Culture, Evolution and 2nd LoT

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WARNING
HIGH ENTROPY AREA
Definition of Life

Living things

GROW
(increase in mass & number of individuals)

RESPOND to environmental stimuli

REPRODUCE
(production of progeny)

CAPABLE to METABOLISE
(reactions occurring simultaneously inside all organism)
Life and \( O_2 \) consumption

![Graph showing the timeline of oxygen build-up with events marking the appearance of life forms.](image)
Life out of Africa

Map showing the spread of life out of Africa with dates in thousands of years ago (KYA): 40 KYA, 47 KYA, 39 KYA, 195 KYA, 50 KYA, and 15-25 KYA.
Complex Systems

Emergence over scale

Game Theory
- Prisoner's dilemma (PD)
- Rational decision making
- Iterative PD
- n-person PD
- Bounded rationality
- Cooperation versus competition
- Spatial network game theory
- Evolutionary game theory

Collective Behavior
- Social dynamics
- Collective intelligence
- Self-organized criticality
- Self-organized modeling
- Phase transition
- Synchronization
- Ant colony optimization
- Particle swarm optimization
- Swarm behavior

Nonlinear Dynamics
- Time series analysis
- Ordinary differential equations
- Iterative maps
- Phase space
- Stability analysis
- Chaos
- Attractors
- Population-dynamics
- Multistability
- Bifurcation

Networks
- Scale-free networks
- Social network analysis
- Small-world networks
- Community identification
- Centrality
- Moths
- Scaling
- Robustness/vulnerability
- Systems biology
- Dynamical networks
- Adaptive networks

Systems Theory
- Homeostasis
- Feedbacks
- Self-reference
- Goal-oriented/behaved behavior
- Systems-dynamics
- Sensing
- Information theory
- Complexity theory

Evolution & Adaptation
- Artificial neural networks
- Evolutionary computation
- Genetic algorithms/programming
- Artificial life
- Machine learning
- Evo-Devo
- Artificial intelligence

Pattern Formation
- Spatial fractals
- Reaction-diffusion systems
- Partial differential equations
- Percolation
- Cellular automata
- Spatial ecology
- Spatial evolutionary biology
- Geomorphology

Self-Organization over time

- Artificial neural networks
- Evolutionary computation
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- Artificial intelligence
The entropy of a closed system shall never decrease, and shall increase whenever possible.
Thermodynamic equilibrium
Systems at different scale
“Let me say first, that if I had been catering for them [physicists] alone I should have let the discussion turn on free energy instead. It is the more familiar notion in this context. But this highly technical term seemed linguistically too near to energy for making the average reader alive to the contrast between the two things.”

“I’d look for an entropy reduction, since this must be a general characteristic of life.”
Ilya Prigogine famously stated:

“in a non-isolated [open] system there exists a possibility for formation of ordered, low-entropy structures at sufficiently low temperatures. This ordering principle is responsible for the appearance of ordered structures such as crystals as well as for the phenomena of phase transitions. Unfortunately, this principle cannot explain the formation of biological structures.”
Life between Order and Chaos
Spontaneous order
Driving forces for development

SOCIETY

MARKET  SCIENCE  LIBERAL DEMOCRACY  CULTURE

CIVIL SOCIETY

PROFIT  TRUTH  FREEDOM  SPIRITUALITY
Transition: from linear to non-linear world
The End
“A generalized **autocatakinetic system**. $E^I$ and $E^{II}$ indicate a source and a sink with the difference between them constituting a field potential with a thermodynamic force $F_1$ (a gradient of a potential) the magnitude of which is a measure of the difference between them. $\Delta E^I$ is the energy flow at the input, the drain on the potential which is transformed into entropy production $\Delta S$ at the output. $E^{III}$ is the internal potential carried in the circular relations that define the system by virtue of its distance from equilibrium that acts back to amplify or maintain input during growth or non-growth phases respectively with an internal force $F_2$.” (Swenson, 1997)
“A tornado is an example of an **autocatakinetic system**, a dynamically ordered flow structure whose identity, in contrast to a machine, or artifact, is constituted not by a set of particular components typically occupying fixed positions with respect to each other, but by the ordered relations maintained by the incessant flow of its components. The dynamical order that defines the persistence of an autocatakinetic system as an object at the macro level, is maintained through constant change at the micro level. This incessant flux of components can be thought of as a generalized metabolism by which the system maintains itself by pulling environmental potentials (or resources) into its autocatakinesis, which it returns in a more dissipated form. All living things from bacteria to **human cultural systems** as well as the planetary system as a whole, which maintains a constant level of oxygen, for example, by this same generalized process, are all members of the class of autocatakinetic systems.”

(Swenson, 1997)
Uh oh: entangled particles break second law of thermodynamics
Predicting human height by Victorian and genomic method
Consciousness: The Ultimate Attractor
There exists a useful thermodynamic variable called entropy ($S$). A natural process that starts in one equilibrium state and ends in another will go in the direction that causes the entropy of the system plus the environment to increase for an irreversible process and to remain constant for a reversible process.

$$S_f = S_i \quad \text{(reversible)} \quad S_f > S_i \quad \text{(irreversible)}$$
Dissecting The Second Law of Thermodynamics: It Could Be Challenged But Not Violated

Carnot
1824
Heat Engine
Reversibility

Clausius
1850
NO Heat
from cold to hot
1865
Entropy

Kelvin-Planck
1848
Abs. Temperature
1865
NO Work
from single reservoir

Gibbs
1870’s
Entropy,
Chem. Potential
Phys. Chemistry

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The Fundamental Laws of Nature:

**The Laws of Thermodynamics** have much wider, including philosophical significance and implication, than their simple expressions based on the experimental observations, they are:

**The Fundamental Laws of Nature:**

- **The Zeroth** (equilibrium existentialism),
- **The First** (conservational transformationalism),
- **The Second** (forced-directional, irreversible transformationalism),
- **The Third** (unattainability of emptiness).

**The Laws** are defining and unifying our comprehension of all existence and transformations in the universe.