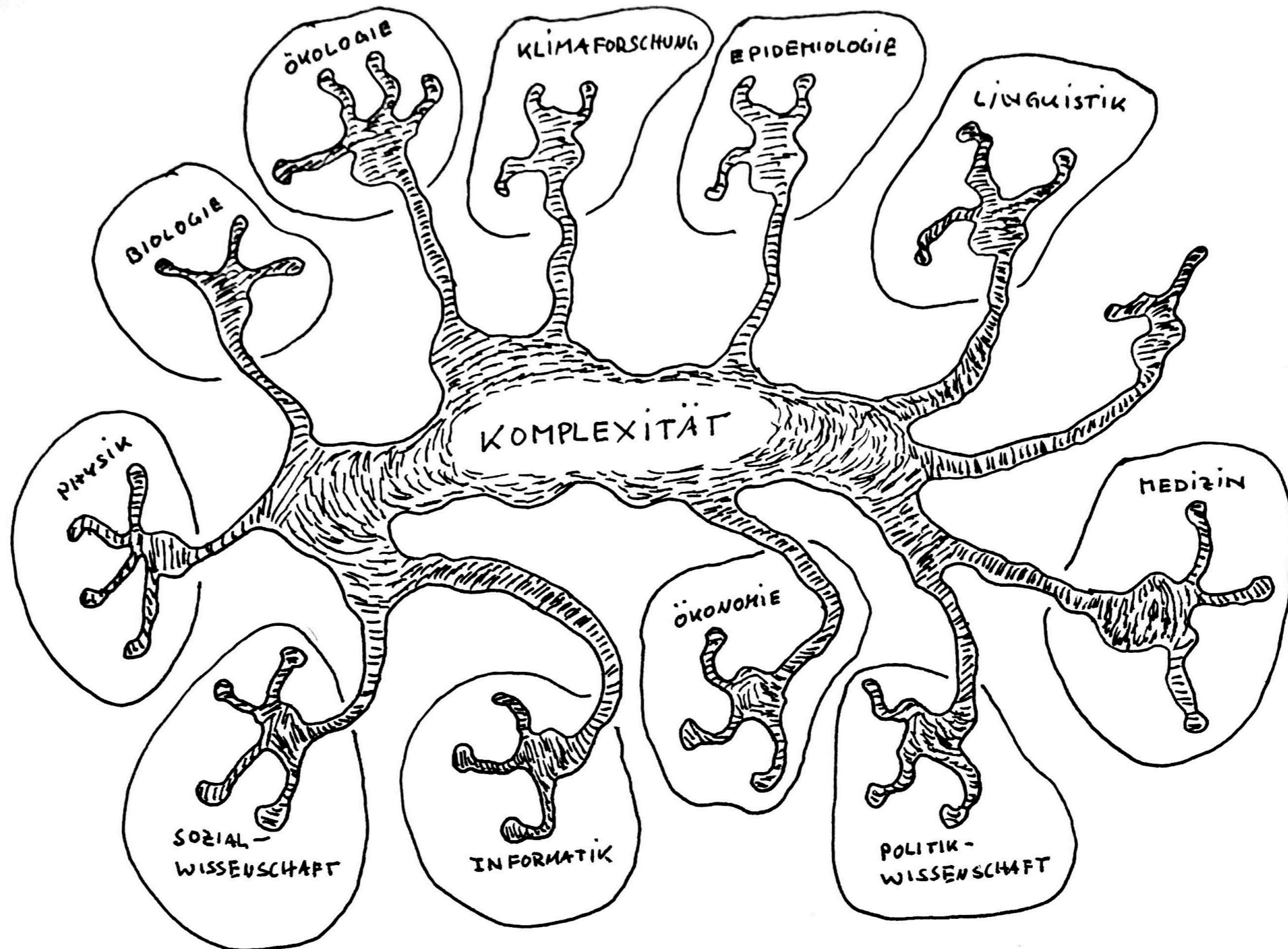
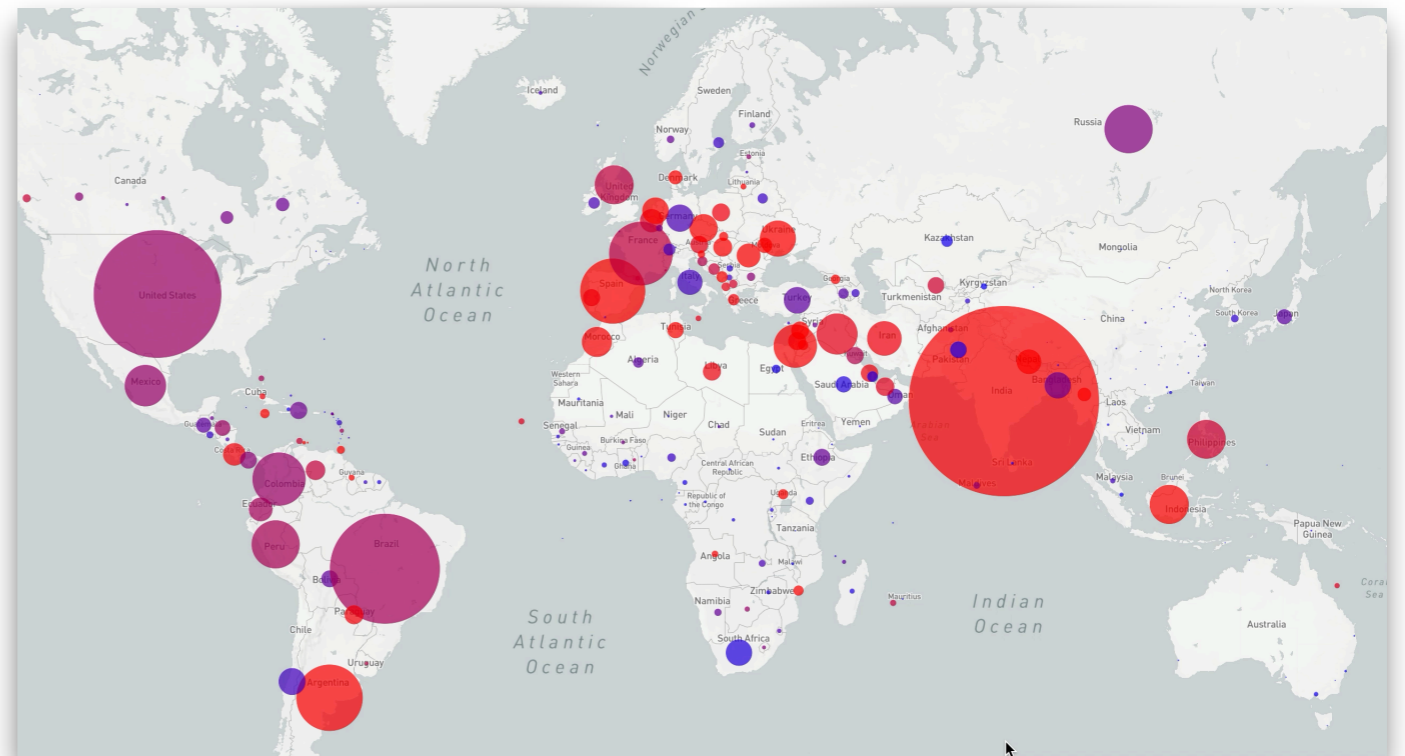
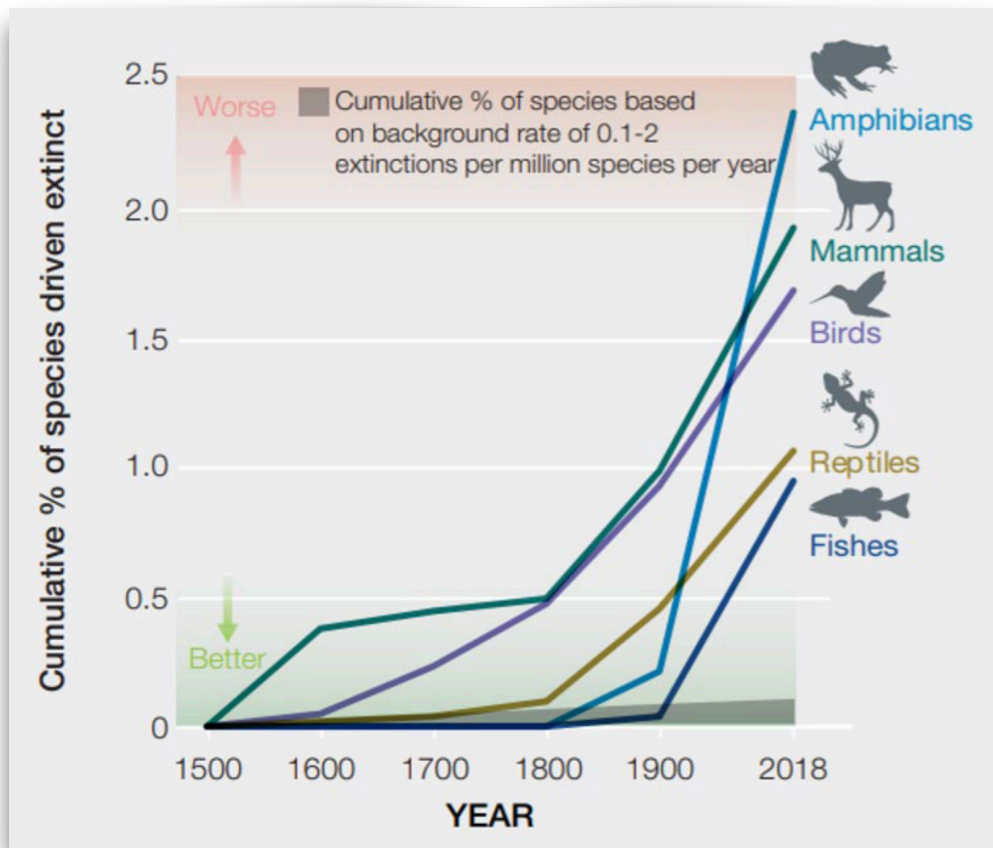
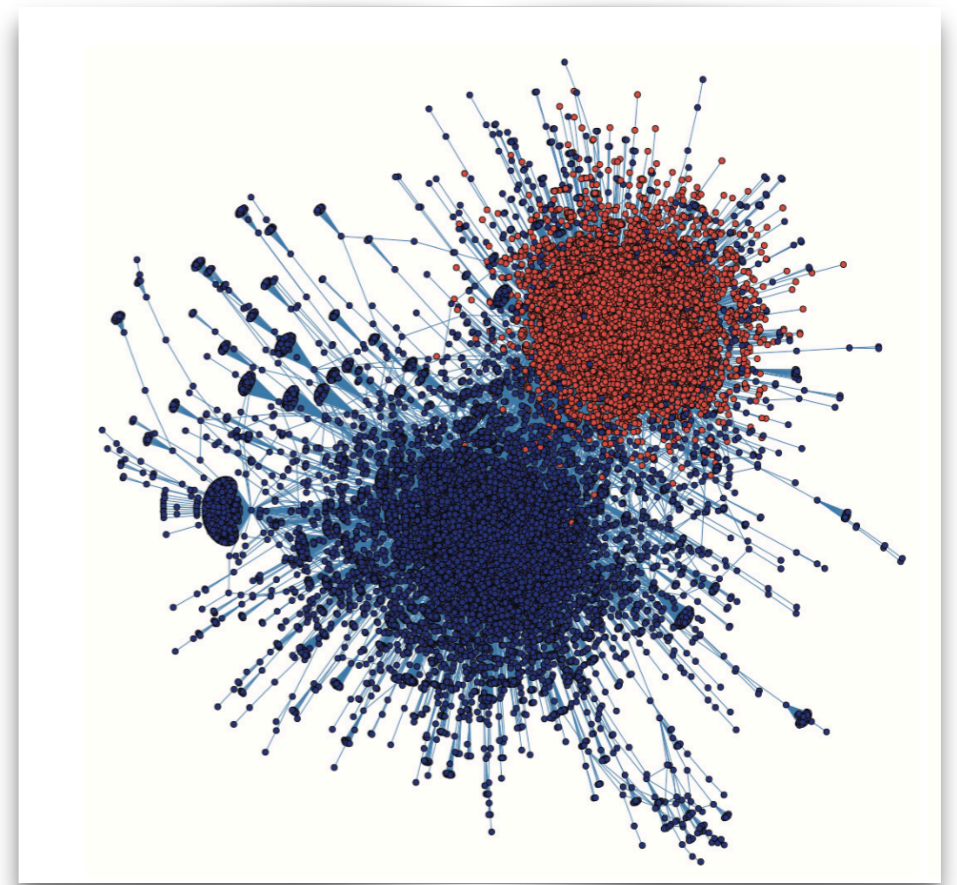
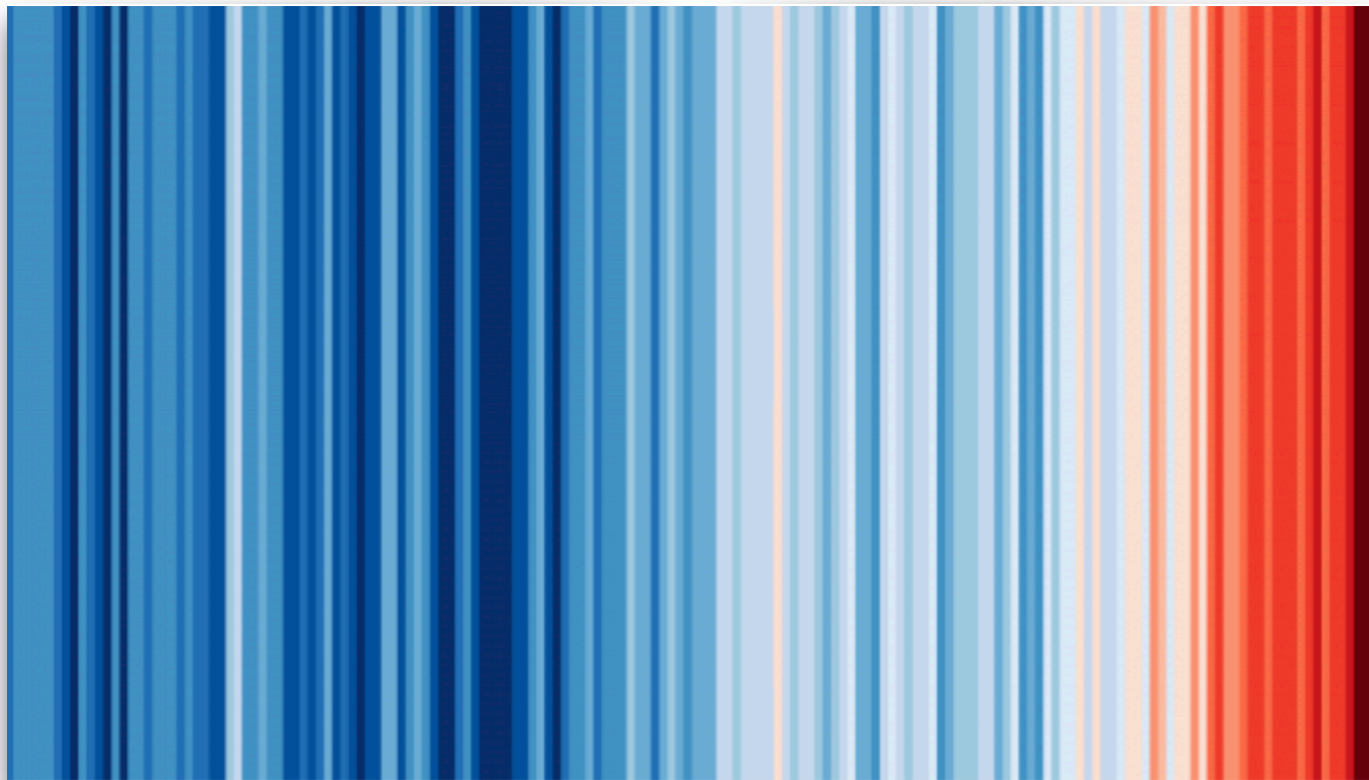
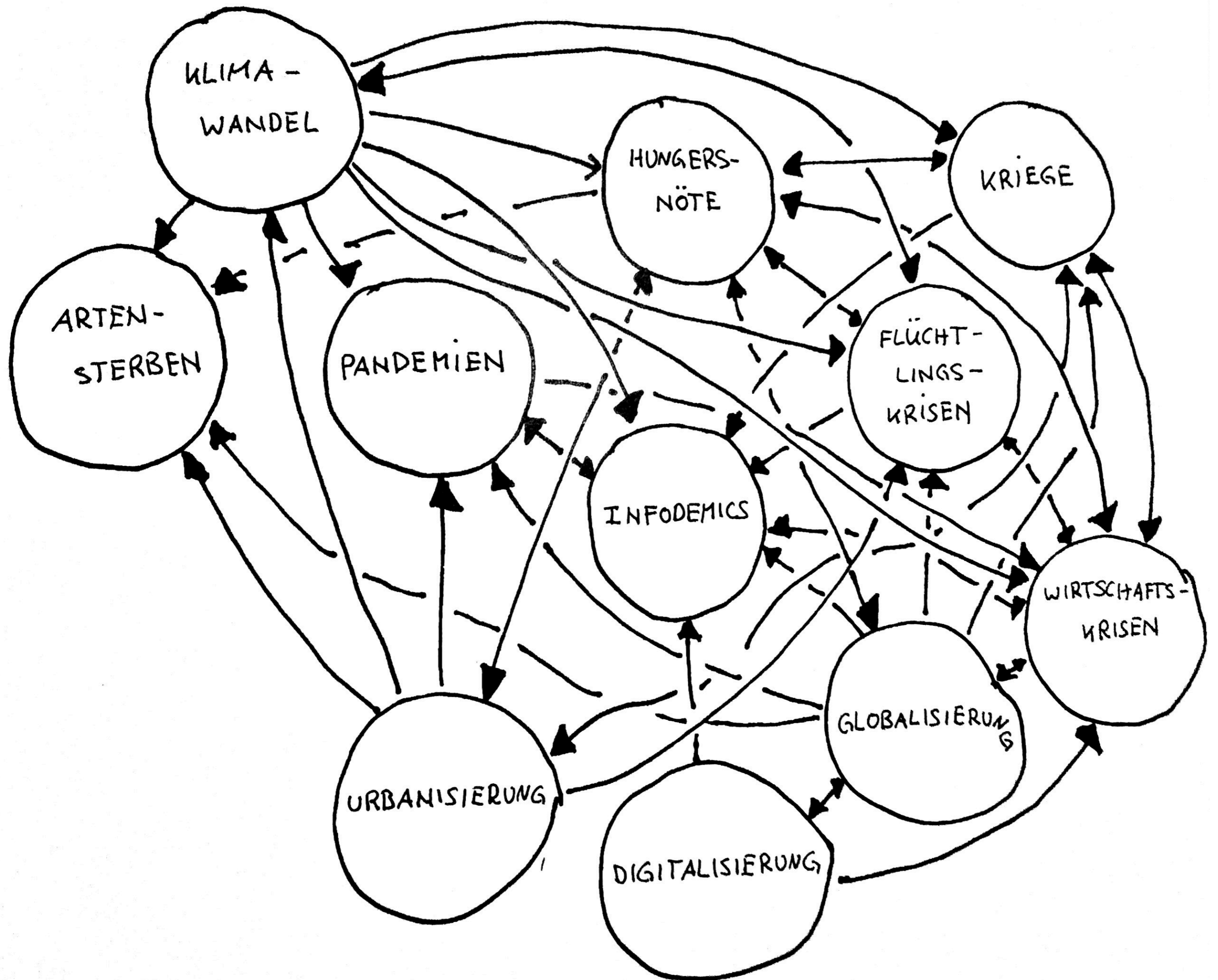


