

# Machines naturelles et machines artificielles

De la métaphysique à la technique

Jean-Pierre Dupuy

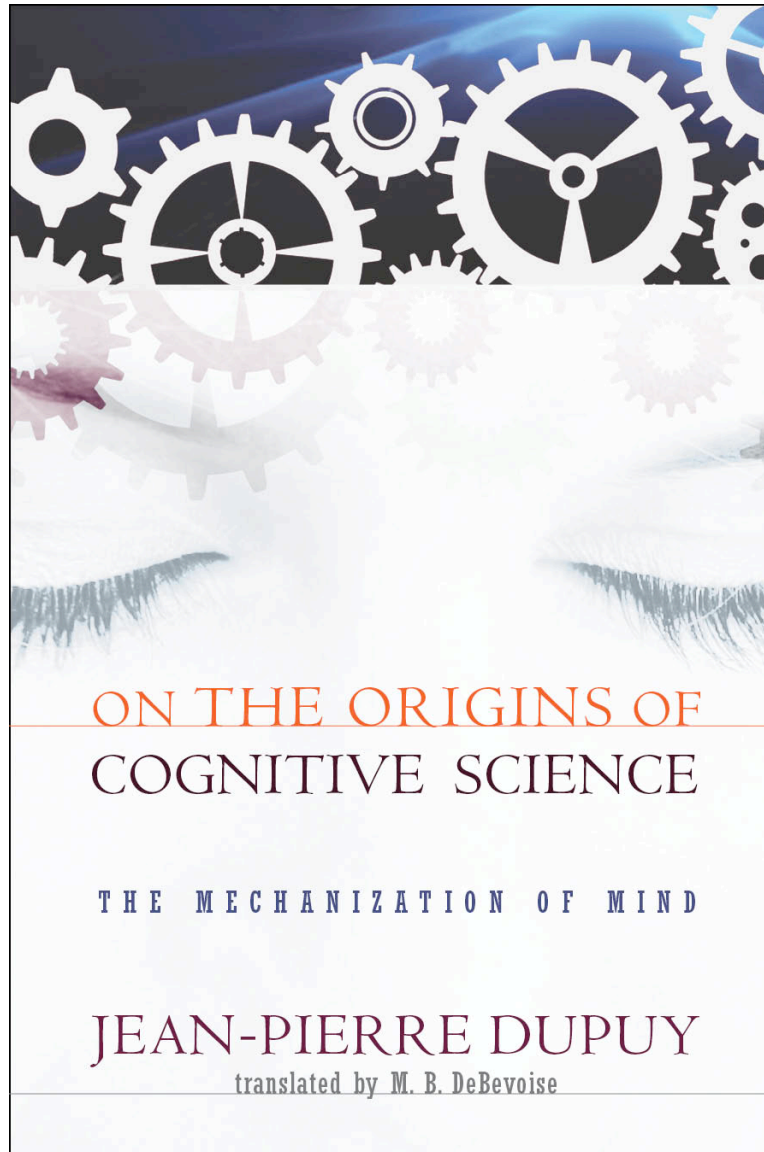
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# Machines naturelles et machines artificielles

L'idée de machine en sciences cognitives

Le triangle d'or: Art, Technique, Vie

- Vie et technique: machines naturelles
- Art et nature: Critique du jugement téléologique
- Les métaphores dangereuses: de la machine vivante à la vie artificielle
- Le paradoxe suprême: fabriquer de la vie



ON THE ORIGINS OF  
COGNITIVE SCIENCE

THE MECHANIZATION OF MIND

JEAN-PIERRE DUPUY

translated by M. B. DeBevoise

# L'idée de machine en sciences cognitives

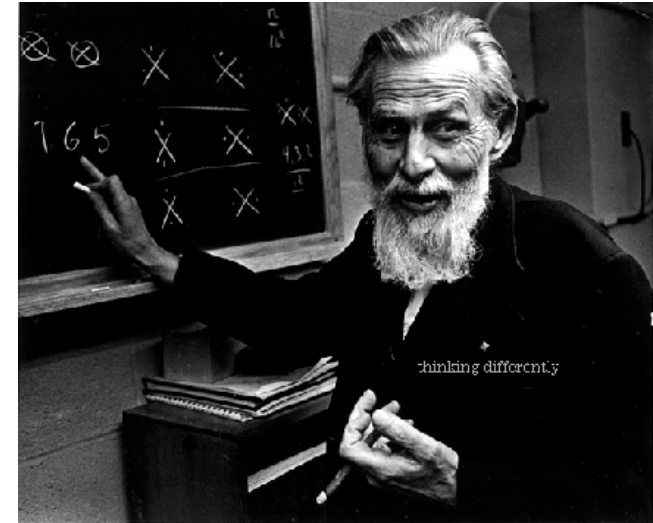
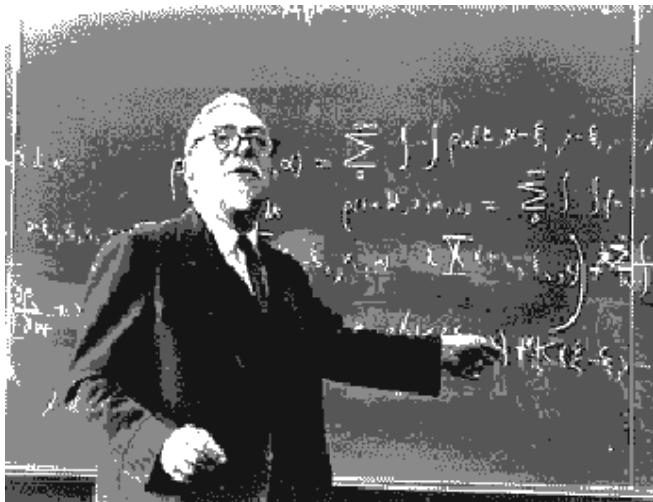
Jean Mosconi, *La constitution de la théorie des automates*, 1989

"Eu égard aux calculatrices existant à l'époque - une fois oubliées les perspectives ouvertes un siècle plus tôt par Babbage - la référence aux possibilités de calcul d'une machine pouvait apparaître comme un rétrécissement arbitraire de l'idée de calculabilité (...) Si pour nous le sens naturel de "calculabilité mécanique" est "calculabilité par une machine", il est vraisemblable que jusqu'à Turing, "mécanique" était employé plutôt métaphoriquement et ne voulait rien dire de plus que "servile" (épithète qui qualifie encore couramment l'exécution d'un algorithme)."



John von Neumann

Norbert Wiener



Warren McCulloch

Macy Conferences

1946 - 1953

From Teleological Mechanisms  
to Cybernetics

# Towards a Physics of Meaning?

Jean Petitot,  
Francisco Varela,  
Bernard Pachoud  
& Jean-Michel Roy (eds),

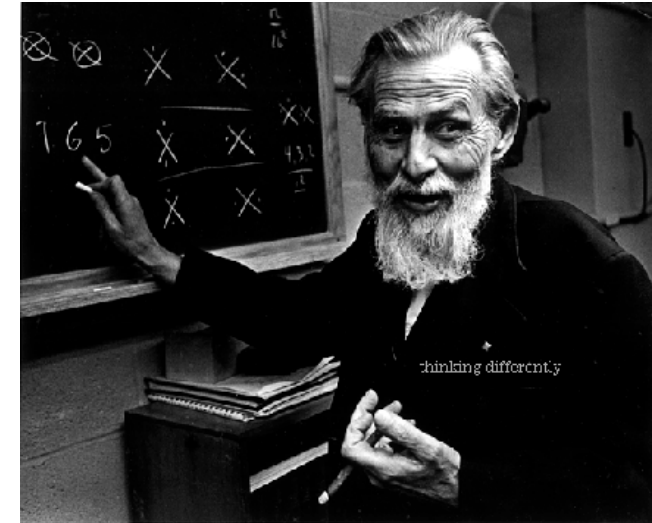
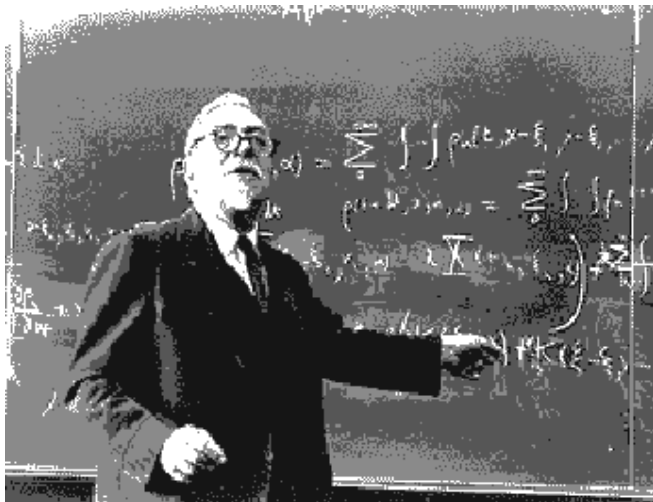
*Naturalizing  
Phenomenology.  
Issues in  
Contemporary  
Phenomenology and  
Cognitive Science,*  
Stanford University Press, 2000.





