

3 fuzzy sets

Sound Music

Mycenae Alpha  
Pithoprakta

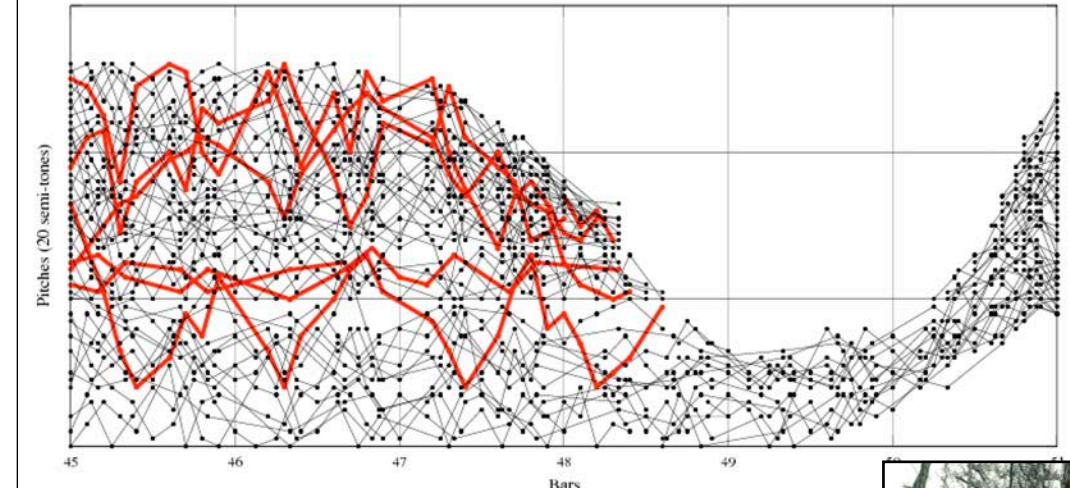
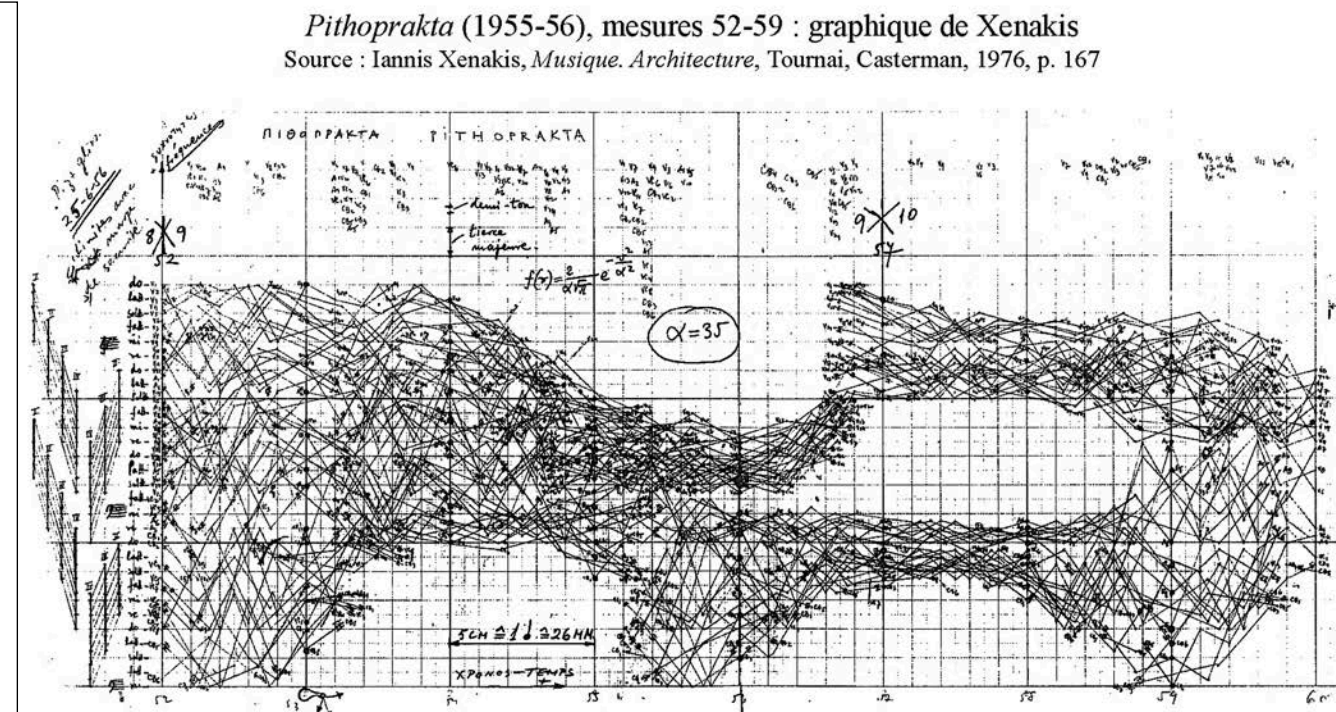
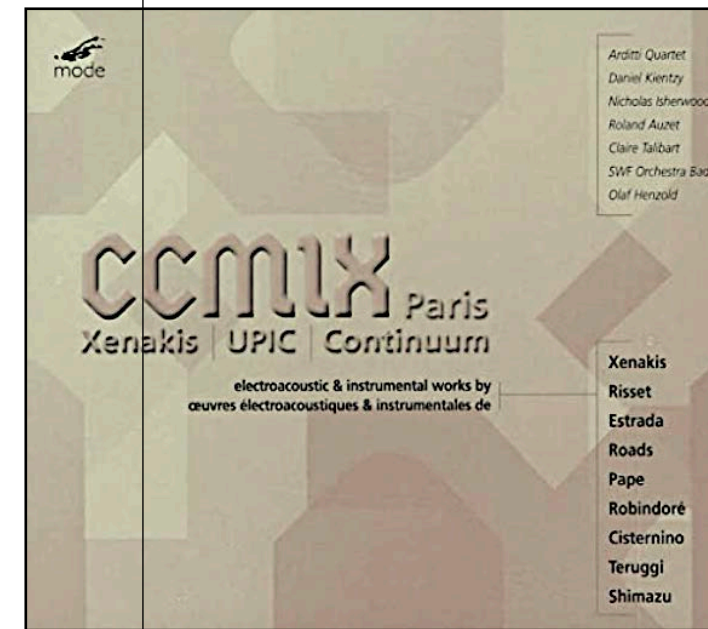
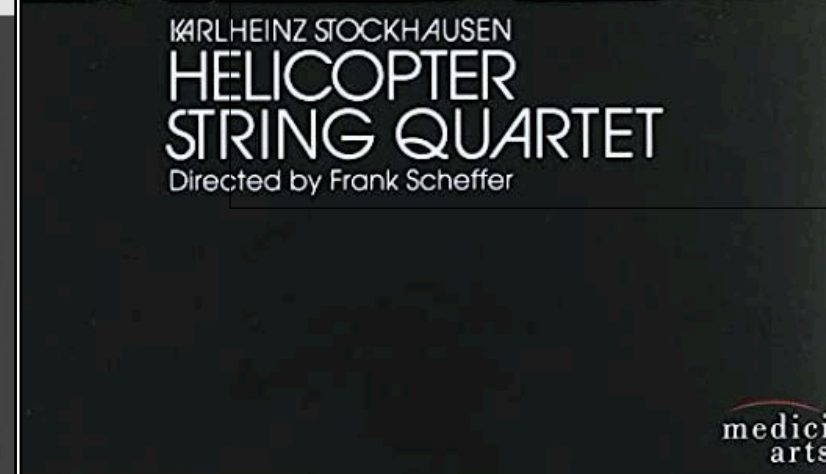
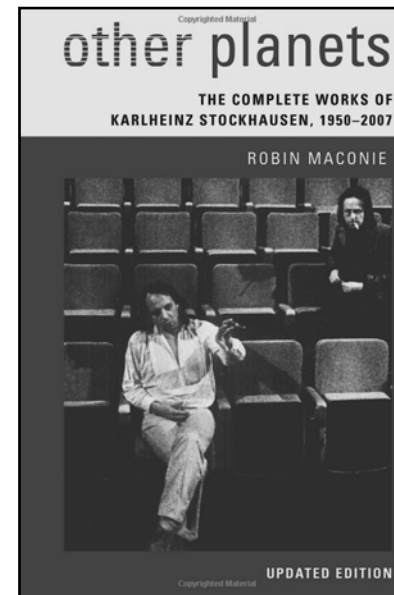
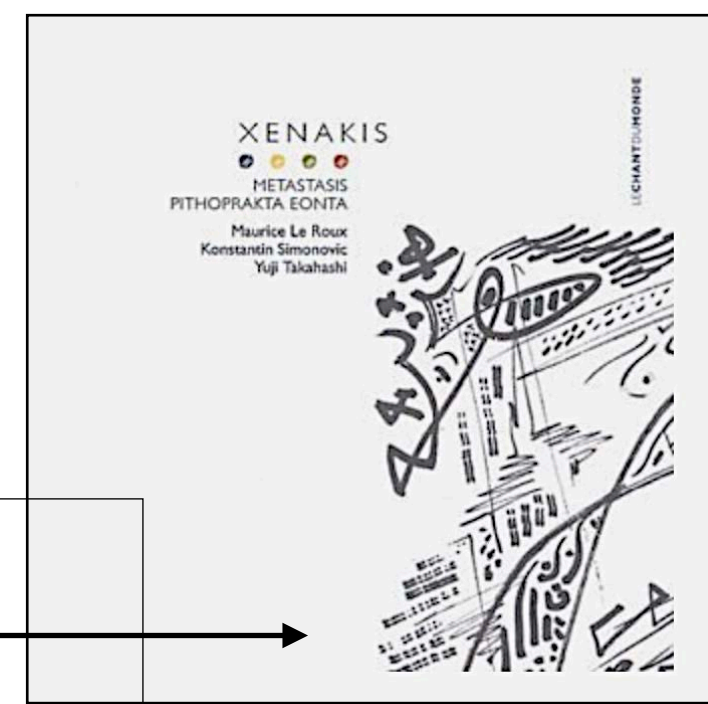
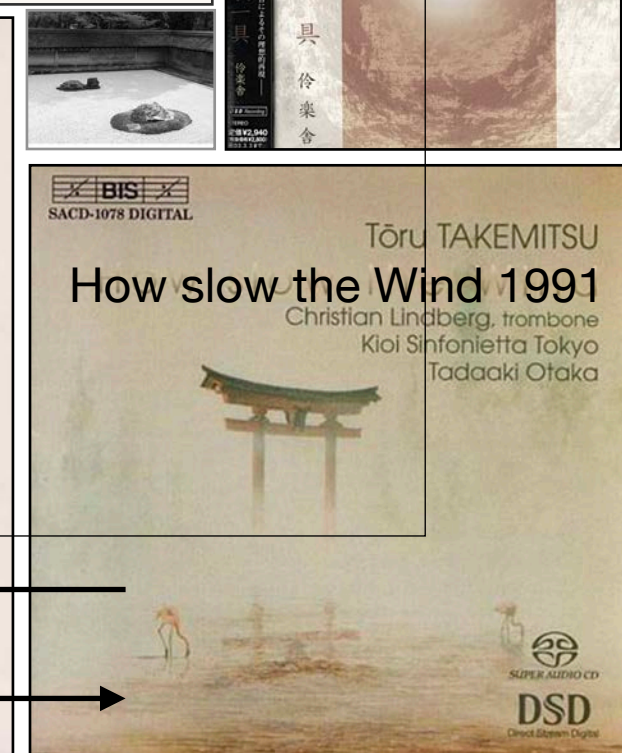
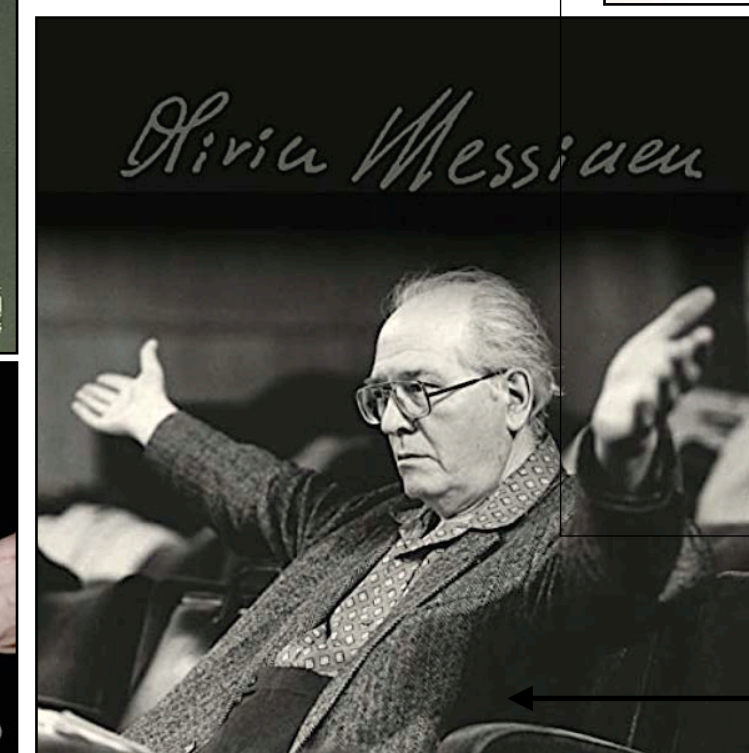
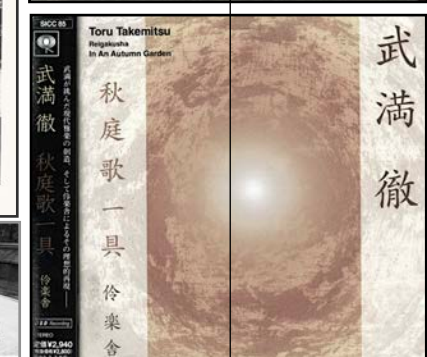
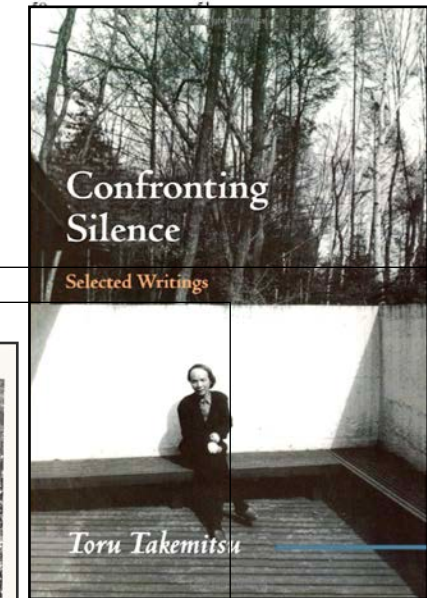
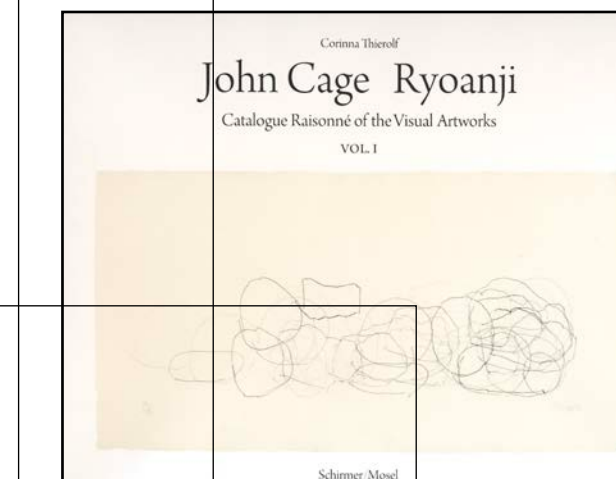


Fig. 14: Graphic Representation of Pithoprakta, bars 45-51.



As I collect Ryoanji stones, it rains hybridity.  
Mientras junto piedras Ryoanji, llueve hibridez.

The Helicopter Quartet, composed in 1993 by Karlheinz Stockhausen. First performance was in 1995

**HELIKOPTER-STREICHQUARTETT**  
**Stockhausen**

**AUFSTIEG**

VI.1 f tremolo  
 VI.2 f tremolo  
 Va. f tremolo  
 Vc. f tremolo

**START 1 FLUG**

♩ = 50,5 [0'00" [23,8]

VI.1  
 VI.2  
 Va.  
 Vc.

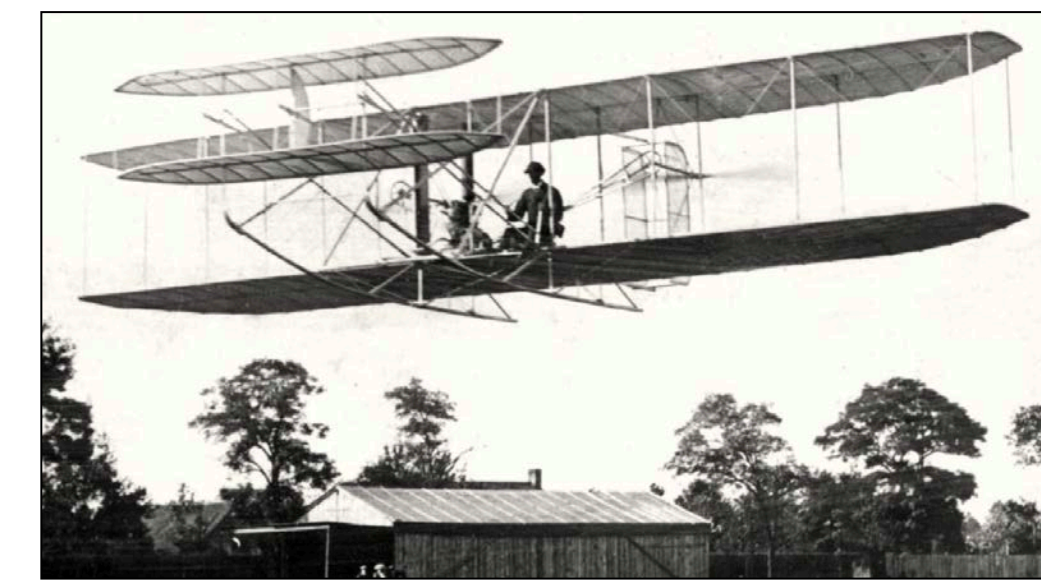
**2** trem. #  
 VI.1  
 VI.2  
 Va.  
 Vc.

**3** c.i. battuto IRR  
 Flag. #2 non trem.  
 Flag. 2  
 trem. sul pont.

**8** 53,5 [23,8" [9]  
 VI.1 trem.  
 VI.2  
 Va. meno  
 Vc. Flag. #2 non trem.

**12** 32,8" [16] 45  
 + c.i. battuto IRR  
 trem. sul pont.

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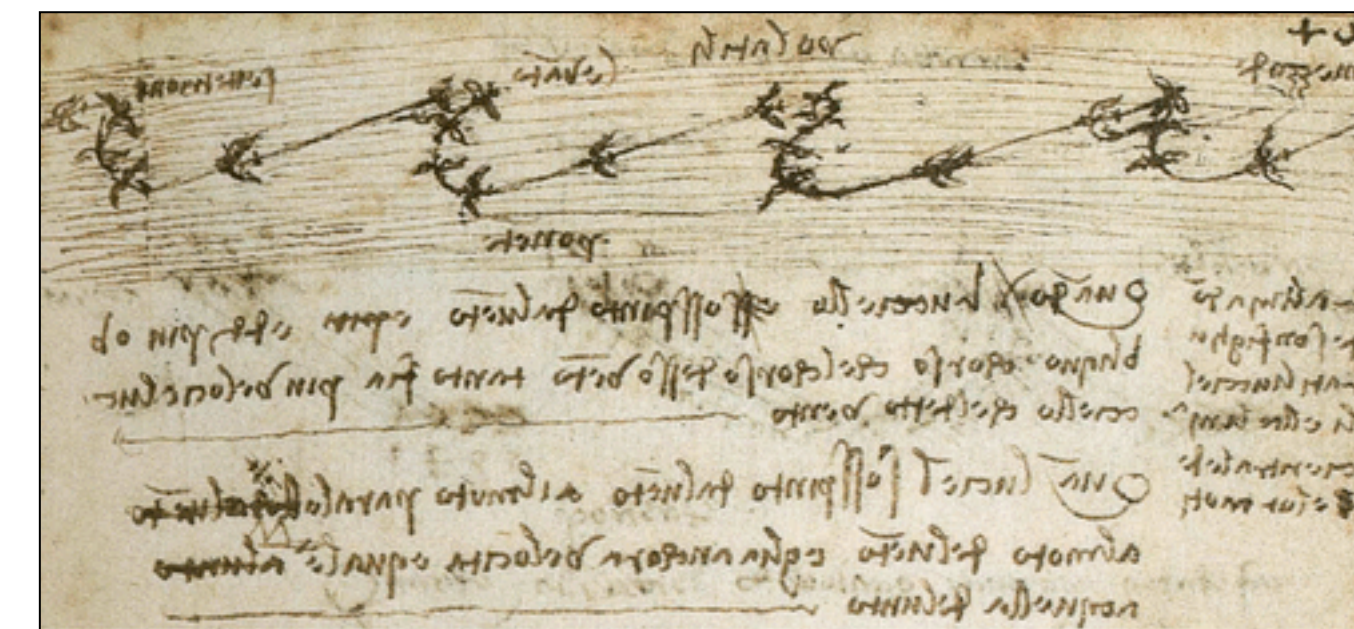
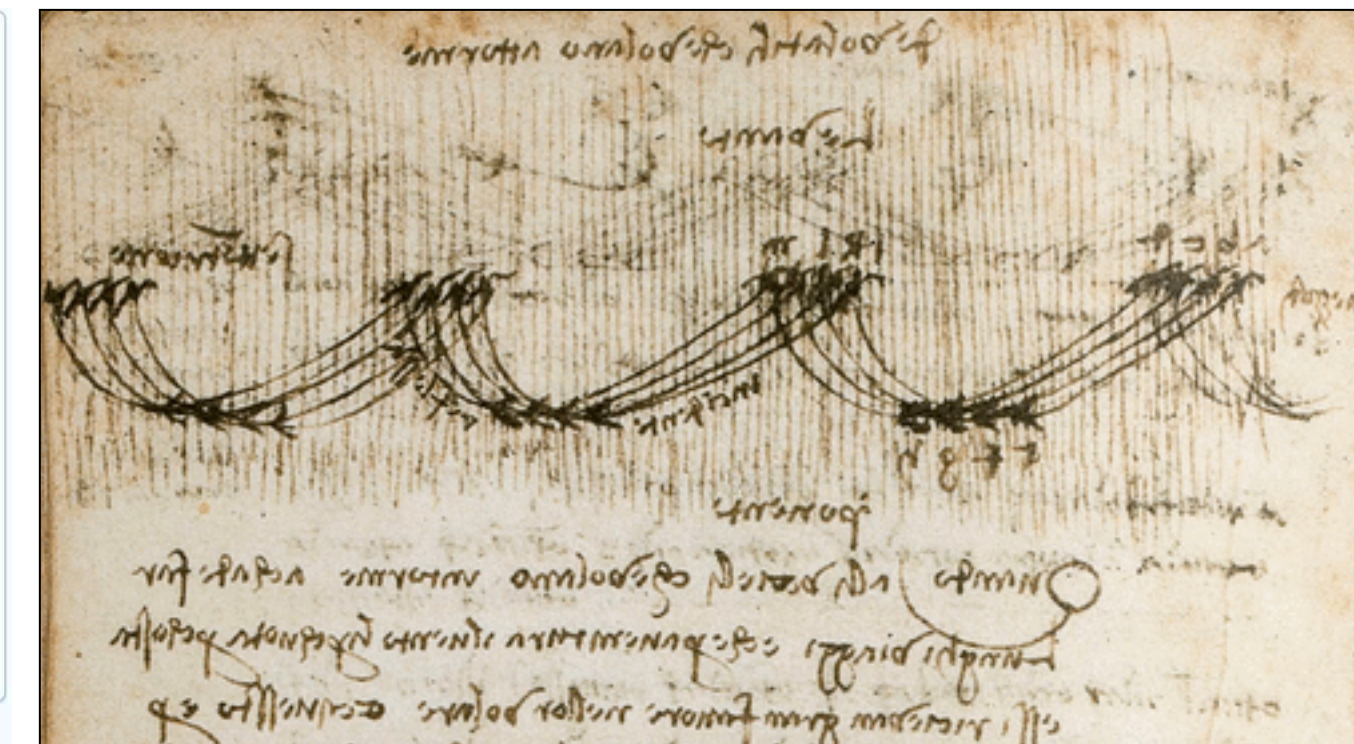
Otto Lilienthal

## strange loop

Leonardo da Vinci - bird flight drawings - human flight - mechanical flight - helicopter - helicopter stretch quartet - Stockhausen - Messiaen - bird - bird flight drawings - Leonardo da Vinci



Máquina de volar de Leonardo



Leonardo was motivated to discover how birds continuously soar in order to use this information for developing human flight.



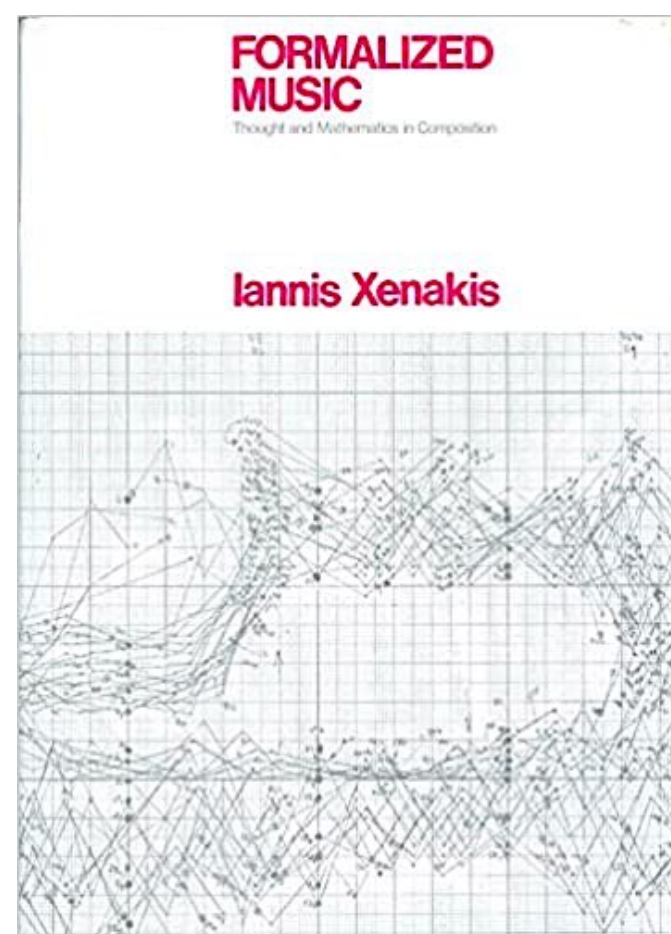
I find a beautiful link between stochastic processes and fuzzy logic (probability and uncertain

*Pithoprakta* is an example of a stochastic work. Stochastic processes are those which have a random probability distribution that may be analyzed statistically, but never predicted precisely. Examples include bacterial growth patterns, electrical current fluctuation, and—in the case of *Pithoprakta*—the movement of particles within a fluid. *Pithoprakta*, composed in 1955, is for 49 musicians—2 trombones, xylophone/woodblock, and 46 strings—where each instrument is conceived as an independent molecule following the Maxwell-Boltzmann distribution law. This law describes the probable velocity ranges of particles moving within an idealized gas at thermodynamic equilibrium. These ranges differ based on the temperature and pressure of the gas. In *Pithoprakta*, Xenakis divides the work into sections each with their own temperature and pressure parameters and calculates the velocity ranges of 1148 theoretical particles, according to the Maxwell-Boltzmann law. He graphed these calculations with the vertical axis representing the speed of the particle and the horizontal axis representing time. An example of this can be seen in Figure 1. These measurements were then connected with lines to show how the velocities change over time based on the temperature/pressure parameters.