Komplexität

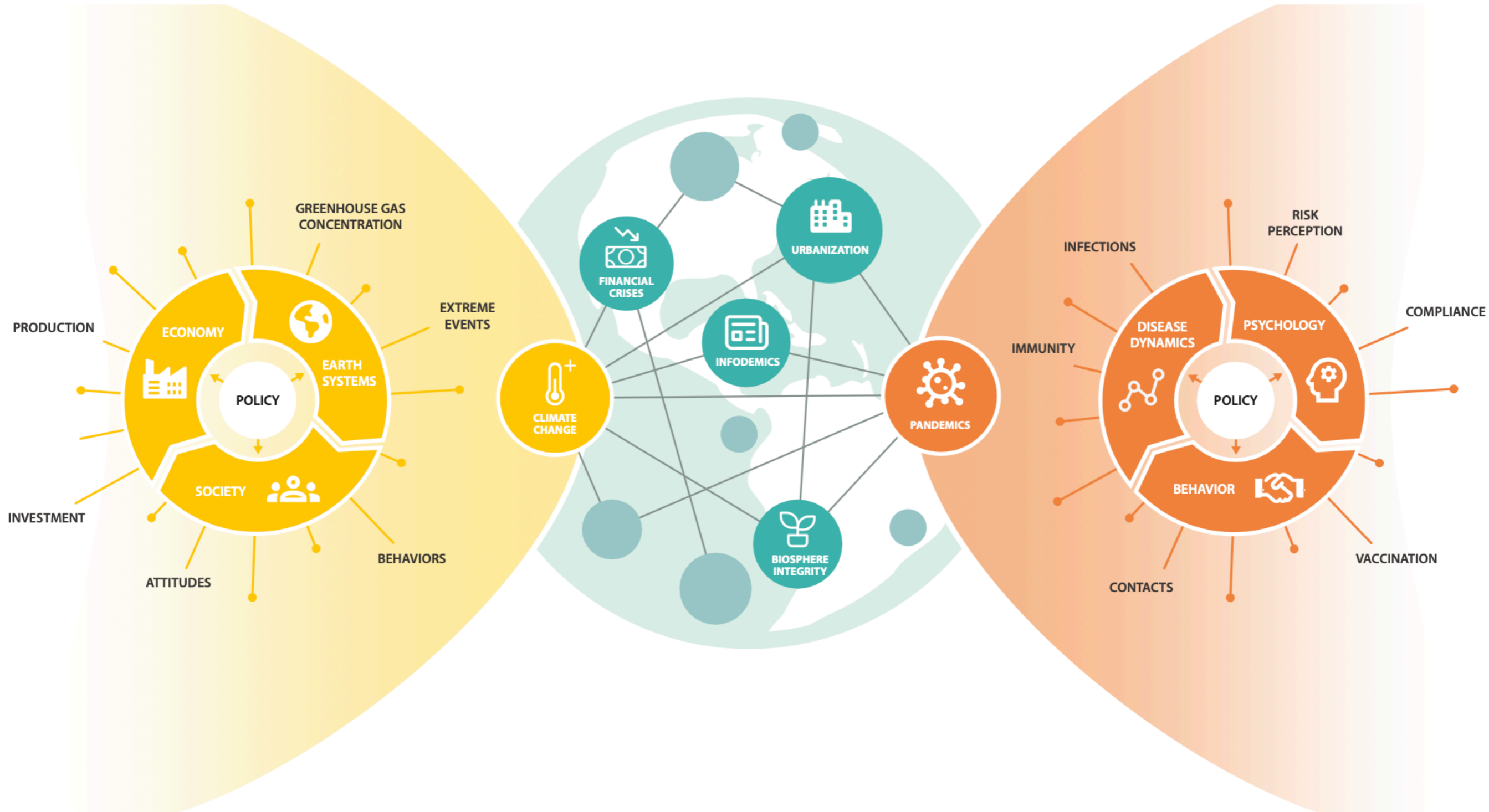


Komplexe Systeme - was macht sie aus?

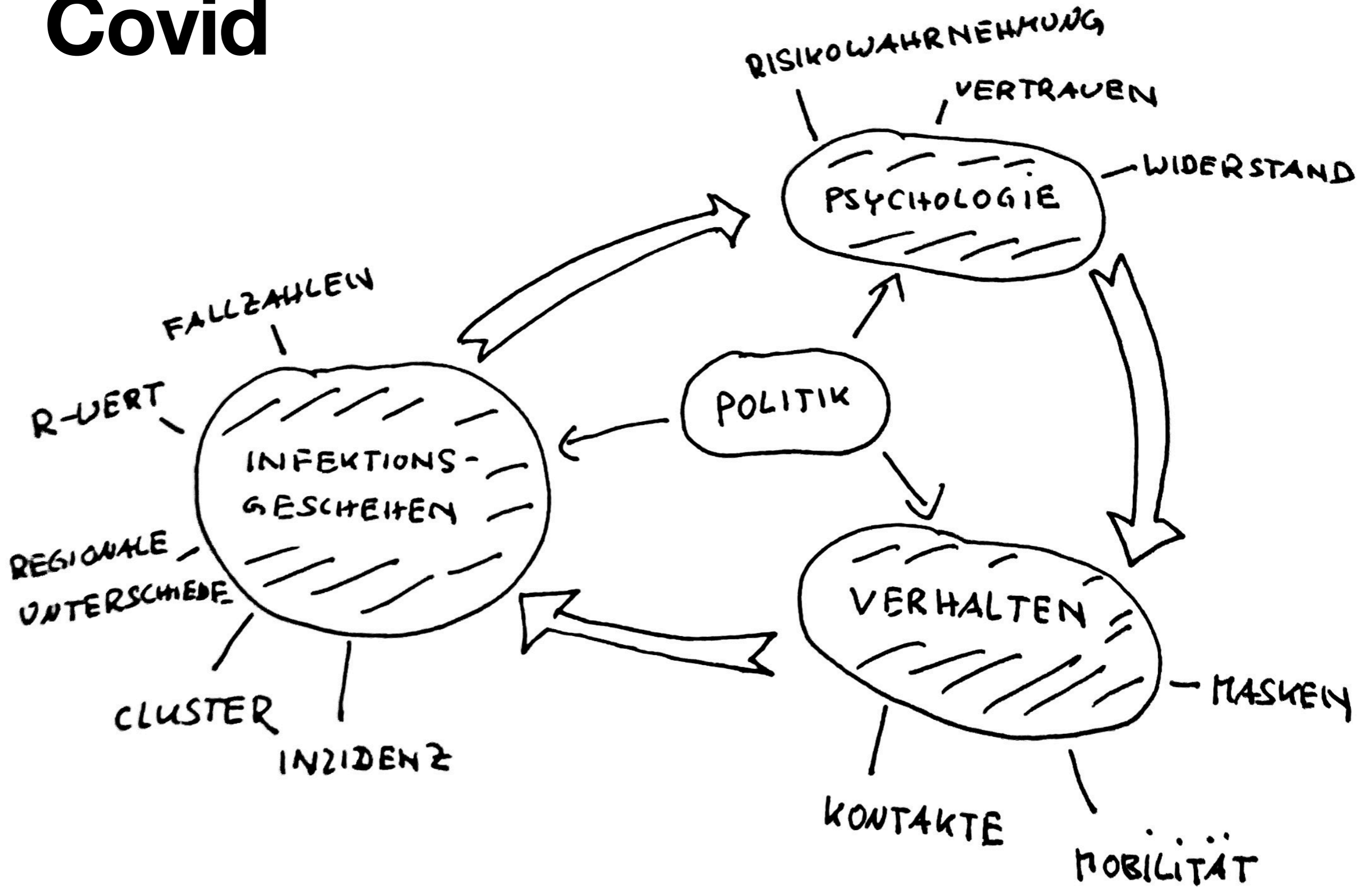


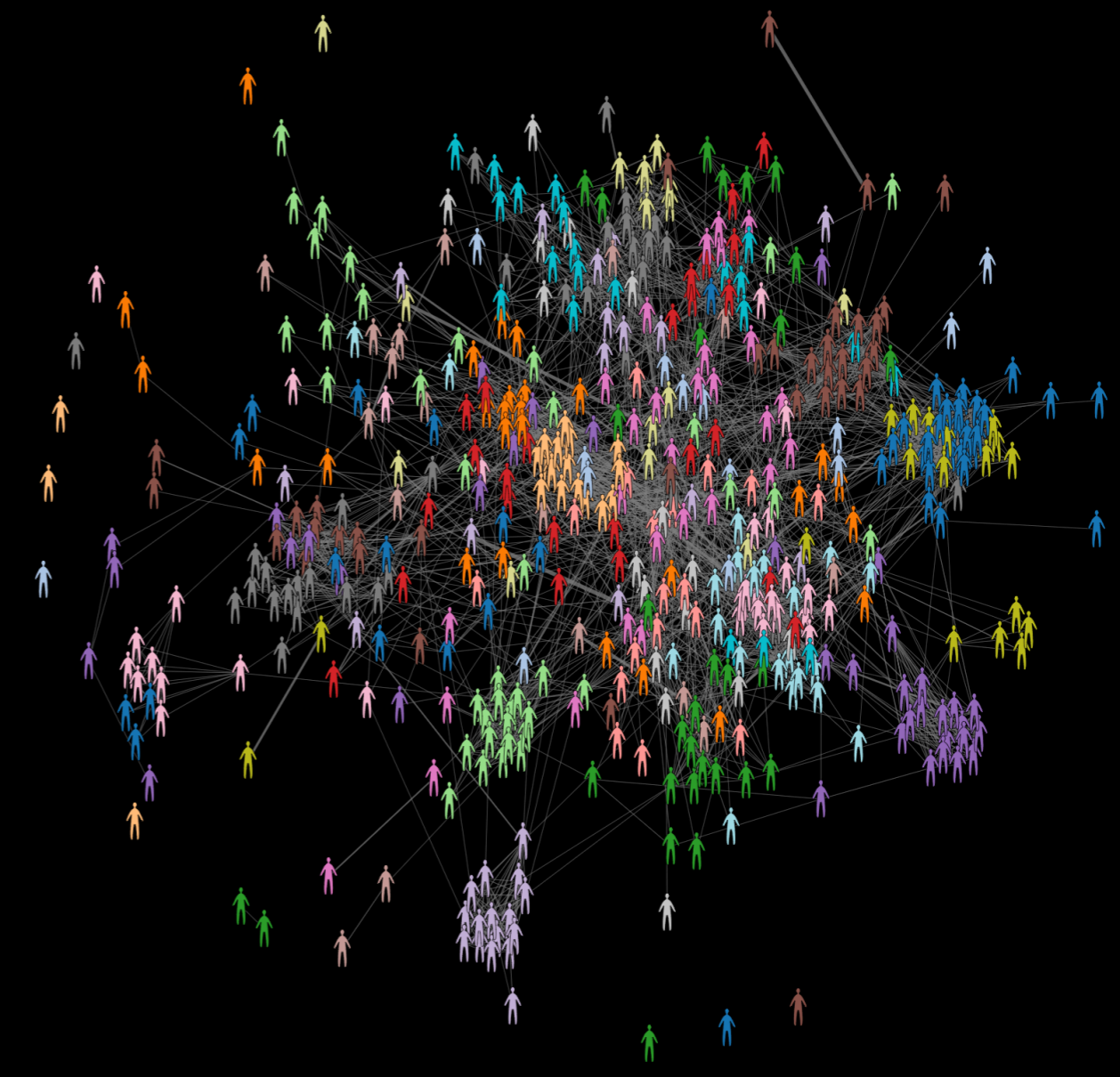
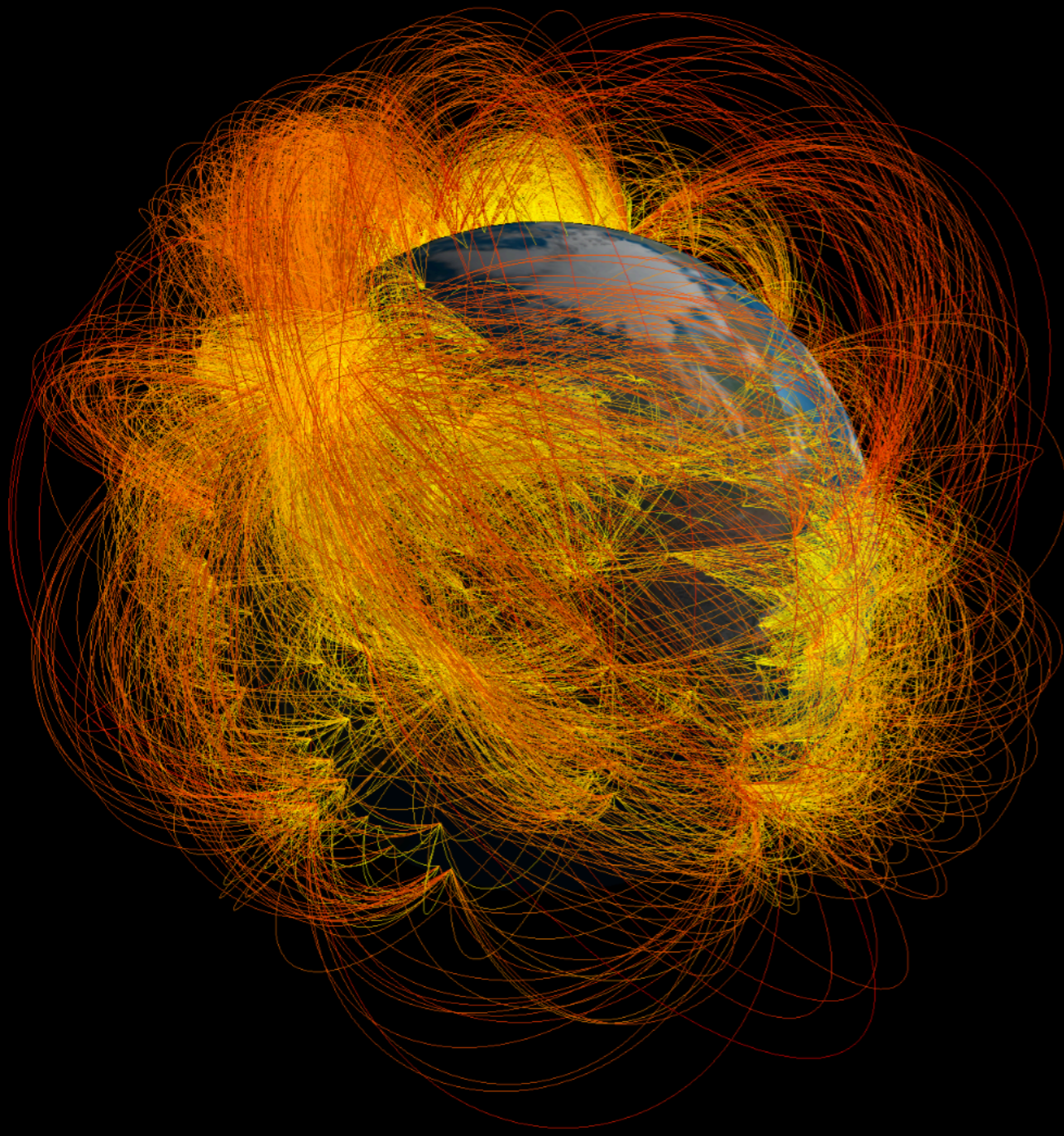


