On the origins of autonomy: protocells as the first forms of functional integration

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Abstract

Session: Origins of Life (Orlic, Pascal, Preto, Ruiz, Pennock).
Maturana and Varela's work on the theory of autopoiesis in the seventies and eighties lead to a conception of life as a certain form of *organization*, by which each living entity recursively produces itself, including the boundary with its local environment (i.e., the cellular compartment). In more recent times, we have applied a similar idea, 'basic autonomy' (Ruiz-Mirazo and Moreno 2004), to design a research agenda in the field of origins of life, proposing it as an intermediate bridge between complex self-organizing phenomena and 'genetically-instructed metabolisms' – i.e., minimal but already full-fledged living organisms, capable of open-ended evolution (Ruiz-Mirazo et al. 2008). For historical reasons (that we will not go into in this contribution), the autopoietic school avoided the use of the term 'function' or 'functional' in their theory. However, a physiologically well grounded naturalization of this fundamental concept for biology could be approached in the context of prebiotic research on protocellular model systems (Moreno & Ruiz-Mirazo 2009). In fact, function can be understood from an organizational perspective (Mossio et al. 2009), as a very reasonable alternative to etiological accounts of it, and provides a good theoretical framework for our approach here. Starting from a relatively simple theoretical model of a protocell (Ruiz-Mirazo & Mavelli 2008) we are trying to implement empirically this first or minimal form of autonomous organization, which would involve functionally integrated components. The 'in silico' simulation model includes a semipermeable membrane (made out of simple amphiphilic self-assembling molecules – e.g., fatty acids or related amphiphilic compounds) where precursor transport mechanisms would be anchored (peptides and oligomers), helping the system to overcome problems like the accessibility of substrates or the regulation of osmotic imbalances, and allowing it to host a proto-metabolic reaction network. The 'in-vitro' approach of this model, dealing with real biomolecules and thermodynamical behaviors, will surely reveal additional difficulties but, at the same time, will hopefully bring about a more realistic understanding of the organizational principles that could have been at play in this origin of life scenario.

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