proceedings

MDPI

Abstract

Information and Intelligence in the Living Cell: A Fundamental Hiatus for Information Science? †

Pedro C. Marijuan * and Raquel del Moral

Aragon Institute of Health Sciences (IACS)—Foundation IIS Aragón, Zaragoza, Spain; rdelmoral.iacs@aragon.es

* Correspondence: pcmarijuan.iacs@aragon.es

† Presented at the IS4SI 2017 Summit DIGITALISATION FOR A SUSTAINABLE SOCIETY, Gothenburg, Sweden, 12–16 June 2017.

Published: 9 June 2017

The new panorama that computers and the new technologies have opened on the entire molecular processes of life, from bioinformatics to "omic" disciplines, and from systems biology to signaling science (to name but a few of the new bioinformational fields), have not cohered yet into a consistent informational scheme or new theory of the cell, so that further high-level characteristics such as meaning, fitness, complexity, and intelligence—closely related to the adaptive relationship with the environment—cannot be consistently approached. Rather, a spattering of dozens of specialized disciplines scarcely interconnected are dealing with multiple partial aspects. Subsequently, explaining the emergence of astonishing integrative inventions related to multicellularity, e.g., the origins of nervous systems and the further development of neuronal complexity, is left in the shadow.

An essential problem at the very root of today's amazing accumulation of biomolecular data revolves around the absence of adequate conceptualizations on the LIFE CYCLE as the generalized source and sink of the information flows exchanged by the living system. Herein, leaving aside the specific matters related to the inner cellular informational dynamics, we will focus on the relationships between the advancing life cycle of the cell and the information flows of the environment.

What are the general conditions to advance a life cycle in the simplest cell? As an open self-producing system, a great variety of inputs and outputs are necessary (even for the simplest prokaryotes) not only consisting of matter and energy flows but also involving information flows. Our analysis herein will involve two basic aspects. On the one side, the structure of the prokaryotic signaling system itself, with all its variety of environmental signals and component pathways (what has been called the 1-2-3 Component Systems), including the role of a few second messengers which have been pointed out in bacteria too. And in the other side, the gene transcription system as depending not only on signaling inputs but also on a diversity of inner factors: from metabolic products, to sigma factors, to house-keeping systems, to channels and transporters, etc. Actually, in spite of this remarkable degree of complexity, the gene expression system of bacteria is highly systematic in its hierarchic organization and has been compared to computer operating systems. So, there is room to explore the organized and systematic convergence of stimuli from different signaling paths "encoding" integrated aspects of the environmental information flows. The specific life cycle of the bacterium will be the essential factor motivating the classes of convergence to be found.

In particular, if we want to ascertain the effect that a given signal or specific information flow produces, we must count the new molecular presences and absences derived from the gene expression consequences of the signaling event. The meaning of a particular signal is thus established through "molecular mining". But there is no fixed reference there: the life cycle itself, in all its enormous multiplicity of possible 'moods' and trajectories, can only be established in retrospect, by

'freezing' it. At every instant we might look behind, we see that the reference that provides, generates, and fabricates the meaning has changed. The whole life cycle is but a temporal sequence of instantaneous meanings continuously churned out from the entire self-production processes and apparatuses of life. Looking from the angle of semiotic conventions, signals appear as compositional structures of the objects themselves, quite indistinguishable and inseparable from them and from the outer world as well; only with the advent of quorum signals and inter-species communication, we may partially distinguish between signals that denote the presence of a very important 'animate' object. As for the subjects, they appear themselves as life cycles in progress, and only that which pertains to the advancement of the life cycle has been evolutionarily incorporated as being part of the subjects' own communication and energy flows.

We have briefly examined the connection of the life cycle with meaning, and similarly we could advance the interconnection with intelligence, complexity, fitness... Some of this work has already been started by the present author (Marijuán et al., 2011, 2013, 2015); but there is a long way ahead. In the opinion of this author, the lack of adequate connection with the life cycle represents a fundamental hiatus in our conceptions around biological information and its correlate of biological or natural intelligence, and all the other associated concepts. Seemingly, without a meaningful interconnection with the life cycle, the further relationships with the information approaches of the physical and computational realms, as well as with the miscellany of humanities' fields, cannot be worked out properly.