multi scale - nonlinear - networked



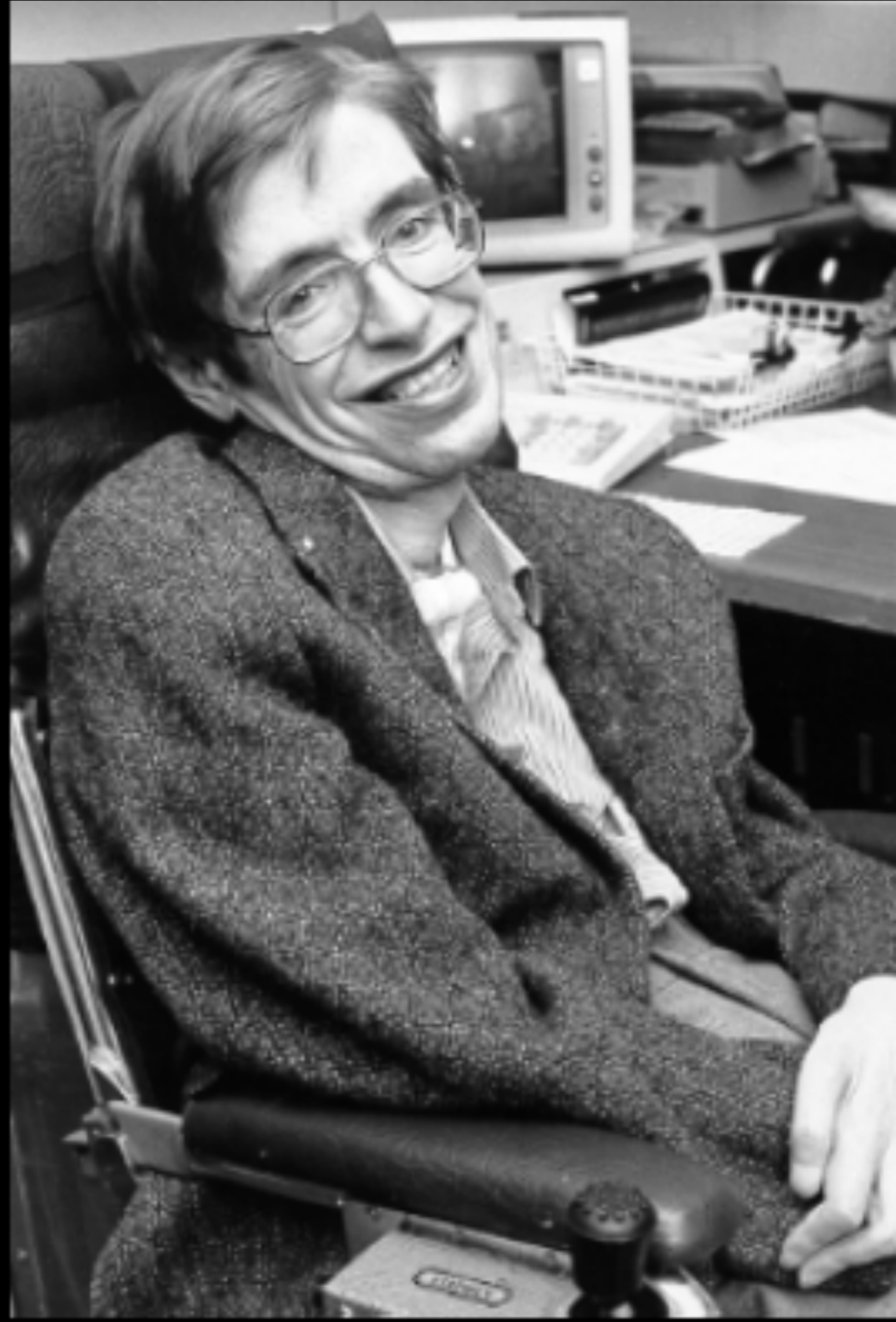
Covid

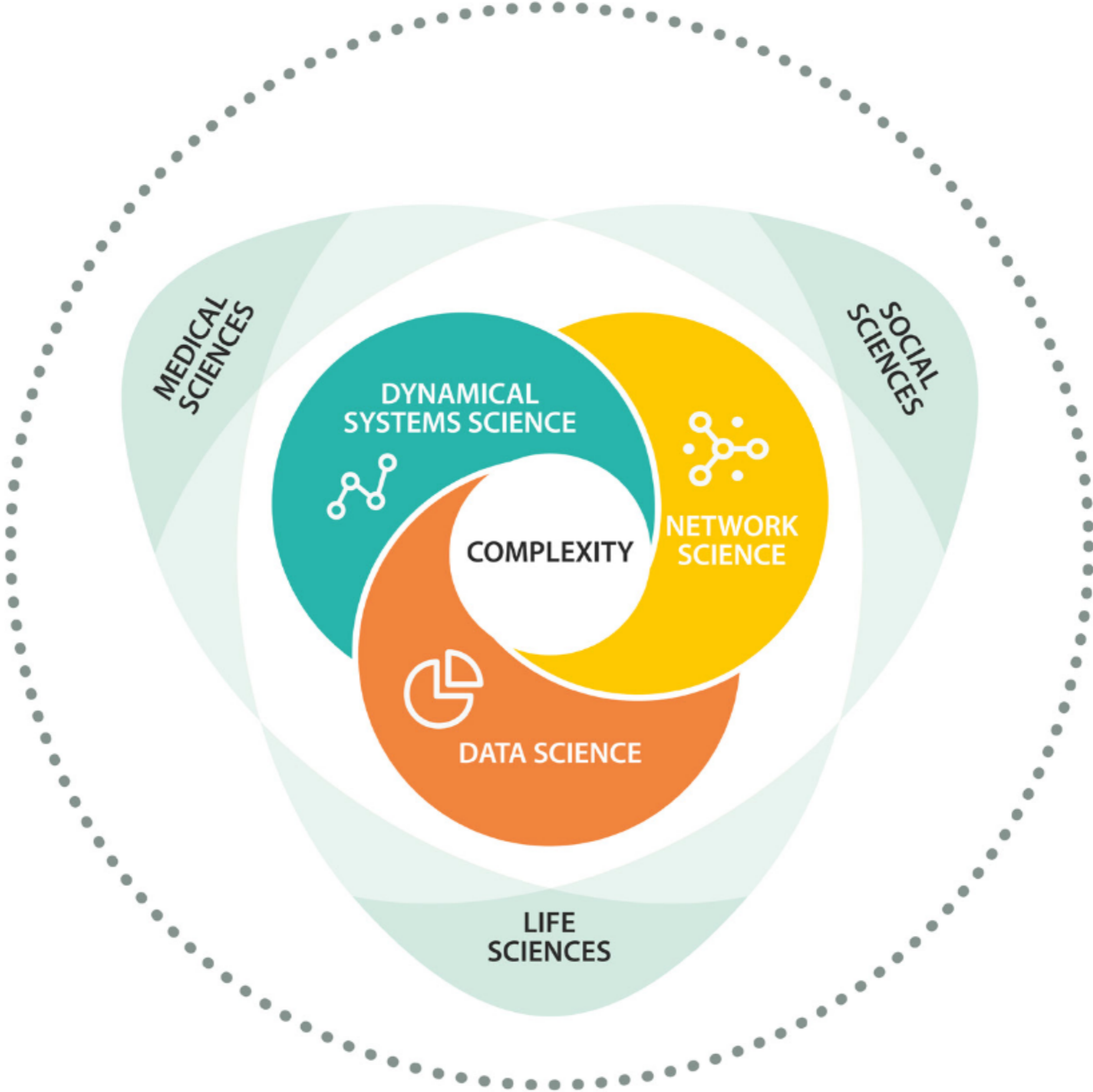




“I think the next century will be the century of complexity.”

Stephen Hawking,
Millennium Interview,
2000





**MEDICAL
SCIENCES**

**SOCIAL
SCIENCES**

**DYNAMICAL
SYSTEMS SCIENCE**

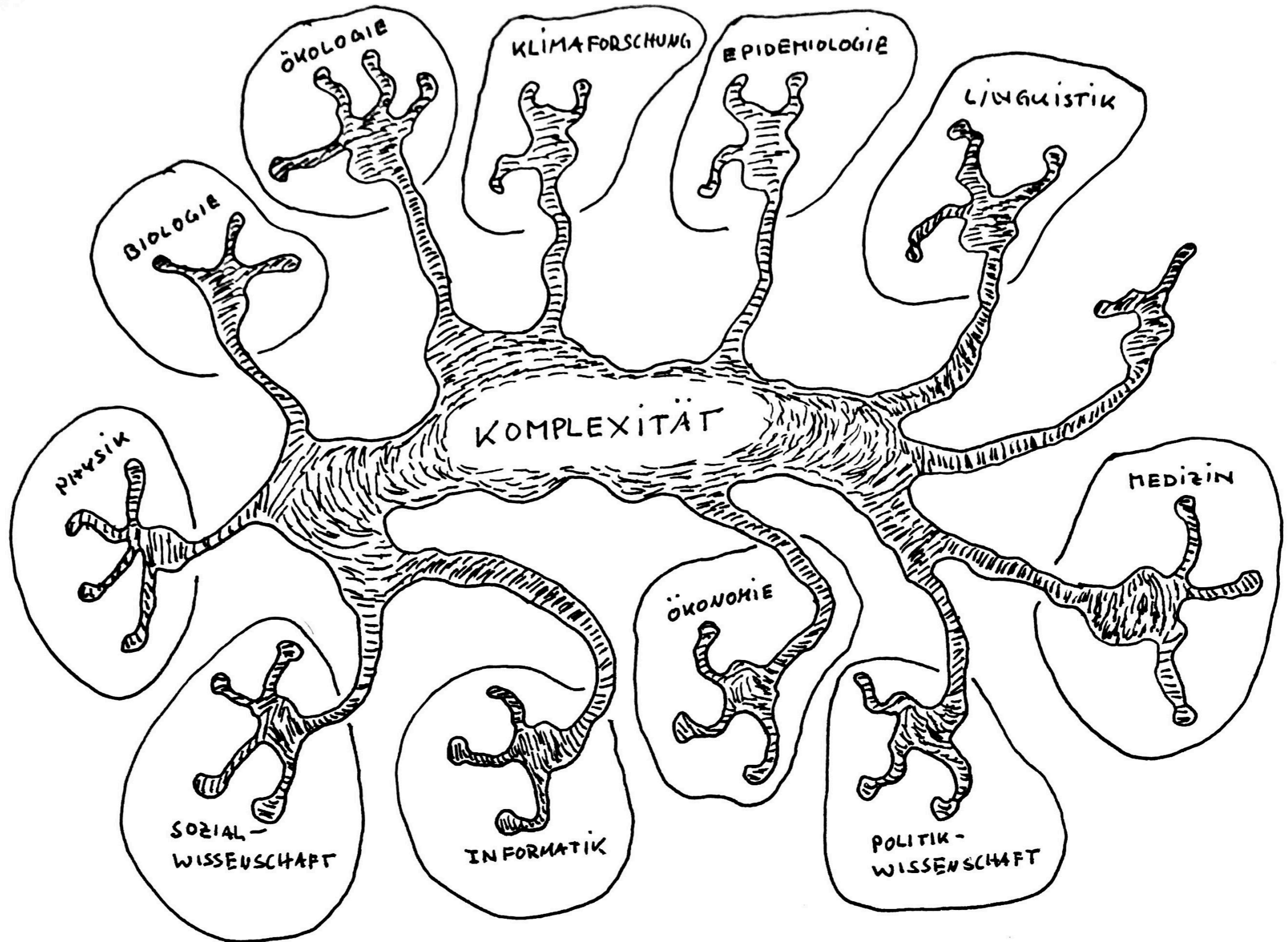
**NETWORK
SCIENCE**

COMPLEXITY

DATA SCIENCE

**LIFE
SCIENCES**

Forschen wie ein Pilz!



“If you are the
smartest
person in the
room, you are
in the wrong
room.”

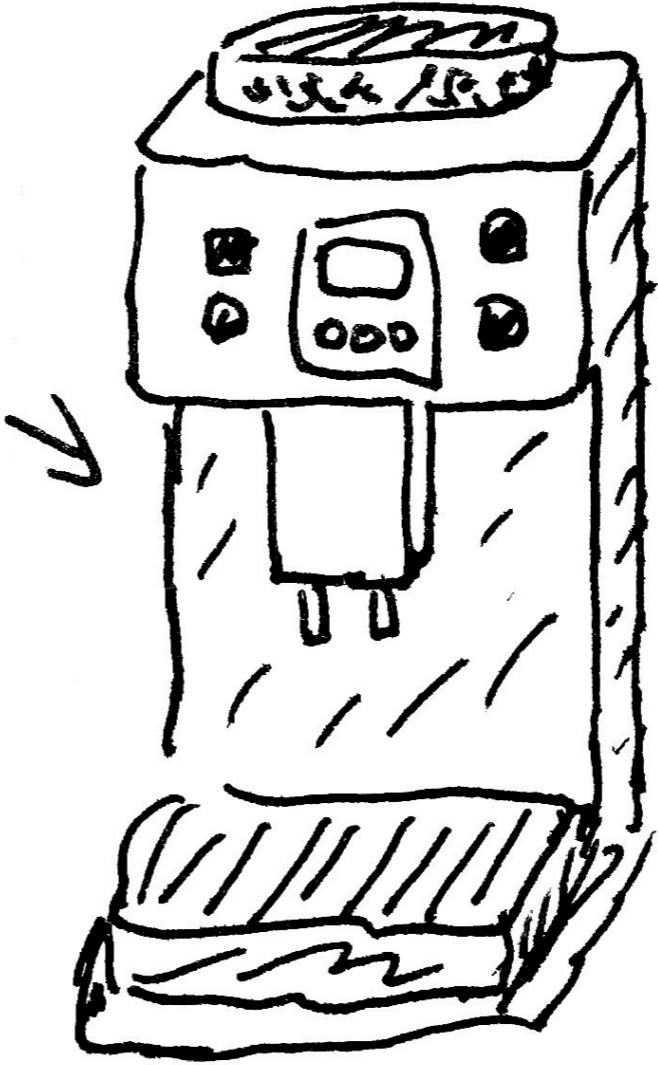
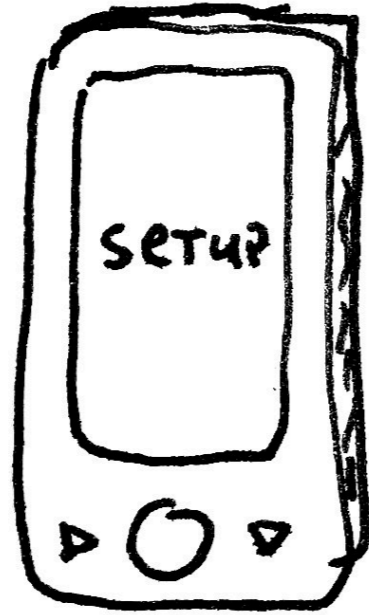
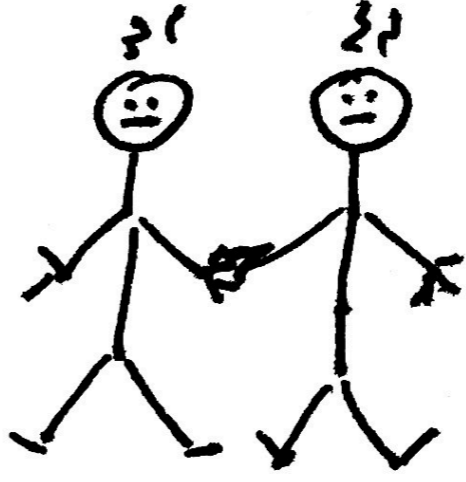
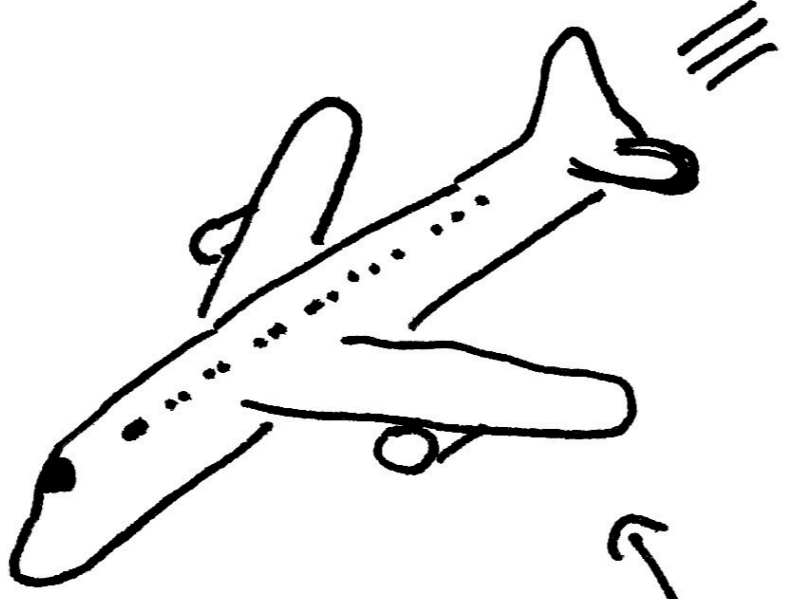
Richard Feynman, Physics
Nobel Laureate 1965



“Science is the
belief in the
ignorance of
experts.”

