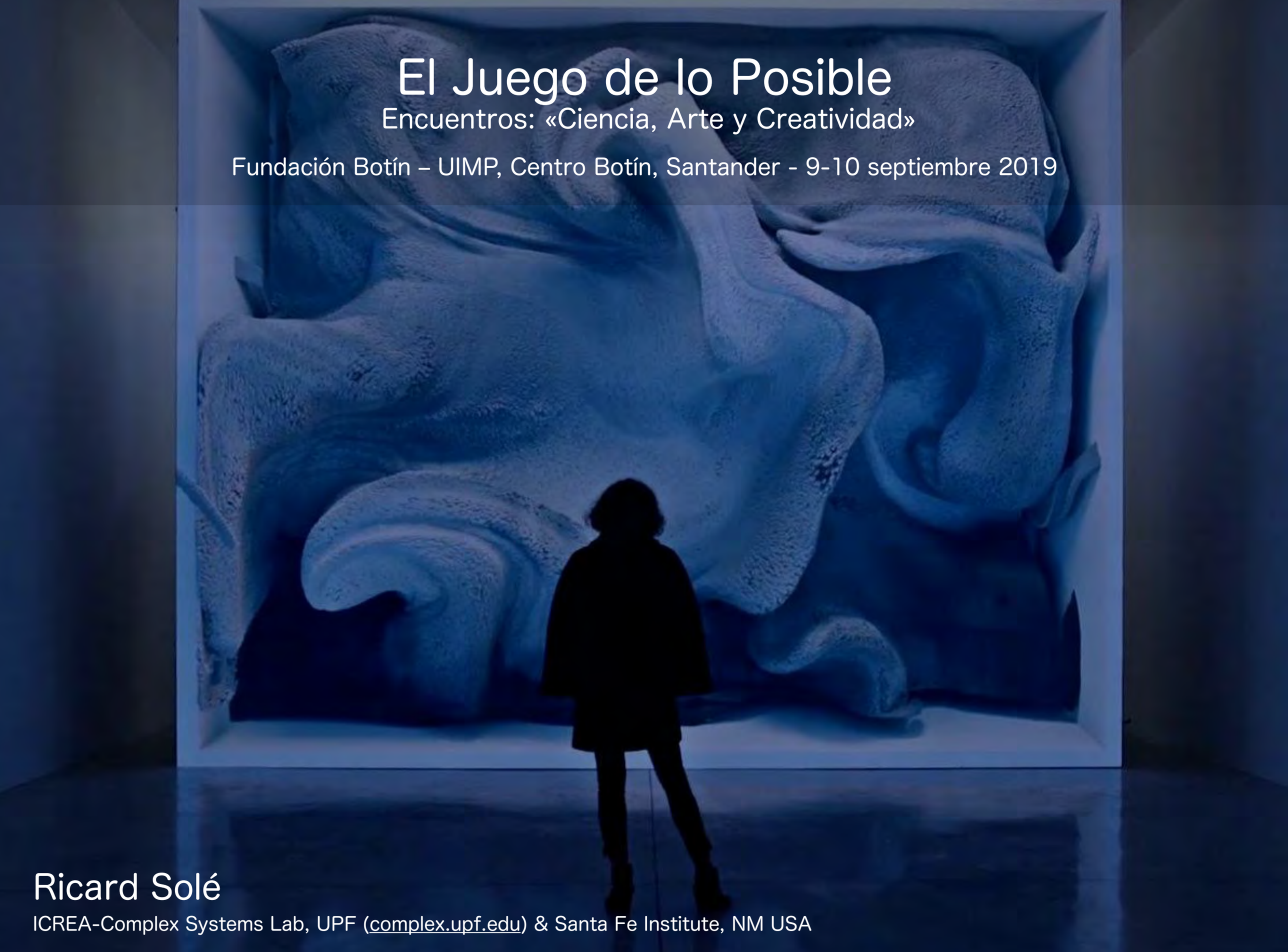
El Juego de lo Posible

Encuentros: «Ciencia, Arte y Creatividad»

Fundación Botín – UIMP, Centro Botín, Santander - 9-10 septiembre 2019

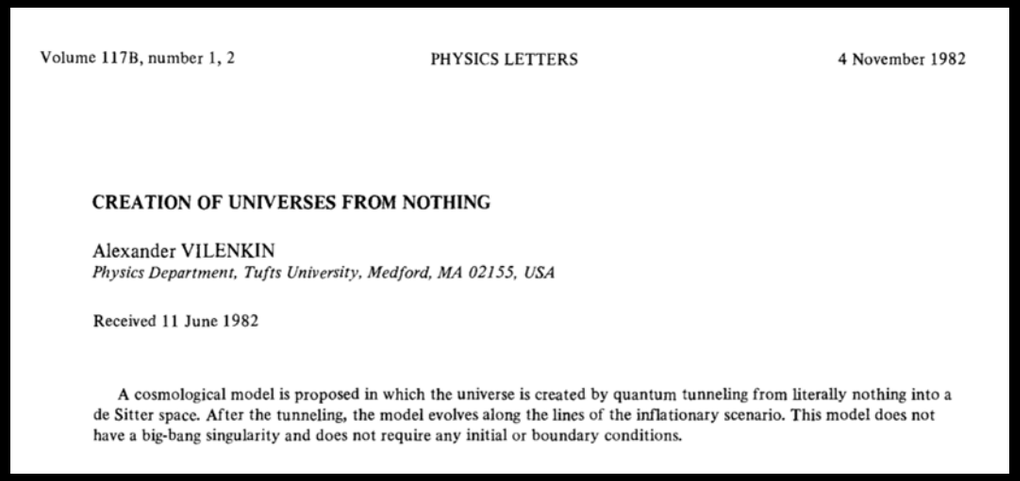


Ricard Solé

ICREA-Complex Systems Lab, UPF (complex.upf.edu) & Santa Fe Institute, NM USA

Why is there something instead of nothing?

“Nothigness” (classic vacuum) does not exist



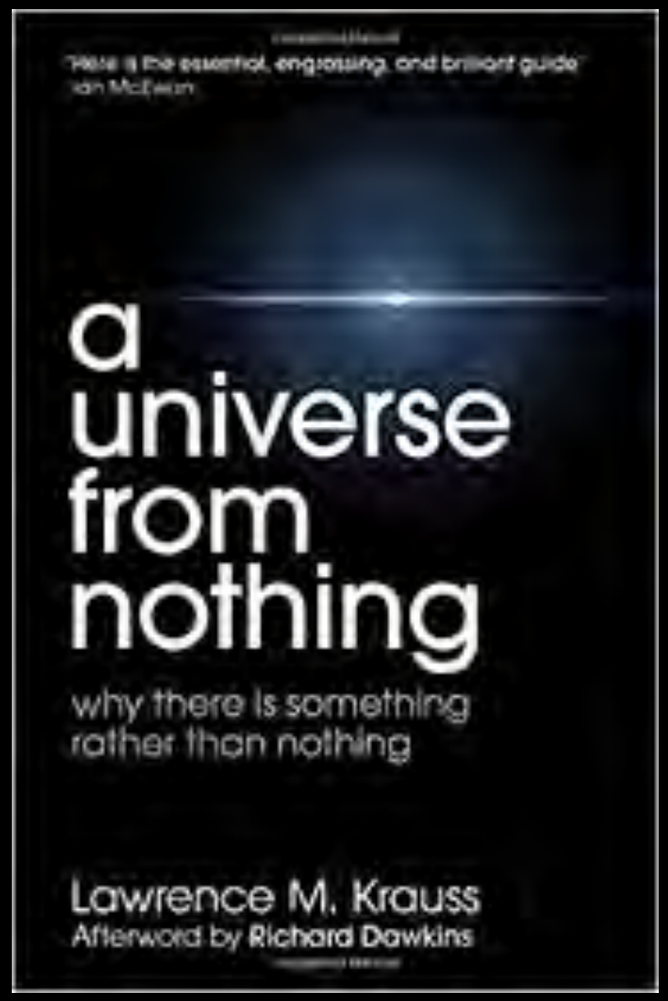
Volume 117B, number 1, 2 PHYSICS LETTERS 4 November 1982

CREATION OF UNIVERSES FROM NOTHING

Alexander VILENKIN
Physics Department, Tufts University, Medford, MA 02155, USA

Received 11 June 1982

A cosmological model is proposed in which the universe is created by quantum tunneling from literally nothing into a de Sitter space. After the tunneling, the model evolves along the lines of the inflationary scenario. This model does not have a big-bang singularity and does not require any initial or boundary conditions.



Why are we fascinated by alternative stories?

How does complexity emerge in evolution?

Why is there something instead of nothing?

What defines life? How life originated?

Cell origins / Can we build artificial cells from scratch?

How complex cells emerged?

How did multicellularity arise?

Can we break evolutionary barriers related to aging and death?

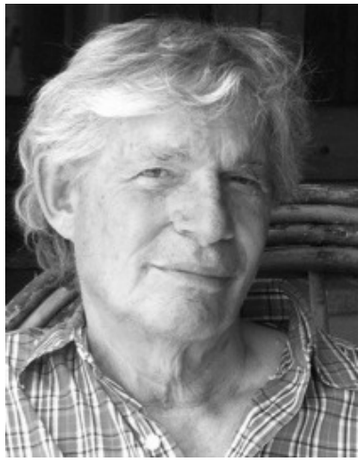
What defines consciousness and/or intelligence?

Can we build a conscious machine?

