ENTROPOMETRICS

A systemic explanation of 'organic life'

On fixing the semantics and understanding entropy

Entropology-series 2019.01

August 2019

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Current dead ends in scientific research

In the scientific community there is no full consensus on and understanding of why and how life exists, specifically in relation to the second law of thermodynamics. After all, how can it be that in an environment where energy can only dissipate (entropy), some structures (organic life-forms) defy this logic, and sustain their structure?

Most research is on how organic life-forms use the so-called Free Energy Principle (FEP) to 'sustain' itself, within a chaotic environment. This FEP uses the concept of so-called 'Markov blankets' to be able to describe an organic living unit in relation to its environment. It is a conceptual term, and can be applied to a single cell, an organism, or even an ecosystem. It is any 'border' that separates a living thing from its outside. It can also refer to a cell within a larger body, or a leaf of a tree: it separates the inside from the outside, to be able to describe the energy-potential that the organic unit uses to sustain itself, and develop itself. Food and light are energy sources for organisms, which ultimately trickle down to microscopic energy-transfers within cells and mitochondria, for example.

The Free Energy Principle states that single cells, mitochondria, organisms, and (most notably) even 'the brain' (any Markov blanket) all try to minimize their 'free energy', by mirroring the sensory inputs they get from their environment. By perfecting this mirroring-technique, they become 'adaptive' to changes in the environment, and can develop into more resilient structures.

There is no 'life'

However, most of these explanations eventually still run into difficulties. Current research can describe how the energetic mechanisms work in impressive detail, but it fails to explain *why* it is working this way, and even why 'life' originally came into being in the first place. After all
These dead ends are caused by two methodological reasons:

1. FEP tries to explain organic life from the perspective of an individual unit of life (instead of from a systemic point of view)
2. FEP makes a naive conceptual distinction between organic life and 'its environment' (semantics)

In other words: the dead ends when explaining life via the FEP are mainly caused by a semantic distinction between life and environment, which is conceptually flawed from a systemic point of view.
We will therefore introduce a single, generic concept, that explains and describes both non-living systems (weather, stars, etc) and what we call 'living systems', from a single principle.

Entropy

The second law of thermodynamics states that in a closed system, entropy will increase over time. In other words, all available energy will dissipate across the system. In principle, any such system will eventually reach an equilibrial or static state, in which all available energy is evenly distributed. It is important to understand that this behavior is not at all intentional, but only a statistical fact: there are more permutations of evenly distributed constellations of energy, then constellations that have some concentration of energy in a small area. It is more

likely for a system to be in a dissipated state, than in a skewed state. Therefore, over time, a system will look like it moves towards a dissipative state.
Nevertheless, in a large enough system, and given enough time, chaos and complexity, a lot of local and temporal skewness will occur, as lots of particles and energy are violently colliding, for example, after the big bang, and stars come into being, or, in fact, on planet Earth some billion years ago.

Entropy production

By the same logic that drives a system towards a state with higher entropy, a system that gets from a state with low dissipation into a state that dissipates more energy, it is hard to put the system back in the previous state (because it will cost energy to do so). In practice, a system will always fall downwards to states of higher entropy production rates (analogous to a state with higher entropy). This principle is called the Principle of Maximum Entropy Production (MEPP).

Accelerations

In 'simple' systems, there is a limited amount of ways to dissipate energy. Such systems will simply move linearly towards an end-state of evenly dissipated energy. But in 'complex' (or non-linear) systems, there are chaotic and abundant interactions between particles with high diversity. In such systems, sometimes small constellations can emerge that dissipate energy more efficiently than 'plain' entropy. Crystallization is an example of this: the cubic structure is sturdy and can be augmented easily. Energetically, it is cheaper for the crystal to grow, than not to.
Of course, this is only local and temporal: it is a single crystal structure. As soon as there are no matching particles left nearby, to grow the crystal further, the process stops. Also, it may hit some counterforce that prevents it from growing further. But only such an external (energetic) force, or a saturation or exhaustion will stop this process.
So the only thing going on is: within chaotic and abundant dynamics, a system will encounter local infrastructures that temporarily accelerate entropy production. And when enough of these infrastructures exist for long enough, and interact with each other, they can reach ever higher forms of complexity. Together, they can form intricate structures of composite saturation and exhaustion processes, that escalate entropy upwards to even higher structural levels.
Such infrastructures can be fractal, in escalating entropy production: clusters of microscopic entropy production structures yield macroscopic entropy production structures. The interdependancy in saturation and exhaustion between these levels of scale can be more complex and non-linear than one can imagine. These levels of scale are not discrete, they are continuous.

Recyling entropy production: life and death

The interactions in entropy production and exhaustion between the levels of scale can also yield circular flows of entropy production, between these levels. This way, entropy production is being *recycled*. Combined with the fractal escalation described above, we can now recognize the metabolic processes in organic life forms as the recycling of entropy production from a microscopic level to macroscopic levels.

So this principle of maximum entropy production alone can fully explain both the *possibility of the emergence* and the *(local and temporal) stability* of organic life (at any scale, from cell to ecosystem).
The saturation-levels can be recognized easily:

- saturation of some cellular metabolism is called apoptosis
- falling leaves of a tree indicate the saturation of entropy production in the endpoints of branches
- the death of an organism is actually the escalated macro-saturation of the all the upward microscopic entropy production recycling

Conclusion

This illustrates that there is no conceptually meaningful distinction between 'organic life' and its environment. Or between 'organic' processes and 'regular' processes like the weather or a shining star.
Also, it illustrates that understanding the emergence and stability of organic life is not possible from the perspective of individual organisms (or Markov blankets) itself, but only from a systemic point of view. Organic life and Markov blankets do not minimize free energy at all, it is the system that maximizes entropy production. The FEP must be seen as a *corrollary* of the maximization of the entropy production of all upper Markov blankets.

The principle of maximum entropy production (MEPP) can fully explain organic life and evolution. Furthermore, it has been demonstrated that our climate system also continually moves to states with maximum entropy production. And the same holds for evolution, ecosystems, and even our economy and financial markets: complex dynamic systems can only 'fall upwards' to higher states of entropy production, until it reaches a saturation/exhaustion point, or some barrier.
We will apply this principle to these domains in other publications.

Technical formulation

Technically formulated at the highest level of abstraction, complex systems with an entropy production infrastructure can yield emergent chaotic attractors of entropy production.
What we call 'organic life forms' are (arbitrary) solutions of a non linear system, so any existing organisms are local and temporal maximae of entropy production, within such infrastructures.
The technical description will be presented in the technical version of this Domain Analysis of organic life.

Further reading

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Entropology-series, August 2019
`TDA.MEPP_OrganicLife.2_1908`
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