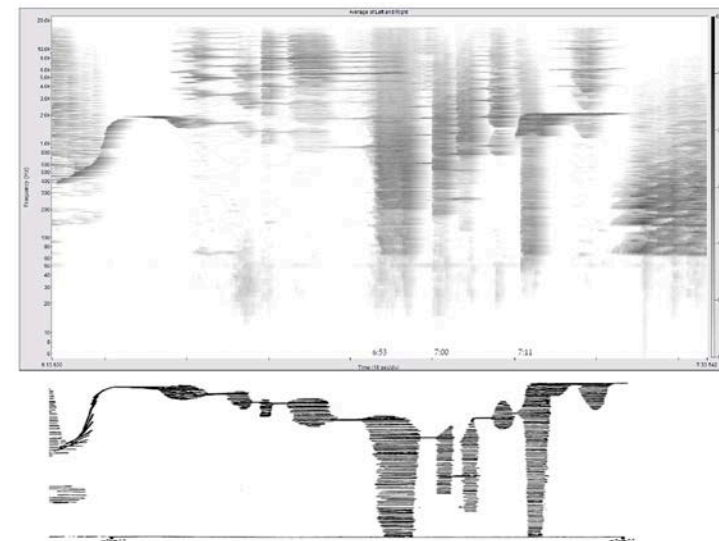
*Pithoprakta* es un ejemplo de trabajo estocástico. Los procesos estocásticos son aquellos que tienen una distribución de probabilidad aleatoria que se puede analizar estadísticamente, pero nunca predecir con precisión. Los ejemplos incluyen patrones de crecimiento bacteriano, fluctuación de la corriente eléctrica y, en el caso de *Pithoprakta*, el movimiento de partículas dentro de un fluido. *Pithoprakta*, compuesta en 1955, es para 49 músicos - 2 trombones, xilófono / bloque de madera y 46 cuerdas - donde cada instrumento se concibe como una molécula independiente siguiendo la ley de distribución de Maxwell-Boltzmann. Esta ley describe los rangos de velocidad probables de las partículas que se mueven dentro de un gas idealizado en equilibrio termodinámico. Estos rangos difieren según la temperatura y la presión del gas. En *Pithoprakta*, Xenakis divide el trabajo en secciones, cada una con sus propios parámetros de temperatura y presión y calcula los rangos de velocidad de 1148 partículas teóricas, de acuerdo con la ley de Maxwell-Boltzmann. He representado gráficamente estos cálculos con el eje vertical que representa la velocidad de la partícula y el eje horizontal que representa el tiempo. Un ejemplo de esto se puede ver en la Figura 1. Estas mediciones se conectaron luego con líneas para mostrar cómo cambian las velocidades con el tiempo en función de los parámetros de temperatura / presión.

# Xenakis

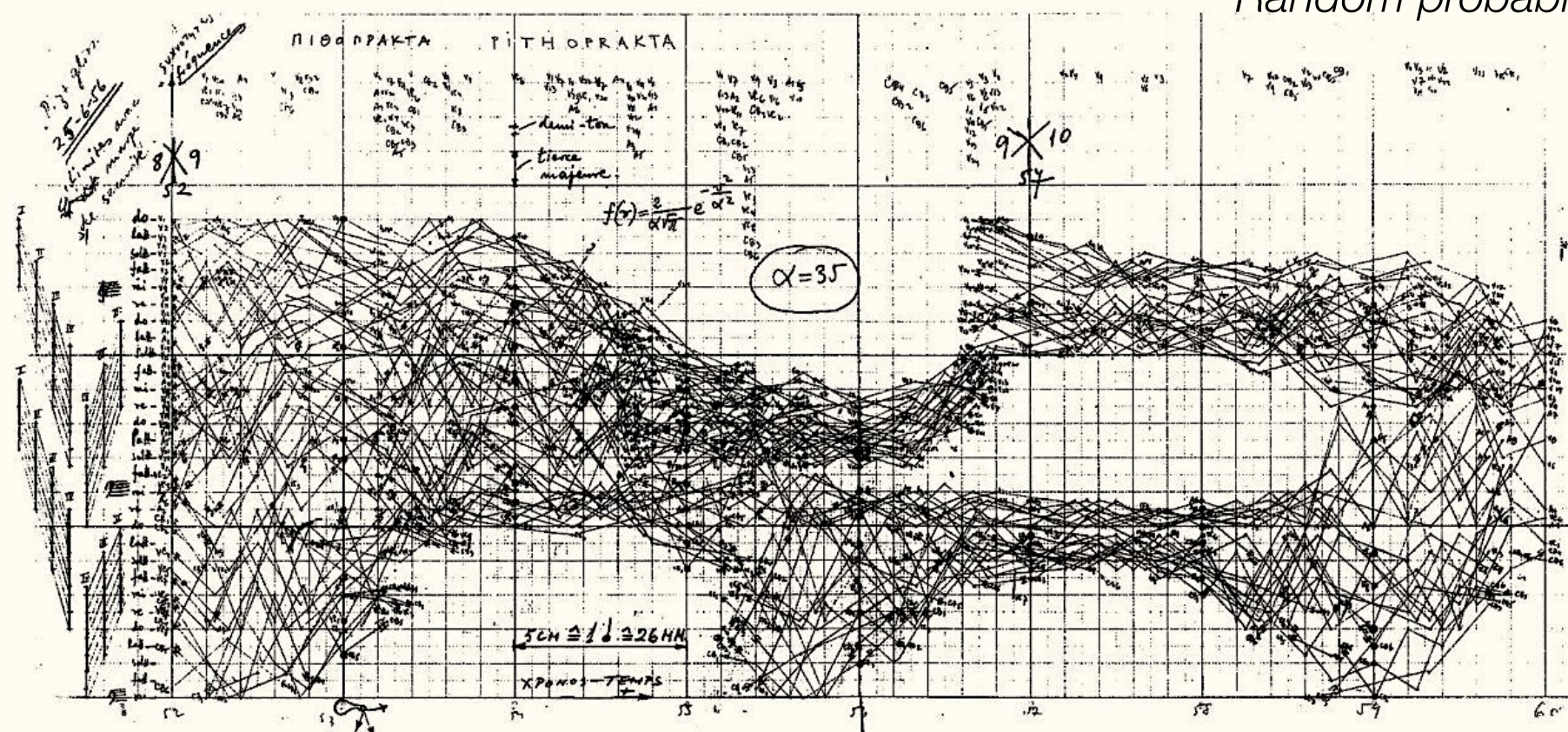
The movement of particles within a fluid.



*Pithoprakta* is an example of a stochastic work composed in 1955, for 49 musicians

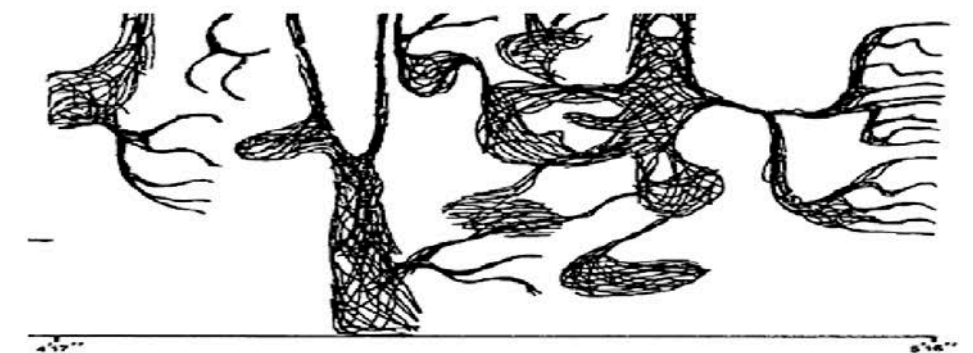


*Pithoprakta* (1955-56), mesures 52-59 : graphique de Xenakis  
Source : Iannis Xenakis, *Musique. Architecture*, Tournai, Casterman, 1976, p. 167



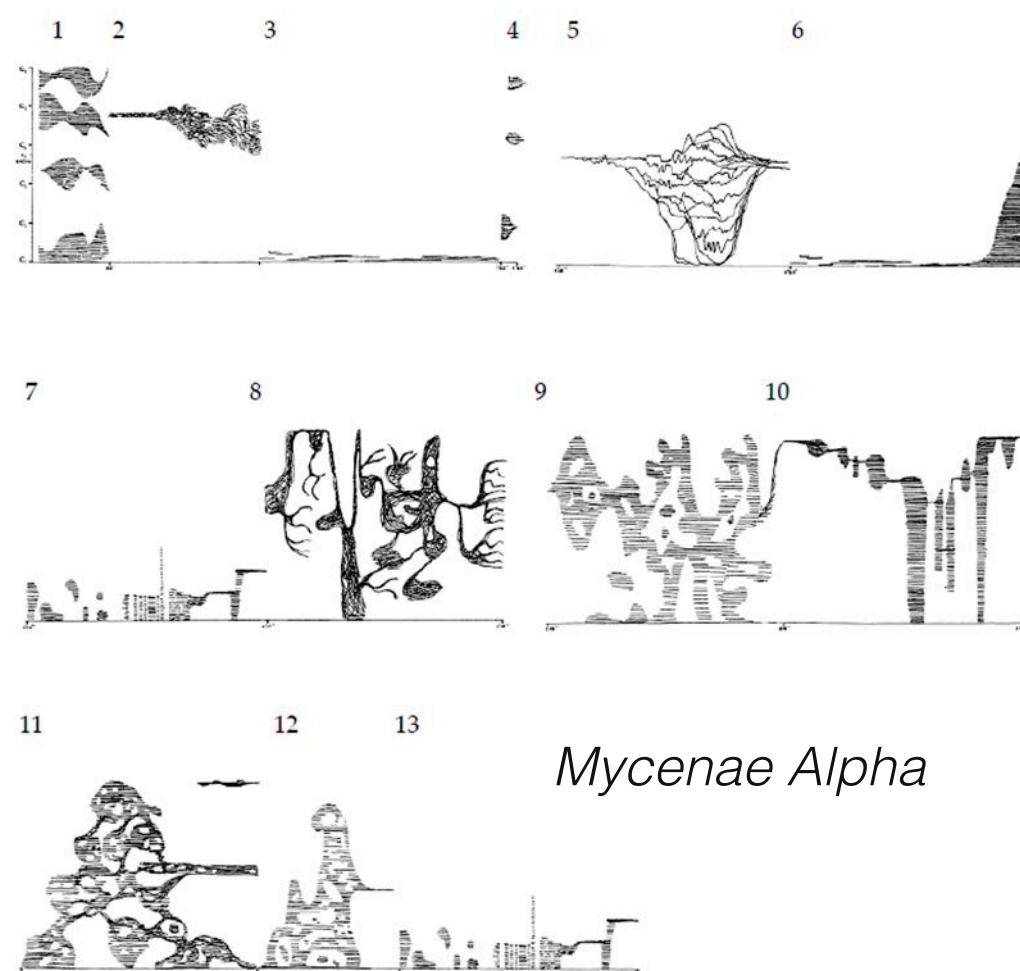
Random probability distribution

*Mycenae-Alpha* is an electroacoustic work that Xenakis 1978



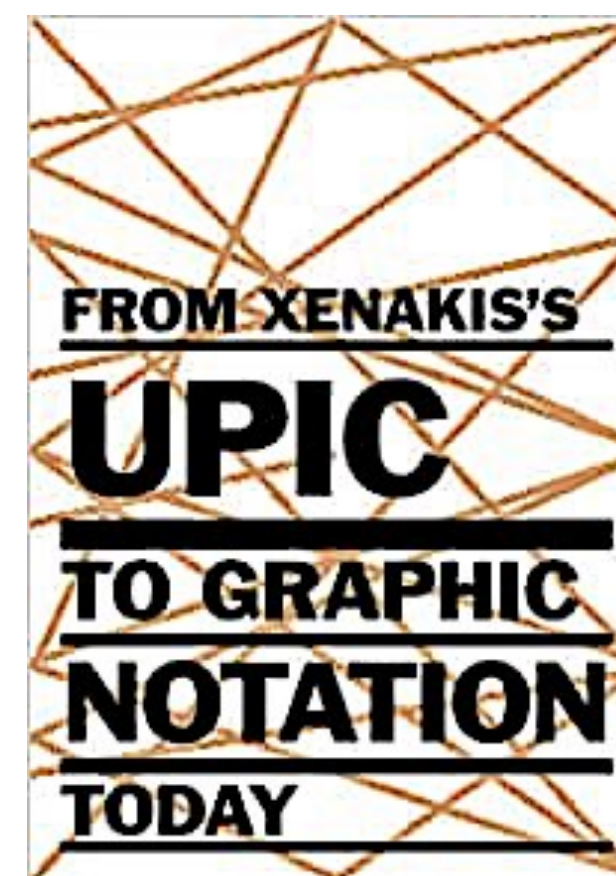
Example 6: *Mycenae Alpha*, Section 8, spectrograph and score

UPIC system' (Unité Polyagogique Informatique du CEMAMu) Iannis Xenakis, France, 1977.



*Mycenae Alpha*

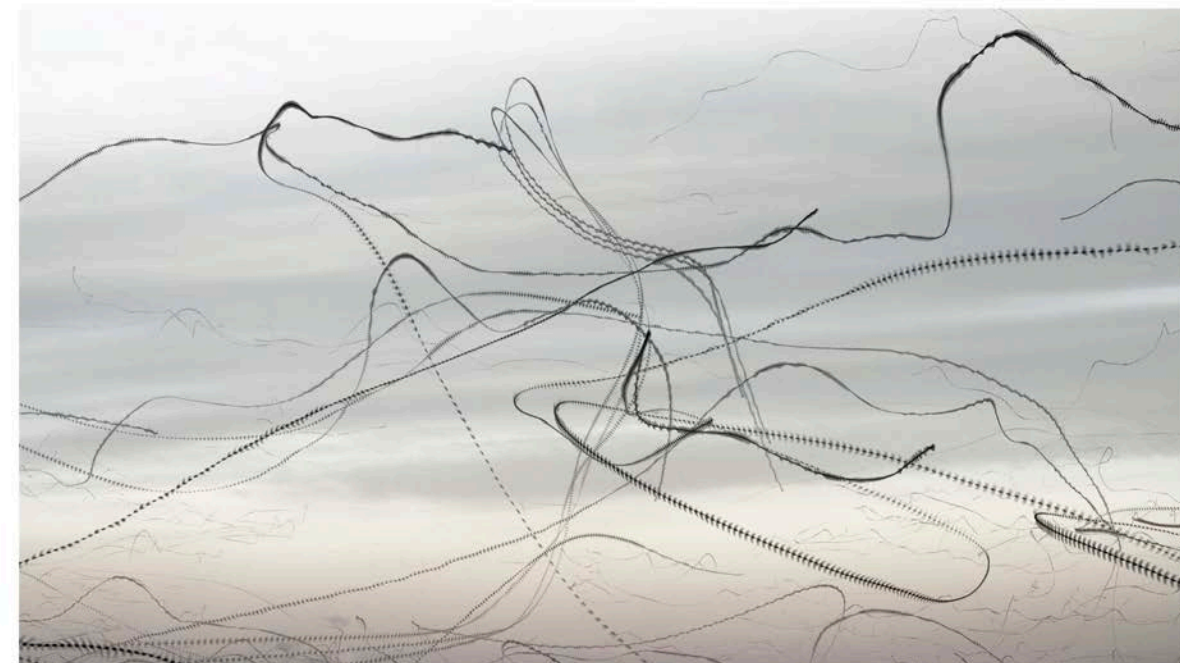
Example 2: UPIC Score of Mycenae Alpha with Section Labels



The original UPIC Model on display at the Museum of Music at La Philharmonie in Paris, France.



Chova piquirroja  
*Pyrrhocorax pyrrhocorax*  
Foto: Xavi Bou



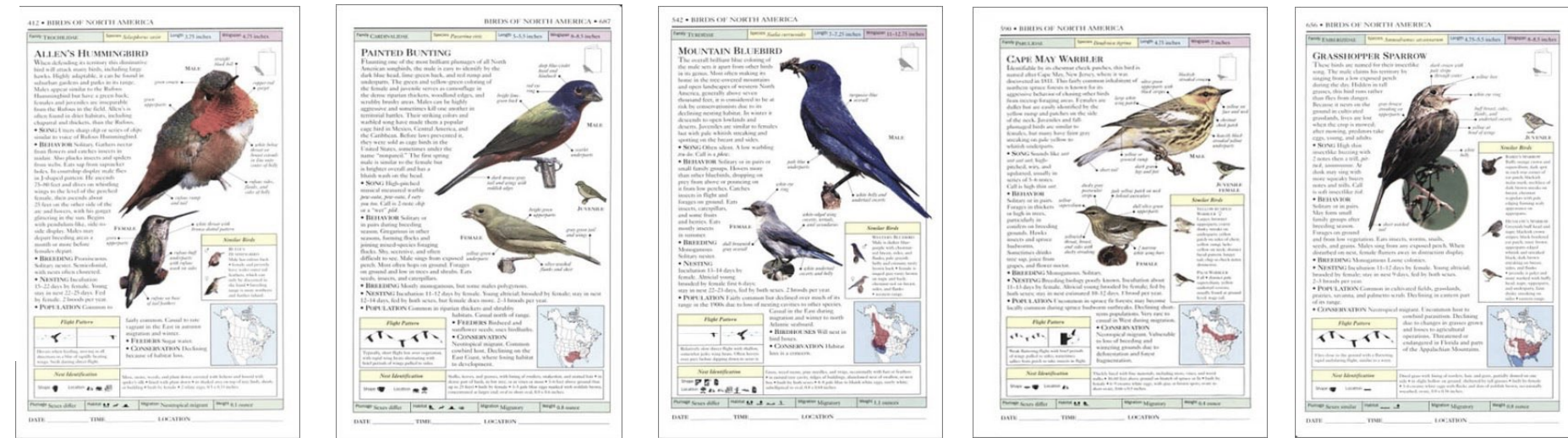
Vencejo común  
*Apus apus*  
Foto: Xavi Bou



Cormorán grande  
*Phalacrocorax carbo*  
Foto: Xavi Bou

The mockingbird does not know what consoles you.

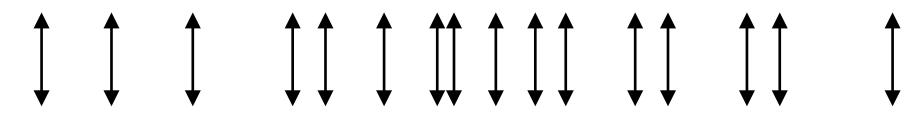
El ruiseñor no sabe que te consuela...



...to think about the air

emergent patterns  
(flight patterns)

self organization  
(different kind)



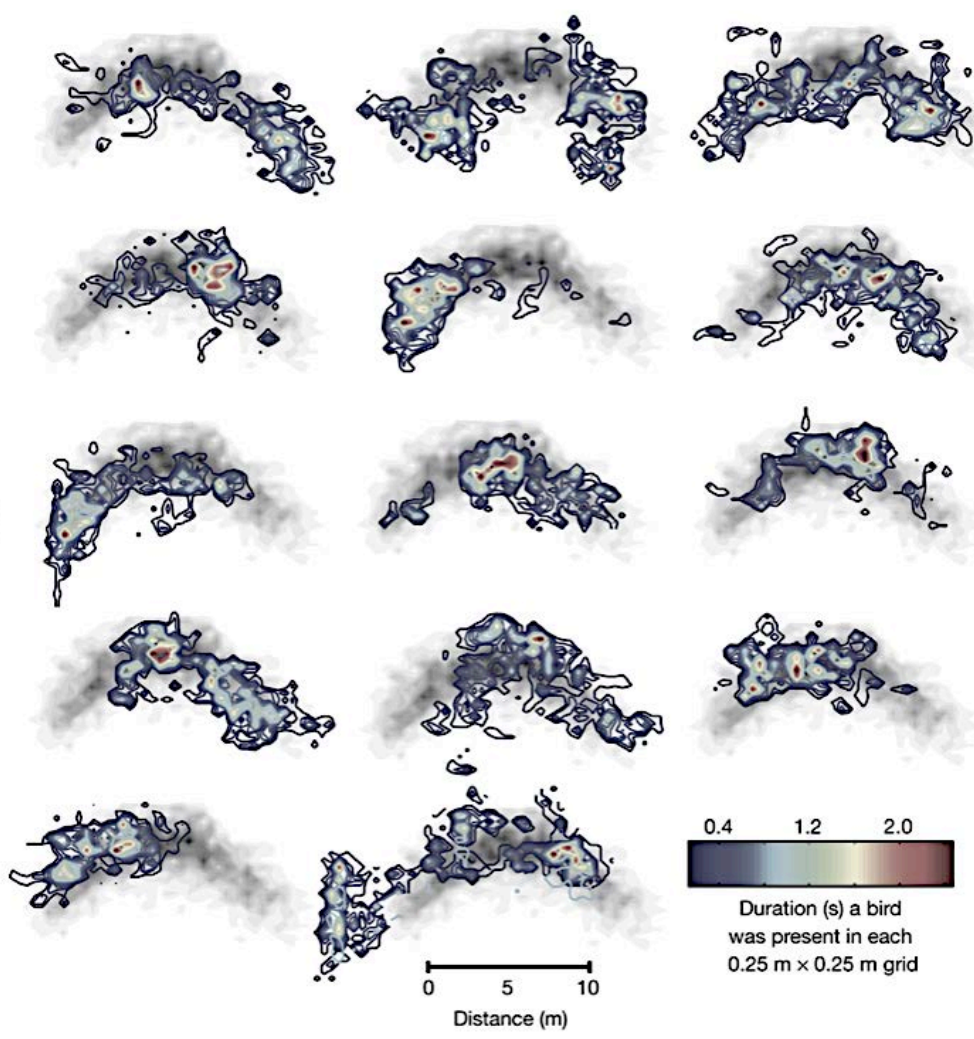
spontaneous synchronizations

micro gestures  
micro choreographies

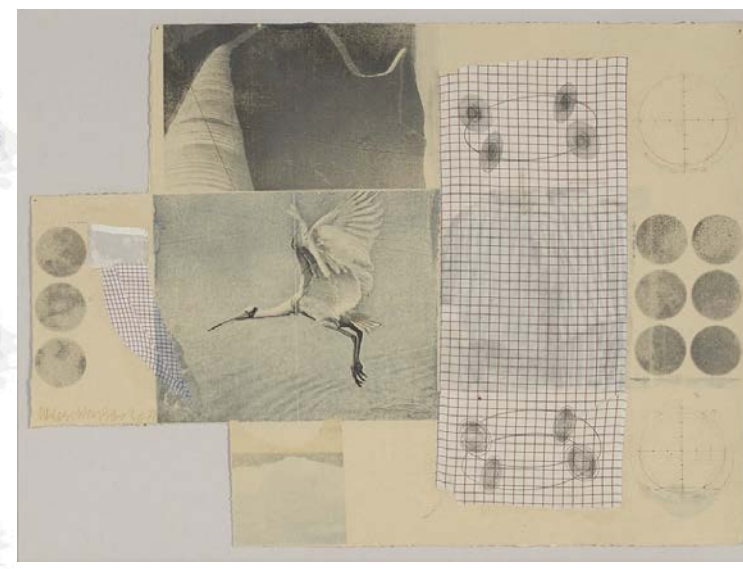
aire  
patrones  
emergentes  
(patrones de  
vuelo)

auto-organización  
micro gestualidad  
micro coreografías





Histograms demonstrating the positional infidelity for each northern bald ibis in the V formation during the migratory flight. The grey shaded V shape behind each individual histogram (n = 14) denotes the structure for all individuals in the flock (see b). The colour code refers to the duration (in seconds) a bird was present in each 0.25 m x 0.25 m grid. Although individual birds showed some bias towards the front, back, left or right regions of the V formation, these positions were not maintained rigidly.



1979 Robert Rauschenberg



1973

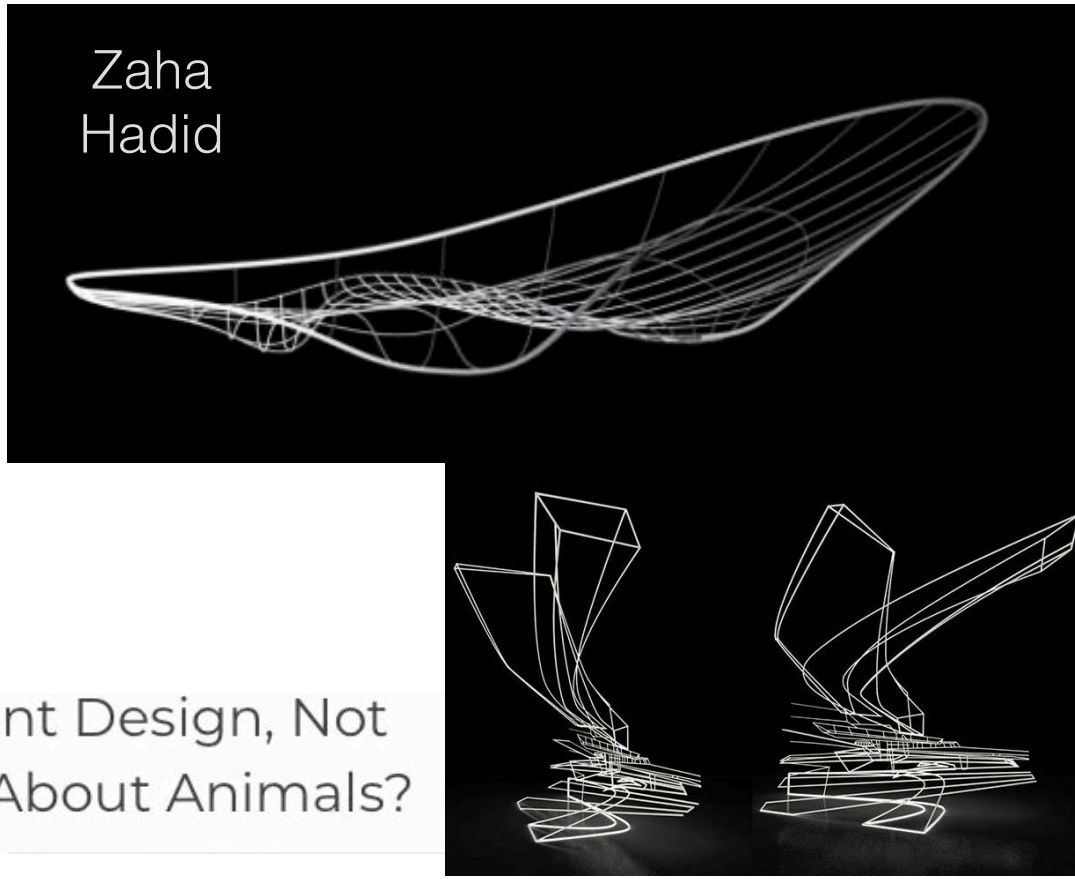


Flight of the Starlings



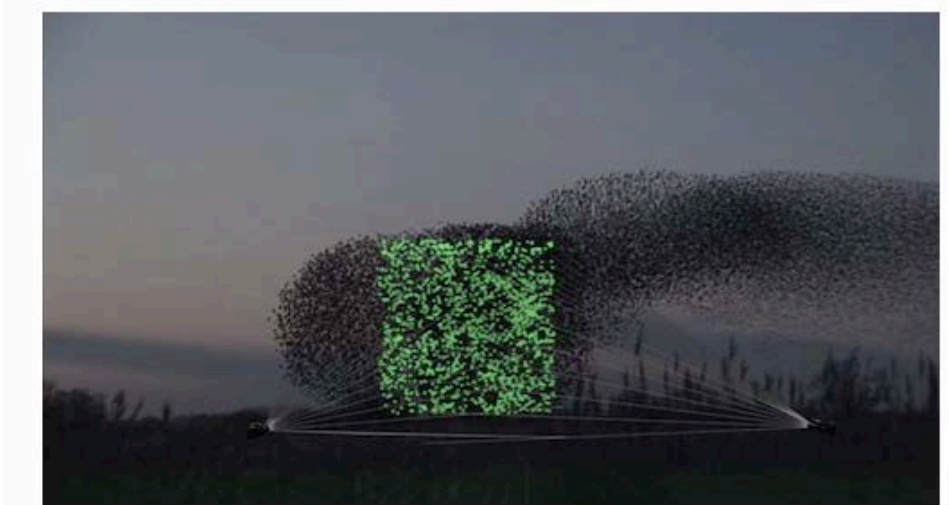
HARVARD School of Engineering and Applied Sciences  
WYSS INSTITUTE

**Self-Organizing Systems Research Group**

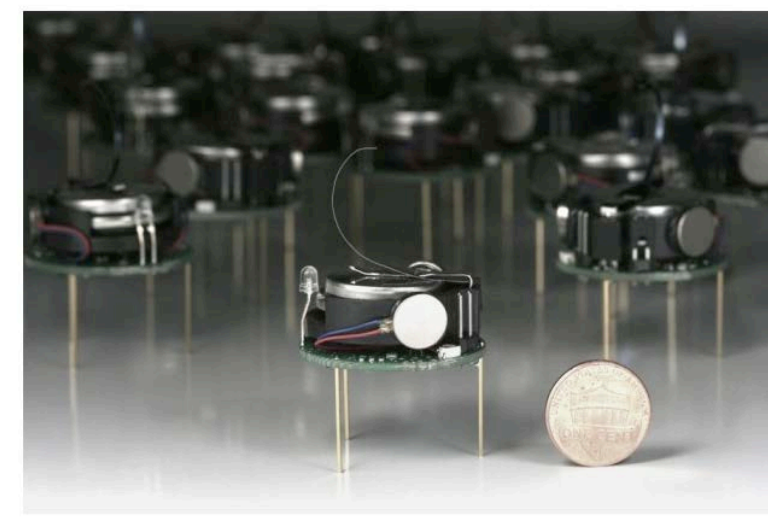


When Robots Swarm, It's Intelligent Design, Not Self-Organization. So Then What About Animals?

