Dynamic changes in Prebiotic Systems

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Abstract

This paper aims to contribute with the debate about the causes that produced the emergence of dynamic organization in living organisms. Understanding the origin of living systems is grasping the most basic capacities that are used in the construction of the organization of these systems. It is possible to think that in the prebiotic epoch the conditions should have existed that enabled the development of the rudiments of a dynamic organization containing the essentials for the subsequent emergence of life, a specific type of dynamic that would be associated with the variability of the different prebiotic systems. Thus, we could speak of a prebiotic evolution that brought about evolution by natural selection.

Keywords: cohesion; complex systems; emergence; evolvability; far from thermodynamic equilibrium; open-ended evolution.

1. Introduction

Understanding the origin of living systems is grasping the most basic capacities that are used in the construction of the organization of these systems [1, 2, 3].
The prebiotic world can be conceived of as a group of systems that generated the move from the inanimate to the animate. In more precise terms, the prebiotic world must have been constituted by a series of more or less successive steps and each one of them, was represented by a specific type of dynamic system. In each successive stage, the respective dynamic system must have contained those capacities/ improvements possessed by the systems from previous steps and, in

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addition, it had the chance to explore new strategies or to improve on what was already there.

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2. Variability in prebiotic systems

We know that two variability types exist in biological systems: one that is produced by genetic changes (mutations) and is therefore inheritable and the second, which is produced by changes in the environment and associated with the system's capacity to maintain its cohesion [4, 5]. It is associated with multiple strategies that produce homeostatic phenomena [6]. Although this second variability type is not "inheritable", in the sense that we are accustomed to thinking of in biology, it is still possible to think about an open-ended evolution that focuses on increasing the complexity of the systems.

More important than preserving some of components that are reliably transmitted to the successive generations, it seems reasonable to claim that during the prebiotic epoch, it was crucial to maintain the cohesion of its organization at all costs. The dynamic of its organization is revealed in the fundamental properties that make its integrity and identity explicit. Therefore, maintaining the conditions that enable the stabilization of these properties – maintaining them robustly – is that which must have been preserved in the different systems of the prebiotic world.

To characterize the identity of the dynamic organization of these systems is to identify the most fundamental properties that define them. Once these properties are located, it is a question of widening the notion of evolution by natural selection towards an open-ended evolution. Therefore, instead of occupying ourselves with having to follow up on the inheritable variability, we are now interested in the variability that preserves the cohesion of the fundamental properties in contexts of increasing the complexity of the networks of processes that allow the expression of these properties.

If we apply this approach to the variations in the prebiotic universe, then we will inevitably arrive at the conclusion that the fundamental causes for variability in those systems were changes in its environment. In other words, since there was nothing like "genetic materials" at the beginnings of the prebiotic world, the system evolved in the face of problems generated by the environment through different ways of preserving the basic properties which characterized them. So, the dynamic systems of the prebiotic world must have developed – taking into consideration that they survived these adverse conditions – strategies that enabled them to establish nexuses between the external environmental changes and the internal developments that perpetuated the dynamic cohesion of their organization.

We now realize that there are a variety of processes in the plasmatic membranes of cells that enables them, within certain limits, to suitably manage their conditions and internal requirements. Including isolation from its environment, it has a capacity that actively selects certain matter-energy components from its exterior and carries them to its interior.

We may hypothesize that the extreme complexity and sophistication of these processes correspond to the final phases of strategies developed very early by evolutionary processes in which improvements were gradually produced. Moreover, their presence is important for resolving problems that seriously place the cellular integrity at risk if they are not worked out, problems such as the osmotic balance, the electrochemical transportation, and the contribution of compounds to internal processes.

The above would reveal to us the earliest ancestor of these actions. It would be pointing out that its importance and age lie in the intimate relationship they have with the spontaneous origin of a dynamic organization of a system that will guide us – much, much later – towards the world of the living.

3. Evolvabilty and Inheritance

In this way, we may hypothesize that from their most primitive origins, the true ancestors of the living systems had the capacity to interact with and to express an active behavior towards their environment. If we are in right track, then, the successive systems in the prebiotic universe had as one of their most important dynamic structures a protoplasmic membrane that formed a fundamental part of their organizational composition. This structure would have been formed of molecules interacting in processes they would have simulated at very basic levels, those we can still see in the plasmatic membranes of the current cells.

Apart of to be a physical barrier, this protoplasmic membrane permits certain properties of chemistry to have a focal point of action to generate problematic circumstances which in turn produce the conditioning situations for exploring different solution strategies. And is this kind of protoplasmic membrane what provided the systems in prebiotic epochs with the *capacity of being evolvable* from its very origins.

We talk about evolvability when we are able to observe a phenotypic variation that is susceptible to being a target of natural selection or, in other words, when an organism has the capacity to generate a phenotypic variation that is inheritable (7, 8, 9, 10, 11). Nevertheless, when we are thinking upon the origins of the prebiotic world, we cannot establish these types of associations. It is nearly impossible to think that in those remote epochs there existed molecular entities so complex and sophisticated as nucleic acids or proteins. Hence, it is not possible to talk about evolution in terms of natural selection during those times; what we are proposing, then, is that it is possible to talk about evolvability in the prebiotic world.

Once these systems are confronted by a specific problem that the environment generates, the different possible solutions (strategies) produced in the system's protoplasmic membranes as a product of the reproduction of these systems are nothing more than the maintenance of the integrity of their dynamic organization. This sort of prebiotic "inheritance" must have been associated with a certain evolvability capacity rather than with a Darwinian type of evolution.

In other words, every time the systems reproduced we could see that inside the processes, the components could be changed, but as a whole, the system's descendents attempted to keep their most fundamental properties intact and compatible with its survival; that is, in conditions compatible with the far from equilibrium state.

To end this work, it seems feasible to propose the idea that the basis of hereditary similarity in "prebiotic evolution" depended on the way cell-like systems were embedded in their environments, rather than on internal, gene-like mechanisms. We also suggest evolution is happening at small-time scales - so it is continuous - due to that the membrane makes the cell "evolvable". Also, we consider interesting to continue the exploration of the possible consequences derived of the previous statements and proposals sketched in this article, with the ultimate goal of to widen our current comprehension of evolution.

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