On minimal regulation in biological systems

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Abstract

The aim of this paper is to provide a theoretical model to address the issue of regulation in living systems, in particular in the context of the origins of life and of the characterization of proto and minimal living systems.
The appeal to the notion of regulation is widespread in biology. This property is usually ascribed to phenomena involved in the persistence of a living system, such as the passive or active compensation of internal and external perturbations, in strict relation to ideas like homeostasis, feedback and adaptation. Yet, this notion is still not well defined and very dissimilar types of phenomena are gathered under this label. In fact, regulative roles are usually ascribed to processes, components, and subsystems whose behaviors and contributions to the functioning of living systems are qualitatively different.
In our paper we provide a basic framework and a minimal set of requirements for regulation, based on the theory of biological autonomy. By characterizing regulation as an adaptive property – *the capability of a system to mediate the effect of a perturbation by acting on its own internal dynamics through modulation or selection between distinct available internal regimes* - we distinguish it from forms of stability (structural and dynamical) that, on the contrary, entail a passive response of the perturbed system and are shared by a wider class of natural systems. From this standpoint we argue that phenomena like feedback loops and homeostasis are characteristic of systems exhibiting dynamical stability and, therefore, are not necessarily equivalent with regulation.

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