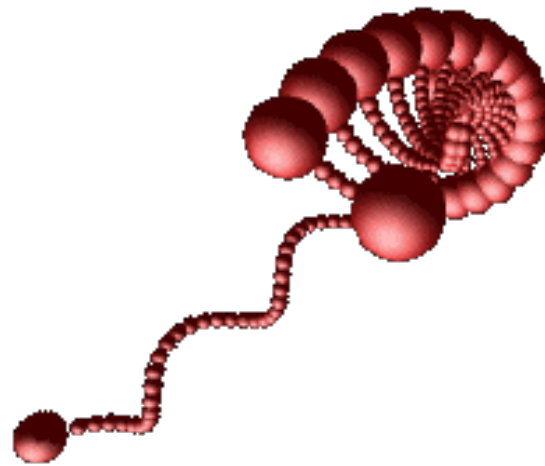


The essence of life is statistical improbability on a colossal scale.





All kinds of complex animated forms can be evolved using artificial evolution and aesthetic selection. The process will even run automatically on the computer if a “fitness function” can be specified explicitly.

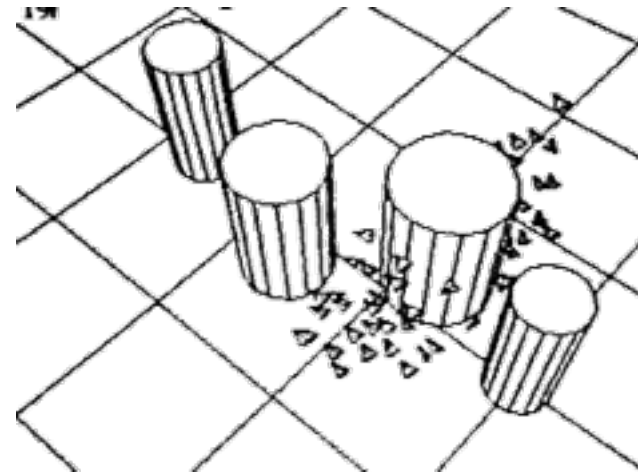


Animation synthesised using aesthetic evolution



# Coordinated group behaviour

Craig Reynolds' distributed model of bird flocking, cow herding, fish schooling etc. (1987)



Reynolds, C. "Flocks, Herds and Schools: A Distributed Behavioural Model"  
Comp. Graph. Vol 21, No. 4 July 1987, (SIGGRAPH 87) p25-34.



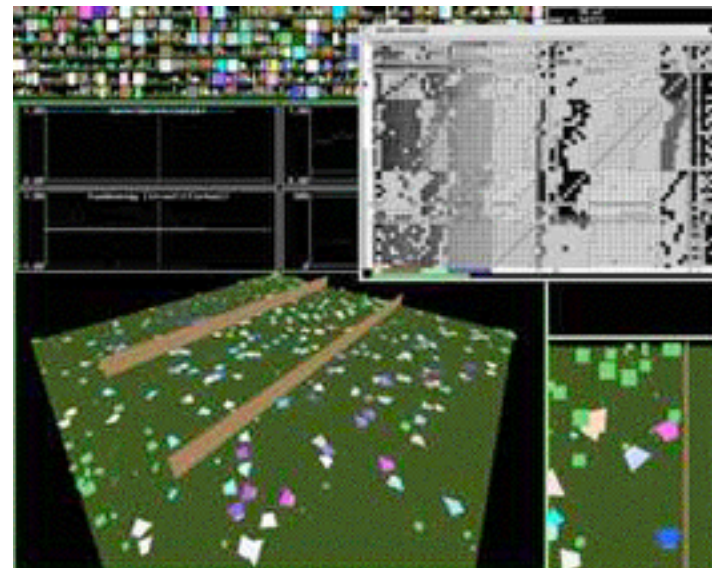
# The Virtual Ecosystem

Models the interactions between organisms, and their environment including (for instance) :

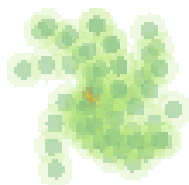
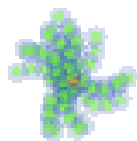
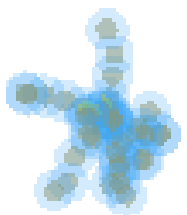
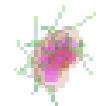
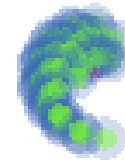
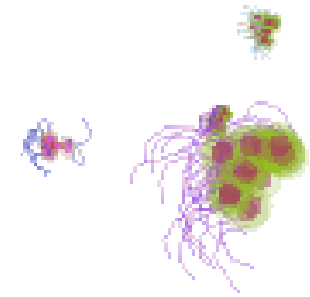
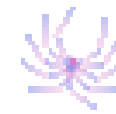
- ▶ Eating
- ▶ Mating
- ▶ Fighting
- ▶ Seeing
- ▶ Moving
- ▶ Dying

In the hope that some complex global phenomena may emerge...