John von Neumann

Norbert Wiener

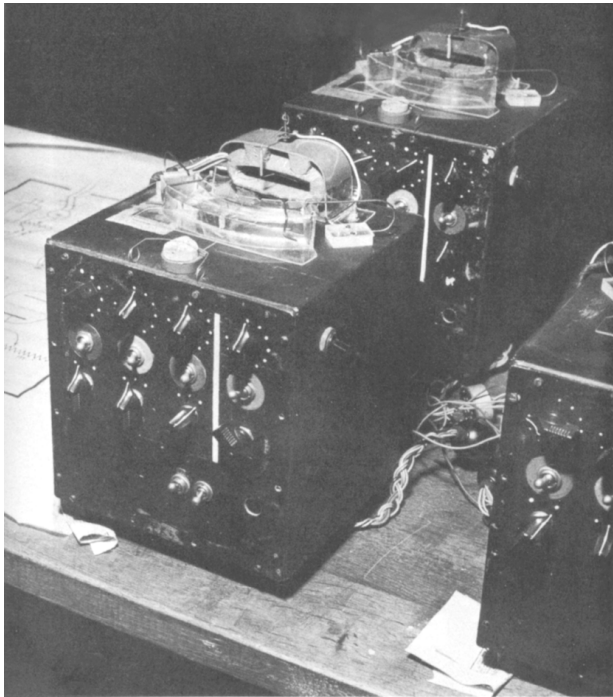


Warren McCulloch

Macy Conferences

1946 - 1953

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A PICTURE OF A REVOLUTIONARY CONCEPT IN MACHINES  
This is a machine that accomplishes everything that it sets out to do; even if all its determinant factors are upset or reversed. Its aspect is most unpretentious and yet this peculiar faculty of Ashby's machine introduces a complete revolution in our former conception of mechanical possibilities.

Source: de Latil (1956, facing 275)



## Cybernetics' Stumbling Block *Designing an Autonomous Machine*

Ross Ashby's  
*Homeostat* (1947)

*Design for a Brain*  
(1952)

## Friedrich Hayek denounced

“the erroneous belief that [the evolutionary approach] is a conception which the social sciences have borrowed from biology. **It was in fact the other way round**, and if Charles Darwin was able successfully to apply to biology a concept which he had largely learned from the social sciences, this does not make it less important in the field in which it originated. It was in the discussion of such social formations as language and morals, law and money, that in the eighteenth century **the twin conceptions of evolution and the spontaneous formation of an order** were at last clearly formulated, and provided the intellectual tools which Darwin and his contemporaries were able to apply to biological evolution. Those eighteenth-century moral philosophers and the historical schools of law and language might well be described ... as **Darwinians before Darwin.**”



*Law, Legislation and Liberty*. Volume I,  
*Rules and Order*, London, 1973.

# On the genesis of complex order without design

“Social order is the  
result of human  
action,  
but not of human  
design.”

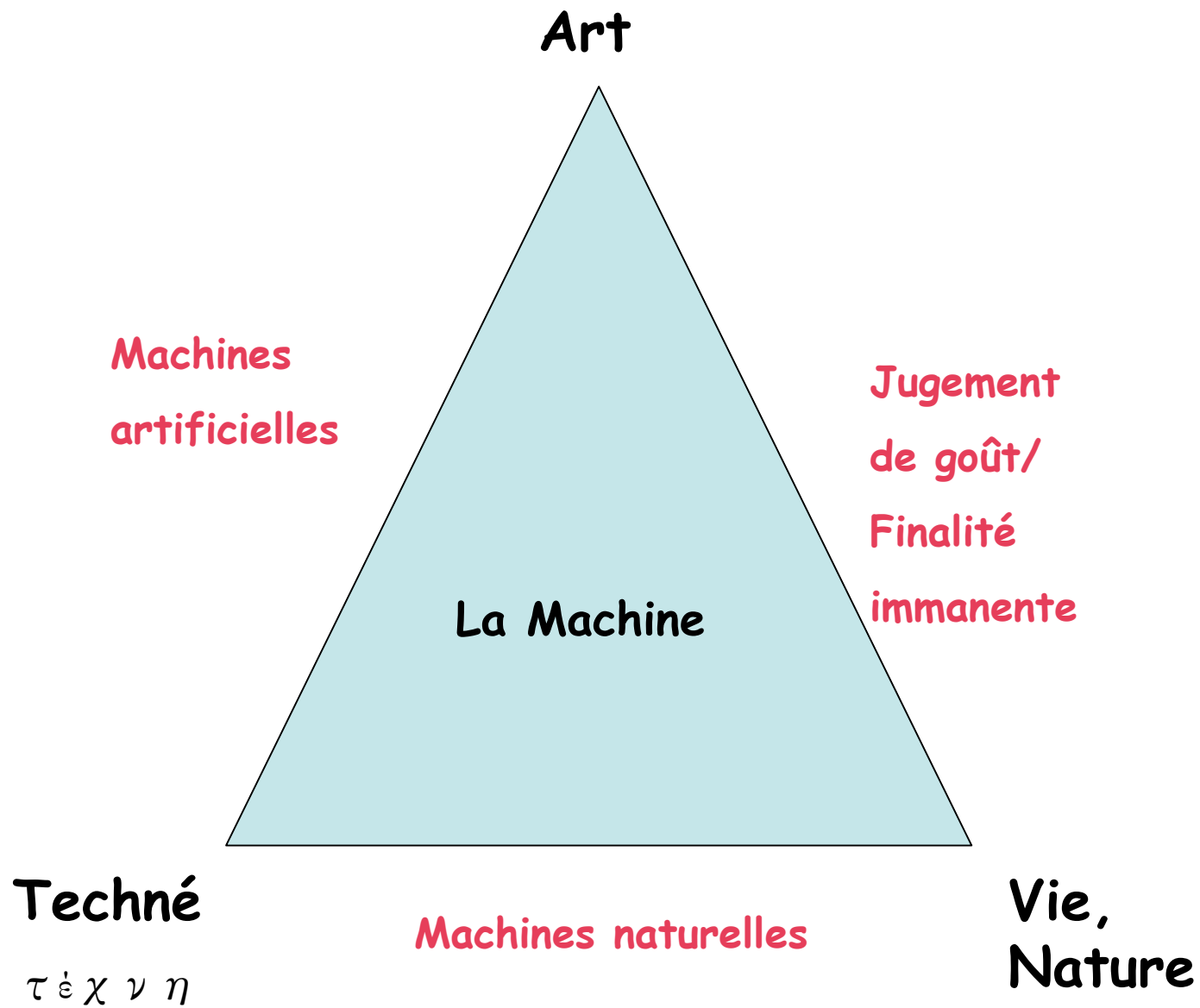
**Adam Ferguson,**  
1772.

