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Toward a theory of organisms: Three founding principles in search of a useful integration

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ABSTRACT

Organisms, be they uni- or multi-cellular, are agents capable of creating their own norms; they are continuously harmonizing their ability to create novelty and stability, that is, they combine plasticity with robustness. Here we articulate the three principles for a theory of organisms, namely: the default state of proliferation with variation and motility, the principle of variation and the principle of organization. These principles profoundly change both biological observables and their determination with respect to the theoretical framework of physical theories. This radical change opens up the possibility of anchoring mathematical modeling in biologically proper principles.

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"All evolutionary biologists know that variation itself is nature's only irreducible essence …"

Gould, SJ. (1985). The median isn't the message. Discover 6, 40–42.

"In the Origin of species (1859), he [Darwin] made it quite clear that variation alone was not enough to account for species transformation: one had also to assume that such variations were passed on to the following generations."

Müller-Wille, S. (2010). Cell theory, specificity, and reproduction, 1837–1870, Stud Hist Philos Biol Biomed Sci. 41: 225–231.

"In all in-depth analysis of a physiological phenomenon, one always arrives at the same point, the same elementary irreducible agent, the organized element, the cell"

Bernard Revue Scientifique C., Sept 26, 1874-(cited by G. Canguilhem, 2008. Knowledge of Life. Fordham University Press, New York).

1. Introduction

The first decade of the new millennium was dubbed as the beginning of "the post-genomic era." Its arrival was greeted by the biological sciences establishment and the pharmaceutical industry with the exceedingly optimistic view that new technology and the usual reductionist approaches that characterized the last half of the 20th century will (again) cure cancer, bring about personalized and precision medicine, and more. Indeed, the rhetoric and promises have not changed from the time President Nixon declared the War on Cancer, in spite of the meager returns of this extremely expensive undertaking. The latest "moon-shot" aimed at curing cancer "once and for all" proposed by President Obama has generated a significant wave of public criticism regarding the costs of the project, its unlikely significant impact on prevention and public health policy, the inequalities of access it would engender due to high cost of the "personalized' therapies and, finally and most important, the dubious probability of success (Interlandi, 2016; Breivik, 2016; Bayer and Galea, 2015; Joyner et al., 2016). However, critiques of the philosophical stance at the core of the biological research fueling this program have yet to propose a cogent theoretical alternative to the one that has dominated biomedical research for the last 70 years. Although the genesis of this special issue is mostly unrelated to this type of gigantic projects, its content provides a critical analysis and addresses the limitations posed by the hegemonic, reductionist, dominant world view which is metaphor-rich and theory- poor. These articles analyse the role of scientific theories not only in their ability to provide intelligibility but also as the most practical tools for framing research and for constructing objectivity. Most importantly, they put forward some basic principles that help in constructing a comprehensive theory of organisms.

Since Aristotle the idea of goal-directedness, i.e., teleology, provided a useful framework for understanding a main characteristic of organisms, namely, the "goal" of keeping themselves alive. A salient example of this phenomenon was provided by a goat studied by Slijper (Slijper, 1942a, 1942b). This animal was born with paralysis of its front legs and soon learned to move around by hopping on its hind legs. This behavioral accommodation resulted in dramatic morphological changes in the bones of the hind legs and the pelvis, as well as changes in the morphology of the pelvic muscles (West-Eberhard, 2005). Two millennia later another great philosopher, Immanuel Kant, worked on the distinctions between the ways of acquiring knowledge regarding the living and the inert. Regarding teleological thinking, he stressed the interrelatedness of the organism and its parts and the circular causality implied by this relationship. Teleological judgement was described as an epistemic organizing principle which allows for the explanation of the biological object through its unity (this object being the cause and effect of itself), before giving a discrete description of its parts. Following Kant's ideas teleology was adopted as a heuristic by the teleomechanists (Lenoir, 1982); for Blumenbach, *Bildungstrieb* (vital force) was a teleological agent the cause of which, like Newton's gravity, was beyond the power of reason. However, the consequences of this organizing principle, like of those of gravity, were still amenable to scientific inquiry (Lenoir, 1980). Thus, teleology was an extremely useful concept for the development of several biological disciplines in the late 18th and the 19th centuries.

Several historians, philosophers and biologists addressed the overall changes in the practice and conceptualization of biological phenomena that took place in the 20th century (Mayr, 1996; Gilbert and Sarkar, 2000). One of them, Lenny Moss, described a turning point, "the phylogenetic turn"; which changed the perception of the organism. In Moss' own words, "the theater of adaptation changed from that of individual life histories, that is, ontogenies, to that of populations over multiple generations, that is, phylogenies." Moss' phylogenetic turn imposes a choice "… between a theory of life which locates the agency for the acquisition of adapted form in ontogeny—that is, in some theory of epigenesis versus a view that expels all manner of adaptive agency from within the organism and relocates it in an external force—or as Daniel Dennett (Dennett, 1995) prefers to say, an algorithm called 'natural selection'" (Moss, 2003). Because of this change, agency, normativity and individuation, hitherto considered the main characteristics of the living, almost disappeared from biological language. Since then, cells and organisms became passive recipients of a program. As a consequence, it is not surprising that biology has a theory of evolution but not a theory of organisms.

In spite of the strong impact of the teleomechanists, their perspective was not universally accepted; in fact, two competing currents emerged regarding biological thinking. Their main difference was whether or not there were singularities of the living that required a different outlook than that used in mechanics. The 200 year old dispute between these two stances continued well into the 20th century as a polarization between reductionists and organicists, although the latter moved from the mechanical worldview to one inspired by the mathematical theories of information (Longo et al., 2012). Indeed, the introduction of the notion of "program" [Perret & Longo, 2016, and (Longo et al., 2012)] was greeted as a sound theoretical way to get rid of the concept of "teleology" (Mayr, 1996). However, the adoption of the metaphors and the powerful tools conceived and used by the reductionists blurred the distance between the two currents (Perret & Longo, 2016, and (Longo et al., 2012). The current state of affairs is that even those that consider themselves organicists are for the most part using the pervasive language of molecular biology, a language that forces causative power into molecules, and in particular, to genes. Nowadays, the main difference between reductionists and organicists is that the latter are keenly aware that, when they practice analytical reductionism, they may be destroying the very phenomena that they are trying to understand.

In addition to the conceptual problems generated by the phylogenetic turn and the molecular biology revolution, the availability of immensely large databases has been greeted by the