

INTRODUCTION TO COMPLEX SYSTEMS

**WINTER TERM, 2022
PROF. DIRK BROCKMANN**

<https://rocs.hu-berlin.de/>

DIRK BROCKMANN

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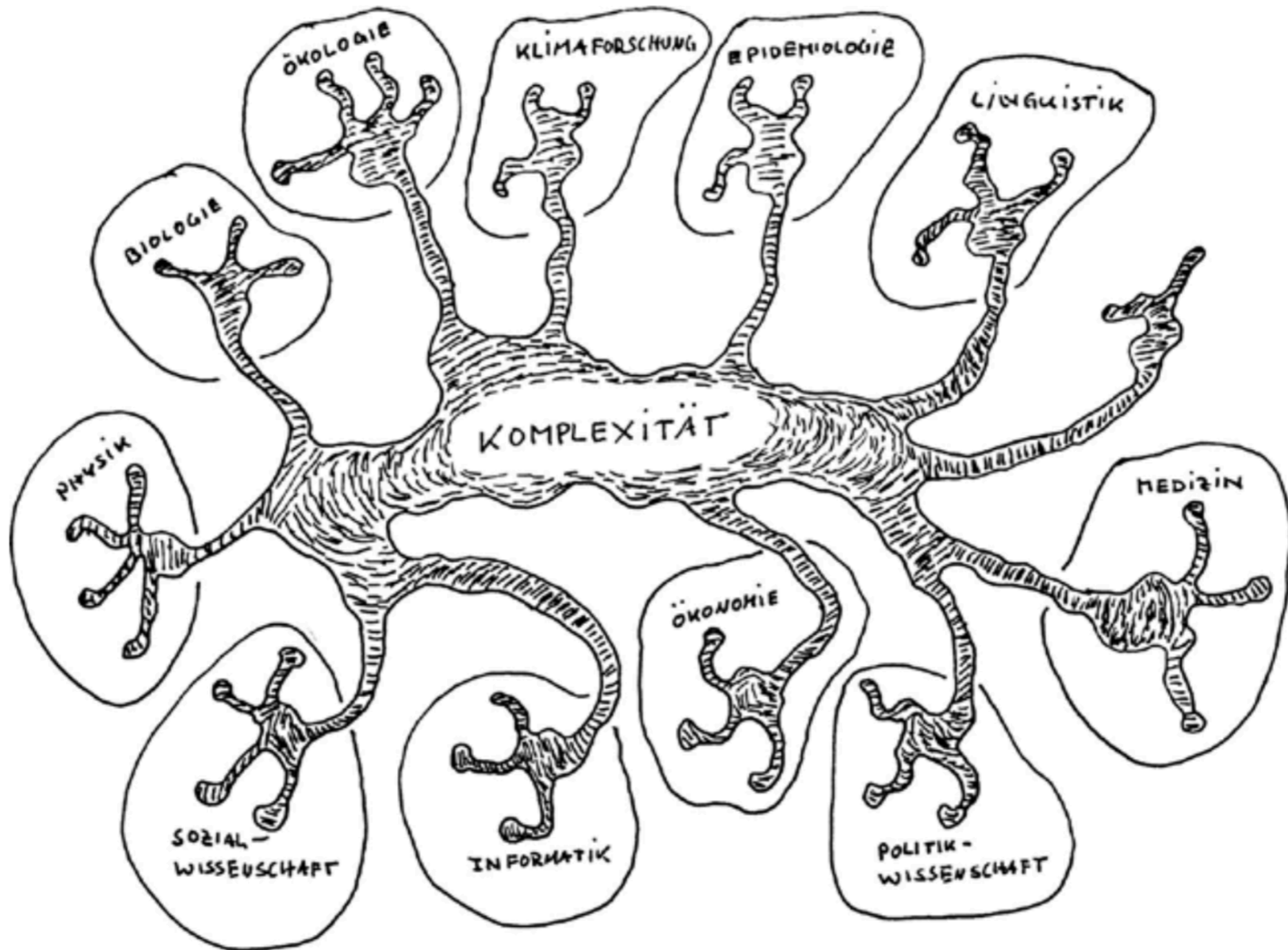
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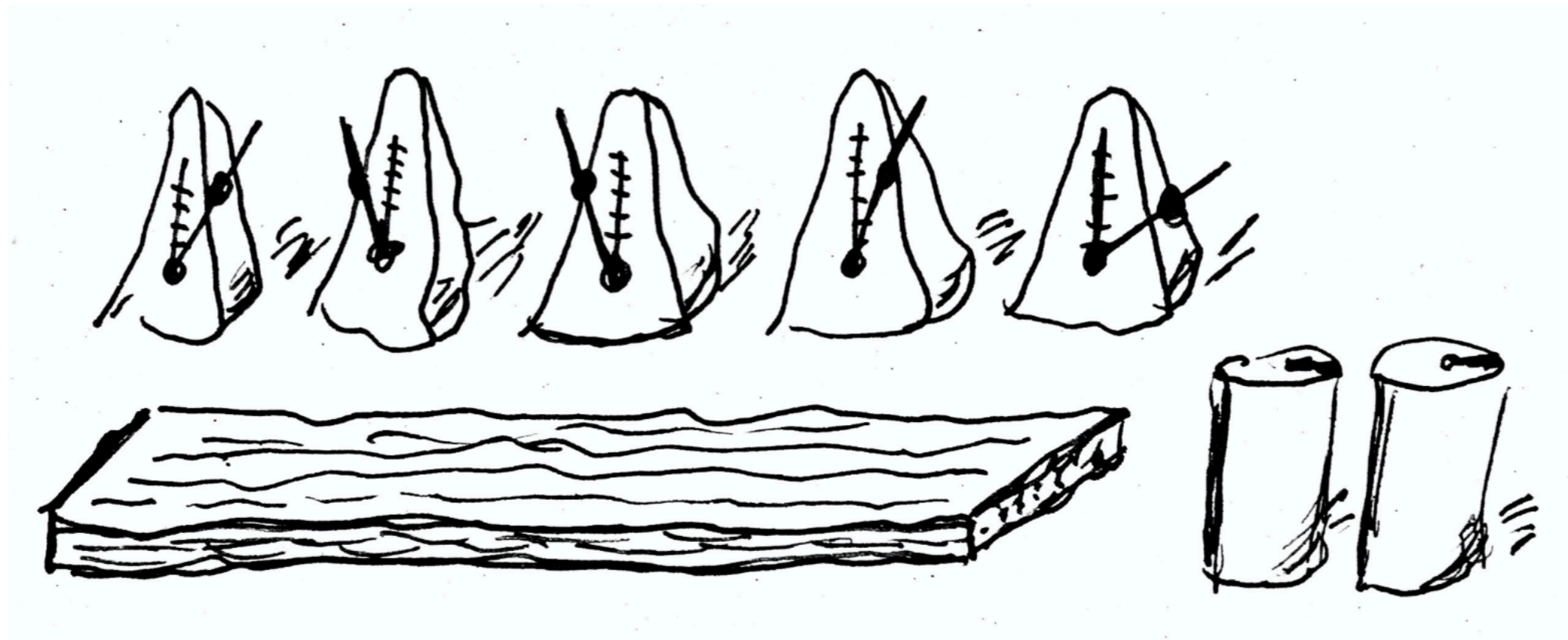
THEORETICAL BACKBONE

- Dynamical Systems - Modelling
- 1-d maps
- 1-d dynamical systems
- Bifurcation Analysis
- 2-d dynamical systems
- randomness & stochastic processes

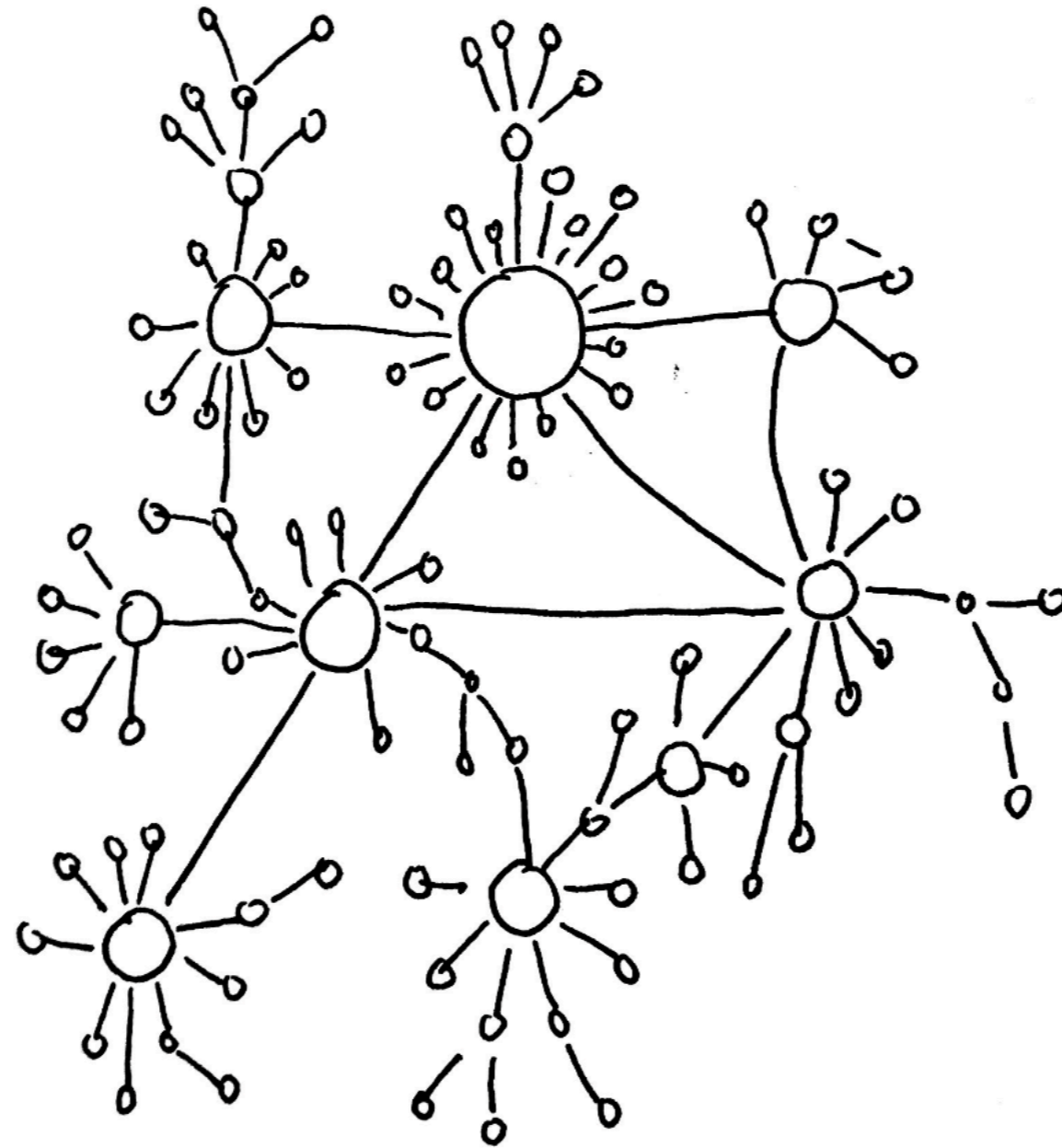
COMPLEXITY



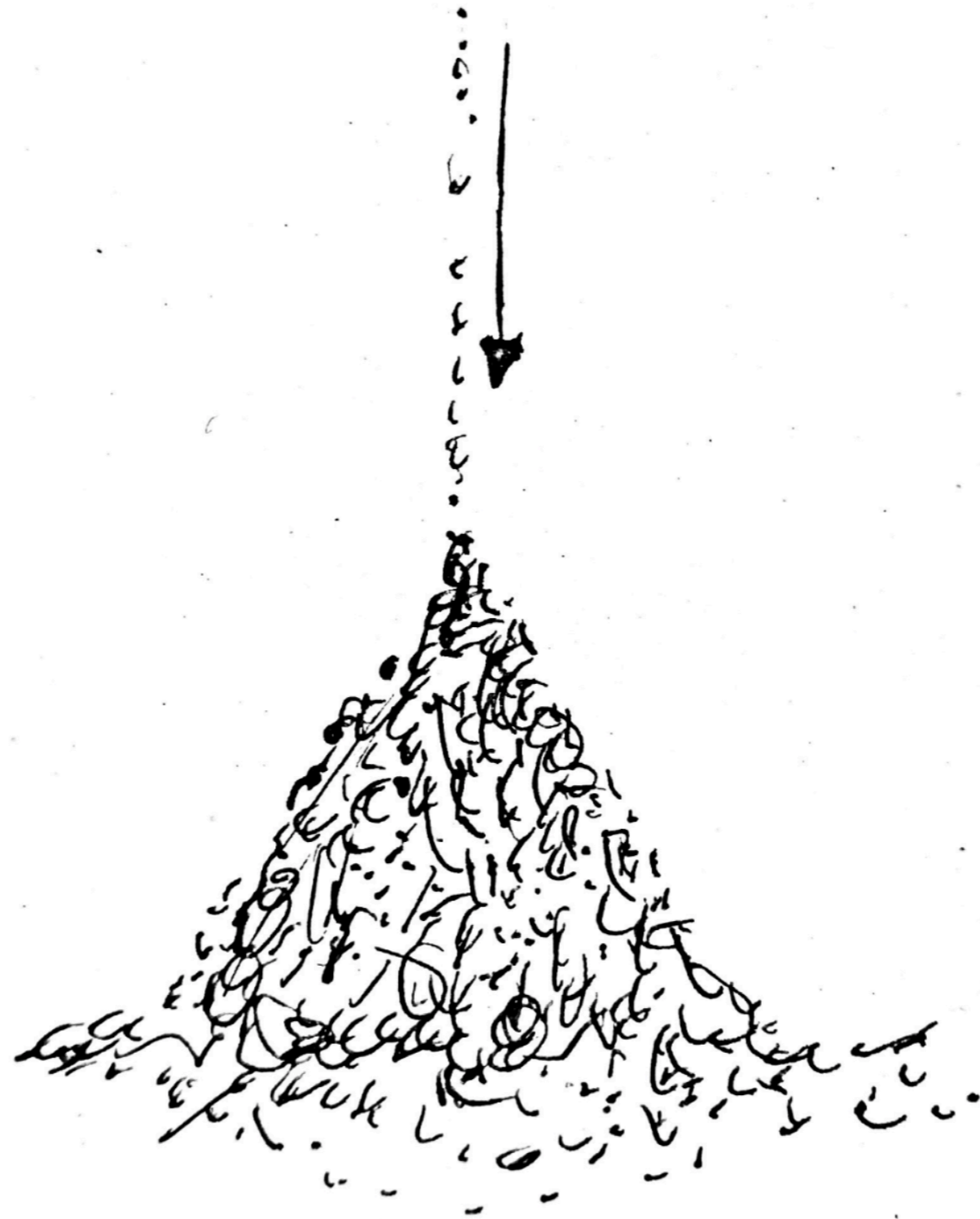
SYNCHRONIZATION



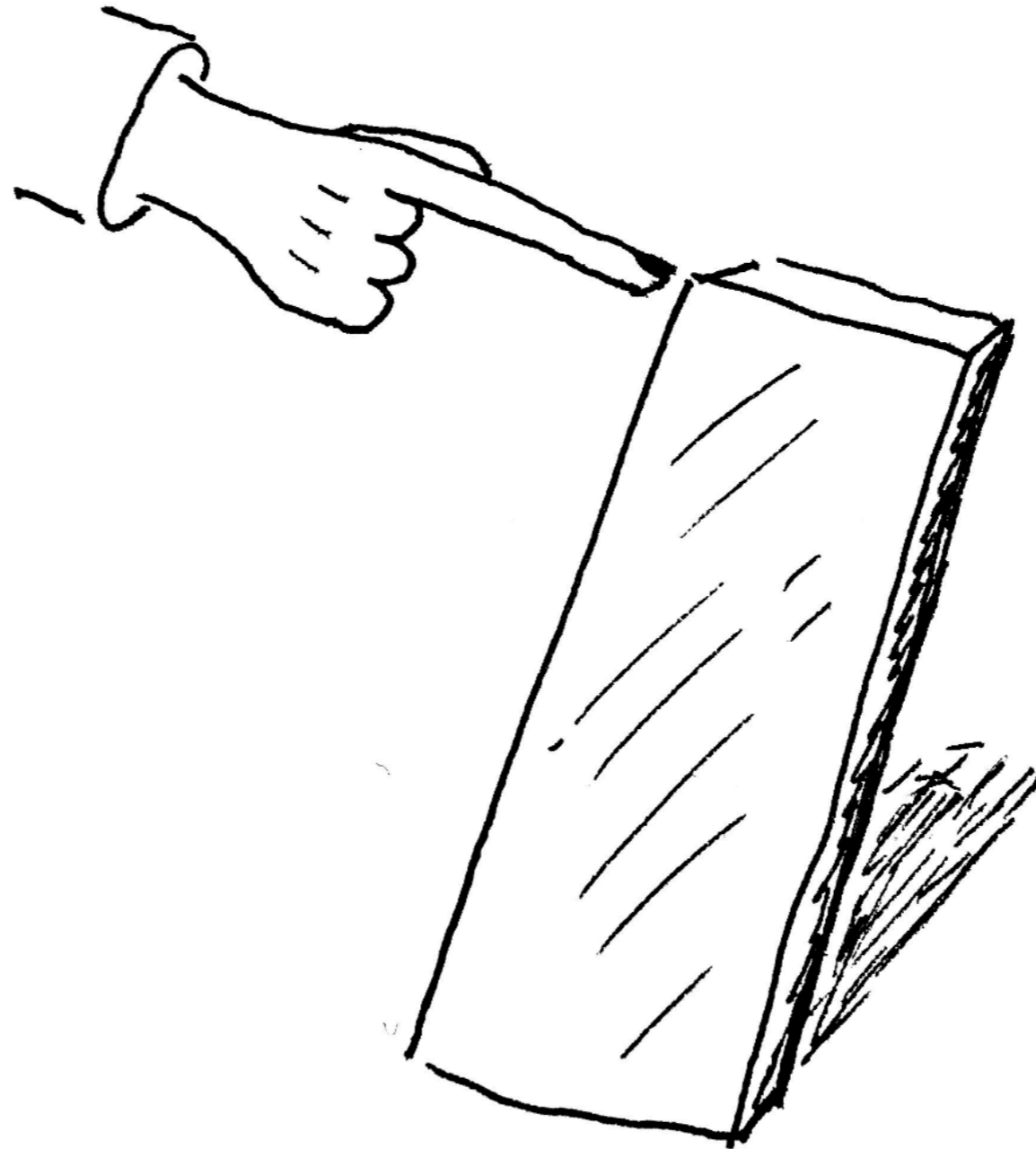
COMPLEX NETWORKS



CRITICALITY



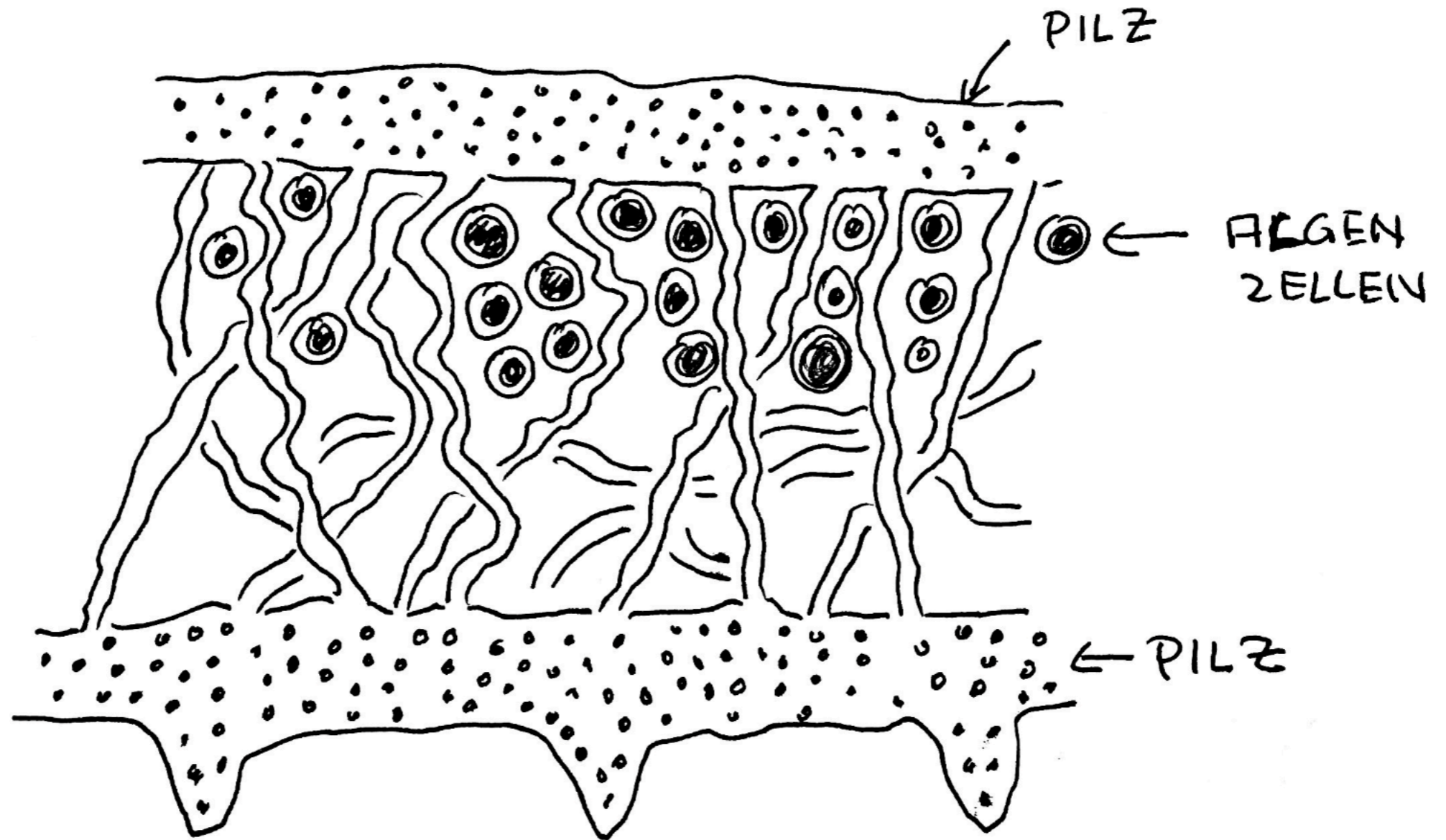
TIPPING POINTS



COLLECTIVE BEHAVIOR



COOPERATION



PATTERN FORMATION



www.complexity-explorables.org

SEMINAR

- Every student presents a complex system from the collection at www.complexity-explorables.org
- 30 minutes + 10 minutes discussion
- Flexible choice
- **First come first serve**
- Content & Skill

Tag	Zeit	Rhythmus	Dauer
-.	10:00 bis 16:00	Block	17.01.2023 bis 20.01.2023

LAB COURSE (FACHKURS)

- Programming complex systems
- No programming skills required
- Everyone needs a laptop
- Programming language: **netlogo**

Tag	Zeit	Rhythmus	Dauer	Raum	Raum-plan	Lehrperson	Status	Bemerkung	fällt aus am	Max. Teilnehmer
-.	10:00 bis 16:00	Block	03.01.2023 bis 13.01.2023			Brockmann	findet statt	Room: Inv42, I-MB, SR 312A	09.01.2023:	30

