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CONSTRUCTING A NICHE: BETWEEN EPISTEMOLOGICAL EXPANSIONS AND DISTORTIONS

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A review of the book

Niche Construction: How Life Contributes to Its Own Evolution

By John Odling-Smee, 2024.
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¿Los pájaros anuncian la mañana? ¿O cantando la hacen?
Eduardo Galeano, *Bocas del Tiempo*

Life delineates the dimensions that are relevant to its own evolution. Partly, this is because biological history and activity create contingencies that influence the likelihood of different evolutionary trajectories being taken (Majic, 2022). But life also impacts its own evolution because the niches within which species evolve are constructed by organisms themselves (Levins & Lewontin, 1985). Such "construction" can be understood from two non-mutually exclusive perspectives. From the perspective of the **fundamental niche**, organisms construct their own niches because the “n-dimensional hypervolume" of ecological conditions that a species can potentially inhabit is defined by the biological traits of those organisms. In other words, the different structures and functions of organisms determine the environmental variables that are relevant for the persistence of a lineage (e.g., light is not a niche dimension of the almost eyeless dolphins living in the murky waters of the Ganges). Under this view, life constructs its niches by *evolving new ways of interacting with* its external physical environment. In contrast, from the perspective of the **realized niche**, life constructs its niches *by actively modifying* its external physical reality. Organisms are capable of altering their environments through their activities (e.g. the building of nests or even the release of metabolic byproducts),

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thereby exerting an active influence in shaping their realized niches. In this view, organisms do not just adapt to their environments—they actively transform them.

In the context of the realized niche perspective on how life influences its own evolution, the so-called **Niche Construction Theory** (NCT) proposes that the alteration of environments by organisms is a central concept in evolution. Rather than being passive responders to environmental changes, species shape their own selective environments through these actions. The evolutionary implications of similar ideas have been recognized for some time, with Waddington (1957), for example, noting how organisms influence their selective pressures through habitat choices and modifications. More recently, there has been a push to formalize niche construction as a theory of evolution. In his book *Niche Construction: How Life Contributes to Its Own Evolution*, John Odling-Smee reviews some key concepts of this formalization, a process in which he has been actively involved over the past few decades (Laland et al., 2015; Odling-Smee et al., 1996; Odling-Smee, 2010). Emphasizing niche construction, he argues that evolutionary theory should go beyond merely describing how populations respond to environmental changes. Instead, it should adopt a framework where organisms and environments co-evolve. This book seeks to expand upon the formalization of NCT by generalizing its concepts and proposing a step towards a "universal theory of evolution" that is broader and more inclusive than what Odling-Smee calls the "standard evolutionary theory" (SET).

To introduce his thesis, Odling-Smee begins with an overview of thermodynamics and information theory. The first two chapters recount the familiar narratives of Maxwell's demon, Schrödinger's *What is Life?*, Shannon's information theory, and Ashby's control theory. These chapters read somewhat like a biologist's summary of James Gleick's recount of the history of information theory in his book *The Information* (2011)—a sentiment I can relate to from my own experience as a biologist reading Gleick's work. While these chapters may seem redundant for readers already familiar with the history and core ideas of information theory, they are crucial for setting the stage for the first of the two parts of the book, which aims to lay the foundations for an evolutionary framework grounded in thermodynamics and information theory. Despite my reservations about physicalist approaches to biology, Odling-Smee offers some thought-provoking conceptual contributions, particularly in his clear distinction between physical resources (*Rp*) and informational resources (*Ri*) in evolution.

Physical resources, *Rp*, are the energy and matter an organism needs to maintain their "improbable existence" in light of the second law of thermodynamics. In contrast, *Ri* refers to the "adaptive know- how" that interprets what is meaningful in the environment and thus enables an organism to extract the necessary *Rp* from that environment. *Ri* may be a product of evolution in the shape of genetic information that has been selected, but *Ri* can also extend beyond genetic "know-how" to include other forms of knowledge acquisition, such as development, learning, and culture. Because of the way in which *Ri* is defined, it can change not only due to changes within organisms but also in response to environmental shifts. When the environment changes, what is meaningful for an organism—and thus its *Ri*—can also shift. A key point in this context is that because organisms can shape their environment, *Ri* not only changes because of changes in organisms but also because of the coevolution between organisms and their environment.

This distinction between *Ri* and *Rp* represents a useful contribution for formalizing the discussion about different modes of inheritance and adaptive knowledge gain that could be relevant for evolution. Furthermore, many of the examples Odling-Smee uses to illustrate this utility offer interesting perspectives about topics such as the evolution of ecosystems and the origins of life. That said, I am not truly convinced by a core rhetorical narrative of the book,

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which concerns the inadequacies and counterproductivity Odling-Smee allocates to "standard evolutionary theory" (SET).

