On the origin of autonomy: from chemical to biological organisation

Alvaro Moreno

IAS-Research, University of the Basque Country (EHU/UPV)

In the natural non-biotic world chemical systems are essentially driven by more or less complex external boundary conditions. Tough occasionally some processes occur in FFE conditions, ultimately processes are under TD control. Instead, in the biological world, organisms are chemical systems whose processes are essentially driven by a big number of highly complex mutually dependent constraints that are internally created and maintained. These processes occur permanently in FFE conditions. How this big change, from chemistry to biology, has been made possible? Here I will discuss which are the fundamental logical steps from the world of (mere) chemistry to that of biology. I will consider the following 3 steps: 1) chemical self-maintaining auto-catalytic cycles, 2) functional networks; and 3) self-regulated functional networks. Autocatalytic cycles are minimal forms of FFE chemical organizations. These systems are not only driven by external BC: a component –a catalyst– drives kinetically the network, and keeps them in FFE conditions. The cycle therefore is not only maintained by the external BC, but (though in a minimal sense) also by the catalyst, and the catalyst is maintained by its own action (minimal organizational closure). How this minimal organization can lead to a more complex type of chemical organization escaping from TD control? Stable organizations in FFE conditions would emerge when a set of constraints come together, in a sort of mutually reinforcing effect, which lies at the core of a new, more robust SM dynamics. This way, the action of constraints (i.e. a catalyst, a membrane) is to harness the underlying chemical interactions so that another constraint is produced, and so on until the process closes itself recursively. These diverse constraints should mutually enable their continuous regeneration. This is crucial for the emergence of a diversified functional domain: by internally synthesizing its own constraints the system becomes much more plastic; i.e., capable to perform a diversified modulation of its own SM dynamics. And it is in this organizational context where different constraints can make *distinguishable contributions* to the global SM of the system. However, the creation of new functional diversity cannot be, in principle, unlimited, because variations can affect the output of a specific constitutive constraint, which in turn may affect the structure and activity of other constraints, and so on. Due to the closure between constraints, the organization may progressively “drift” and, most likely, become disrupted after a short time. The solution is the invention of (self)regulation, namely, a set of endogenously synthesized second-order constraints operating on other, (primary or constitutive) constraints already present in the system, putting it together. These constraints must be *dynamically decoupled* from the subsystem or the process network that they regulate. Once regulation is in place, we have a chemical organization that is capable to manage the flow of matter and energy through it so that it can, at the same time, modify and control: (i) internal self-constructive processes and (ii) processes of exchange with the environment. This is what is an autonomous system and what, at the same time, essentially characterizes a living organism.