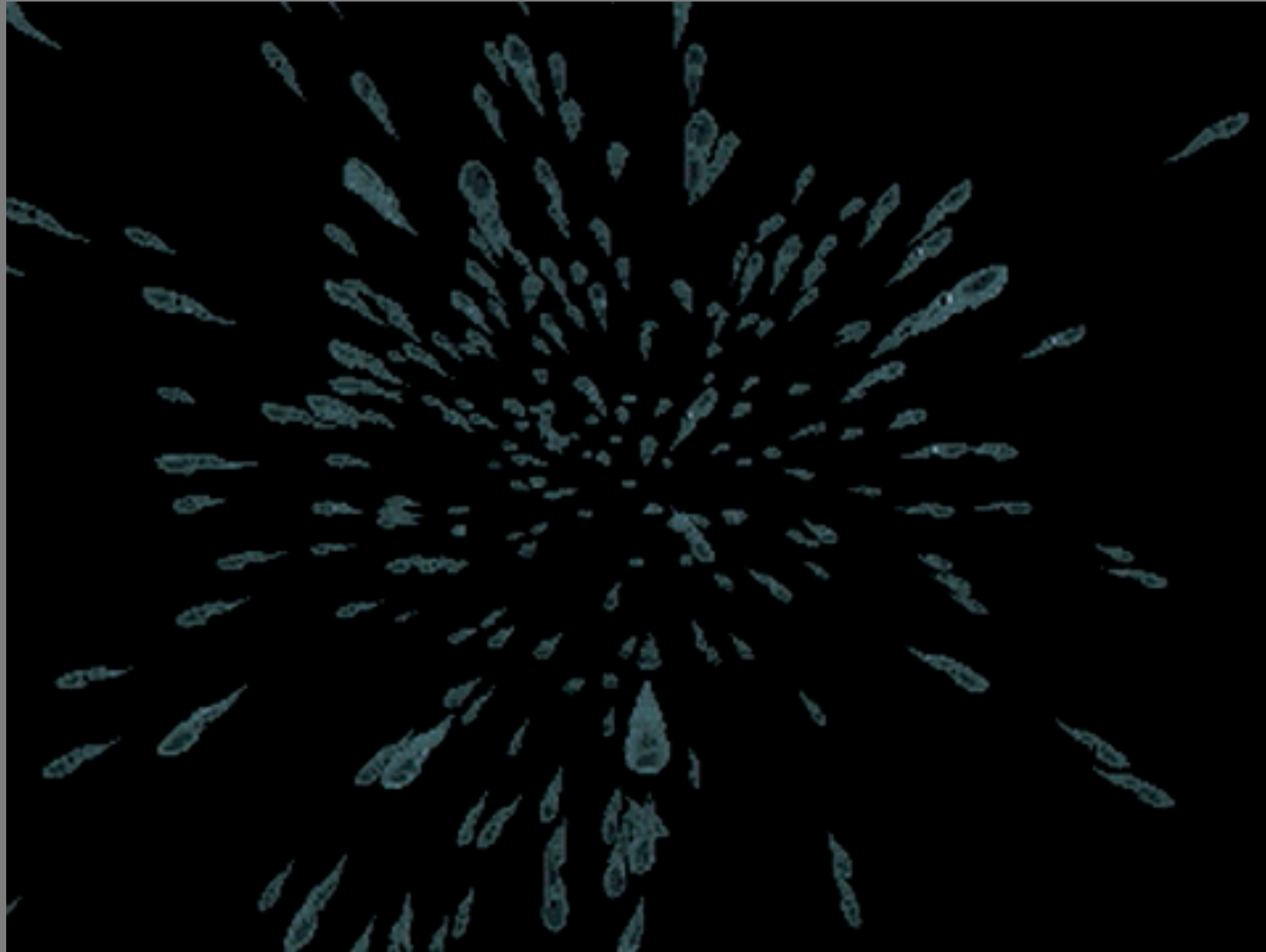
- ▶ Flocking
- ▶ Predation
- ▶ Symbiosis
- ▶ Competition
- ▶ Trade
- ▶ Nest construction



Yaeger, L. (1992). Computational Genetics, Physiology, Metabolism, Neural Systems, Learning, Vision and Behavior or Polyworld: Life in a New Context. *Artificial Life III*. C. Langton, Addison-Wesley: 263-298.



Animation synthesised using behavioural rules





# Some Sculptural Artificial Life Art

“The stabilized dynamic system will become not only a symbol of life but literally life in the artist’s hands and the dominant medium of further aesthetic ventures.