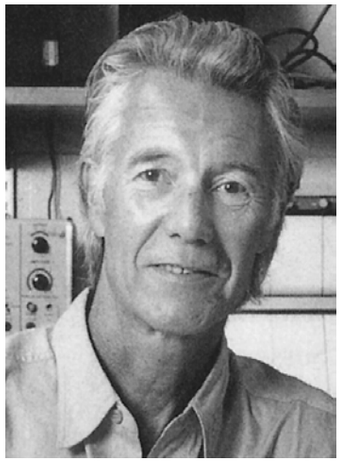
http://darwin-online.org.uk/

Santa Fe Institute

On the edge: Santa Fe Institute



Stuart Kauffman



Brian Goodwin

Chis Langton

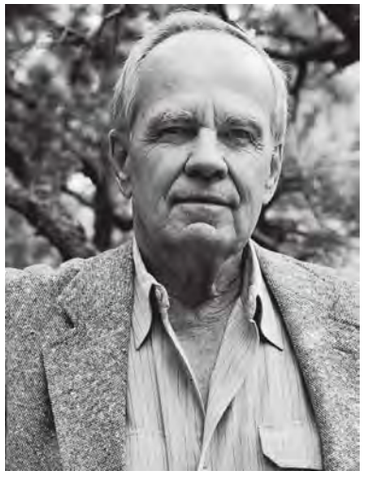
Stephanie Forrest

Per Bak

Jessika Trancik

Murrav Gell-

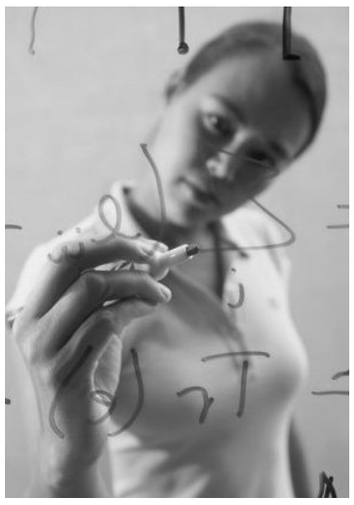
George Cowan



Cormac McCarthy

Peter Schuster

Daniel Dennett



Michelle Girvan

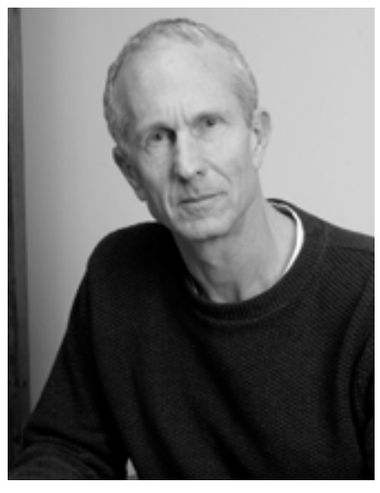
Eric Smith

Melanie Moses

Melanie Mitchell

Brian Arthur

Norman Packard

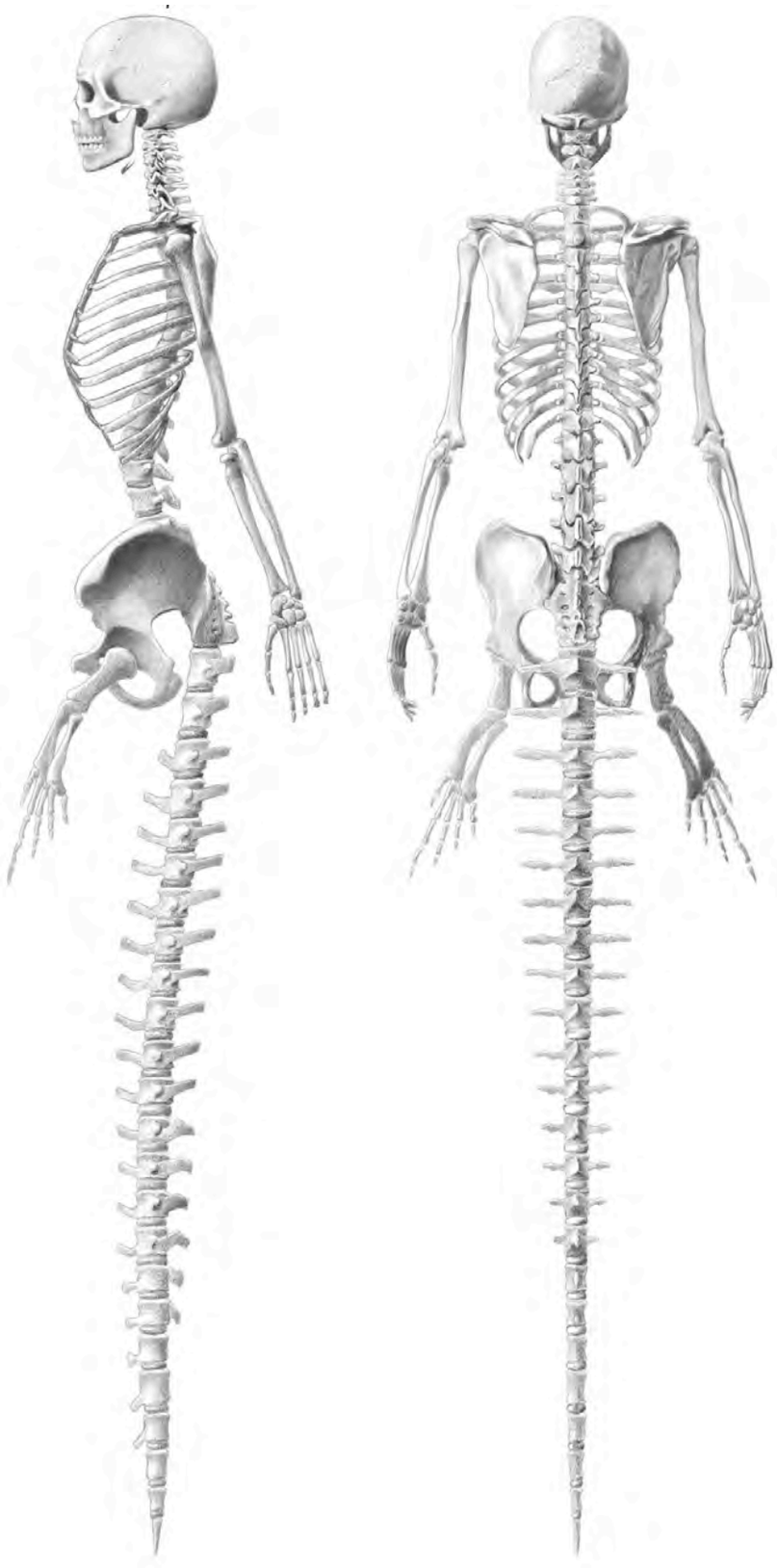


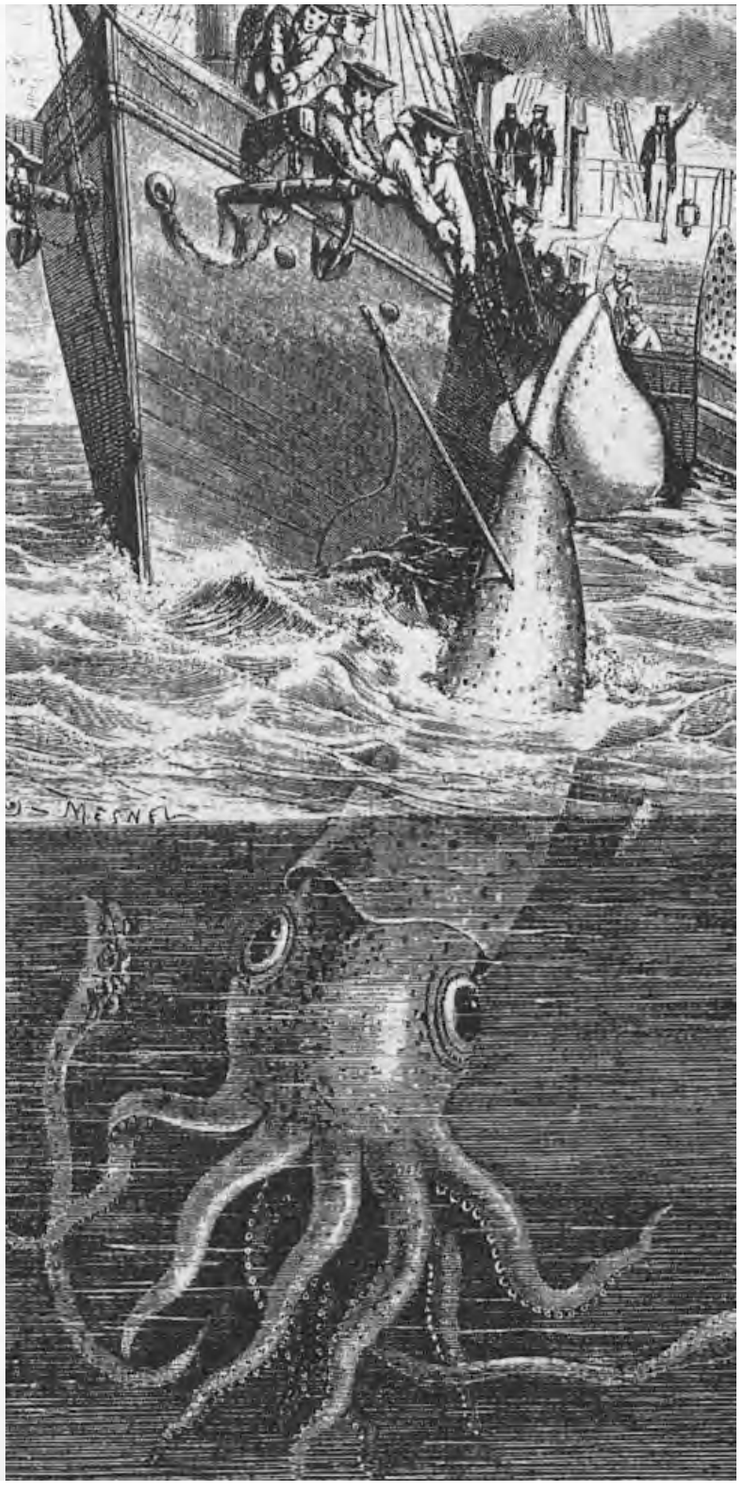
Doyne Farmer

The possible and the actual

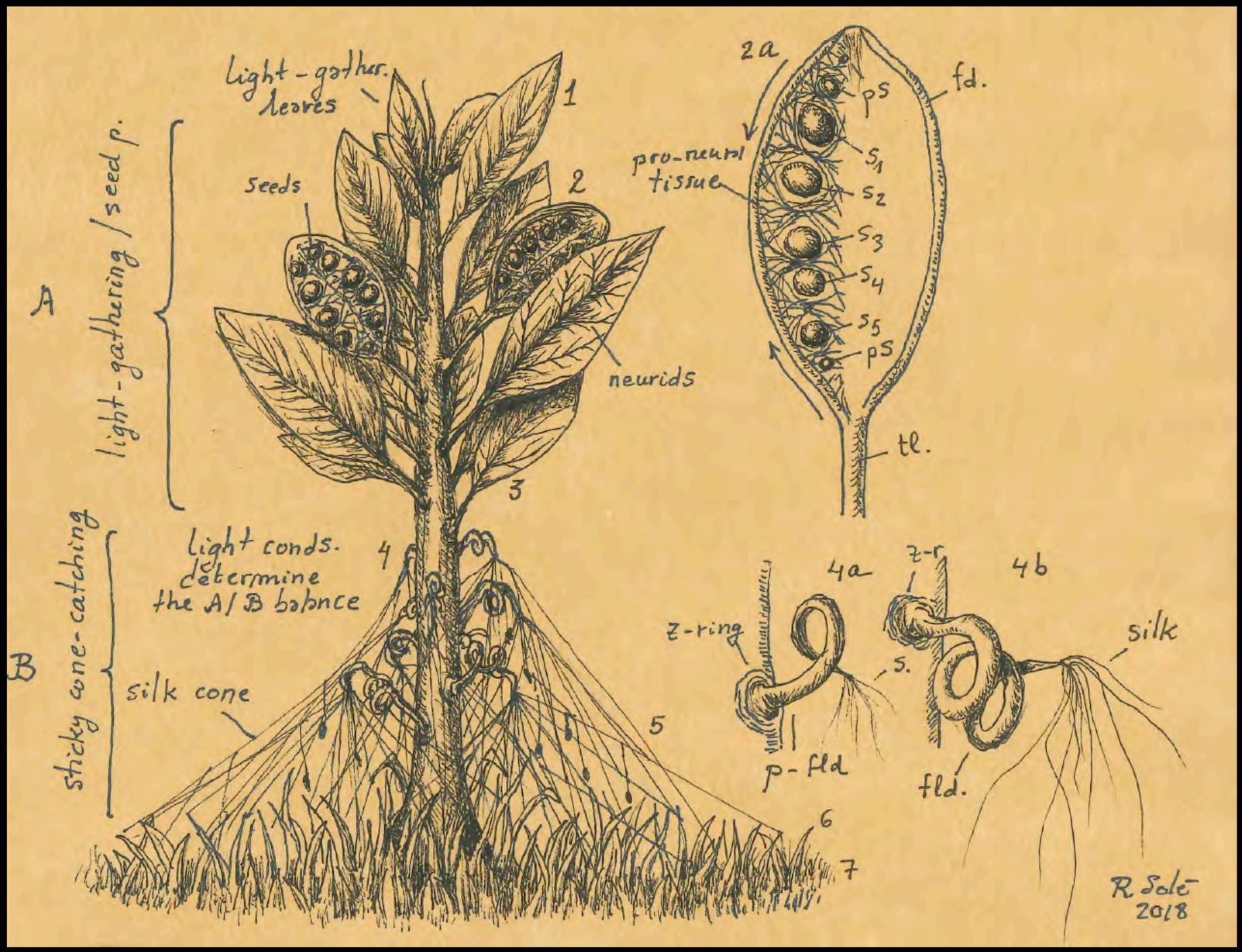
Cantos de sirena

The possible and the actual

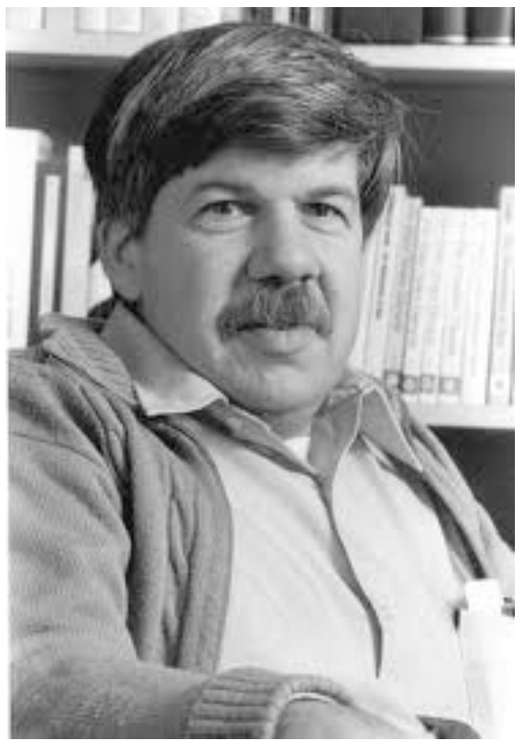


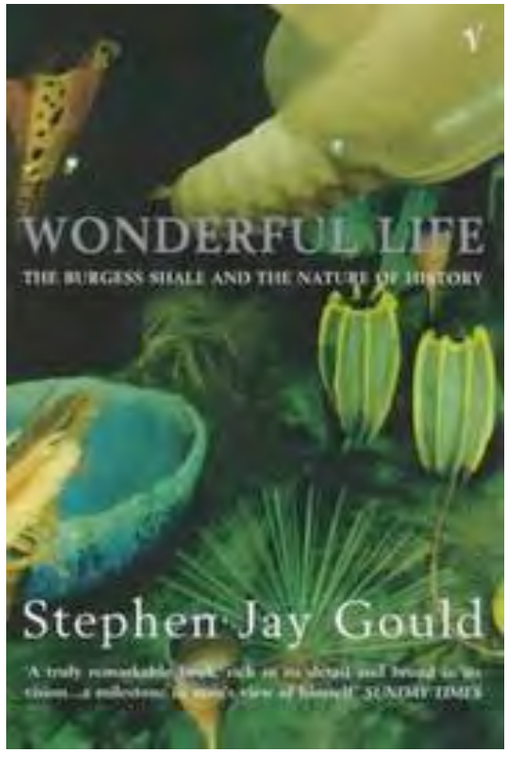


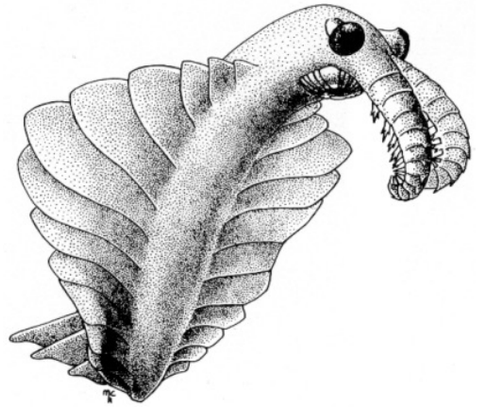
Imaginary plants: do plants (in our biosphere) have cognition?