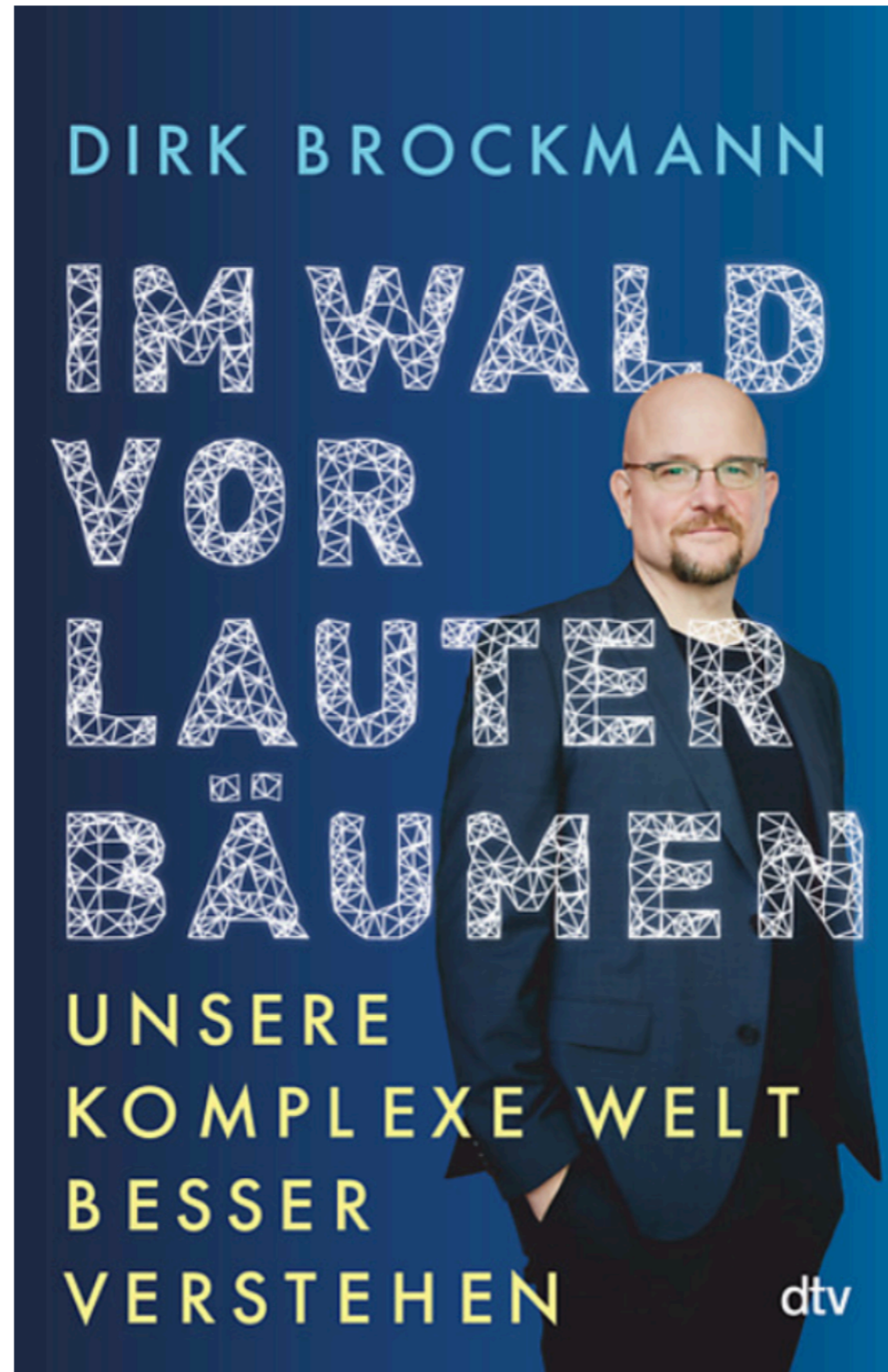
NETLOGO

netlogo is a simple to learn, platform independent, and free programming language that we will use frequently throughout this course. You will need to download a copy and install on your computer.

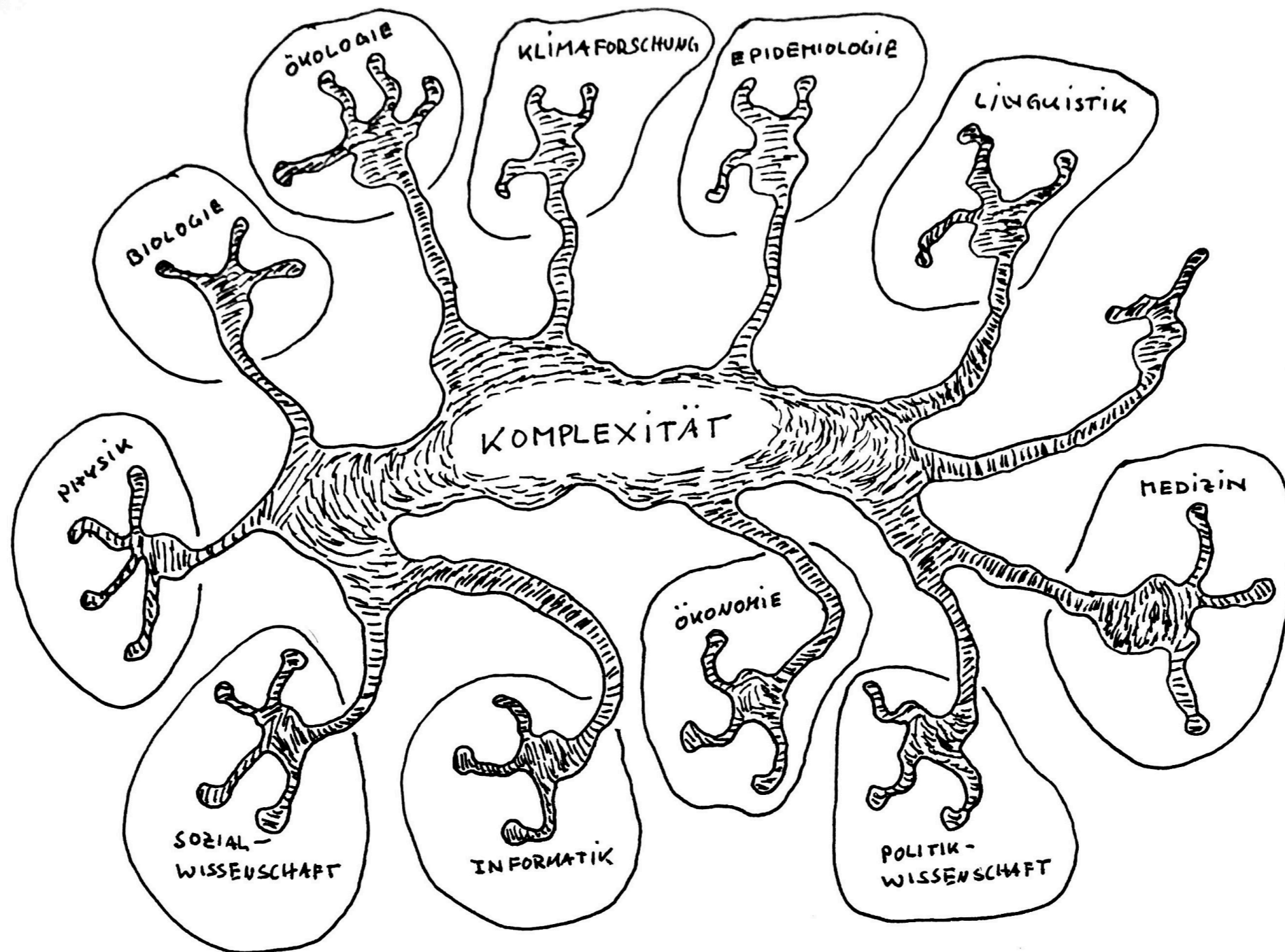
<https://ccl.northwestern.edu/netlogo/>

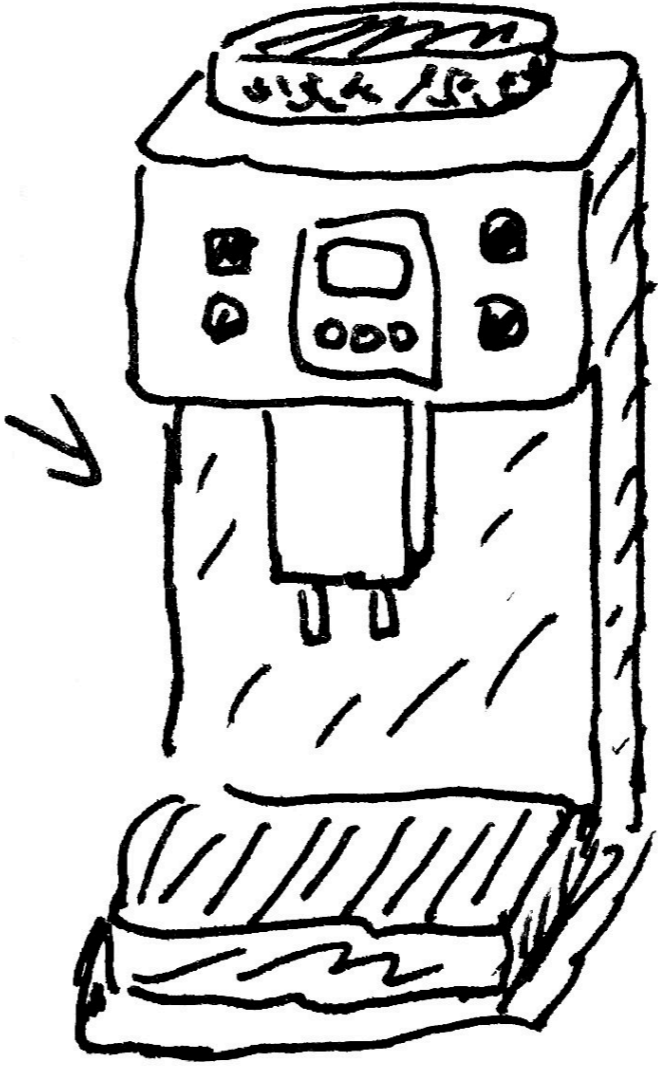
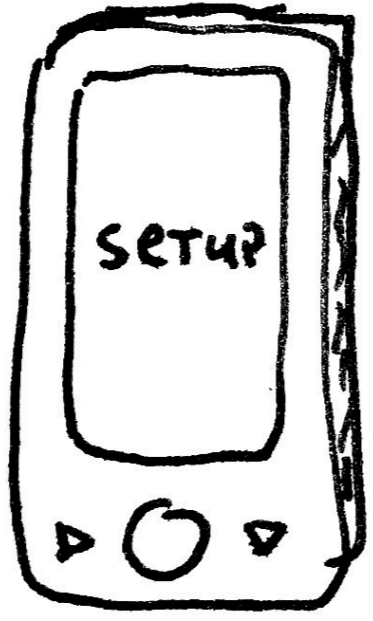
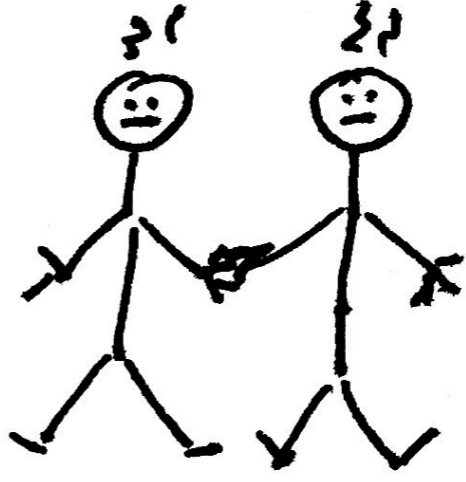
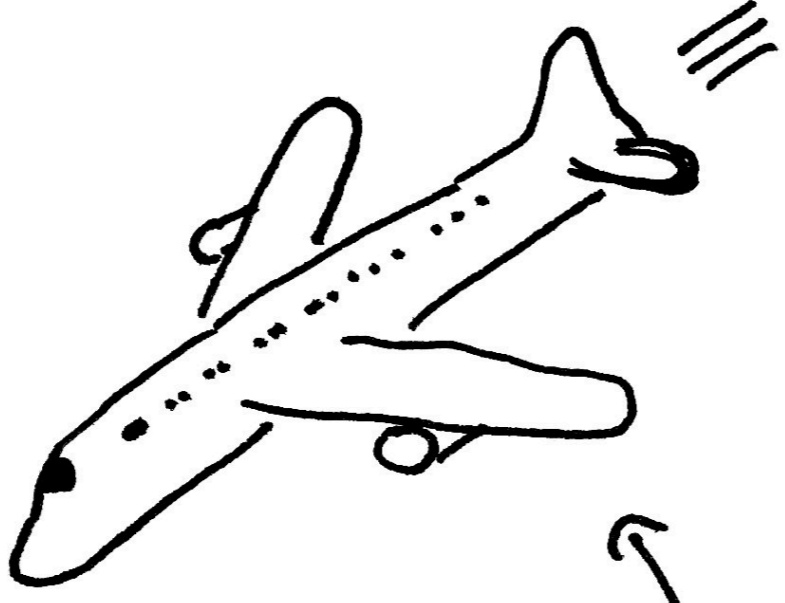
Download this and install, questions: complexsystems2021@gmail.com

BUT IT'S IN GERMAN :(



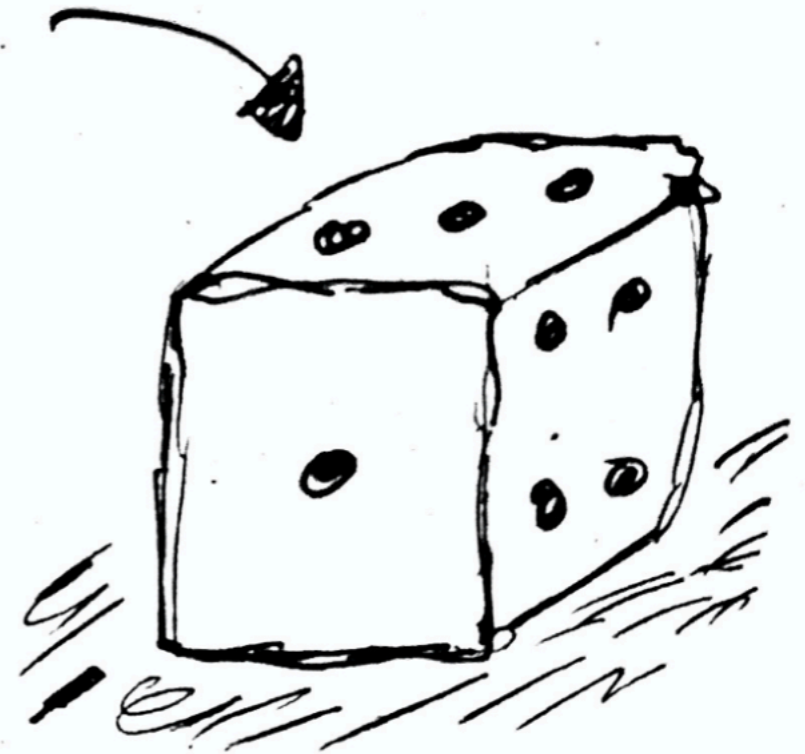
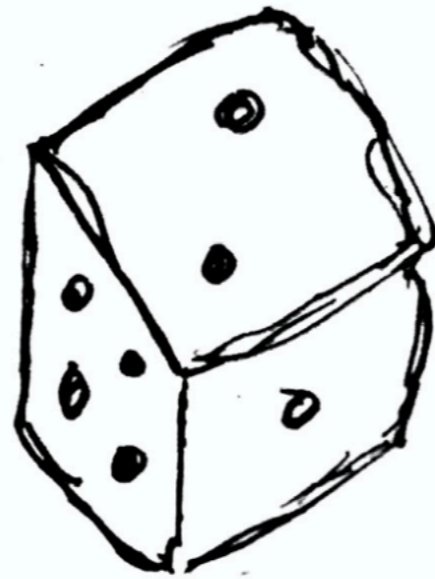
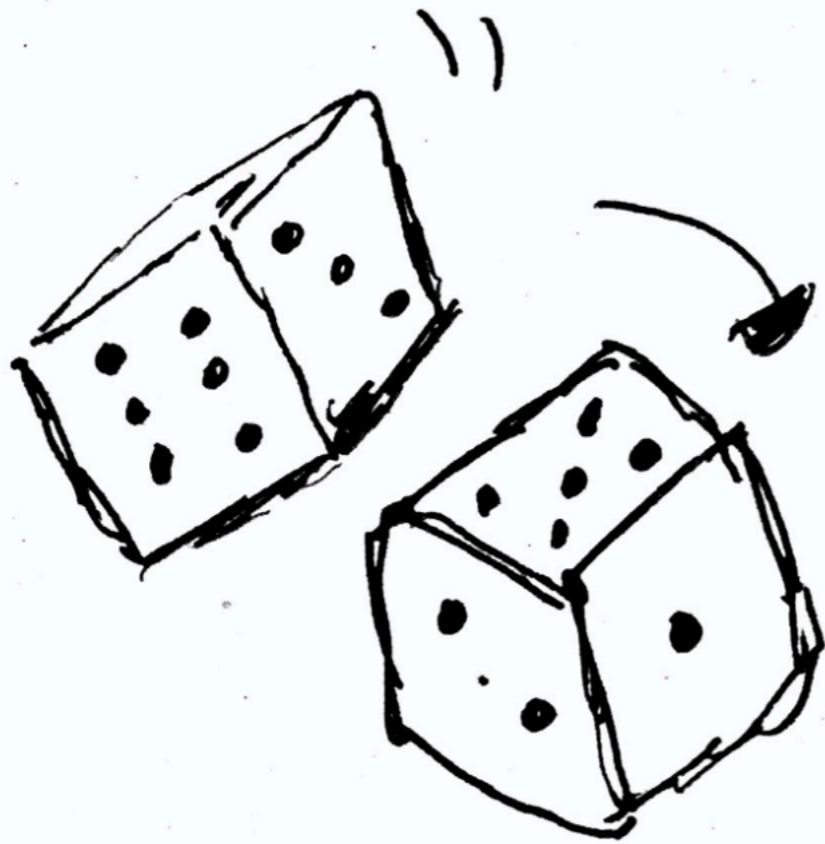
Komplexität