Richard Feynman, Physics
Nobel Laureate 1965





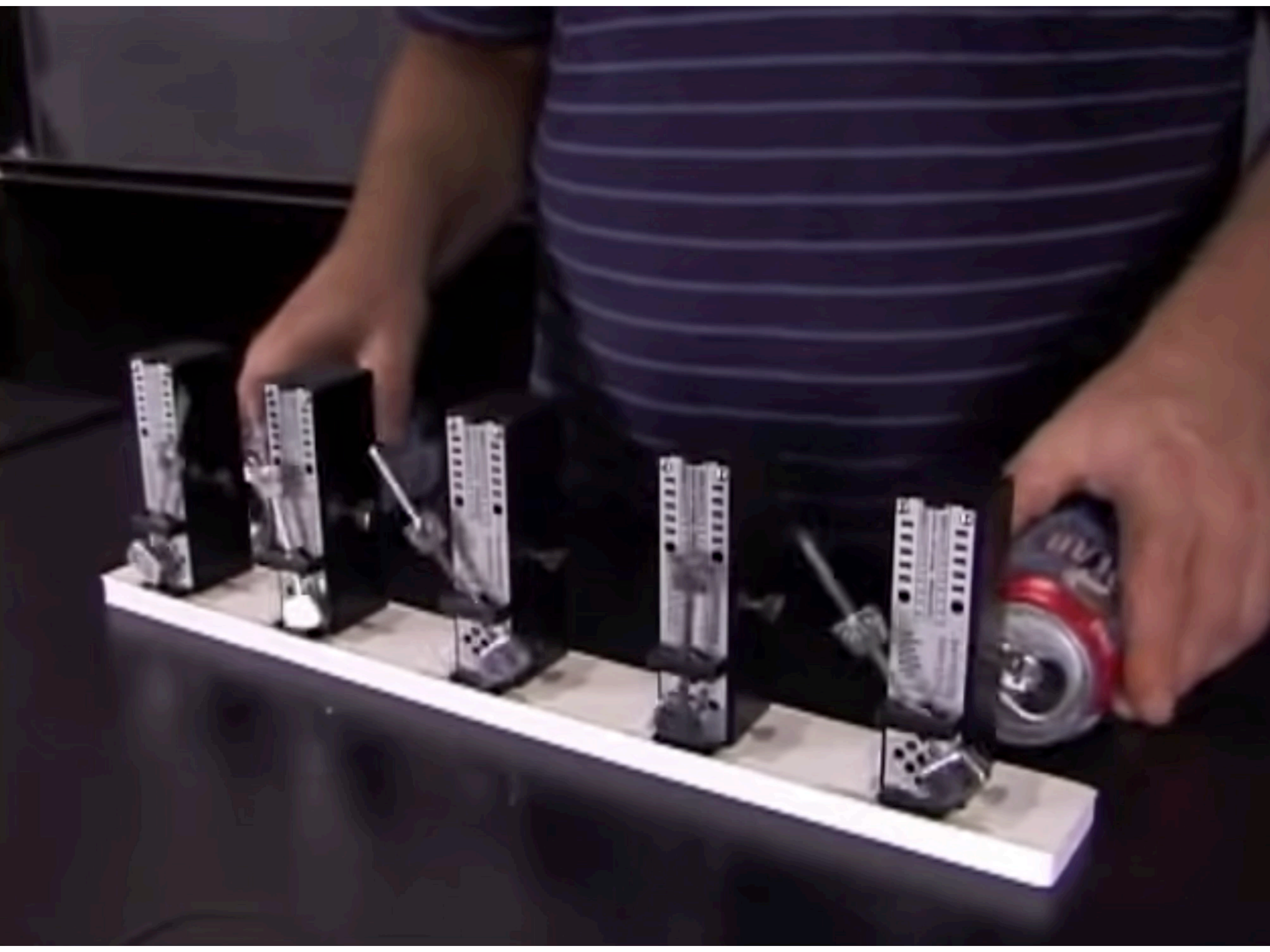
↑
KOMPLIZIERT





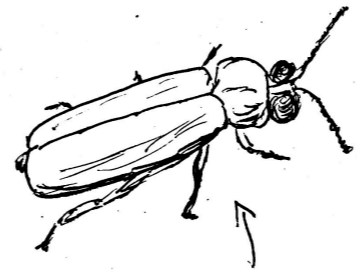
›Thought-transference (or what?) in birds‹

Edmund Selous 1931





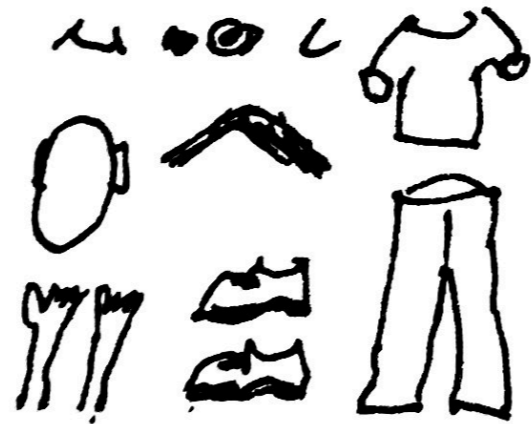
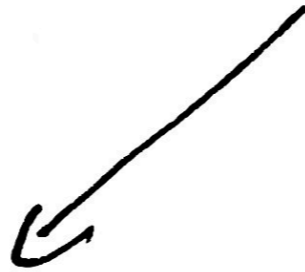
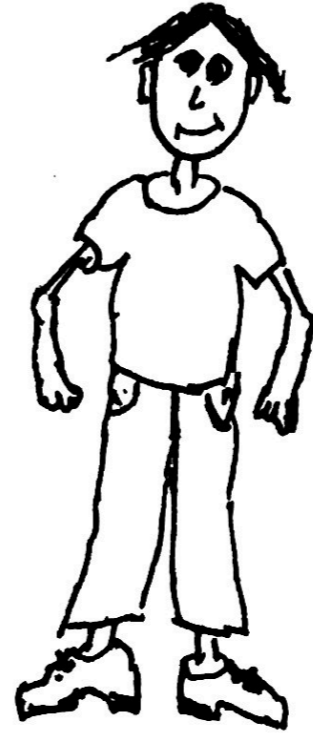
PTEROPTYX TENER



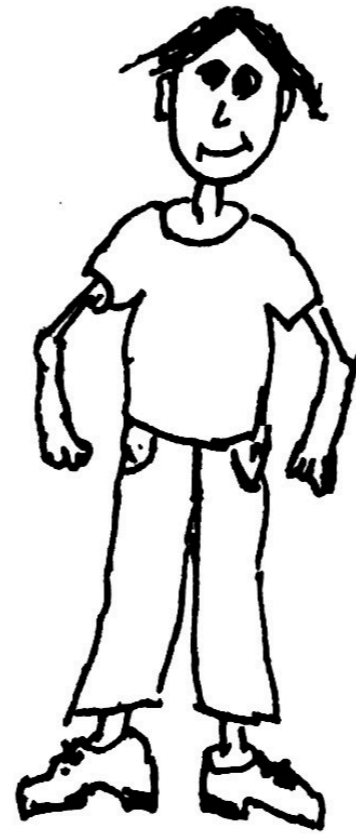
PTEROPTYX TENER



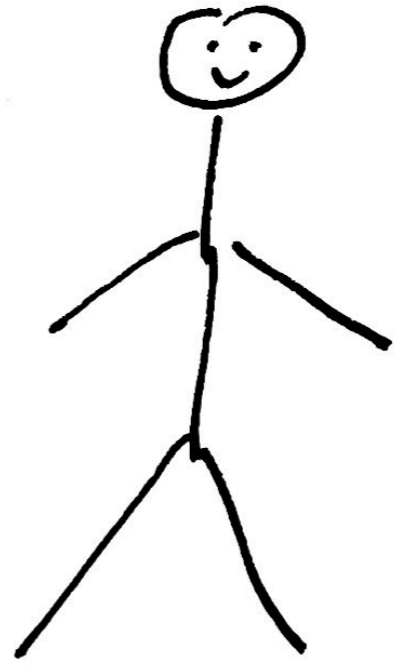
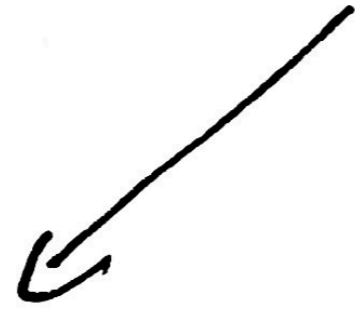
KLASSISCHER
REDUKTIONISMUS



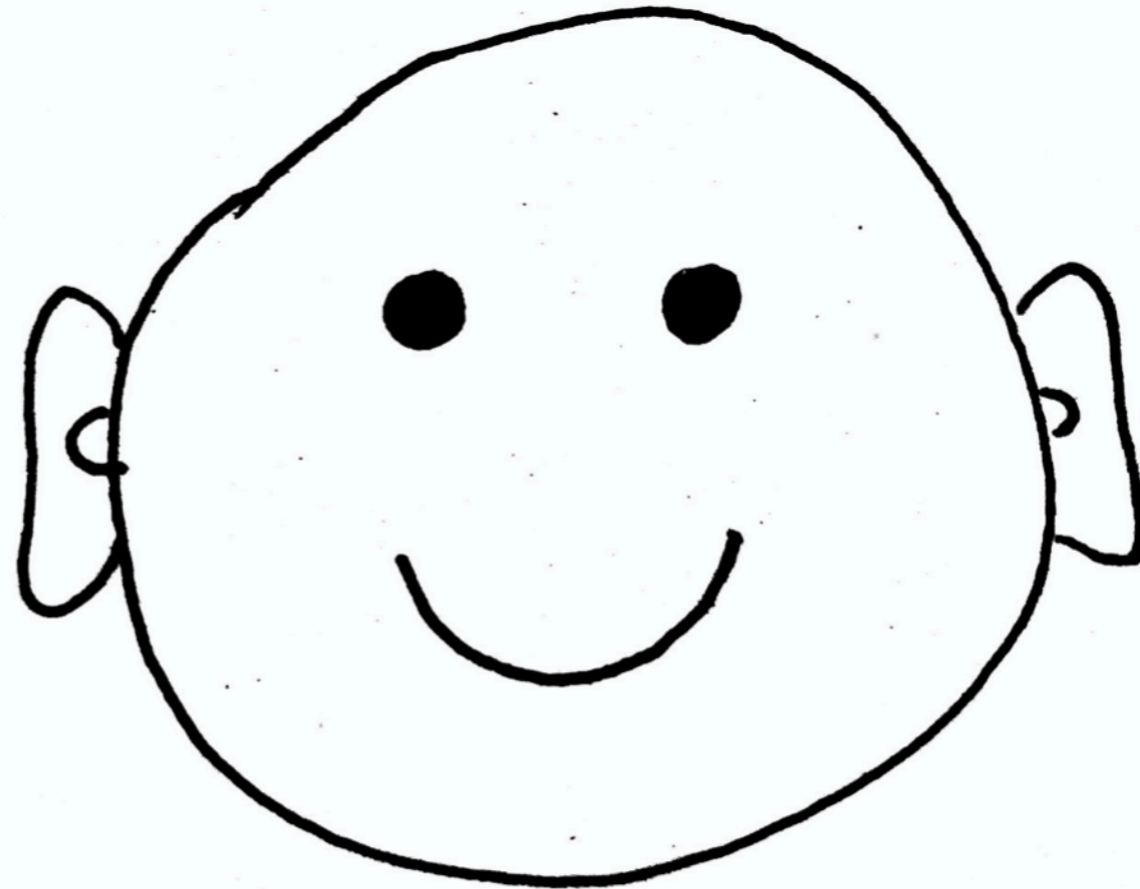
KLASSISCHER
REDUKTIONISMUS



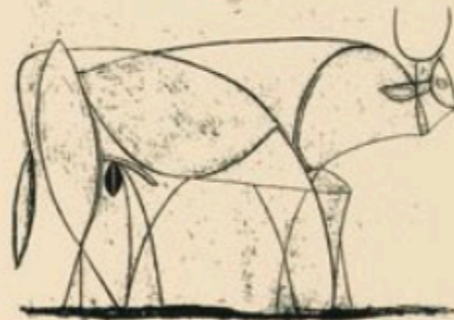
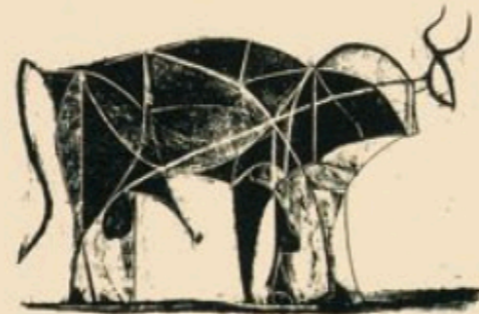
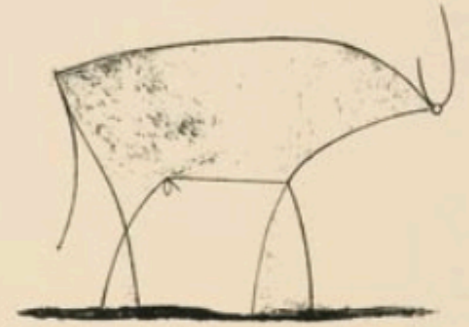
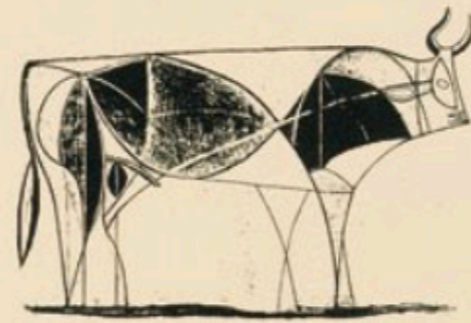
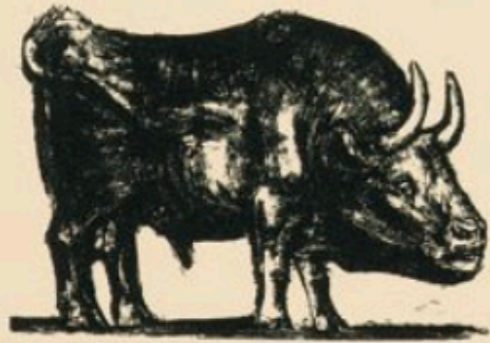
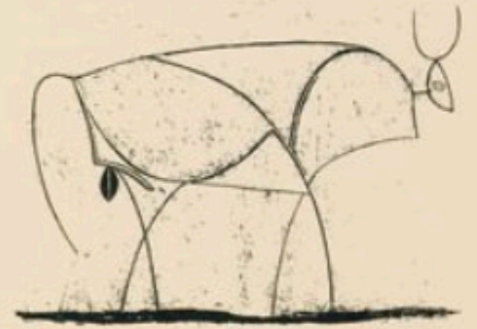
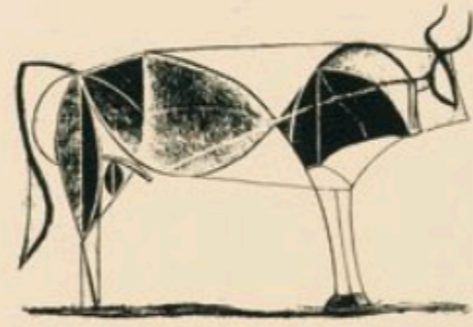
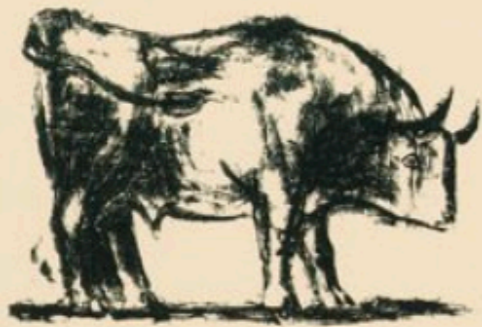
KOMPLEXITÄTS-
REDUKTIONISMUS



KANN
WEG!