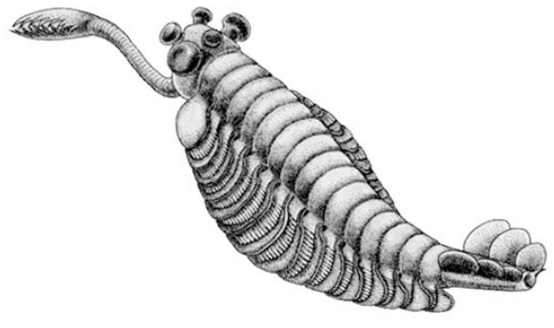


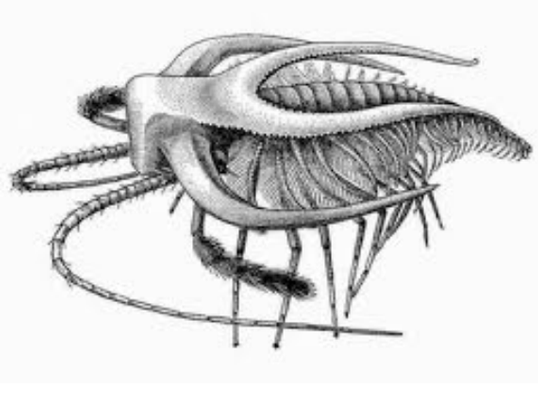
Evolution and accident: Wonderful Life





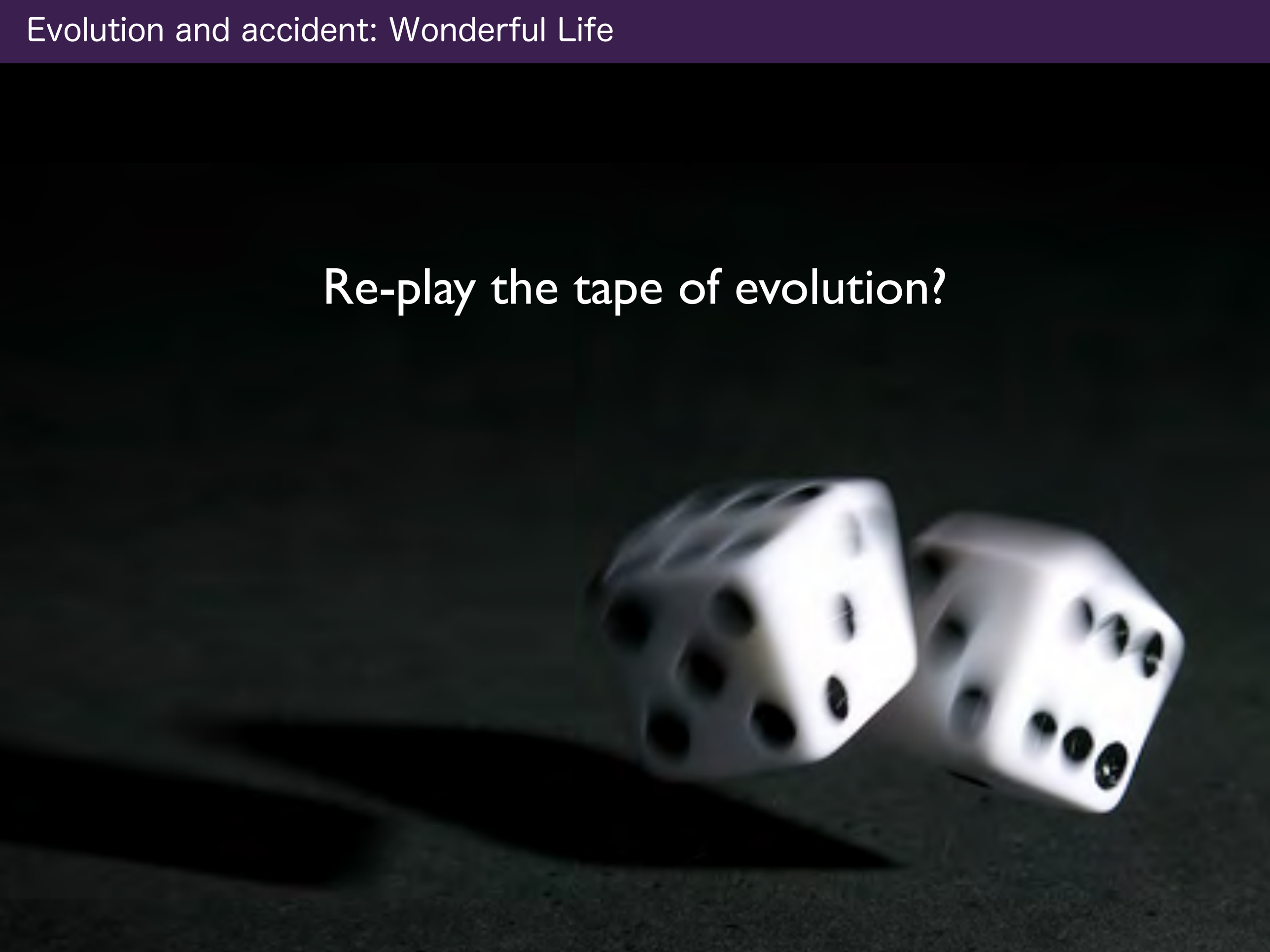






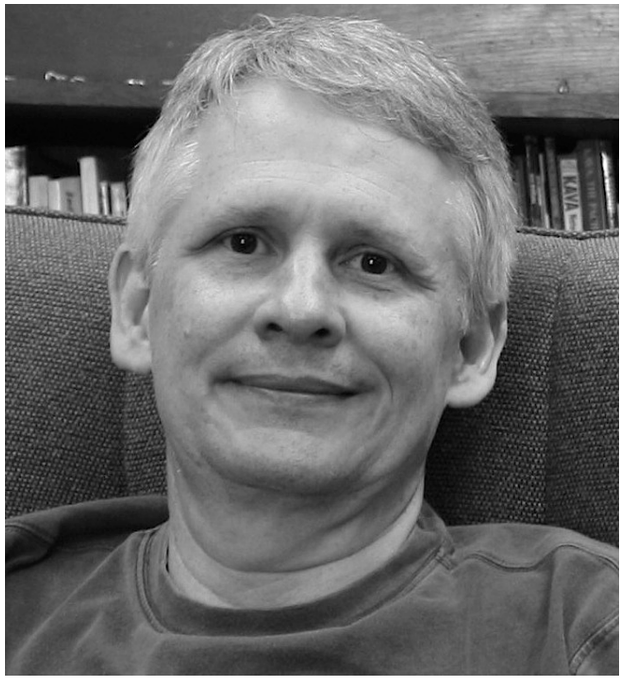
Evolution and accident: Wonderful Life

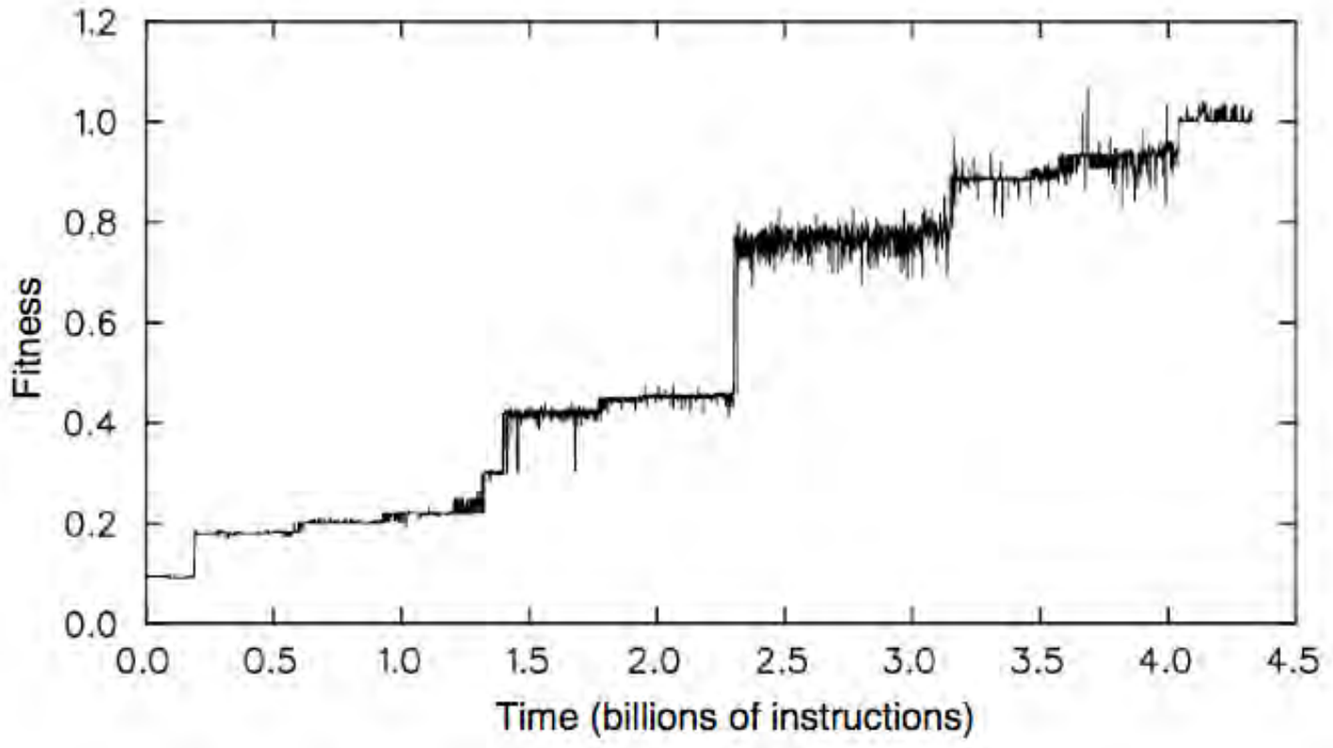
Re-play the tape of evolution?



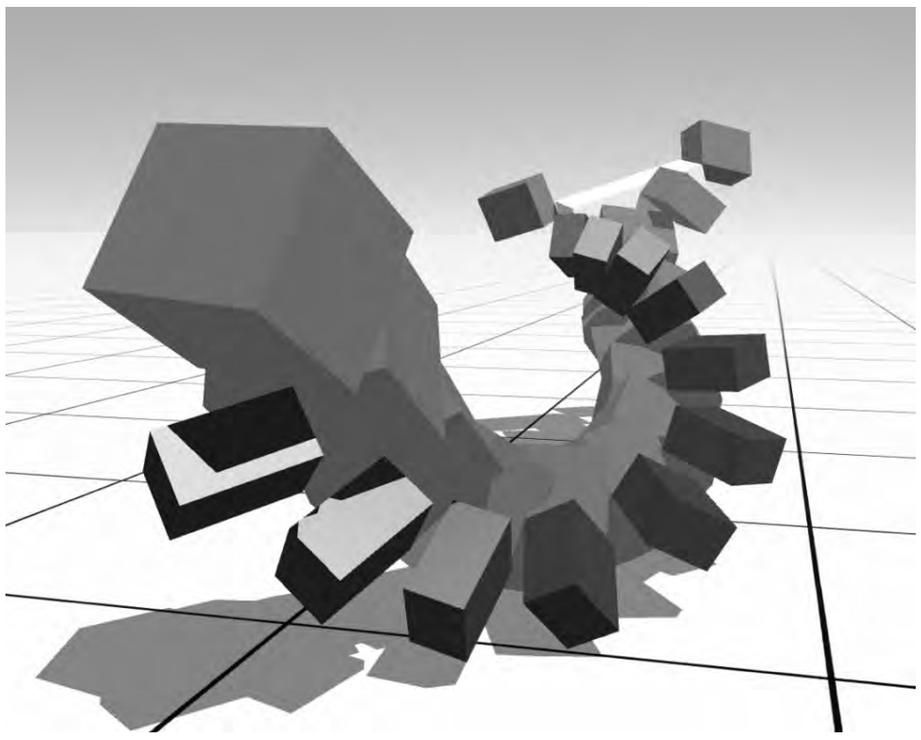
Evolution and accident: technological frozen accidents

Artificial life: replaying the tape of evolution





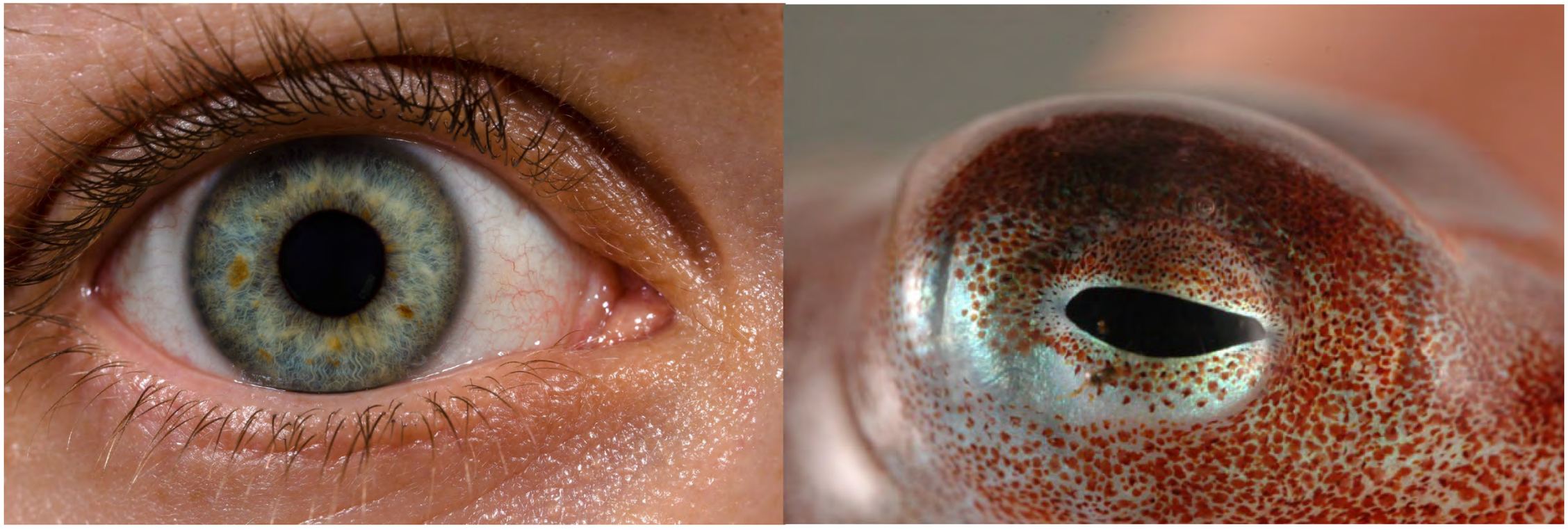
"An approach to the synthesis of life"
Thomas S. Ray
Artificial Life II, 1991

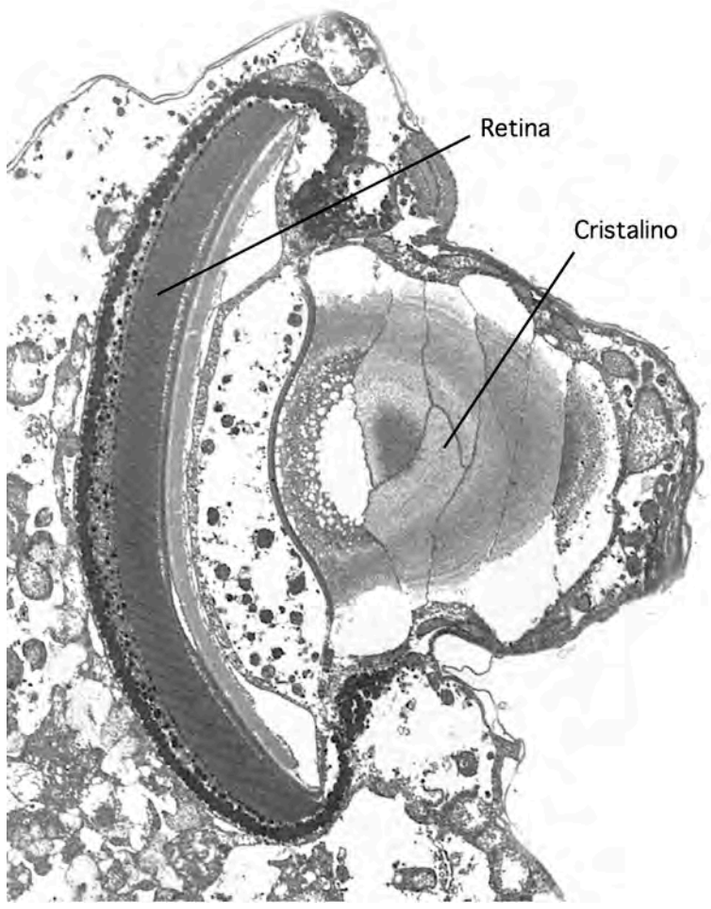


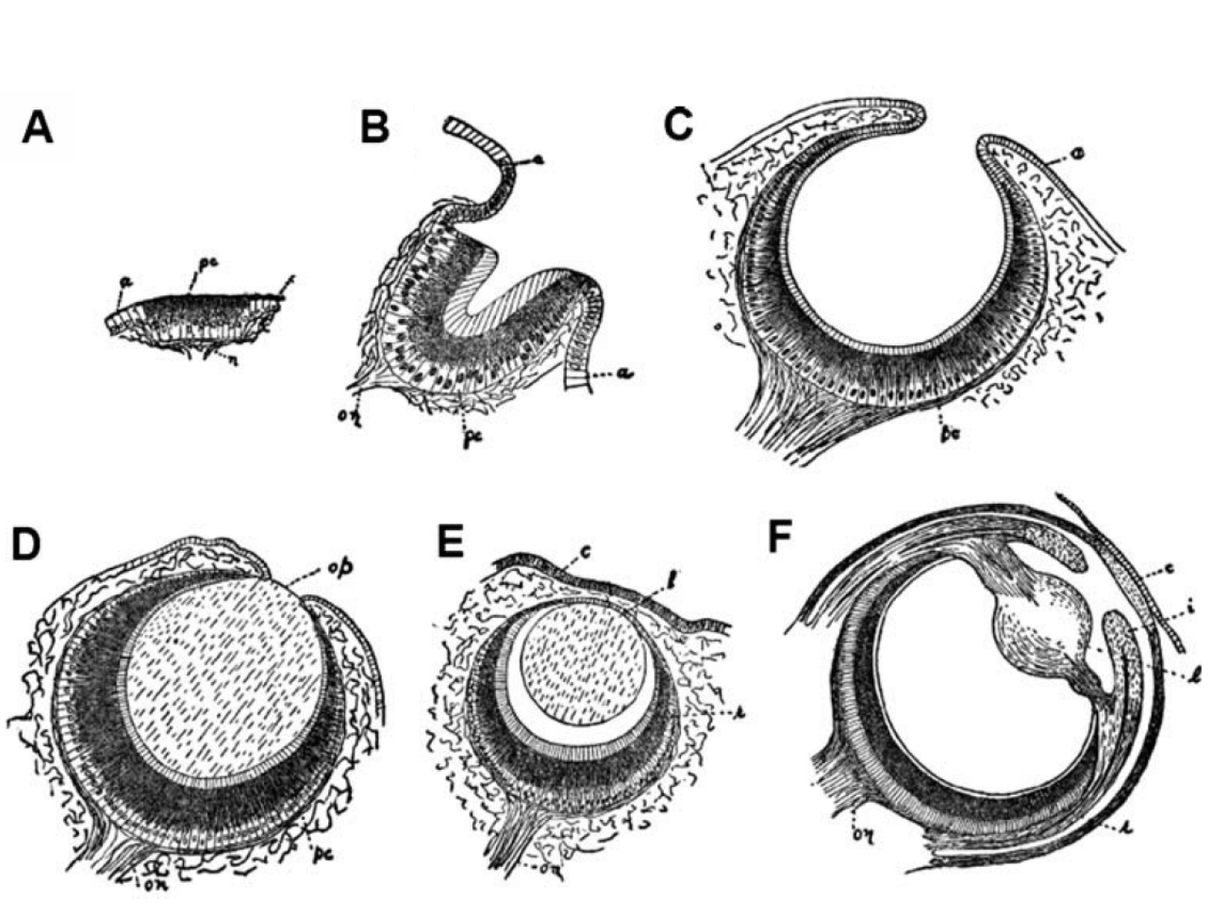
Is everything possible?