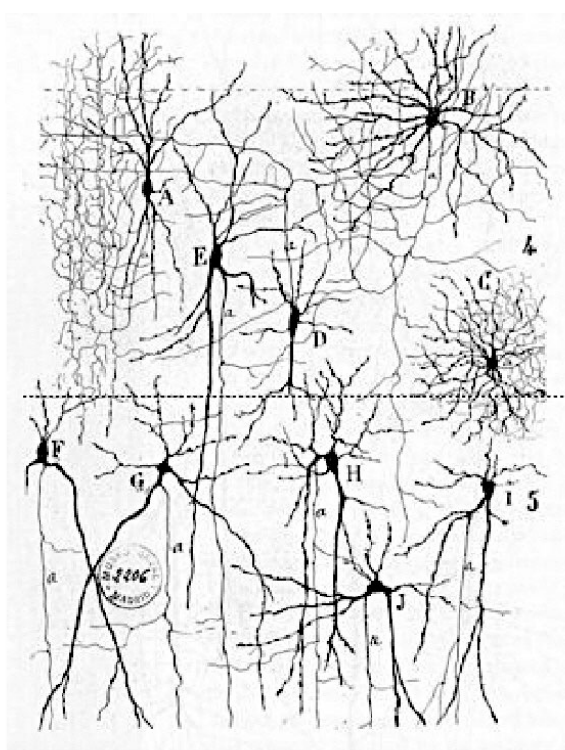
Evolution News | @DiscoveryCSC  
August 21, 2014, 5:23 AM



A video clip at [Nature News](#) shows a robot swarm marching into formation, creating a star shape. This is the latest achievement of the "Self-Organizing Systems Research Group" of Harvard's Wyss Institute for Biologically Inspired Engineering. Their "Kilobot army" can create any predetermined 3-D shape on command. They call it "Programmable Self-Assembly."

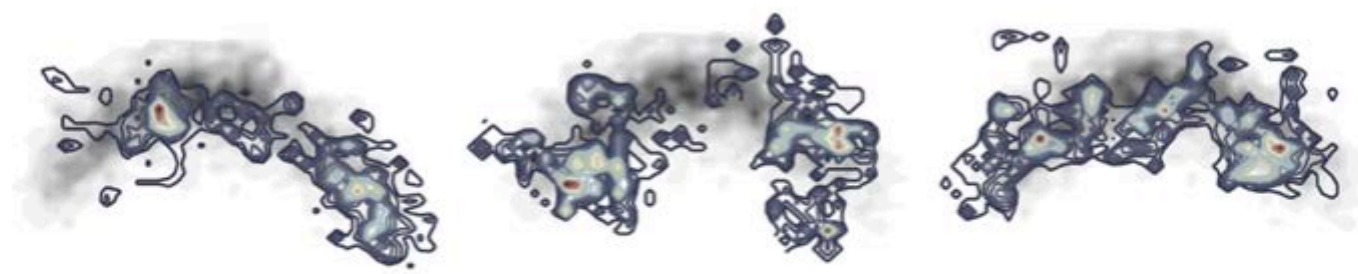
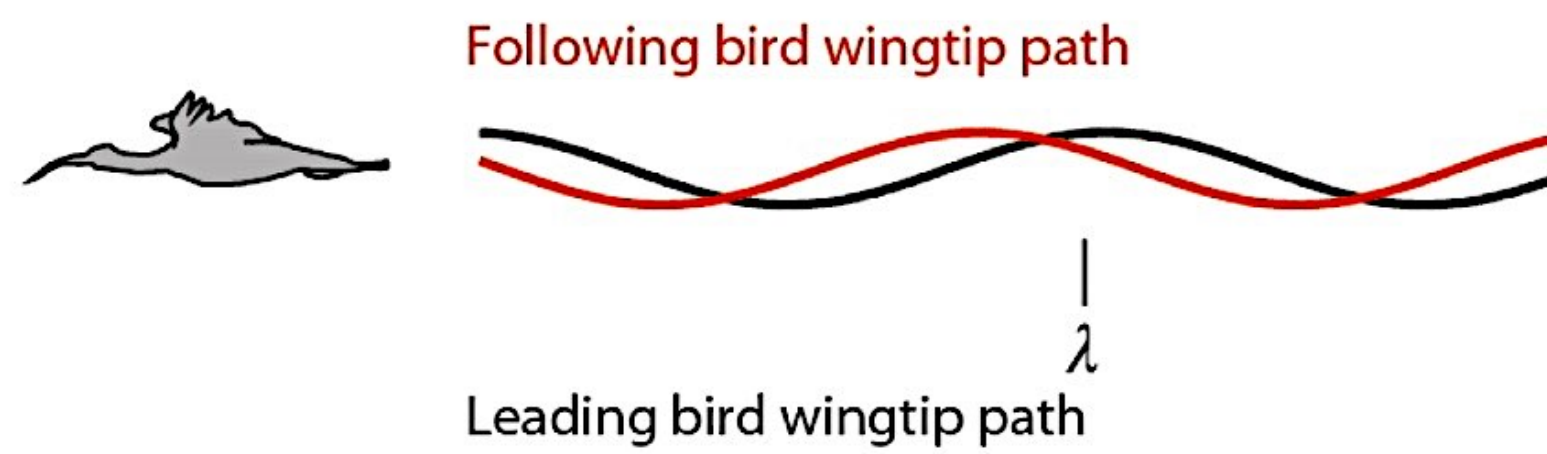


Michael Rubenstein/Harvard University

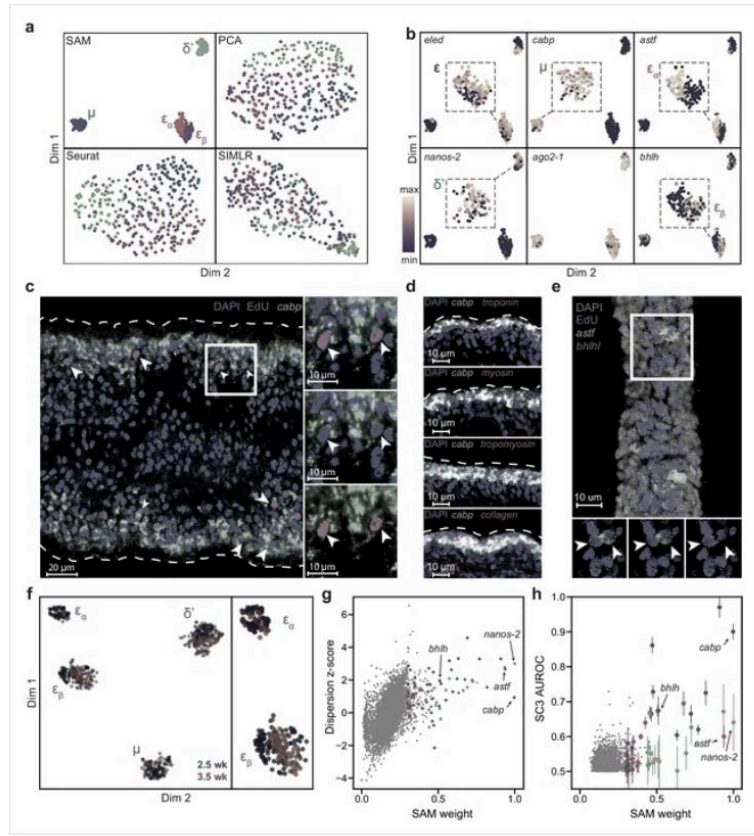
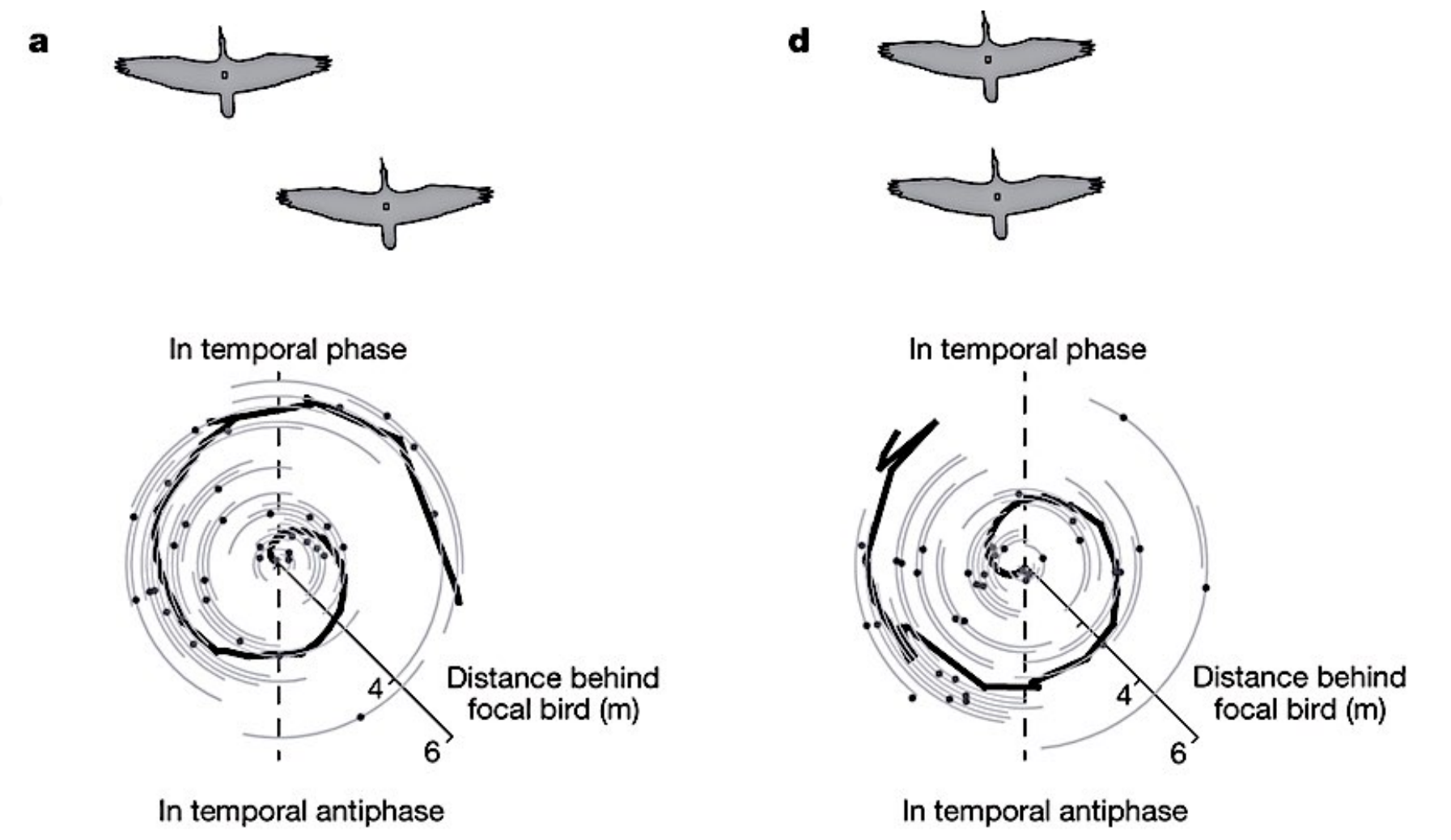
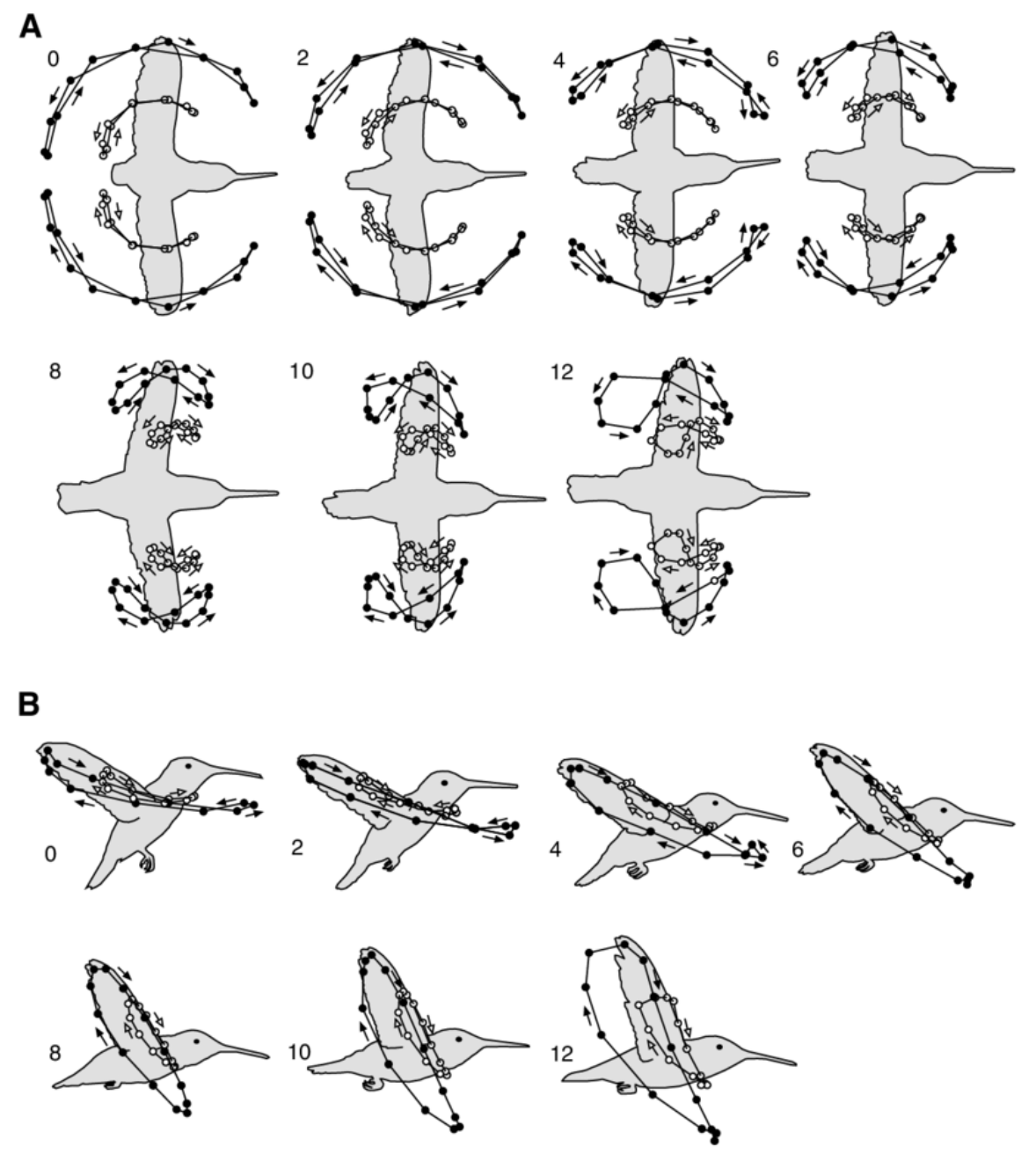
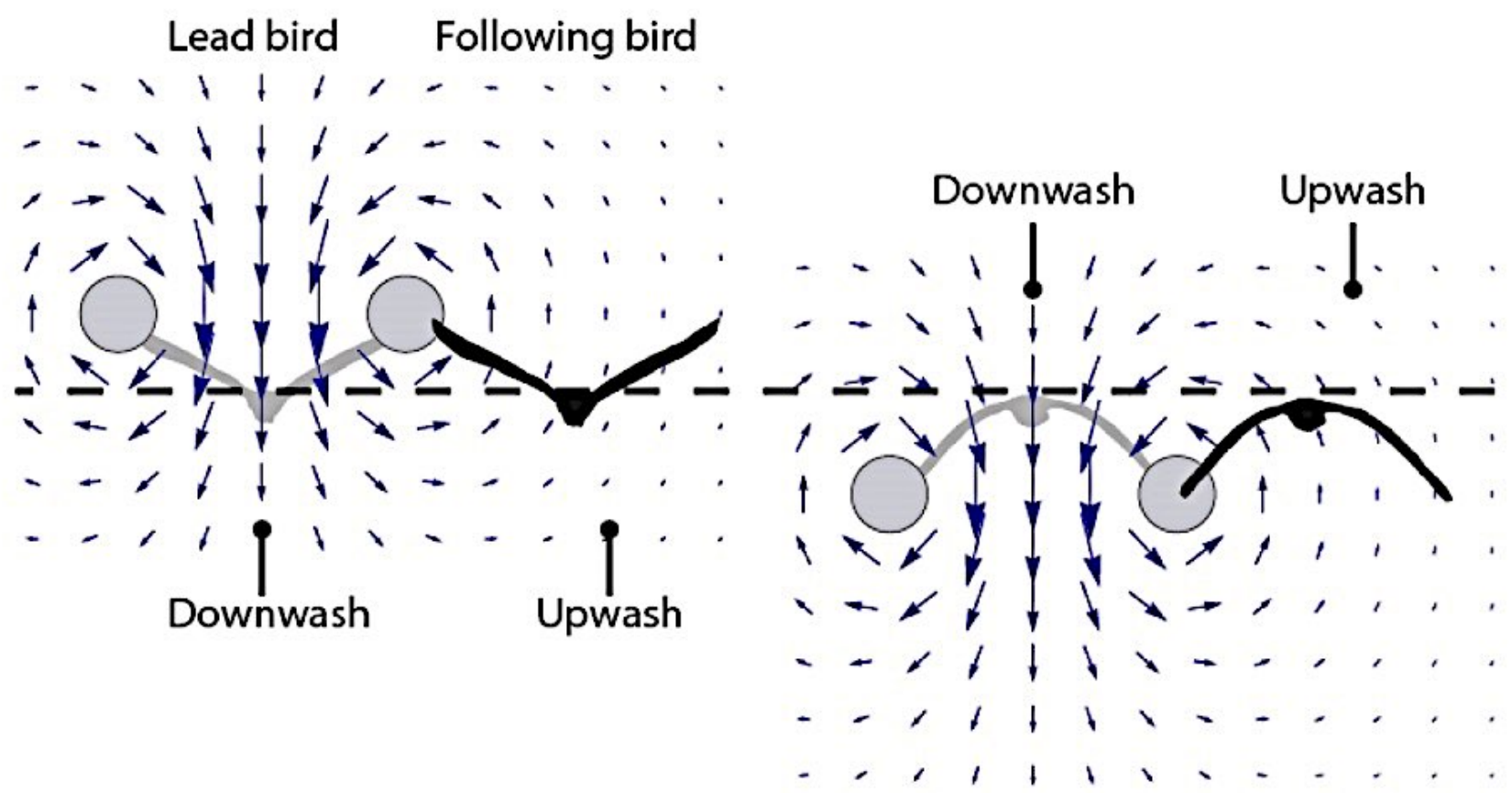


High Complexity

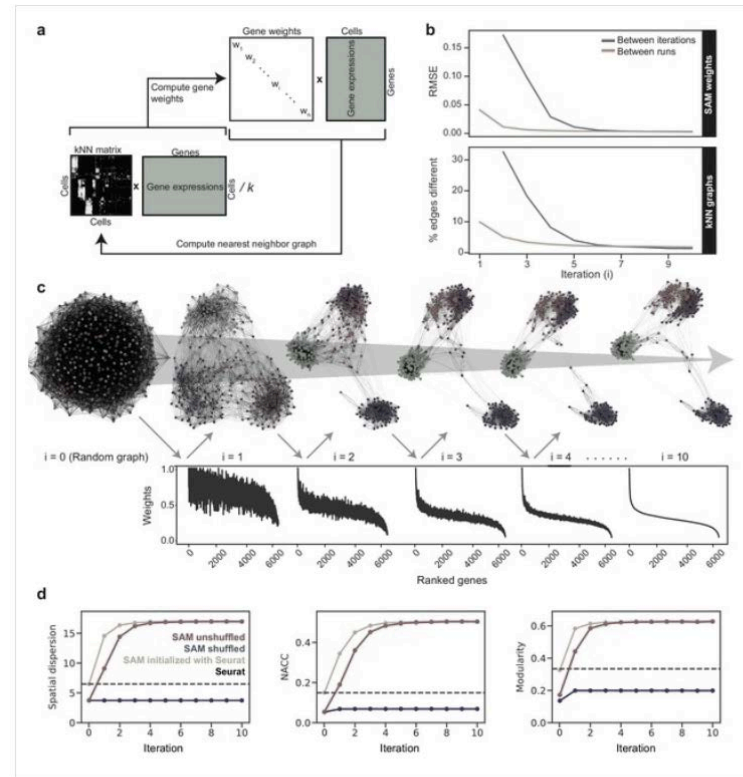
Low Complexity



flight dynamics



SAM identifies novel subpopulations within schistosome stem cells.  
 (a) UMAP projections of the manifolds reconstructed by SAM, PCA, and Seurat. SIMLR outputs its own 2D projection based on its constructed similarity matrix using a modified version of t-SNE. The ... see more >  
<https://doi.org/10.7554/eLife.48994.006>



The SAM algorithm.  
 (a) SAM starts with a randomly initialized kNN adjacency matrix and iterates to refine the adjacency matrix and gene weight vector until convergence. (b) Root mean square error (RMSE) of the gene ... see more >  
<https://doi.org/10.7554/eLife.48994.003>

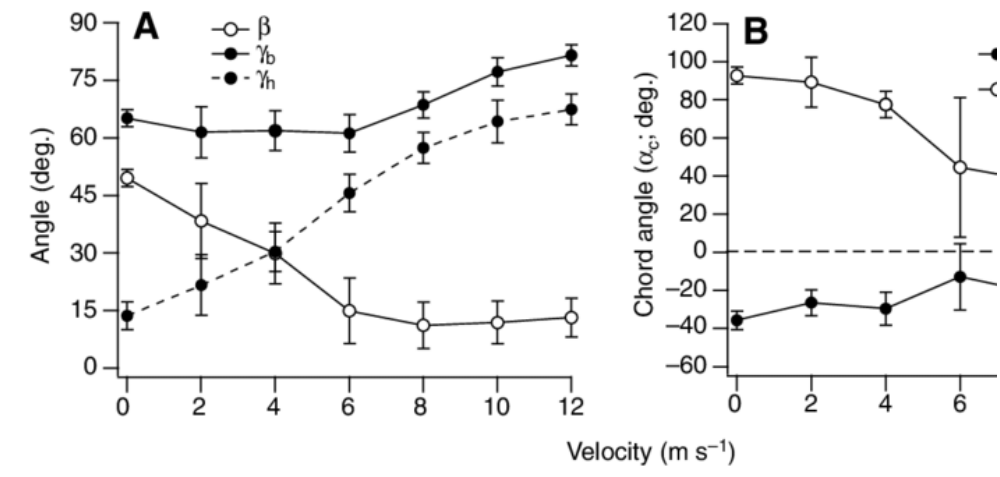
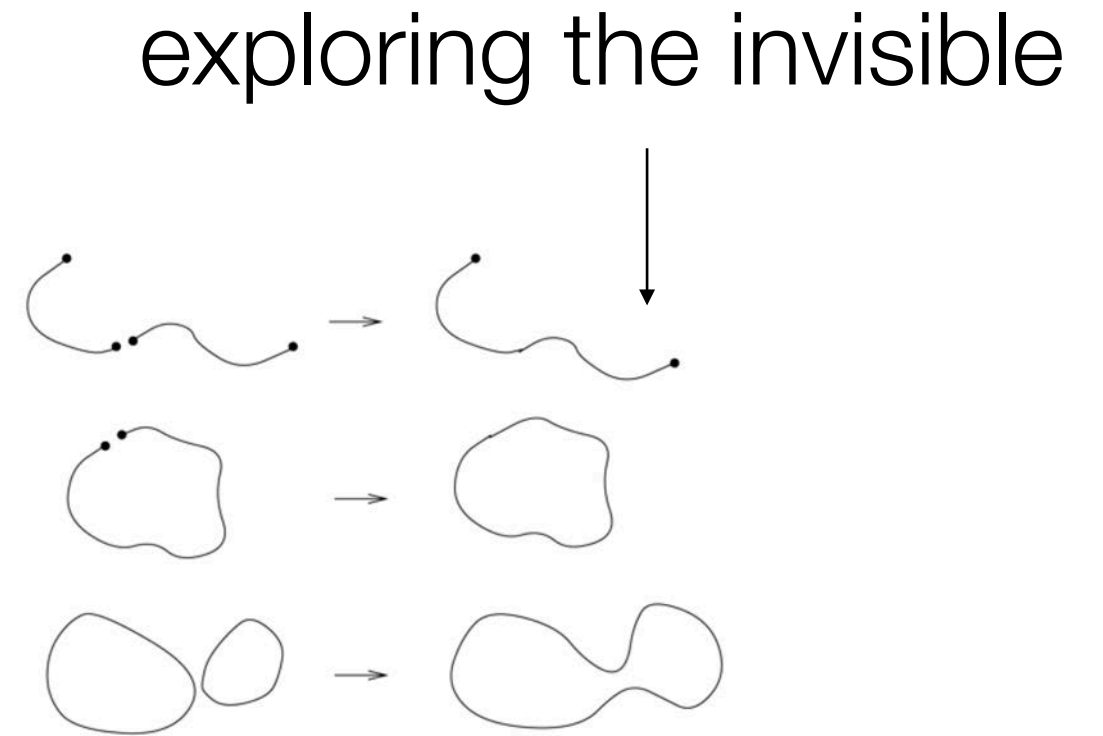
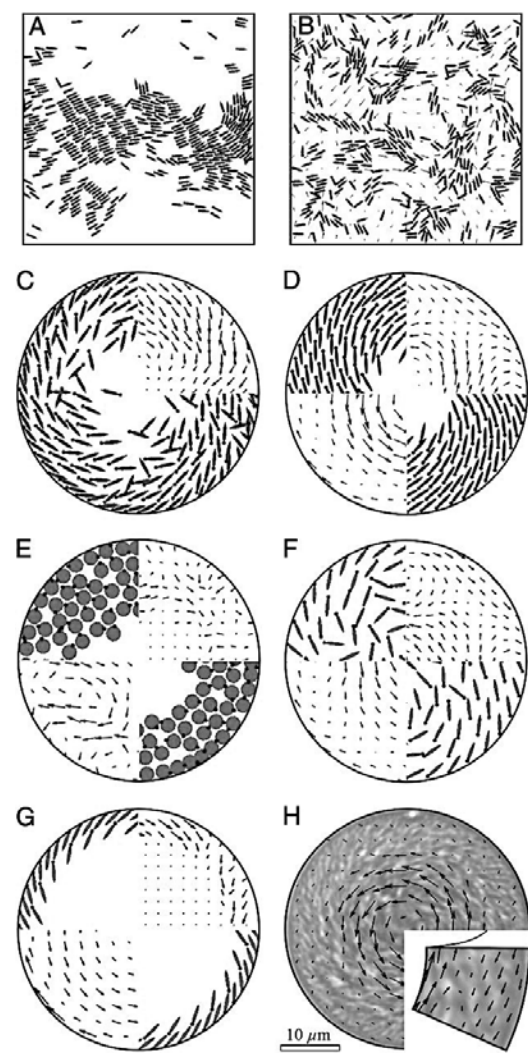


Fig. 3. Angles describing bird-centered wing and body kinematics in rufous hummingbirds (*Selasphorus* 0–12  $m s^{-1}$ ). (A) Body angle relative to horizontal ( $\beta$ ), tracking stroke-plane angle relative to horizontal relative to mid-frontal plane of body ( $\gamma_b$ ). (B) Chord angle of wing relative to mid-frontal plane of upstroke. Values are means  $\pm$  s.d.

