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Evolution and transitions in complexity: the science of hierarchical organization in nature. By Gerard A. J. M. Jagers op Akkerhuis

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Evolution and Transitions in Complexity: The Science of Hierarchical Organization in Nature. Gerard A. J. M. Jagers op Akkerhuis. Springer, 2016. 295 pp., illus. \$159.00 (ISBN: 9783319438016 cloth).

Gerard Jagers op Akkerhuis is a biologist working at the University of Wageningen (the Alterra Institute), in the Netherlands, where he primarily researches animals in agricultural soils but also shares his fascination with thinkers working at the frontiers of physics, biology, and philosophy (Sir Arthur Koestler, Teilhard de Chardin, Bertrand Russell, among others). His book, written with 12 collaborators (biologists, physicists, and philosophers, from various countries), is the result of a long-standing endeavor to find a law in the “organization of nature,” according to the expression used in an enlightening foreword. From 1994 on, Jagers op Akkerhuis developed a conceptual system called the *operator hierarchy* allowing us to view nature (a concept encompassing all scales of the whole universe) as a ladder, with rungs of increasing complexity from quarks to neural networks, which he considers “increasing perfection.” Although I am personally reticent about defining perfection (a human-sided view, strongly endowed with religious belief) as the main target of “nature,” I must admit that I have been fascinated by the wealth of knowledge (from theoretical physics to artificial intelligence, passing by molecular biology and physiology) Jagers op Akkerhuis embraced for buttressing his arguments. Therefore, we cannot brush aside this persevering effort to clarify intriguing processes such as the emergence of life or the appearance of atoms from particle soaps. How many scientists were engaged in such Sisyphean tasks? Charles Darwin himself, the high priest of evolutionary biology, tried to understand why and how organisms were “evolving” and was celebrated for that.

The concept of hierarchy, with *operator theory* (or *O-theory*) as tool for understanding it, is developed in the first two introductory chapters. The basic principle is simple. Closure is the general criterion used for the hierarchical ranking of systems. After its closure, a system becomes a stable unit that can in turn be included in a higher ranking system, and so on. Functional and structural closures (called dual closures, both objects and interaction systems) are familiar to the biologist: DNA molecules, proteins, plastids, cells, and multicellular

organisms are examples of dual closures. How closure happens is a more complicated process that is based on interaction chains and hypercycles, which is clearly explained along several chapters written by Jagers op Akkerhuis himself and the one written by Henk Barendregt, a mathematician. One may regret that the relationship between *closure* and *emergence* (a concept more familiar to most scientists and philosophers of science) was neither explained nor discussed, even if the term emergence appears repeatedly in the course of the lecture.

In a collaborative chapter, written by Jagers op Akkerhuis and two Dutch colleagues, Darwinian evolution is revisited in the light of more recent knowledge, and in particular of epigenetics, niche construction theory, and horizontal DNA transfers, which all challenge selection as the driving force of evolution. Clearly, it is highly pleasant to see (the first time for me) that the term *change* is preferred to *evolution*, which gets rid of the human-oriented sense too often given to Darwinian evolution. A conceptual approach of Darwinian evolution, in the form of graph patterns, is to be preferred to the population approach, which has been so abusively popularized by Darwin's disciples as a measure of evolution. From the perspective of operator theory, levels of selection are no longer populations, but rather, they are the interactions among individual organisms and with their environment. Even though it is not explicitly stated in this chapter, it means, at least in my opinion, that ecology is the focus of evolution, and ecosystems the units of selection. This seminal contribution to evolutionary biology is followed by a chapter written by two other Dutch scientists who challenge Jagers op Akkerhuis's views about Darwinian evolution. It is highly pleasing, and quite uncommon, to see a scientific debate about a novel approach included in the book that introduces it.

The object-based graph-pattern approach is the subject of the next chapter, which places Darwinian evolution in a more general context, from atoms to cultural networks, called *General Darwinism*. The chapter also responds to some of the defects highlighted in the previous chapter. In particular, Jagers op Akkerhuis explains how Darwinian evolution at the smallest scale explains the appearance of sexual reproduction. In turn, this generalization is challenged by Thomas Reydon, a philosopher of science, in the following chapter. He compares General Darwinism, here proposed by Jagers op Akkerhuis to embrace all aspects and scales of the universe, with Dawkins's Universal Darwinism (Dawkins 1983); the latter author cautioned against seeing Darwinian evolution everywhere. Even though the matter is challenging for a novice, the main argument of Reydon's criticism of General Darwinism is

that its proponents have not proved convincingly that entities present in the living world (reproduction, selection, interactions), on which Darwinian evolution is based, are also present in nonbiological domains.

The following chapters are more specialized and embrace several problems, such as transitions that lead to the formation of different kinds of organisms, demarcation against gradualism, operator theory versus Maynard Smith's major evolutionary transitions theory, defining life, and thermodynamics in the emergence of self-organization. The book closes with a merry-go-round ride around all aspects discussed in the previous chapters, followed by a short bibliography of the book's contributors.

As such, the book seems to be a major contribution to the warm debates about self-organization and evolution. Operator theory, which opens new avenues for our understanding of the creation of the universe, including the emergence of life, is clearly explained, with numerous examples taken from various disciplines, and it seems a promising tool for the intended fusion of physics and biology. The constant reference to Charles Darwin is somewhat irritating, and we may hope that, in a near future, Jagers op Akkerhuis will successfully "kill the father" in favor of his own line of reasoning.

Reference cited

Dawkins R. 1983. Universal Darwinism. Pages 403–425 in Bendall DS, ed. *Evolution from Molecules to Men*. Cambridge University Press.

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