Our complex hierarchical world of processes

- and nothing else

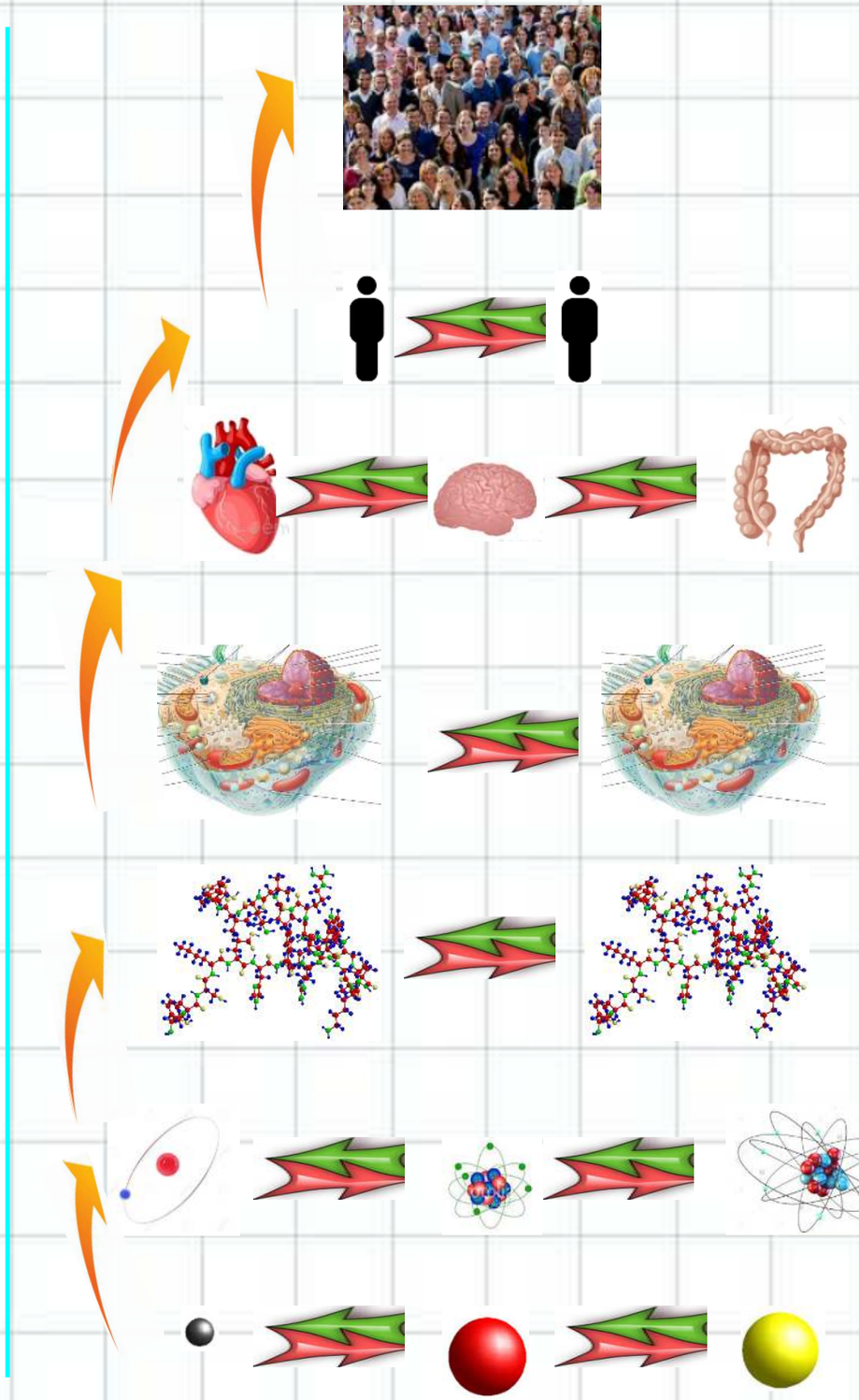
There is not such a *thing* as a *thing*

Henrik Jeldtoft Jensen

(1) Centre for Complexity Science &
Department of Mathematics
Imperial College London

(2) Centre for Innovative Research
Tokyo Institute of Technology

(3) Complexity Science Hub Vienna



Imperial College London

Complexity Science

— both the most fundamental
and the most applied of sciences.

- Applied — addresses the most urgent scientific and societal problems we face today
- Fundamental — pushes the frontier of science by developing concepts, language and formalism to help us understand *systems*

The Vienna hub's quest is a continuation of Boltzmann's work in Vienna around 1900.