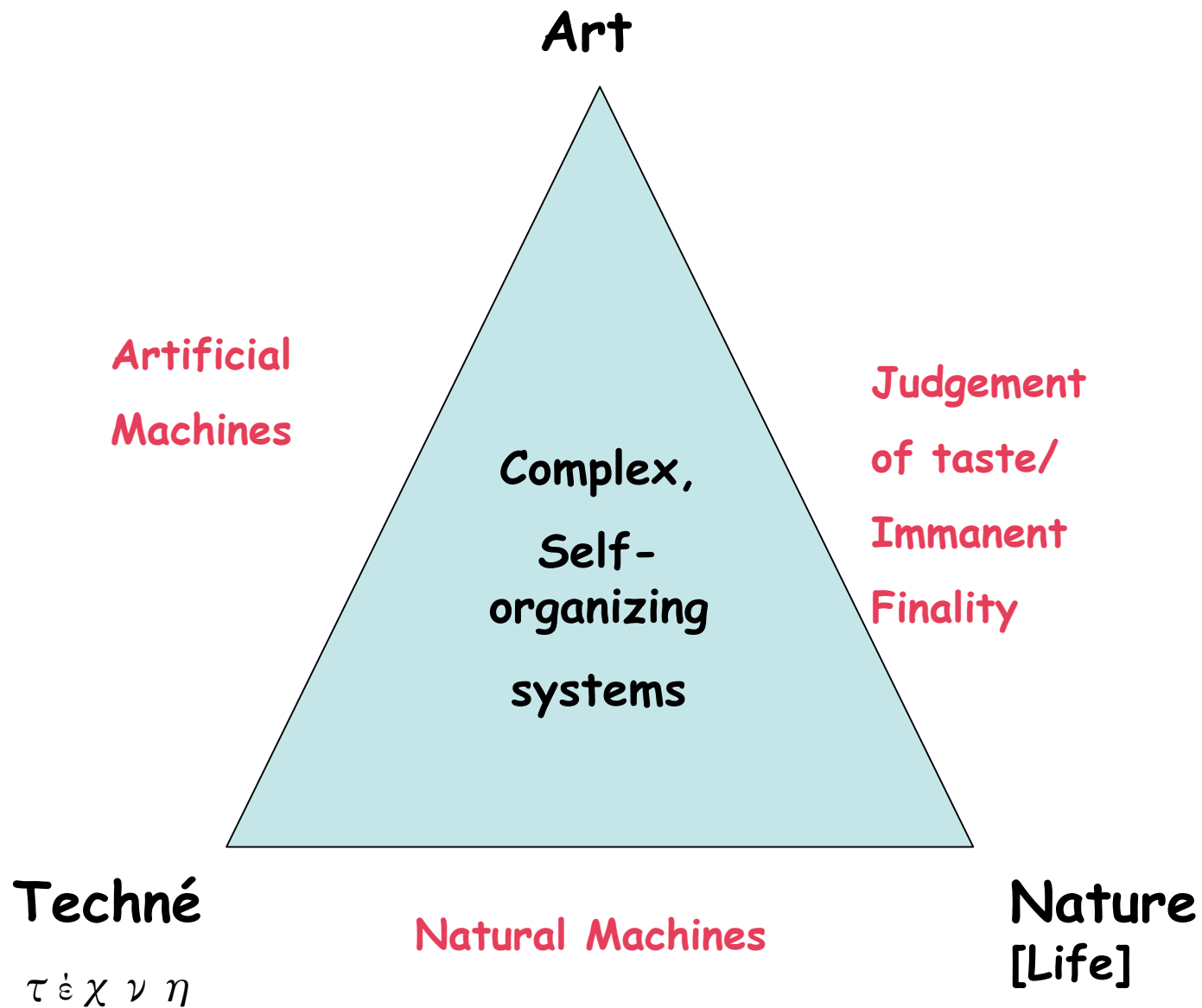


## Mécanisme et finalité

On peut donc dire qu'en substituant le mécanisme à l'organisme, Descartes fait disparaître la téléologie de la vie ; mais il ne la fait disparaître qu'apparemment, parce qu'il la rassemble tout entière au point de départ. Il y a substitution d'une forme anatomique à une formation dynamique, mais comme cette forme est un produit technique, toute la téléologie possible est enfermée dans la technique de production. A la vérité, **on ne peut pas, semble-t-il, opposer mécanisme et finalité**, on ne peut pas opposer mécanisme et anthropomorphisme, car si le fonctionnement d'une machine *s'explique* par des relations de pure causalité, la construction d'une machine ne *se comprend* ni sans la finalité, ni sans l'homme. **Une machine est faite par l'homme et pour l'homme, en vue de quelques fins à obtenir, sous forme d'effets à produire.** »

Georges Canguilhem, « Machine et organisme » (1946-1947) ; repris in *La connaissance de la vie*, Vrin, 2006, p. 143-146



