Autopoiesis: A Concept With Even More Far-Reaching Consequences for Evolutionary Theory

Jörg Räwel
Kazimieras Simonavičius University, Lithuania
joerg.raewel/at/gmail.com

> Abstract • I appreciate the consistency in Mpodozis's theoretical approach. However, by assuming that autopoiesis can only be applied to the molecular mode of operation of organisms, he fails to exploit the potential of autopoiesis for elucidating evolutionary theory.

« 1 » From a constructivist perspective, i.e., one that always considers not only what is observed but also the observer, we discern at least two angles for observing the relationship between theories and the reality they construct. In a realist context, scholars are determined to know whether theories reconstruct an alleged mind-independent reality adequately – or, at least, plausibly. Here, however, I am posing a different perspective, namely: What is the nature of the reality that Jorge Mpodozis's "minimal theory" constructs? From Mpodozis's target article I deduce that the reality it constructs refers to the time before the evolutionary development of sexual reproduction and eukaryotic life took place. Mpodozis does not take into account the implications various forms of reproduction have. It makes no difference, according to Mpodozis, that in prokaryotic reproduction (by "cloning") structures are varied randomly (for instance by mutations or horizontal gene transfer), whereas in eukaryotic life, structures are varied in *each* generation by genetic recombination. According to Mpodozis, the evolutionary development of (prokaryotic) life is to be understood exclusively in the sense of structural change by means of *molecular* operations maintaining individual autopoietic systems as organisms or "living being[s]" (§14). In his view, reproduction does not function as a (meta-) form of autopoietic operation, but merely represents a "fracture" in the autopoietic continuance of organisms: "In general terms, reproduction involves a structural fracture of a living being (the parental one), as a result of which a new living being (the offspring) arises" (§19). This theory thus plausibly and consistently describes the evolution of prokaryotic life, but cannot accurately explain the origin of species and the emergence of species in the sense of the biological species concept.[1] Considering the observer in her observations, it follows that the theory cannot include the current state of evolutionarily developed life: Neither Mpodozis's theory nor my commentary on it, namely as constructions in the *social-evolutionary* emerging functional system of science, could be constructed or reconstructed on the state of prokaryotic life. In other words, Mpodozis's theory of natural drift grounded exclusively in molecular structures could not explain how we are now able to write about evolution.

« 2 » According to Mpodozis, the potential of evolutionary change is exclusively tied to individual organisms' capacity for structural change in maintaining their autopoiesis, be it as ontogenic structural drift (§13ff) or as phylogenic drift (§33). This has the effect of distorting the meaning of the term "structure." He states: "Autopoietic systems are constituted by processes, that is, flows of molecular transformations. Therefore, they are in *continuous structural change*" (§5, my emphasis). According to this understanding, the resistance to change that is essential to the meaning of the concept of structure is lost. Without at least a rudimentary resistance of structures to change, structures would not be distinguishable as structures at all. Thus, as an example of a social structure, the expectation that plagiarism is unacceptable in science is maintained even in the face of unmet expectations that can be understood as impetuses for structural change. In this sense, the notion of "continuous structural change" appears as a logical contradiction. The distortion of the understanding of the term arises because Mpodozis's proposal places the total burden of evolutionarily possible change exclusively on structural changes within individual organisms.

« 3 » Contrary to what Mpodozis assumes, a "continuous change" does not occur on the level of *structures* but on the level of *operations* of autopoietic systems. Since Mpodozis locates autopoiesis exclusively on the level of molecularly operating systems, there is no need for him to distinguish between operations and structures of autopoietic systems. This is the reason why he can hold on to the logically inconsistent theoretical construction of a "continuous structural change." Only when the concept of autopoiesis is applied to other than merely molecular operations, does it become readily evident that a distinction has to be made between the operations and the structures of autopoietic systems. For example, Niklas Luhmann (1995) suggested a distinction between communication as an autopoietic operation of social systems on the one hand, and their structures such as the above-mentioned resistance to plagiarism on the other hand. In Räwel (2020), I suggested a distinction between sexual reproduction as an operation in maintenance of autopoiesis of biological species on the one hand, and individual organisms as their structures on the other hand.

« 4 » Mpodozis's theory is limited to a single factor, "natural drift," to explain the emergence of evolutionary complexity, while other factors, such as changes in the operational form of autopoiesis, are not considered. While such changes could be accounted for in terms of natural drift, this means that, by implication, Mpodozis ultimately leaves the explanation of the emergence of evolutionary complexity to a single factor, i.e., time. So, to come back to the point I made at the end of §1 Mpodozis's theory could not account for the complexity in social evolution that now allows scientific articles to be written. It remains unclear how natural drift can explain various forms of evolutionary phenomena, such as long periods of stability of organisms, as far as the world of prokaryotes is concerned, or periods of comparatively rapid change of eukaryotic life, as in the so-called "Cambrian explosion."[2] Here the question arises: How can these examples of various forms of evolutionary phenomena be explained merely by the concept of "natural drift"? Q1

« 5 » Mpodozi's focus on only one form of autopoiesis (concerning "living beings")

1| "*Species are groups of interbreeding natural populations that are reproductively isolated from other such groups*" (Mayr 1969: 314, emphasis in the original).