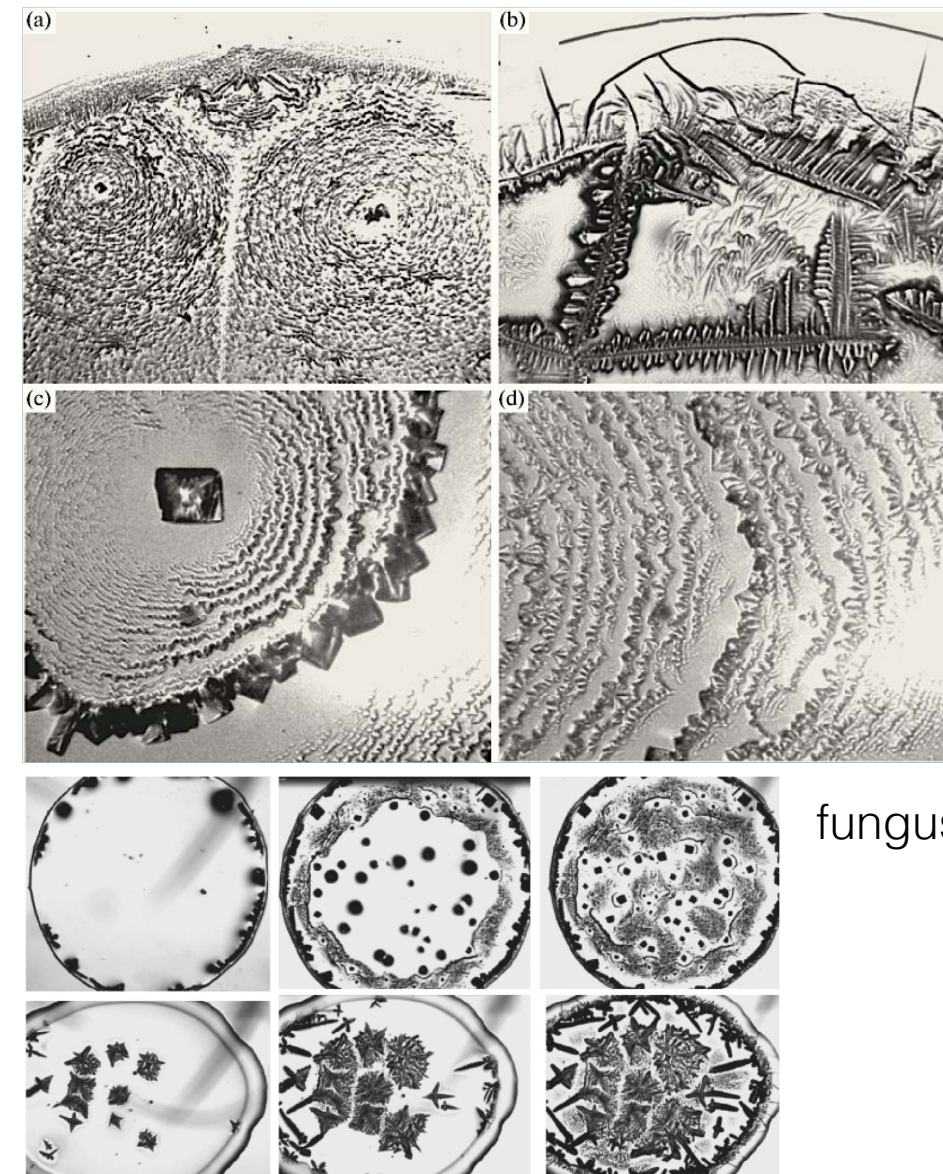


Self-assembling manifolds in single-cell RNA sequencing data

Colectores de autoensamblaje en datos de secuenciación de ARN de una sola célula

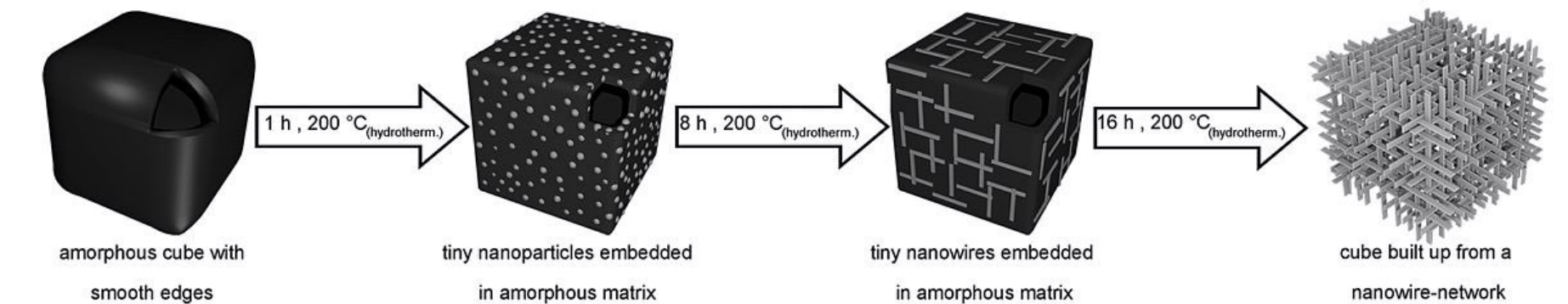
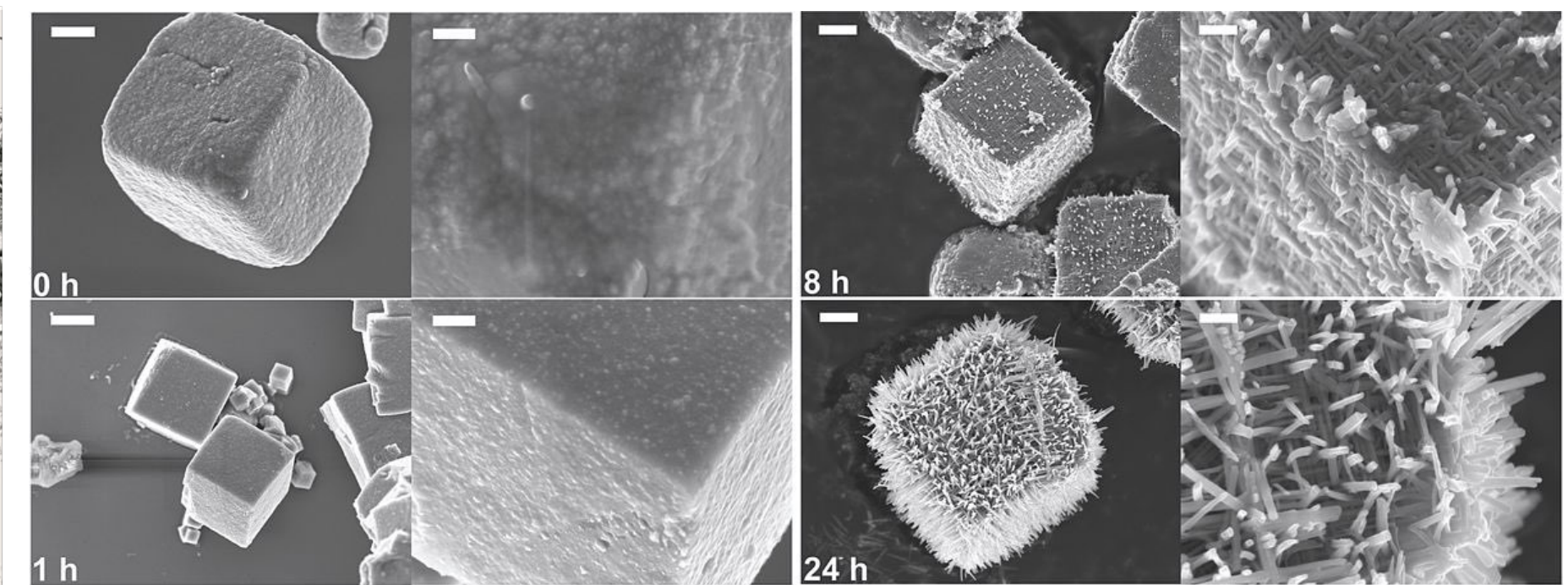


Suspension organization in periodic domains and inside circular confinement

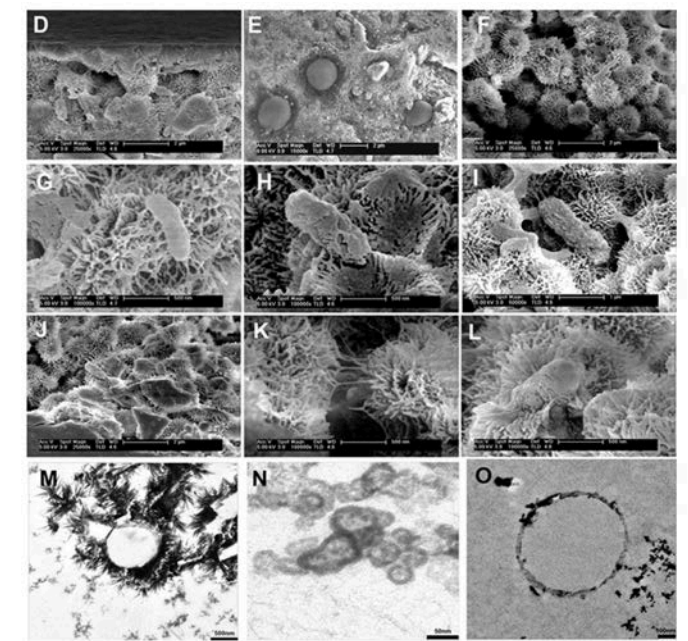


fungus

crystallizations and self-organization



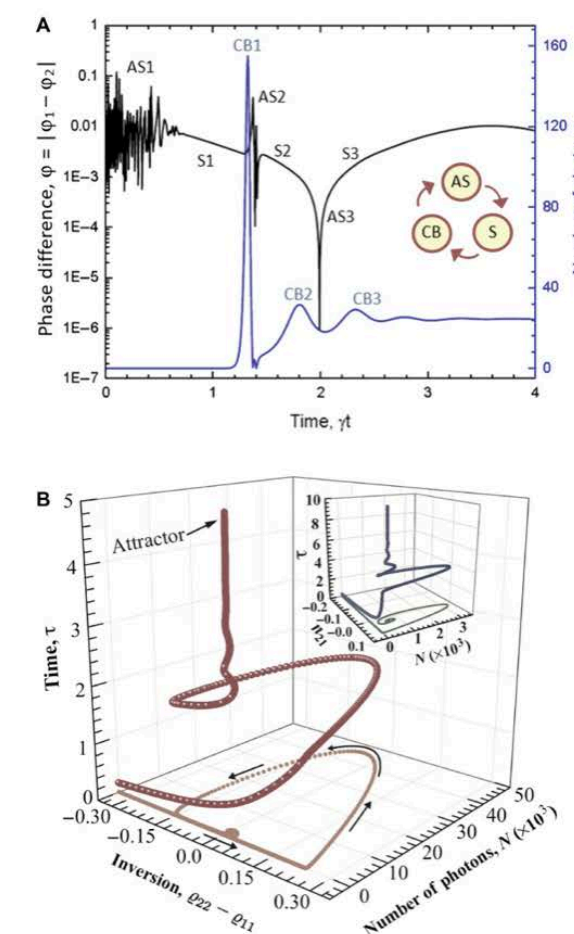
spontaneous synchronizations  
↓  
Emergence of attractors



Imágenes (de la D a la L) de microscopía electrónica de barrido (SEM) y de microscopía electrónica de transmisión (TEM), desde la M a la O, de una muestra mostrando las morfologías de microorganismos ultra pequeños enterrados en las capas de mineral. / CAB

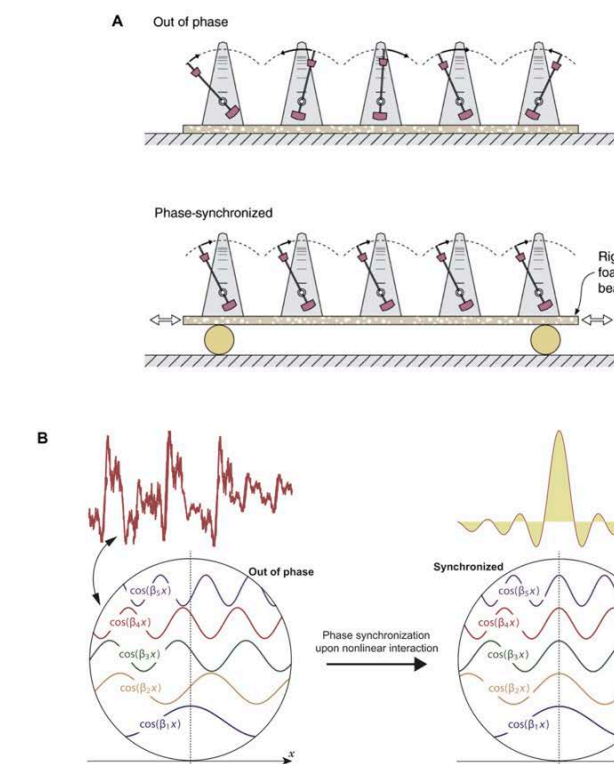
self - organization

Fig. 5 Spontaneous synchronization and emergence of attractors.



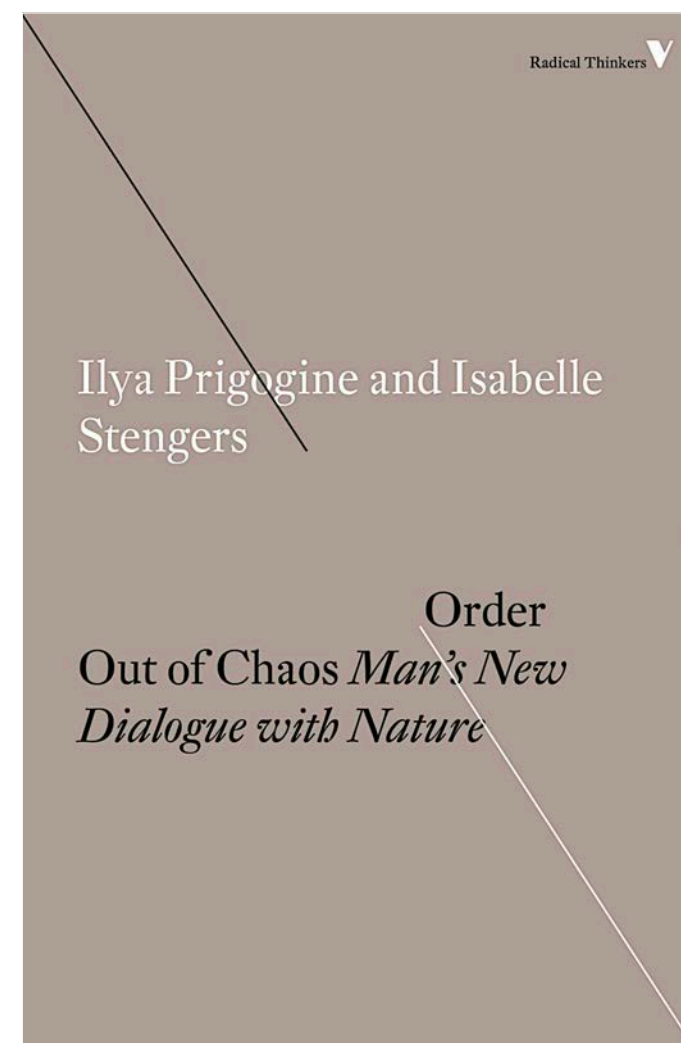
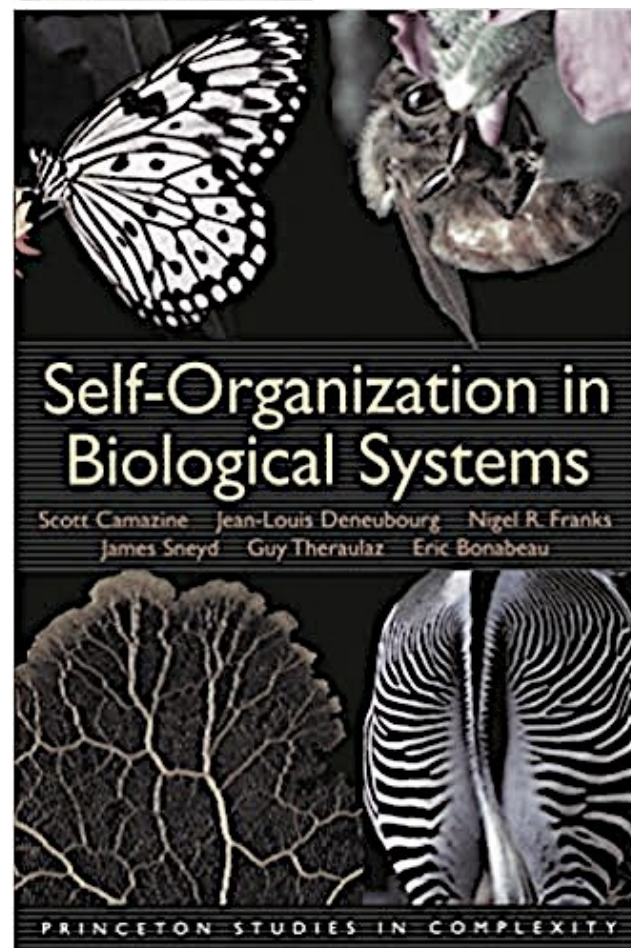
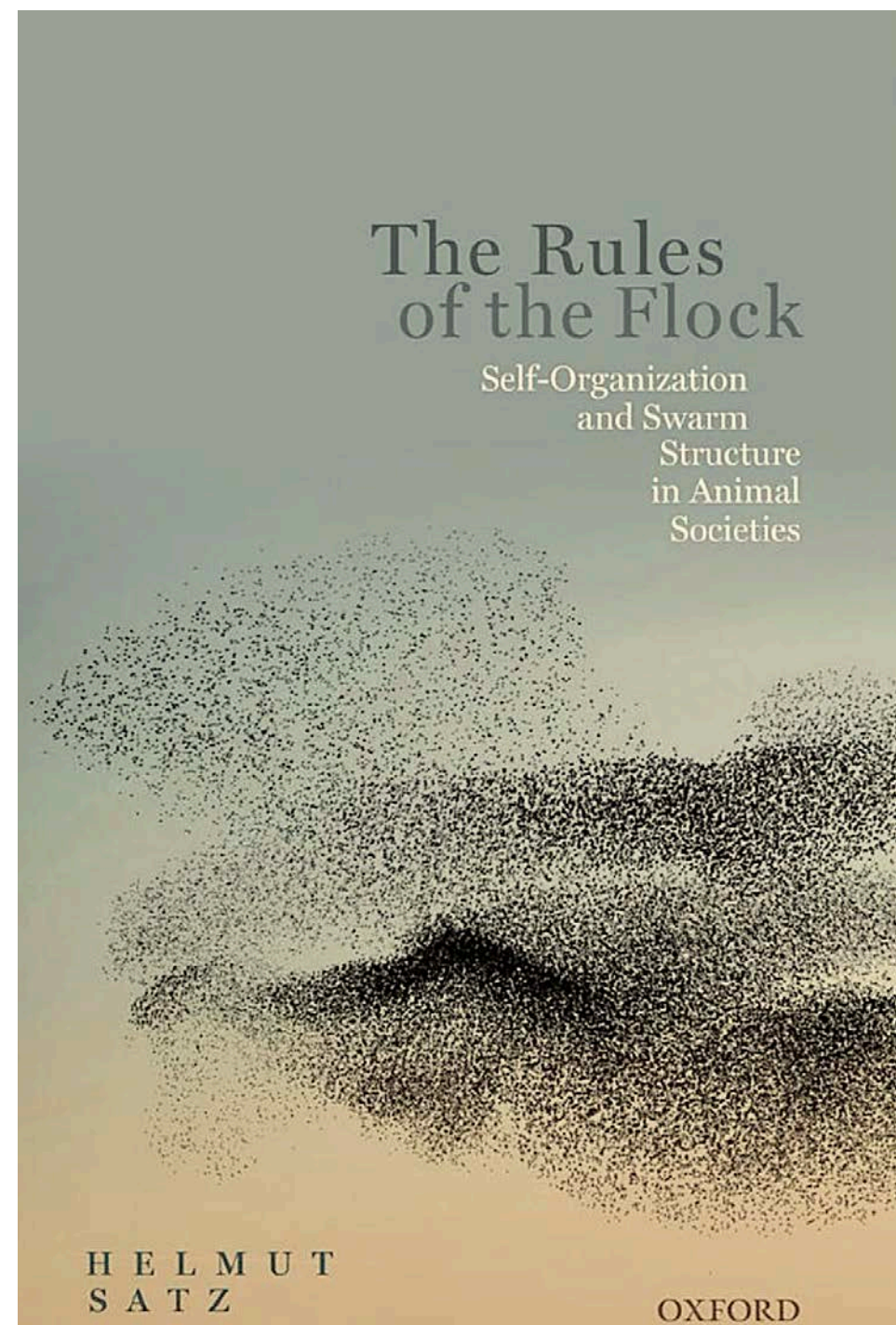
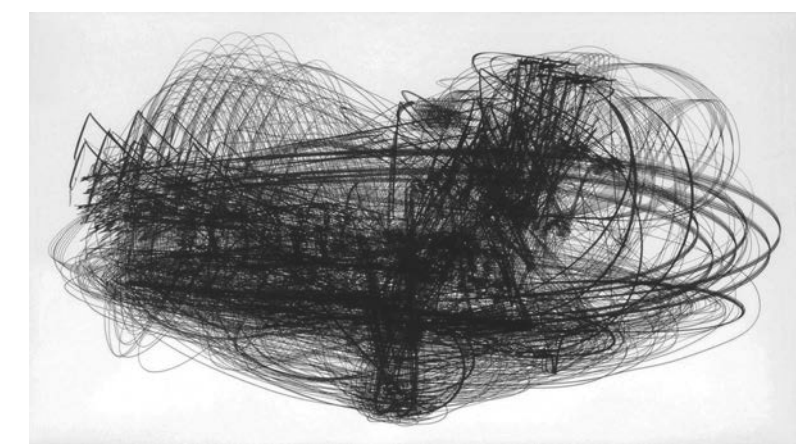
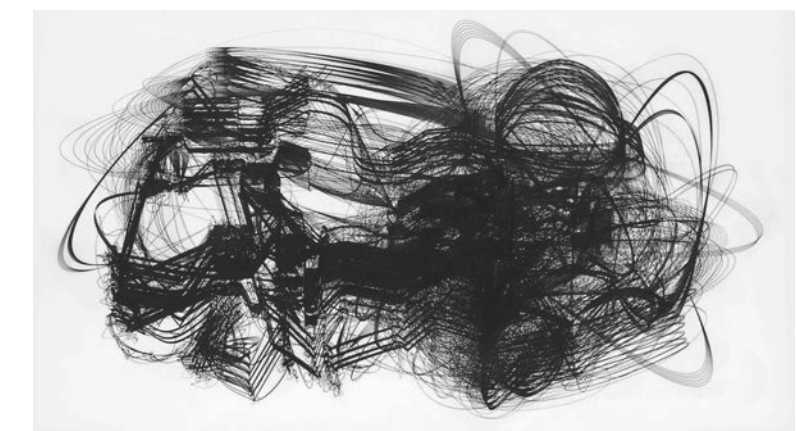
Kosmas L. Tsakmakidis et al. Sci Adv 2018;4:eaaq0465

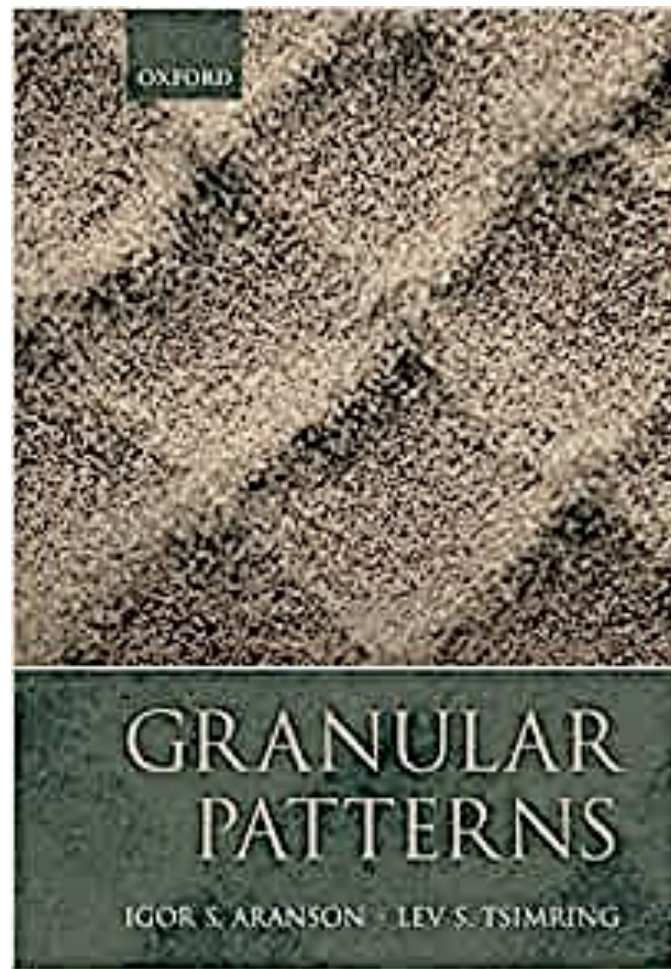
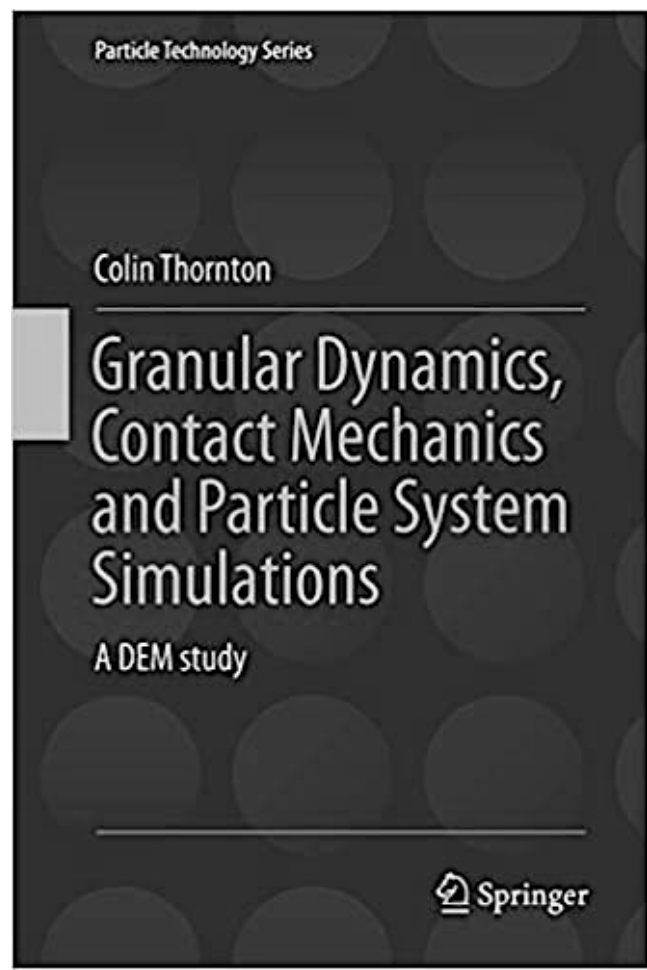
Fig. 2 Synchronization in classical mechanics and in optics.