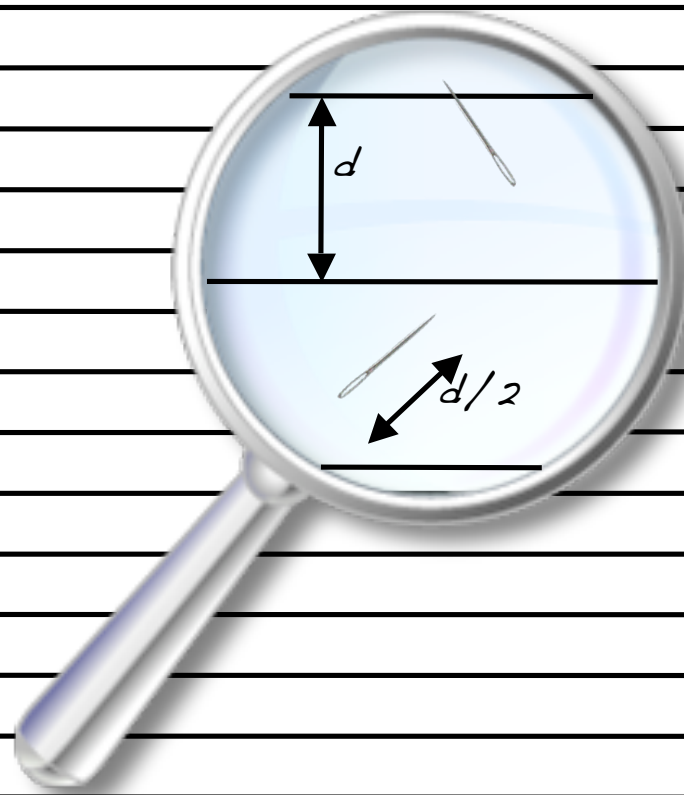


# **Chance and Necessity**

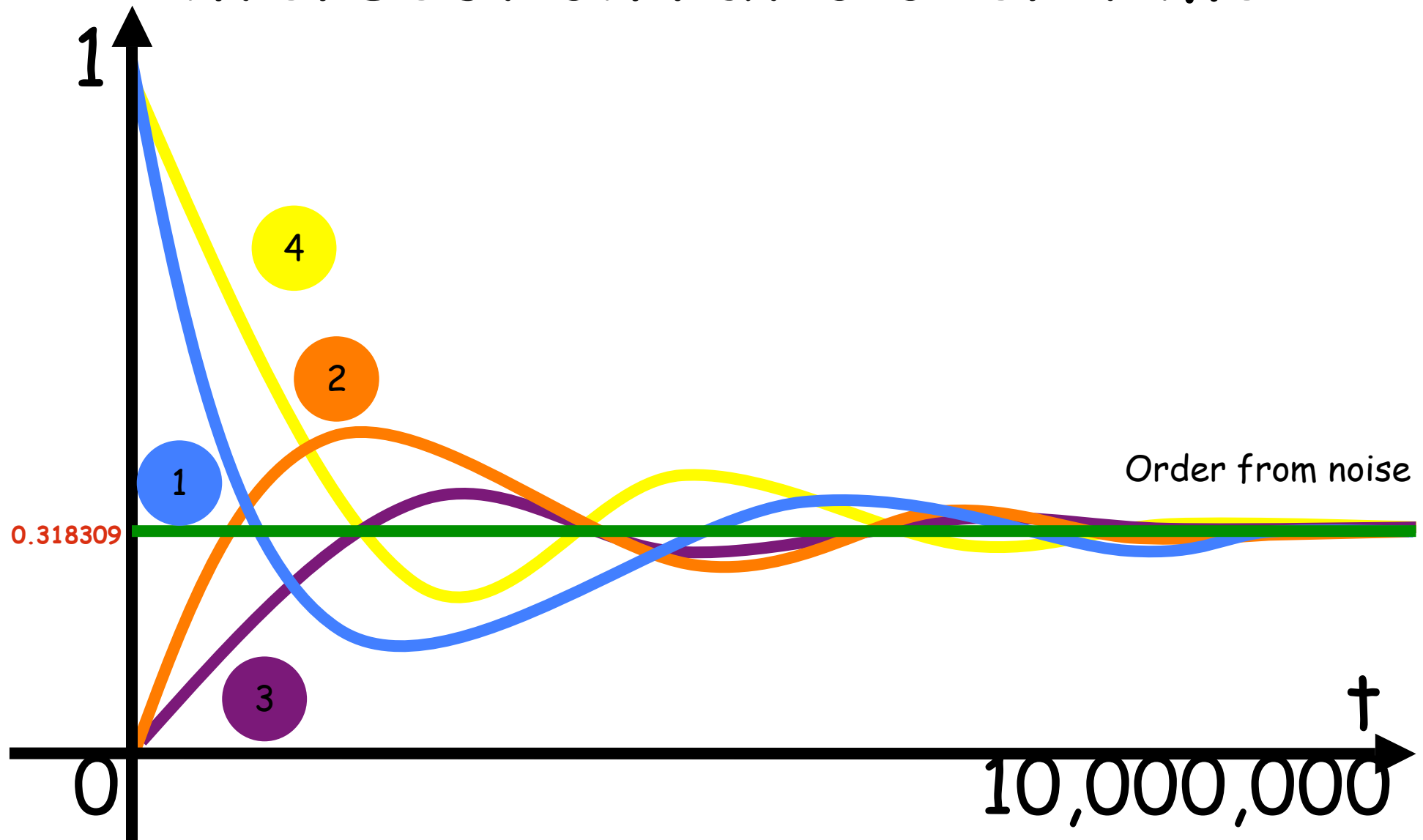
Two principles of evolution

**Order from noise**

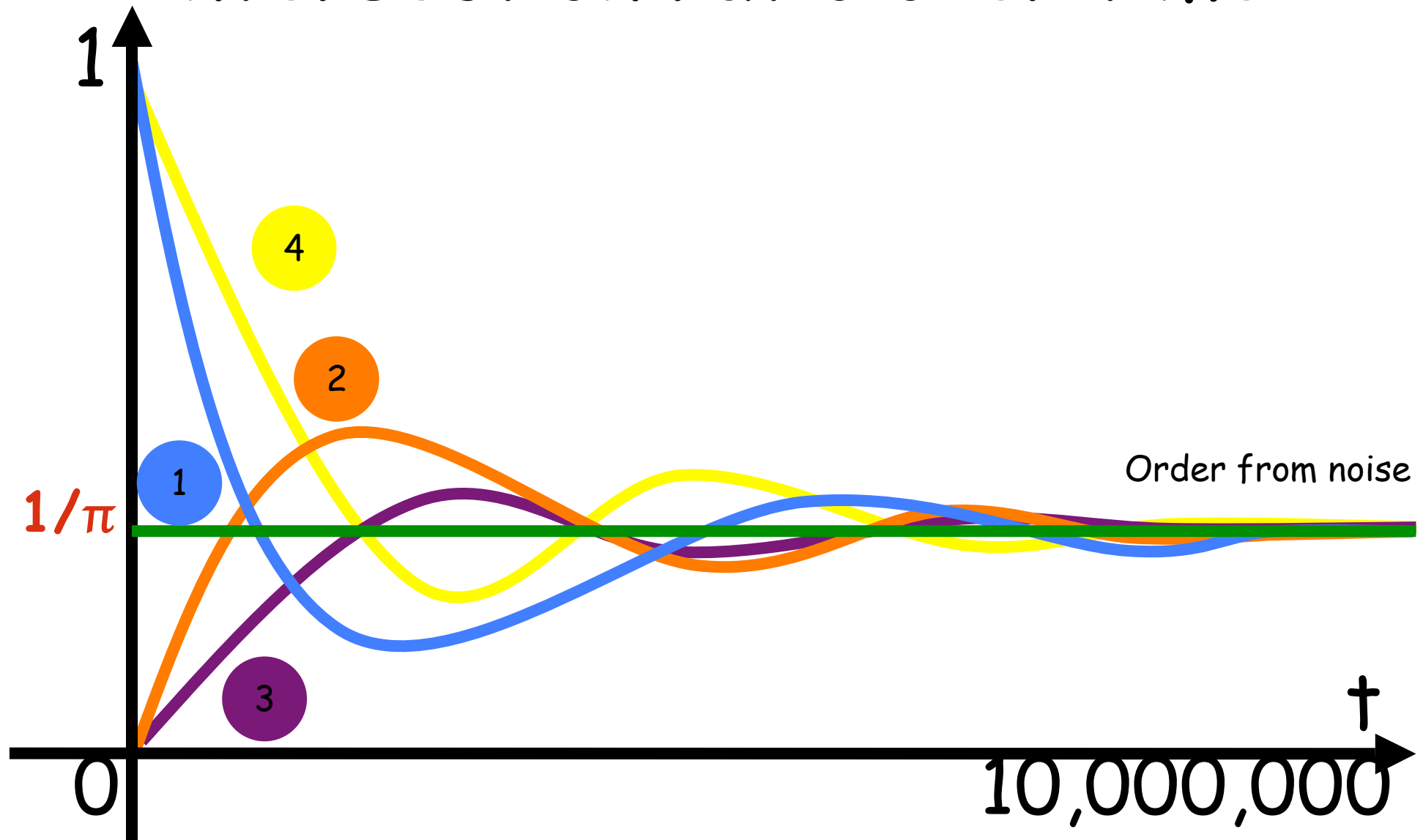
# Buffon's needle



# Buffon's needle: intersection ratio over time

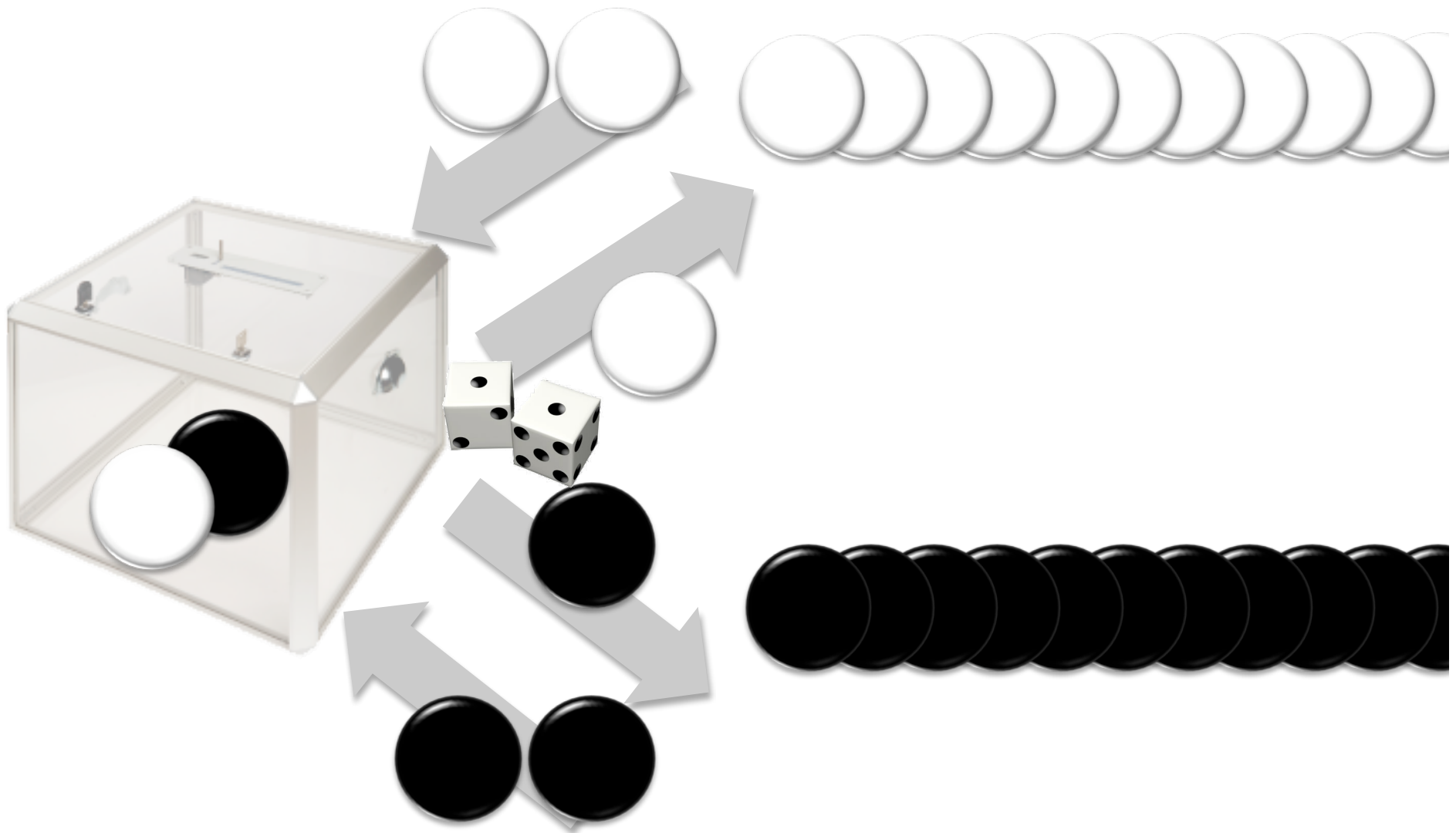


# Buffon's needle: intersection ratio over time



**Complexity from noise**

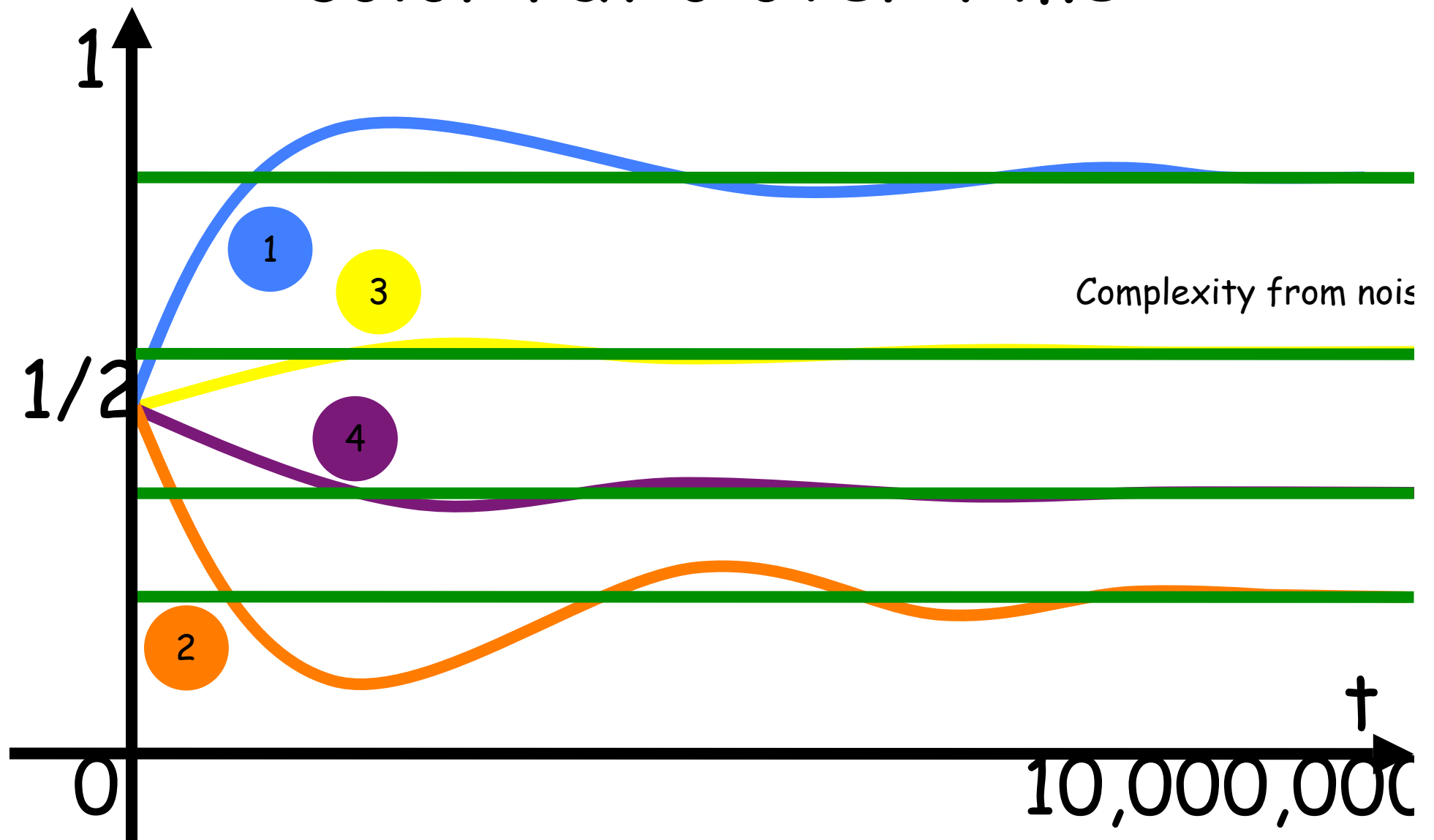