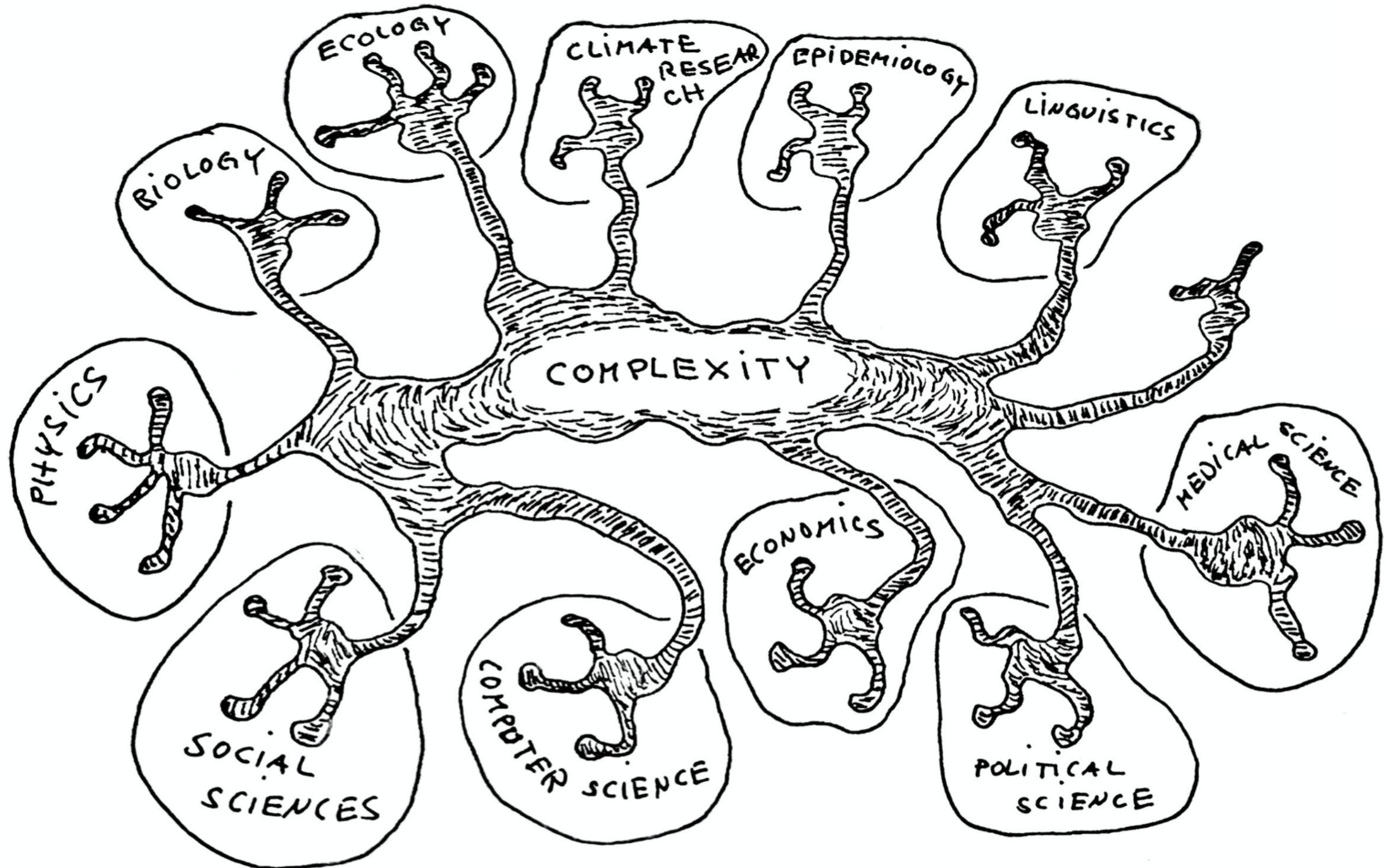


KANN AUCH
WEG!

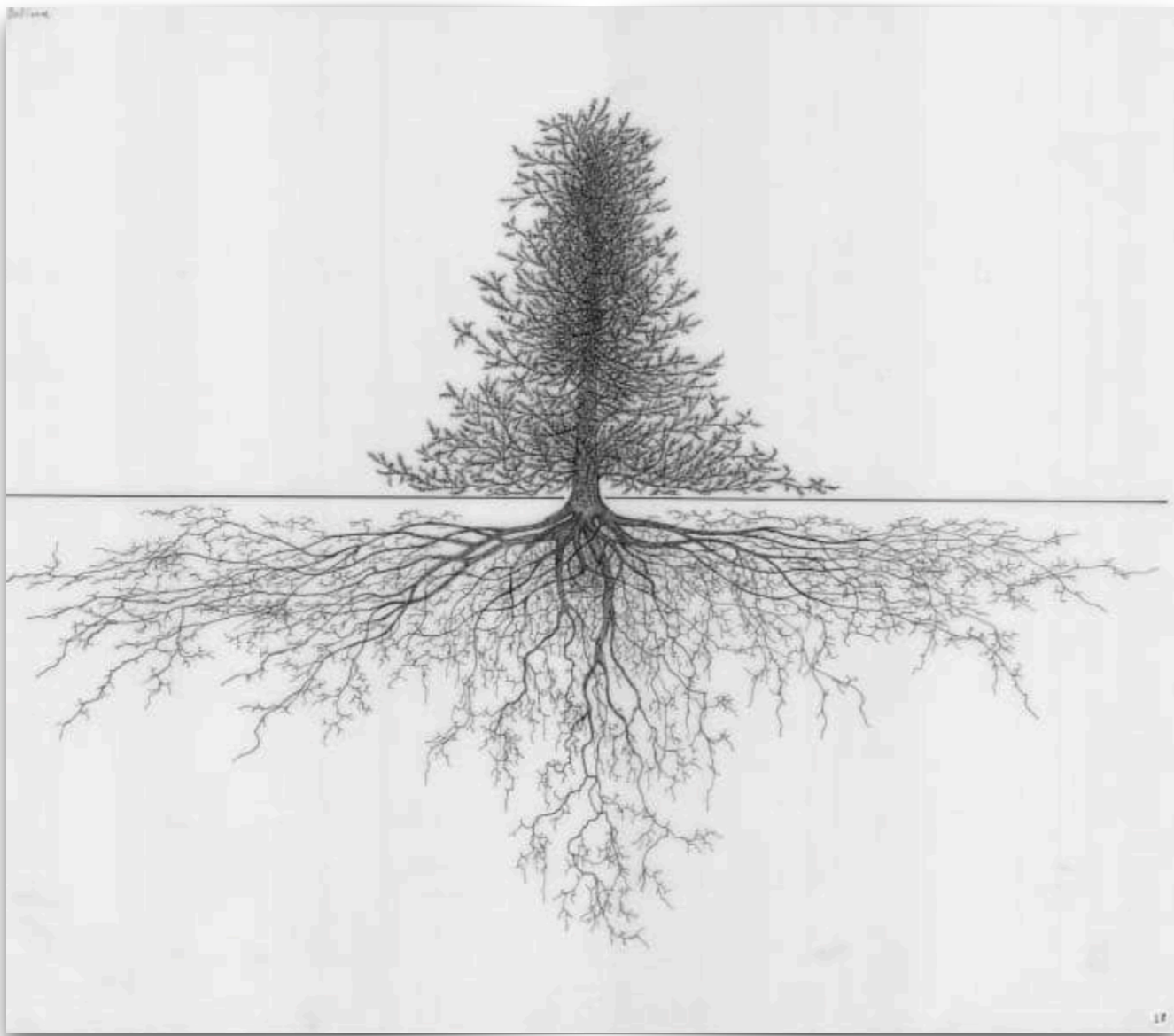


P. 20

simplicity & similarity



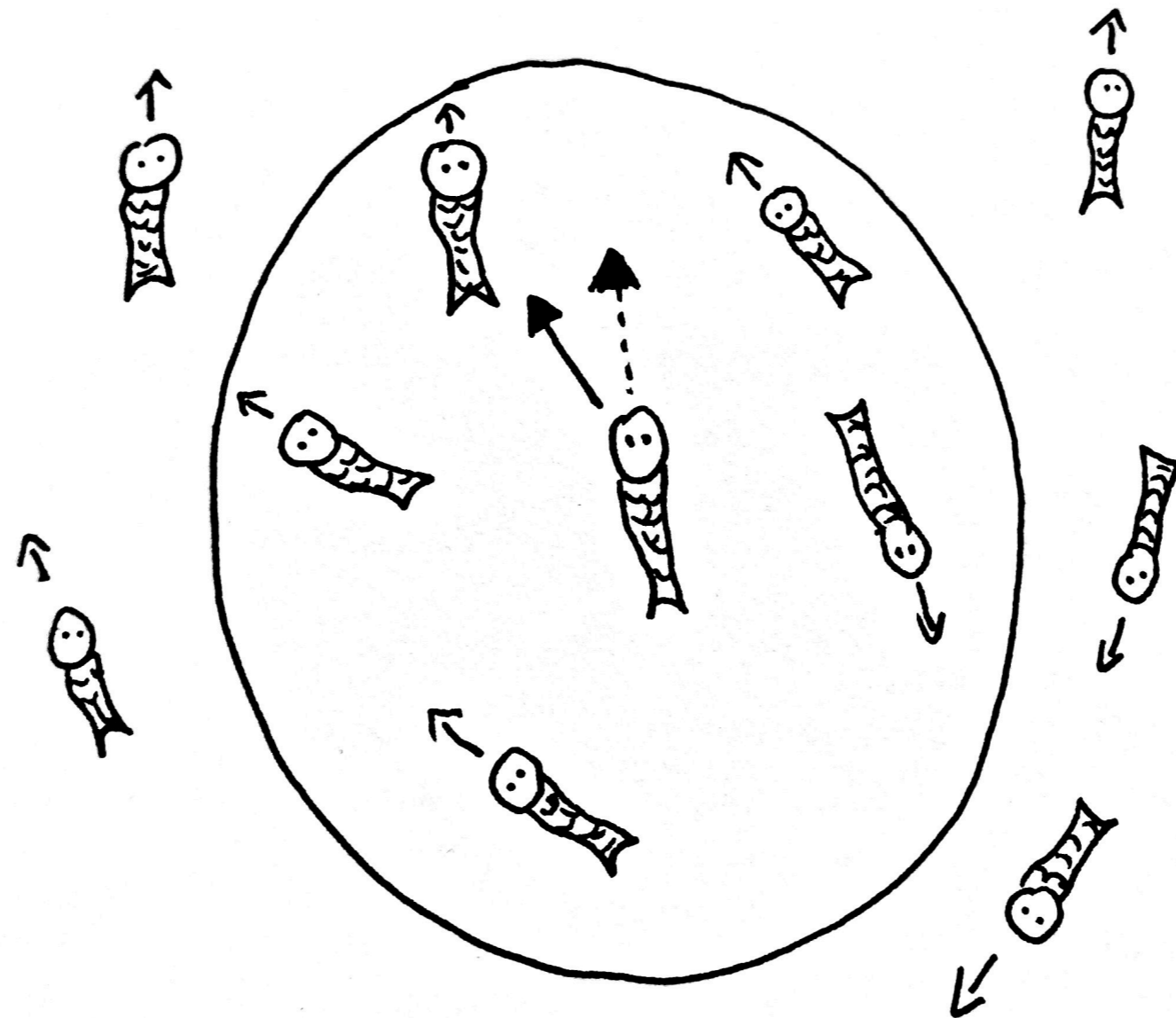
Roads to Rome

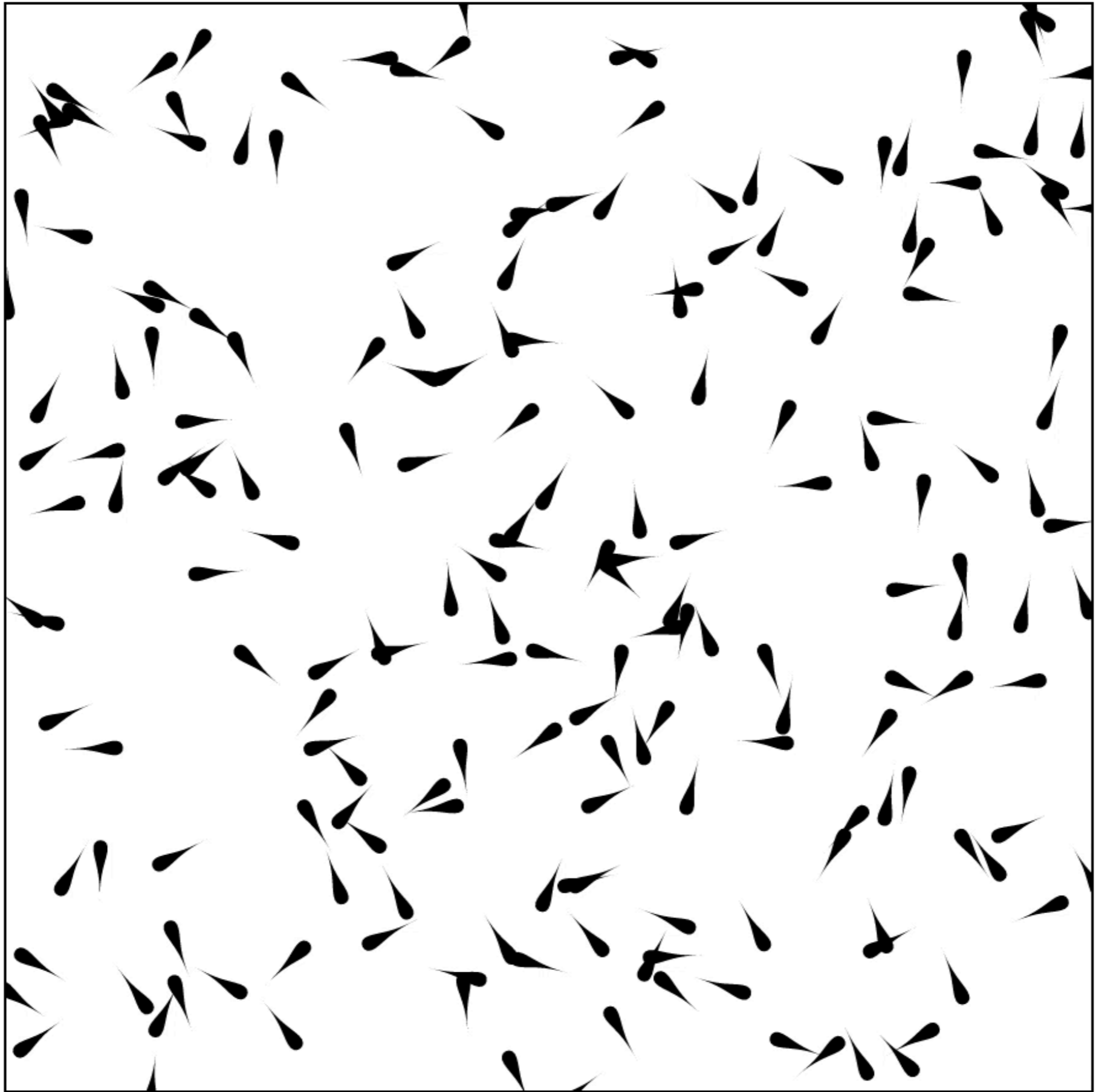


credits: Benedikt Groß, Raphael Reimann, Philipp Schmitt



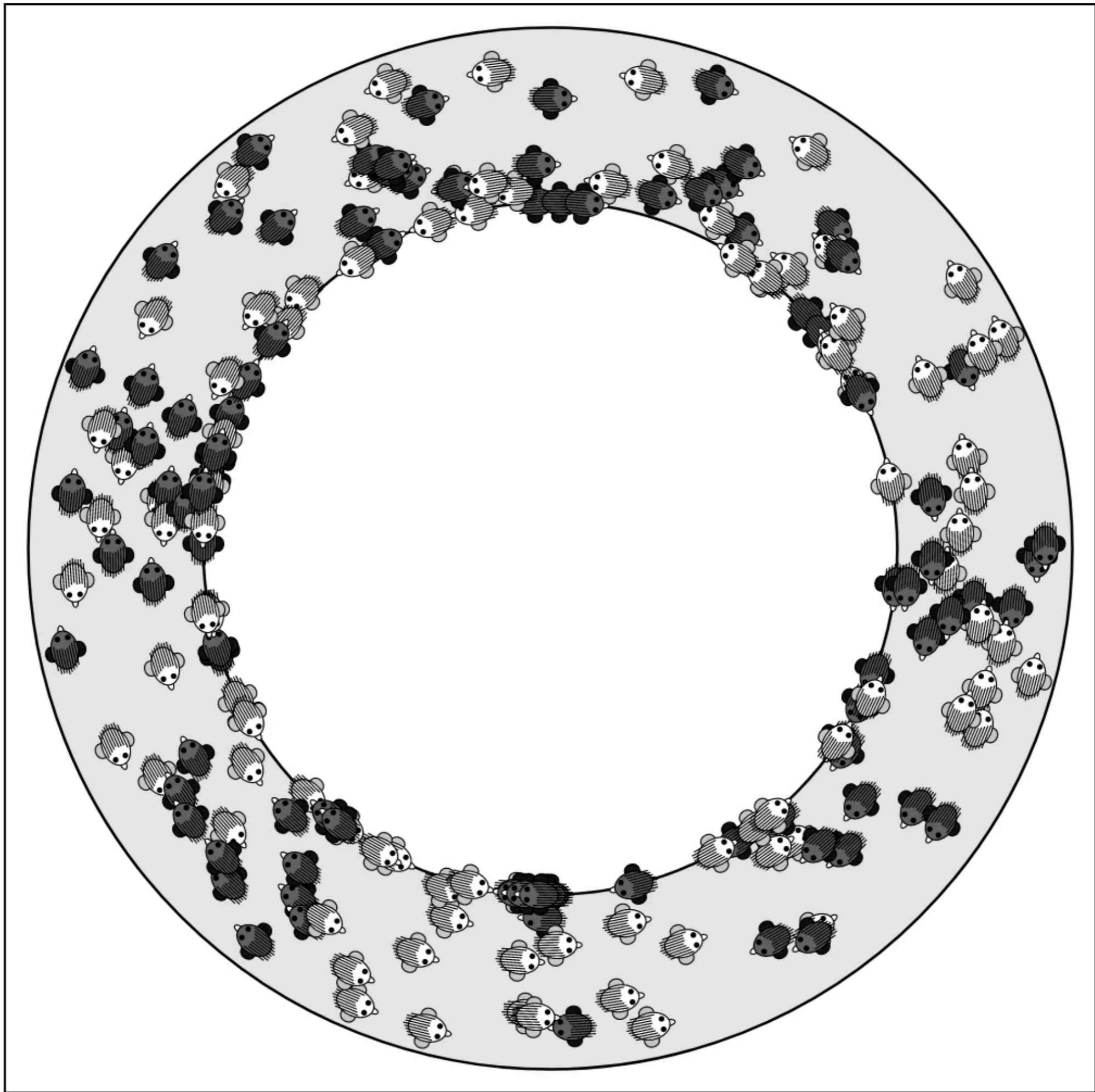
1. Avoid collisions
2. Stay with the group
3. Align with your neighbors