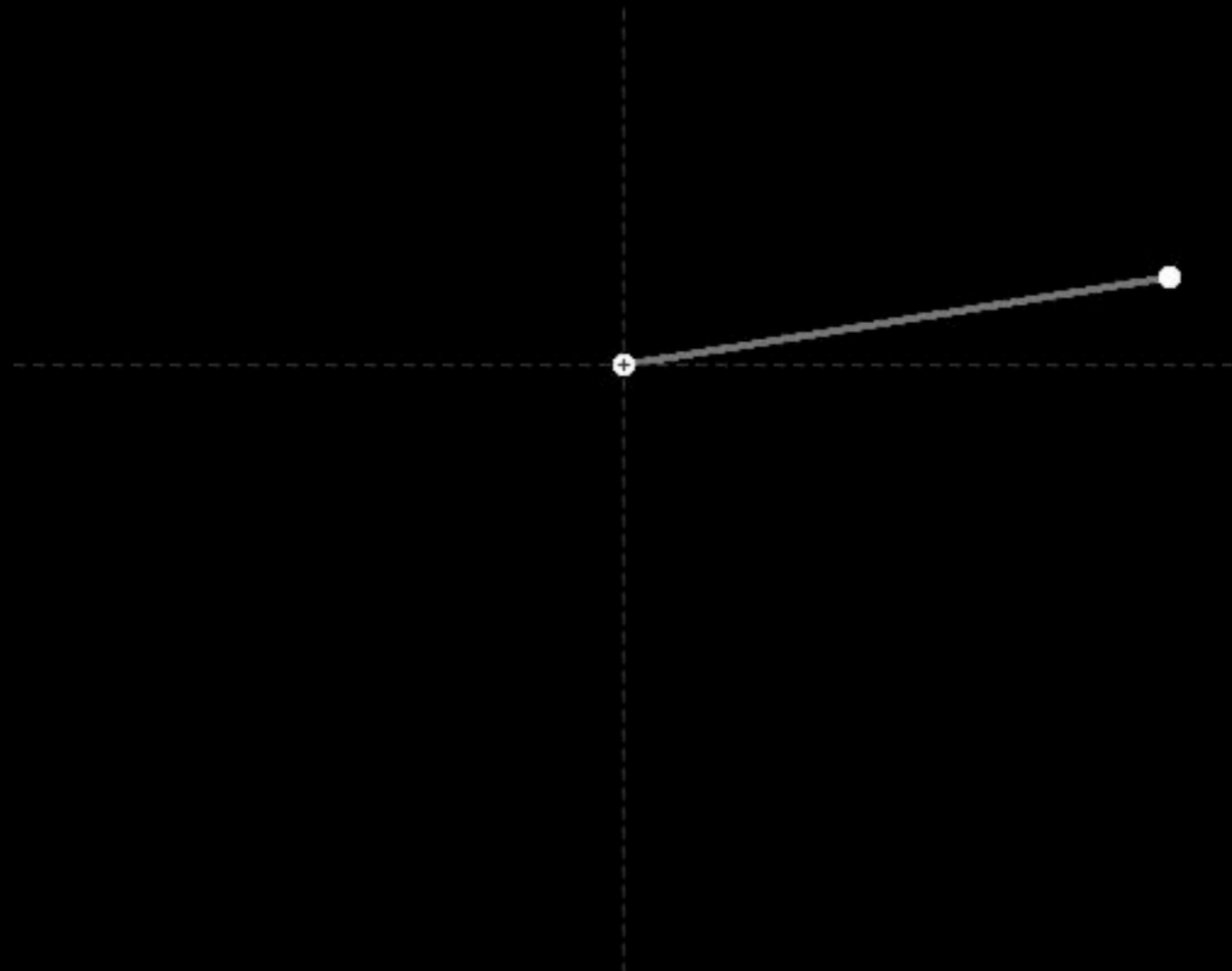


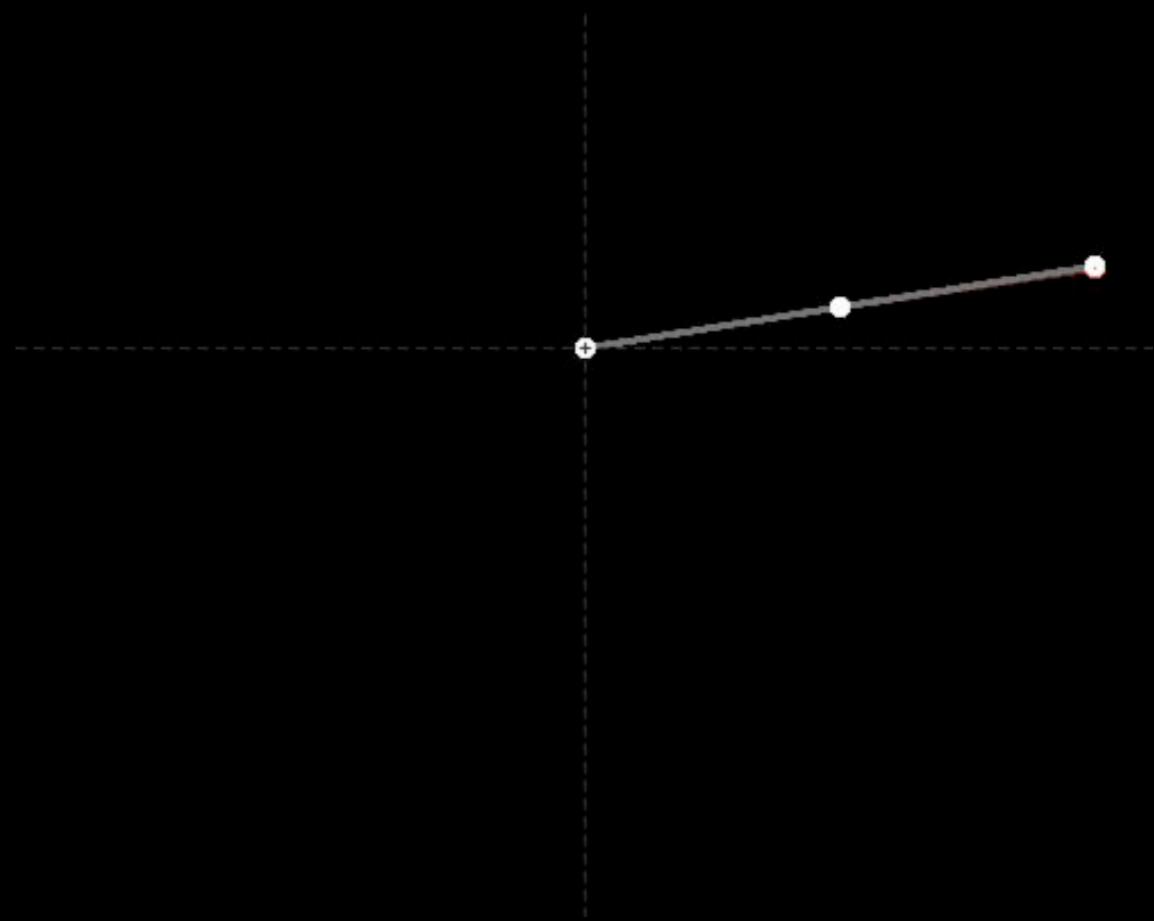
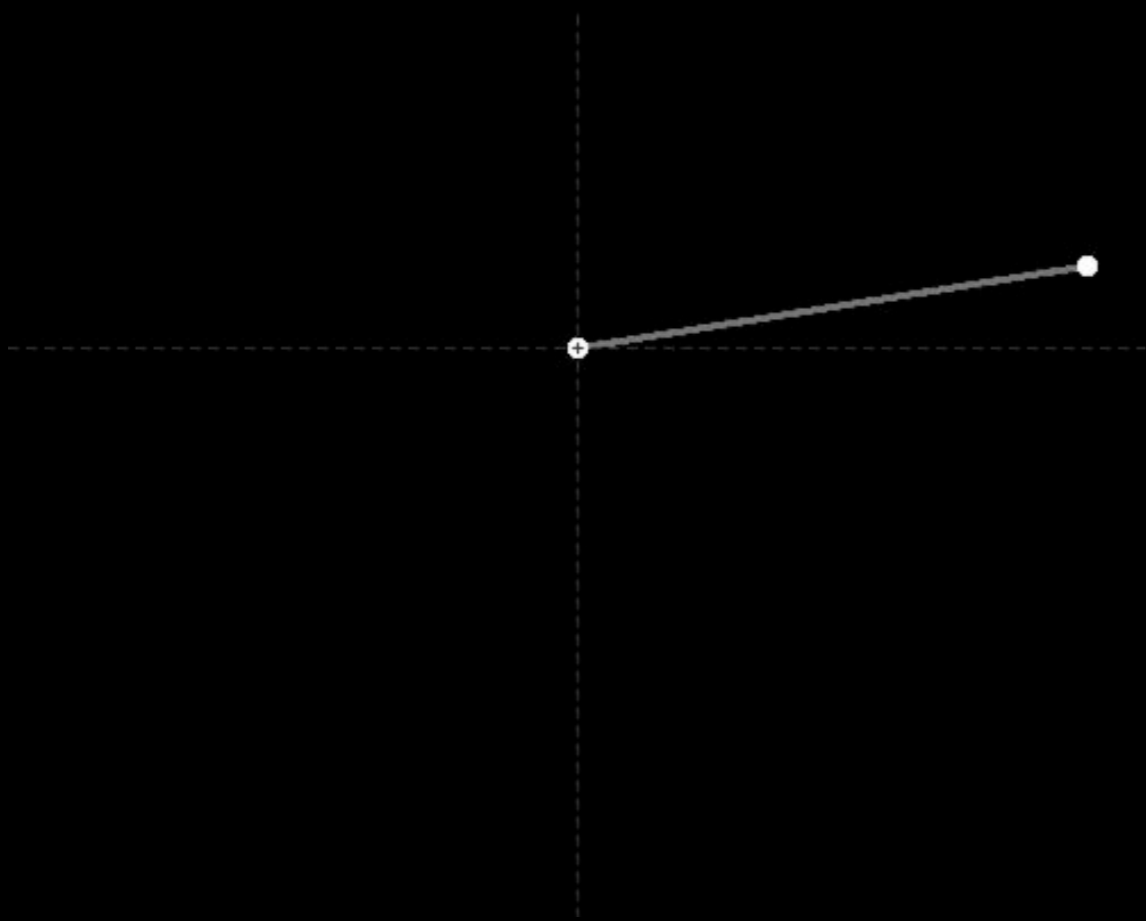


↑
KOMPLIZIERT





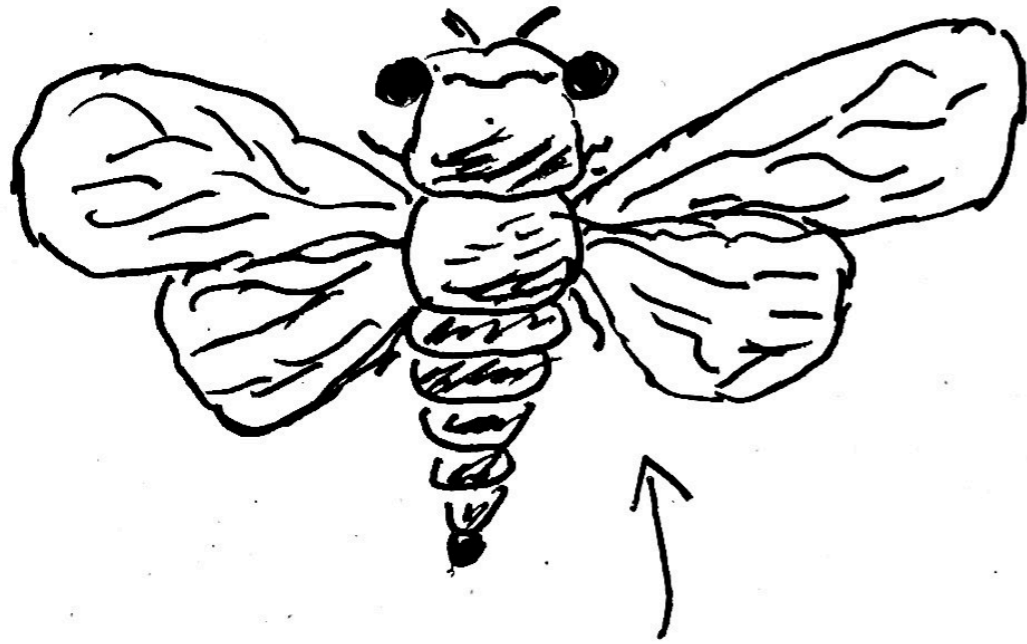






›Thought-transference (or what?) in birds‹

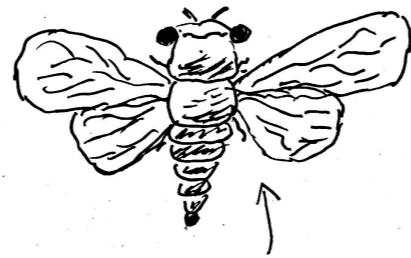
Edmund Selous 1931



MAGIZICADA
C



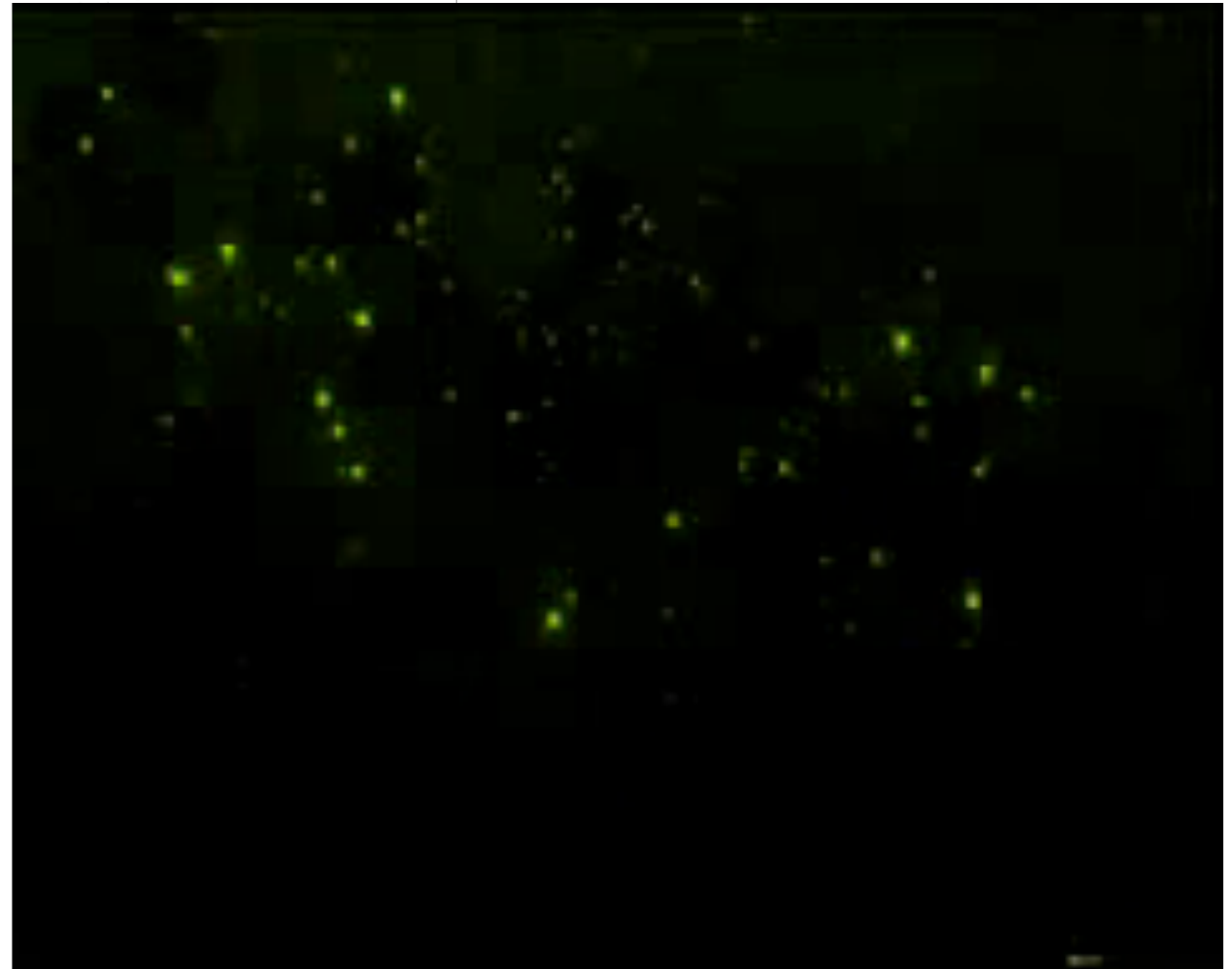
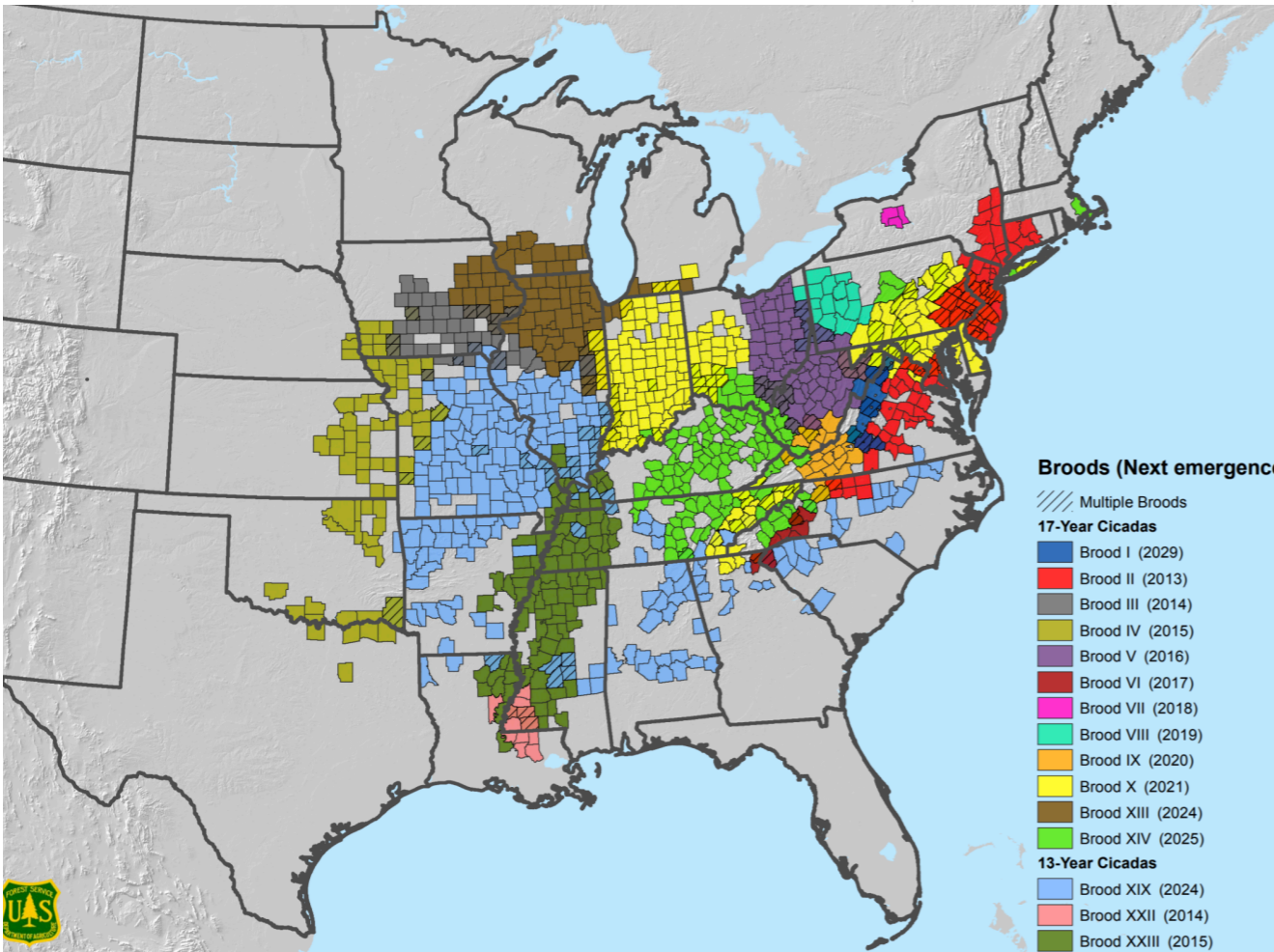
PTEROPTYX TENER



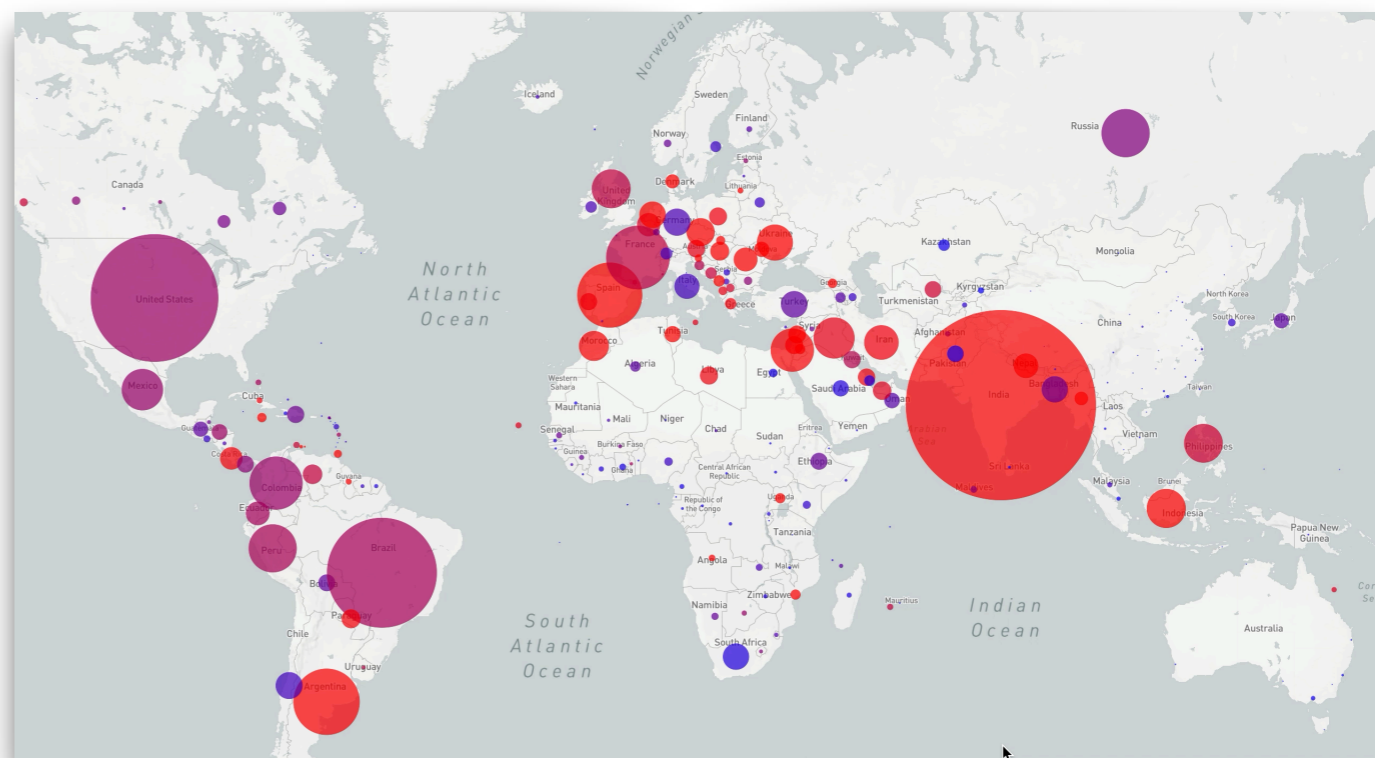
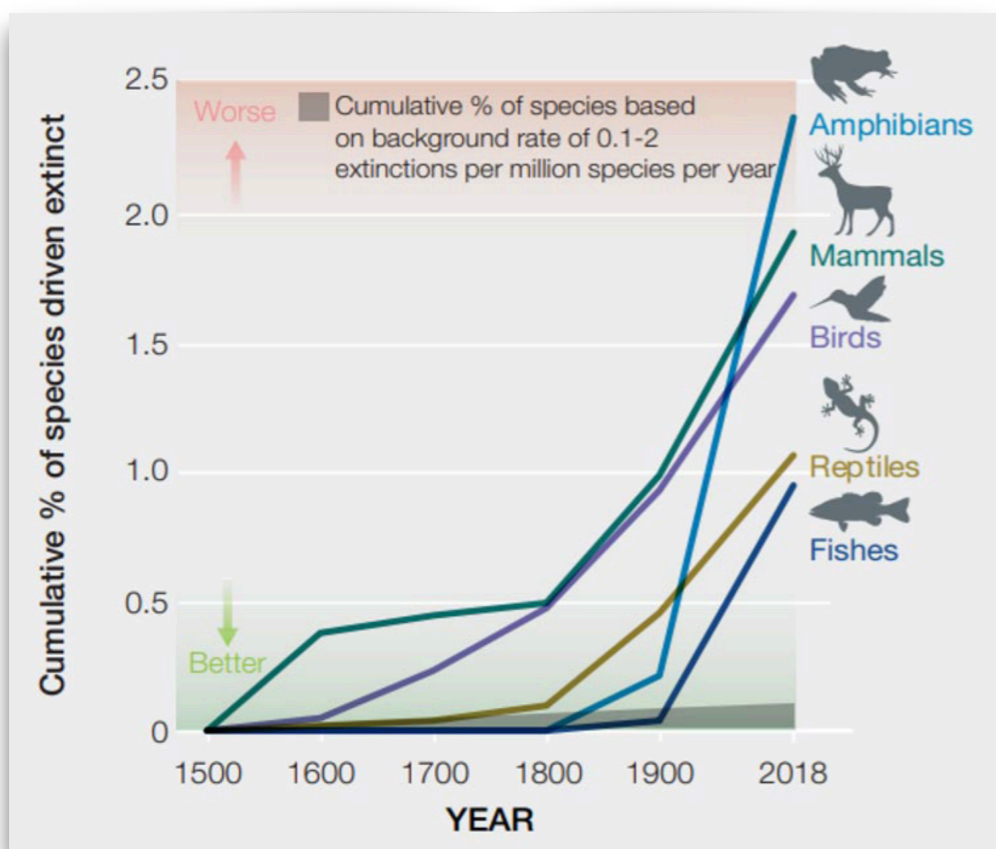
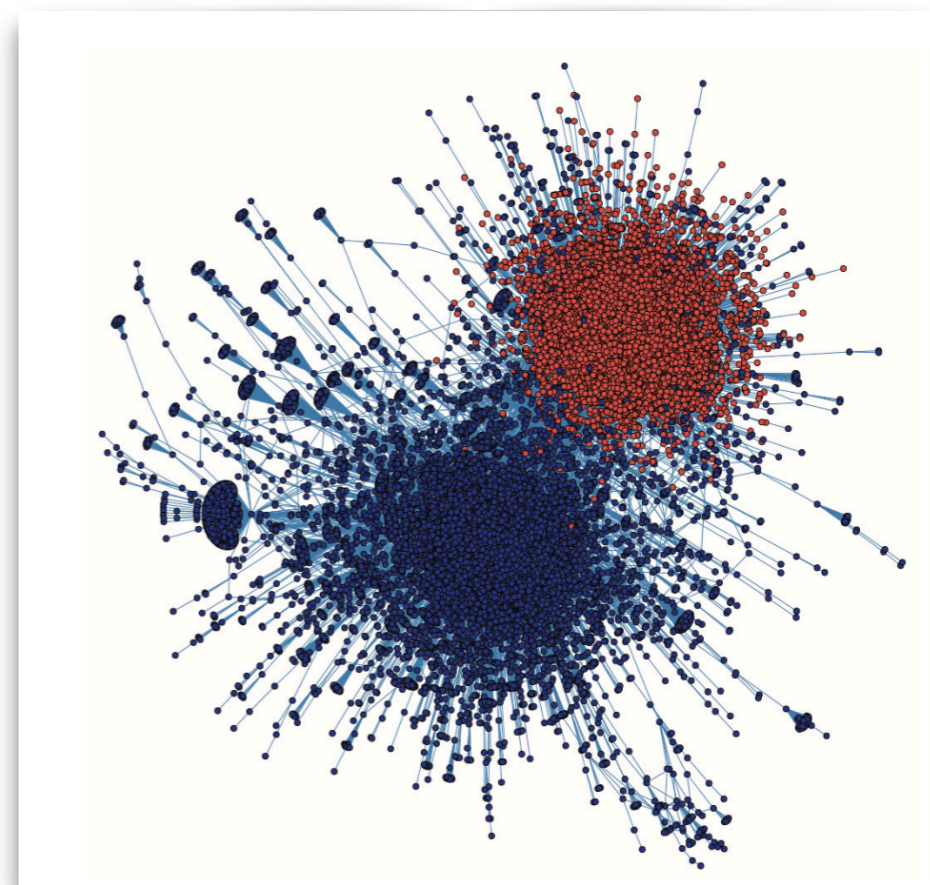
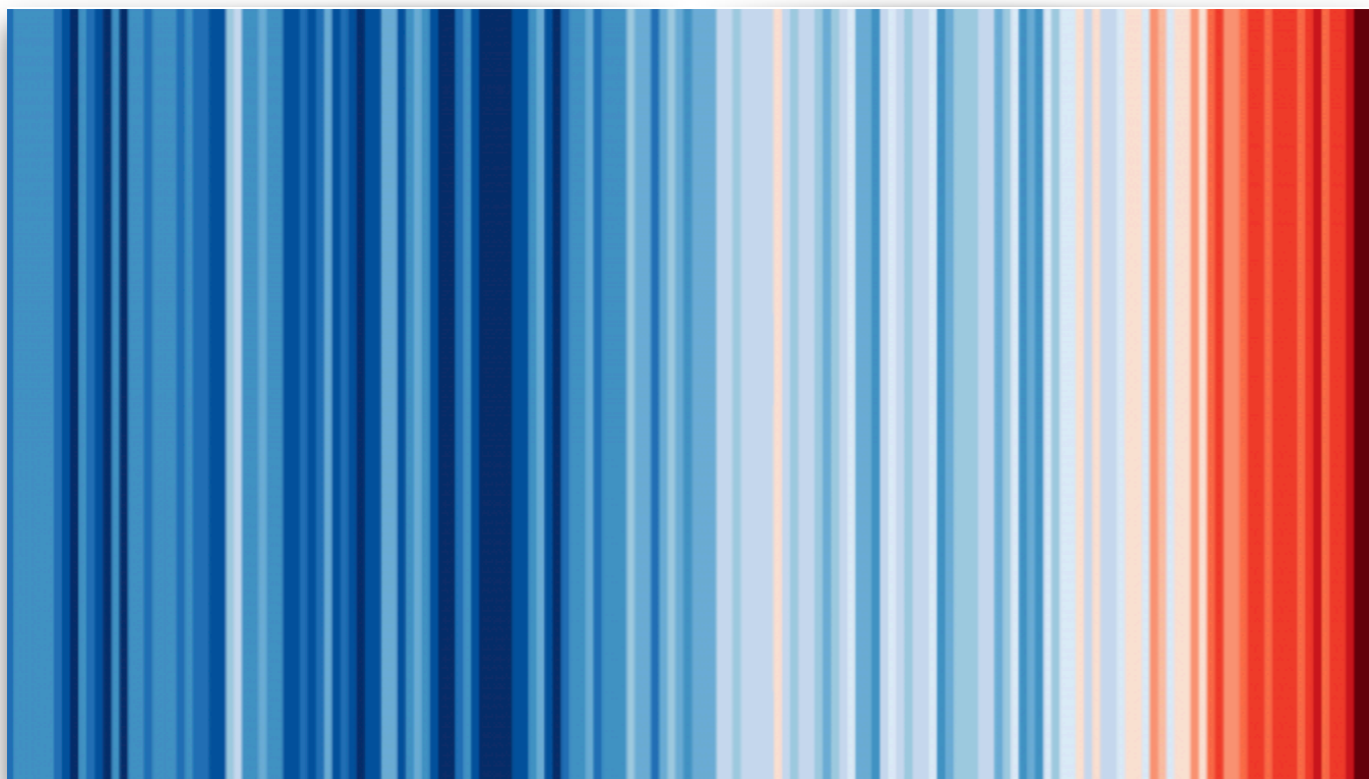
MAGICALCADA
C