Universal designs are repeatedly discovered

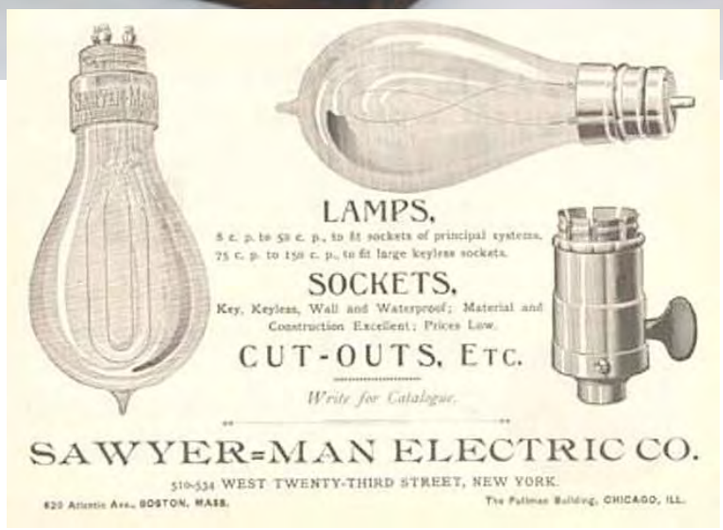
Universal designs are repeatedly discovered

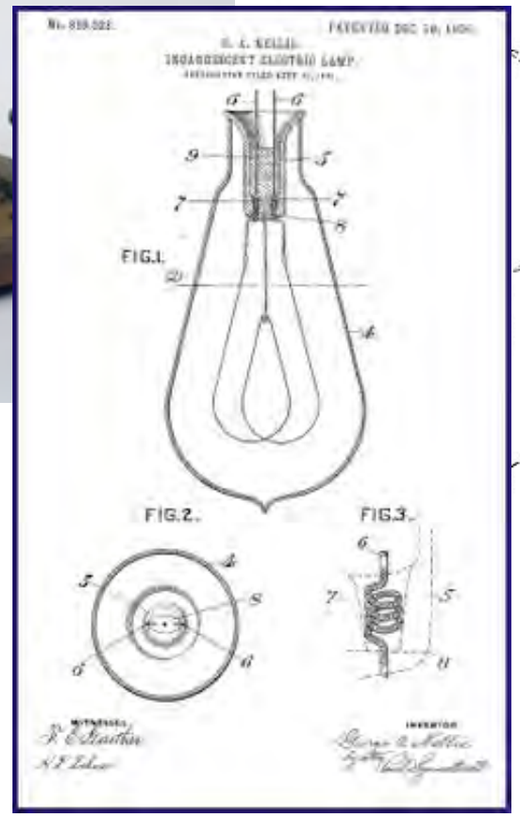


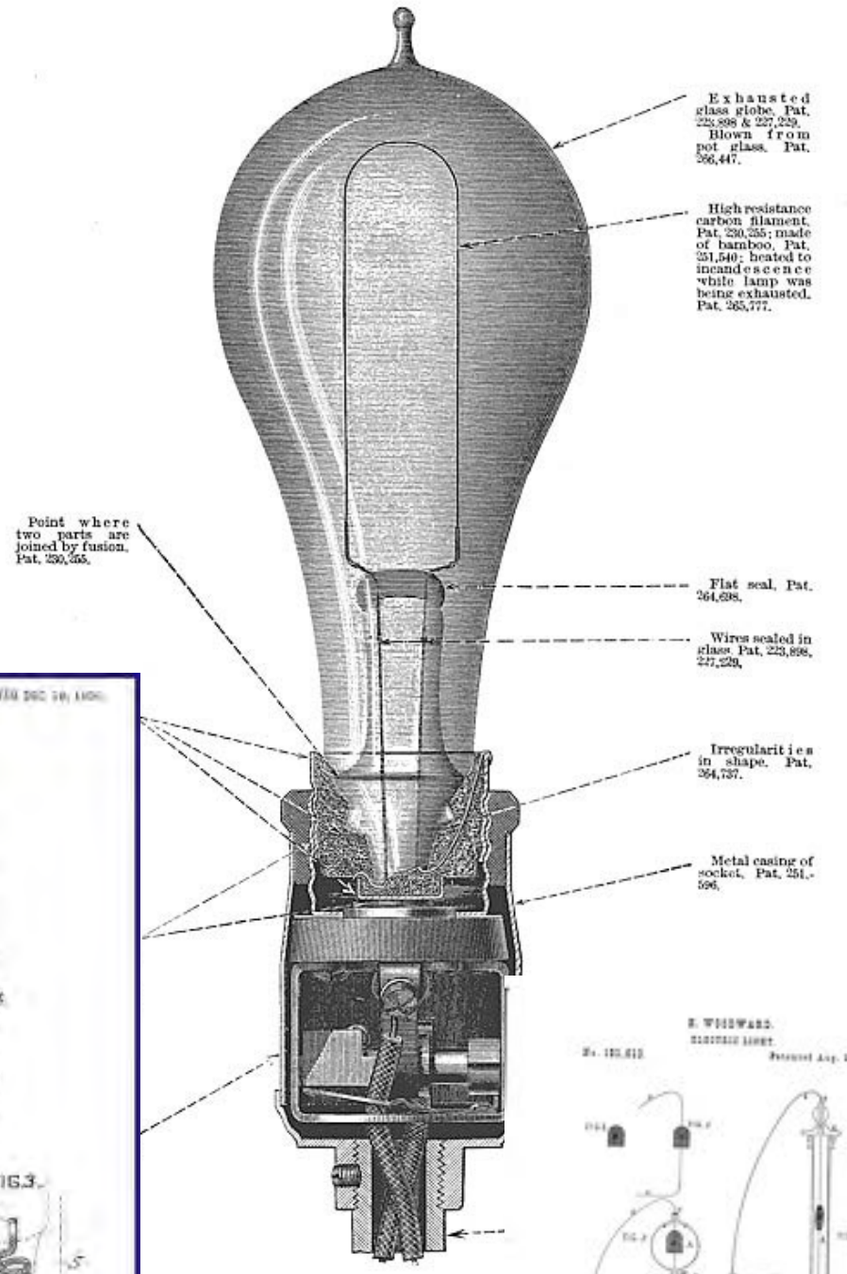


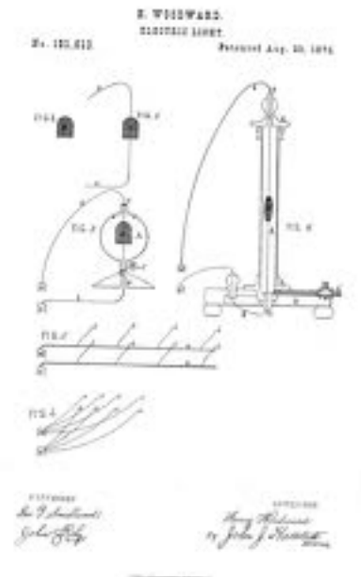


Universal designs are repeatedly discovered









The logic of monsters: universals, physics in complexity

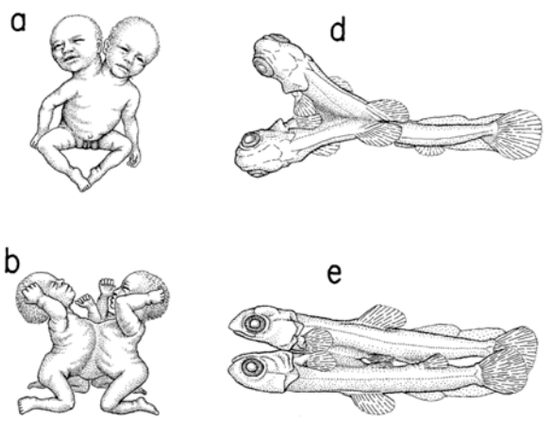
Geobios, mémoire spécial n° 12 p. 21-57, 19 fig., 2 pl. Lyon, 1989

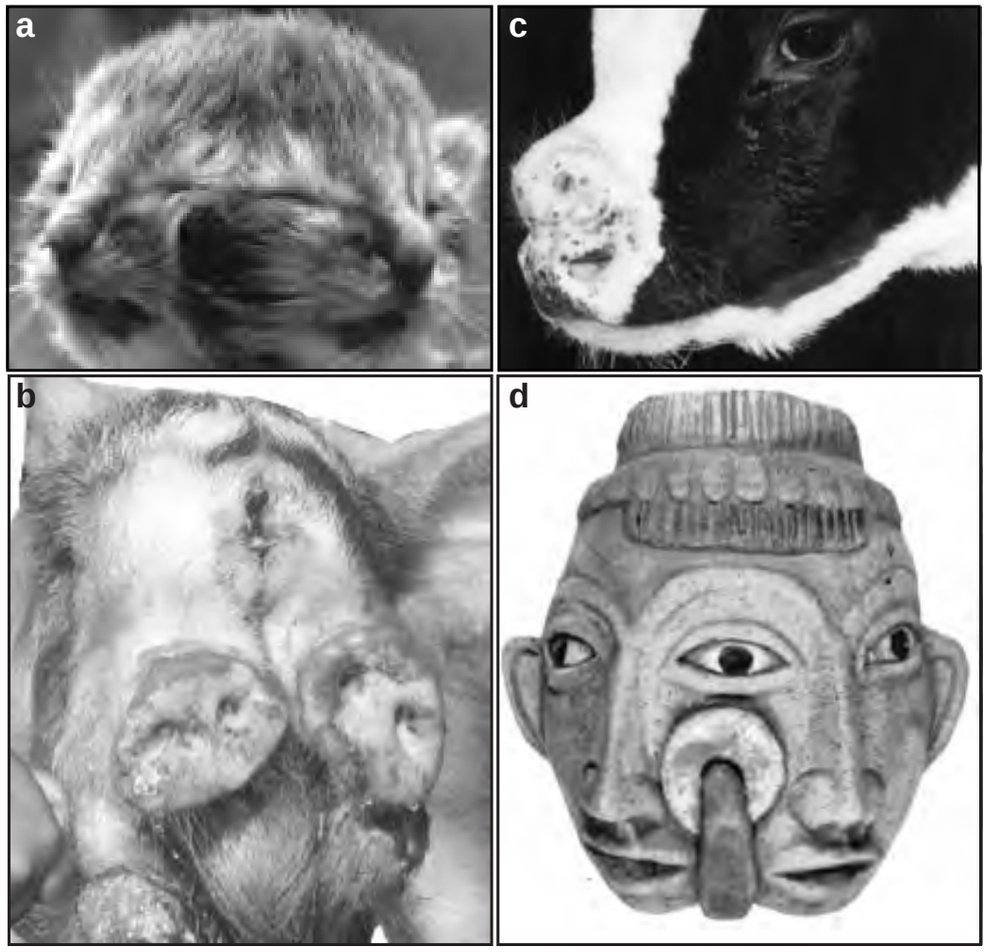
THE LOGIC OF MONSTERS : EVIDENCE FOR INTERNAL CONSTRAINT IN DEVELOPMENT AND EVOLUTION

Pere ALBERCH*

ABSTRACT

One of the most outstanding properties of natural diversity is its discreteness and order. Species can be identified and classified because of this property. There are two philosophical approaches to interpret the orderliness of natural systems. These two conceptual positions, wich I refer to as "externalist" and "internalist", prescribe drastically distinct methodological approaches. Classical neo-Darwinism falls within the "externalist" tradition, with its emphasis in natural selection as the main ordering agent in evolution, this approach basically argues that the properties of the physical ant biotic environment determine the selective pressures and consequently dictate which form will be selected over others. Therefore, the discreteness and order of natural diversity is a direct reflection of the topography of the adaptative landscape. The interna-





Can brains and minds be different?

Neurons and neural circuits

frontiers in
NEUROANATOMY

REVIEW ARTICLE
published: 10 March 2010
doi: 10.3389/neuro.05.009.2010

The histological slides and drawings of Cajal

Pablo Garcia-Lopez[1,2†], Virginia Garcia-Marin[1,3*†] and Miguel Freire[1]

[1] Instituto Cajal, Consejo Superior de Investigaciones Cientificas, Madrid, Spain
[2] School of Visual of Arts, New York, NY, USA
[3] Laboratorio de Circuitos Corticales, Centro de Tecnologia Biomédica, Universidad Politécnica de Madrid, Madrid, Spain

Edited by:
Laurence J. Garey, International Brain Research Organization, Switzerland