2| In Räwel (2020: Section 4.7), I describe the circumstances under which an accelerated emergence of species is possible.

leads him to consider evolutionary developments only unilaterally in terms of *similarities*. The focus on similarities becomes especially clear when he seeks to emphasize functional equivalence in the existence of living beings by referring to "alligatoring," "humanning" (§18), "ducking" or "chickening" (§36). To such metaphors we could certainly add "bacteriuming." However, to grasp the complexity of evolutionary developments, we must *also* address their *differences*; for example, the difference between a "humanning," which enables us to write scientific articles, and a "bacteriuming" or "alligatoring," which manifestly does not. However, explaining this difference requires an acknowledgement of *different operative forms* of autopoiesis, e.g., communication (Luhmann 1995) or reproduction (Räwel 2020). Mpodozis's proposal does not account for this. He addresses the differences between different forms of life merely by using different verbalizations ("chickening," "humanning," etc.). However, this approach, at least as a scientific explanation, hardly does justice to the complexity of the differences to be explained.

« 6 » Nevertheless, Mpodozis succeeds in elaborating central features of evolutionary change under the condition of autopoiesis of living systems. His observation that adaptation must be understood as a *premise* in the autopoiesis of living systems (§16c), already represents a paradigmatic difference to "[m]ainstream biological thinking" (§1). From the mainstream perspective, both in terms of modern synthesis and evo-devo, adaptation is understood as a *condition* (rather than a premise) for living organisms to exist at all. As a condition, adaptation is considered to be primarily responsible for evolutionary change in the sense of the selection of individual organisms ("natural selection"). From the mainstream perspective, adaptation of organisms is understood as a variable that is changed by different environmental conditions. However, due to the fundamental operative self-referentiality of autopoietic systems, environmental influences can affect these systems only in the sense of perturbations, but not in the sense of determinations. In this respect, I agree with Mpodozis that the change in the understanding of "adaptation" is an important consequence that arises from the concept of autopoiesis: autopoietic systems are "either adapted or they are not," (§16c) as Mpodozis states (see also §§8f, 28).[3]

« 7 » Humberto Maturana has repeatedly refused to apply the concept of autopoiesis to any process other than the molecular operation of individual organisms (e.g., Maturana 2014). Whether the application of autopoiesis in domains other than biology will prove fruitful is beyond the scope of discussion here.[4] In Mpodozis's case, his article illustrates that, for the discipline of (evolutionary) biology itself, limiting the applicability of the concept of autopoiesis to *molecular operations* is unsatisfactory. He fails to exploit the potential of this concept in specifically allowing evolutionary changes – not least the emergence of species according to the concept of biological species itself (Räwel 2020) – to be explained in a more differentiated way. As a scientific explanation, in this context, merely referring to the assessments of taxonomists is insufficient (§24). We should not assume that taxonomists themselves are (external) observers but must consider them as a phenomenon itself also requiring explanation in (social) evolutionary terms.

« 8 » This leads to the following question: What is the argument against understanding the classification "species" as an autopoietic system whose structural elements are its individual organisms? Q2 After all, sexual reproduction can be understood as an autopoietic operation, because (a) sexual reproduction recursively maintains sexual reproduction, and (b) species are operationally closed since they can only operate in relation to their own species. At this juncture, I would like to point out that the unity of an autopoietic system results only from its continuous differentiation from its environment by means of its self-referential operations (§6). To reify the boundaries of autopoietic systems, for instance, to argue that autopoietic systems, in contrast to biological species, have a "membrane," would be an adequate explanation only from the perspective of an ontological realism. The definition of autopoietic systems does not determine the form of the operations by which they recursively close themselves from their environment:

> "[Autopoietic systems] are systems that are defined as unities as networks of productions of components that (1) recursively, through their interactions, generate and realize the network that produces them; and (2) constitute, in the space in which they exist, the boundaries of this network as components that participate in the realization of the network." (Maturana 1981: 21f)

« 9 » What is crucial is that autopoietic systems close themselves off from their environment by means of *recursive operations* and achieve organizational autonomy exactly in this way. Maturana's definition of autopoiesis allows, at least in principle, that operations apart from molecular processes, such as sexual reproduction, can also constitute autopoietic systems. Whether this can be done successfully or fruitfully cannot be determined in advance. Rather, if we understand communication also as a possible form of autopoietic operation, this is the subject of discussing autopoietic reproduction or evolution within the social system of science.