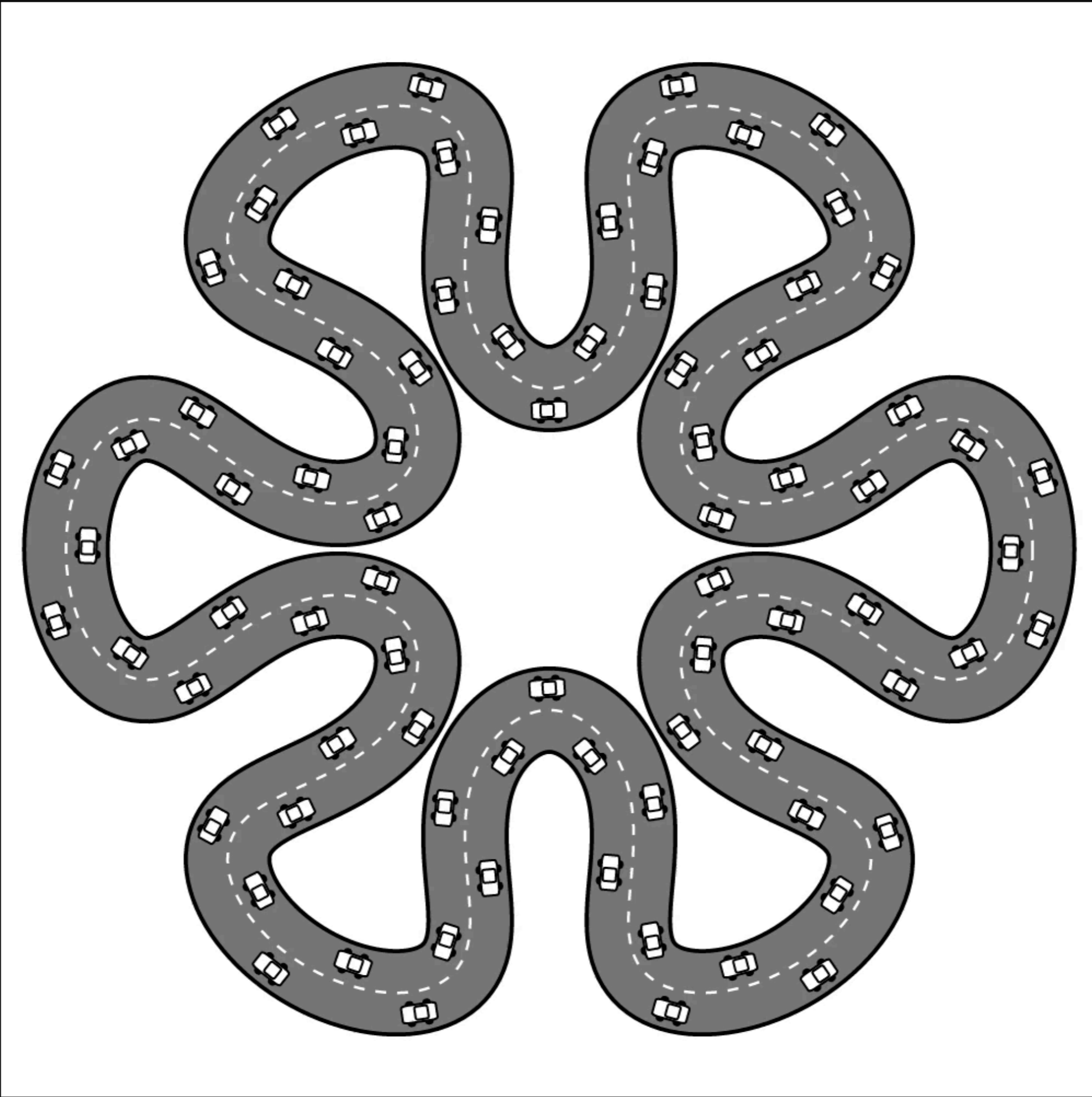
Experimente mit Menschen in Hallen



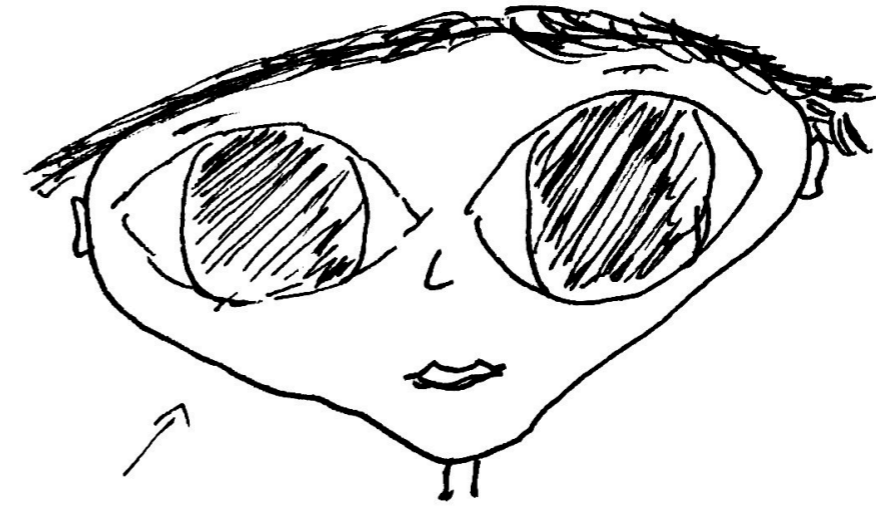




Play (k)

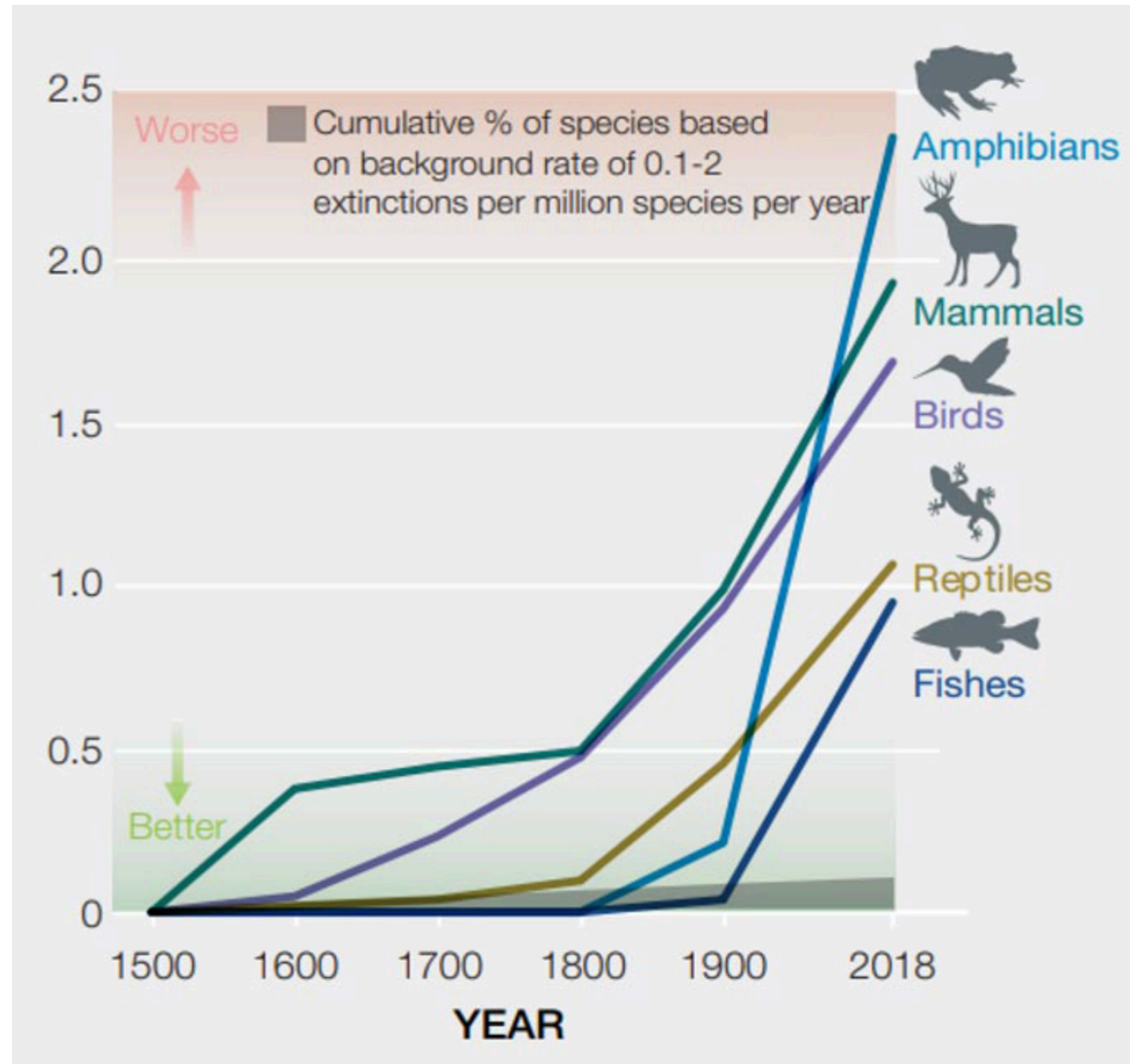
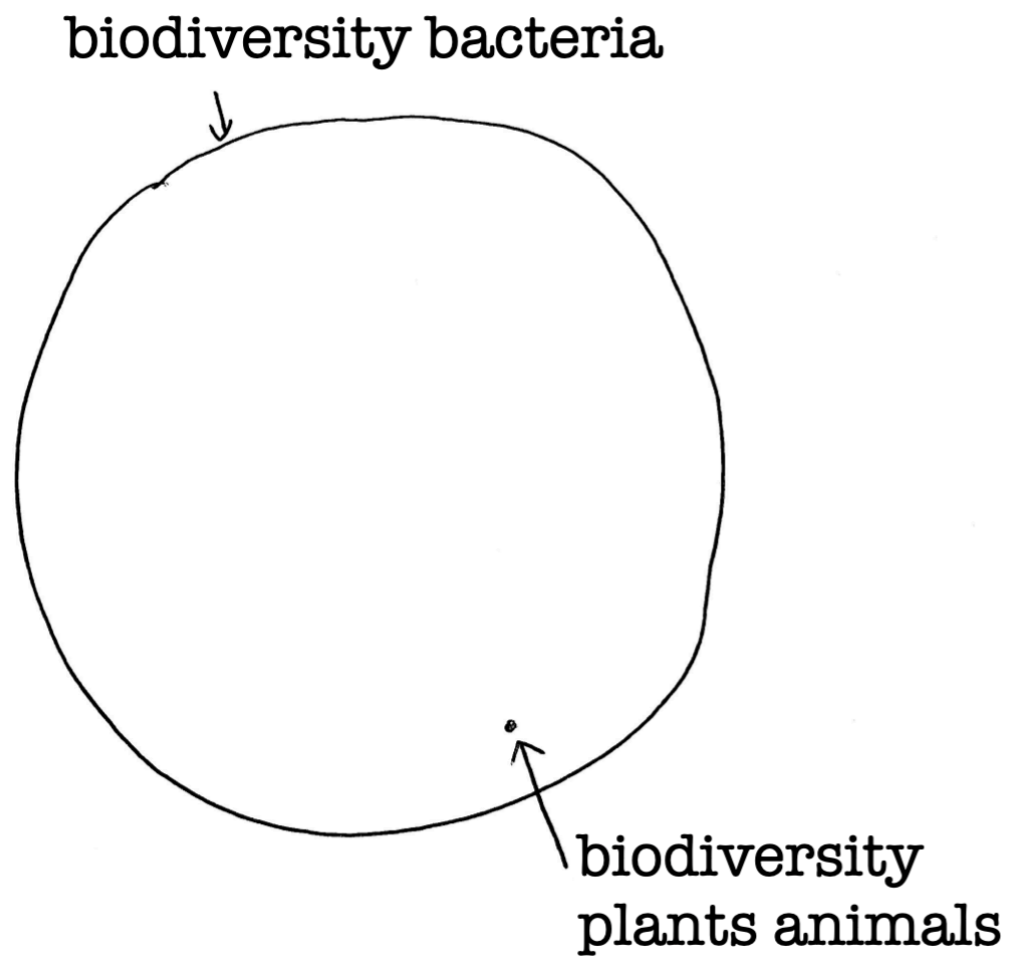