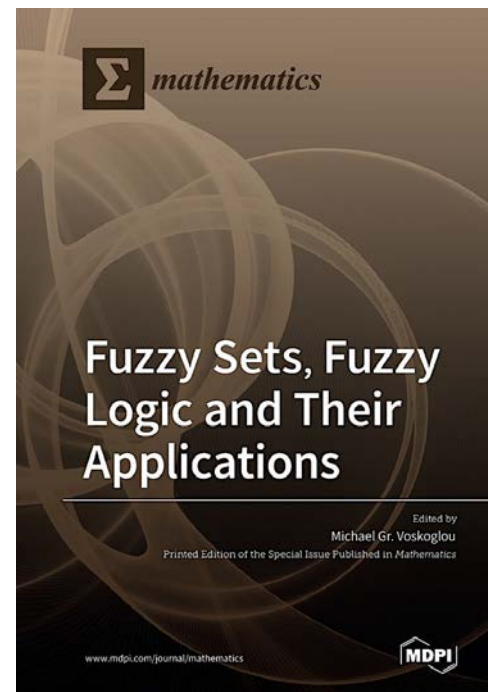
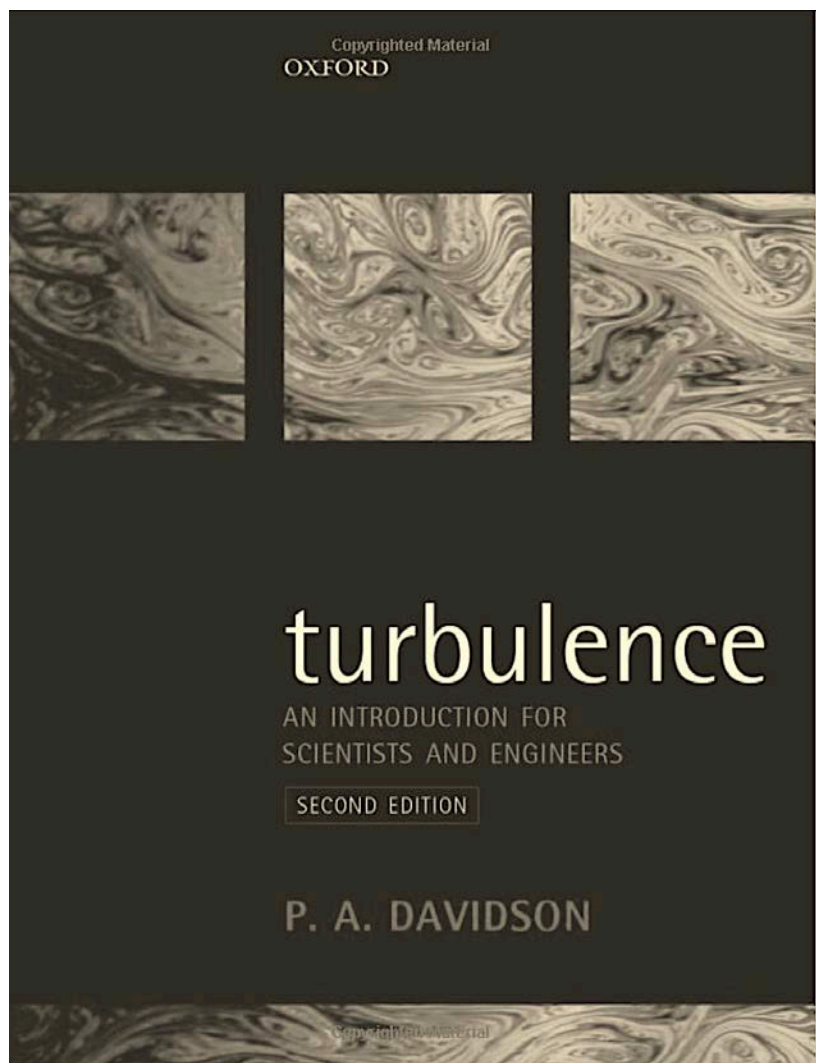
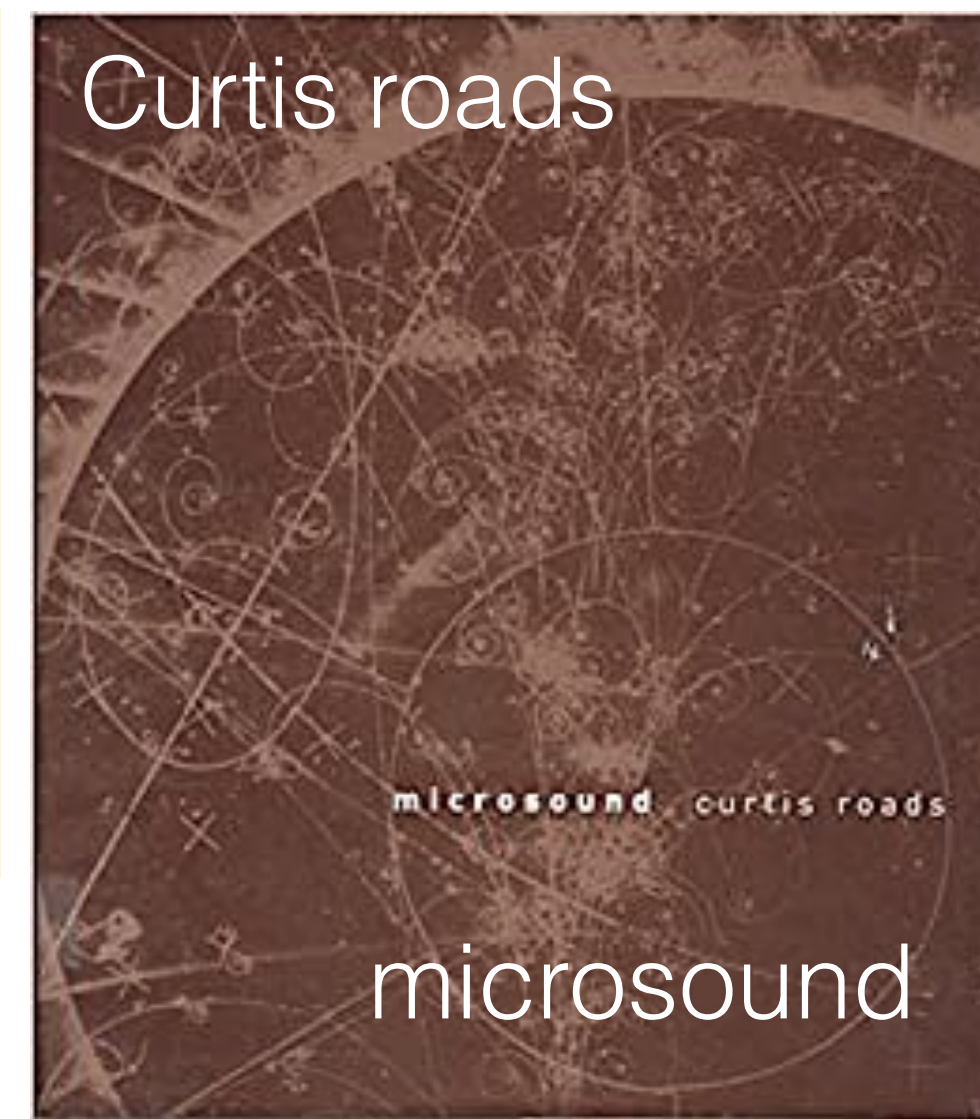
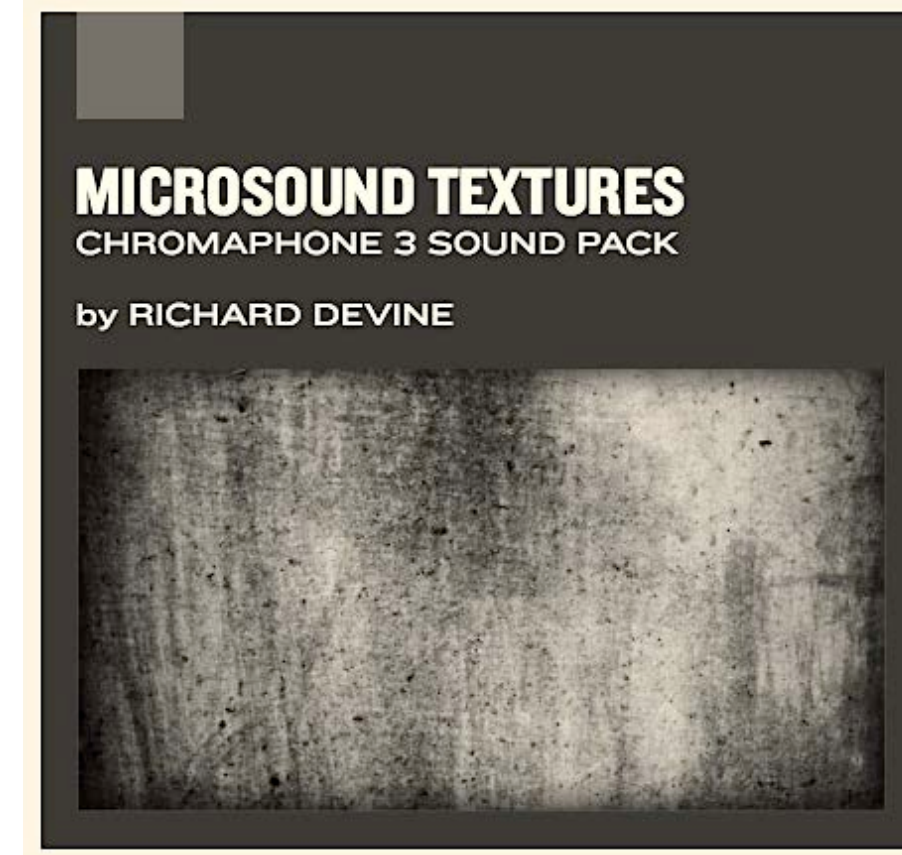
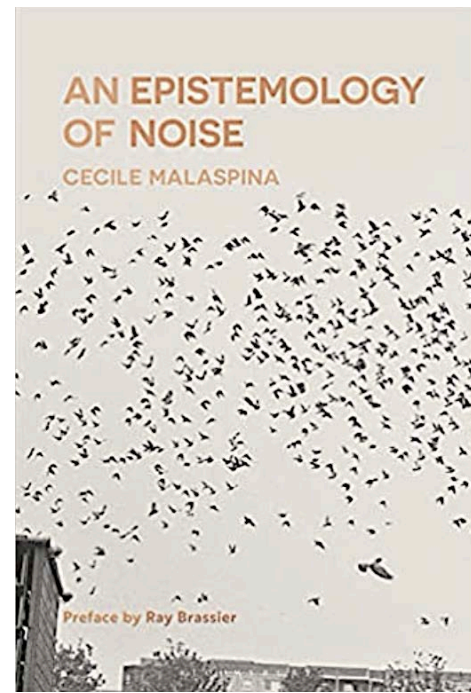
Kosmas L. Tsakmakidis et al. Sci Adv 2018;4:eaaq0465

ScienceAdvances



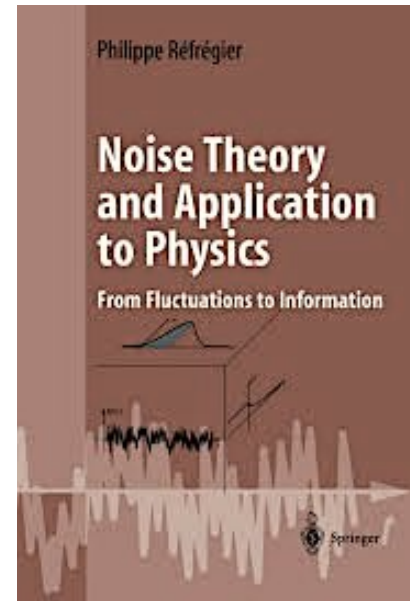


complex emerging patterns  
granulations



Dr. Lotfi Zadeh  
1965  
UC Berkeley

Uncertainty, Complexity and Fuzzy Logic  
Fuzzy logic is intended to model logical reasoning with vague or imprecise statements



Criticality  
Granulations  
Fuzzy sets/rough sets  
Oscillations  
microsound

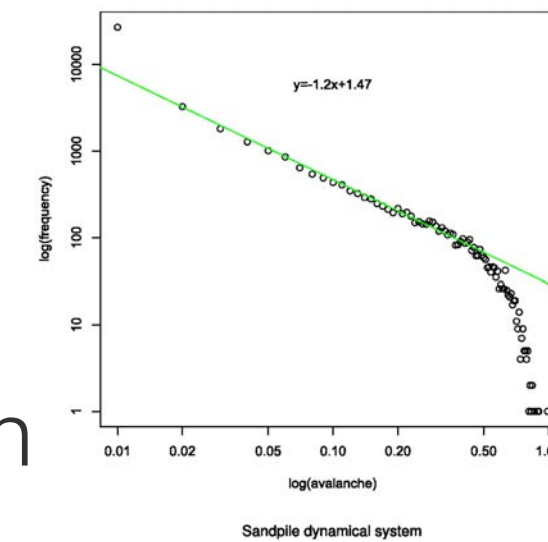
The theory of Self -Organised Criticality

binary logic

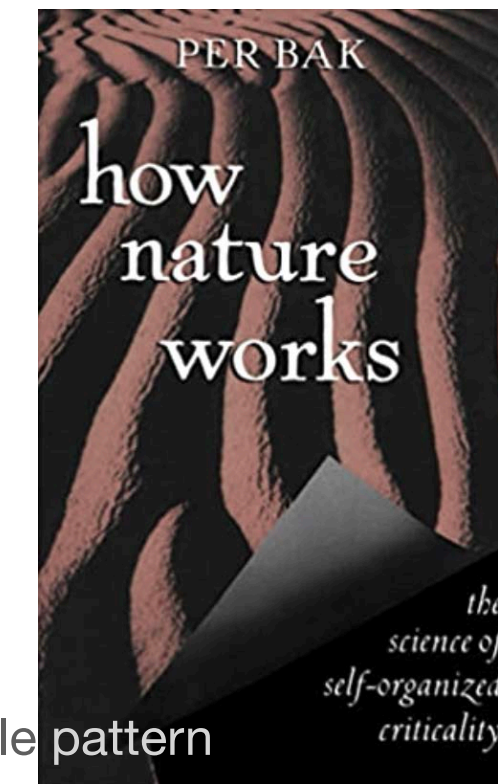
Standard logic 1-0 truth1 vs completely false 0  
Fuzzy logic degree of truth anywhere between 0.0 and 1.0

Fuzzy logic degree of truth

Per Bak → Criticality



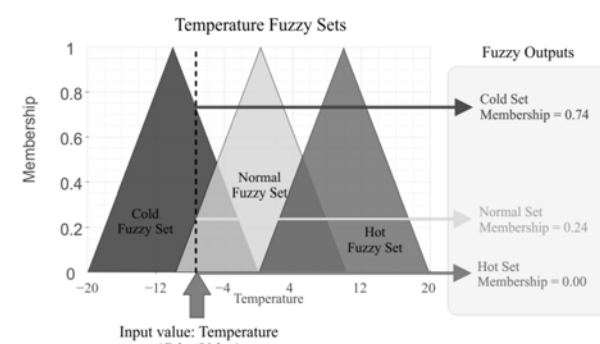
Catastrophes follow a simple pattern



Boundary conditions  
condiciones de contorno

fluid dynamics  
dinámica de fluidos

Fuzzy logic



Schrödinger's cat drinks water from the Klein bottle.

El gato de Schrödinger bebe agua de la botella de Klein.

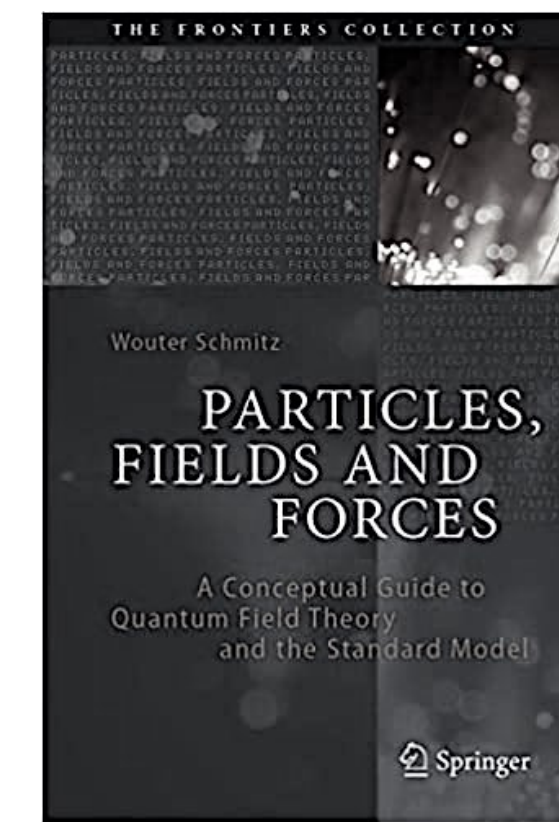
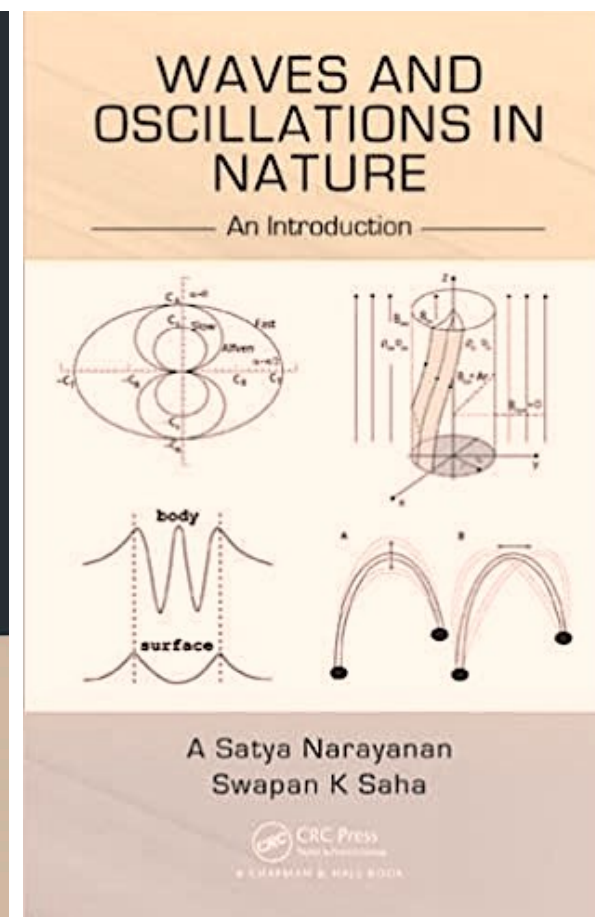
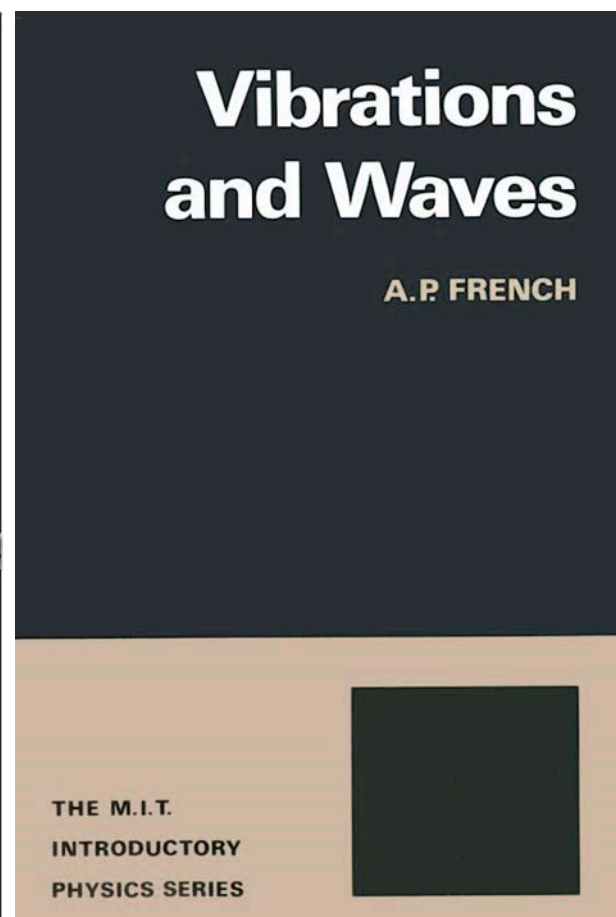
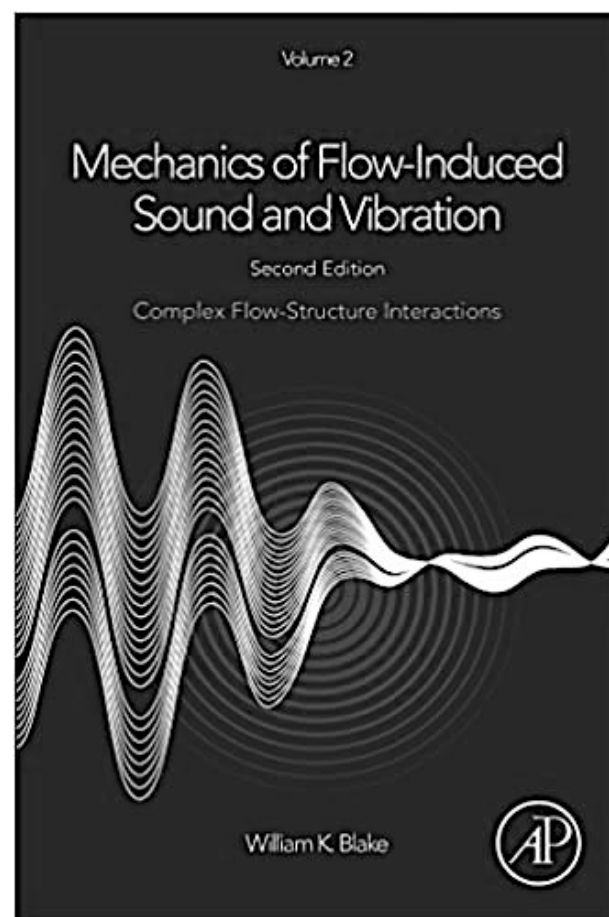
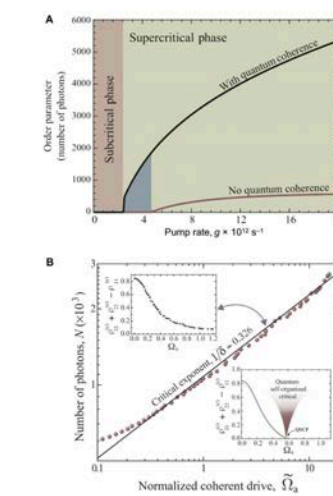


Fig. 6 Emergence of scaling and toward the quantum self-organized critical regime.