# Polya's urn



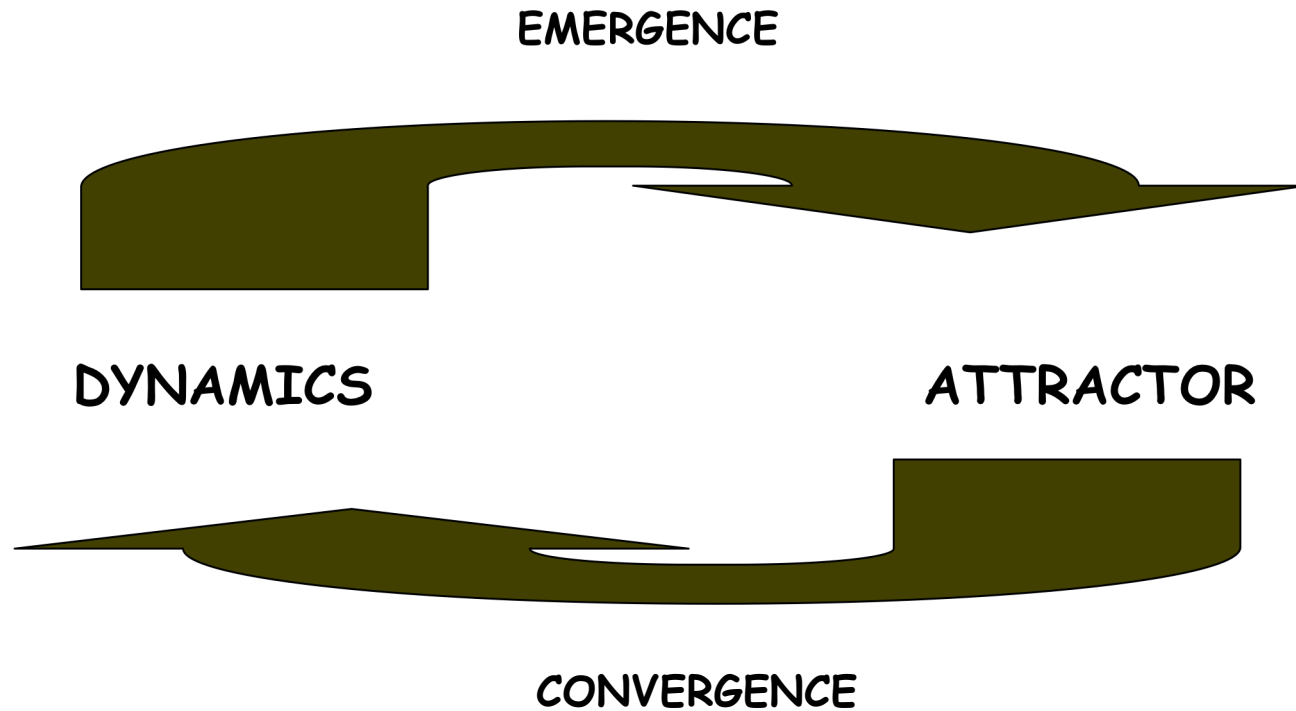
## Variation on the two absent-minded professors case



# Polya's urn: color ratio over time



# Complexity from noise



The dynamics converges towards an attractor that is generated by itself. The evolution is said to be *path-dependent*.

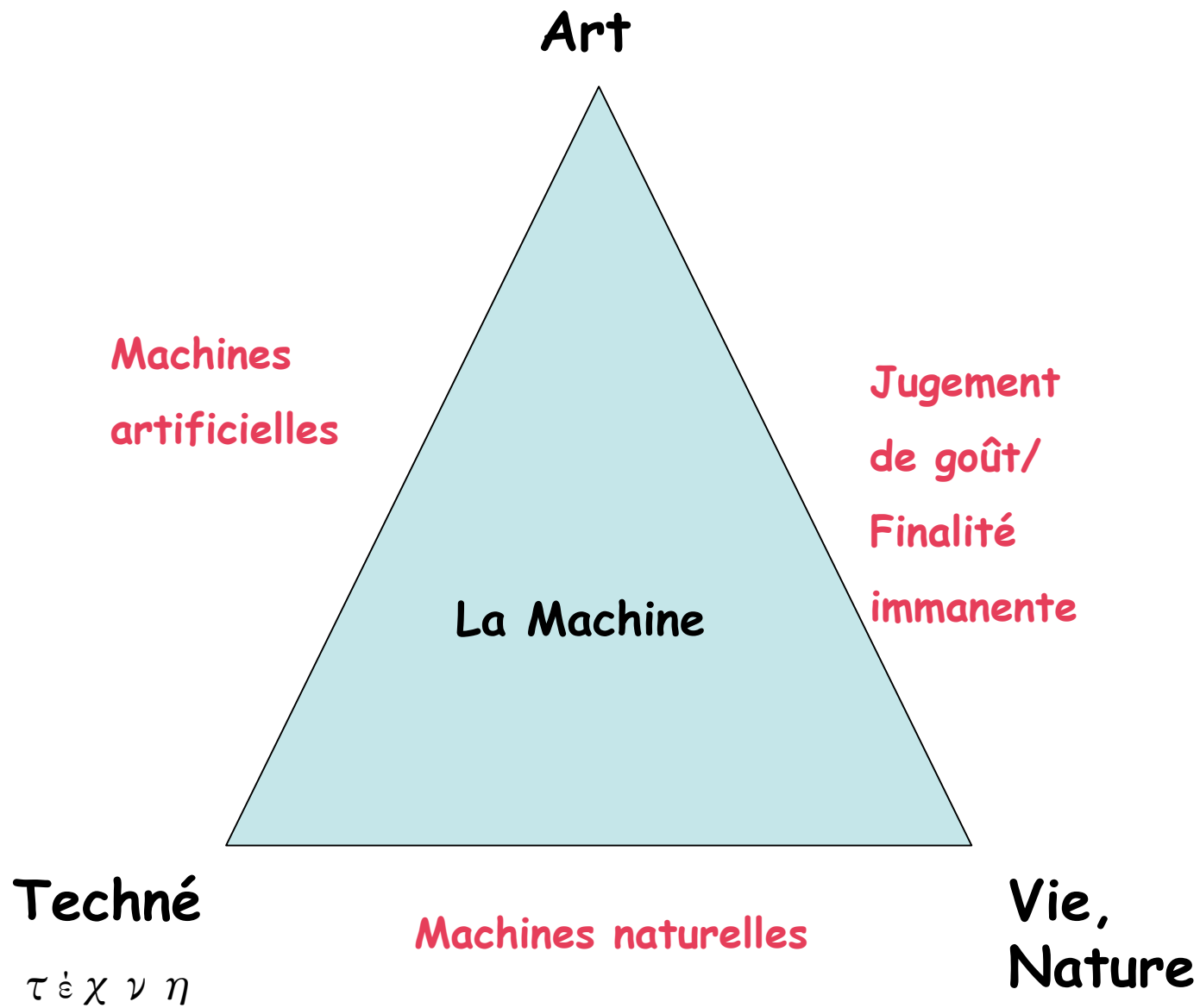
# Is selection indispensable for evolution?