REALITÄT

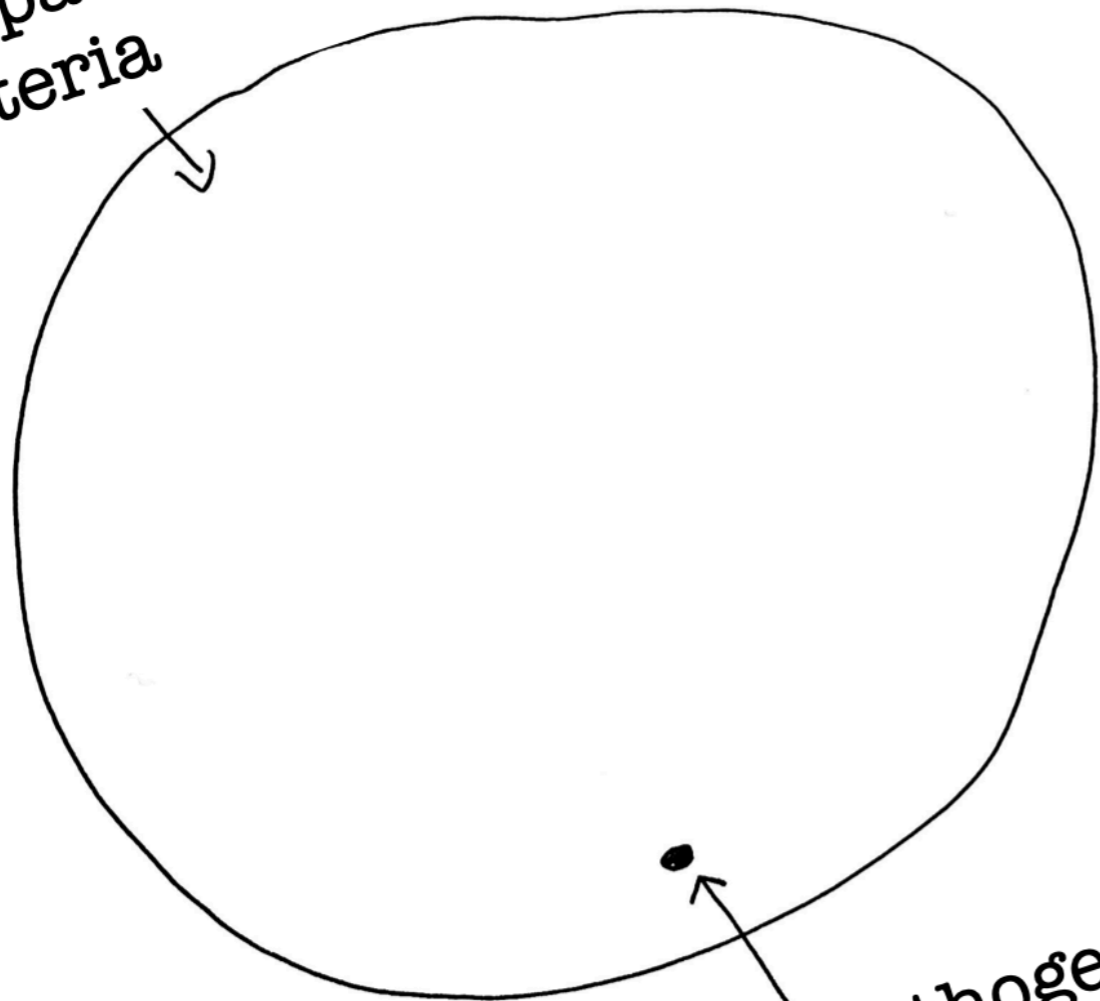


IN UNSEREN
KÖPFEN

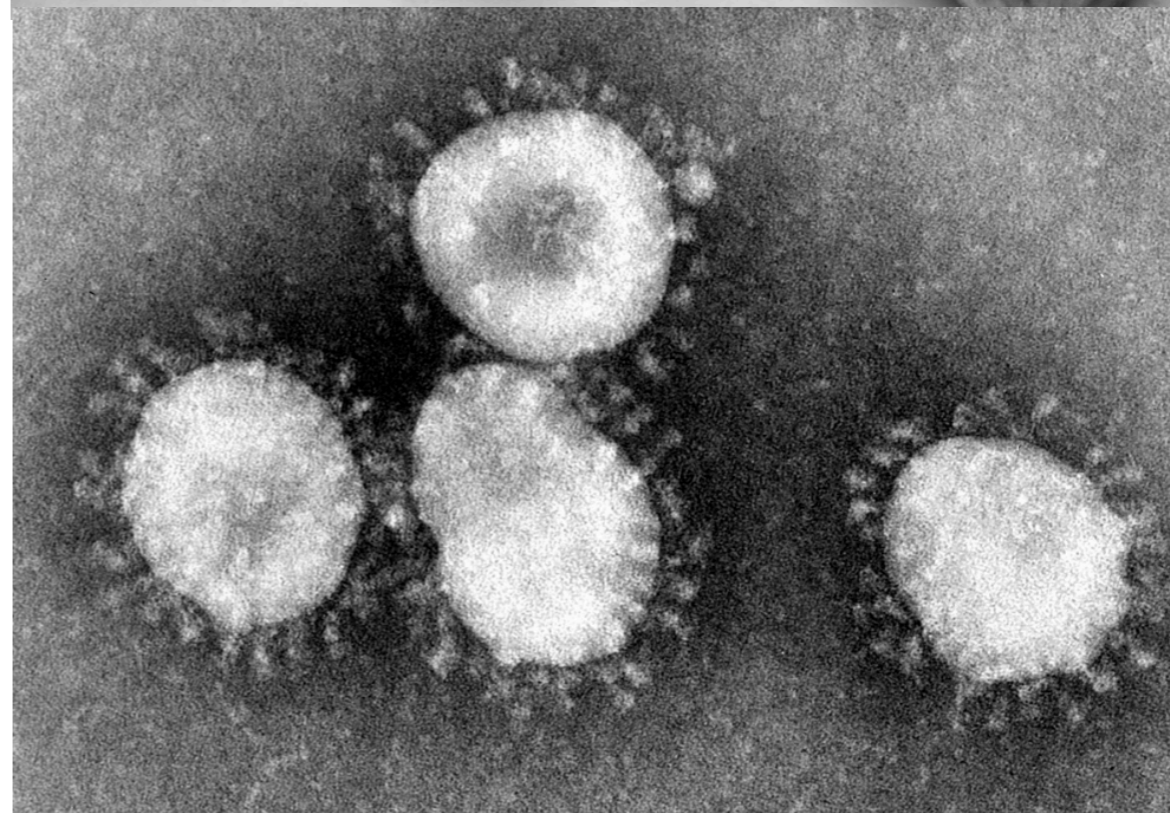
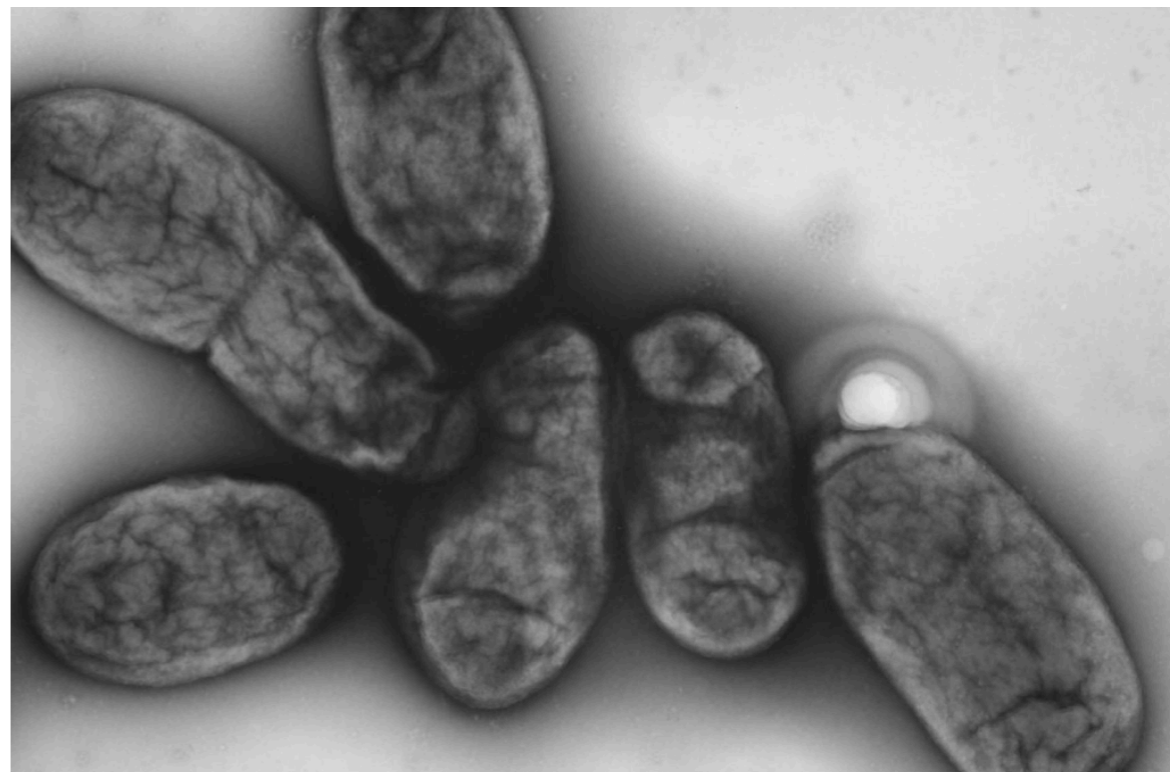




non pathogenic
bacteria

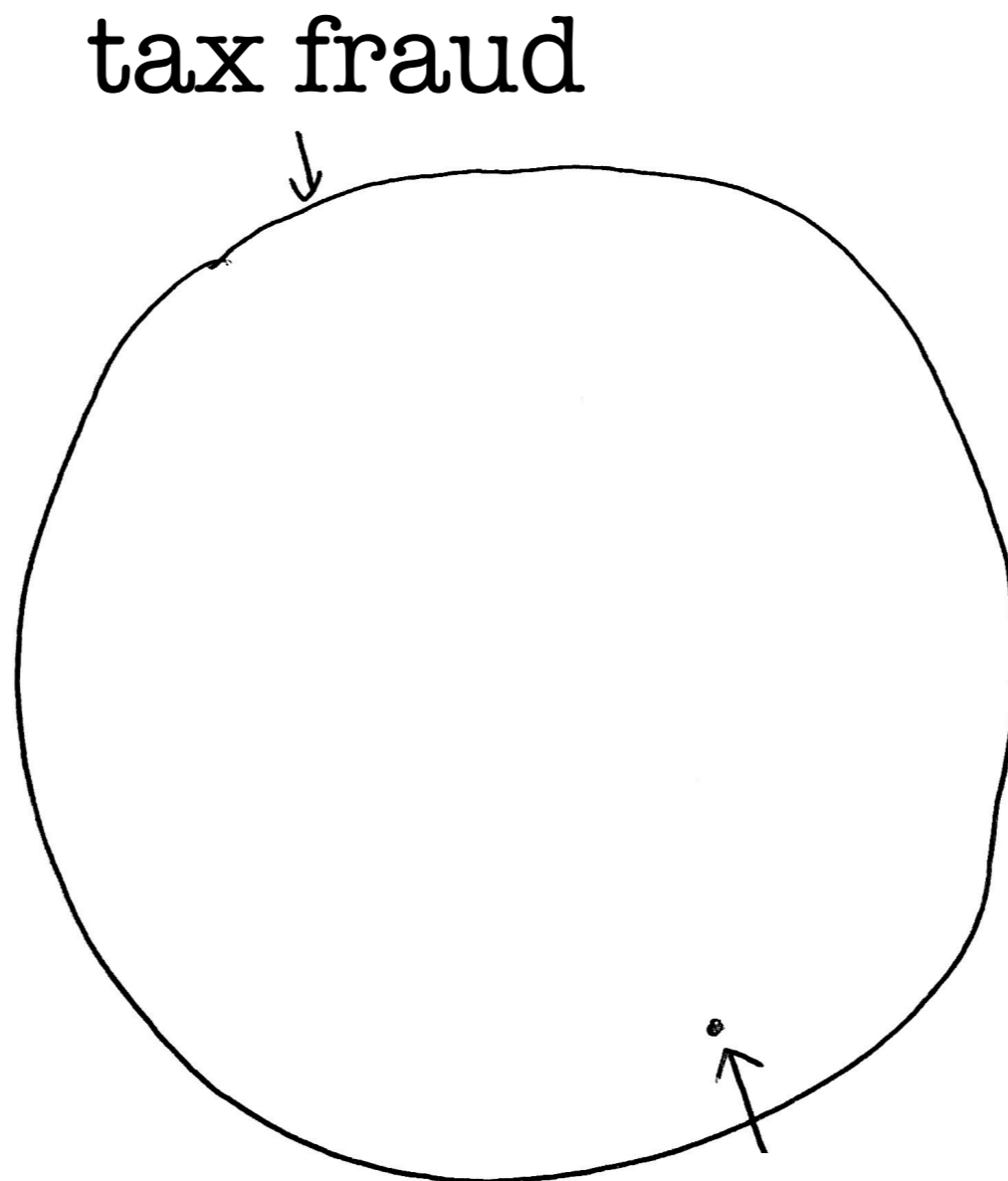


pathogenic
bacteria





**100
billion
Euros
annually**



tax fraud

unemployment
benefit fraud

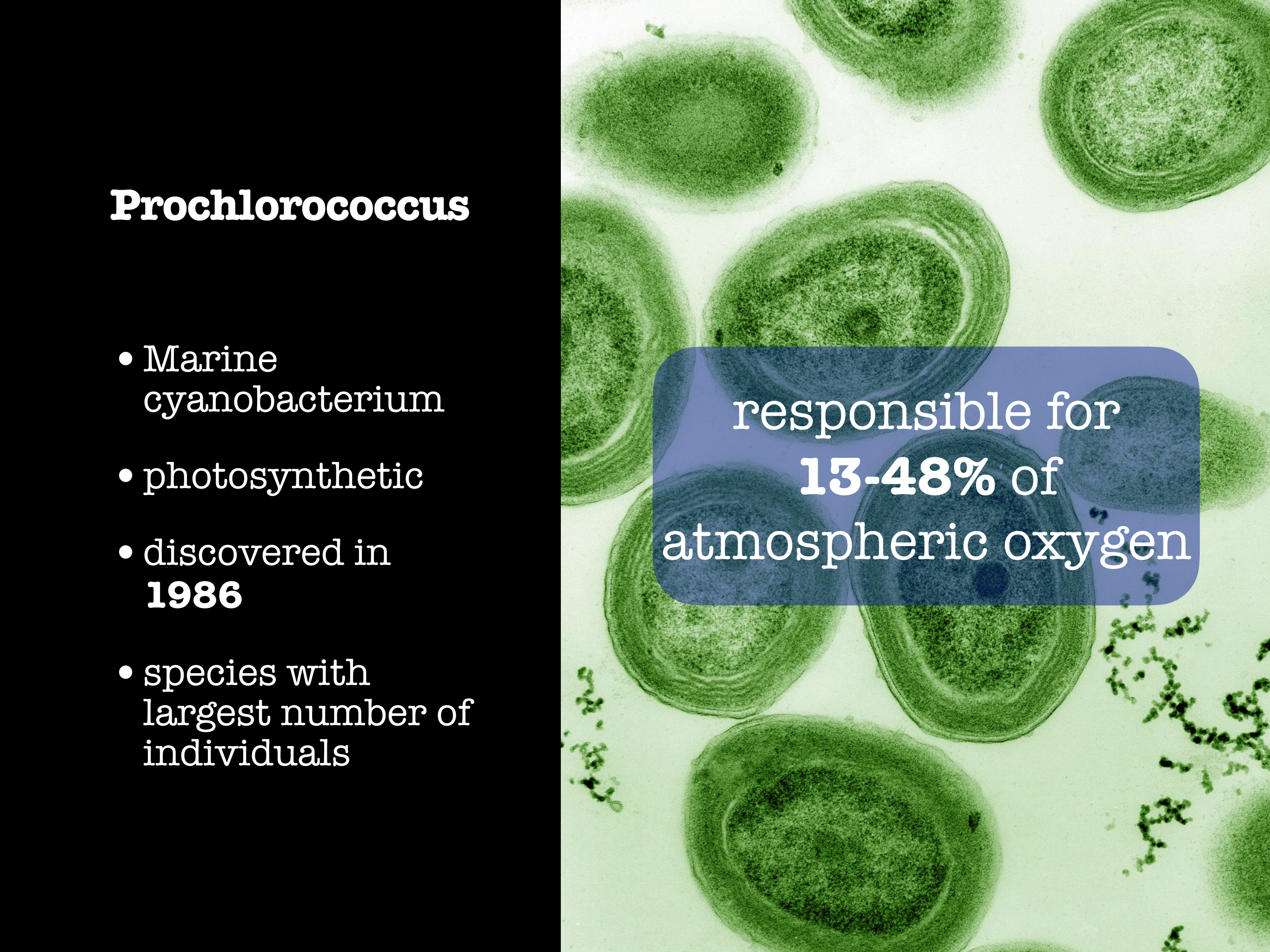


**58
million
Euros
annually**



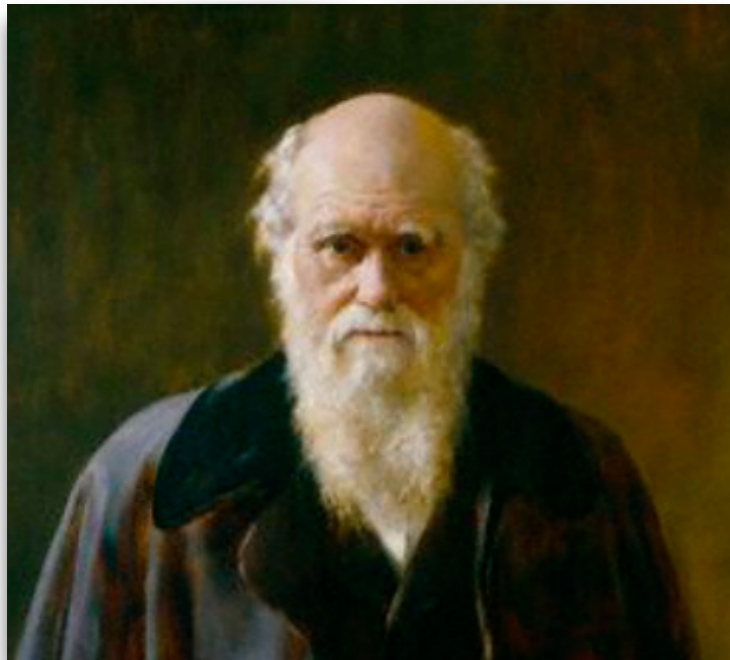
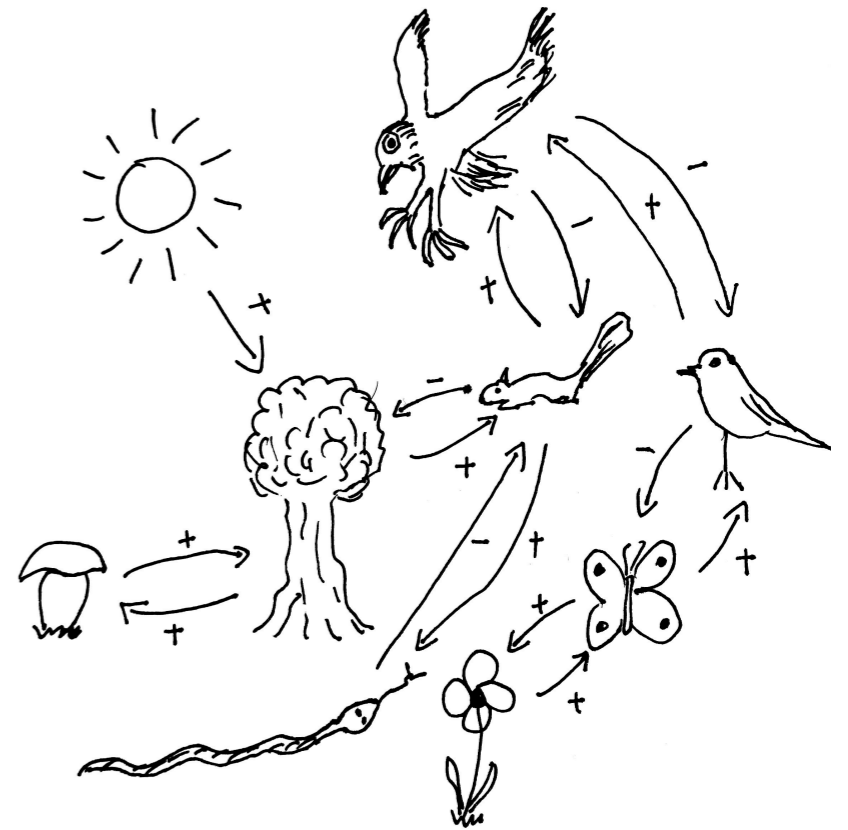
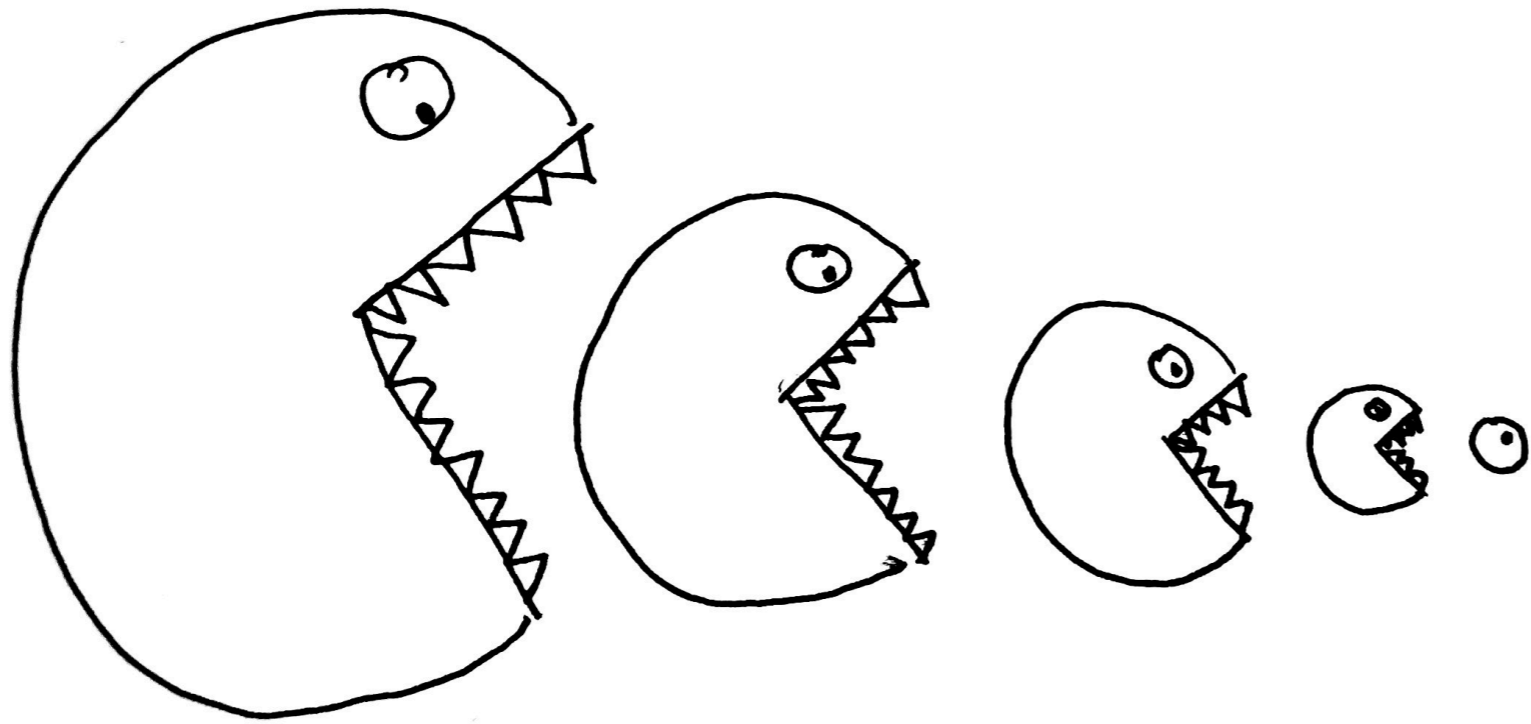
Prochlorococcus