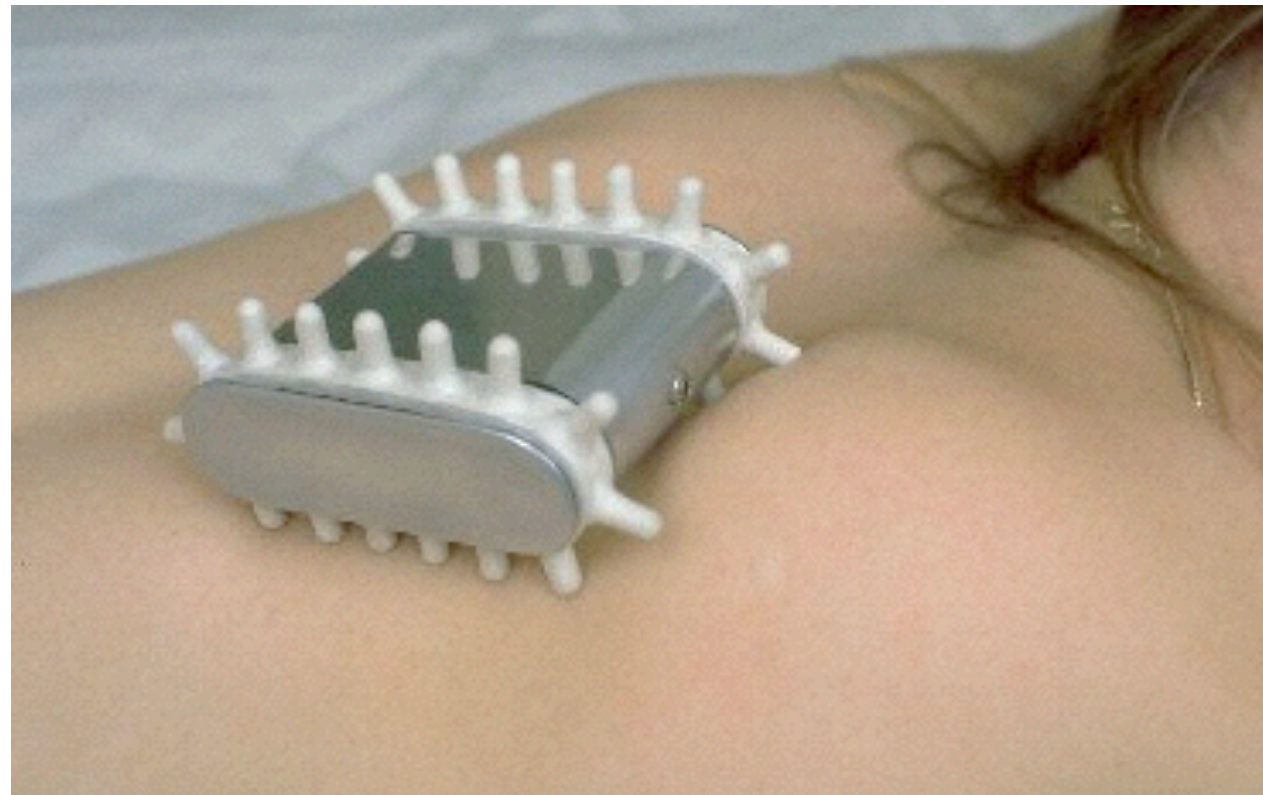
...As the Cybernetic Art of this generation grows more intelligent and sensitive, the Greek obsession with ‘living’ sculpture will take on an undreamed reality.”

*Beyond Modern Sculpture*, Burnham.



