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Entropy, the 'Constructal Law' & the Emergence of Structural Organization

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❖ Plan

1. Context: physics & biology.
2. Two Entropic Explanatory Strategies.
3. Emergence & Organization.
4. The Constructal Law.
5. Conclusion.

Context – I

❖ Mecanism-Vitalism Debate

- The need to explain the *complexity* of living things.
- It is not because you cannot offer a mechanistic explanation that you are committed to vitalism.
- And it is not because you reject vitalism that you are committed to mecanism.

Context – II

❖ Darwinian Specificity

- All living things are explained (i.e. their evolution) by an overarching set of laws (NS).
- Thus, humans are not "special" in comparison with other living things.
- ❊ An explanation can give an unification of phenomena.

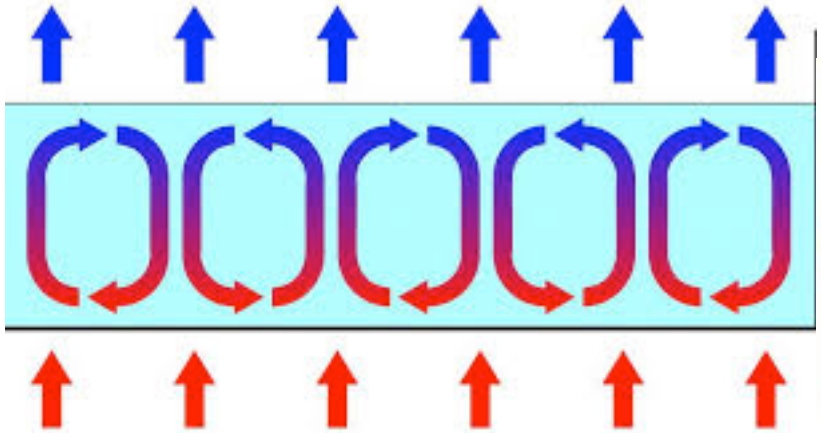
Explanatory Strategies

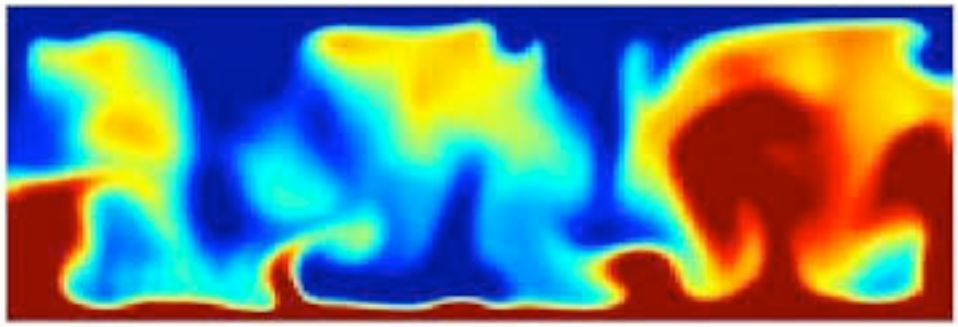
❖ Two Kinds of Entropic Explanatory Strategies

- Substantial Approach.
    - Complex systems like living organisms are 'open systems' capable of 'self-organization' because they expel entropy onto their environment (e.g. Schrödinger ; Prigogine).
- Analogical Approach.
    - Thermodynamical phenomena, like evolutionary ones, are stochastic process of large number of interacting constituants (e.g. Fisher ; Barton & Coe).

Explanatory Strategies

❖ Substantial Approach of Entropic Explanatory Strategy





Emergence & Structural Organisation

❖ Are living things *just* molecules?

- Yes – does physics can explain biology?
- No – there must be something else…
  - radically different: dualism (vitalism);
  - or not *that* much: emergence.

Emergence & Structural Organisation

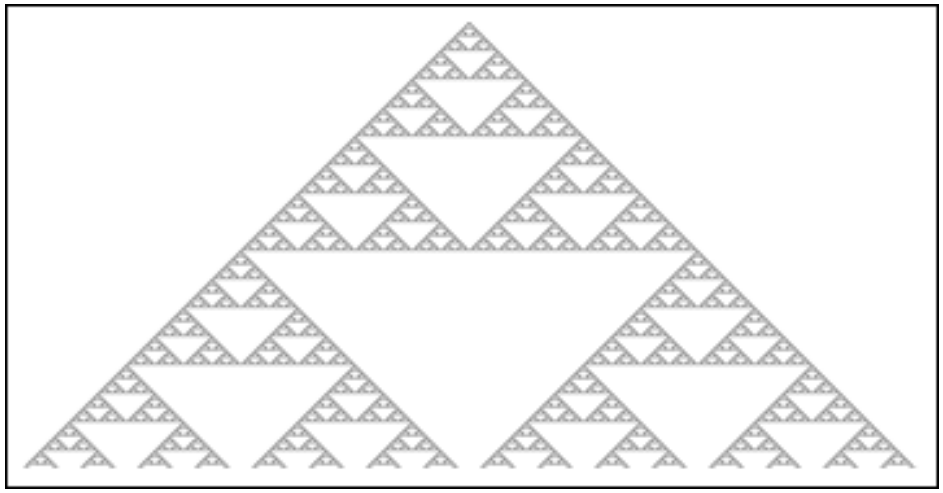
❖ Slogan : “The whole is more than the sum of its parts”.