Throughout the book, Odling-Smee uses shortcomings he ascribes to SET to justify the relevance of his evolutionary perspective. In his description of SET, Odling-Smee refers to it as a causal model of adaptation in which "natural selection sorts among phenotypes of varying fitness in the current generation of populations" (pp. 69). Throughout the book, SET is described to be composed by concepts such as: i) the directionality of evolution as being *exclusively* given by natural selection, ii) genetic inheritance being the *only* inheritance system that is evolutionarily relevant, iii) random mutations as the *only* source of variation, and iv) phenotypes as mere "survival machines" for genes. Furthermore, more closely relating to his main thesis, Odling-Smee brings up three other main reasons why SET is an unfit candidate to a "universal theory of evolution" (pp. 150-151). He argues that SET, "did not, and still does not, fully recognize the relevance of the laws of thermodynamics to biological evolution"; "SET also falls short by failing to acknowledge that organisms are purposeful systems"; and "SET fails to recognize that niche construction is an obligate feature of evolving organisms".

One epistemological issue I have with what Odling-Smee refers to as SET is that it does not seem to correspond to an actual conceptual framework or scientific community. Instead, it appears to be more of a generalized representation. As Hull (1988) notes, "Social groups and conceptual systems can be made to have essences only by means of distortions of the most extreme sort." As such, I don't believe SET, as Odling-Smee presents it, accurately represents an actual cohesive theory, or if it does, its presentation is somewhat oversimplified. The concepts Odling-Smee ascribes to SET are often framed in categorical extremes, such as "exclusively" or "only," and the theory is frequently portrayed as a unified set of interlocking axioms. However, while these ideas may indeed be part of the evolutionary biology lexicon[1], they are not fixed or monolithic. Instead, they are more modular and flexible, capable of being independently accepted, refuted, or reinterpreted in different contexts. Among the architects of the Modern Synthesis, for instance, there were drastically different ideas about key premises (Plutynski et al., 2016). Even in regard to niche construction theory, Ernst Mayr, a major figure of what could be considered to be orthodox evolutionism, stated that "The selective pressure in favour of the structural modification is greatly increased by a shift to a new ecological niche, by the acquisition of a new habit, or by both" (as cited in Corning et al. (2023)). A perspective that anticipates key notions later articulated by Lewontin (1983) about how organisms act as both objects and subjects of their own evolution—an idea that Odling-Smee himself acknowledges as a precursor of niche construction theory.

Furthermore, I would argue against the perception that the concepts ascribed to SET have held back biologists as Odling-Smee claims (pp. 223, 288). Quite the contrary, I would argue that research within the framework of these concepts may have dialectically promoted conceptual advances such as why it is necessary to account for neutrality at the molecular level (Jensen et al., 2019), why regulatory evolution is of major importance for phenotypic evolution (Prud'homme et al., 2007), and how microevolution and macroevolution can be reconciled (Rolland et al., 2023). Not to mention that, as Odling-Smee discusses, there is a growing body of studies opposing the categorical concepts he ascribes to SET. Such as studies showing how evolutionary directionality can be given by sources other than selection (Cano &

[1] Whether each of these concepts represent a lexical element in the active paradigms of evolutionary theory would merit a discussion of their own. For example, I do think that thermodynamic principles are at the core of any Darwinian argument that recognizes that variation can be selected because of how limited resources are, and, while I agree that modifications of the environment by organisms is an inevitable feature of life, I would argue that the evolutionary relevance of such modifications is a question of relative importance.

Payne, 2020; Harms & Thornton, 2014; Herrera-Álvarez et al., 2025; Merlin, 2016), how different inheritance systems can be evolutionarily relevant (Jablonka & Lamb, 2005), how selectable variation can stem from non-genetic causes (Price et al., 2003) and how organisms are more than mere survival machines for genes (Majic et al., 2022; Majic et al., 2025). I would therefore argue that the premises of SET have independently fueled discussions in the community of biologists for over seven decades, rather than stalled the development of evolutionary biology.

Overall, I believe the book has many merits, particularly in offering a summary of the lexical tools related to the *Rp* and *Ri* distinctions. The discussion on how organisms and environments co-evolve is also a timely contribution. Additionally, the book serves as a good introduction to questions about how life can define its own path—a topic that resonates with me personally (Majic, 2022). However, I also think that these tools need to be emphasized over the tired iconoclasm against classical paradigms. This issue extends beyond just this book; many proposals about extending the modern synthesis suffer from this same focus. In my view, expansions of scientific theories occur on their own right, driven by the historical development of conceptual frameworks. In this regard, I would be interested in a narrative that explores the historical development of ideas, concepts, and experiments relevant to understanding, for example, the evolutionary significance of niche construction. Such a narrative could more convincingly highlight the potential of these evolving conceptual schemes to shape future research.

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Paco Majic obtained his degree in Biology from Universidad de la República (Montevideo, Uruguay) specializing in Genetics and Evolution and with a strong focus on zoology and natural history. He carried out his Master's degree studies in the University of Tokyo, Japan. There he worked in the field of developmental biology investigating the regeneration of echinoderms from a molecular perspective. In 2022 Paco Majic received his doctoral degree from ETH Zurich in Switzerland. In his thesis, he discussed how the evolution of complex molecular mechanisms can facilitate the evolution of completely novel biochemical components, and how the ontological configuration of an organism can guide the evolutionary trajectories of its lineage. Currently, Paco Majic is a postdoctoral fellow at the EMBL in Heidelberg, Germany. There, he is carrying out his research combining experimental work on the fruit fly with evolutionary theory and a Bergsonian intuition. The core theme of his investigation is concerned with the ways in which phenotypic development can guide the evolutionary process.

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