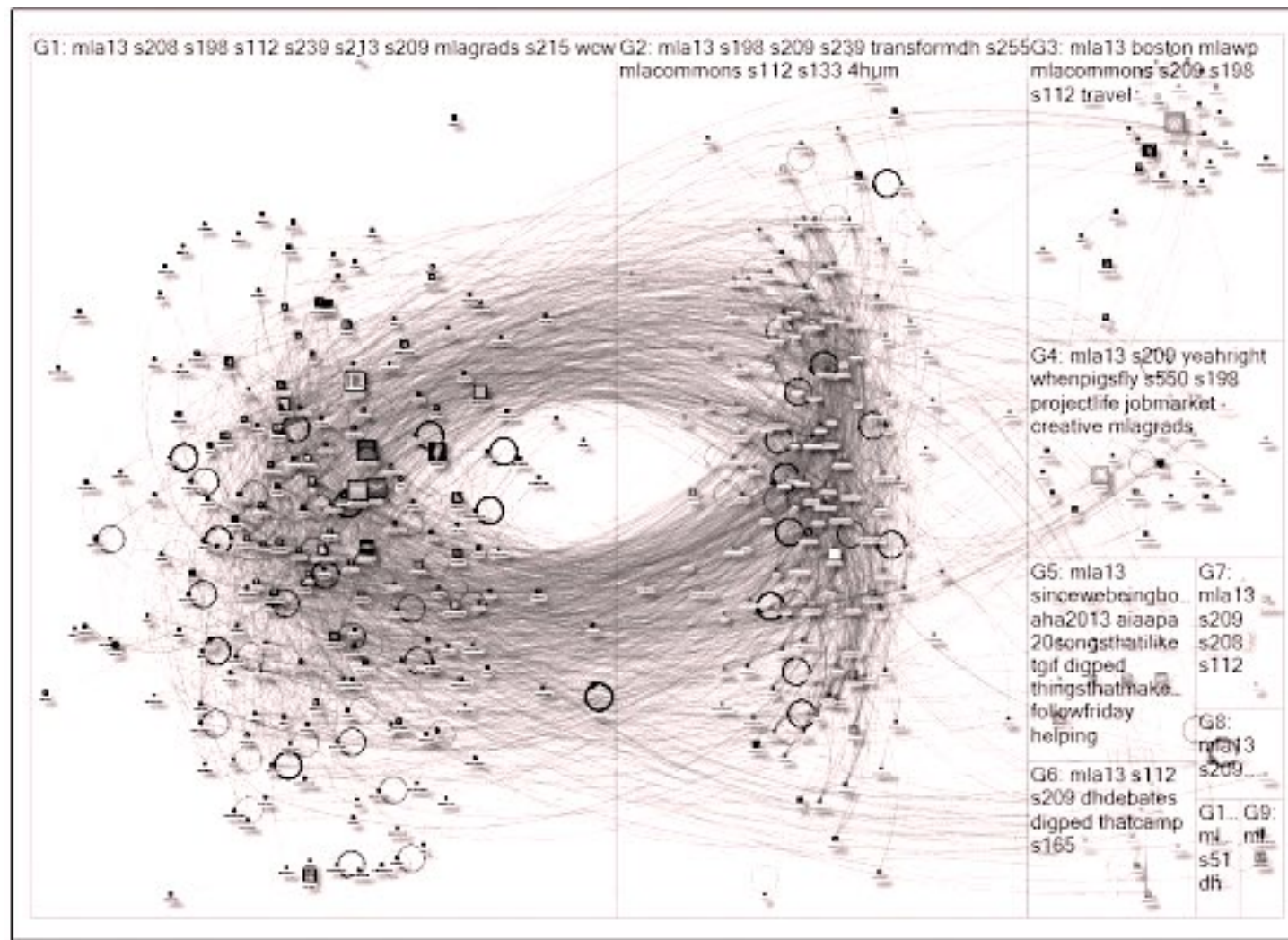


Kosmas L. Tsakmakidis et al. Sci Adv 2018;4:eaag0465

ScienceAdvances

D-branes  
String Theory  
D-branas

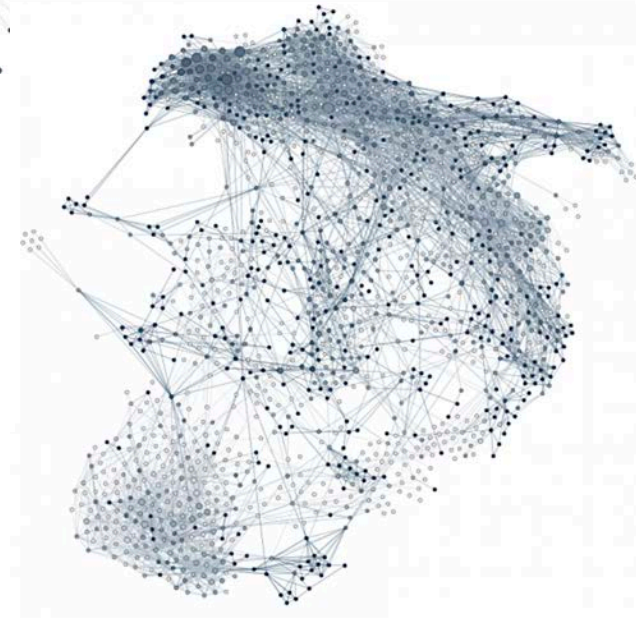
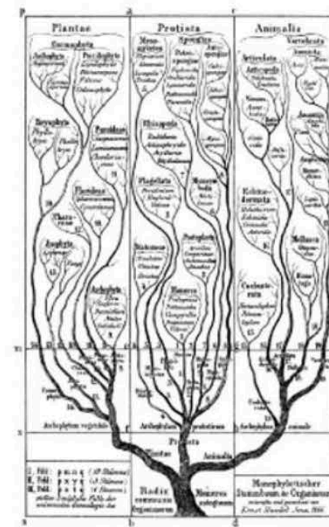
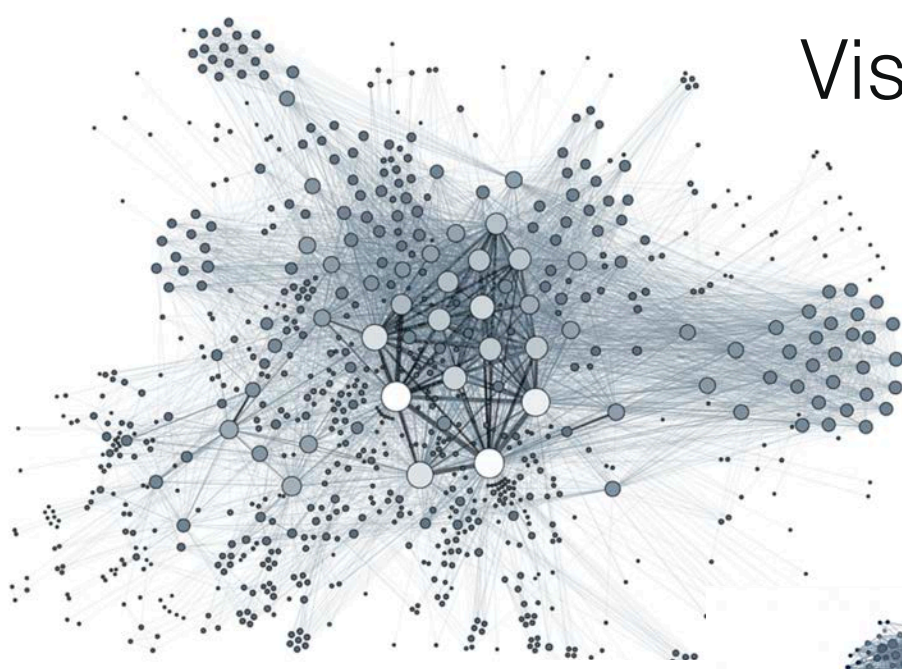




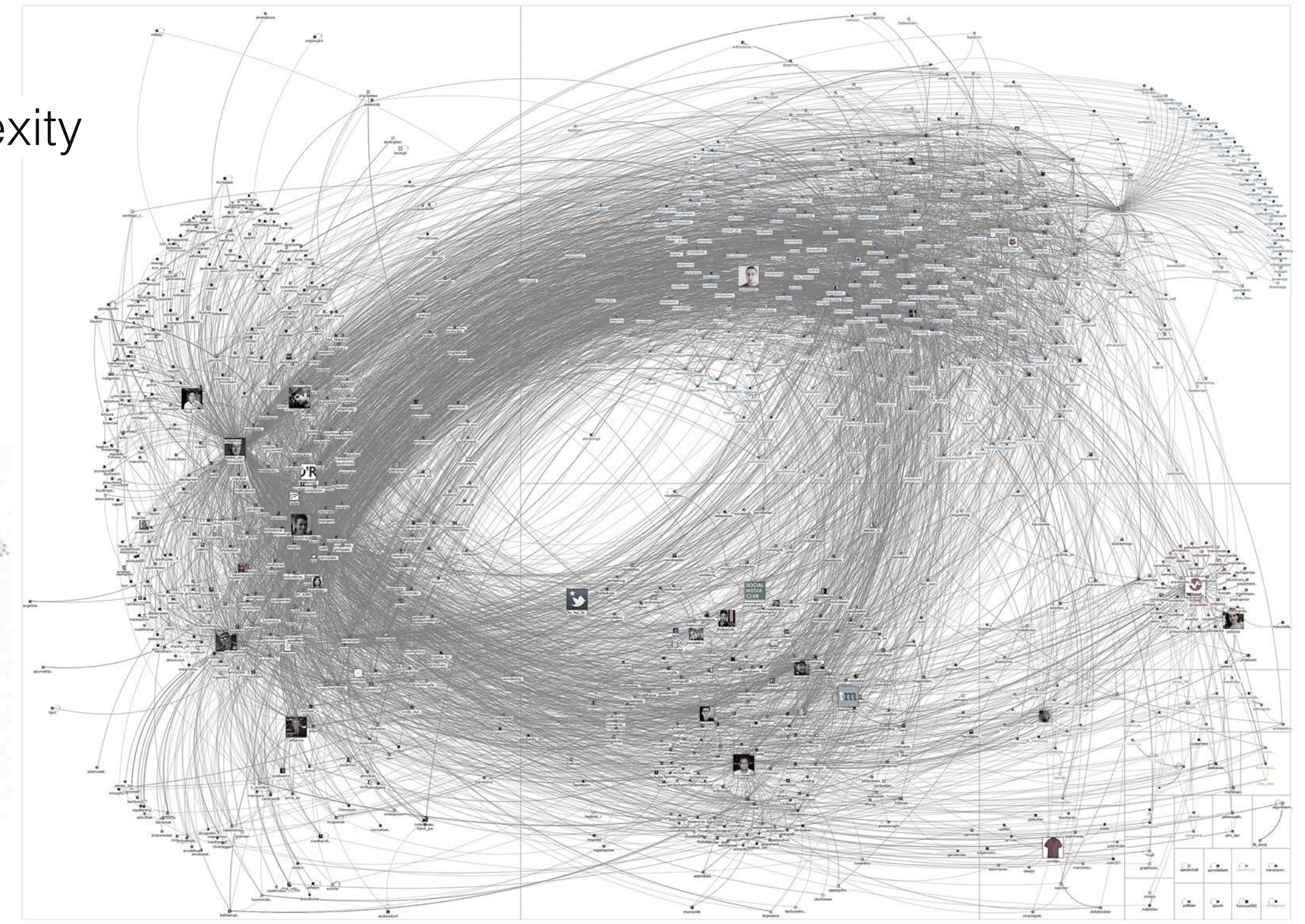
BIG DATA

Mapping Patterns of Information

Visual Complexity



Social media network connections among Twitter users

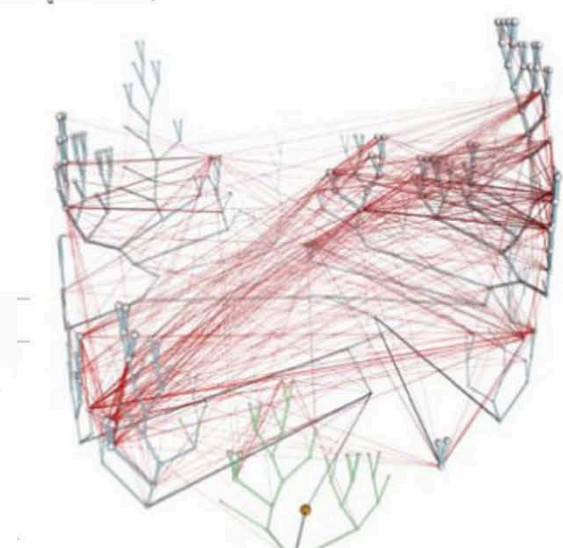
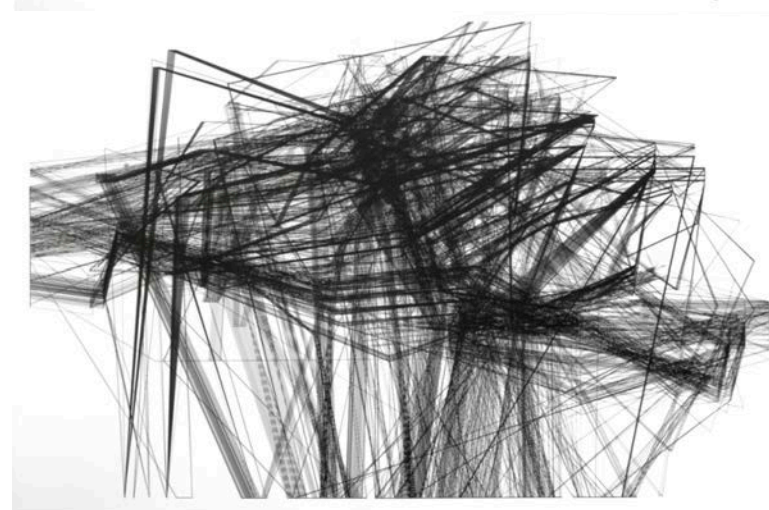
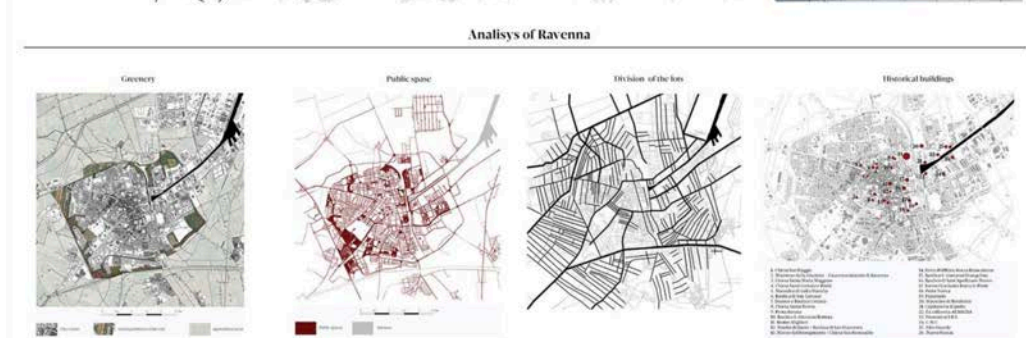
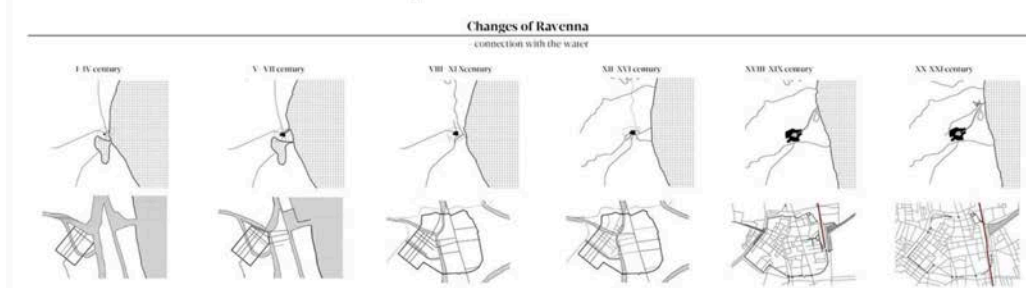
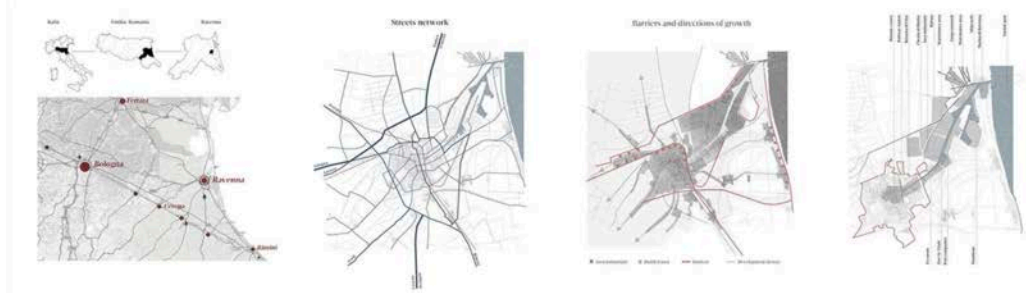


Created with NodeXL (<http://nodexl.codeplex.com>) from the Social Media Research Foundation (<http://www.smfoundation.org>)

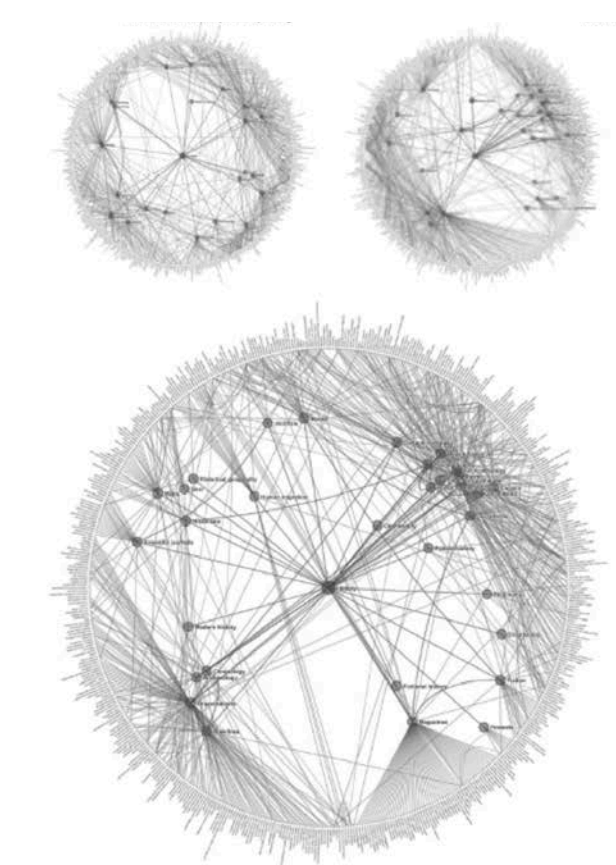
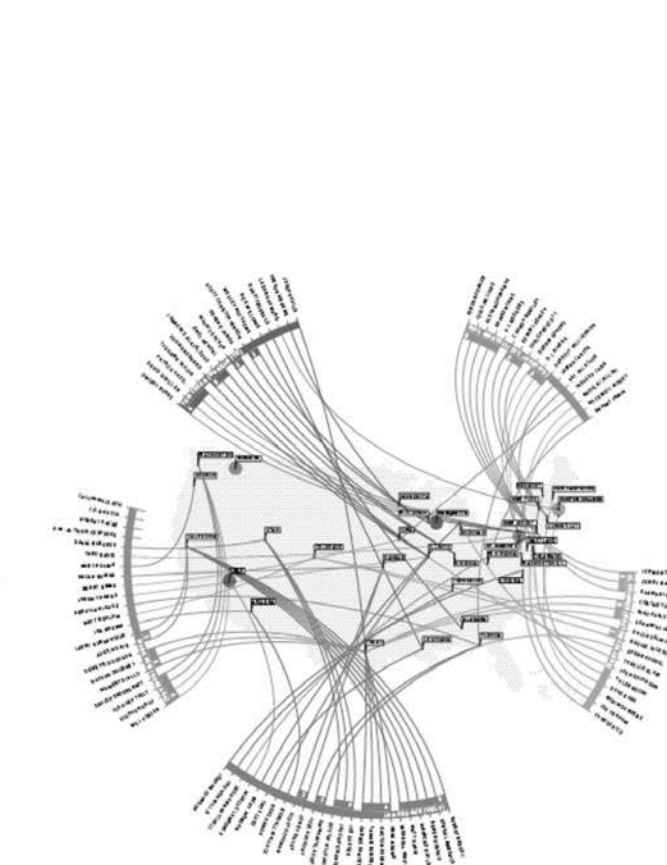
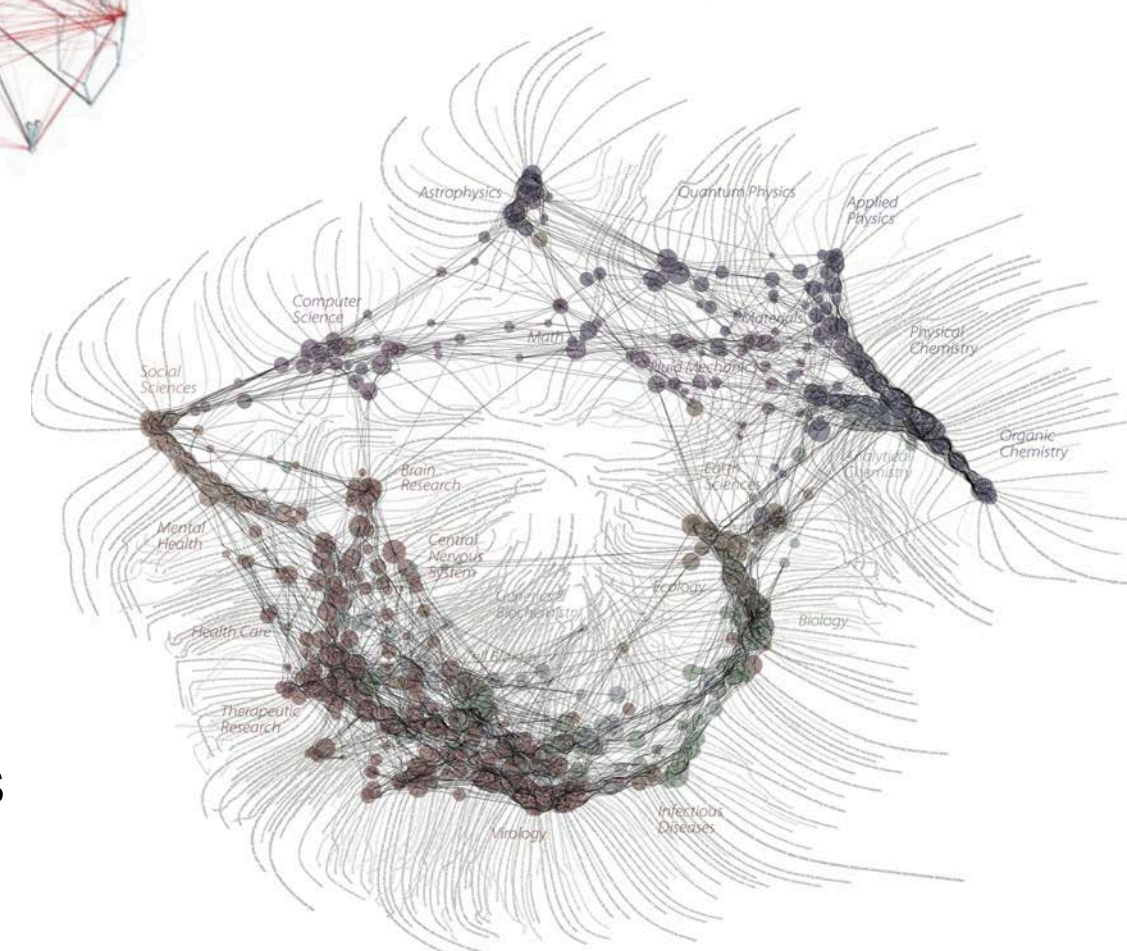
cartographies

patterns

network theory



trajectories  
routes



*On Salvation by Deeds*

by  
Jorge Luis Borges

One autumn, one of the autumns of time, the Shinto divinities gathered, not for the first time, at Izumo. They are said to have numbered eight million. Being a shy man I would have felt a bit lost among so many. In any case, it is not convenient to deal in inconceivable numbers. Let us say there were eight, since eight is a good omen in these islands.

They were downcast, but did not show it: the visages of divinities are undecipherable kanji. They seated themselves in a circle on the green crest of a hill. They had been observing mankind from their firmament or from a stone or from a snowflake. One of the divinities spoke:

Many days, or centuries, ago, we gathered here to create Japan and the world. The fishes, the seas, the seven colors of the rainbow, the generations of plants and animals have all worked out well. So that men should not be burdened with too many things, we gave them succession, issue, the plural day and the singular night. We also bestowed on them the gift of experimenting with certain variations. The bee continues repeating beehives. But man has imagined devices: the plow, the key, the kaleidoscope. He also imagined the sword and the art of war. He has just imagined an invisible weapon which could put an end to history. Before this senseless deed is done, let us wipe out men. They remained pensive. Without haste another divinity spoke: It's true. They have thought up that atrocity, but there is also this something quite different, which fits in the space encompassed by seventeen syllables.

The divinity intoned them. They were in an unknown language, and I could not understand them.

The leading divinity delivered a judgment:

Let men survive. Thus, because of a haiku, the human race was saved.

Izumo, April 27, 1984

DE LA SALVACIÓN POR LAS OBRAS

Jorge Luis Borges

En un otoño, en uno de los otoños del tiempo, las divinidades del Shinto se congregaron, no por primera vez, en Izumo. Se dice que eran ocho millones pero soy un hombre muy tímido y me sentiría un poco perdido entre tanta gente. Por lo demás, no conviene manejar cifras inconcebibles. Digamos que eran ocho, ya que el ocho es, en estas islas, de buen agüero.

Estaban tristes, pero no lo mostraban, porque los rostros de las divinidades son kanjis que no se dejan descifrar. En la verde cumbre de un cerro se sentaron en rueda. Desde su firmamento o desde una piedra o un copo de nieve habían vigilado a los hombres. Una de las divinidades dijo:

- Hace muchos días, o muchos siglos, nos reunimos aquí para crear el Japón y el mundo. Las aguas, los peces, los siete colores del arco, las generaciones de las plantas y de los animales, nos han salido bien. Para que tantas cosas no los abrumaran, les dimos a los hombres la sucesión, el día plural y la noche una. Les otorgamos asimismo el don de ensayar algunas variaciones. La abeja sigue repitiendo colmenas; el hombre ha imaginado instrumentos: el arado, la llave, el calidoscopio. También ha imaginado la espada y el arte de la guerra. Acaba de imaginar un arma invisible que puede ser el fin de la historia. Antes que ocurra ese hecho insensato, borremos a los hombres.

Se quedaron pensando. Otra divinidad dijo sin apuro:

- Es verdad. Han imaginado esa cosa atroz, pero también hay ésta, que cabe en el espacio que abarcan sus diecisiete sílabas.

Las entonó. Estaban en un idioma desconocido y no pude entenderlas.

La divinidad mayor sentenció:

- Que los hombres perduren.

Así, por obra de un haiku, la especie humana se salvó.

Izumo, 27 de abril de 1984.

kanso  
shizen  
shibui  
yugen  
datsuzoku  
fukinsei



Keith Jarrett



*La pila de arena, el rio y la piedra...*  
The pile of sand, the river and the stone...



fluid dynamics  
system criticality

*Thom*  
Structural  
Stability and  
Morphogenesis  
  
René Thom



Tokyo, 1984



exploring the invisible



THE FRONTIERS COLLECTION

Wouter Schmitz

**PARTICLES,  
FIELDS AND  
FORCES**

A Conceptual Guide to  
Quantum Field Theory  
and the Standard Model

**D-branes**



Eric Maria Couturier ( Helmut Lachenmann - Pression)

Eric Maria Couturier ( Vinko Globokar - Corporel)

New York Philharmonic concert of April 6, 1962  
incredible story of that moment (risk)



Philippe Petit

The Word Trade Center's twin towers, August 7 th, 1974



Man on wire



Keith Jarrett

Photo © Henry Leutwyler/ECM Records

live improvisation

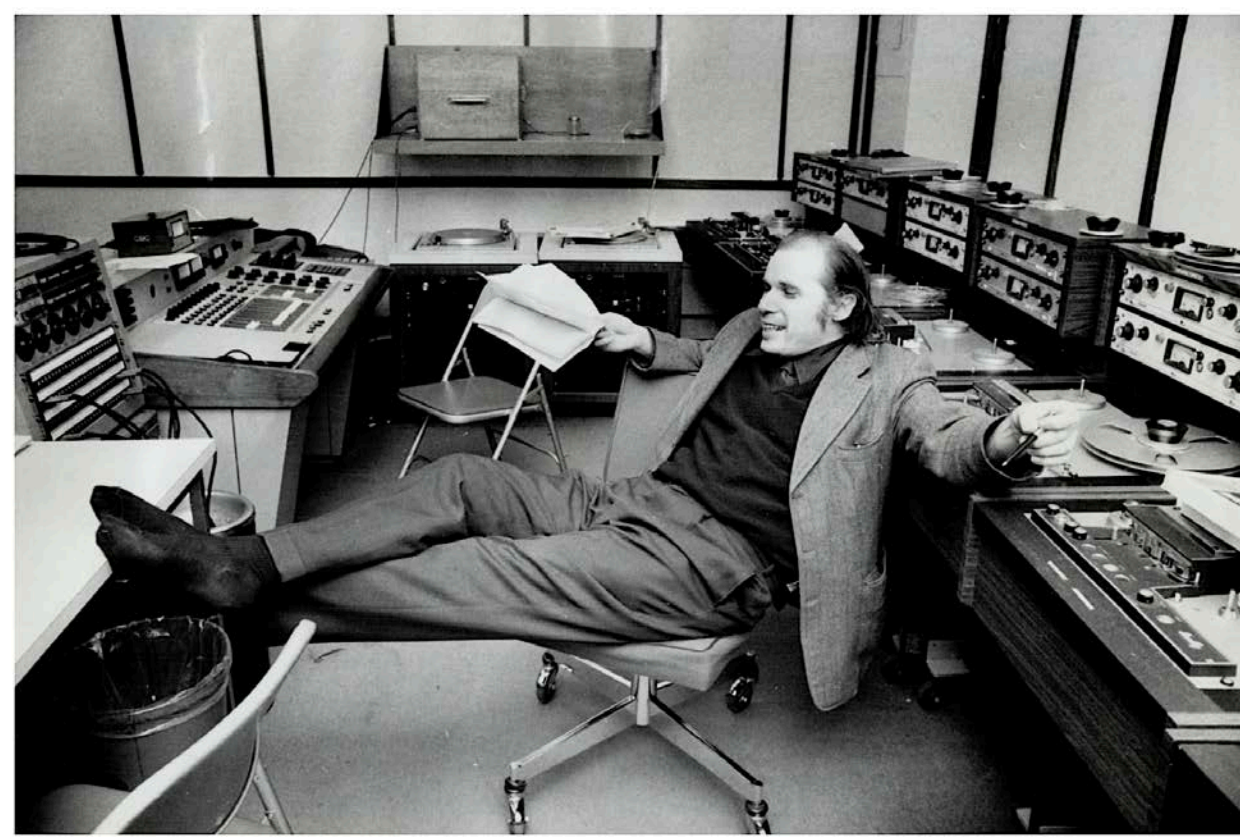
awareness of the moment

Live / studio

There is a beautiful tension between these concepts

Espontáneo ← Idea de montaje / edición / construcción

Conciencia del instante



Glenn Gould is devoted to the recording studio as a hermit to a cave - and usually without shoes. November 26th, 1973.  
Ron Bull/Toronto Star via Getty