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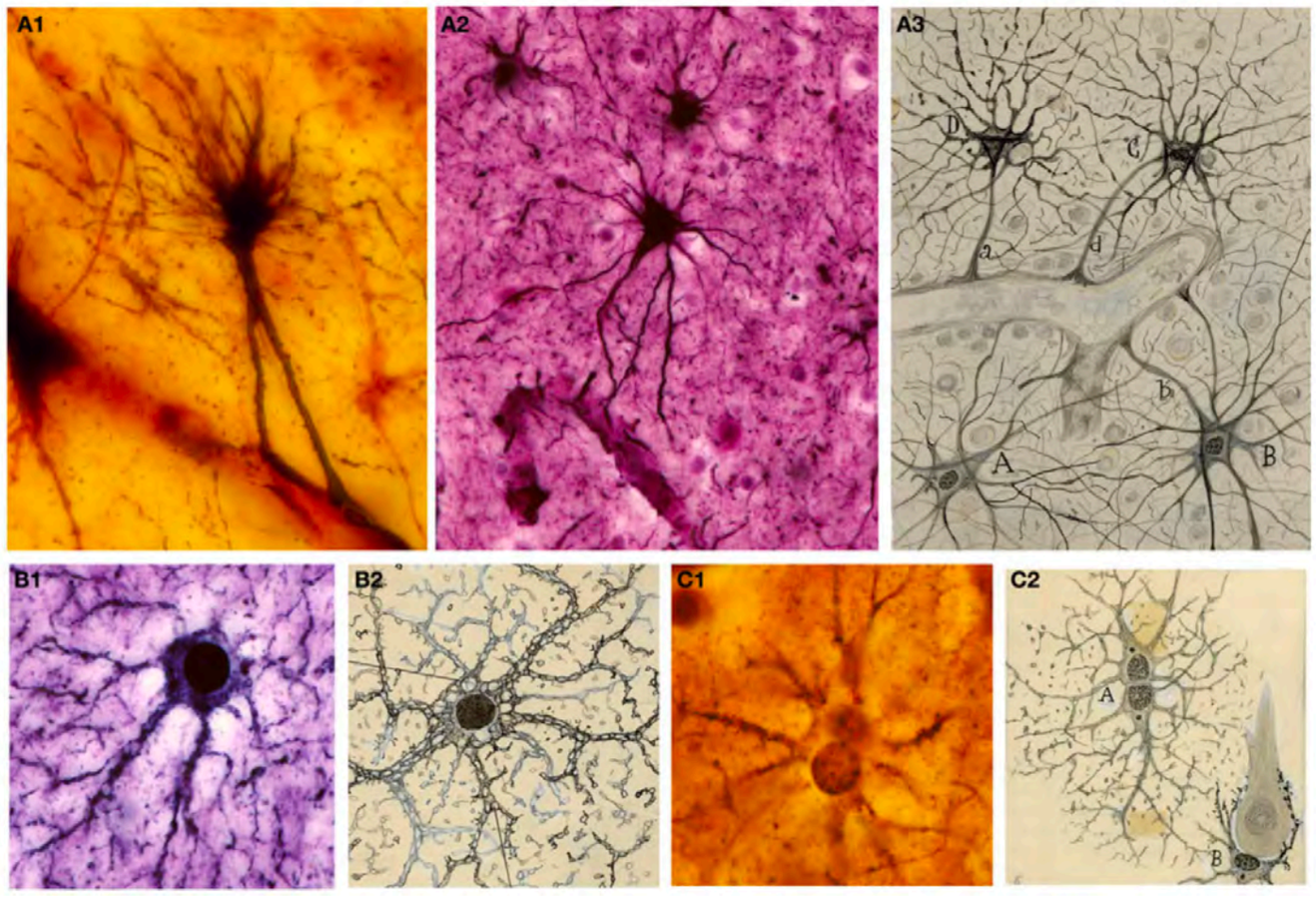
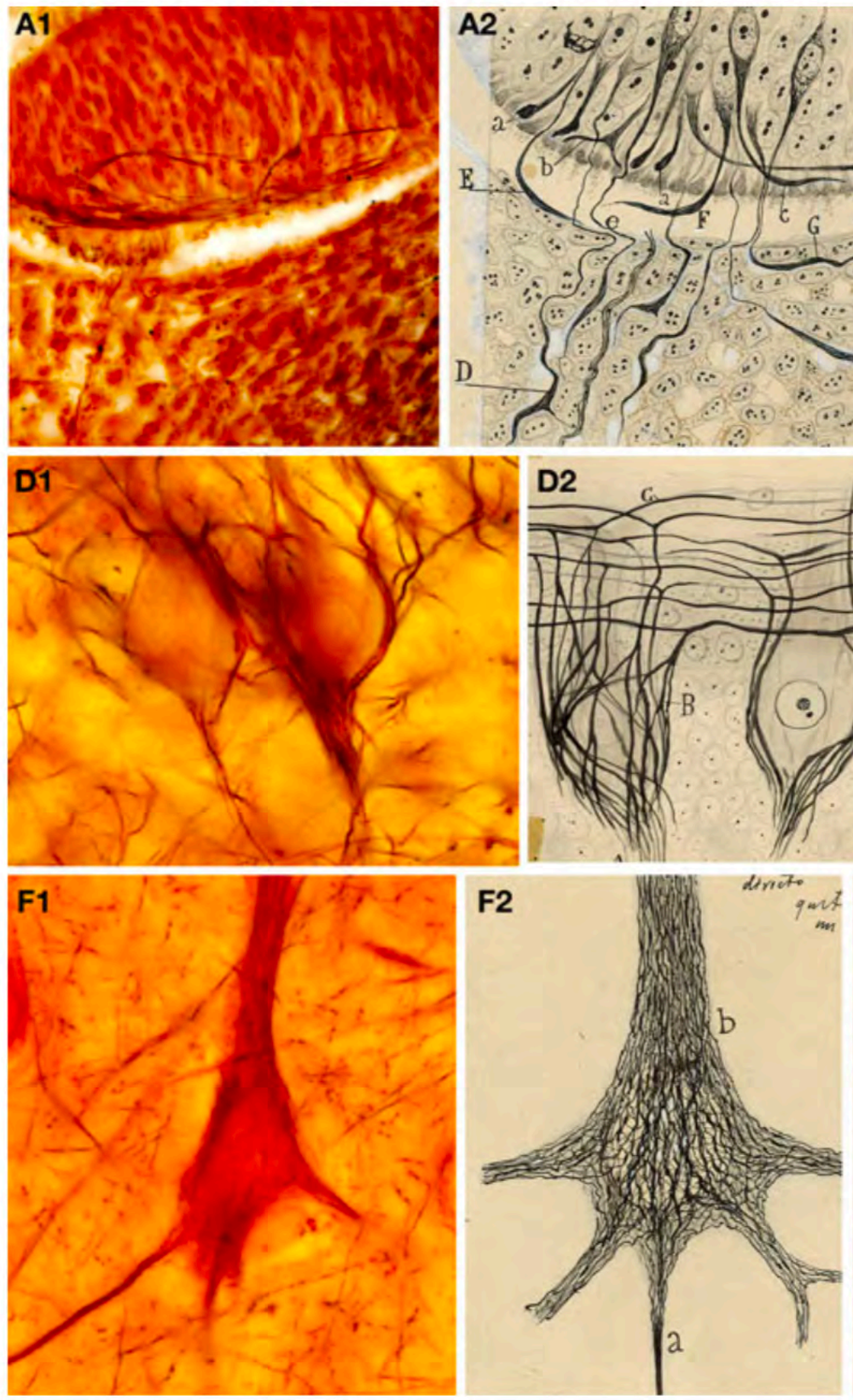
***Correspondence:**
Virginia Garcia-Marin, Laboratorio de Circuitos Corticales, Centro de Tecnologia Biomédica, Universidad

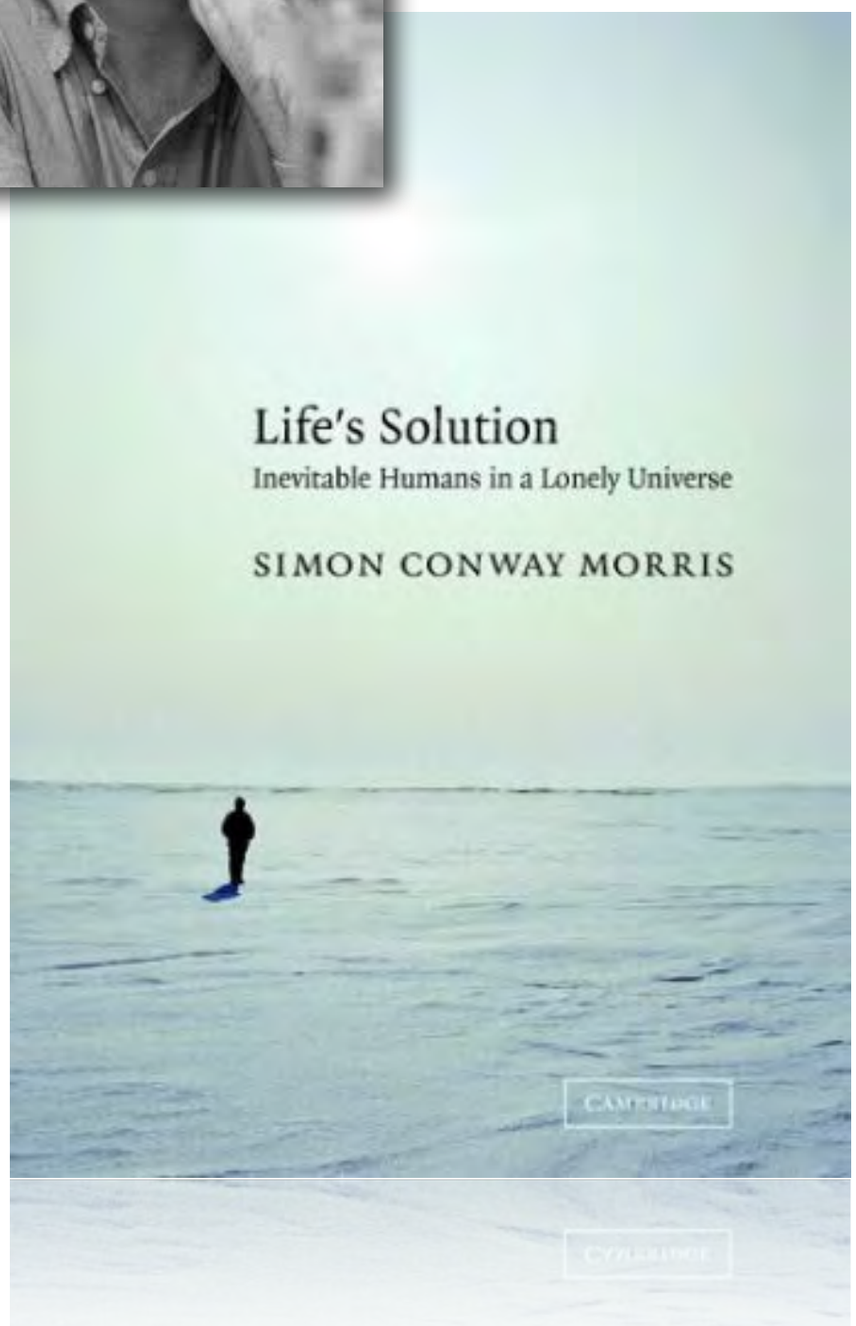
Ramón y Cajal's studies in the field of neuroscience provoked a radical change in the course of its history. For this reason he is considered as the father of modern neuroscience. Some of his original preparations are housed at the Cajal Museum (Cajal Institute, CSIC, Madrid, Spain). In this article, we catalogue and analyse more than 4,500 of Cajal's histological preparations, the same preparations he used during his scientific career. Furthermore, we catalogued Cajal's original correspondence, both manuscripts and personal letters, drawings and plates. This is the first time anyone has compiled an account of Cajal's enormous scientific production, offering some curious insights into his work and his legacy.

Keywords: Cajal, histological preparations, drawings





Convergent optimal circuits?



The Interpretation and Application of Rent's Rule

Phillip Christie, *Member, IEEE*, and Dirk Stroobandt, *Member, IEEE*

***Abstract*—This paper provides a review of both Rent's rule and the placement models derived from it. It is proposed that the power-law form of Rent's rule, which predicts the number of terminals required by a group of gates for communication with the rest of the circuit, is a consequence of a statistically homogeneous circuit topology and gate placement. The term "homogeneous" is used to imply that quantities such as the average wire length per gate and the average number of terminals per gate are independent of the position within the circuit. Rent's rule is used to derive a variety of net length distribution models and the approach adopted in this paper is to factor the distribution function into the product of an occupancy probability distribution and a function which represents the number of valid net placement sites. This**

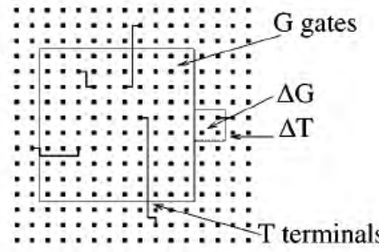


Fig. 1. Perturbation of a bounding box to assess the change in terminals requirement.

OPEN ACCESS Freely available online PLoS COMPUTATIONAL BIOLOGY

Efficient Physical Embedding of Topologically Complex Information Processing Networks in Brains and Computer Circuits

Danielle S. Bassett[1,2,3,6*], Daniel L. Greenfield[4,5], Andreas Meyer-Lindenberg[5], Daniel R. Weinberger[6], Simon W. Moore[4], Edward T. Bullmore[3*]

Physical laws constrain potential complexity

The optimal brain: good designs

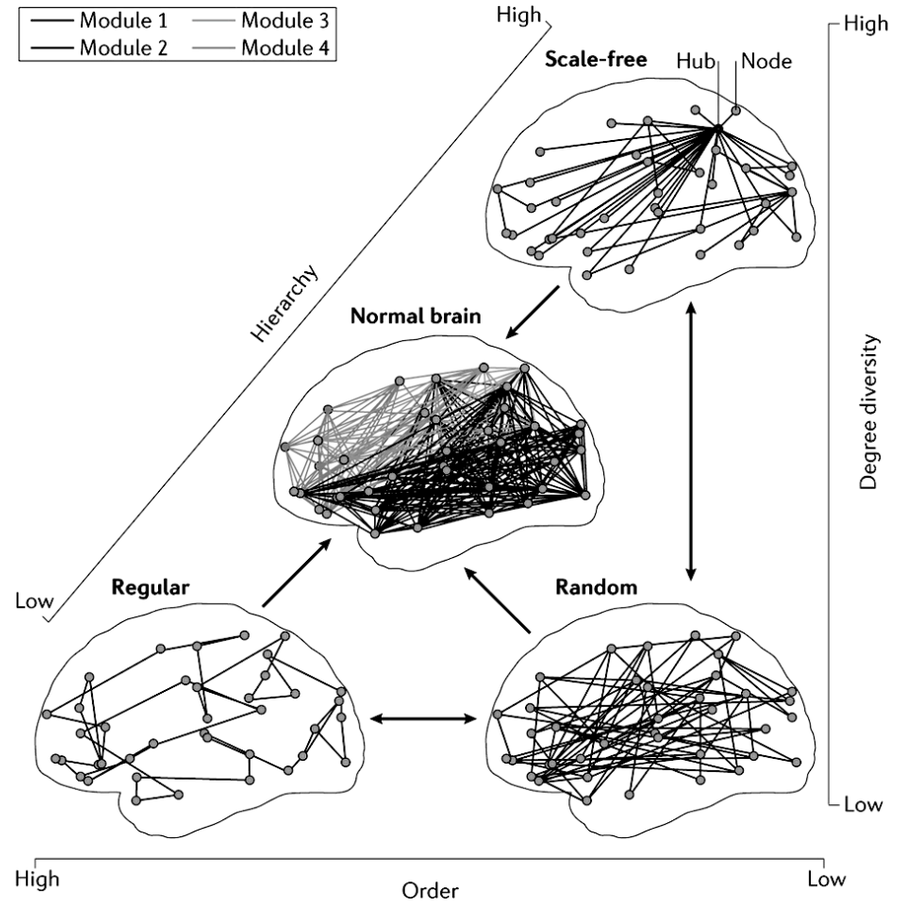
REVIEWS

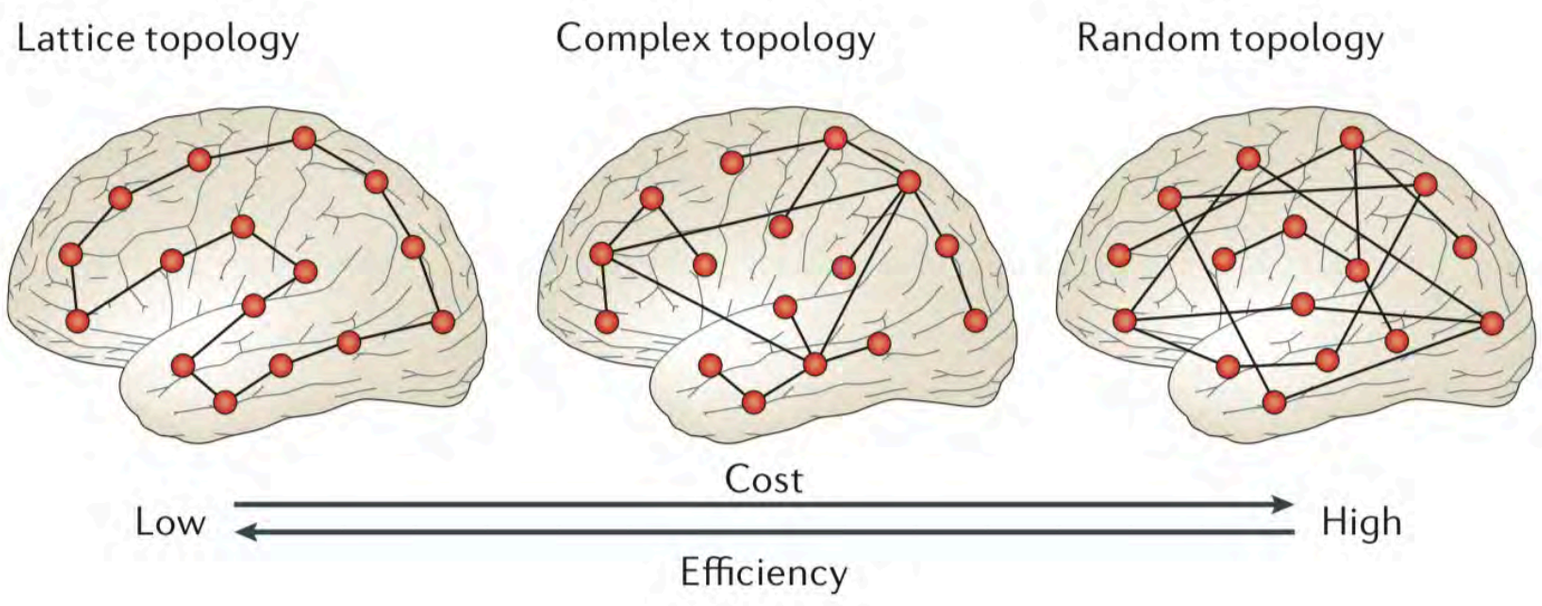
Nature Reviews Neuroscience | AOP, published online 13 April 2012; doi:10.1038/nrn3214