« 10 » I agree with Mpodozis (§37) that being ignored is certainly something one encounters when trying to establish a new perspective or paradigm. However, a new perspective has to demonstrate that it can cope better than (or at least differently from) established theories with problems – with "puzzles" in the Kuhnian sense. The new perspective should be able to deal with the "puzzle" of differentiated forms of evolutionary change, such as the "Cambrian explosion," or the "puzzle" of the emergence or effects of forms of reproduction that ensures intergenerational variation in the structures of living systems (through genetic recombination by sexuality).

3| See Räwel (2017) for an analysis of the consequences for biotic and social evolution associated with the *necessary presupposed* adaptation of autopoietic systems.

4| For a discussion of the applicability to sociology (Luhmann 1995), see Urrestarazu (2014), Cadenas & Arnold-Cathalifaud (2015), and the related open peer commentaries, including Maturana (2014, 2015).

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Jörg Räwel is a sociologist. His current research interests are the application of evolutionary theories in the social sciences, the development of social media communication theories, and the study of social change through the "digitalization" of society. He is a Research Fellow at the Next Society Institute at Kazimieras Simonavičius University in Vilnius. His most recent publication is: *Die nächste Gesellschaft: Soziale Evolution durch Digitalisierung* [*The next society: Social evolution through digitization*] (2022). https://independent.academia.edu/JörgRäwel

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Is Natural Drift a Mechanism?

Sergio Rubin
Université Catholique de Louvain, Belgium
sergio.rubin/at/uclouvain.be

> Abstract • In its current formulation, natural drift, despite being non-adaptationist, apparently follows the machine metaphor. I scrutinize the notion of machines on the basis of the four Aristotelian causes and argue that, following Rosen's work, living systems are causal systems but not mechanisms and, therefore, not "machines." This leads to the question as to whether natural drift is a blind and reactive mechanism or whether it entails anticipation in the sense that organisms are able to distinguish the potential effects of their actions on their environment. This aspect has a bearing on the question of whether natural drift can account for the origin of Earth's habitability.

« 1 » The natural drift theory of evolution is not formulated as transcendentally explanatory of a reality or environment independent of organisms' actions. Neither does it explain evolution as guided by the unfolding of an informational genomic program shaped by natural selection and random mutations (teleonomy), nor by internal or external teleological agents. Furthermore, natural drift is not a revisionist theory of the modern synthesis of evolution either, nor does it belong to the extended evolutionary synthesis (as presented in Pigliucci & Müller 2010).

« 2 » Different from modern and extended synthesis, which assume that all traits are adaptations,[1] natural drift explains that all traits of organisms have evolved through the conservation and change of ontogenetic phenotypes, which are determined by behavior rather than genetics (Maturana & Varela 1984; Varela, Thompson & Rosch 1991: Ch. 9; Maturana & Mpodozis 1992, 2000). As such it is worthwhile casting a critical eye on its explanatory premises.

« 3 » Natural drift starts from the characterization of living beings as autopoietic systems.[2] This implies that living beings are autonomous and therefore their evolution depends not on adaptation, but on their way of living their epigenetic pathways in structural coupling with their environment. Following Humberto Maturana and Francisco Varela (1973), Jorge Mpodozis suggests that autopoietic systems are "machine[s]" (§3). By "machine" I understand that he did not mean an artefact but, rather, a self-producing system whose operation is determined by its structure, i.e., a system that embodies *causality*.

« 4 » For the precision that natural drift deserves, I will first clarify the "machine metaphor" in relation to causal embodiments of autopoiesis, and thus natural drift. Then I will discuss the implications that the concept of natural drift could have for the origin of Earth's habitability.

« 5 » Originally from Descartes, the machine metaphor has its mathematical foundation in Newtonian mechanics. The metaphor is meant to respond to the question of how natural systems undergo change from a unique perspective of causation. It claims that the causality of *all* natural systems is a mechanism of *state transition sequences*, which are the function of only past and present rather than *future* states. The machine metaphor can be traced back to three of the four Aristotelian causes, since the material (initial conditions), efficient (dynamical equations) and formal causes (parameters) are treated *independently* of one another, and only the final cause is entirely excluded from the system description.

1| The view that all traits are adaptations has been criticized and categorized by Stephen Jay Gould and Richard Lewontin (1979) as the adaptationist program.

2| According to Aloisius Louie, a system is "a collection of material or immaterial things that comprise one's subject of study. When the 'subject of study' is in the world of sensory phenomena with their causal entailment, the system is called a natural system. When the object of study is the world of ideas with their inferential entailment expressed in some language, the system is called a formal system" (Louie 2020: 2). The natural system that Louie refers to corresponds to what Mpodozis affirms in his Footnote 1 (as what is proper to a system).