Glenn Gould

record studio edition

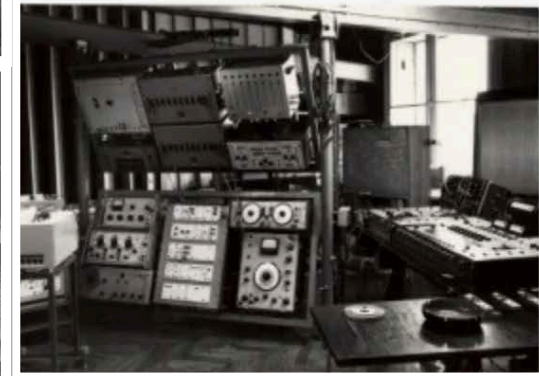
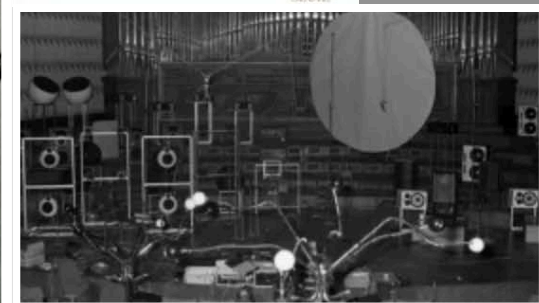
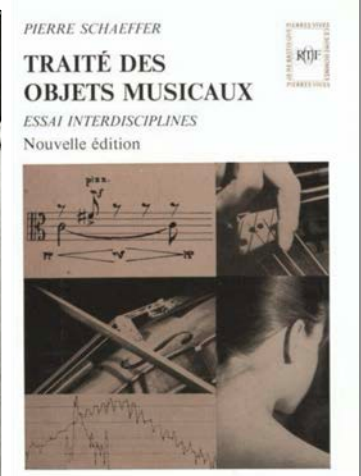


edition

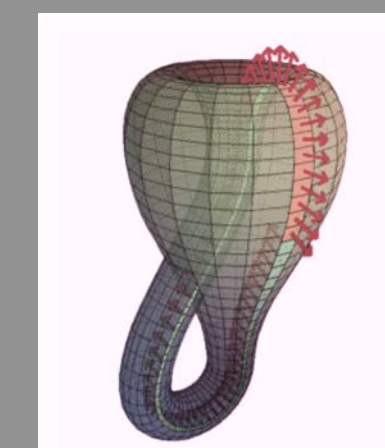
The performatic chair / The quantum chair



Grouppe de Recherches Musicales



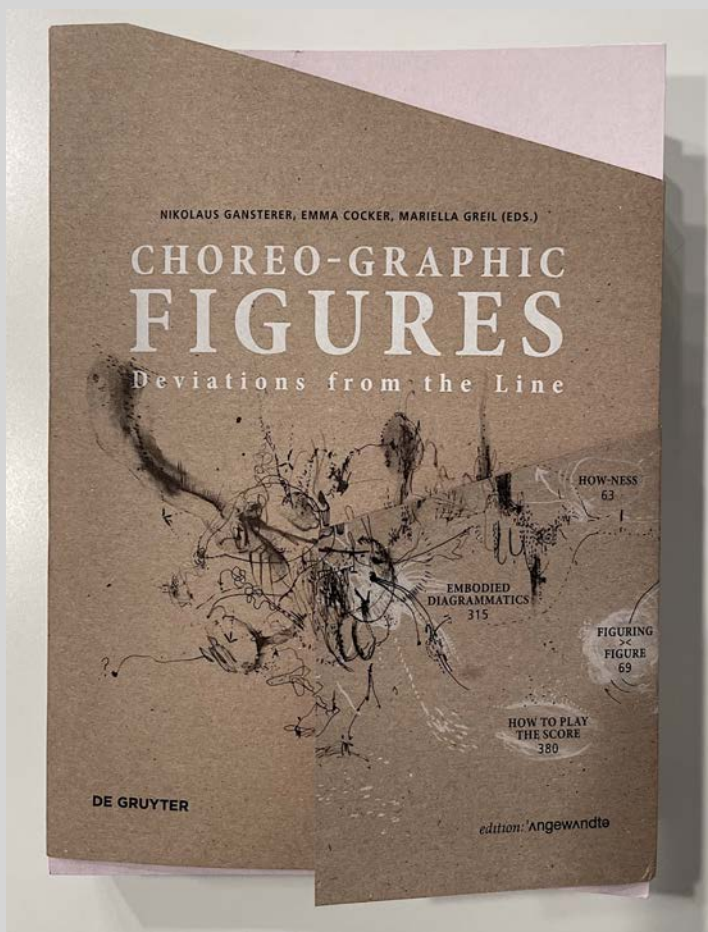
GRM



klein bottle



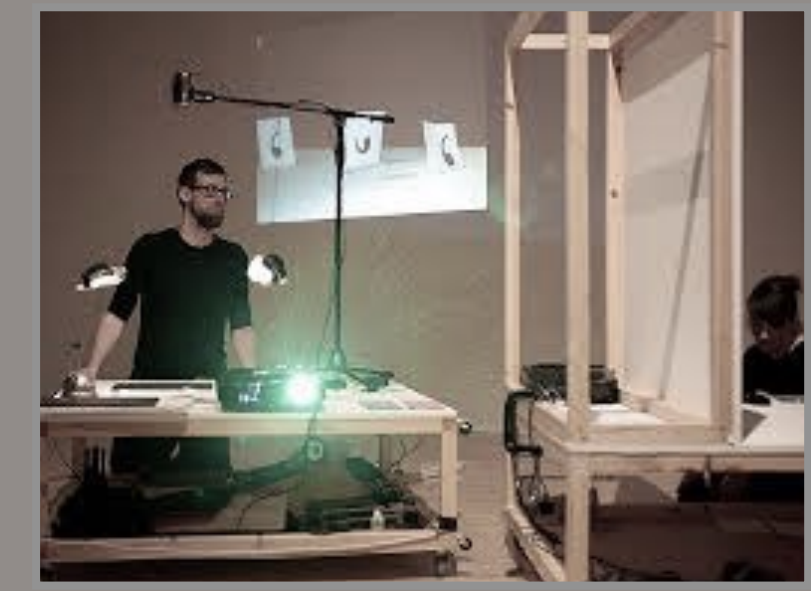




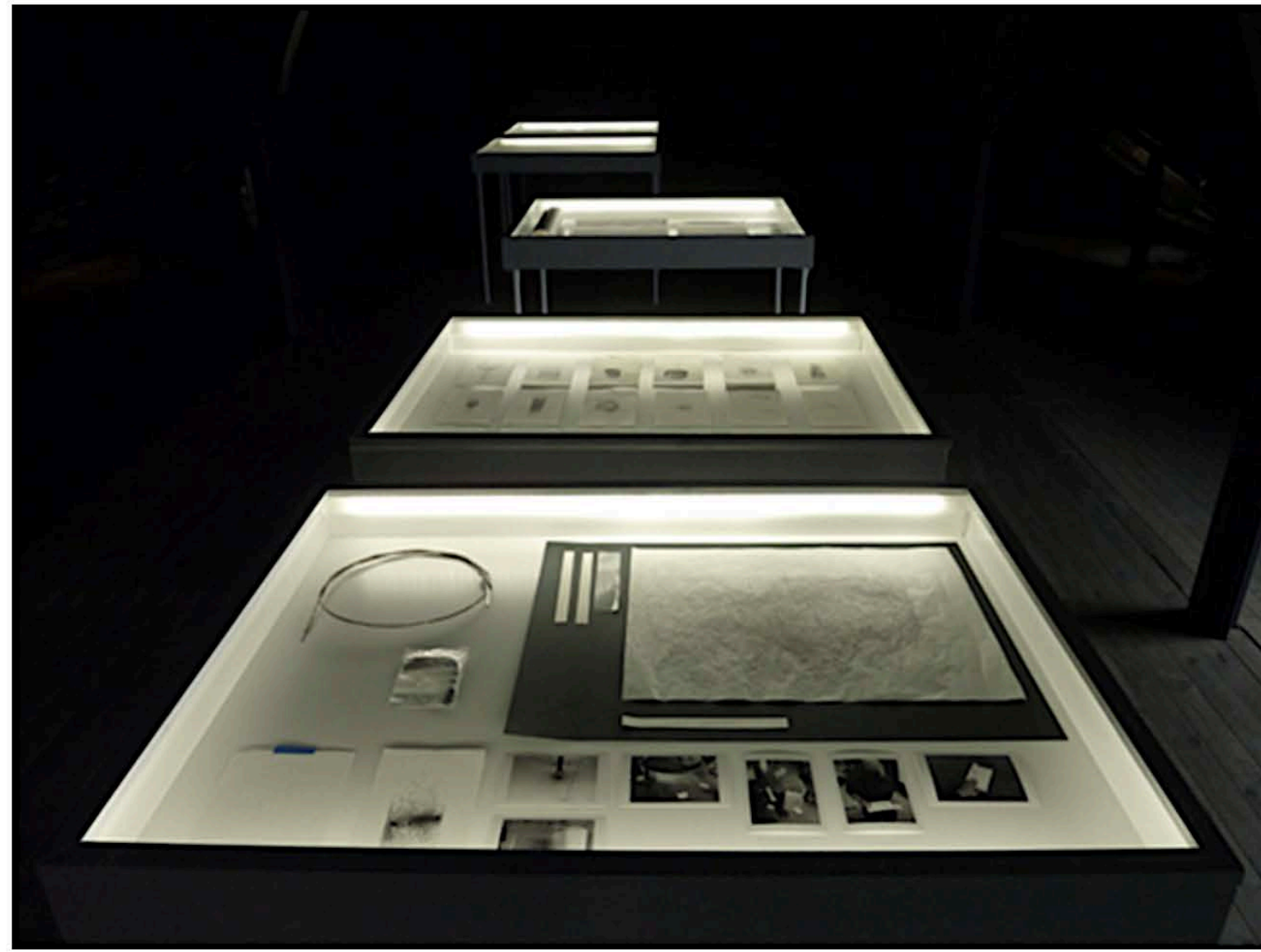
Nikolaus Gansterer



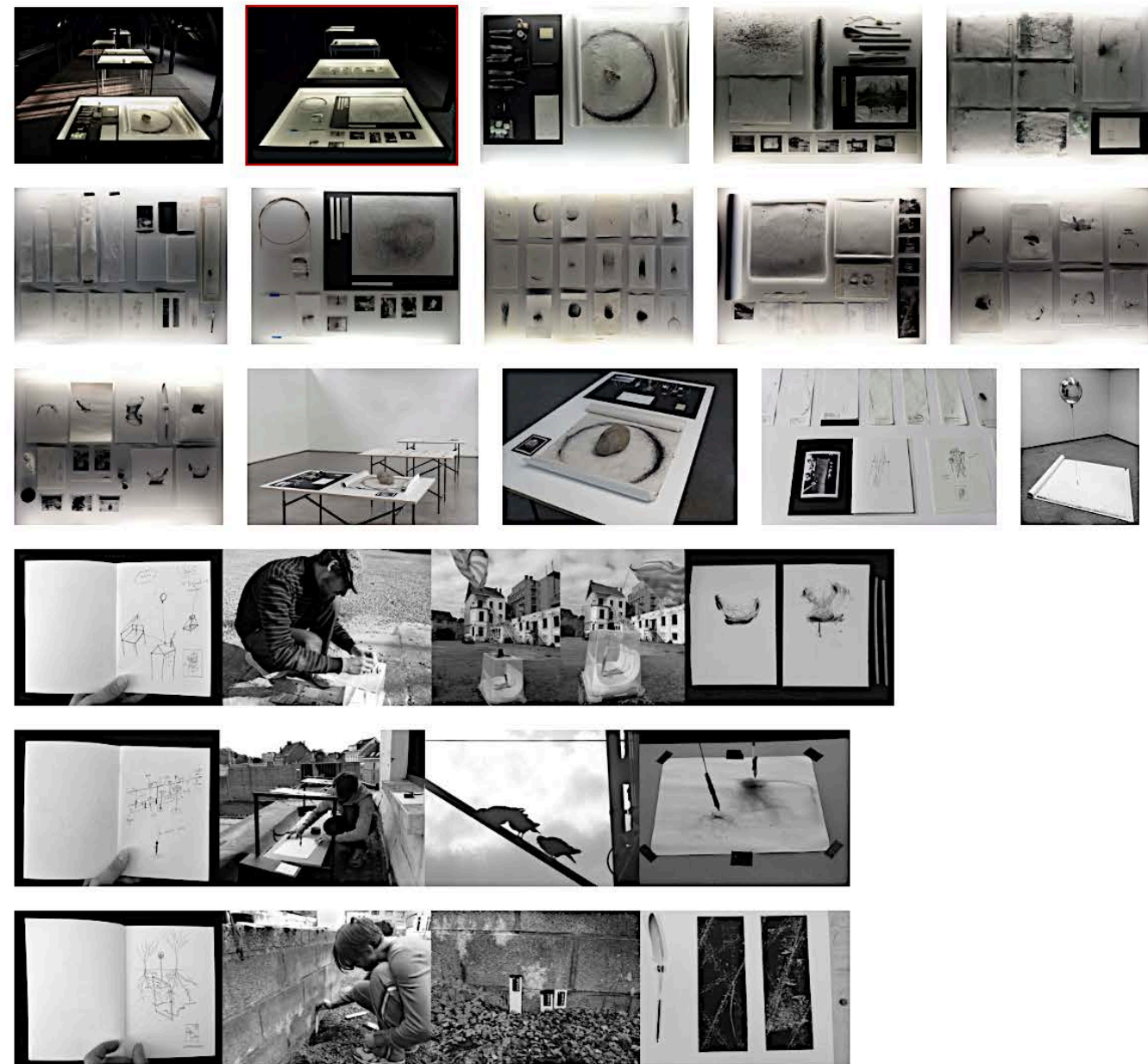
CHOREO-GRAPHIC FIGURES: DEVIATIONS FROM THE LINE



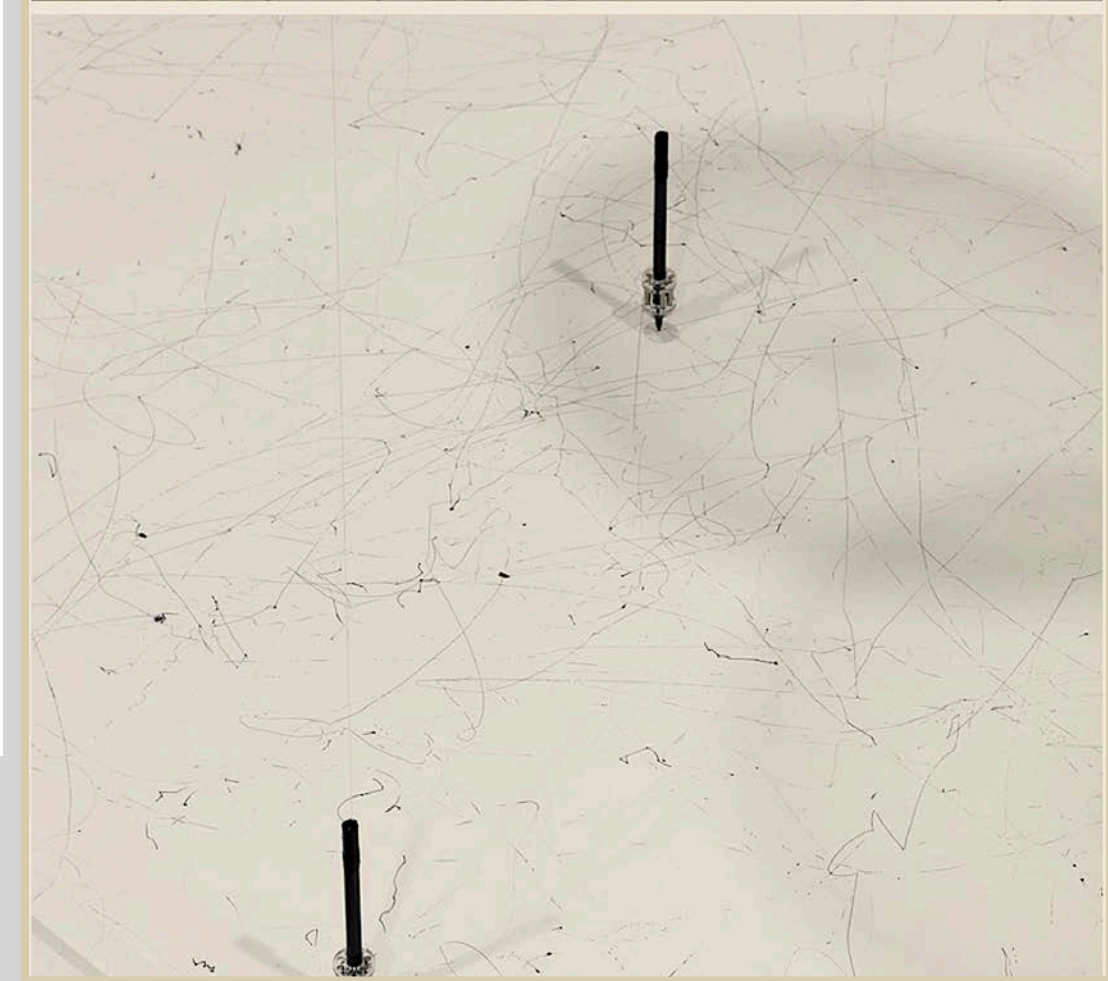
TRACES OF SPACES



Installation view, Traces of Spaces, Vooruit Art Centre, Gent, Belgium, 2011



Tomás Saraceno, Aerographies



A project for several mapping stations in and outside.

The artist Nikolaus Gansterer has a deep interest in the links between drawing, thinking and action. While having had an ongoing practice of mappings and diagrams, in his recent project he is focussing on the exploration of expanded drawing.

Is it possible to let the inherent dynamics of space be recorded, mapped and drawn by themselves? Therefore, dynamic things in public space such as trees, wind, insects, etc., are tested to become drawing tools, capturing unique described movements. Thus, for example, a writing tool suspended inside hardware inscribes on a paper the wave movement of a canal, drawing instruments held on stretched ropes are pressed onto paper by birds sitting on the ropes, papers attached to street cars brush through the city or even plain papers get buried in the park becoming a test field for microbial activities: All of these experiments offering a very specific insight on the otherwise invisible traces of the urban spaces. Each of the drawing stations distributed in the city is its own performative spot at which the observer can follow the process.

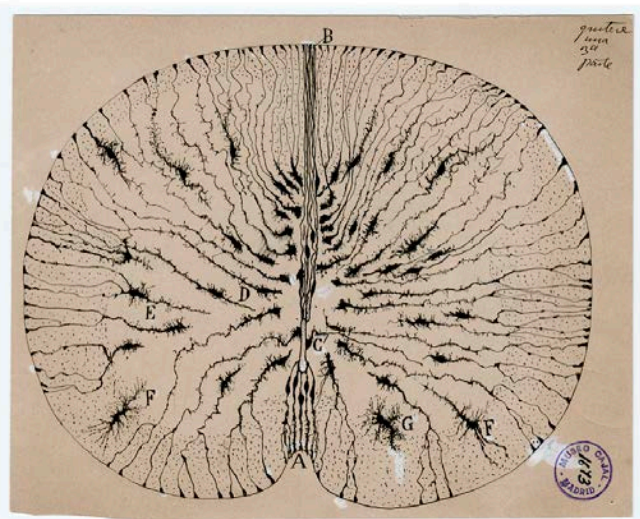
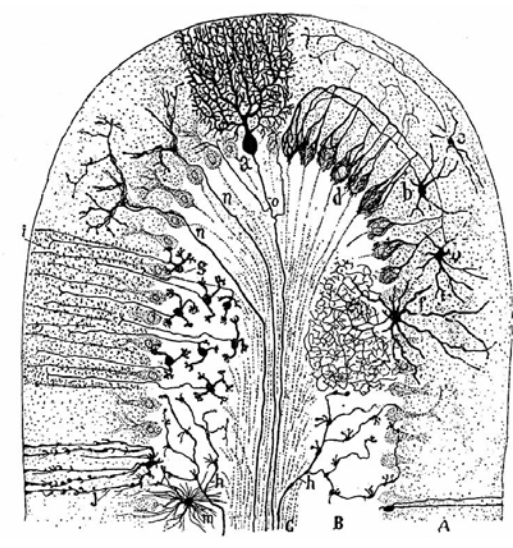
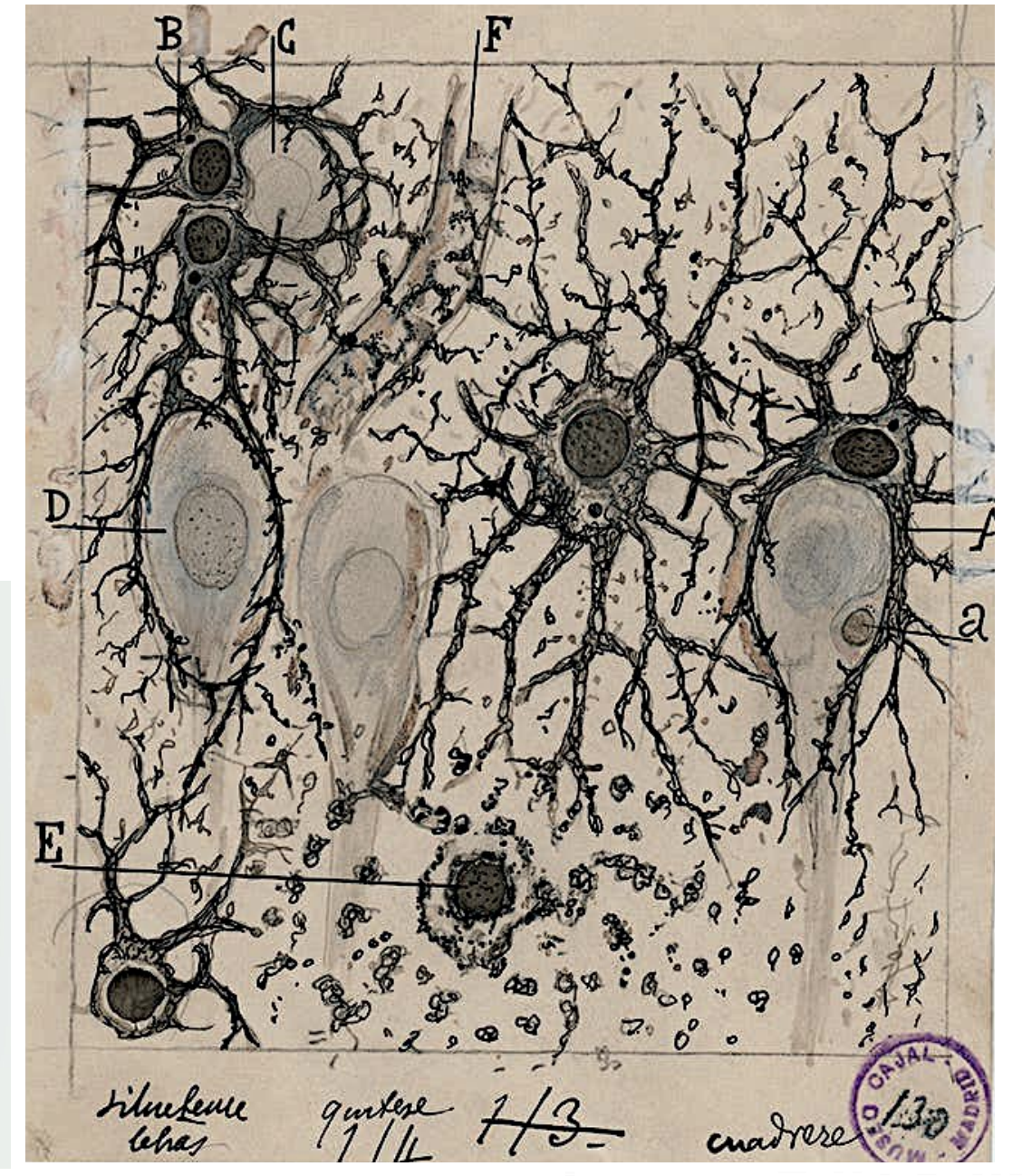
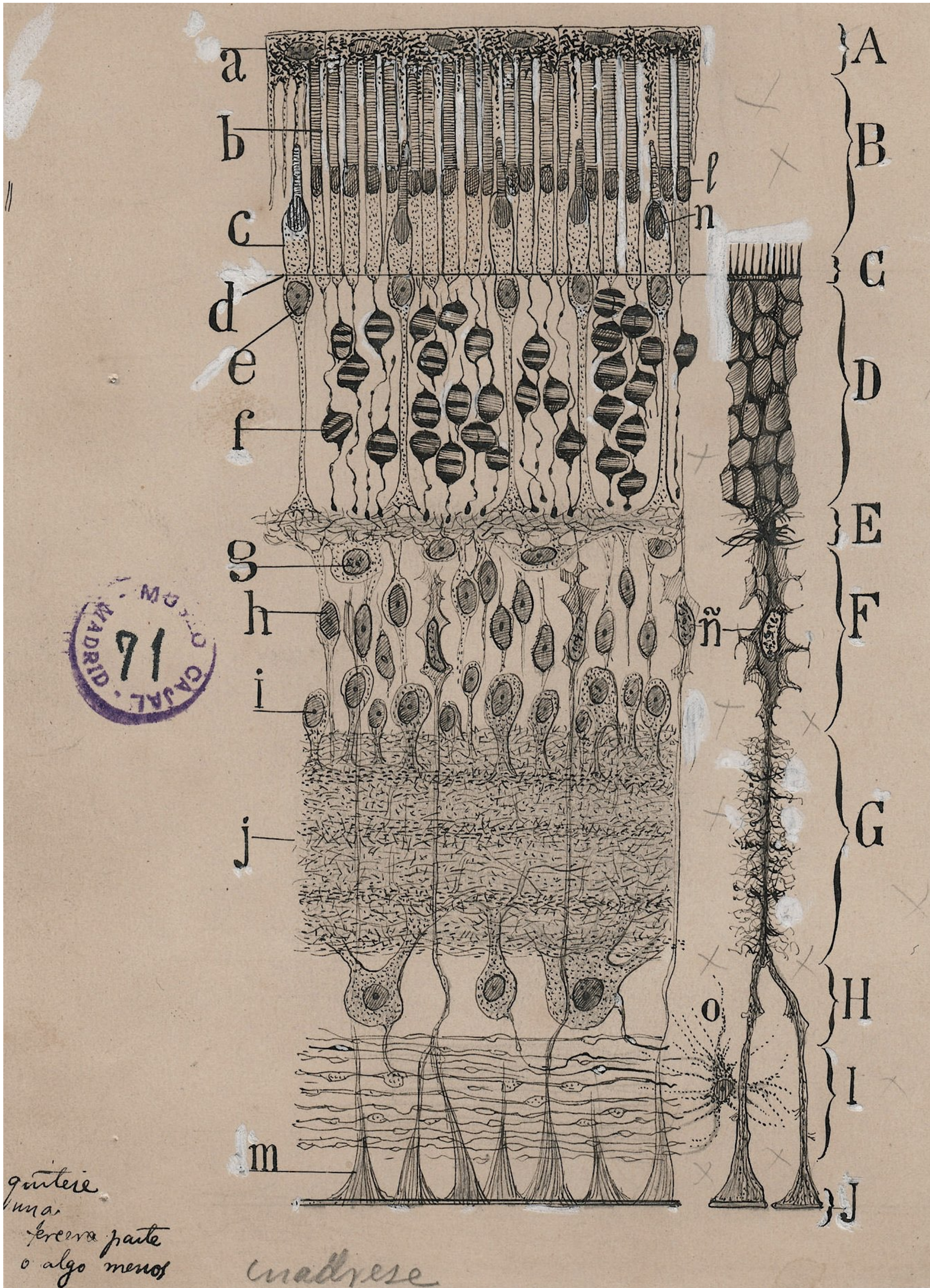
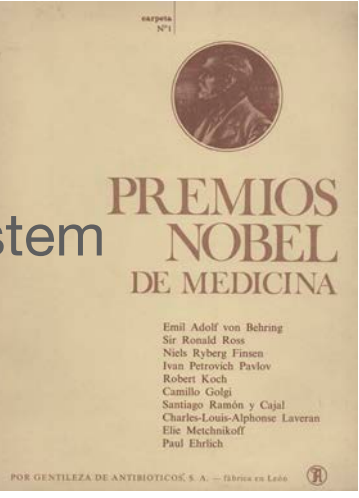