The economy of brain network organization

Ed Bullmore[1,2,3] and Olaf Sporns[4]

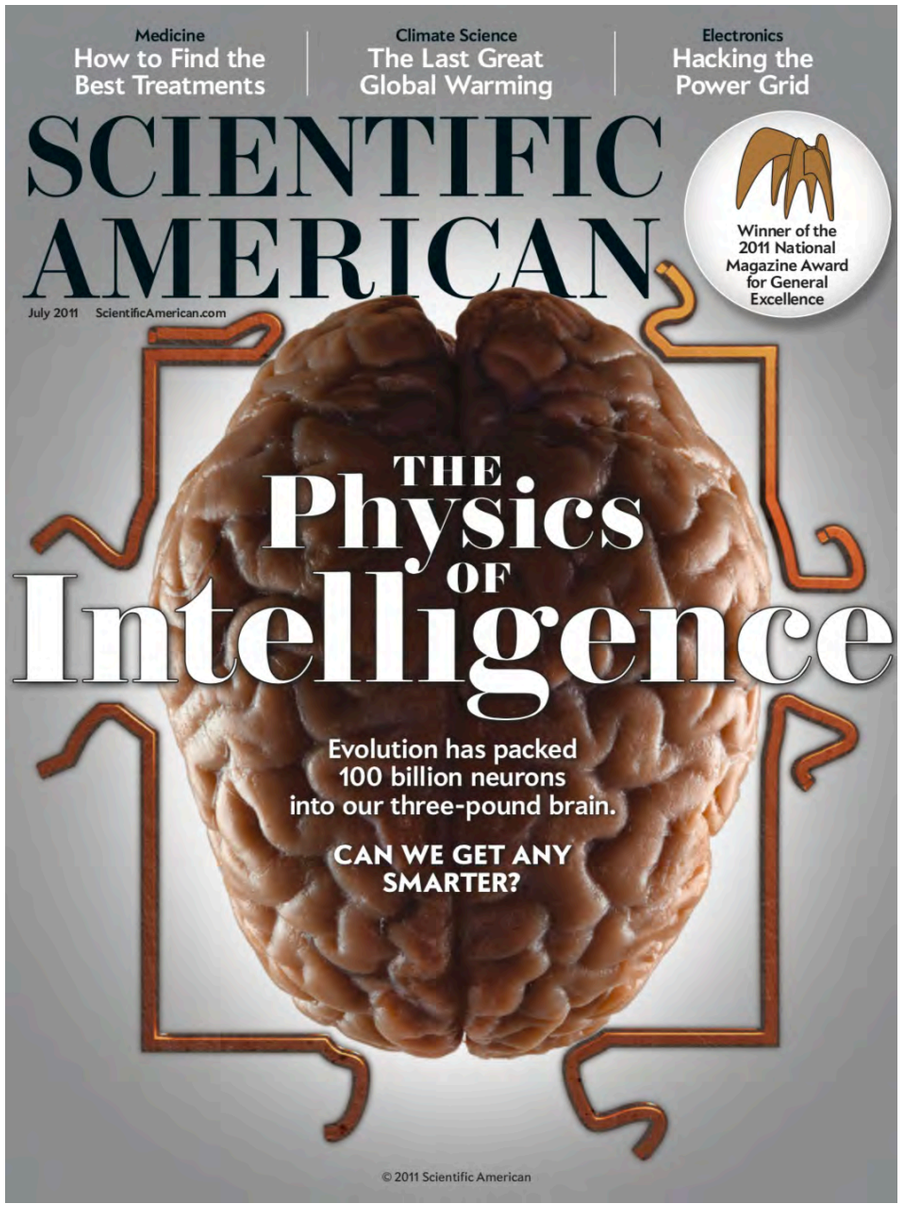
Abstract | The brain is expensive, incurring high material and metabolic costs for its size — relative to the size of the body — and many aspects of brain network organization can be mostly explained by a parsimonious drive to minimize these costs. However, brain networks or connectomes also have high topological efficiency, robustness, modularity and a 'rich club' of connector hubs. Many of these and other advantageous topological properties will





Trade-offs are crucial

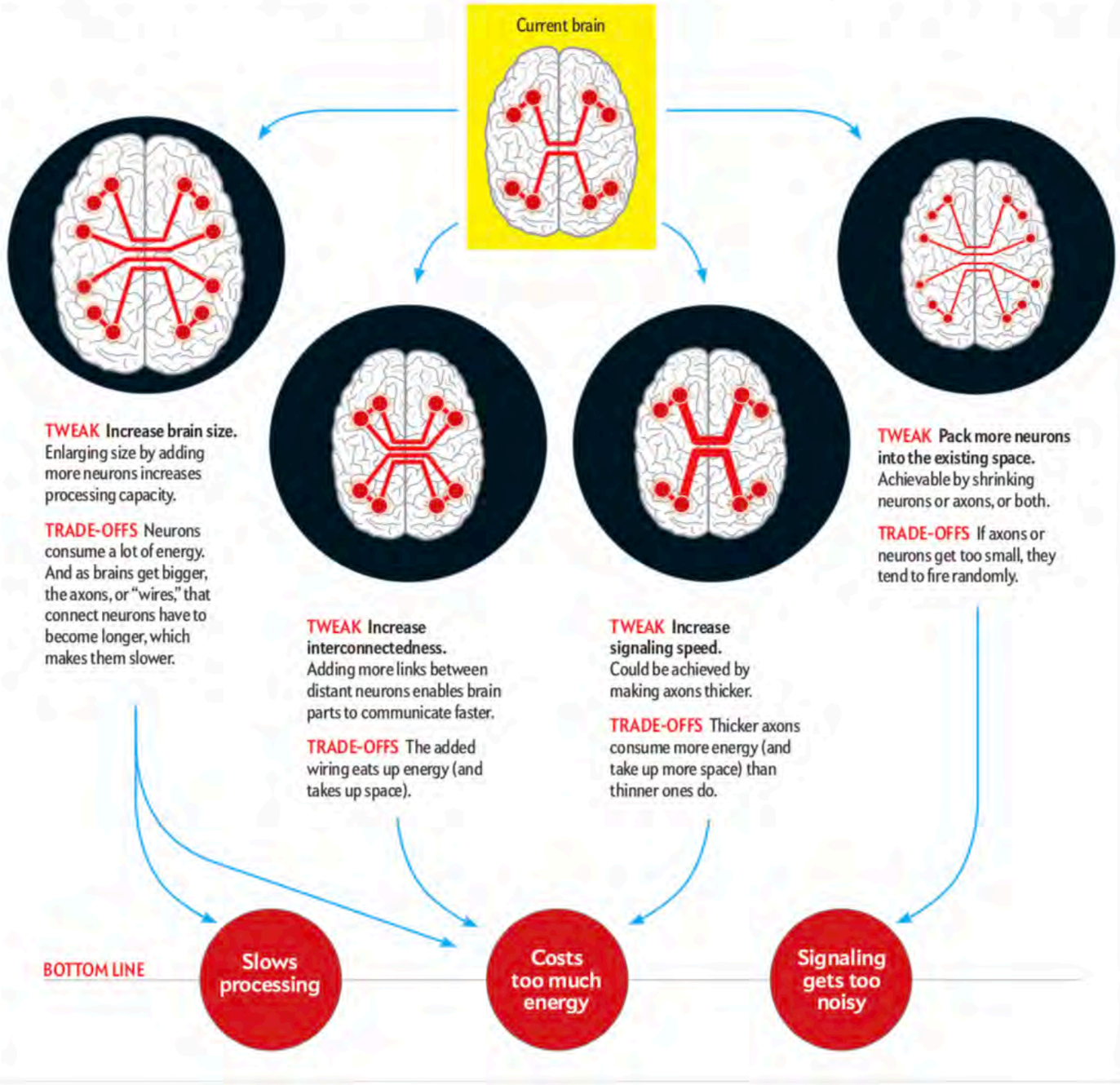
Is brain wiring already optimised?



THE TRADE-OFF PROBLEM

Why We Probably Cannot Get Much Smarter

Miniaturization is just one of several evolutionary tweaks that could, in principle, enhance our intelligence and at the same time carry disadvantages and run into thermodynamic hurdles. Perhaps we are already close to being as smart as a neuron-based intelligence can be.



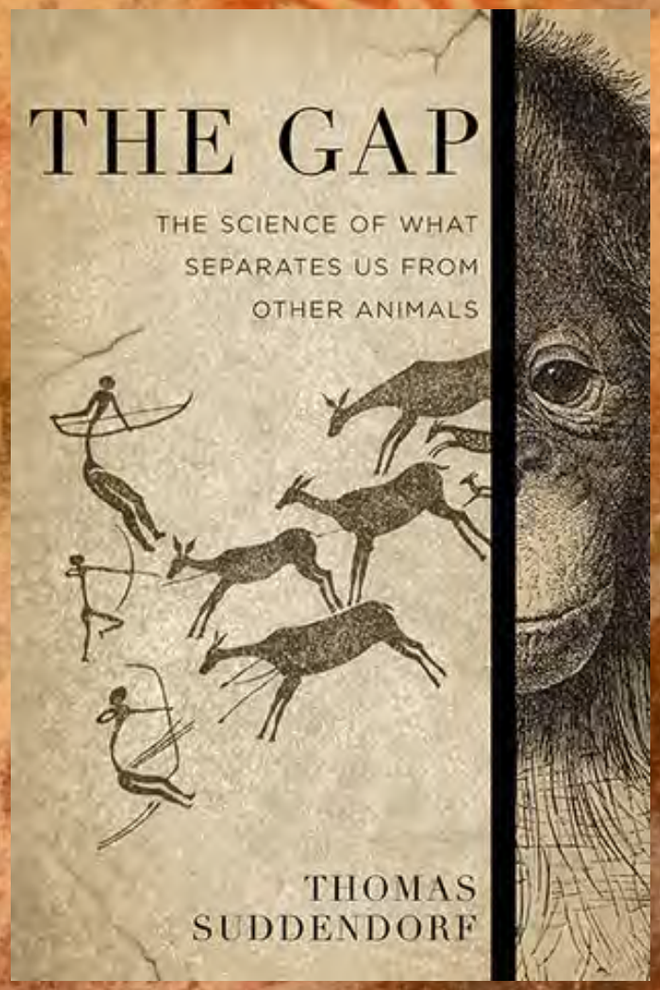
How to exploit your brain powers?

Is human imagination limitless?

Problem: imagination does not leave (much) fossils

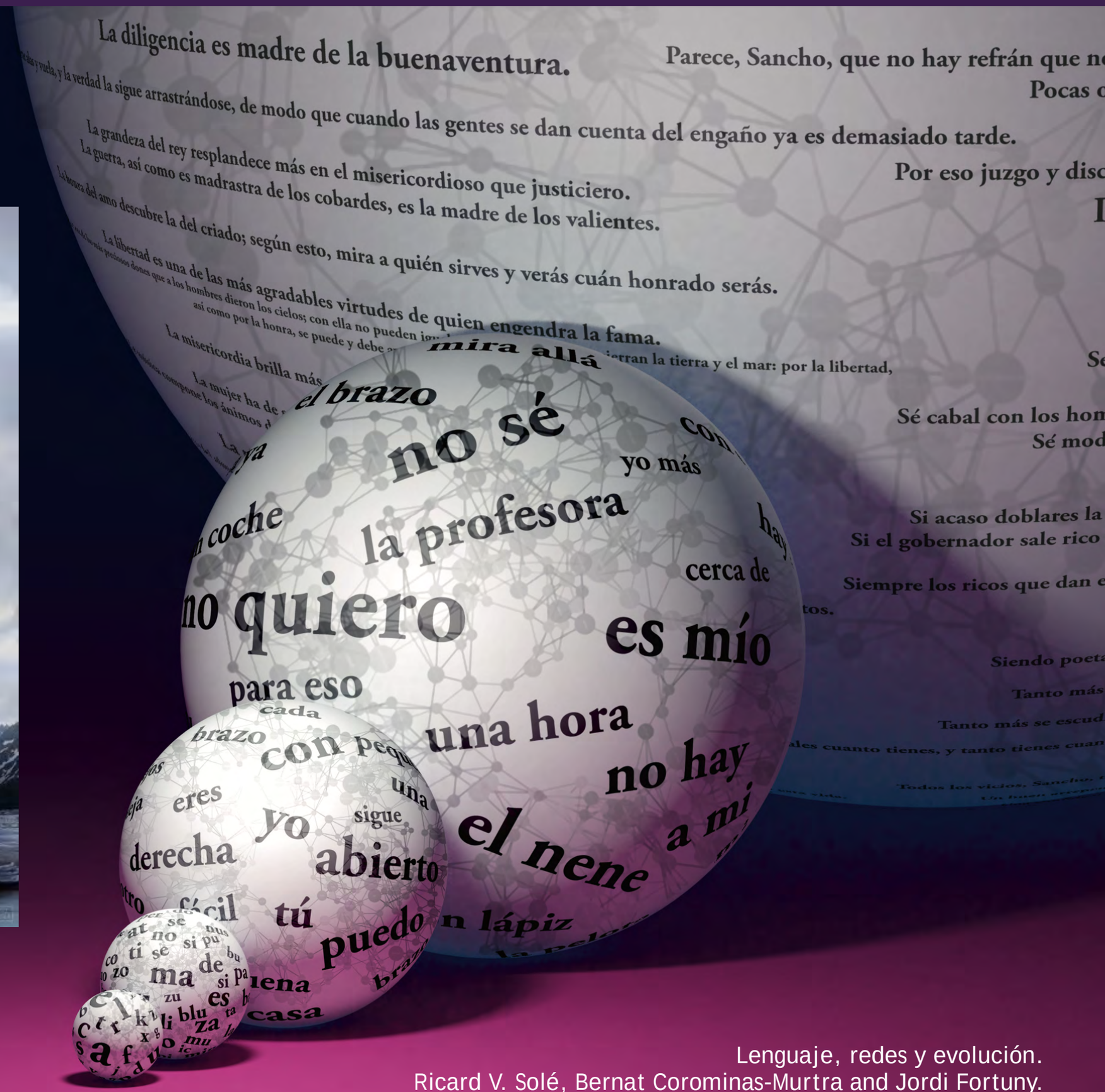
Language allows infinity to materialize

Are we unique? Yes, we are



Talking apes
Remaining relatives
Mind readers
Smarter apes
Time travelers
Right and wrong
Extended childhood

Universals in language?



