A systemic explanation of 'organic life'

The Maximum Entropy Production Principle

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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.
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)

The distinction between living systems and their environment, and the distinction between living and non-living entities, are both conceptually flawed, from a systemic point of view.
For a fundamental understanding, we need to raise the bar in abstraction, and leave the domain of biology.
At this higher abstraction level we will find a single concept that explains and describes both non-living systems (weather, stars, etc) and what we call 'living systems'.

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 energetically skewed state. Therefore, over time, a system will look like it moves towards a state with a higher dissipation level.
Of course there are a lot of systems (rather: relatively closed subsystems in the universe-system), that have not reached a fully dissipated state yet. Some systems show highly skewed distributions of energy (e.g. the sun). In large systems with lots of chaos and complexity, the dissipation of energy can even occur non-linearly. As we will see, this non-linear entropy is a key aspect of living systems.

Entropy production

By the same logic that makes a system fall towards states with higher entropy, a (sub-)system that accidentally gets from a state with low dissipation-rates into a state that dissipates more energy, it is hard to get the system back in the previous state. It will require energy to do so. So, in effect, systems will always fall downwards to states with *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.
Of course, these constellations can only exist locally and temporally. As soon as the subsystem reaches a saturated state, the process stops. Also, it may hit some stronger counterforce from outside.
But only such an external (energetic) force, or a saturation or exhaustion will stop this process.
So the only thing going on is: systems with chaotic and abundant dynamics, can encounter local infrastructures that temporarily accelerate entropy production. The growing of a crystalline structure is an example of this.
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.
These 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. The Markov-blanket hierarchy is not discrete, but 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 non-linear 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*, a statistical inference, 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, others have demonstrated that our climate system also display this principle of 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 a non-linear entropy production infrastructure can yield emergent chaotic attractors of entropy production.
What we call 'organic life forms' are (arbitrary) solutions of this 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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