Towards Modelling the Processes of a Minimal Protocell

Walter Riofrio [1]

[1] Complex Thought Institute Edgar Morin, University Ricardo Palma, Av. Arequipa 5192, Miraflores, Lima 18, Lima - Perú
walter.riofrio.rios@gmail.com

Abstract.

When we are in the pursuit of trying to understand how simple molecular structures within specific molecular processes could produce the emergence of a cellular system may be more valuable an approach in where self-assembly processes and self-organization are the key requirements rather than looking for isolated macromolecules (like DNA or proteins).

Then we need to highlight both the synchronization phenomenon and the correlation between processes, both of which are necessary to ensure sustainable growth in protocells, which will be necessary to attaining evolvable capacities.

Remarkably, correlations between processes can be attained when a system is in a far from the thermodynamic equilibrium state. In this condition, the time evolution of protocells could show an array of feedbacks, nonlinearities and the appearance of patterns that are unequivocal signs of correlation between processes [1], [2].

I additionally hold that the dawning of the prebiotic world implied formation of a self-organizing dynamic that, in reality, was a determined type of protocell. It emerged in the remote past, thanks to the correlation produced among three very different types of molecular processes, two of which act as different system constrictions [3].

The model I propose consists of at least two correlated processes whose states would cause the emergence of two basic characteristics of living beings: (A) the system is maintained separate from its environment, and (B) it is self-maintaining, being driven by its own dynamics away from thermodynamic equilibrium. It would be a kind of dissipative structure.

These two processes will have been highly interconnected, as they shared a chemical compound. This would have been a kind of high-energy compound, because it had to have had a large negative free energy of hydrolysis. It would have served as the ancestral “energy currency” molecule.

The third group of processes is a network of reactions that would perform the regeneration of the organizational dynamic, maintenance, and reproduction processes of this prebiotic system.

What is interesting here is that each process, left by itself, has no evolutionary potential. Yet, when they are interrelated, they trigger the appearance of an entity which contains a certain level of interaction with its surroundings, that is, it behaves as an autonomous agent [4].

This provides it the capacity to adapt to its environment – it is a complex adaptive system – and, hence, it would have the ability to evolve (while this trait would have been minimal at its start up).

In addition, my protocell model contains properties that would not have been found within the process types that form it if those were separated one from another.

This interdependence to which we are alluding has to do with the three process types that interact amongst each other so as to become a self-sustaining and self-maintaining molecular network of processes vis-à-vis an ever changing environment.

In other words, this protocell would have already contained within itself a certain degree of minimal complexity that could not be reduced into its parts or constituents.

The main thrust of my paper shall focus on a series of possible foundational and theoretical aspects arisen from a new research area that is potentially interesting for modelling biological processes: the evolutionary consequences of a proposal about the cellular origin of prebiotic evolution [5], [6].

References

1. Kosztin, I., Schulten, K.: Fluctuation-driven molecular transport through an asymmetric membrane channel. Phys. Rev. Lett., 93(2004) 238102
2. Levine, R.D.: Molecular reaction dynamics. Cambridge: Cambridge University Press (2005)
3. Riofrio, W.: Understanding the emergence of cellular organization. Biosemiotics, 1(3) (2008) 361-377
4. Kauffman, S.: Investigations. Oxford University Press (2000)
5. Morowitz, H.J.: Beginnings of Cellular Life: Metabolism Recapitulates Biogenesis. Yale University Press, New Haven, CT (1992)
6. Riofrio, W.: Studies on Molecular Mechanisms of Prebiotic Systems. Found. Sci., 17 (3) (2012) 277-289