- Marine cyanobacterium
- photosynthetic
- discovered in **1986**
- species with largest number of individuals

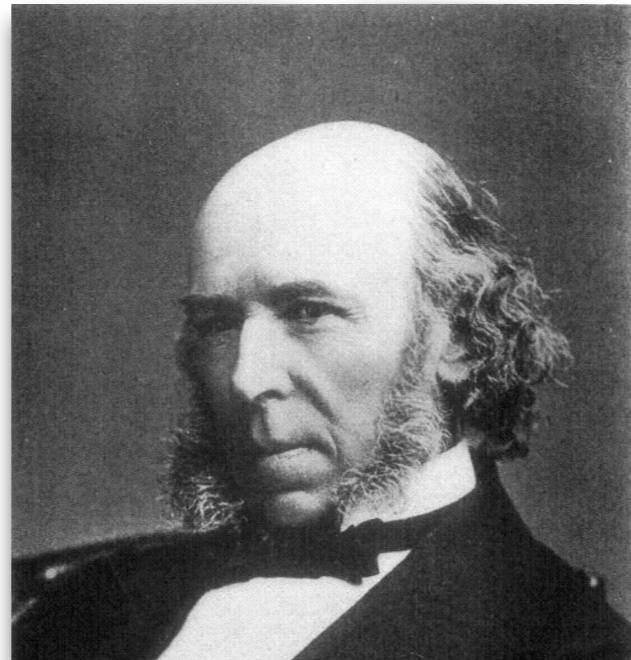
A microscopic image showing numerous spherical, green Prochlorococcus cells. The cells are densely packed and exhibit a distinct layered structure, characteristic of their photosynthetic membranes. A semi-transparent blue box is overlaid on the right side of the image, containing text.

responsible for
13-48% of
atmospheric oxygen

Competition and Conflict



Darwin



Spencer

“Survival of the fittest” dude



Sozialdarwinismus



“Life did not
take over the
world by
combat but by
networking!!”

Lynn Margulis (1938 -
2011)



Every higher organism
(animal/plant/human/
fungi) entertains a large
number of **mutualistic**
relationships with
microorganisms.

Every major transition
in the evolution of life
(photosynthesis, cells,
replication, genes,
multicellular organisms,
complex body plans, social
systems, land plants, etc.)
**is a result of a new
cooperation.**

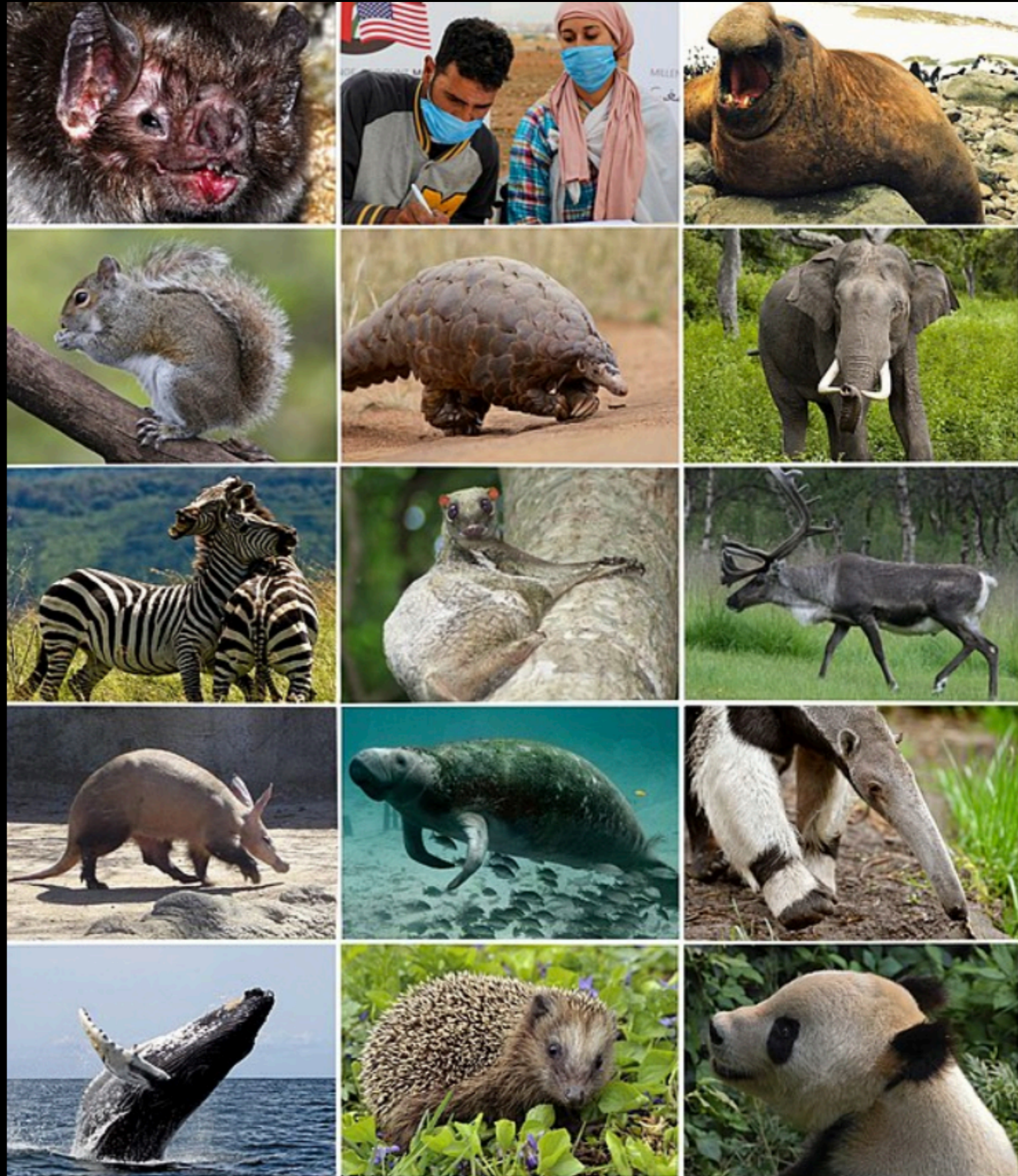
Lichens

- Symbiotic Organism involving a **fungus** and **algae** or **cyanobacteria**
- origin of land plants
- 700 million years ago
- 70-80% of all land plants in symbiosis with Arbuscular mycorrhiza fungi



Placentalia

- Mammals only exist because of a **retroviral infection**, a cooperation of animal with a virus.
- **Syncytin** is a retroviral protein that permits the growth of an embryo inside the mother.
- Human Endogenous Retrovirus-W (HERV-W) infection **90 Mio. yrs ago**.



Aphids & Densovirus

- Aphids come in two forms, **wingless** and **winged**.
- Only **when infected** with a virus, **winged** offspring are produced
- **Cooperation of insect with virus** makes sure virus and insect can move to new locations.

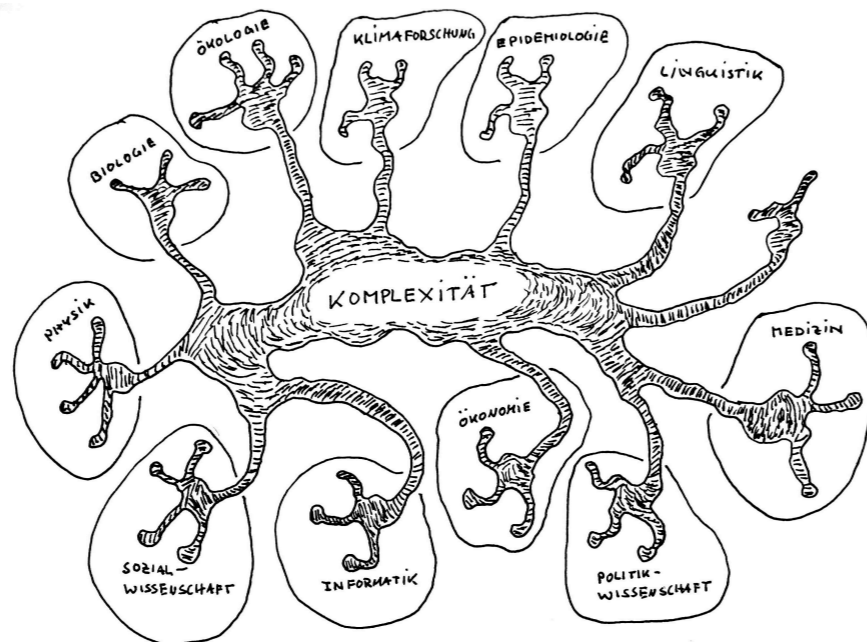
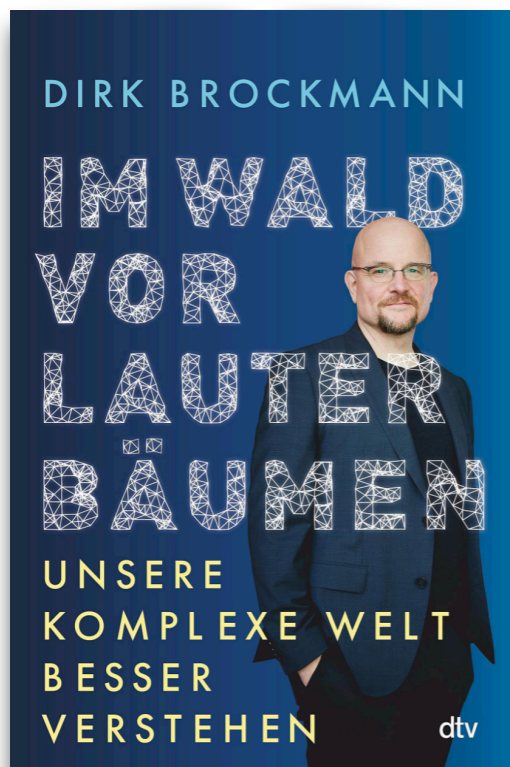
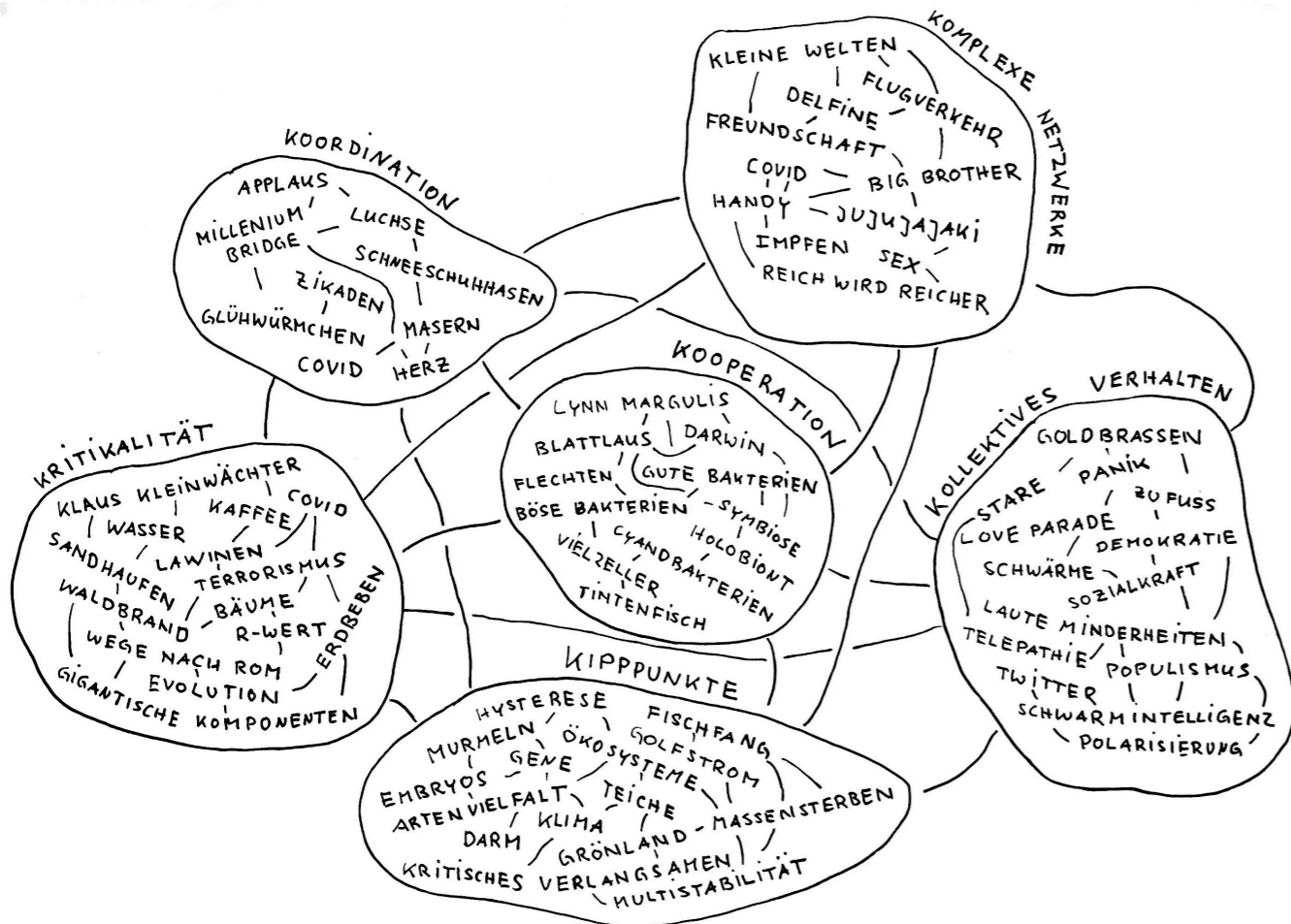


“Life did not
take over the
world by
combat but by
networking!!”

Lynn Margulis (1938 -
2011)



Innovation in evolution is **almost always** driven by the establishment of novel **mutualistic, beneficial and cooperative** relationships.



Complexity Explorables

Explorables Flongs Slides About Contact Bucket List

Complexity Explorables

A collection of interactive explorable explanations of complex systems in biology, physics, mathematics, social sciences, epidemiology, ecology and other fields...

Biology Chemistry Ecology Epidemiology Mathematics Network science Neuroscience Physics Social sciences

#Agent based models · #Cellular automata · #Chaotic dynamics · #Collective behavior · #Complex networks · #Coupled oscillators · #Critical phenomena · #Diffusion · #Dynamical systems · #Epidemics · #Evolution · #Fractals · #Growth processes · #Lattice systems · #Nonlinear dynamics · #Pattern formation · #Population dynamics · #Random walks · #Reaction diffusion · #Self organization · #Self similarity · #Stochastic processes · #Synchronization

f t i +

Most recent Explorables:

"Swärmaalätors"
Oscillators that sync and swarm
November 18, 2019

This explorable illustrates how remarkable spatio-temporal patterns can emerge when two dynamical

<p>Jujujajaki networks March 20, 2019</p> <p>A mechanism that may explain community structures in social networks</p>	<p>Prime Time March 12, 2019</p> <p>A visual exploration into the funky distribution of prime numbers</p>	<p>I sing well-tempered March 1, 2019</p> <p>A simple model for critical behavior in a system of spins</p>
<p>Anomalous Itinerary January 8, 2019</p> <p>Superdiffusive, Scale-Free Random Walks</p>	<p>Hopfed Turingles December 30, 2018</p> <p>This reaction-diffusion system generates a variety of spatio-temporal patterns</p>	<p>Albert & Carl Friedrich December 11, 2018</p> <p>A geometric explanation of the central limit theorem</p>
<p>Critically Inflammatory November 14, 2018</p> <p>Spatial patterns, dynamics and criticality in forrest fire dynamics</p>	<p>Dr. Fibryll & Mr. Glyde November 12, 2018</p> <p>Pattern formation and spiral waves in spatially distributed pulse-coupled oscillators</p>	<p>Facebooked Flu Shots October 9, 2018</p> <p>Counter-Intuitive Vaccination Strategies in Complex Networks</p>