How is this done

Applied

Through collaborative research: complexity learns from and contributes to our understanding of the most basic aspects of

- finance
- economics
- neuroscience
- ecology
- …

Fundamental

To understand the typical behaviour of such systems, complexity science investigate concepts such as

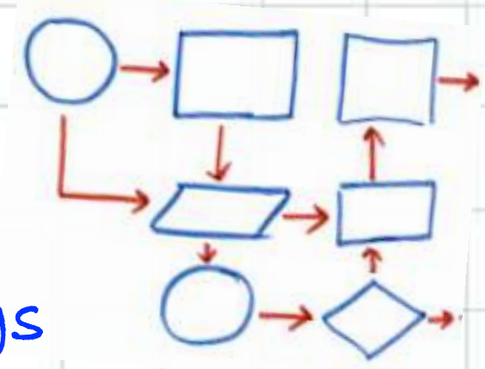
- emergence
- synergy
- co-evolution
- collective dynamics
- bottom-up versus top-down
- ….

Complexity Science

How is it possible? The building blocks of the world

How can general rules govern diverse systems such as

- an ecosystem
- a network of financial agent
- the brain
- …



Because the world consists of processes - not *things*

At the most basic level a “thing” like

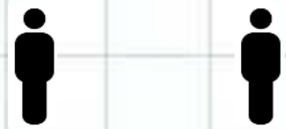
- an atom
- a human
- the brain
- a company

consists of hierarchically structured processes,
not of balls, springs and levers.