**NO !**

**“I am convinced that selection has been the main, *but not the exclusive*, means of modification.”**

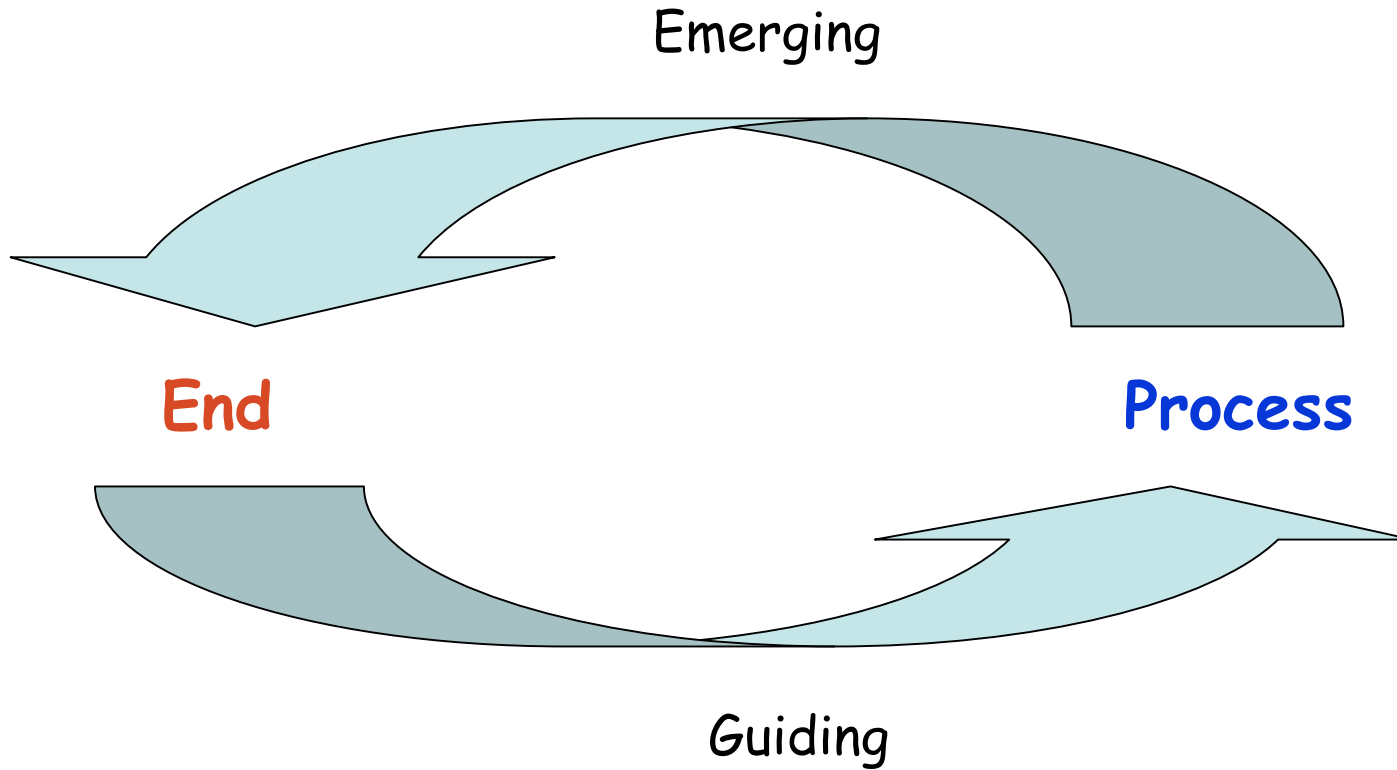
*The Origin of species (1859)*



# The Beauty of Nature



# Immanent Finality in Self-Organizing, Complex Processes



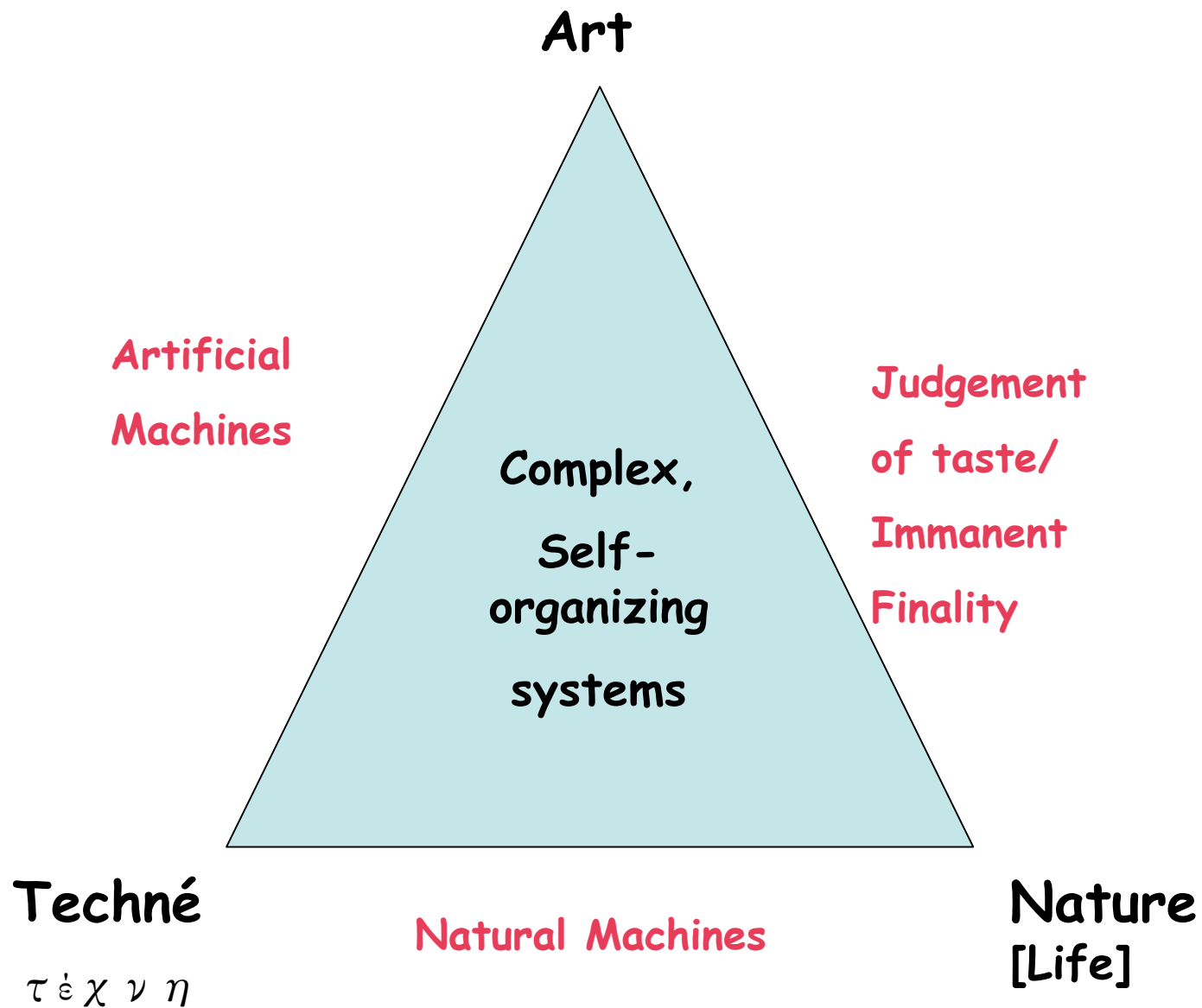
Tangled Hierarchy Between Two Hierarchical Levels

From Kant's *Critique of Judgment*  
to Luigi Pareyson's *Aesthetics*  
“La forme est à la fois formée et formante”.