Lenguaje, redes y evolución.
Ricard V. Solé, Bernat Corominas-Murtra and Jordi Fortuny.
Investigación y ciencia 440 (Mayo 2013), 58-67

Alternative minds: synthetic brain evolution?

Is human creativity outside these limits?

A Neural Algorithm of Artistic Style

Leon A. Gatys,[1,2,3*] Alexander S. Ecker,[1,2,4,5] Matthias Bethge[1,2,4]

REVIEW

doi:10.1038/nature14539

Deep learning

Yann LeCun[1,2], Yoshua Bengio[3] & Geoffrey Hinton[4,5]

Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. Deep learning discovers intricate structure in large data sets by using the backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer. Deep convolutional nets have brought about breakthroughs in processing images, video, speech and audio, whereas recurrent nets have shone light on sequential data such as text and speech.

Machine-learning technology powers many aspects of modern society: from web searches to content filtering on social networks to recommendations on e-commerce websites, and it is increasingly present in consumer products such as cameras and smartphones. Machine-learning systems are used to identify objects in images, transcribe speech into text, match news items, posts or products with users' interests, and select relevant results of search. Increasingly, these applications make use of a class of techniques called deep learning.

Conventional machine-learning techniques were limited in their ability to process natural data in their raw form. For decades, con-

intricate structures in high-dimensional data and is therefore applicable to many domains of science, business and government. In addition to beating records in image recognition[1–4] and speech recognition[5–7], it has beaten other machine-learning techniques at predicting the activity of potential drug molecules[8], analysing particle accelerator data[9,10], reconstructing brain circuits[11], and predicting the effects of mutations in non-coding DNA on gene expression and disease[12,13]. Perhaps more surprisingly, deep learning has produced extremely promising results for various tasks in natural language understanding[14], particularly topic classification, sentiment analysis, question answering[15] and language translation[16,17].

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

Can machines create music? How?

Proc. Natl. Acad. Sci. USA
Vol. 87, pp. 938–941, February 1990
Physics

Fractal geometry of music

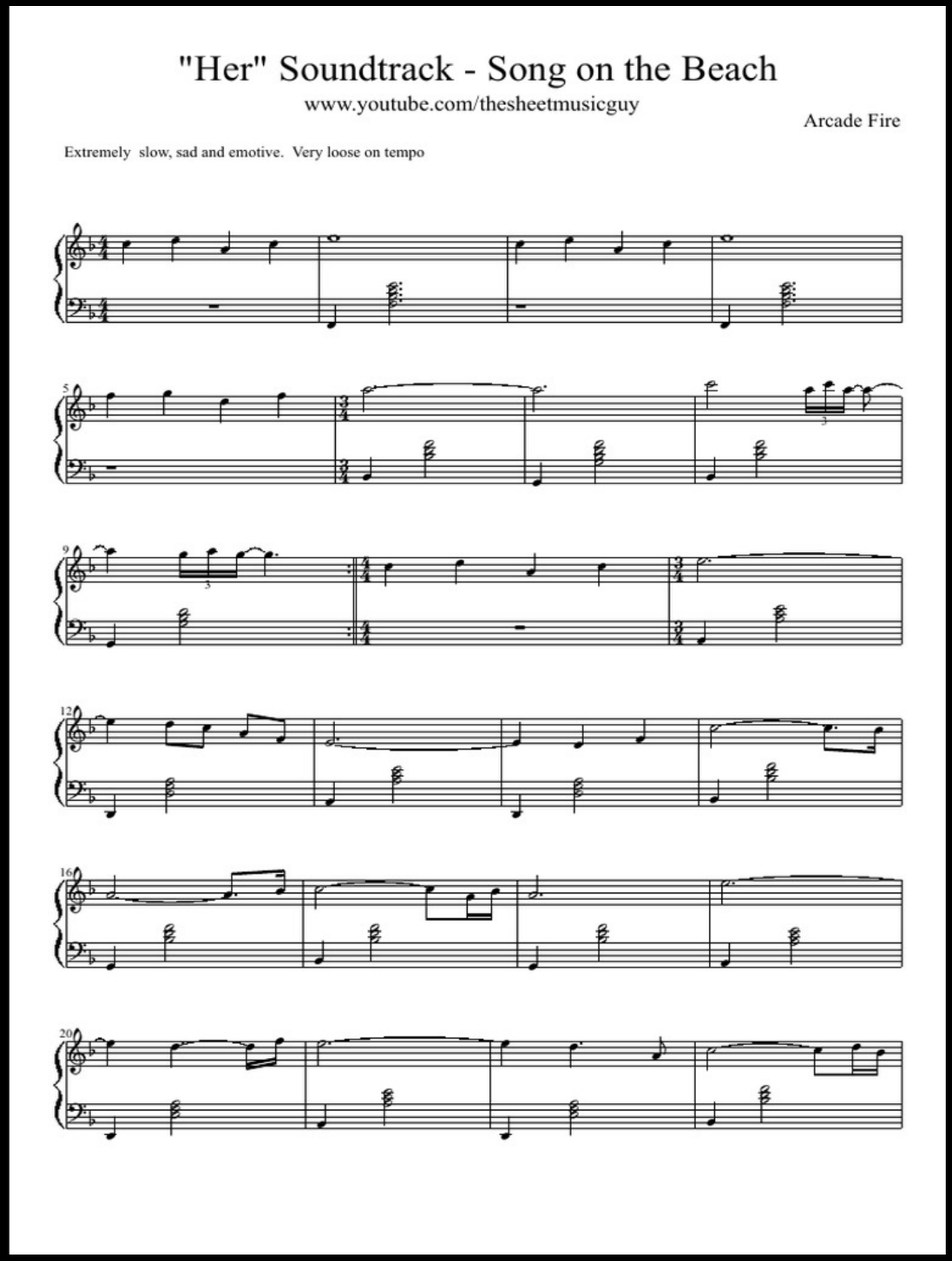
(physics of melody)

KENNETH J. HSÜ* AND ANDREAS J. HSÜ†

*Eidgenössische Technische Hochschule, Zurich, Switzerland

Contributed by Kenneth J. Hsü, October 31, 1989

ABSTRACT **Music critics have compared Bach's music to the precision of mathematics. What "mathematics" and what "precision" are the questions for a curious scientist. The purpose of this short note is to suggest that the mathematics is, at least in part, Mandelbrot's fractal geometry and the preci-**



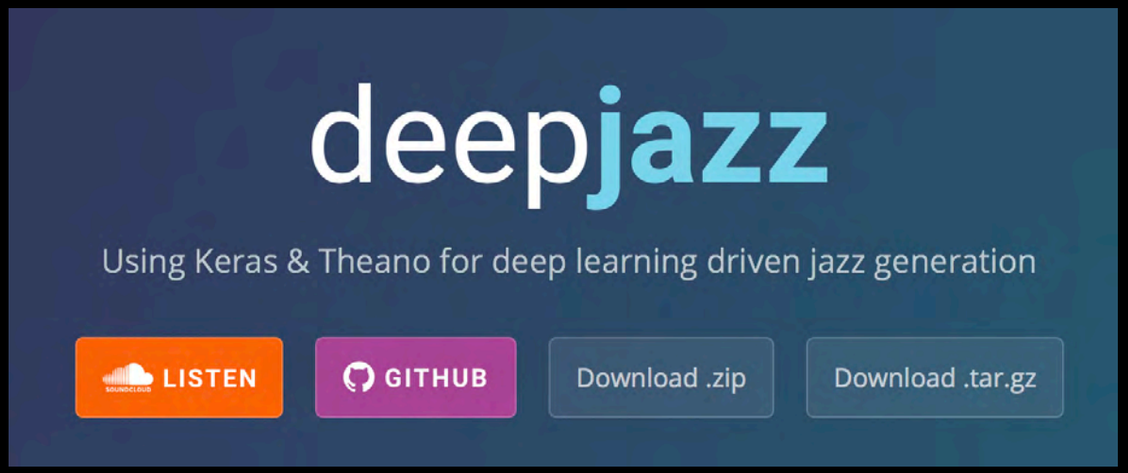
"Her" Soundtrack - Song on the Beach

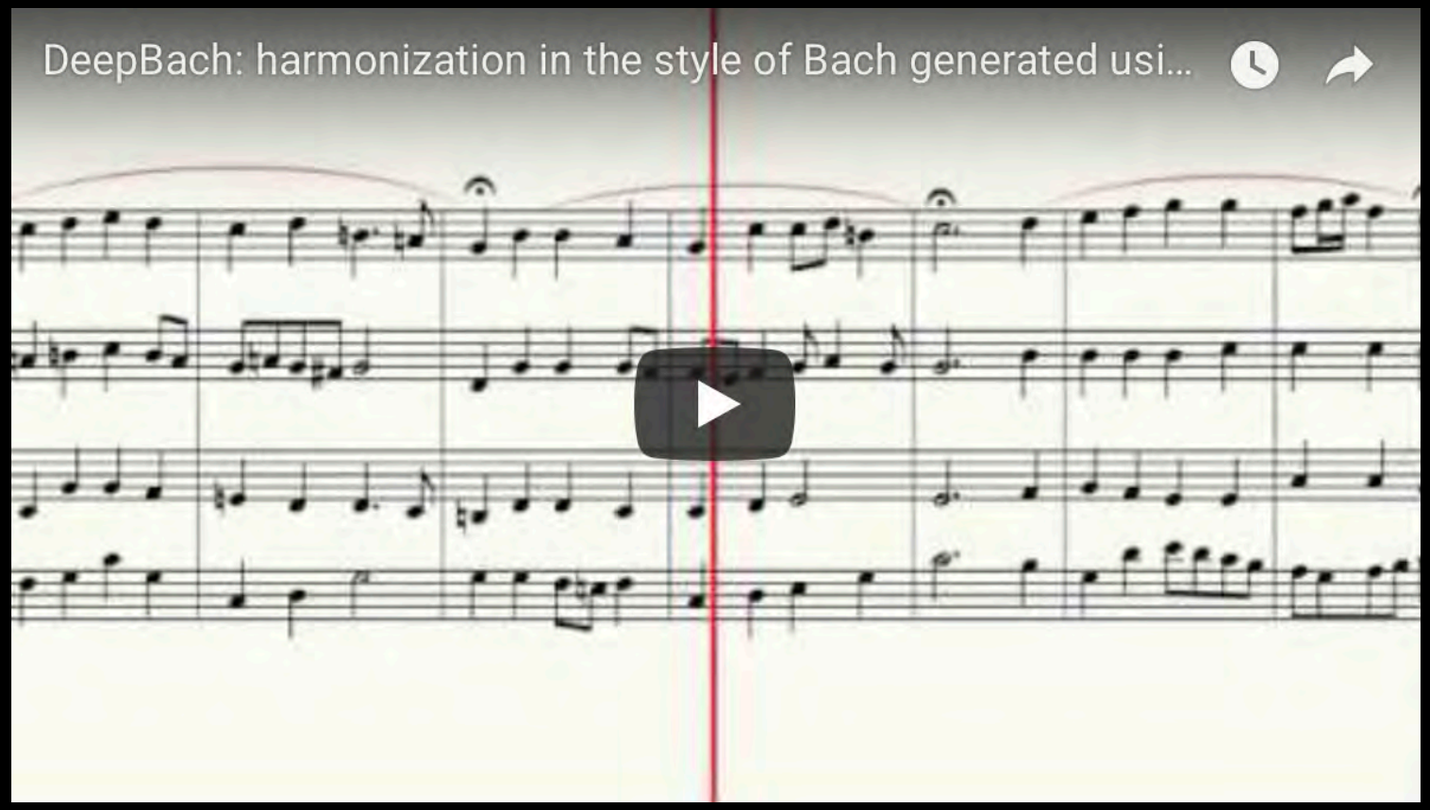
www.youtube.com/thesheetmusicguy

Arcade Fire

Extremely slow, sad and emotive. Very loose on tempo

Is human creativity outside these limits?