The subfields

Sociology

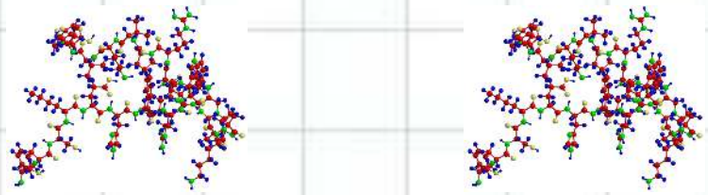
Psychology



Physiology

Cell biology

Proteins

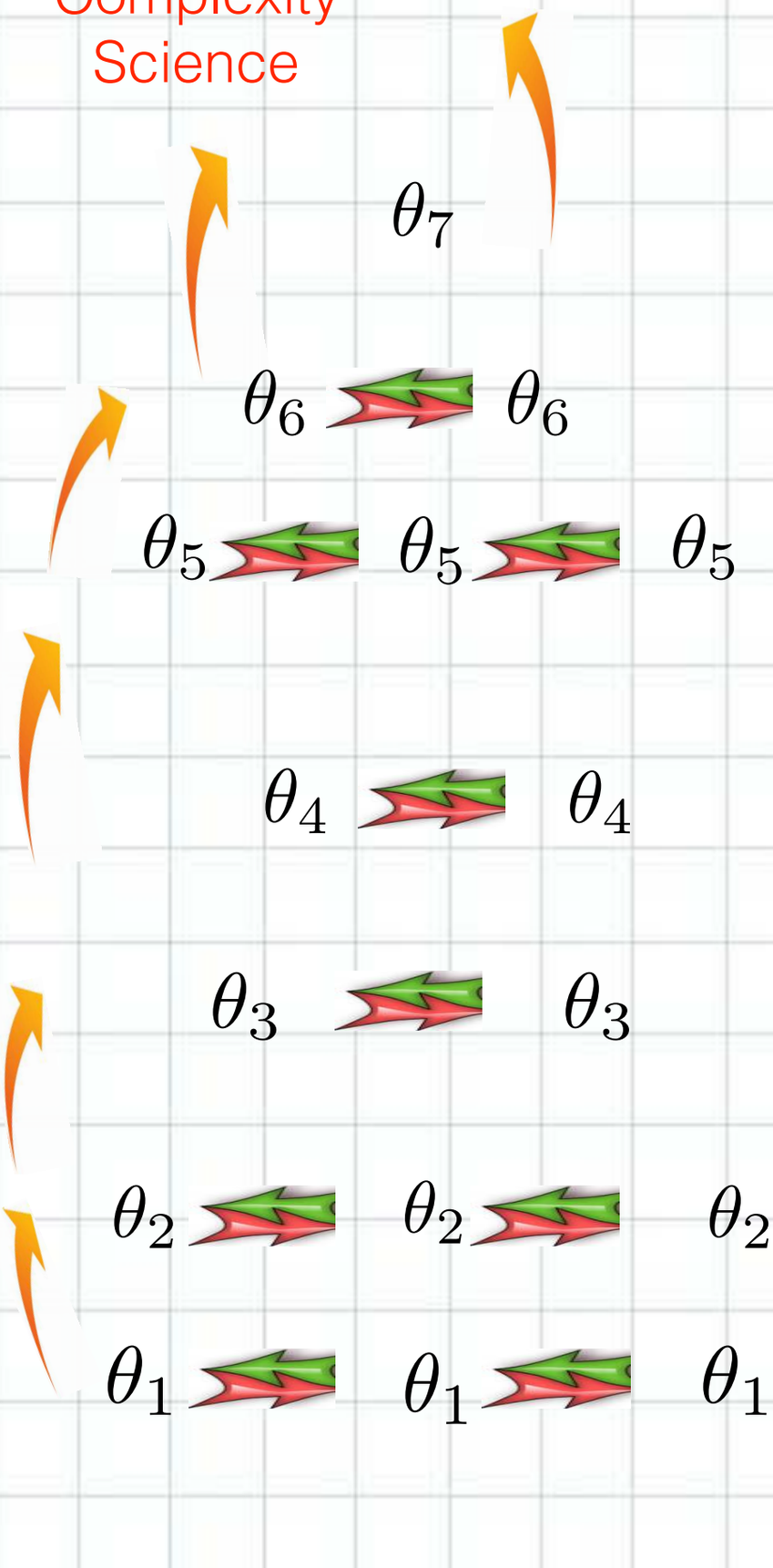


Atoms

Particles

Henrik Jeldtoft Jensen

Complexity Science



Imperial College London

Complexity science is the science of the laws governing the dynamics of interrelated processes.

Long, but sparse, history

- Aristotle: The whole is greater than the sum of the parts
- Marx: Merely quantitative differences, beyond a certain point, pass into qualitative changes.
- Anderson: More is different

Or according to Niels Bohr

> the wetness of water “emerges” out of the proper combination of hydrogen and oxygen and cannot in principle be found or predicted by analysing those chemicals individually …

RH Jones: Reductionism: Analysis and the Fullness of Reality

Imperial College London

Complexity Science

Complexity Science achievements

- Goes beyond the cross disciplinary collaboration
- Beginning to identify general laws of complex systems
- One example:

Self-organisation towards dynamics characterised by

- scaling: self similarity (brain structure, financial fluctuations, precipitation, …)
- adaptation co-evolution brings about (economics, cancer growth, …)
  - intrinsic instability (economic crashes, ecosystems collapse, …
  - the exogenous ⟷ endogenous (dynamics of finance, brain, fossil record, …)

Imperial College
London

Complexity Science

Complexity Science achievements

Specific examples

Papers

Neuroscience: self-similar brain

P. Massobrio, L de Arcangelis, V. Pasquale, H.J. Jensen and D. Plenz, Criticality as a signature of the healthy neural systems. (Editorial), frontiers in Systems Neuroscience. 25 Feb. 2015, doi: 10:3389/fnsys.2015.00022.

25 Years of Self-Organised Criticality: Solar and Astrophysics

Markus J. Aschwanden · Norma B. Crosby · Michaila Dimitropoulou · Manolis K. Georgoulis · Stefan Hergarten · James McAteer · Alexander V. Milovanov · Shin Mineshige · Laura Morales · Naoto Nishizuka · Gunnar Pruessner · Raul Sanchez · A. Surja Sharma · Antoine Strugarek · Vadim Uritsky
Space Sci Rev (2016) 198:47–166 DOI 10.1007/s11214-014-0054-6

Conference

Cancer: tumour growth - evolution

Quantifying the evolutionary dynamics of tumor growth and metastasis
Cancer evolution and metastasis: From single cells to population dynamics

Imperial College
London

Complexity
Science

Complexity Science

the fundamental science enabling the subject specific sciences

somewhat similar to mathematics

understanding emergence

COMPLEXITY
SCIENCE
HUB
VIENNA

Henrik Jeldtoft Jensen

東京工業大学
Tokyo Institute of Technology

Imperial College
London

Complexity
Science

Henrik Jeldtoft Jensen

Imperial College
London

Complexity
Science

Henrik Jeldtoft Jensen

Imperial College
London

Complexity
Science

Henrik Jeldtoft Jensen