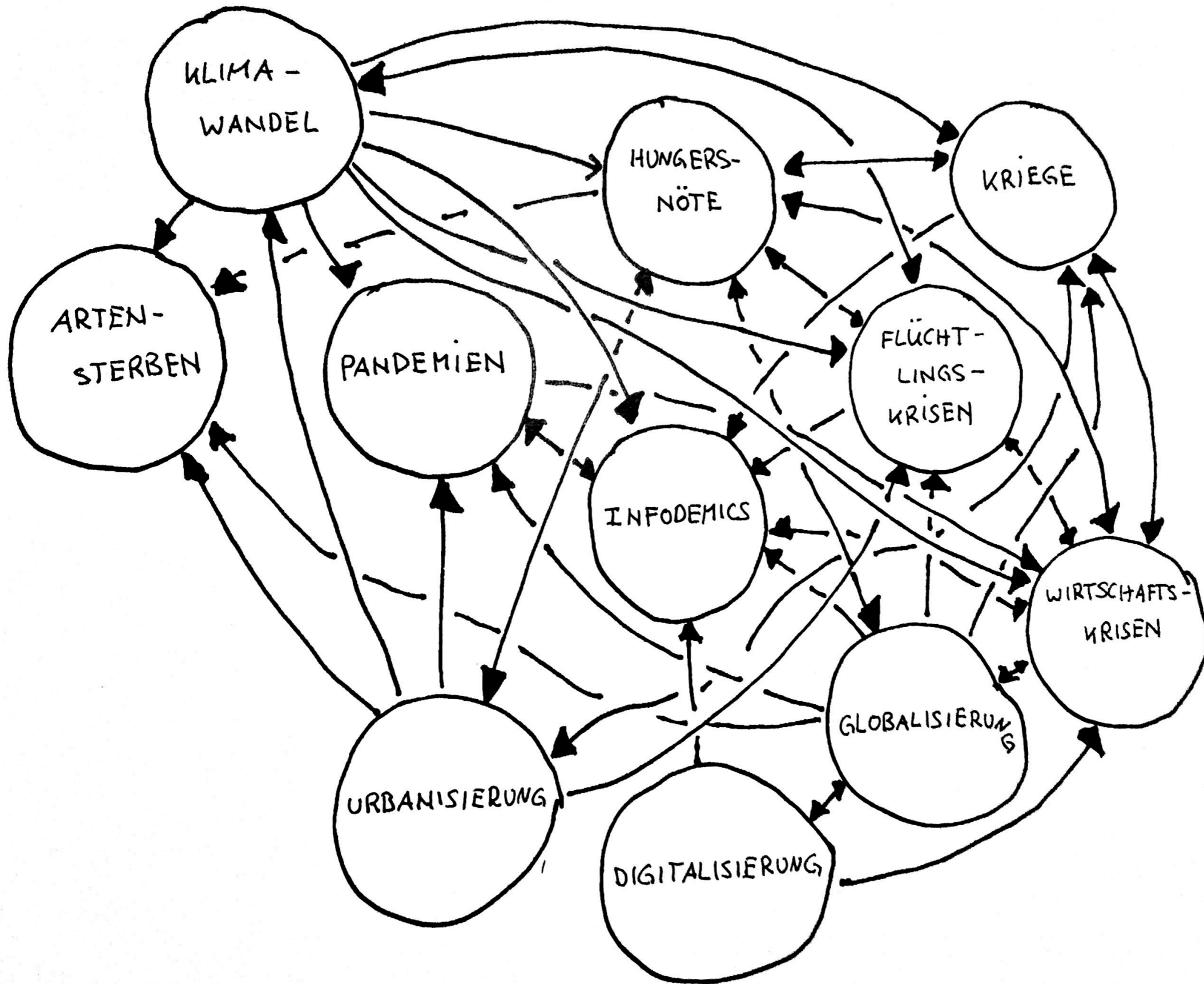


PTEROPTYX TENER

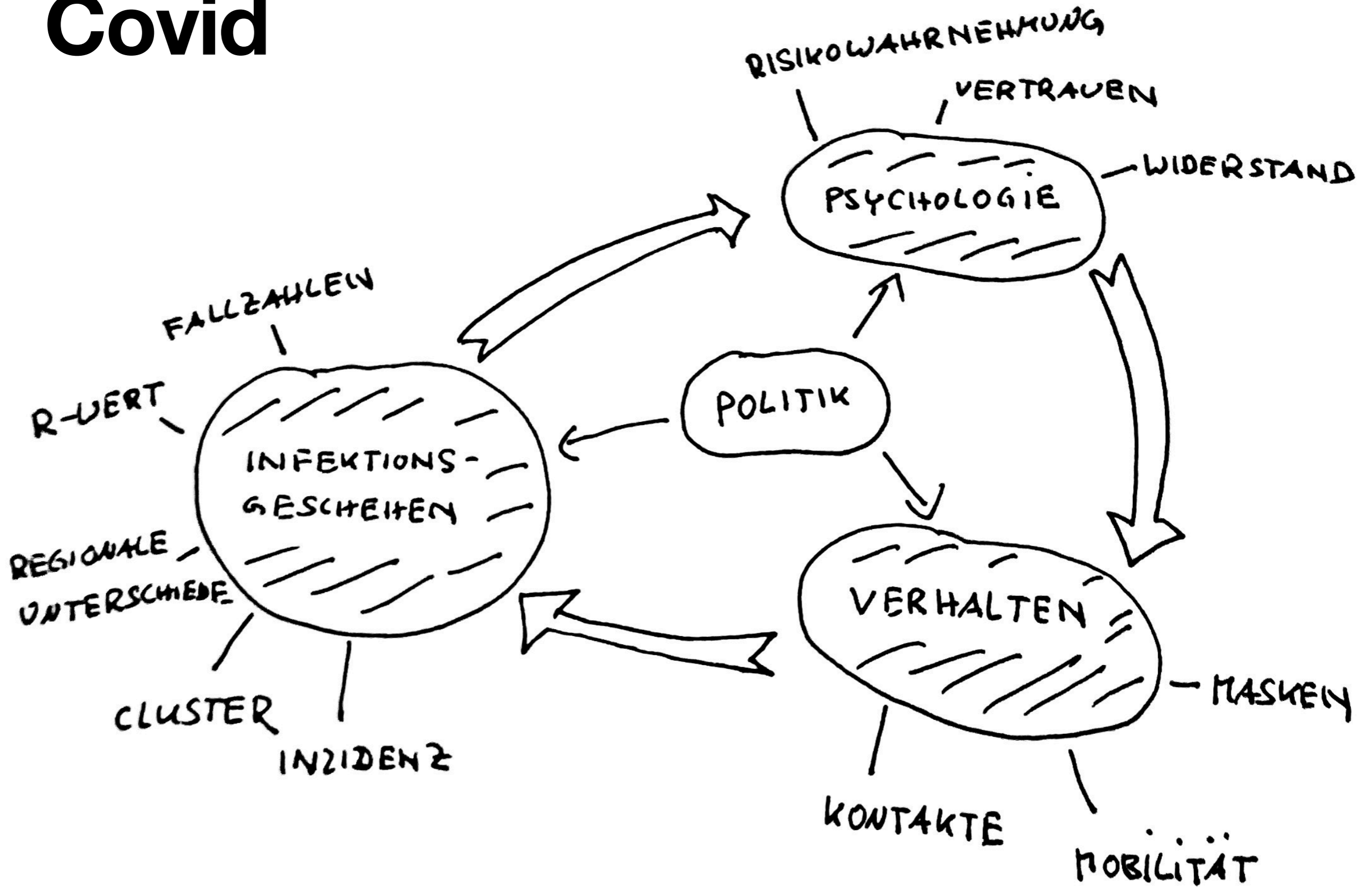






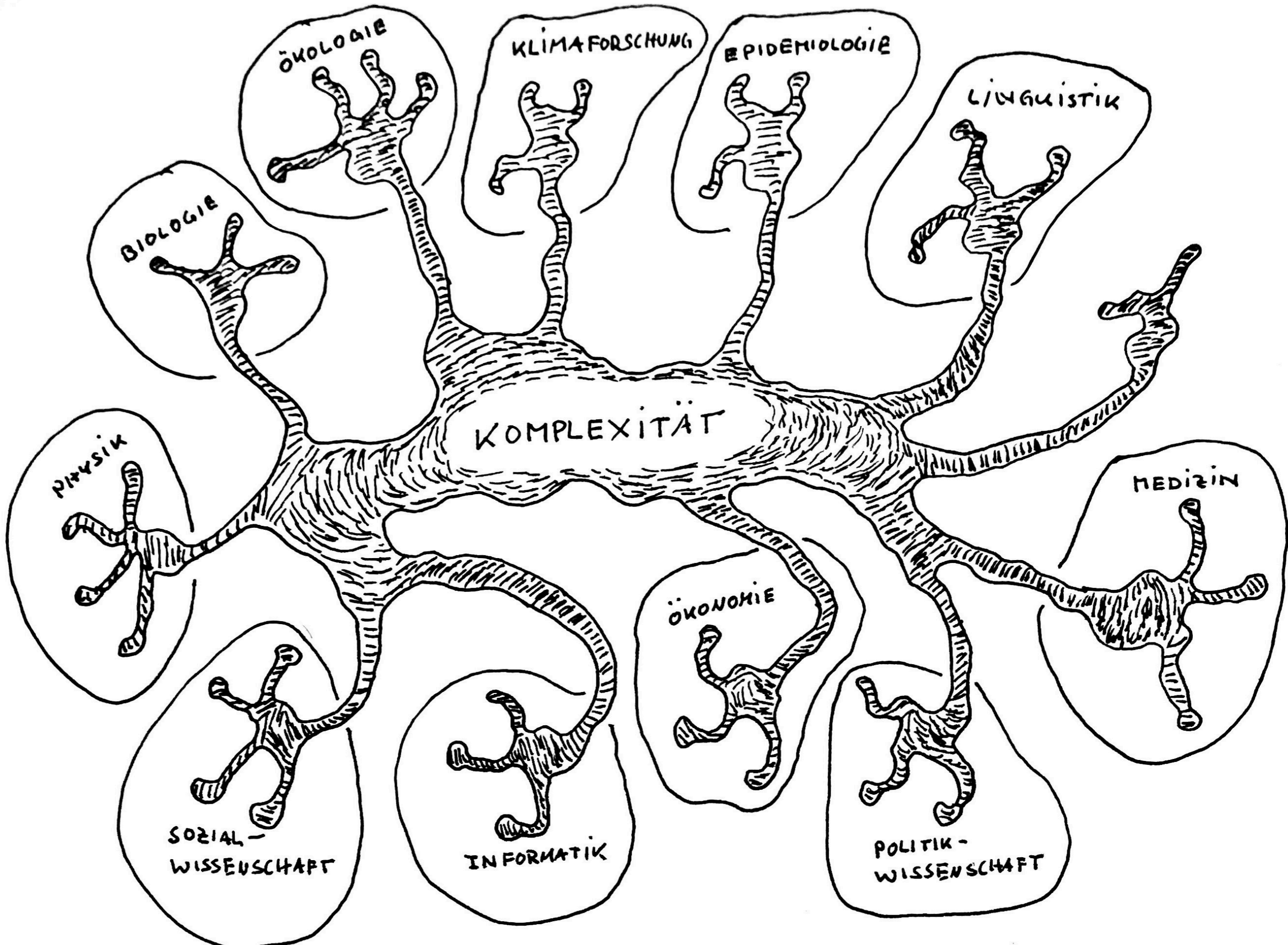


Covid





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



ÖKOLOGIE

KLIMAFORSCHUNG

EPIDEMIOLOGIE

LINGUISTIK

MEDIZIN

POLITIK-WISSENSCHAFT

ÖKONOMIE

INFORMATIK

SOZIAL-WISSENSCHAFT

PHYSIK

KOMPLEXITÄT

BIOLOGIE

KOORDINATION
APPLAUS
MILLENIUM BRIDGE
LUCHSE
SCHNEESCHUHHASEN
ZIKADEN
GLÜHWÜRMCHEN
COVID
MASERN
HERZ

KOMPLEXE NETZWERKE
KLEINE WELTEN
DELFIN
FLUGVERKEHR
FREUNDSCHAFT
BIG BROTHER
COVID
HANDY
IMPFFEN
REICH WIRD REICHER
JAJAJAJAKI
SEX

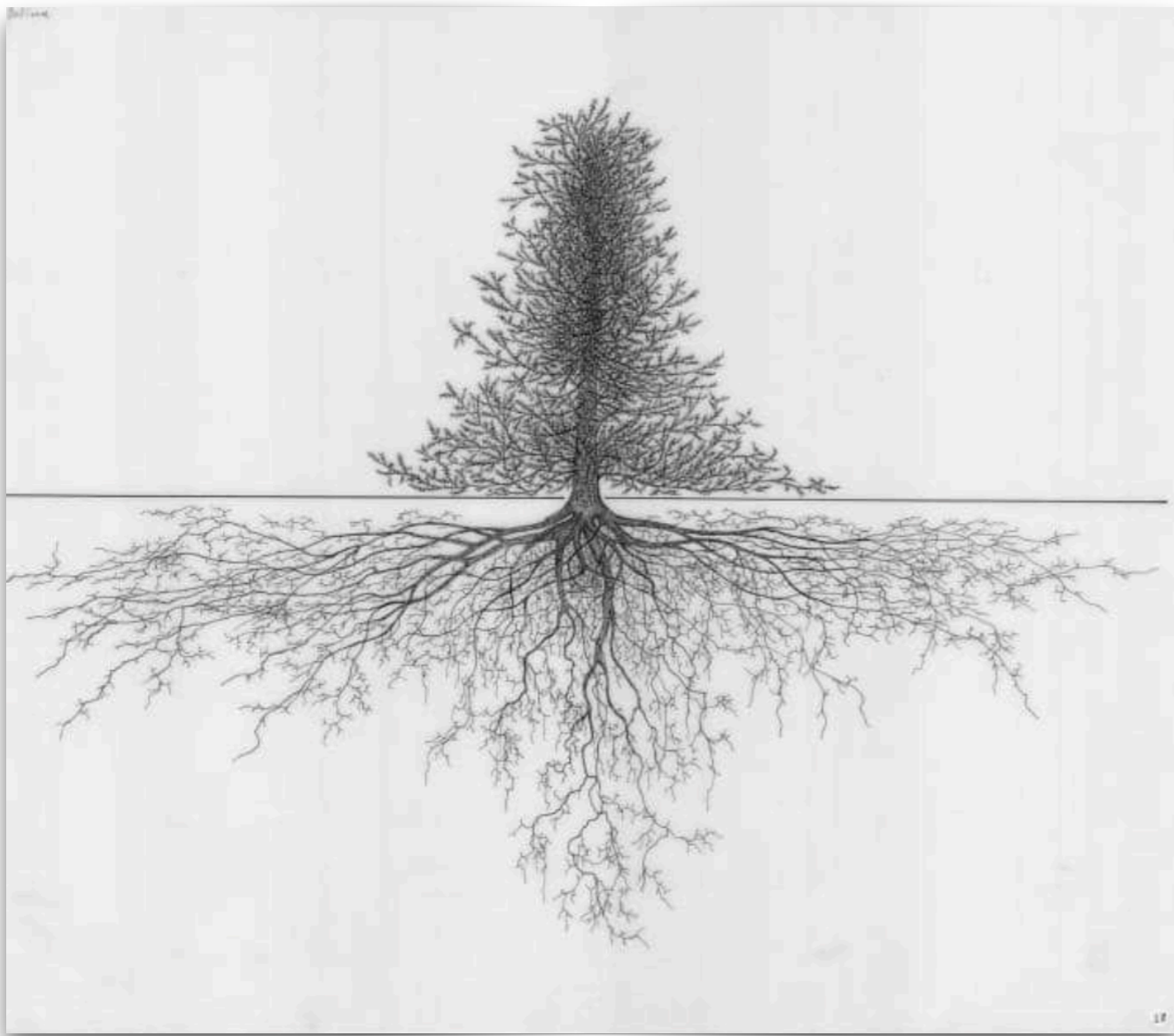
KOOPERATION
LYNN MARGULIS
BLATTLAUS
FLECHTEN
BÖSE BAKTERIEN
VIELZELLER
TINTENFISCH
DARWIN
GUTE BAKTERIEN
SYMBIOSE
HOLOBIOT
CYANDBAKTERIEN

KOLLEKTIVES VERHALTEN
GOLDBRASSEN
PANIK
STARE
LOVE PARADE
SCHWÄRME
LAUTE MINDERHEITEN
TELEPATHIE
TWITTER
SCHWARMINTELLIGENZ
POLARISIERUNG
ZUFUSS
DEMOKRATIE
SOZIALKRAFT
POPULISMUS

KRITIKALITÄT
KLAUS KLEINWÄCHTER
WASSER
SANDHAUFEN
WALDBRAND
WEGE NACH ROM
GIGANTISCHE KOMPONENTEN
KAFFEE
LAWINIEN
TERRORISMUS
BÄUME
R-WERT
ERDBEBEN
COVID

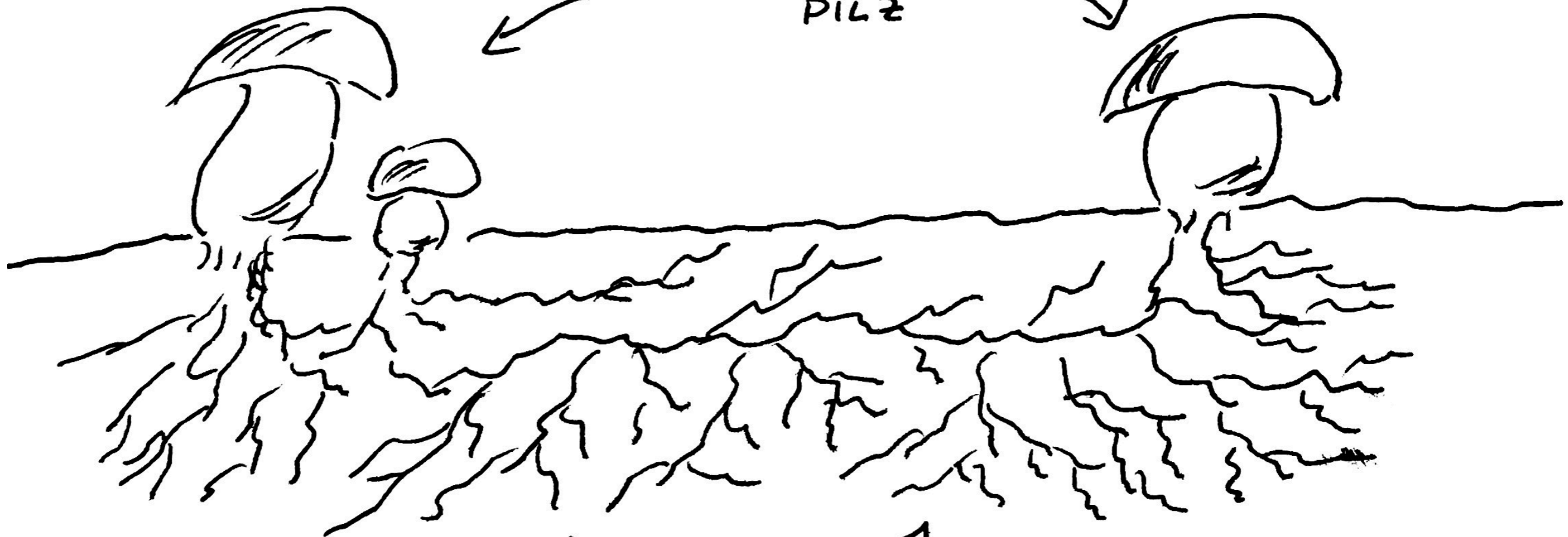
KIPPPUNKTE
HYSTERESE
MURMELN
EMBRYOS
ARTENVIELFALT
DARM
KRITISCHES
FISCHFANG
GOLFSTROM
ÖKOSYSTEME
TEICHE
KLIMA
GRÖNLAND
VERLANGSAMEN
MULTISTABILITÄT
MASSENSTERBEN

Roads to Rome



credits: Benedikt Groß, Raphael Reimann, Philipp Schmitt

DER GLEICHE
PILZ

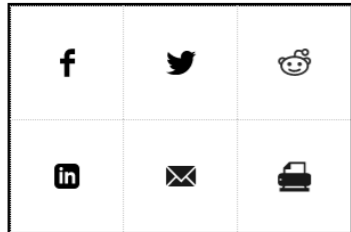


MYCEL

Strange but True: The Largest Organism on Earth Is a Fungus

The blue whale is big, but nowhere near as huge as a sprawling fungus in eastern Oregon

By Anne Casselman on October 4, 2007



Credit: USDA FOREST SERVICE, PACIFIC NORTHWEST RESEARCH STATION

READ THIS NEXT

THE SCIENCES

Do Fungi Feast on Radiation?