- What is the *whole*?
- What are the *parts*?
- And “more” how?
- ❊ What are the *relata* and their *relation*?
  - Properties, substances, laws…

Emergence & Structural Organisation

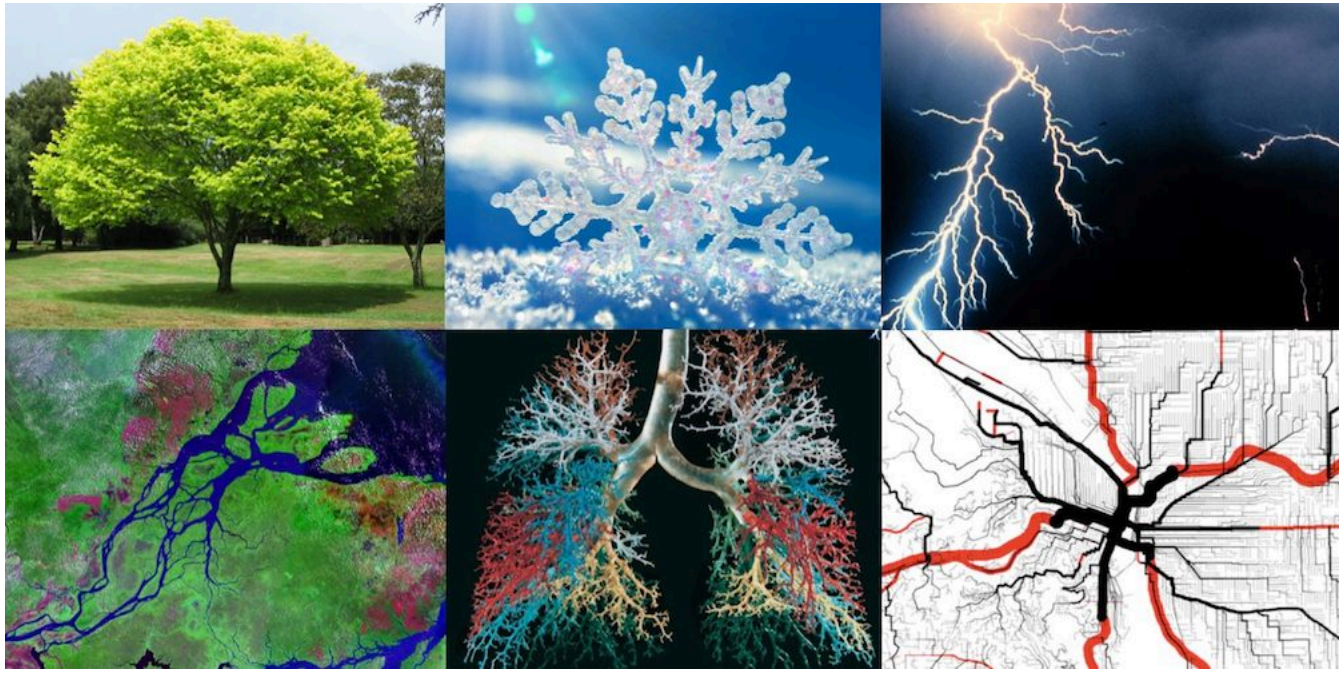
❖ Example: Computational Approach

- The 'result' (the pattern, the whole) is "emergent" iff there is no 'algorithmic shortcut' to it.
- The algorithm is quite arbitrary.
- Reproducing is not quite explaining.



Physical (entropic) explanations

❖ The Constructal Law



Physical (entropic) explanations

❖ Constructal Law

- Proposed by Adrian Bejan (1998, 2006, 2012).
- "For a finite-size flow system to persist in time (to live), its configuration must evolve in such a way that provides easier access to the currents that flow through it."
- In other words, it caracterizes the process, the way the structural organization is built (in the entropic substantial approach).

Physical (entropic) explanations

❖ Constructal Law

- Constrains' optimization (i.e. access-maximization problem) determined by the physical context in order to facilitate the flow leads to the maintenance of a structural organization with energy and entropy exchanges.
- Many parameters need to be defined:
    - emergence (micro-parameters & "cells");
    - structural organization (determined 'pattern');
    - explaination by (*a*) entropy principle and
      (*b*) 'constructal law'.
- Thus, the Constructal Law helps to choose among various emergent relata and relations. And it complements the entropic explanatory strategy.

Conclusion

❖ *Emergence of structural organization can be explained by an entropic explanatory strategy with the Constructal Law.*

- Emergence does not mean the impossibility of micro-explanation (but rules out *total* reductionism).
- Structural (self-)organization can be explained – in biological systems and elsewhere – by the same (physical) explanatory strategy.
- It thus provide a kind of unification of physical and biological phenomena (without reducing one to the other).

Merci!
Thank you!

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