MIT Technology Review

Intelligent Machines

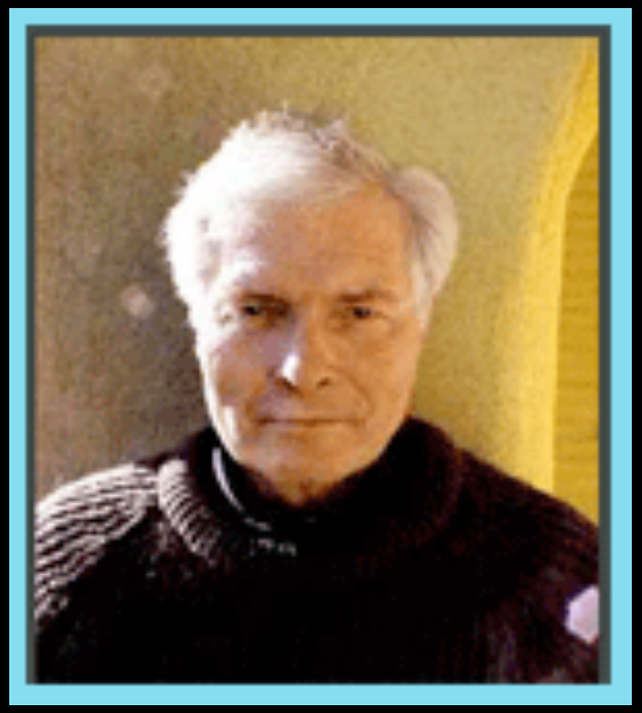
Deep-Learning Machine Listens to Bach, Then Writes Its Own Music in the Same Style

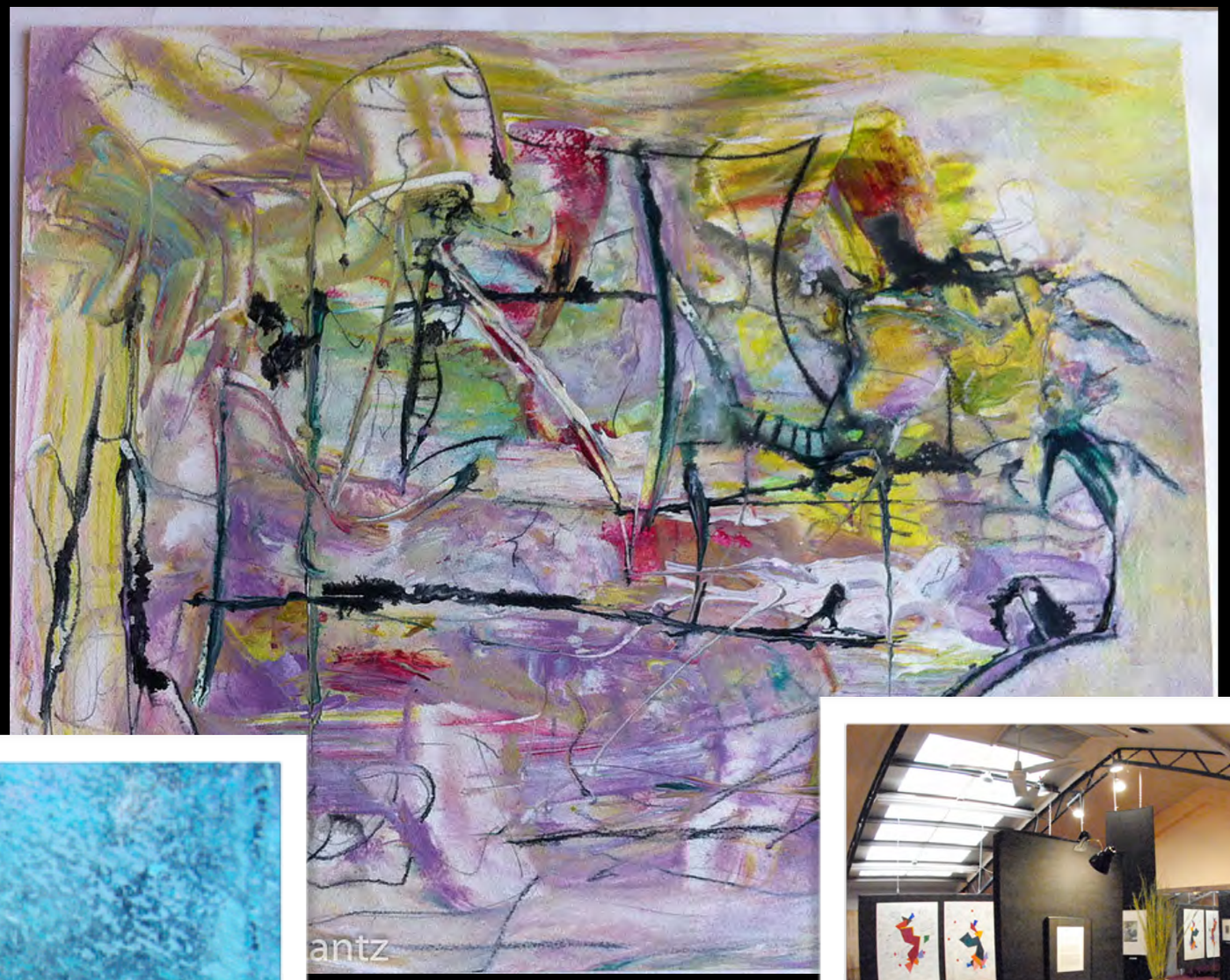
Can you tell the difference between music composed by Bach and by a neural network?

by Emerging Technology from the arXiv December 14, 2016

Can an Artificial Intelligence Create Art?

Is art unique? Are there alternatives?





Reading musing from paintings: a possible path?

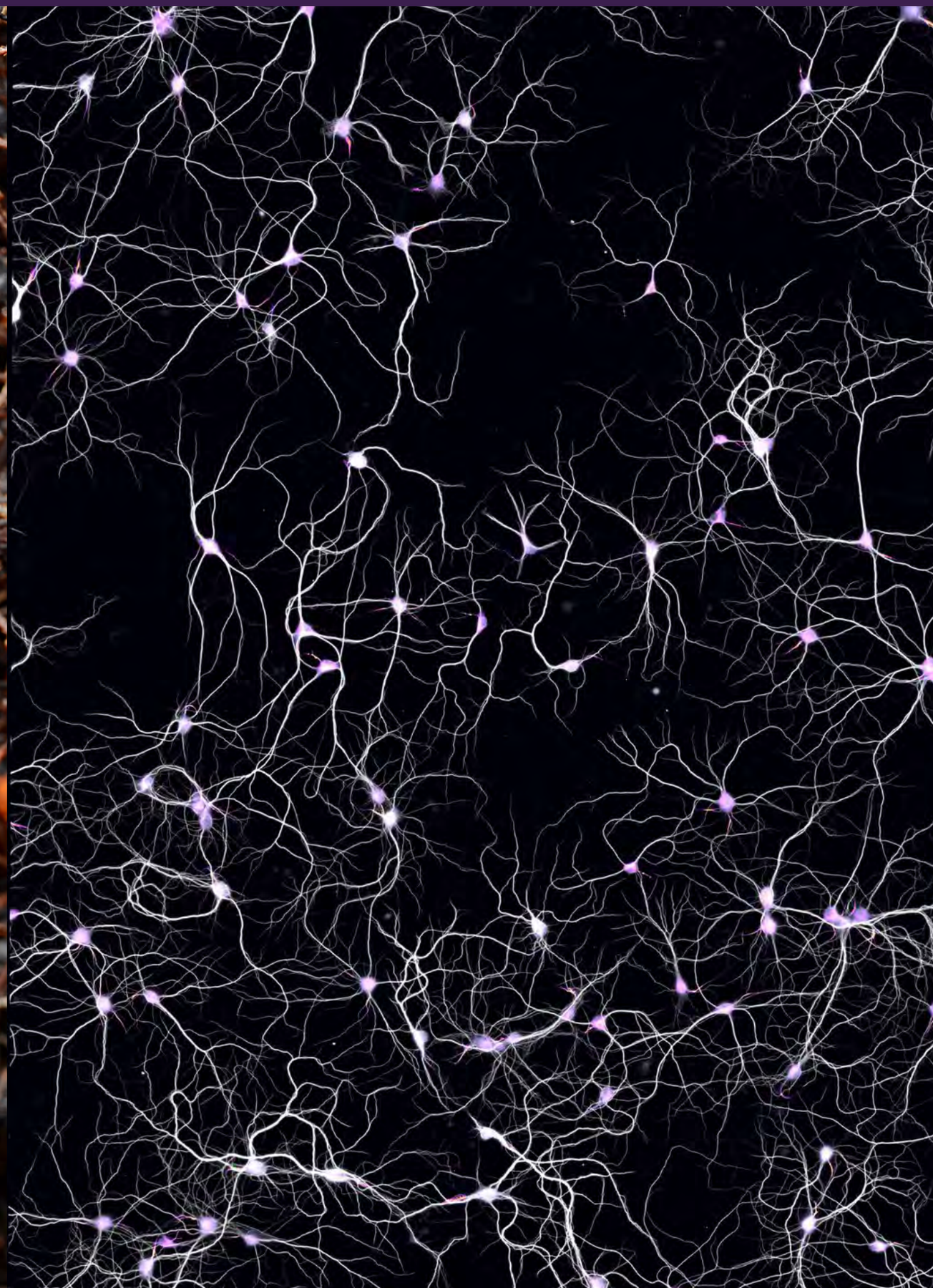
How to get inside our minds?

Can art help going deep inside?

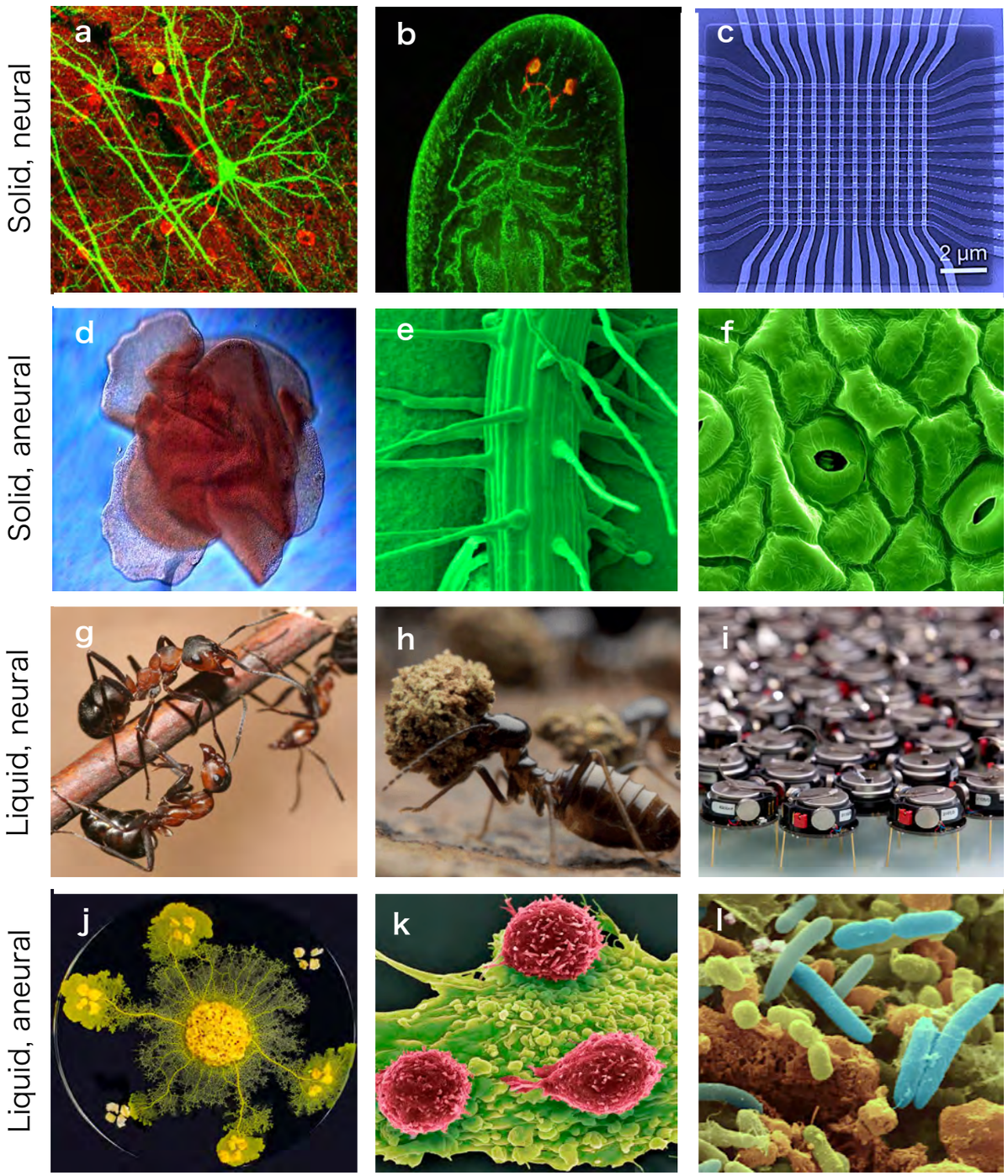
Refik Anadol

https://www.thisiscolossal.com/2018/04/melting-memories/

Liquid versus solid “brains”



Liquid versus solid “brains”



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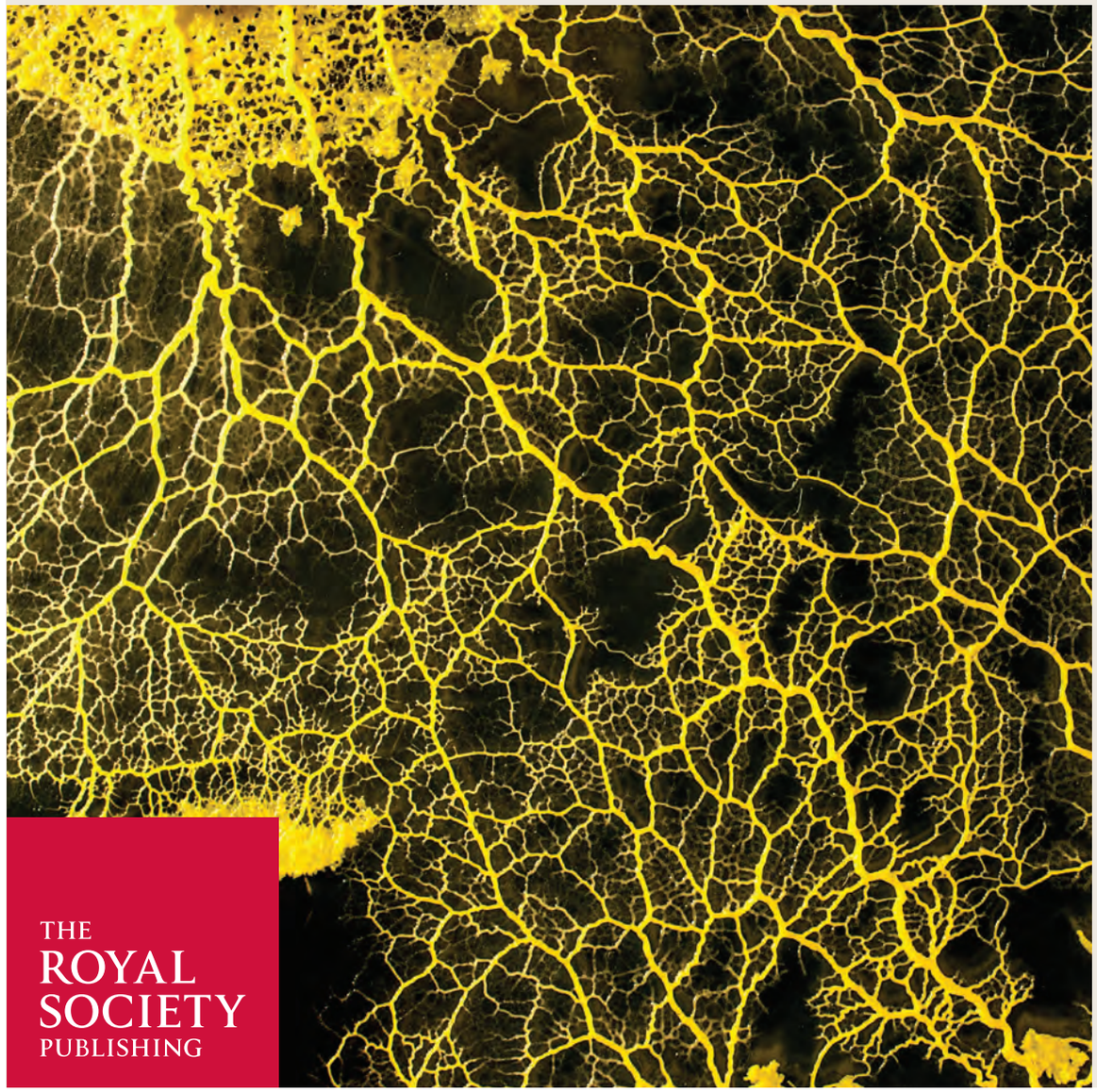
PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

BIOLOGICAL SCIENCES

Liquid brains, solid brains: How distributed cognitive architectures process information

Theme issue compiled and edited by Ricard Solé, Melanie Moses and Stephanie Forrest



THE ROYAL SOCIETY PUBLISHING

Plant intelligence?

“The brain of an ant is one of the most marvelous atoms of matter in the world, perhaps more so than the brain of a man”.

Charles Darwin