David Biello

THE SCIENCES

Common Mushrooms Produce Unique Pigments

Sarah Graham



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

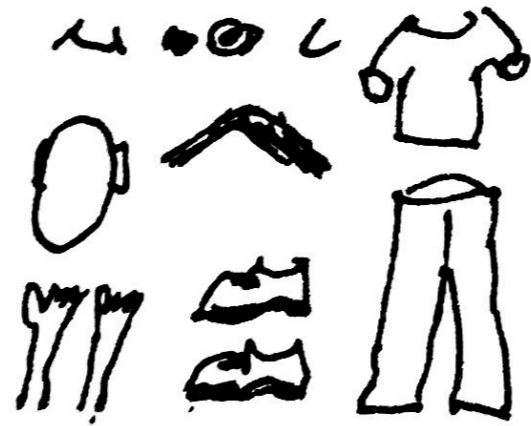
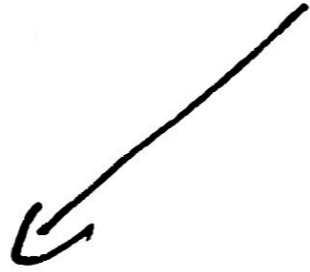
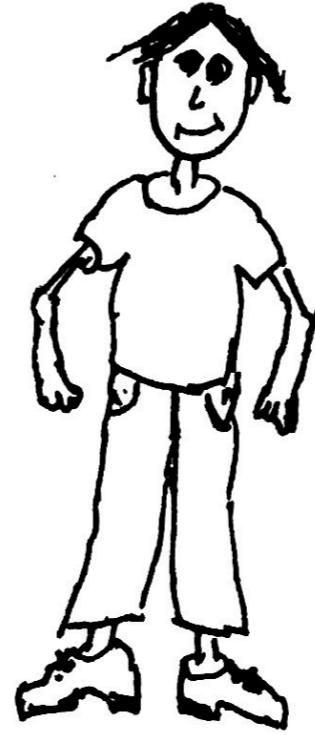
**“If you are the smartest person in the
room, you are in the wrong room”**



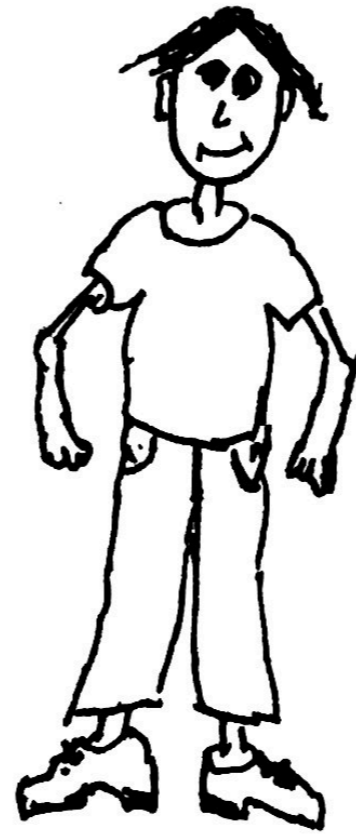
Richard Feynman, Nobel laureate physics 1965

**“physics is to math
what sex is to
masturbation”**

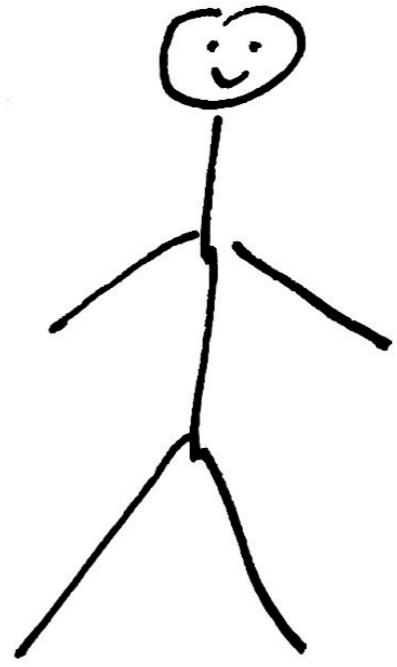
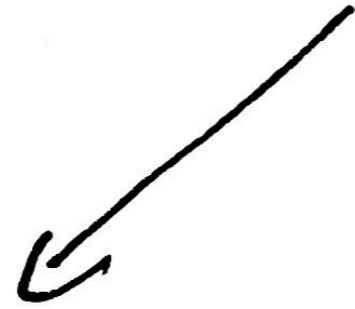
KLASSISCHER
REDUKTIONISMUS



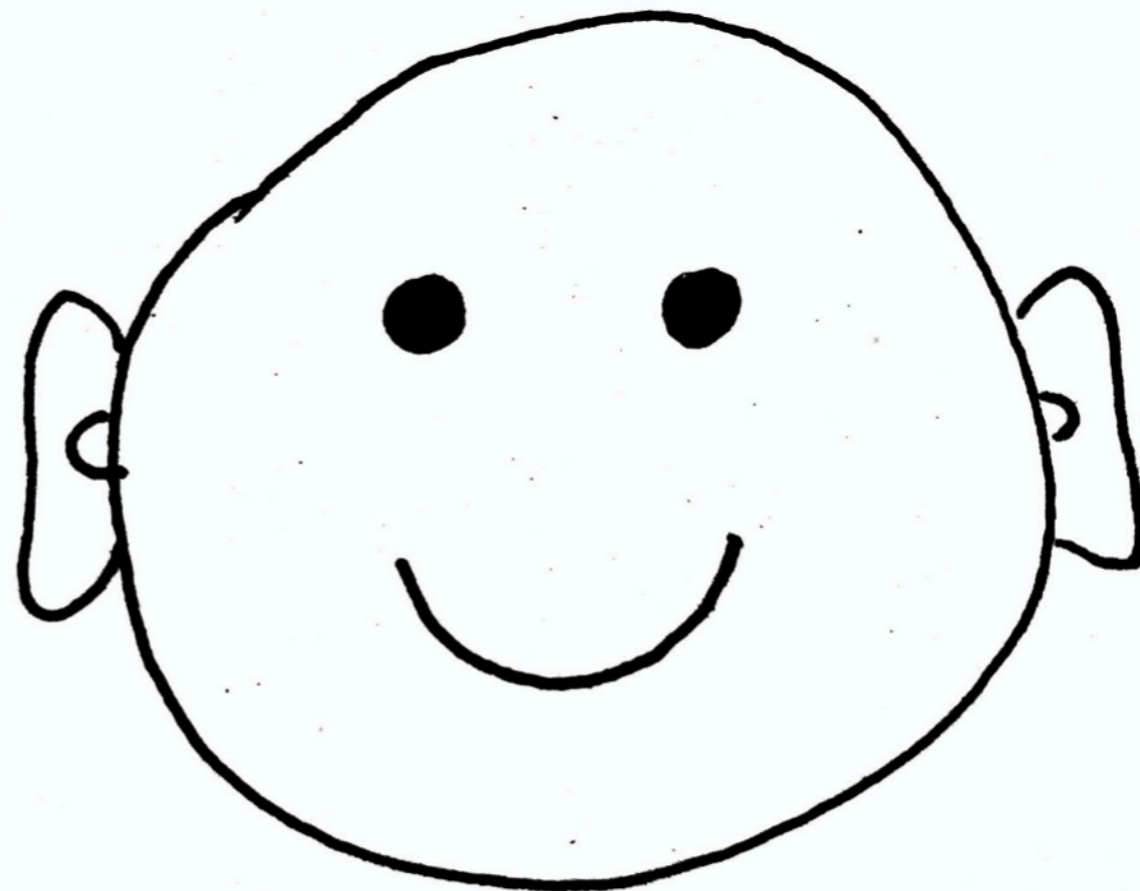
KLASSISCHER
REDUKTIONISMUS



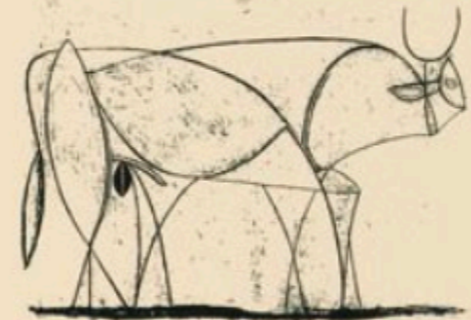
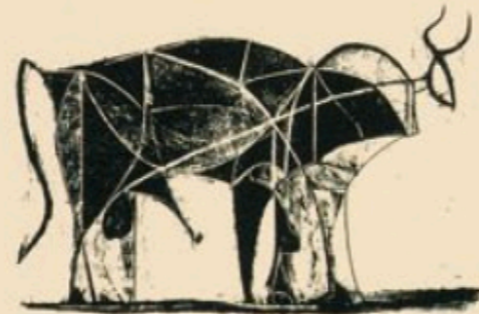
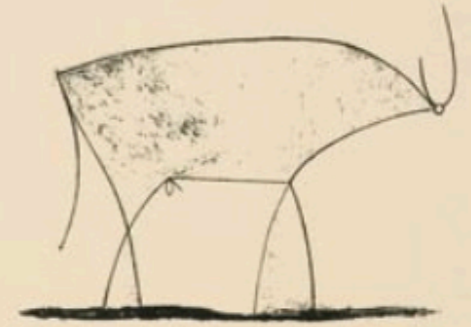
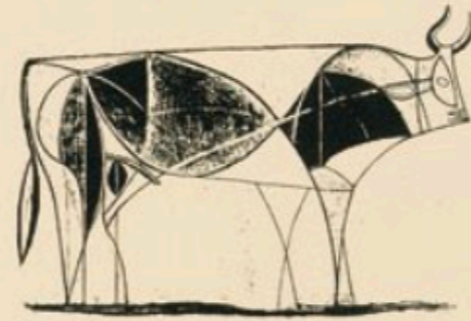
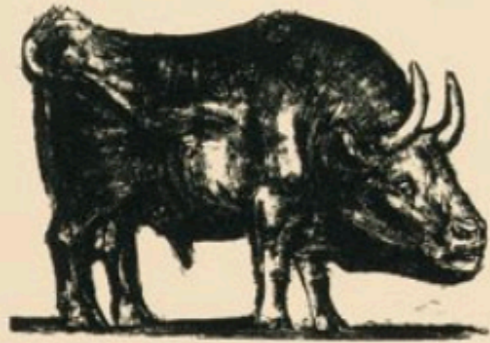
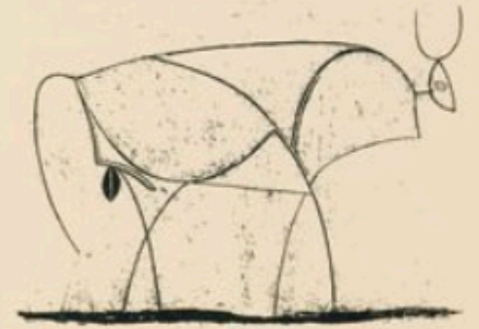
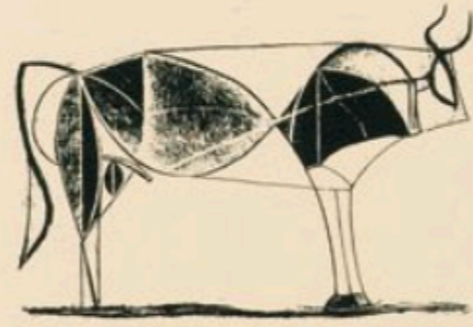
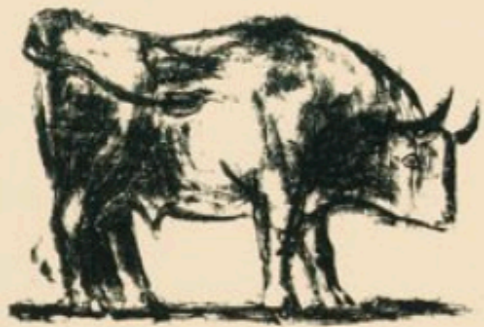
KOMPLEXITÄTS-
REDUKTIONISMUS



KANN
WEG!



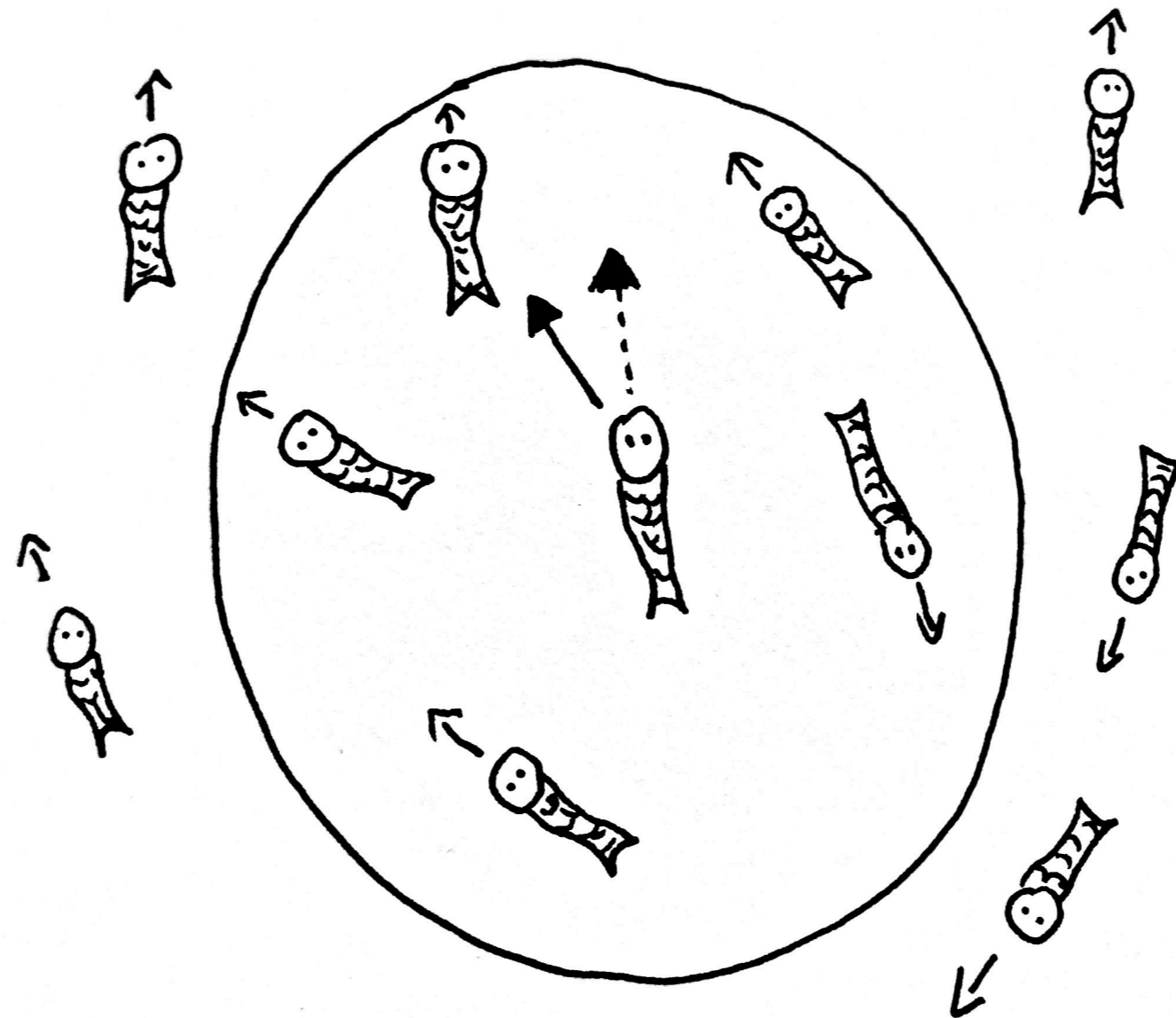
KANN AUCH
WEG!

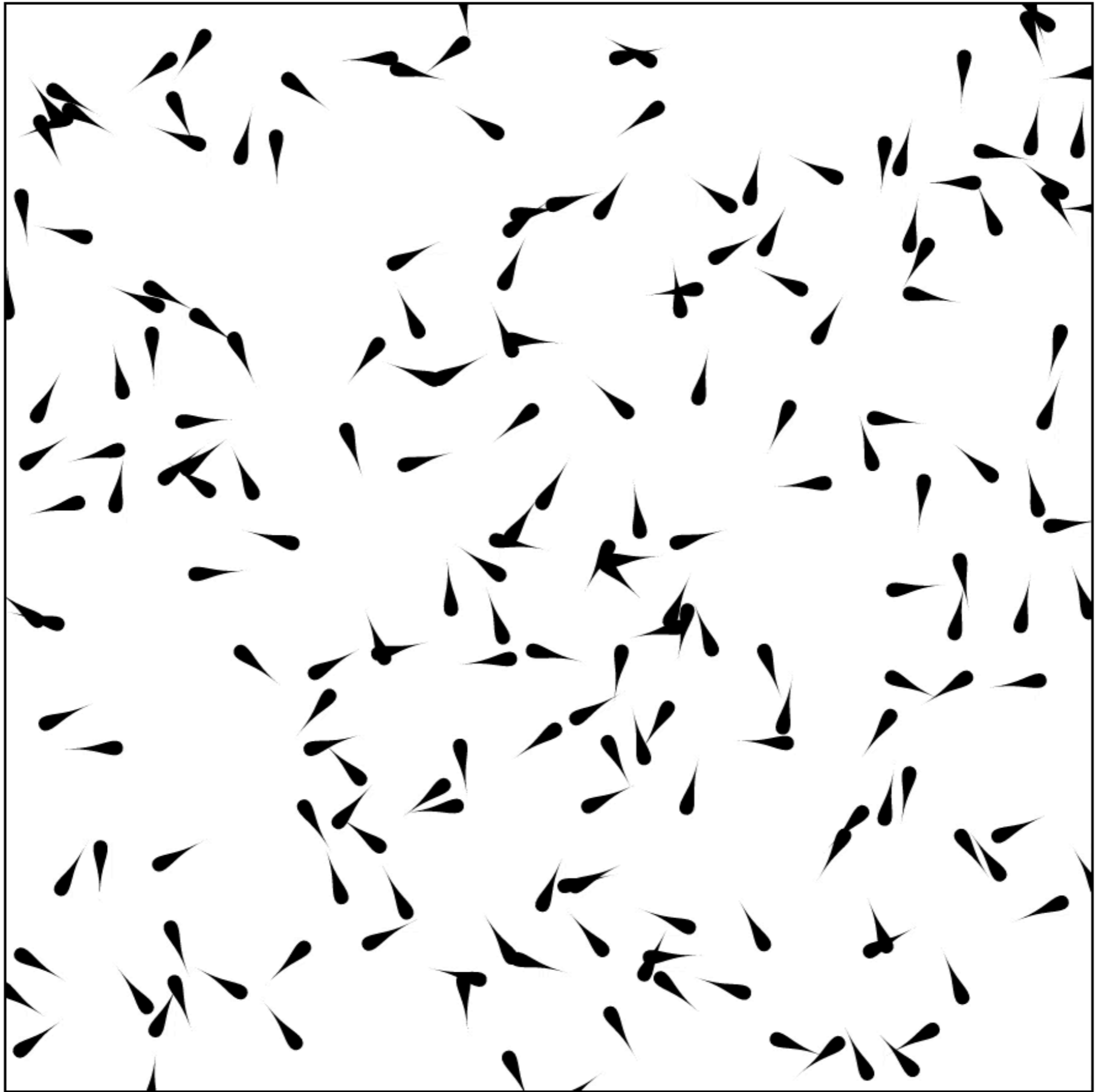


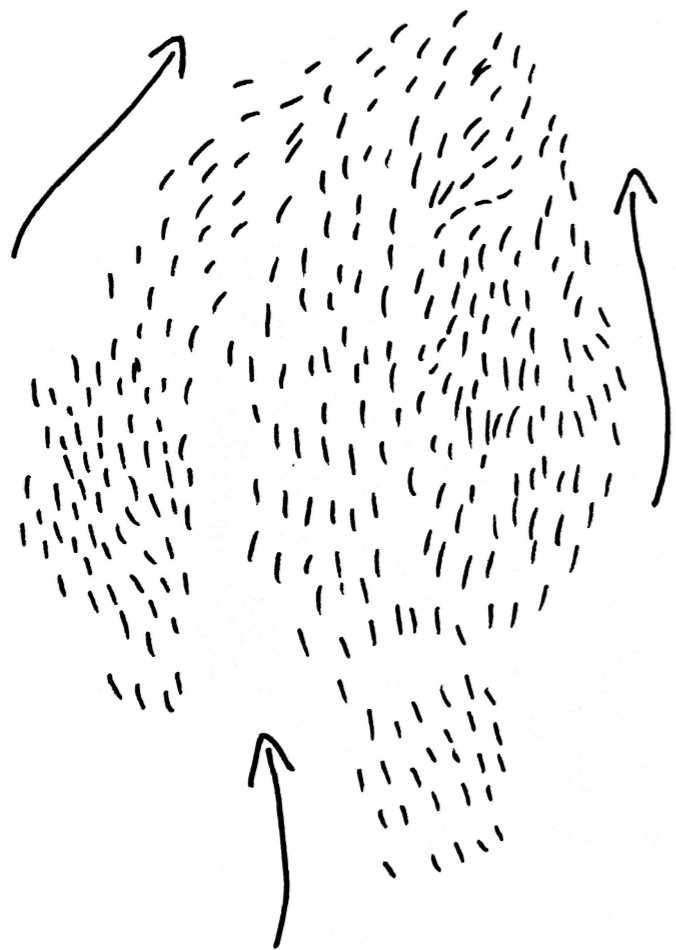
P. 20



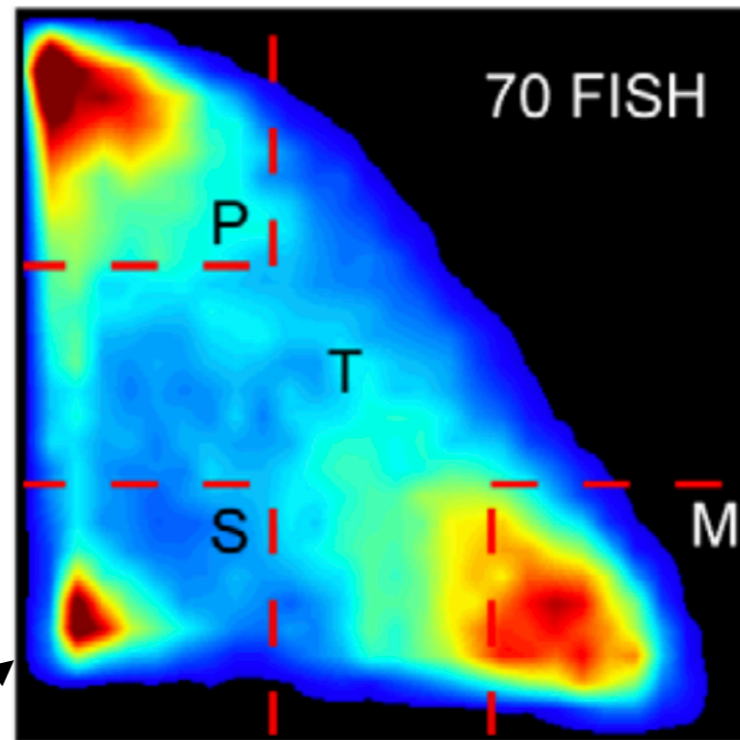
1. Avoid collisions
2. Stay with the group
3. Align with your neighbors