“La composition de la  
*Jeune Parque*,  
ce fut comme  
**la croissance  
naturelle d'une  
fleur artificielle.**”

Paul Valéry (1917)





# Nano Bio Info Cognitive Convergence

If the Cognitive Scientists can *think* it  
the Nano people can *build* it  
the Bio people can *implement* it, and  
the IT people can monitor and *control* it.

Roco, M.C. & Bainbridge, W.S., *Converging Technologies for Improving Human Performance. Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, Washington: National Science Foundation, 2002.

# **Dangerous Metaphors**

**From Living Machinery to  
Artificial Life**

Look round the world: contemplate the whole and every part of it: You will find it to be nothing but one great machine, subdivided into an infinite number of lesser machines, which again admit of subdivisions to a degree beyond what human senses and faculties can trace and explain. All these various machines, and even their most minute parts, are adjusted to each other with an accuracy which ravishes into admiration all men who have ever contemplated them. **The curious adapting of means to ends**, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human **designs**, thought, wisdom, and intelligence. Since, therefore, the effects resemble each other, we are led to infer, **by all the rules of analogy**, that the causes also resemble; and that **the Author of Nature is somewhat similar to the mind of man, though possessed of much larger faculties, proportioned to the grandeur of the work which he has executed**. By this argument a posteriori, and by this argument alone, do **we prove at once the existence of a Deity, and his similarity to human mind and intelligence**.

David Hume, *Dialogues Concerning Natural Religion*, II, 1776.

Neil Shubin, author of *Your Inner Fish* (2008),  
interviewed by Michael Krasny on NPR/KQED Forum, Jan.30, 2008

NS: **We are not designed very intelligently. We're designed historically.**

When you look at the human body, ... you find bizarre detours and loops and turns and twists that **make no sense. Nobody in their right mind would have designed a body like this.**

MK: You mean, **God wasn't in His right mind?**

[Laughters]

NS: The fish were in their right mind. [Illustration] The spermatic cord in human males makes a weird loop around the pelvis: **a really bad design!**



# Dangerous metaphors or the inevitable temptation

"Can nanostructuring improve on *Nature's design*?"

Hongyou Fan et al, *Nature Material*, May 2007

Is it likely that nanosystems, designed by human minds, will bypass **all this Darwinian wandering**, and leap straight to *design success*?

Damien Broderick, *The Spike*, 2001

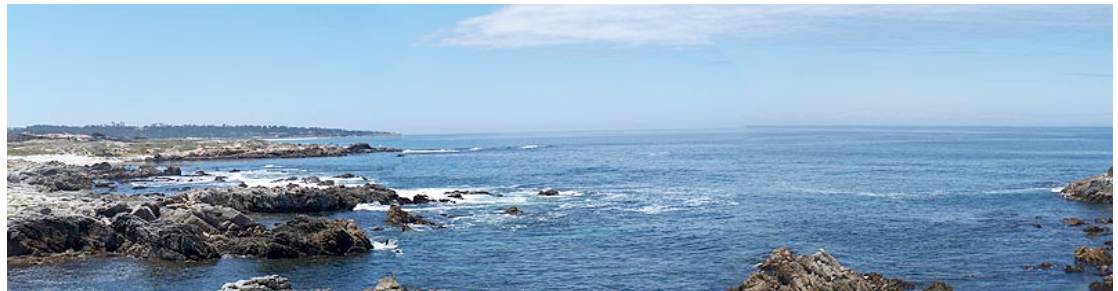
The supreme paradox

*Making Life From Scratch*

# From Asilomar (February 1975) to Ilulissat (June 2007)

On the first Kavli Futures Symposium at the University of Greenland in Ilulissat, leading researchers from around the world gathered to announce the **convergence of work in synthetic biology and nanotechnology** and to take stock of the most recent advances in the manufacture of artificial cells.

Their call for a global effort to promote “the construction or redesign of biological systems components that do not naturally exist” evoked memories of the statement that was issued in Asilomar, California more than thirty years earlier, in 1975, by the pioneers of biotechnology.



# La “vie artificielle” n’est pas la vie

“**Artificiel veut dire qui tend à un but défini. Et s’oppose par là à vivant.** Artificiel ou humain ou anthropomorphe se distinguent de ce qui est seulement vivant ou vital. Tout ce qui parvient à apparaître sous forme d’un but net et fini devient artificiel et c’est la tendance de la conscience croissante. C’est aussi le travail de l’homme quand il est appliqué à *imiter* le plus exactement possible un objet ou un phénomène spontané. La pensée consciente d’elle-même se fait d’elle-même un système artificiel. **Si la vie avait un but, elle ne serait plus la vie.** »

Paul Valéry, *Cahier B*, 1910 ;  
cité par Georges Canguilhem, « Machine et organisme » (1946-1947) ; repris in *La connaissance de la vie*, Vrin, 2006, p. 150.

# Unchaining Complexity

“The unleashed power of the atom has changed everything save our modes of thinking, and we thus drift toward unparalleled catastrophe”

Albert Einstein

# In praise of out-of-controlness



"It took us a long time to realize that the power of a technology is proportional to **its inherent out-of-controlness**, its inherent ability to surprise and be generative. In fact, **unless we can worry about a technology, it is not revolutionary enough.**"

Kevin Kelly, "Will Spiritual Robots Replace Humanity by 2100?"  
in *The Technium*, a book in progress,

<http://www.kk.org/thetechnium/>

[...] To what extent we have begun to *act into nature*, in the literal sense of the word, is perhaps best illustrated by a recent casual remark of a scientist who quite seriously suggested that "*basic research is when I am doing what I don't know what I am doing*." [Wernher von Braun, December 1957].

This started harmlessly enough with the experiment in which men were no longer content to observe, to register, and contemplate whatever nature was willing to yield in her own appearance, but began to prescribe conditions and to provoke natural processes. What then developed into an ever-increasing skill in *unchaining elemental processes*, which, without the interference of men, would have lain dormant and perhaps never have come to pass, has finally ended in a veritable art of 'making' nature, that is, of creating 'natural' processes which without men would never exist and which earthly nature by herself seems incapable of accomplishing [...].

The very fact that natural sciences have become exclusively sciences of process and, in their last stage, *sciences of potentially irreversible, irremediable 'processes of no return'* is a clear indication that, whatever the brain power necessary to start them, *the actual underlying human capacity which alone could bring about this development is no 'theoretical' capacity, neither contemplation nor reason, but the human ability to act* - to start new unprecedented processes whose outcome remains uncertain and unpredictable whether they are let loose in the human or the natural realm.

In this aspect of action [...] *processes are started whose outcome is unpredictable, so that uncertainty rather than frailty becomes the decisive character of human affairs.*

Hannah Arendt, *The Human Condition*, 1958

# Descartes' Dream and Heidegger's Error



"... nous rendre comme  
maîtres et possesseurs de  
la nature."

"... becoming as masters  
and possessors of nature."

