QUESTION 3

Why Minimal life requires teleological functional constraints

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ABSTRACT

Unlike physic-chemical self-organizing systems, living systems have internally differentiated parts playing differentiated roles. Living systems are characterized by the fact of being chemical self-maintaining/producing systems, namely, recursive component production networks *harnessed* by highly specific catalysts that are produced within the very network they harness. This is captured in the idea of metabolism, which essentially is a cyclic, self-maintaining network of reactions under kinetic control by means of which the components of a system are continually produced, in far-from-equilibrium (FFE) conditions. The concept of chemical self-maintaining/producing network can be interpreted as an entailment of *self-constraining* processes, i.e., as the generation by a system of the local rules (constraints) that govern its dynamic behavior (Pattee 1972). So it is through this self-constraining action that the system actually defines itself, *constructs an identity of its own*. Regardless of the chemical specificities, what is more significant is to notice that, even in this minimal case, a living system is constituted when, first, a *variety* of constraints (catalysts, membrane) come together and second, these constraints are internally produced. These two features are central to understanding why the concept of chemical self-maintaining/producing network may hold the key to naturalizing the idea of *function*, as I will argue next.

As has been argued recently by Bickhard (2000), Christensen (Christensen & Bickhard 2002) and Mossio, Saborido and Moreno (2009) functions are specific causal relations attributed to differentiated parts of a FFE self-maintaining system, whose organizational homeostasis is thus preserved. As I have already pointed out, a variety of material constraints would be required to bridge the gap between self-organization and self-construction. And this precisely corresponds with one of the main requirements ("distinguishability" in the part-whole relationship) that are necessary to demarcate, within the general class of far-from-equilibrium dissipative systems, those showing functional features, like living systems. Indeed, not all self-maintaining chemical systems would satisfy the requirements to harbor functions; for example a candle flame does not show functionally differentiated parts. But if this network involves the endogenous production of distinguishable constraints (membrane, catalysts, etc.) that contribute in different ways (i.e., through remarkably different constraining actions) to the constitution and maintenance of a whole, integrated entity (a protocell), whose organizational homeostasis would reinforce the conditions for stability of those very component parts, and if these constraints contribute in some way to their respective

production within the system, i.e., they satisfy the requirement of closure of constraints, then these constraints are functional parts (Mossio & Moreno, 2010). Furthermore, this organization would become the reference to ground *normativity* in the system. Let us explain why.

In this type of self-maintaining systems, the activity of the constraints harnessing the underlying processes so as to satisfy the recursive maintenance (or organizational closure) of the system is at the same time the condition of possibility of their own presence. Since, as I just discussed, the central feature of self-maintaining systems is that (at least some of) their constitutive processes generate the constraints that contribute to maintain the far from thermo-dynamical equilibrium conditions, which in turn enable the constitutive processes to occur, organizational closure justifies the fact of explaining the existence of a component by referring to its effects: a component is submitted to closure in a self-maintaining system when it contributes in fact to the maintenance of some of the conditions required to its own existence. In this sense, organizational closure provides a naturalized grounding for a teleological dimension: to the question "why X?" it is legitimate to answer: "because it does Y": a given component is functional because it exists by virtue of its effects (i.e., the heart is there because it pumps blood). As a consequence, organizational closure provides a criterion to determine in a not arbitrary way what are "the goals" of the constraints constituting the FFE system. Similarly, organizational closure grounds normativity. Because of the organizational closure, the activity of the system has an intrinsic relevance for the system itself, to the extent that its very existence *depends on* the effects of its own activity. Such intrinsic relevance generates a naturalized criterion to determine what the system is "supposed" to do. In fact, the whole system (and then its constitutive processes) "must" behave in a specific way in the sense that, *otherwise*, it would cease to exist. Accordingly, the activity of the system becomes its own norm or, more precisely, the conditions of existence of its constitutive processes and organization are the norms of its own activity. In sum, the fundamental difference between mere physico-chemical systems and specifically biological ones is the existence of a functionally distinguishable self-maintaining chemical production network.

A minimal system harboring some form of functional diversity could be Budin & Szostak (2011) model. Considering the low levels of membrane phospholipids in the early stages of prebiotic evolution, these authors enquire into the selective advantage that may drive the evolution from self-assembled simple single-chain lipid membranes to phospholipid membranes. According to their research, phospholipid-driven competition could generate increasing phospholipid content in their membranes. In these conditions, protocells could start to evolve membrane transporters along with proto-metabolic networks for synthesising their own building blocks, and may begin to explore new environmental niches compatible with compounds that otherwise decayed rapidly in fatty acid membranes. Thus, the transition from highly permeable vesicles to less permeable and more stable protocells may result in the evolution of the functional domain of the protocells.

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