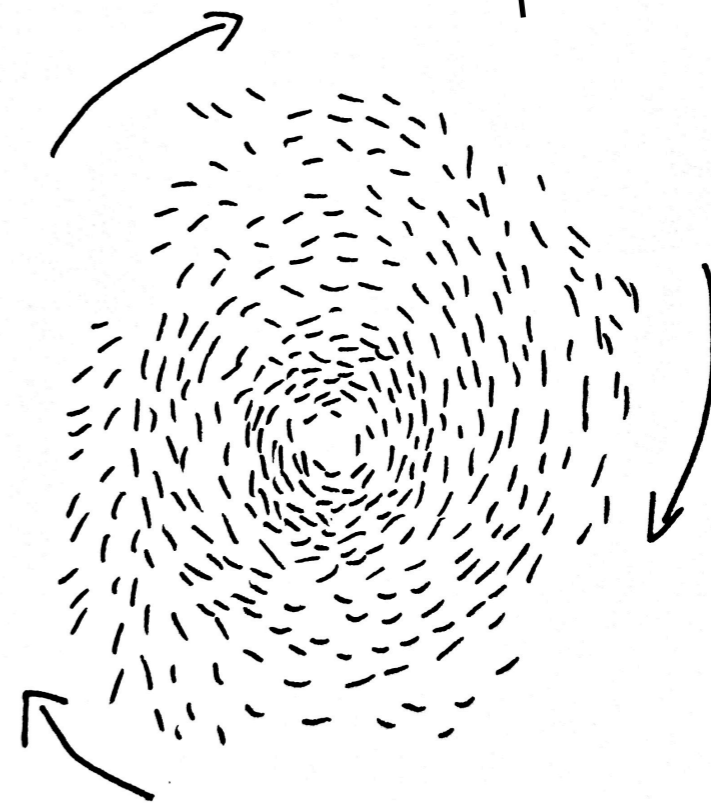
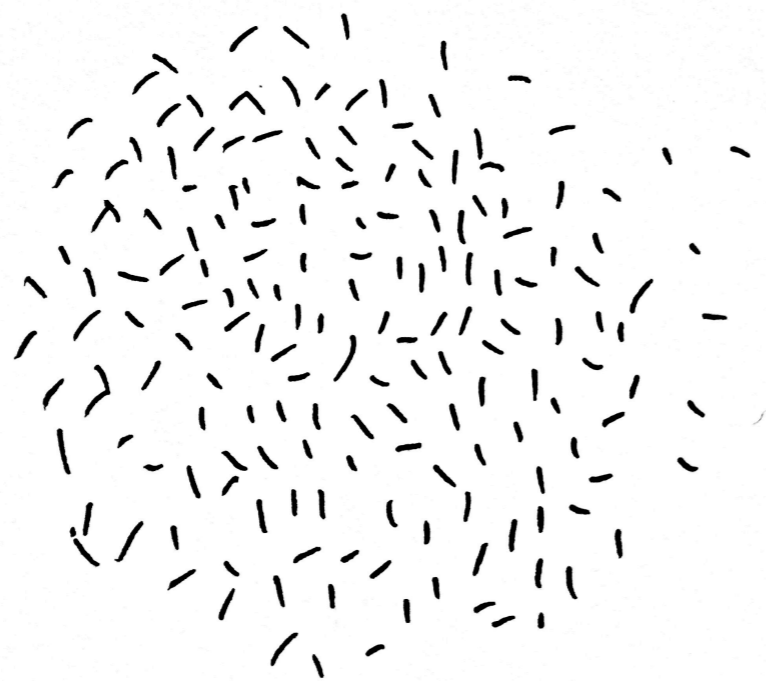