*Strandbeest*  
Theo Jansen

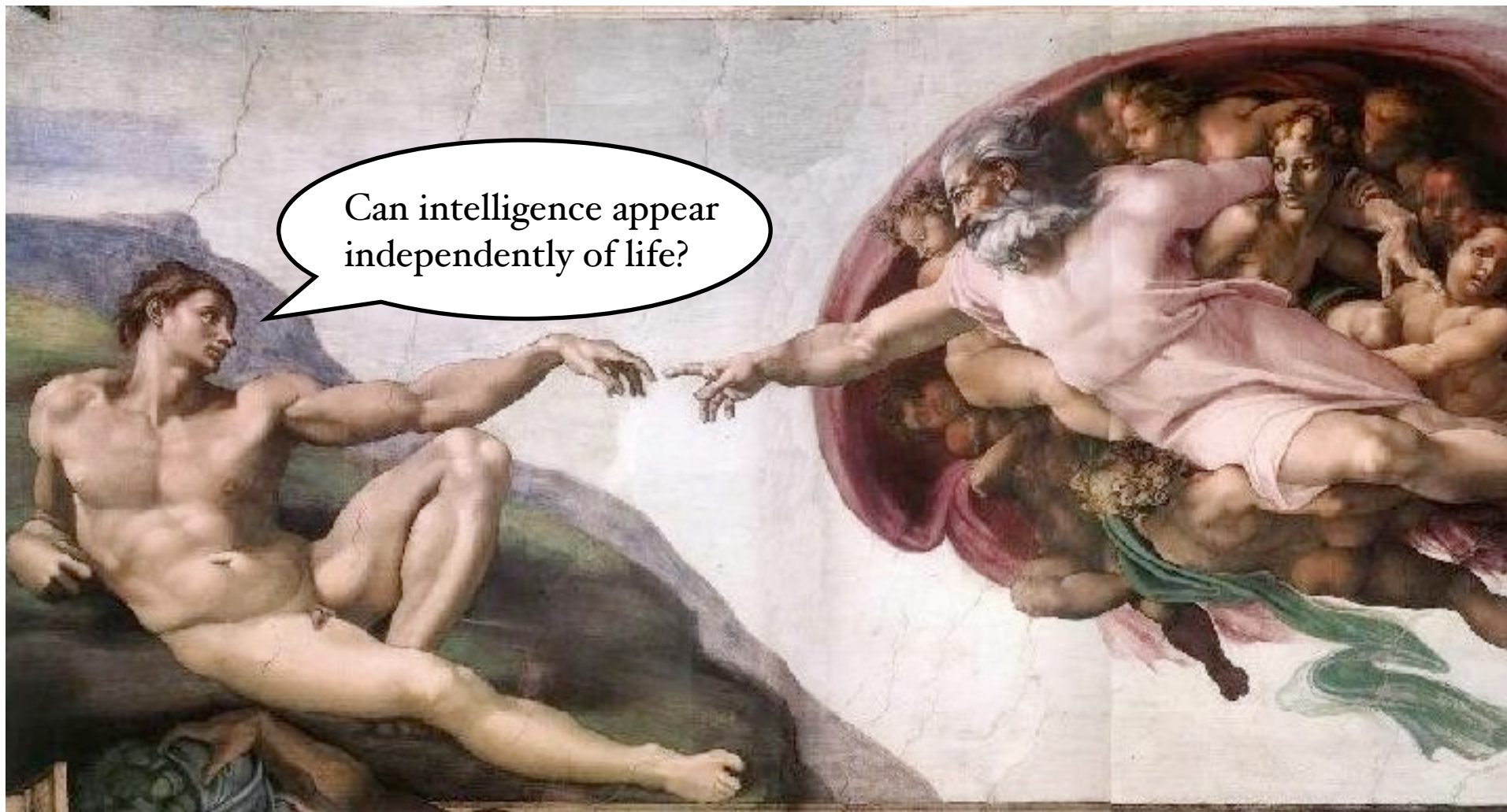
[www.strandbeest.com/](http://www.strandbeest.com/)



*Tickle*  
Erwin Driessens & Maria Verstappen

[www.xs4all.nl/~notnot/](http://www.xs4all.nl/~notnot/)



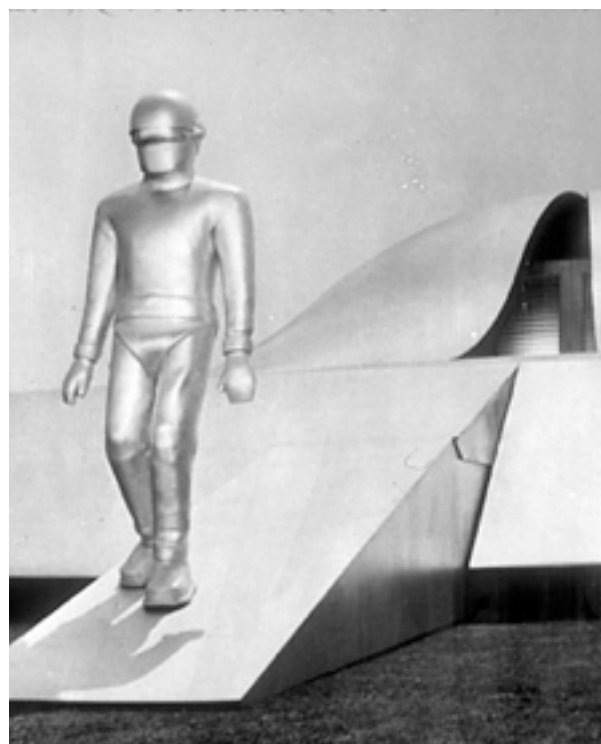


**Adam**

**God**  
(artist's impression)

Can intelligence appear independently of life?

Can AI appear independently of A-Life?



**Gort**



**Paris Hilton\***

Is there any evidence for life forms that are unintelligent?

\* **Ms. Hilton** is smart enough not to ask this question.