Santiago Ramón y Cajal

1852-1934

neuroscience

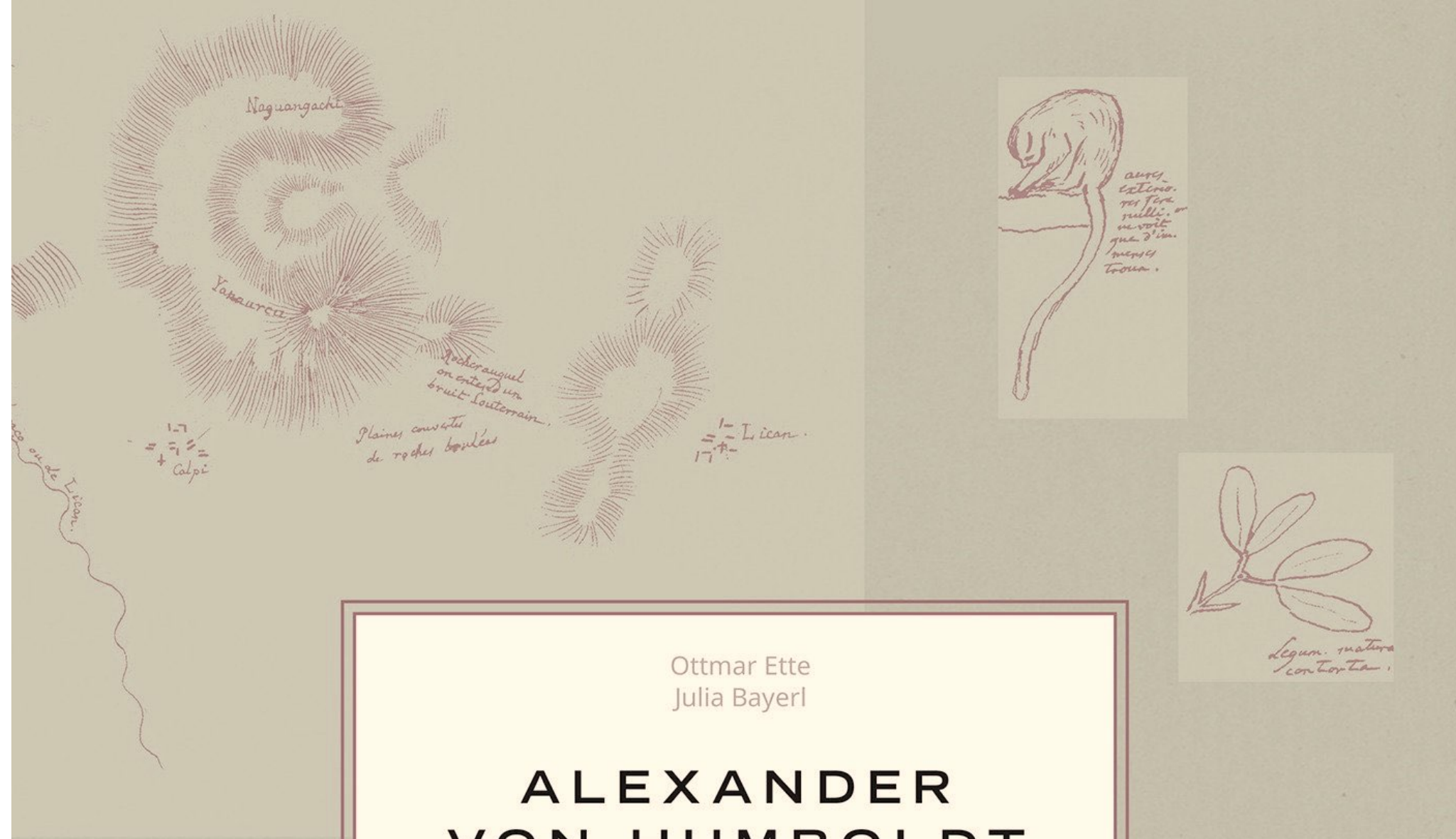
nervous system  
1906



Santiago Ramón y Cajal. Glial cells of the mouse spiral cord, 1899. Ink and pencil on paper, 5 7/8 x 7 1/8 in. Credit: Cajal Institute (CSIC), Madrid

*quiere una tercera parte o algo menos madrese*

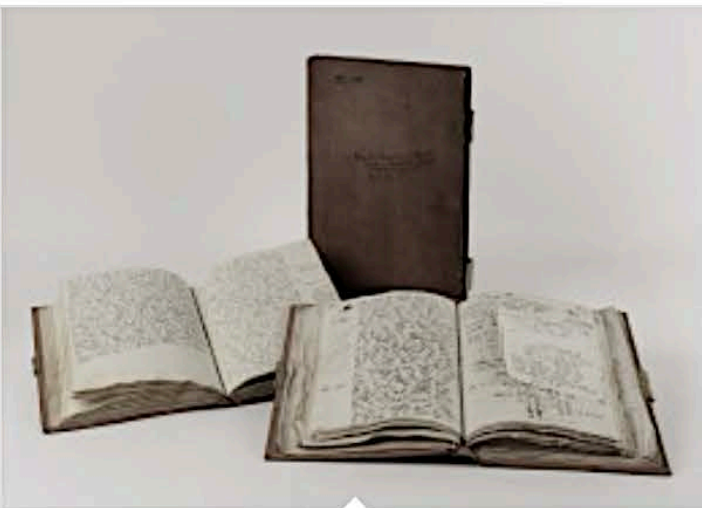
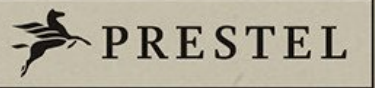
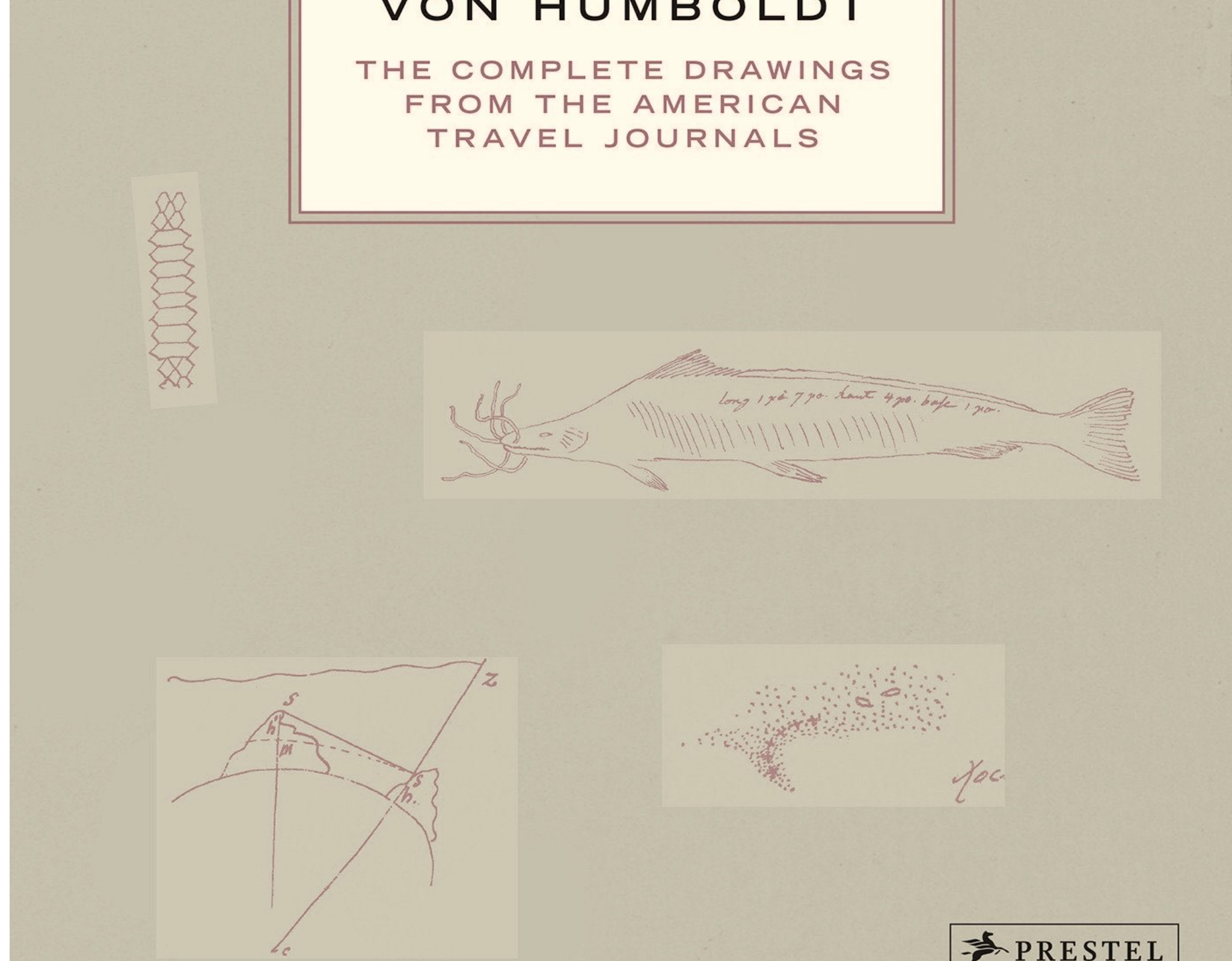
The purpose which guided him was not impossible, though supernatural. He wanted to dream a man; he wanted to dream him in minute entirety and impose him on reality.  
...El propósito que lo guiaba no era imposible, aunque sí sobrenatural. Quería soñar un hombre: quería soñarlo con integridad minuciosa e imponerlo a la realidad.



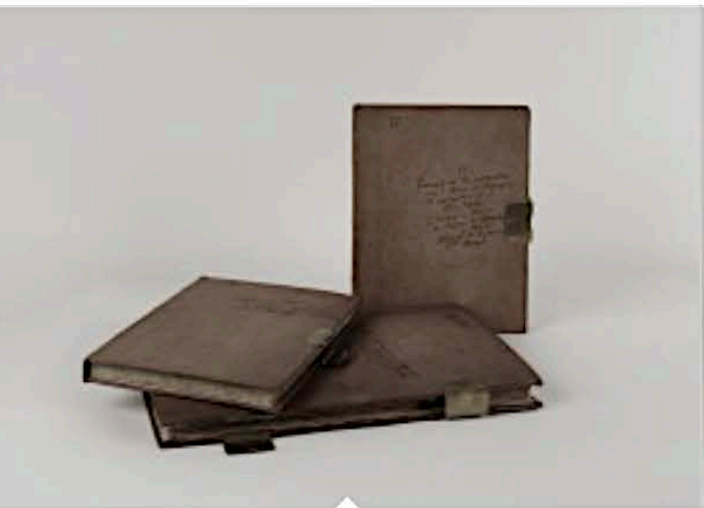
Ottmar Ette  
Julia Bayerl

# ALEXANDER VON HUMBOLDT

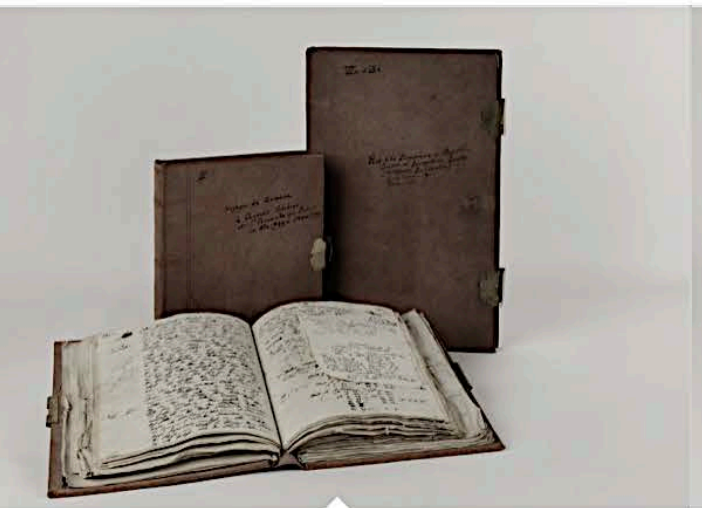
## THE COMPLETE DRAWINGS FROM THE AMERICAN TRAVEL JOURNALS



Journal I June to October 1799



Journal II and VI 1798-1805



Journal III 1799-1800



Journal IV 1800



Journal V 1797, 1799-1800



Journal VII a/b 1801-1802



Journal VII bb/c 1801-1802



Journal VIII 1802-1804



Journal IX 1803-1804

288 — SURFACE AND INTERIOR OF THE EARTH

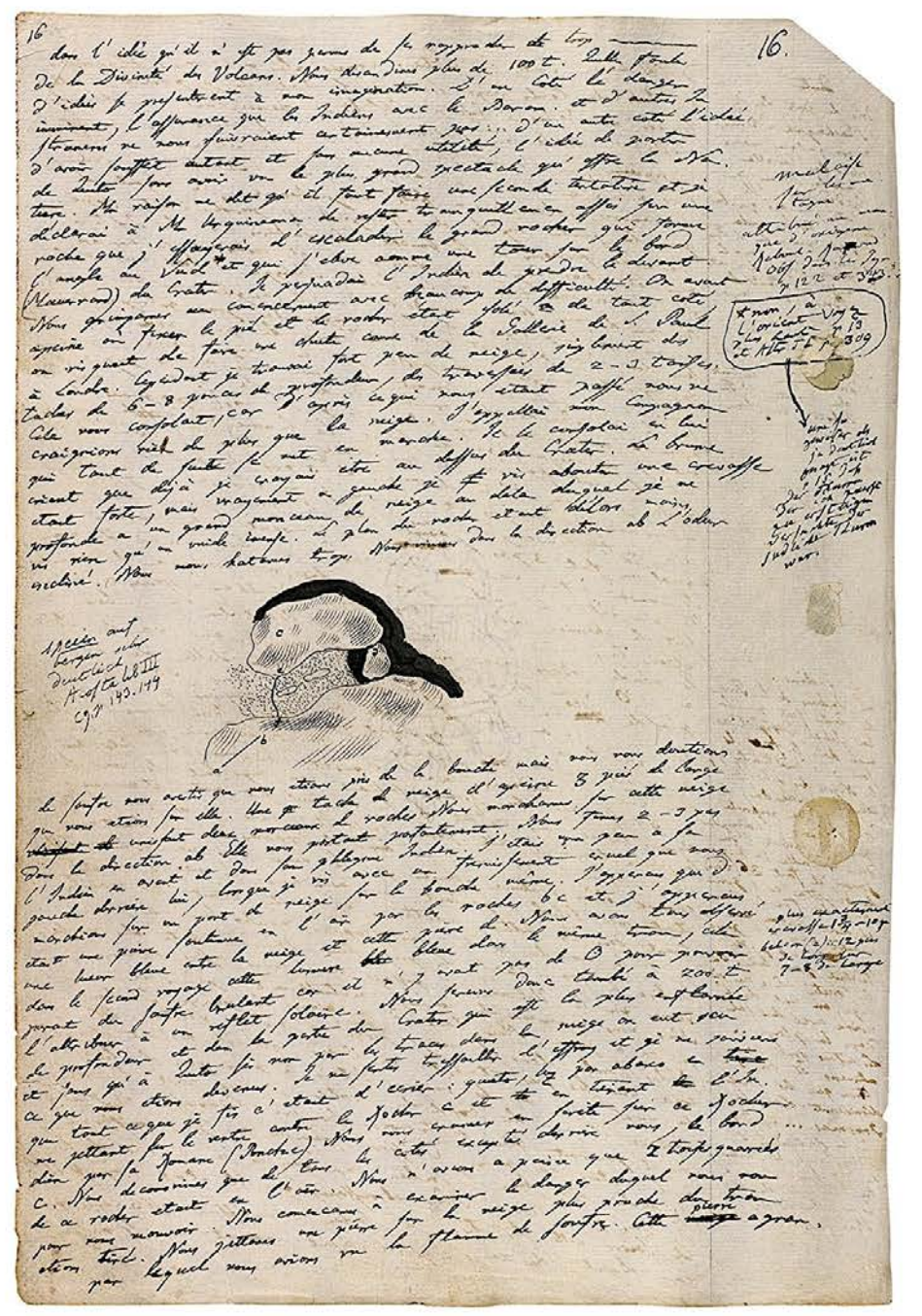
294

Choreography (m.) of the crossing of snow-covered rocks above the crater of the volcano Pichincha (Viceroyalty of New Granada), May 26, 1802

Ink on paper, 308 x 211 mm, Diary VIIIb & VIIIc, p. 16, 10 v

CARTOGRAPHY OF MOUNTAINS AND RIVERS — 289

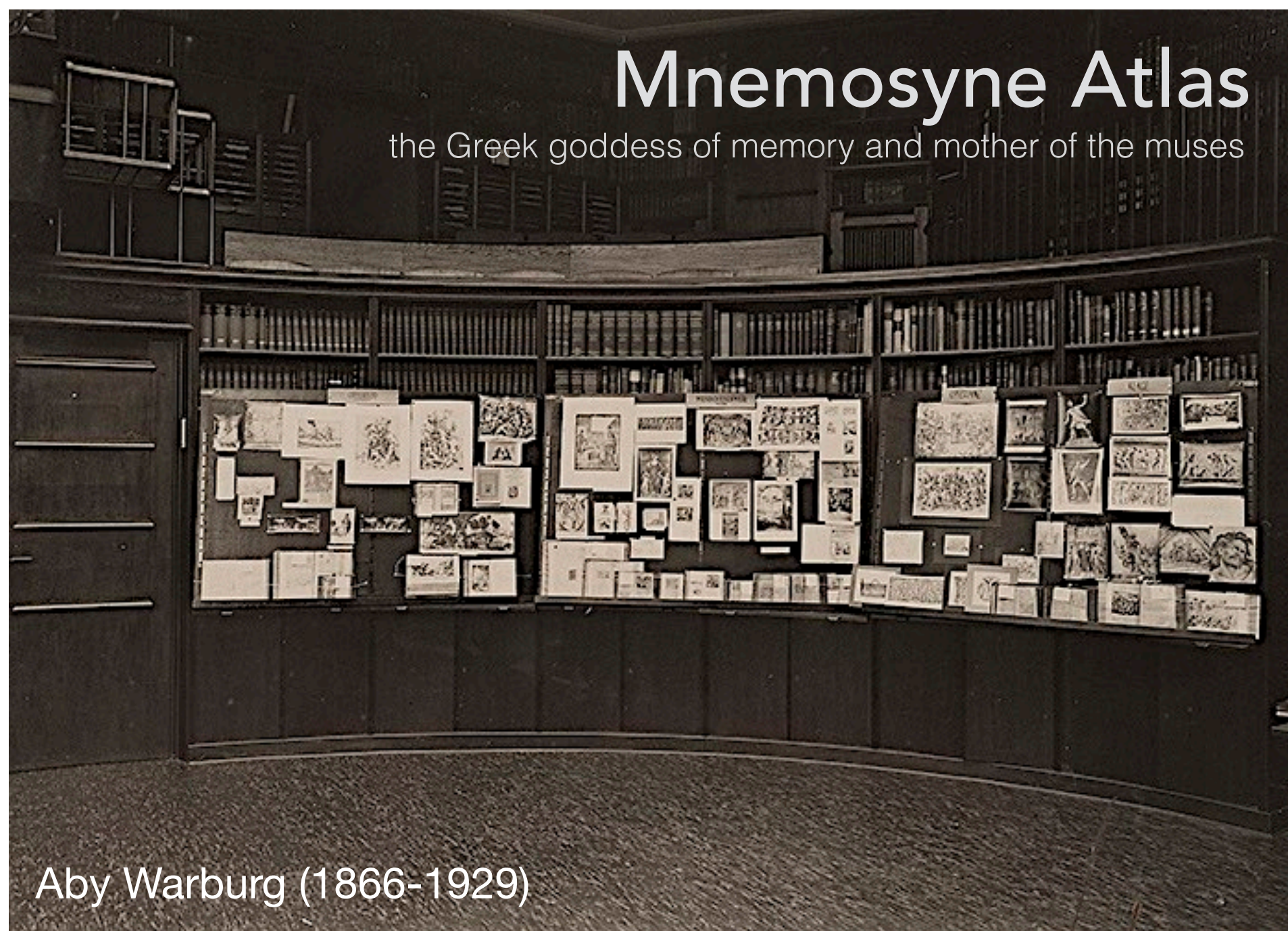
"There were barely any footholds, and because the rock stood by itself on all sides, one risked a fall comparable to one from the gallery of Saint Paul's Cathedral in London. But I came across very little snow, only 6-8-inch patches, passageways of 2-3 toises. This comforted us, because after what we had experienced, we feared nothing more than snow. I called out to my companion, who moved at once. I consoled him by calling out to him that I believed I was already above the crater. The fog was thick, but to the left I saw a really deep crevice next to a larger pile of snow, across which there was nothing but an endless expanse. From that point on, the area of the rock was less declivitous. We hurried too much. We looked down in that direction. The smell of sulphur announced that we had reached the crater, but we doubted that we were above it. A snowy area barely three feet wide connected two boulders. We crossed this snow in the direction ab. It carried us completely. We took two to three steps. The Indian went first, and in his Indian stolidness, I was behind him slightly to his left when I realized with a shudder that we were walking on a snow bridge above the crater itself. I noticed that it was a stone that was held up in the air by the rocks bc, and I noticed a blue light between the snow and this stone d. During the second expedition, all of us saw this blue light in the same hole; it seemed to be burning sulphur, because there was no sun to whose reflection to attribute it. We would thus have fallen 200 toises deep and into the crater's most inflamed part, and without anyone in Quito knowing what had become of us, unless one had found our tracks in the snow. I felt myself tremble with fright, and I remember that all I did was cry out: 'Do not move, below is light,' while at the same time throwing my stomach against rock and pulling the Indian back by his ruana (poncho). We believed we were safe on this rock c. [...] We began to test the danger from which we had escaped. We threw a stone into the snow that was closest to the hole through which we had seen the sulphur flame. The stone widened the hole, and we made sure that we had walked across a crevice between the two rocks b and c and that a sheet of frozen snow 8 inches thick had held us. We believed that this crevice reaches only to e, because from there to the left we had not been able to penetrate the snow, and we think that there, rock c connects with rock b."





# Mnemosyne Atlas

the Greek goddess of memory and mother of the muses



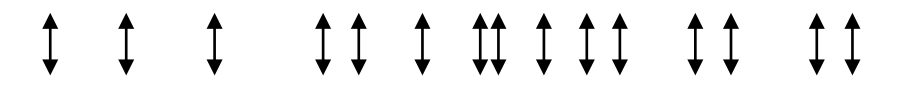
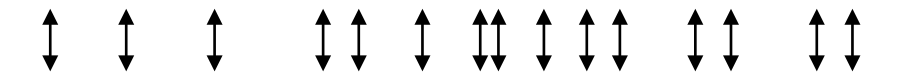
Aby Warburg (1866-1929)

The Atlas (unfinished) consisted of 63 panels, on which he laboriously organized sequences of close to 1,000 black-and-white reproductions

I think it is a beautiful idea, and the first methodological attempt of diagonal thinking

for me... the first fuzzy sets in history

Pensar distinto...





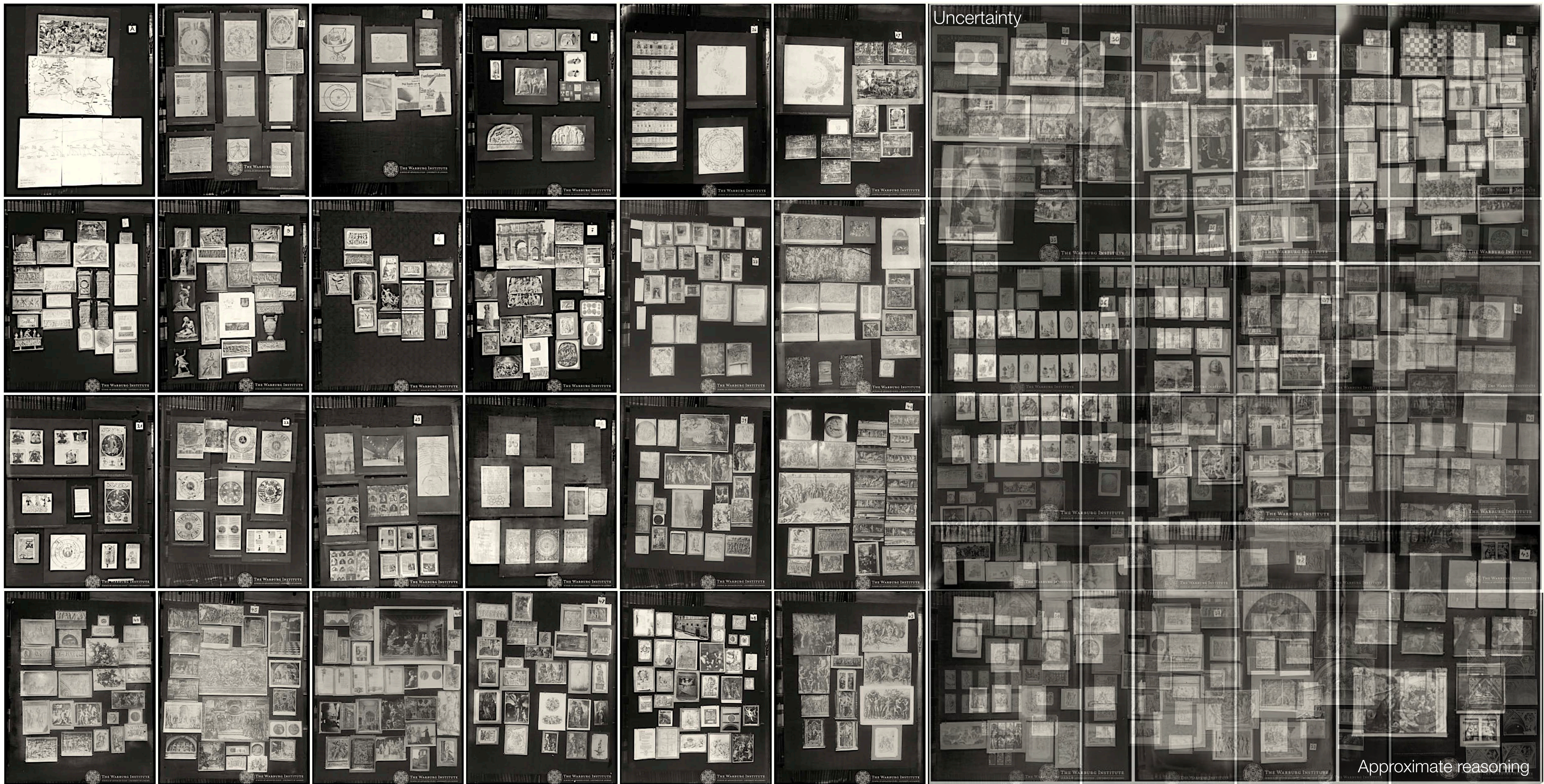
The Library of Babel  
J.L. Borges

Library is *unlimited and periodic*. If an eternal traveler should journey in any direction, he would find after untold centuries that the same volumes are repeated in the same disorder (which, repeated, becomes order: the Order). My solitude is cheered by that elegant hope.  
La biblioteca es *ilimitada y periódica*. Si un eterno viajero la atravesara en cualquier dirección, comprobaría al cabo de los siglos que los mismos volúmenes se repiten en el mismo desorden (que, repetido, sería un orden: el Orden). Mi soledad se alegra con esa elegante esperanza.





Aby Warburg, Mnemosyne Atlas, 1924–29, panel 32 and 39. All panels have been reconstructed from the Warburg Institute Archive. Courtesy: The Warburg Institute, London; photograph: Wootton/Fluid



Warburg x Warburg  $\approx$  Zadeh