ORIENTATION

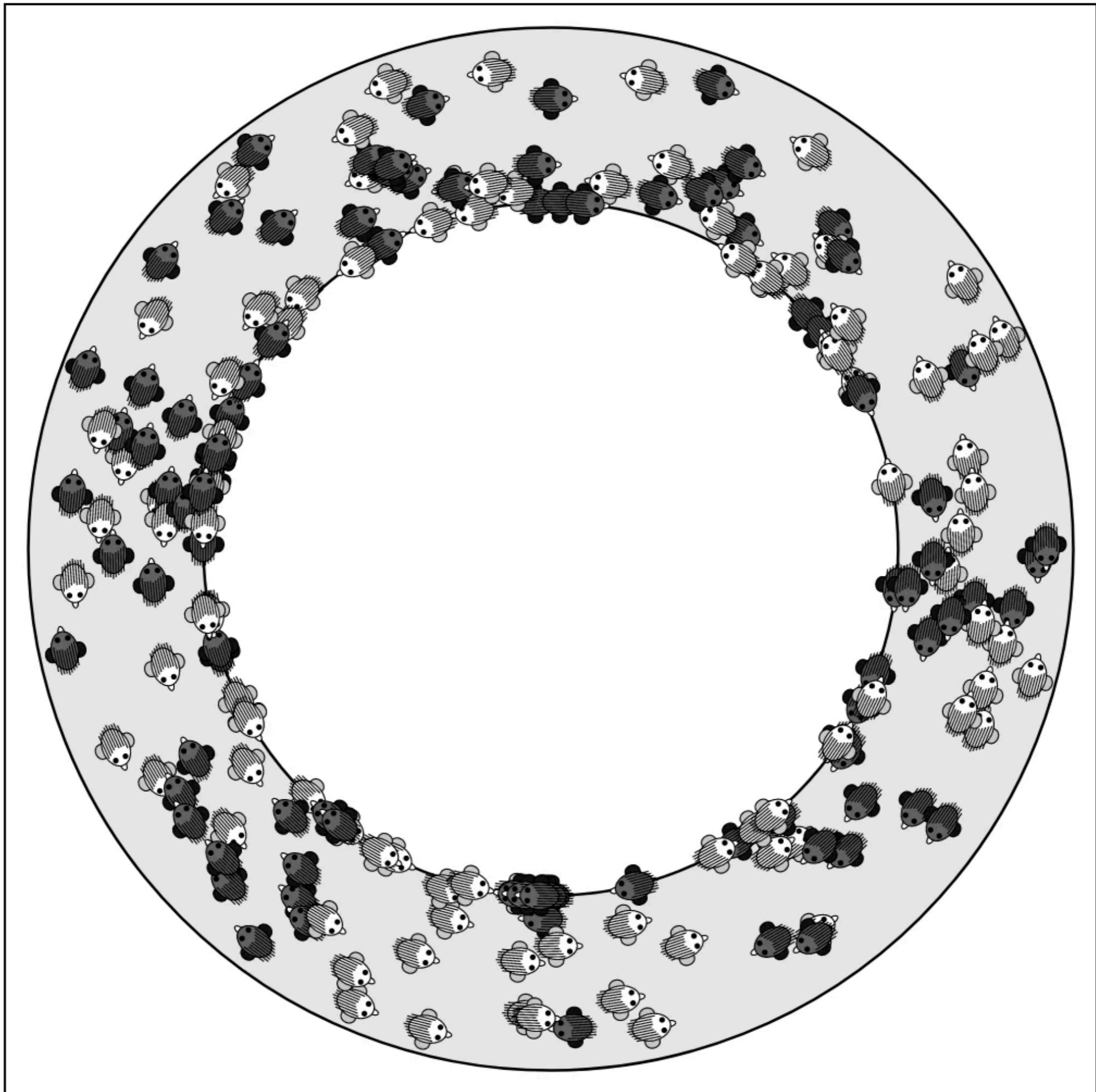


POLARIZATION

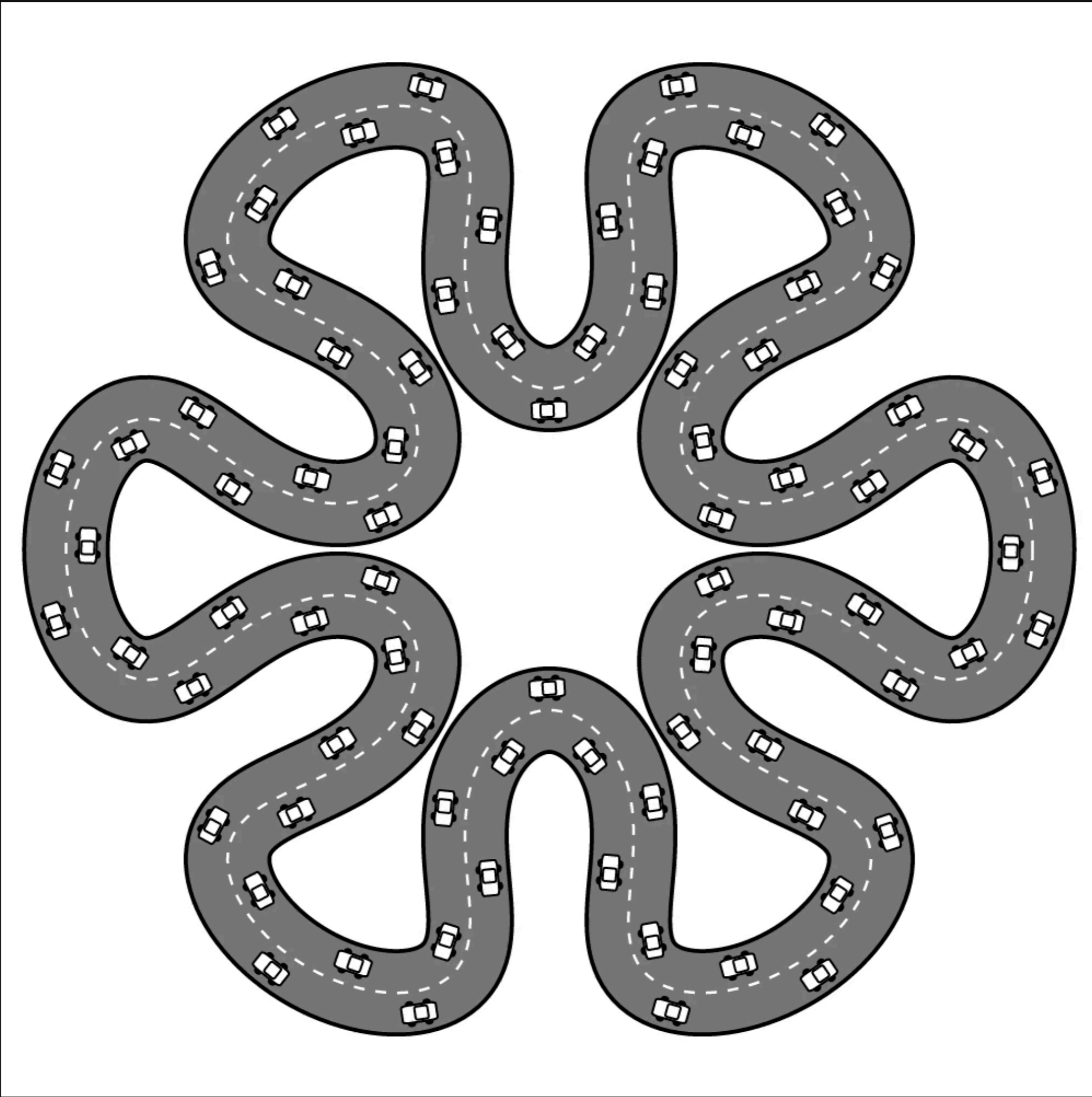


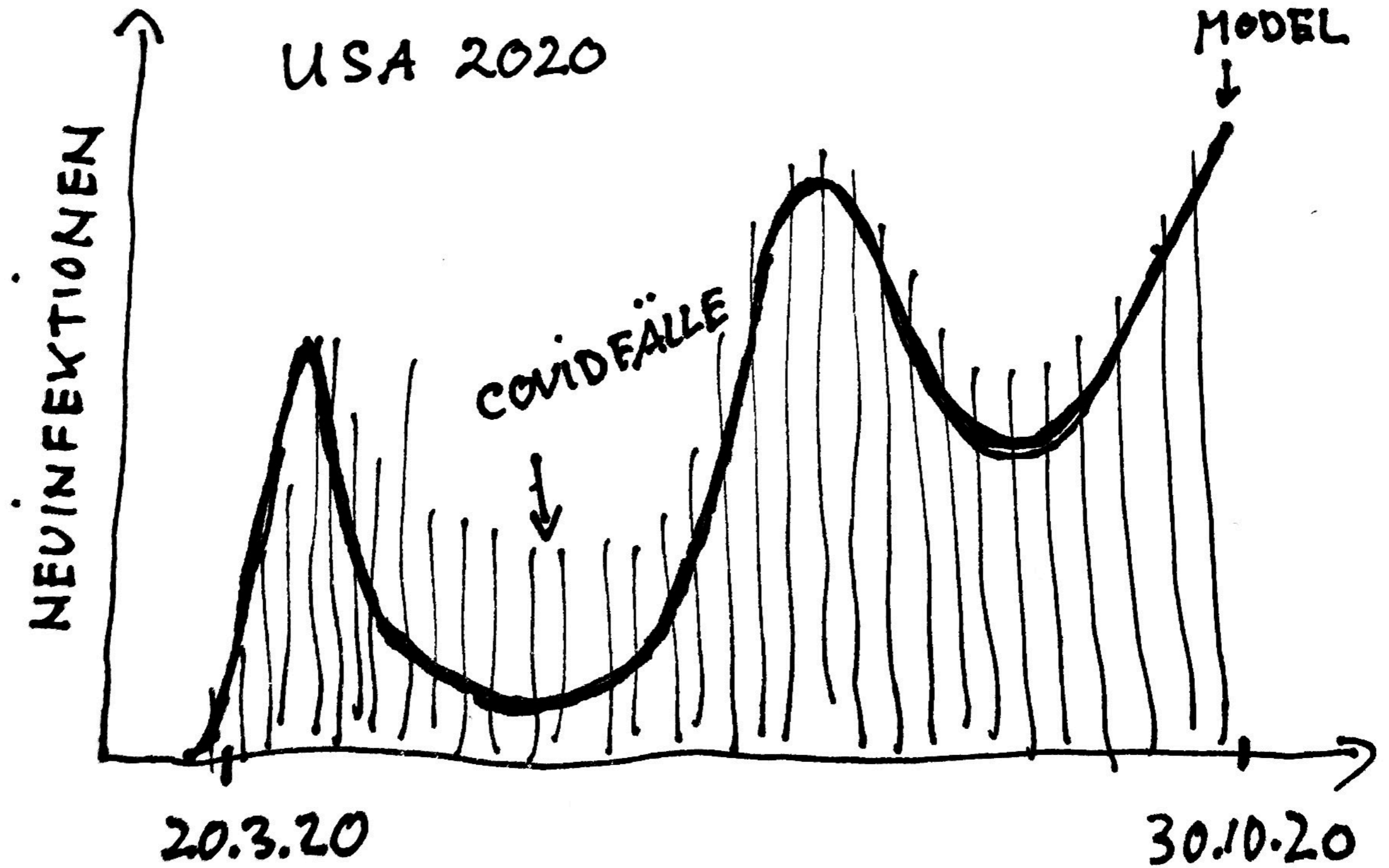
Experimente mit Menschen in Hallen

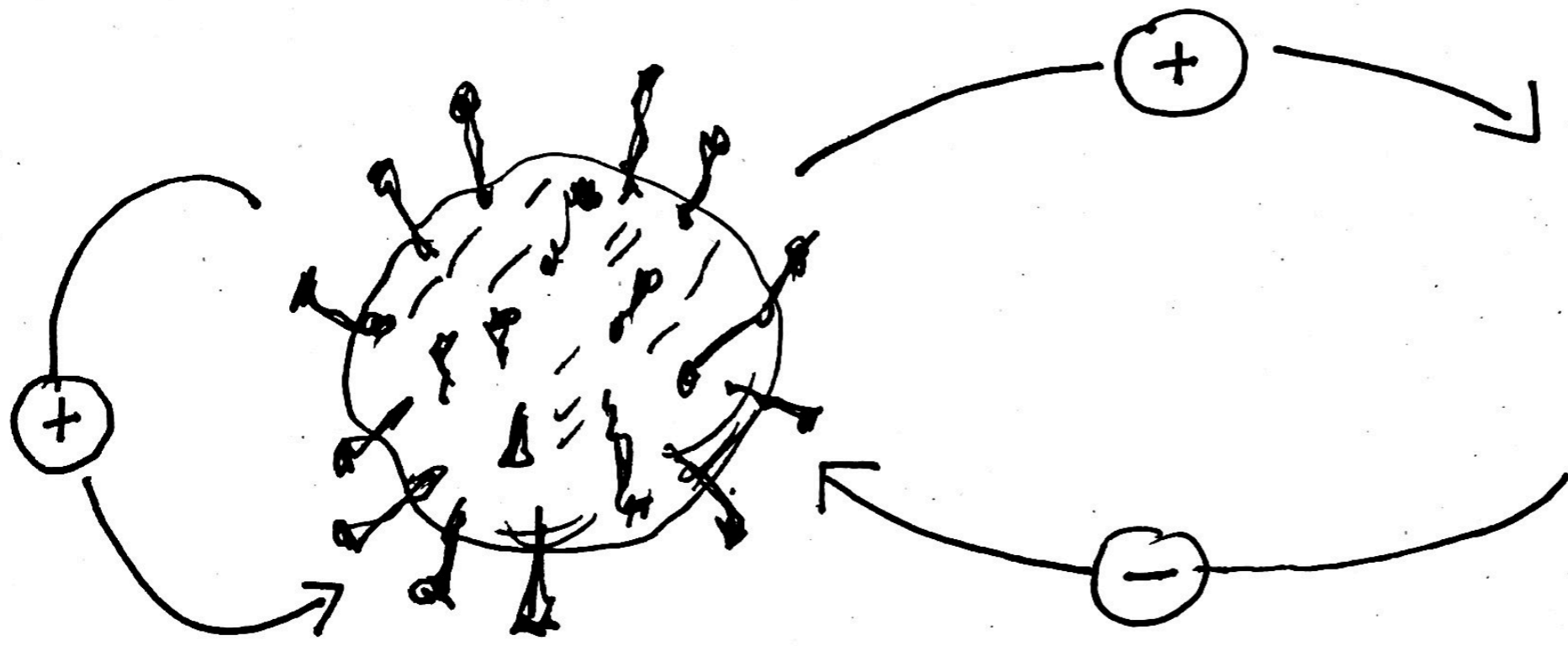




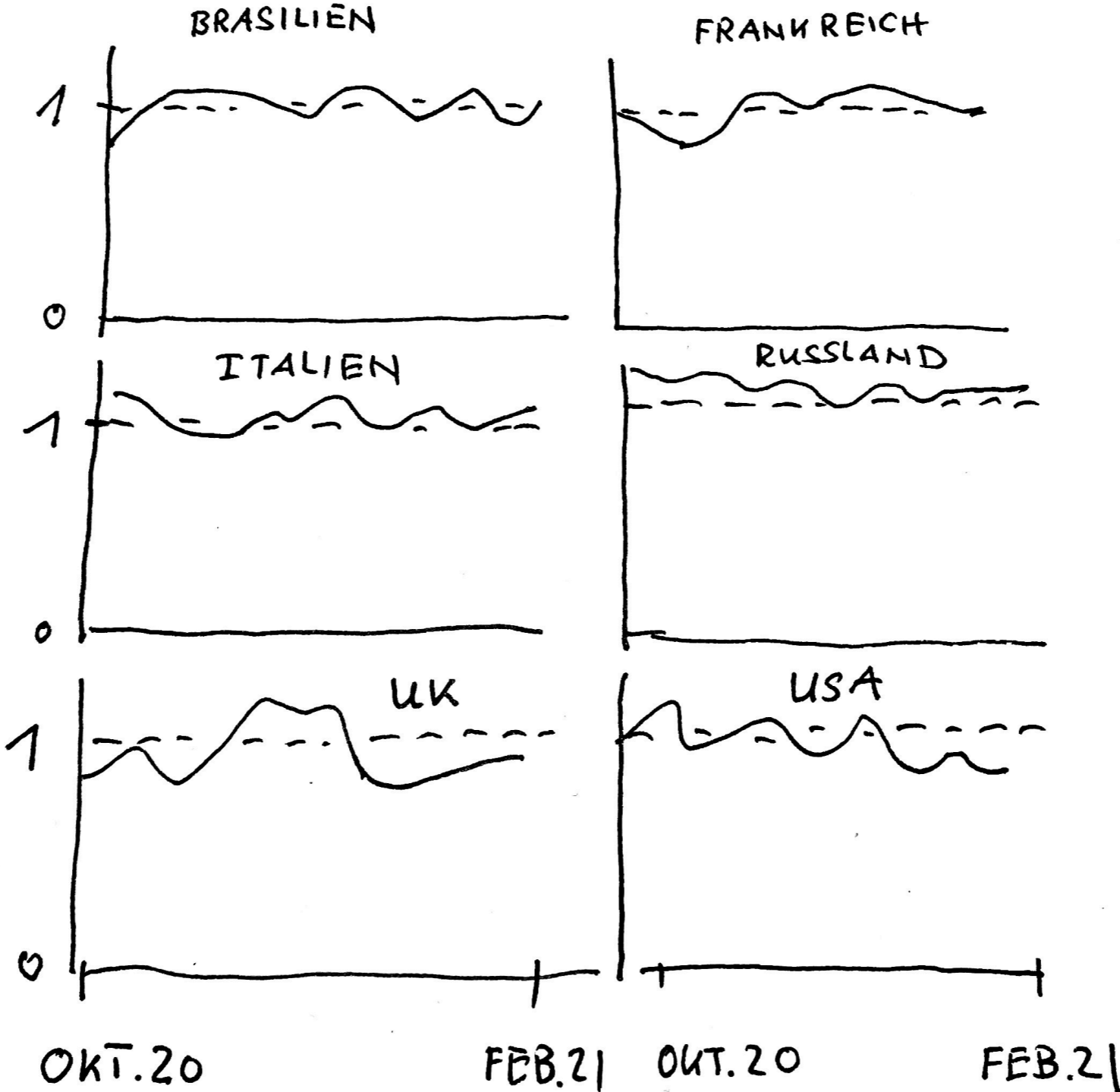




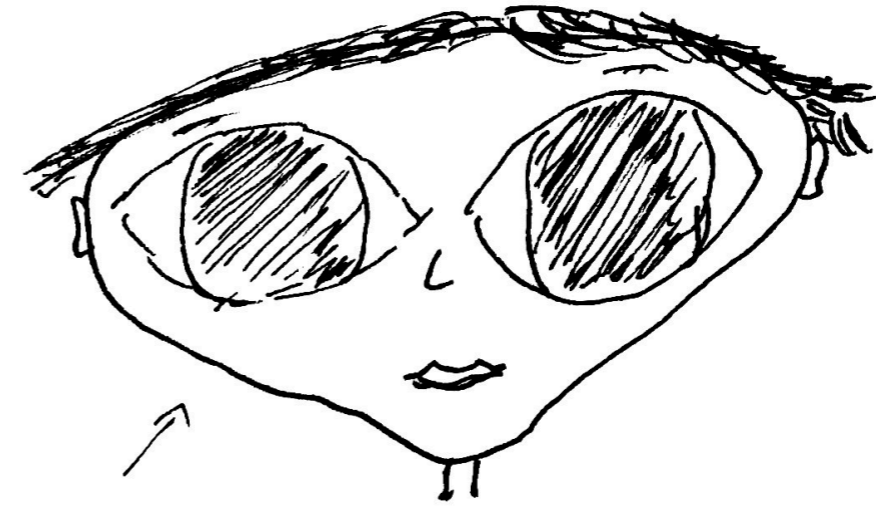




R-Wert irgendwie immer so eins

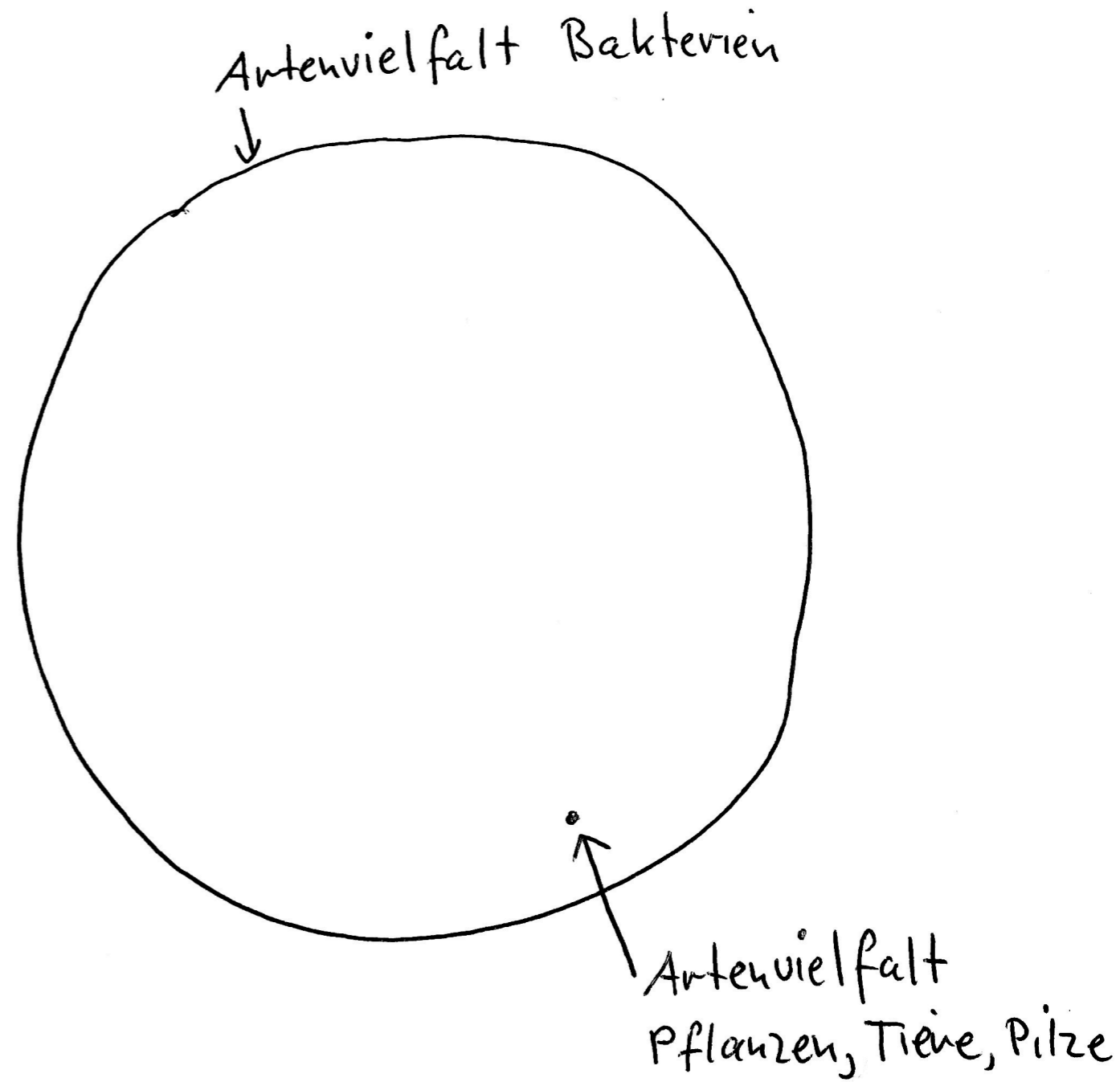
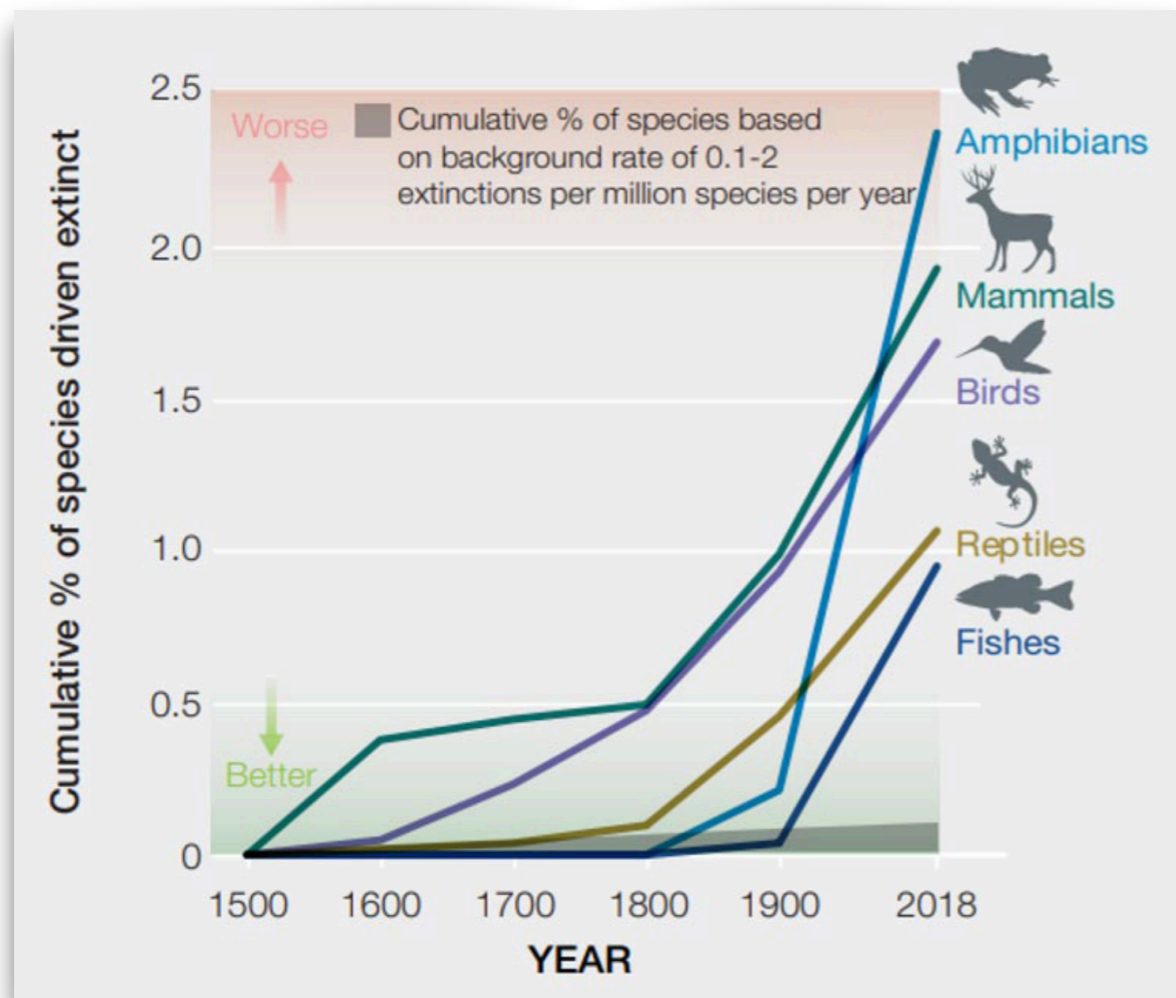


REALITÄT



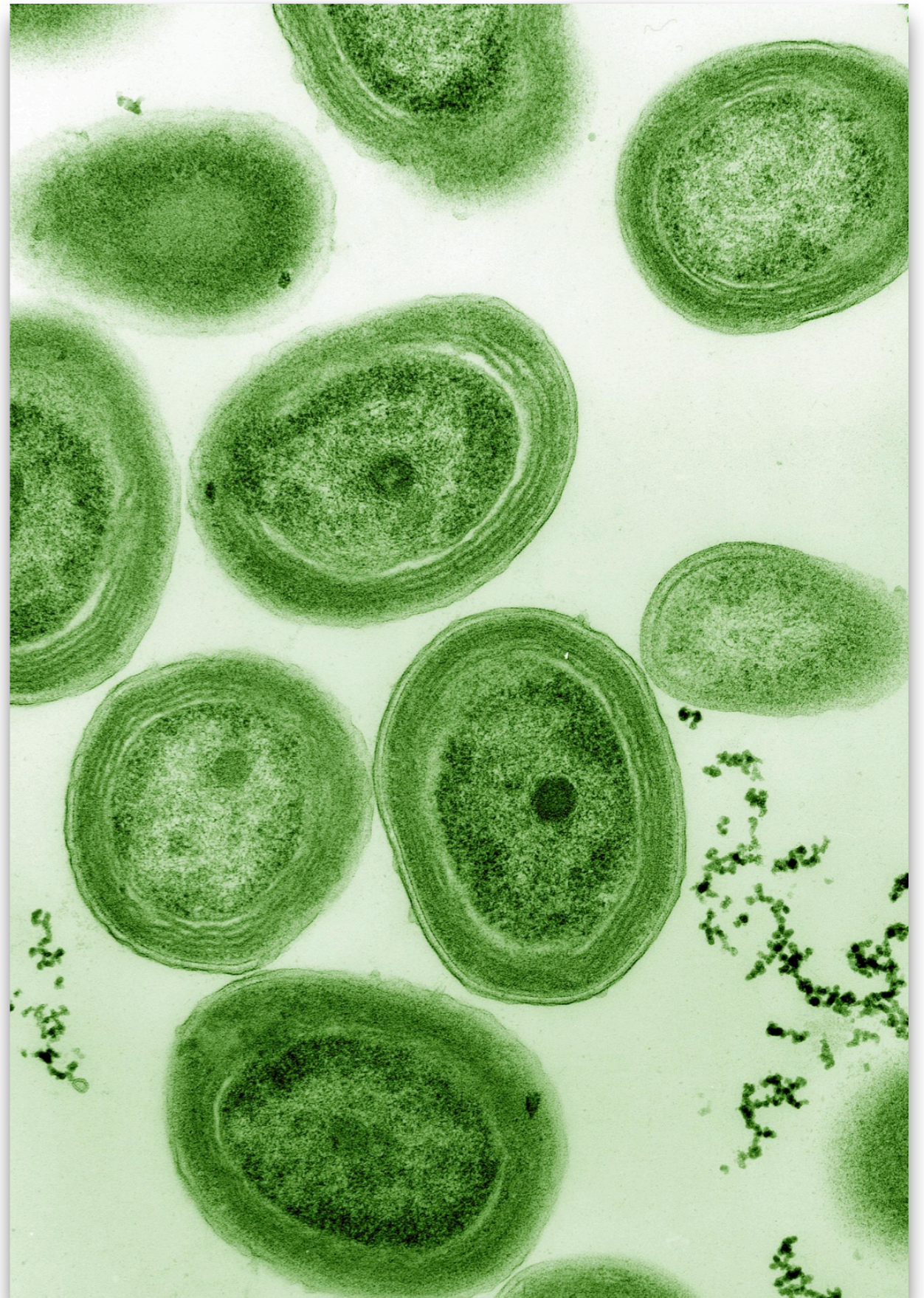
IN UNSEREN
KÖPFEN

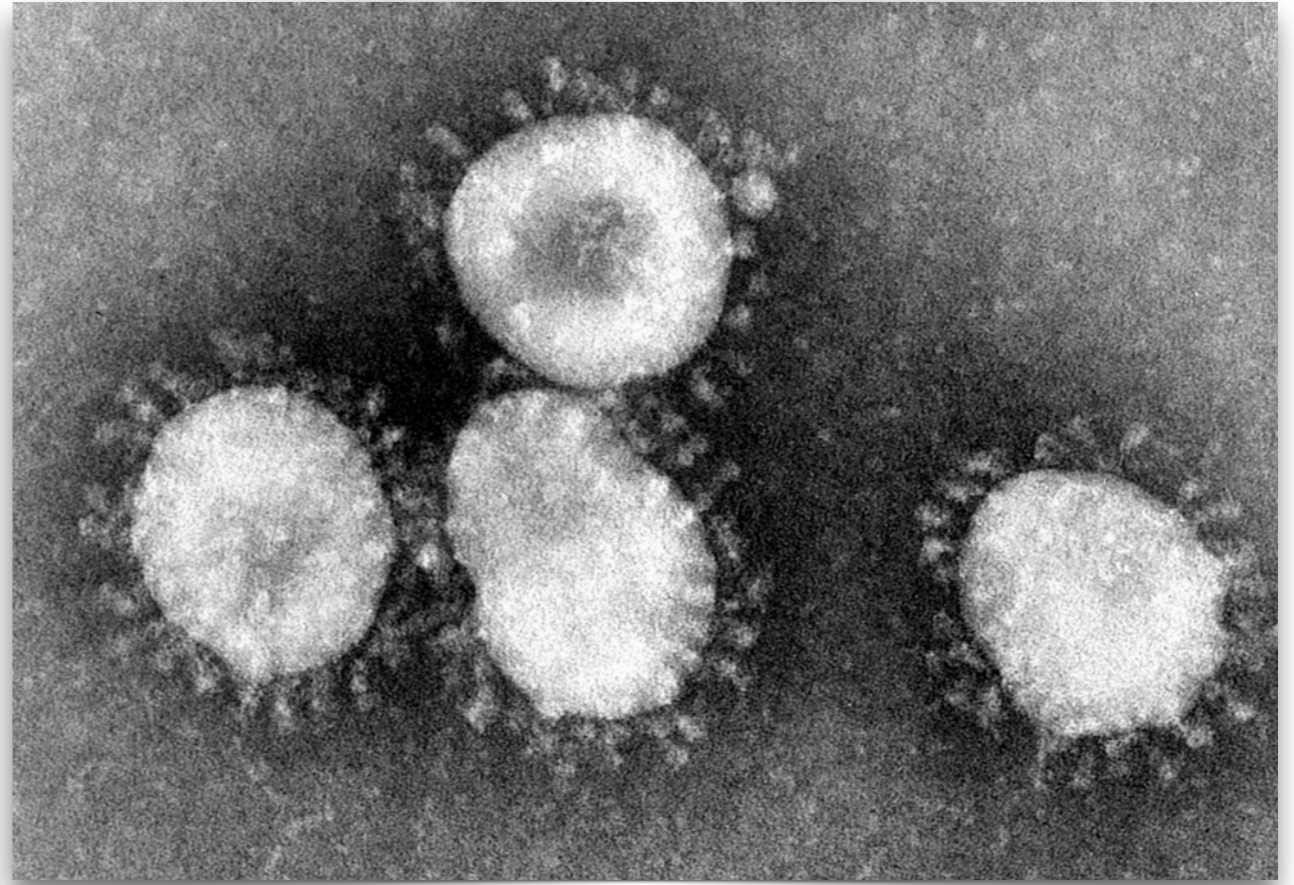
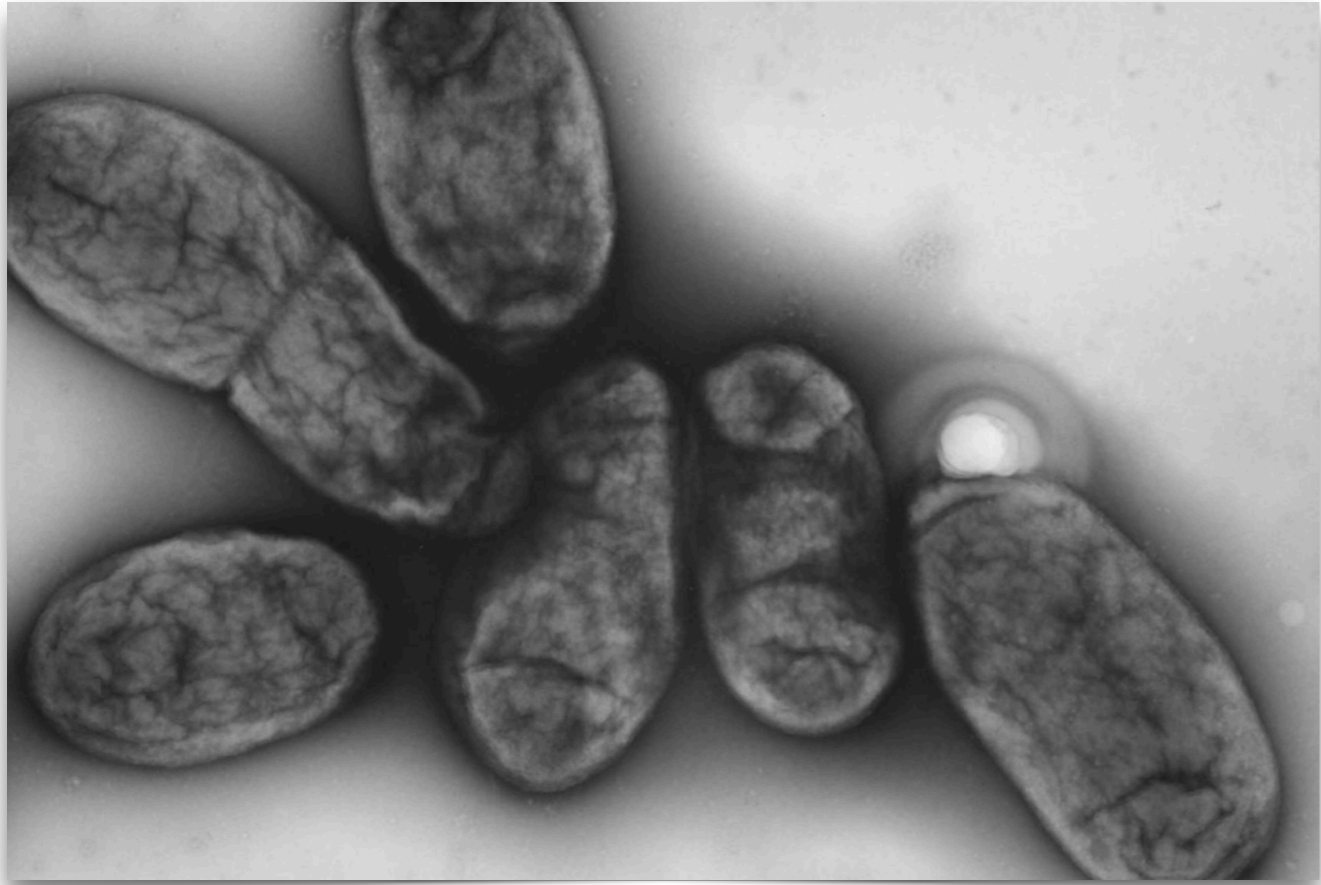




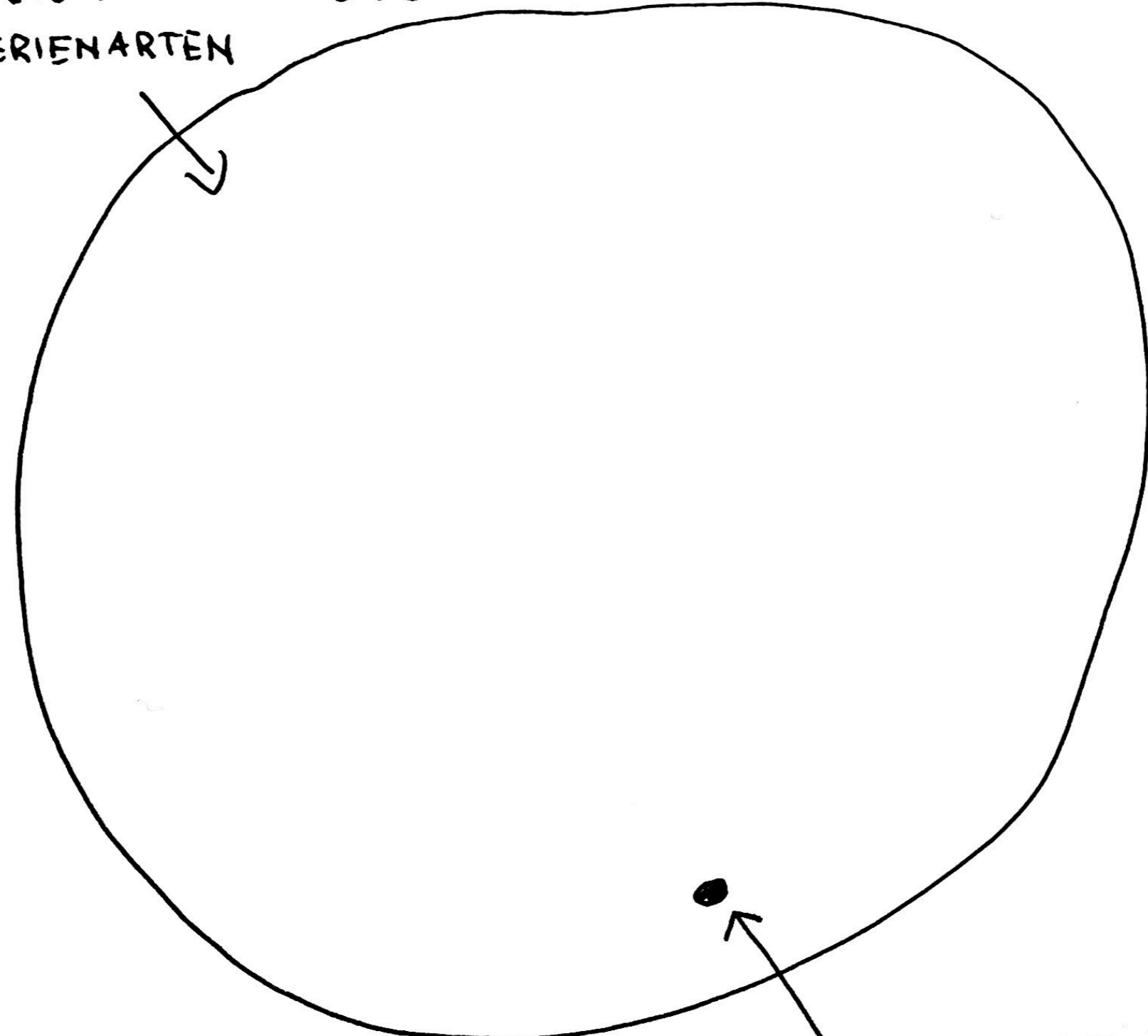
Prochlorococcus

- Marines Cyanobacterium
- Photosynthese
- 1986 entdeckt (sehr klein)
- Individuenreichste Art der Erde
- **verantwortlich für 13-48% der atmosphärischen Sauerstoff**