# Heidegger's Error



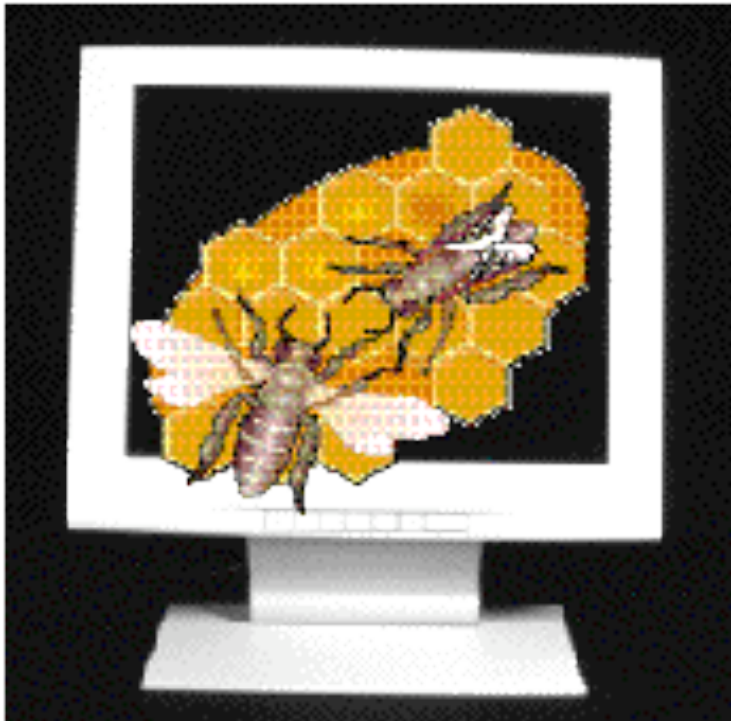
“Cybernetics is the metaphysics of the atomic age.”

Martin Heidegger (1976)

*The sorcerer's apprentice myth must be updated: it is neither by error nor by terror that Man will be dispossessed of his own creations but **by design**.*

**“For the first time, God has competition.”**

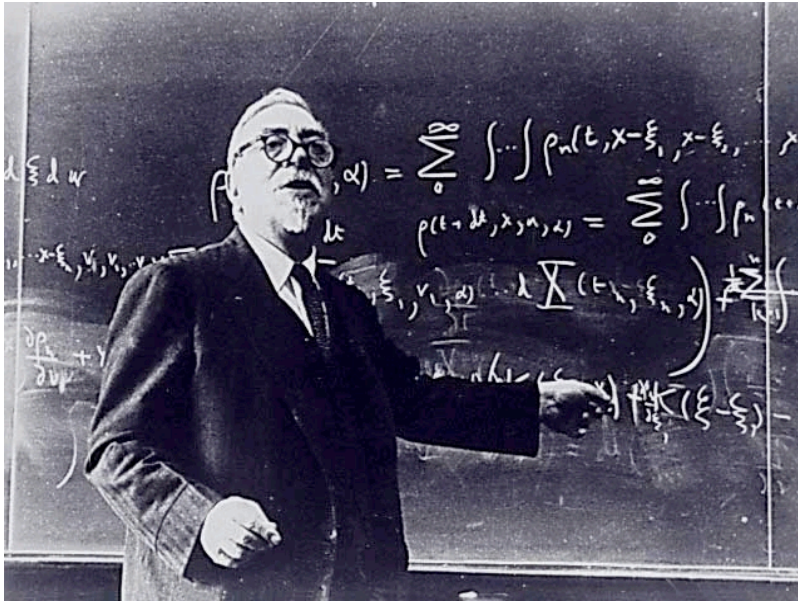
**Pat Mooney, ETC Group**



If the Ilulissat Statement is to be believed, the actual synthesis of an organism equipped with an artificial genome (“a free-living organism that can grow and replicate”) will become a reality in the next few years.

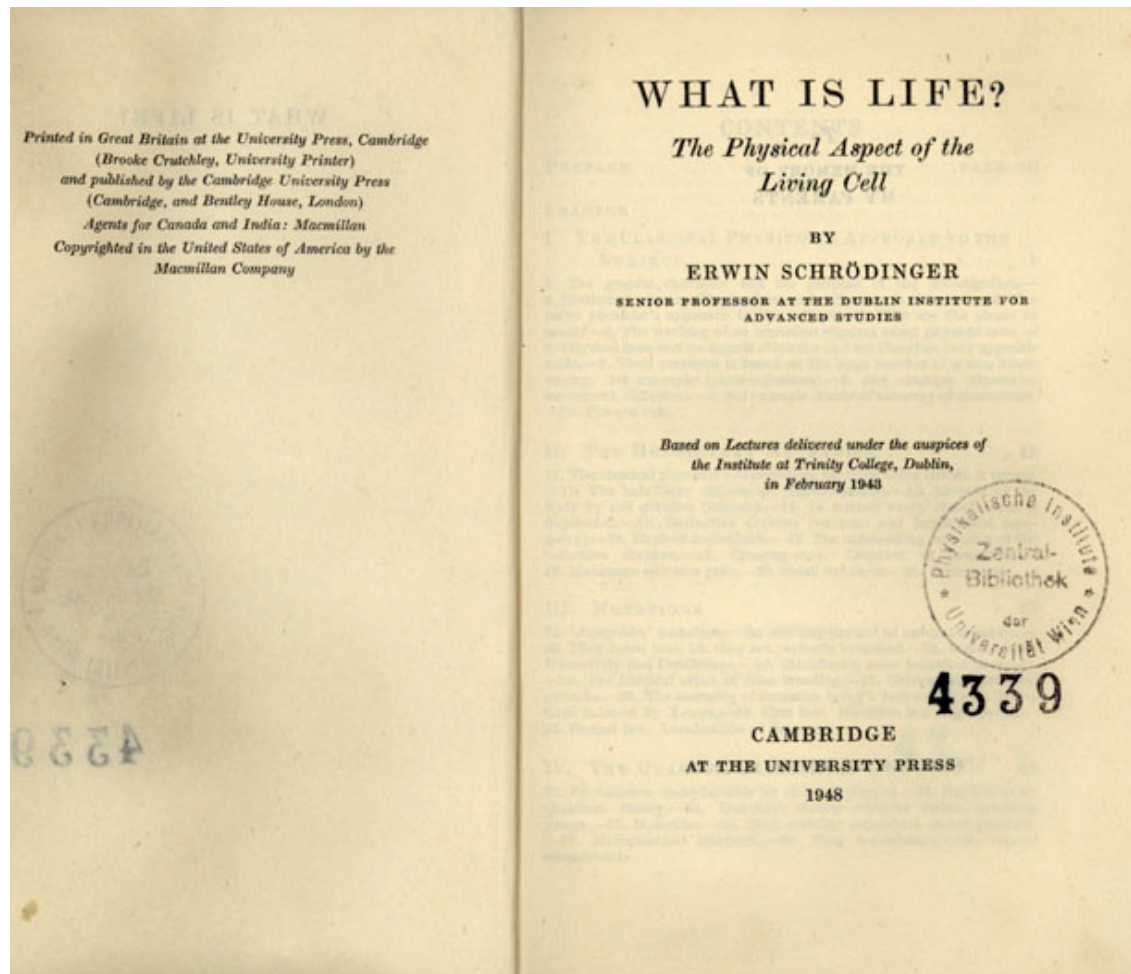
## Norbert Wiener

### *God and Golem, Inc.: A Comment on Certain Points where Cybernetics Impinges on Religion (1964)*



God is supposed to have made man in His own image, and the propagation of the race may also be interpreted as a function in which one living being makes another in its own image. In our desire to glorify God with respect to man and Man with respect to matter, it is thus natural to assume that machines cannot make other machines in their own image; that this is **something associated with a sharp dichotomy of systems into living and non-living; and that it is moreover associated with the other dichotomy between creator and creature.** Is this, however, so?

# From Biophysics to Synthetic Biology



“What is Life?”

A silly question!”

Philip Ball, *Nature*,  
June 26, 2007

The question arises, however, whether such an achievement will really amount to **creating life**. In order to assert this much, one must suppose that between life and non-life there is an absolute distinction, a **critical threshold, so that whoever crosses it will have shattered a taboo**, like the prophet Jeremiah and like Rabbi Löw of Prague in the Jewish tradition, who dared to create an artificial man, a *golem*.

In the view of its promoters and some of its admirers, notably the English physicist and science writer Philip Ball, **synthetic biology has succeeded in demonstrating that no threshold of this type exists**: between the dust of the earth and the creature that God formed from it, there is no break in continuity that permits us to say (quoting *Genesis 2:7*) that He breathed into man's nostrils the breath of life. And even in the event that synthetic biology should turn out to be incapable of fabricating an artificial cell, these scientists contend, it would still have had the virtue of **depriving the prescientific notion of life of all consistency**.

Once again, we find that **science oscillates between two opposed attitudes**: on the one hand, vainglory, an excessive and often indecent **pride**; and on the other, when it becomes necessary to silence critics, a **false humility** that consists in denying that one has done anything out of the ordinary, anything that departs from the usual business of normal science. As a philosopher, I am more troubled by the false humility, for in truth it is this, and not the vainglory, that constitutes the height of pride. I am less disturbed by a science that claims to be the equal of God than by a science that drains one of the most essential distinctions known to humanity since the moment it first came into existence of all meaning: **the distinction between that which lives and that which does not; or, to speak more bluntly, between life and death.**