

Book Review

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Information and Living Systems: Philosophical and Scientific Perspectives. G. Terzis and R. Arp (Eds.). (2011, MIT Press.) \$50.

In his seminal and pioneering work on the social context of science, Ludwick Fleck [2] argues that ideas acquire “magical power” simply by being used. “Information” is a concept that has acquired magical power despite the fact that its specific context of use—Shannon’s theory of communication—was far removed from various fields in which it has been applied, such as biology. In retrospect, one cannot separate the magical power information has acquired from the revolutionary success of information technology and its widespread use. Nevertheless, the meaning of information and its relevance as an organizing concept for other fields of inquiry, such as biology, is far from clear. In this context, examining the meaning and role of information in living systems is a welcomed venture.

The current book has 13 chapters organized around (1) the definition of life, (2) information and biological organization, and (3) information and the biology of cognition, value, and language. As it is impossible to review all the chapters, I have focused on three representative examples that reflect my personal interest.

The opening chapter by Ruiz-Mirazo and Moreno deals with the definition of life. The authors criticize the reductionist approach, arguing that it overshadowed the “idea that there is something else relevant for biology to do, namely to explain the complex dynamic *integration* of those components into functional units.” This awareness is clearly in line with the non-reductionist and systemic approach to biology (e.g., [1, 5, 7]). In this context, what should a definition of life look like? That is a tricky issue, as I have recently argued in response to a novel definition [6]. The authors are well aware of the difficulty in dealing with a definition of life. Interestingly, they suggest that in order to define life, what matters “is determining the set of enabling constraints on the physical and chemical laws.” This proposal clearly echoes Michael Polanyi’s seminal article and avoids the essentialist fallacy they criticize. Here we get into the authors’ tentative definition of life, which involves two interacting and complementary levels of analysis: the individual autonomous agent and the meta-network of these agents, which generate information that is fed back and forth between the levels. This idea echoes Gregory Bateson’s idea of a *recursive hierarchy* [3] and his idea of information as a relational construct. The challenge facing the authors in defining life along these lines is to identify the precise nature of the constraints operating on living systems and to discuss them in terms of information in order to better describe their role in constituting the organization of living systems and their landscape of potential complexity.

In the second part of the book, Queiroz, Emmeche, Kull, and El-Hani present the biosemiotic approach to biology. The appearance of a chapter dealing with biosemiotics in a book dedicated to information is far from trivial. From the perspective of information theory, living systems are just one concrete realization of a Turing machine that processes strings of letters. For the semiotician, in contrast, the basic unit of analysis is the *sign* that has a totally different sense from a bit. From the biosemiotic perspective (e.g., [4]), living systems process signs rather than information. The authors draw on a specific semiotic perspective, the one developed by Charles Sanders Peirce, to describe the genetic system and signal transduction in the immune system. They present the argument that the probabilistic measure of information is indifferent to meaning, whereas the way living systems make sense of signals is crucial for understanding their behavior. In contrast to information theory, the idea of meaning is built into Peirce’s triadic definition of the sign. According to this thesis, a sign, whether a biological sign or a linguistic sign, is a non-reducible triad composed of the sign, the signified, and the interpretant—the effect the sign produces on the interpreter. Applying this perspective to the genetic

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system, we learn that the process of sign use—semiosis—is actually information and that in the DNA we can find information only “in potency.” Genes are signs, but without their transcription and their translation into proteins, they have no meaning and hence no information value. This biosemiotic perspective has an appealing descriptive value. However, in order to present a serious alternative to the information theory perspective, biosemiotics, like bioinformatics, should provide rigorous evidence supporting its theoretical and explanatory value. Bioinformatics has already passed this test, while biosemiotics, as a young and radical venture, is still striving to establish itself as an appealing alternative for the working scientist.

The idea of constraints that we have already encountered in the first chapter returns in the third part of the book, in a chapter about information theory and perception written by Baddeley, Vincent, and Attewell. The authors suggest that early vision is amenable to study using information theory for several reasons, which include the amount of data gathered by researchers with regard to the process of early vision. The transmission of information from the eyes to the cortex involves several bottlenecks. Here the importance of constraints enters the picture, as “A system that is under severe constraints about how much information can be transmitted is more likely to be, in some sense, efficient” (p. 290). For instance, the image formed on the retina cannot be transmitted to the brain as it is. Therefore, the images transmitted to the brain are compressed, and this process of compression can be studied through information theory. Another constraint is the energy consumption of neurons in the brain. Therefore, the authors present a model that maximizes information transmission while minimizing energy consumption. The model they present and its empirical support are described as a “major breakthrough” in the study of vision. Indeed, this model is an excellent illustration of the way information theory may be used to model the behavior of living systems by taking into account real-world constraints.

The three chapters here presented as illustrative examples represent the way information is a relevant theoretical construct for the study of living systems, a construct that may be used to develop new conceptualization about big questions facing biology (e.g., the definition of life), that may be formulated in novel and radical ways (e.g., information as semiosis), and that may be used to model real-world constraints in order to better understand the behavior of living systems, as in the case of early vision.

In sum, this edited book introduces a polyphonic view of information and its relevance for understanding living systems, and therefore it is a promising venture.

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