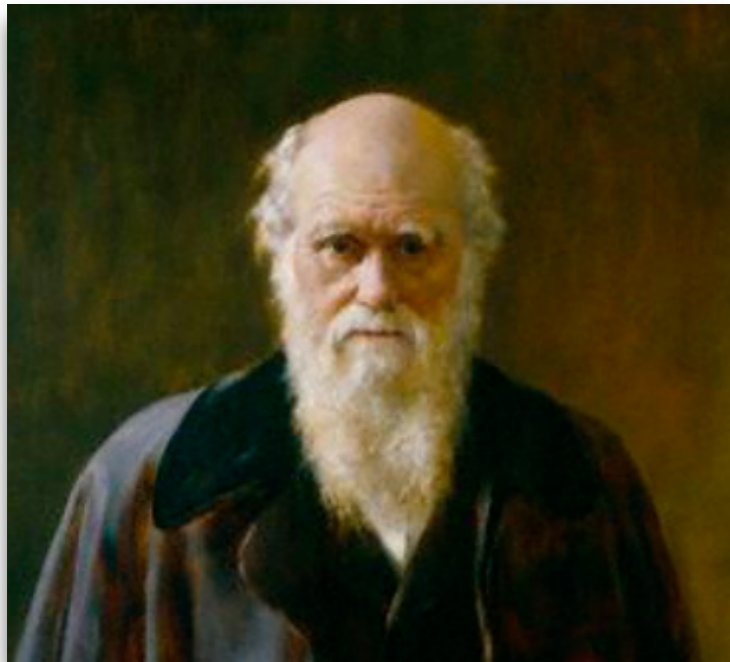
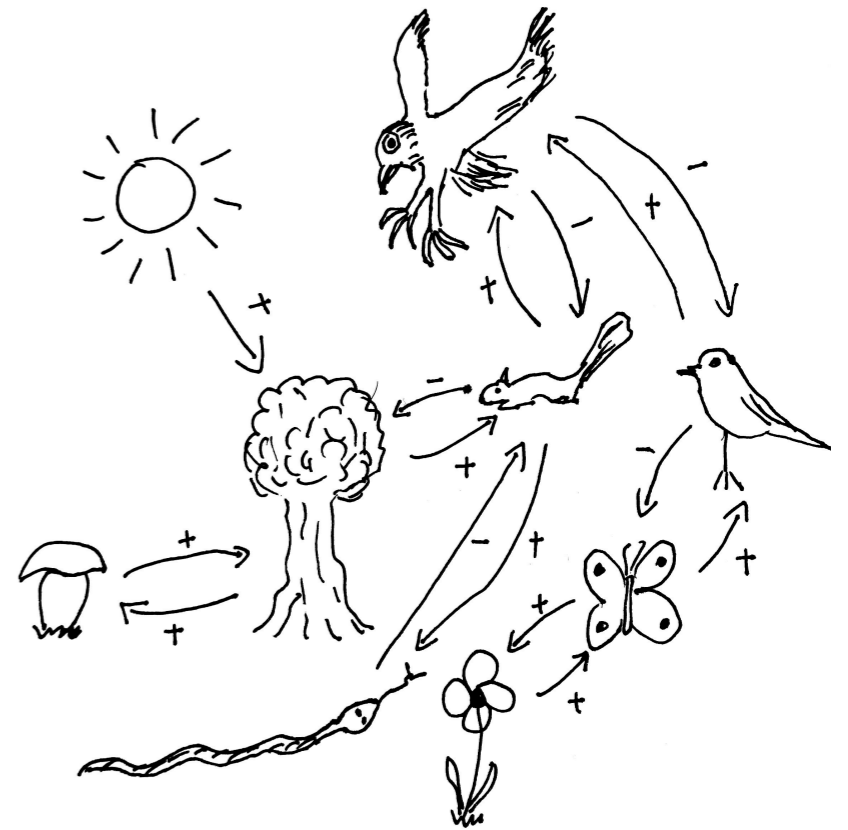
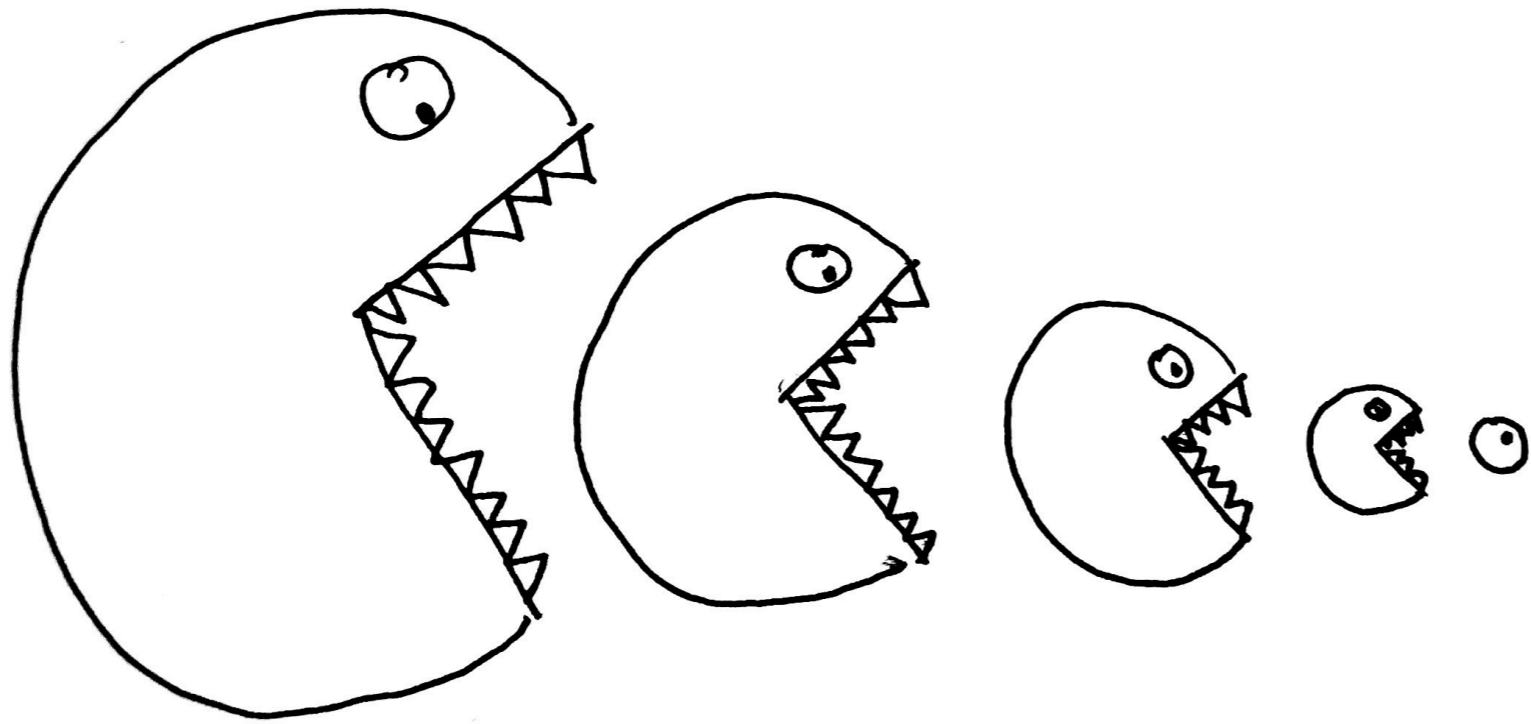
NICHTPATHOGENE
BAKTERIENARTEN



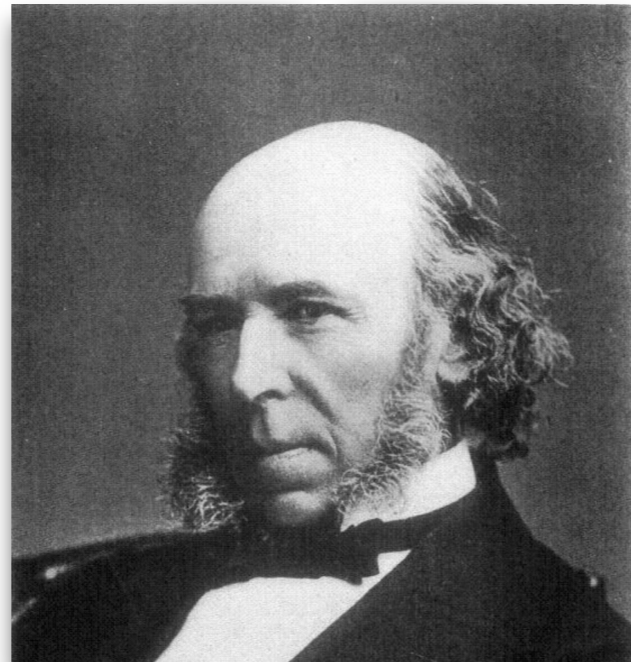
PATHOGENE
BAKTERIENARTEN



Competition and Conflict



Darwin



Spencer

“Survival of the fittest” dude



Sozialdarwinismus



holobionts everywhere

Lynn Margulis (1938 - 2011)

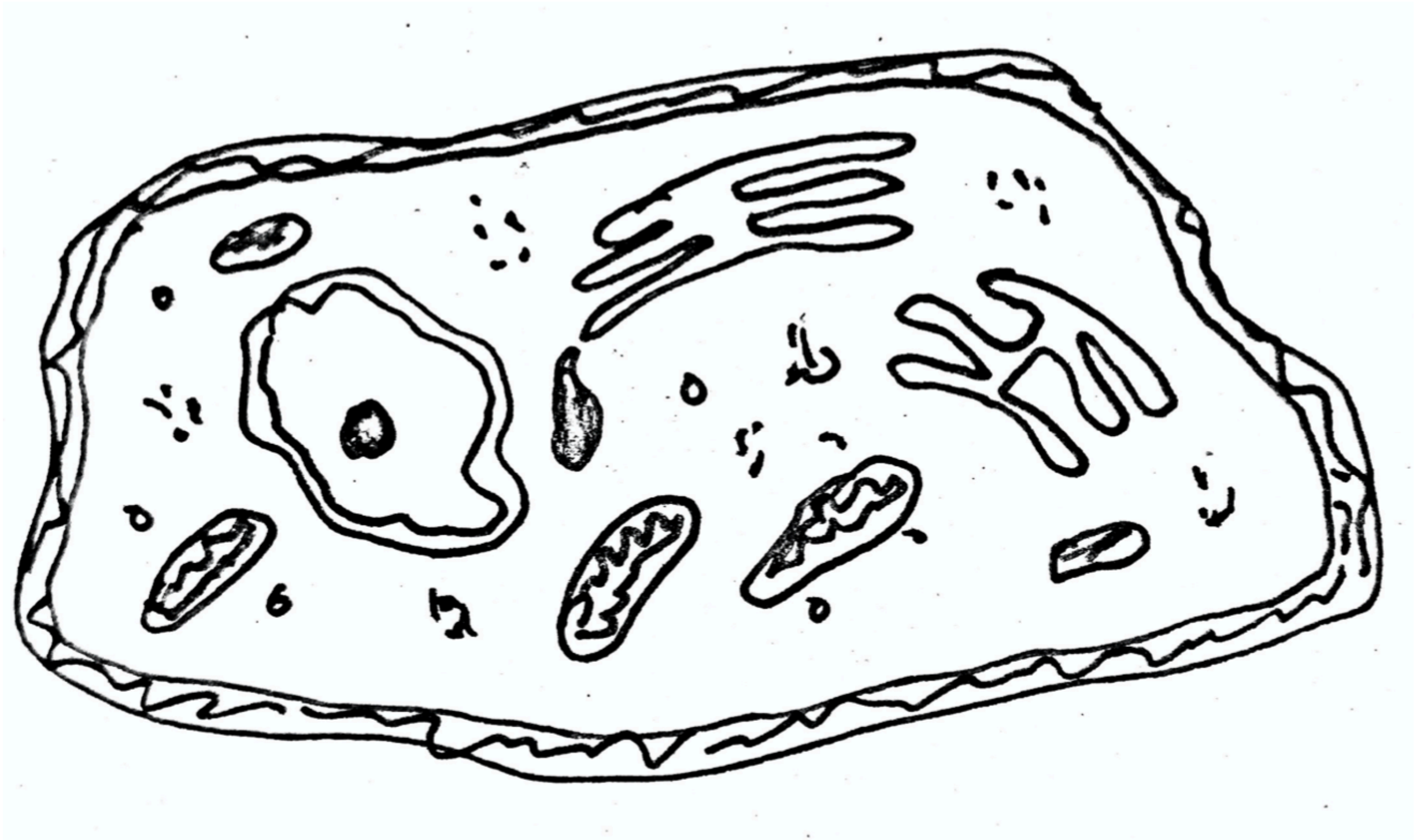
Jeder höhere Organismus hat symbiotische, mutualistische Beziehungen zu Mikroorganismen (und das war schon immer so)

Natürliche Evolution und Innovation entsteht **primär** durch neue, **kooperative** Beziehungen, neue "Links".



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

Pilze, Pflanzen, Tiere sehen so aus



Richard Dawkins

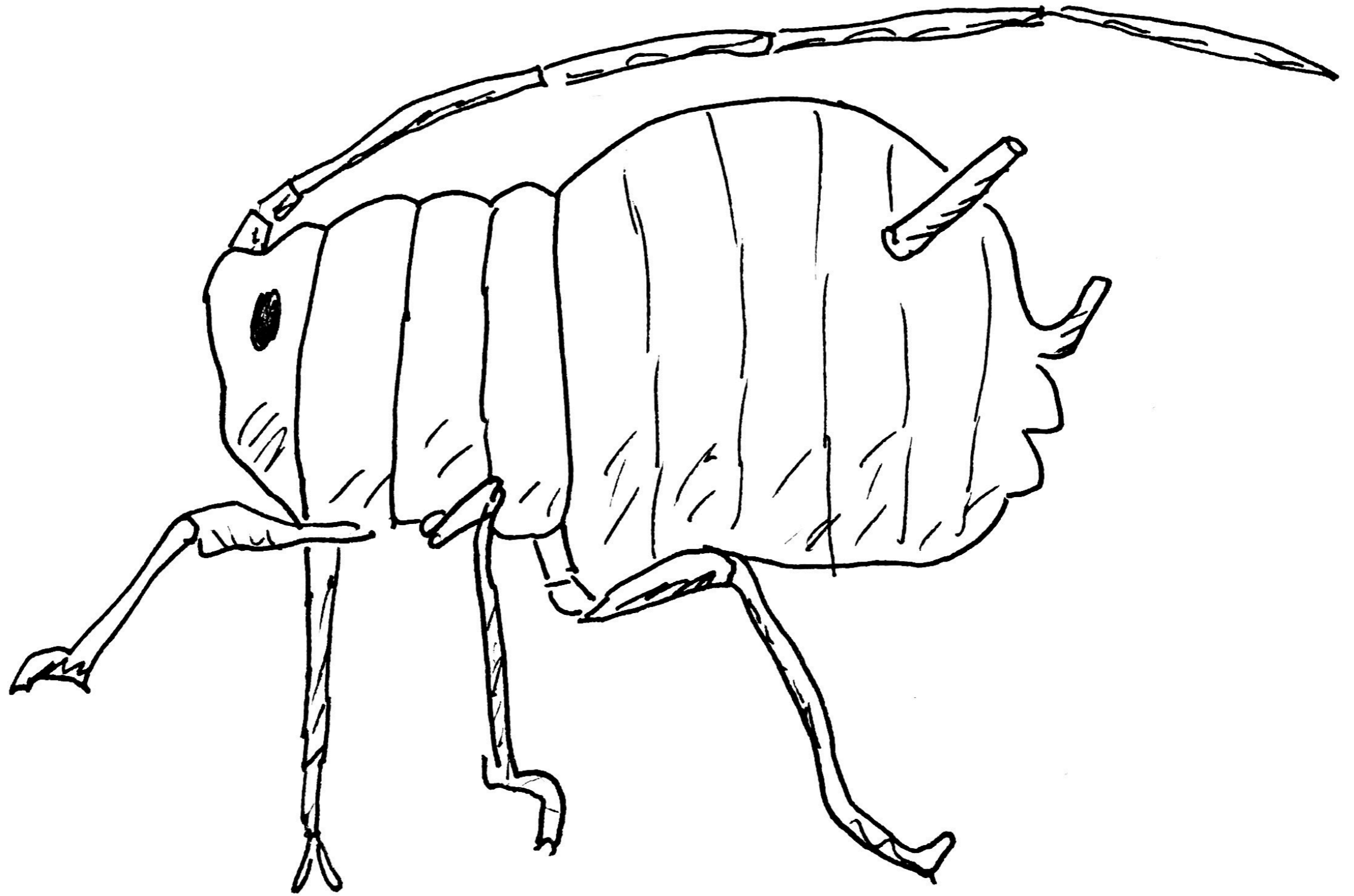


“Why do you have to drag symbiosis into evolution. It’s so unparsimoneous?”

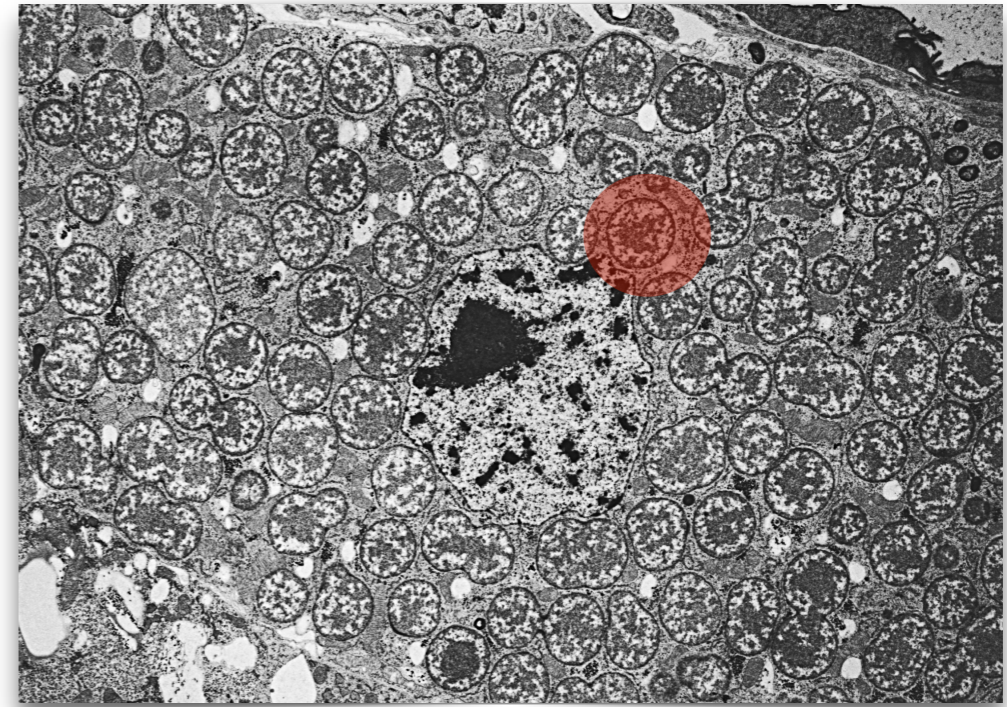
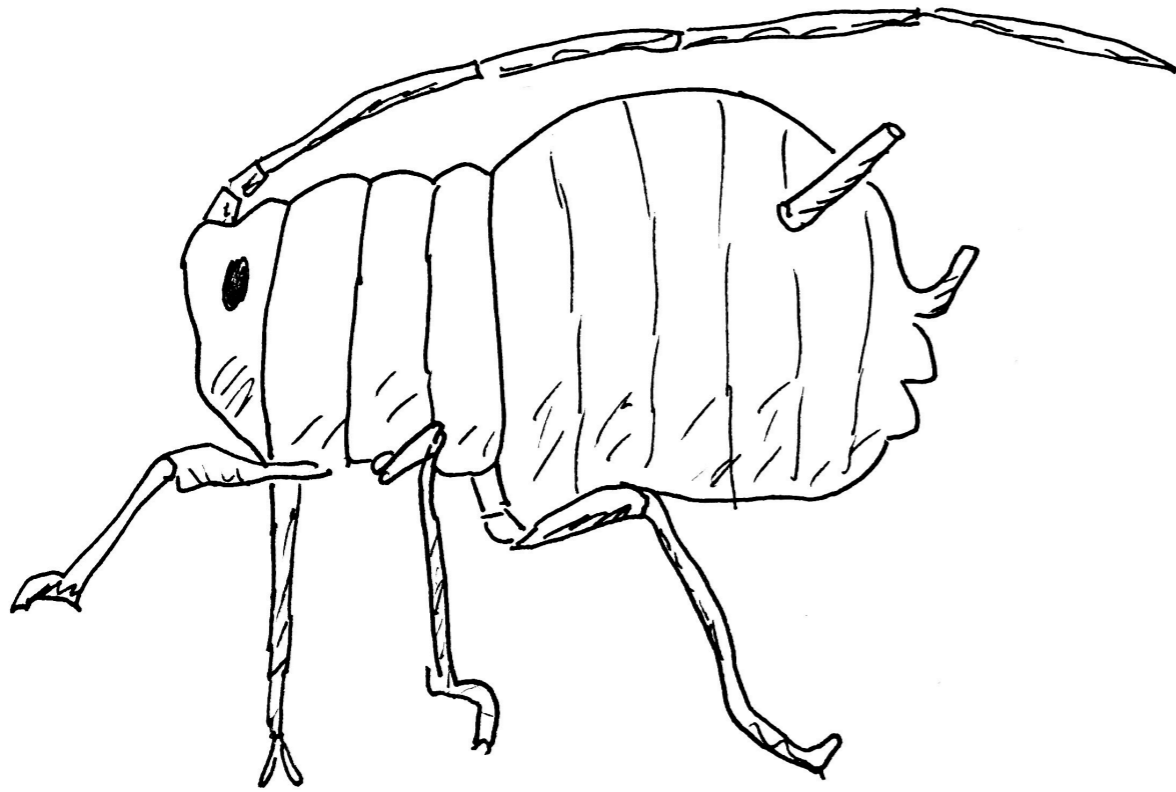
Lynn Margulis



“Because it’s there.”



Buchnera aphidicola



Nancy Moran

- **Hilft Laus bei der Verdauung**
- **Symbiose seit 160-280 Mio. Jahren**
- **Extrem kleines Genom**
- **Extrem stabiles Genom**



