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Niche Construction

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Niche construction is an evolutionary process by which organisms actively modify, or construct, aspects of their own environments and, in doing so, alter the natural selection pressures to which they are subject. Examples of niche construction can be found across all biological kingdoms and include activities such as nest building, nutrient cycling, farming, and food storage. Such activities can create systematic and directional changes to a population's *evolutionary niche*, defined as the sum of natural selection pressures to which the population is exposed. Thus, from a niche construction perspective, organisms are not passive objects of evolutionary forces such as natural selection but instead act as co-producers and modulators of these forces.

History

Ideas about the active role that species may play in their own evolution and in-depth studies of niche constructing organisms, such as beavers and coral species, date back to the 19th and 20th centuries (e.g., [Darwin, 1851](#); [Schrödinger, 1944](#); [Waddington, 1959](#)). More recently, the niche construction perspective was brought to greater prominence by evolutionary biologist Richard Lewontin.

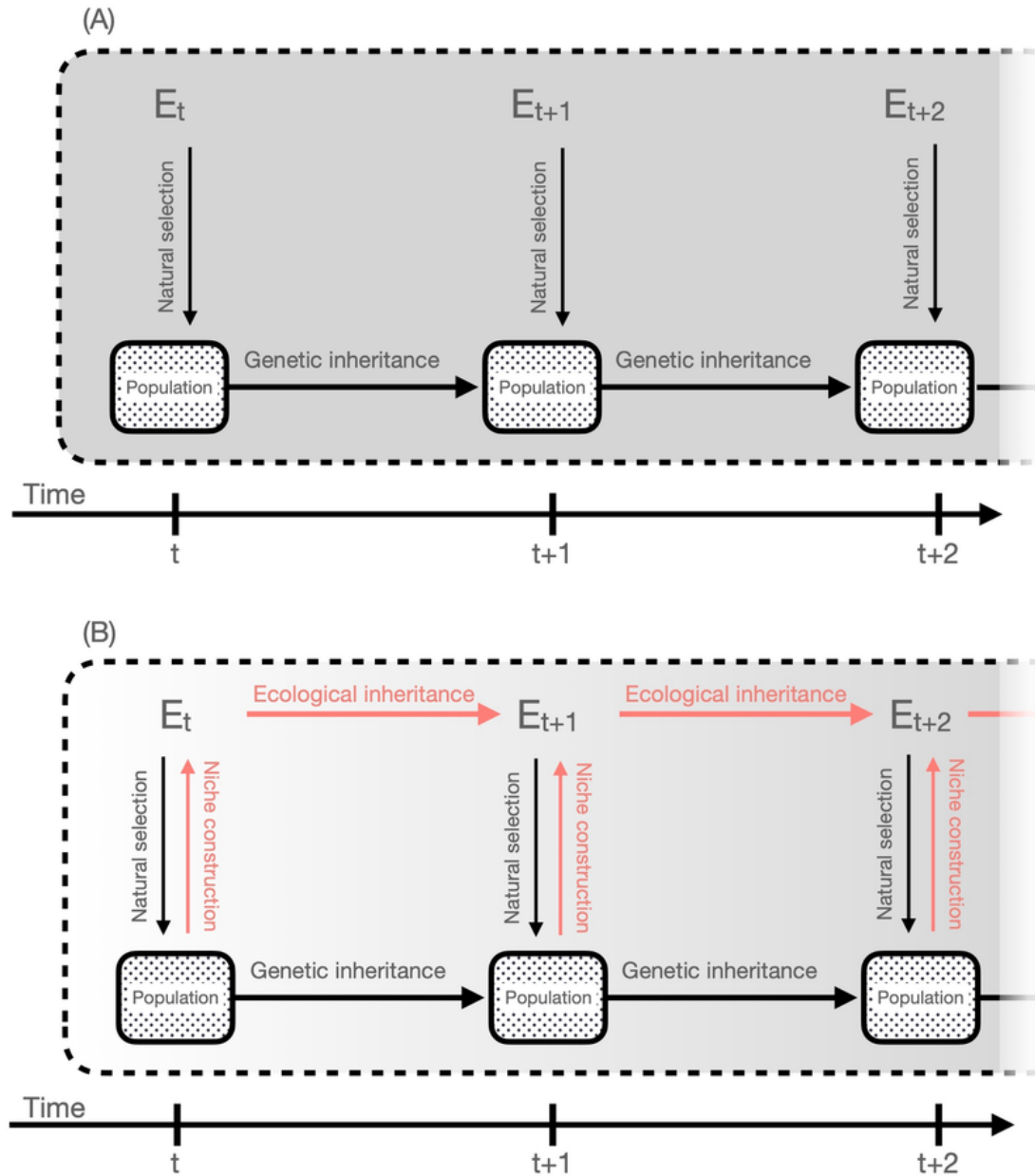
Lewontin was a vocal critic of *adaptationism* within standard evolutionary theory (e.g., [Gould & Lewontin, 1979](#)), which typically viewed adaptation as a process by which a population becomes better fitted to a relatively static prevailing environment ([Lawrence, 2005](#)). Lewontin and colleagues maintained that organisms do not simply adapt to existing, well-defined environmental conditions but rather create and construct those conditions themselves from what he described as “bits and pieces” of the external environment ([Lewontin, 1983](#)).

These ideas were first formalized by John Odling-Smee, Kevin Lala, and Marcus W. Feldman (e.g., [Laland et al., 1996, 1999](#); [Odling-Smee et al., 2003](#)). This work used mathematical models from population genetics to examine the effects of niche construction on evolutionary dynamics. These papers, and those subsequent, showed that niche construction could create new evolutionary equilibria, change the pace of evolutionary change, allow the spread and fixation of otherwise deleterious alleles ([Laland et al., 1999](#)), create complex cyclical dynamics ([Creanza & Feldman, 2014](#)), and facilitate the evolution of cooperation ([van Dyken & Wade, 2012](#)).

Many organisms make modifications to their environments that can persist or accumulate over long periods of time. Such persistent modifications might form part of the evolutionary niche of offspring generations, too—a result of niche construction known as ecological inheritance ([Odling-Smee, 1988](#)). Especially when its effects persist over generations, niche construction can become a significant force in evolution, contributing to adaptation ([Odling-Smee et al., 2003](#)), heritability ([Fogarty & Wade, 2022](#)), and parent–offspring similarity ([Bonduriansky, 2012](#)).

Core concepts

Feedback is at the core of the niche construction perspective, which brings the feedback between organisms, their environments, and their evolution to the fore. The difference between standard evolutionary theory and an evolutionary theory including niche construction can be seen in [Figure 1](#) (adapted from [Laland et al., 2000](#)). [Figure 1A](#) represents standard evolutionary theory, in which natural selection affects the population of genotypes. [Figure 1B](#) represents the niche construction perspective, in which natural selection plays the same role but there now exists feedback between the environment and the organism's gene pool alongside ecological inheritance (changes shown in red).

**Figure 1**

Panel A shows a schematic diagram of the standard evolutionary perspective in which a population of organisms (shown as small shaded squares) is affected by natural selection exerted by the environment in which they live (shown by a large shaded box). The organisms transmit genes between generations, for example, from time t to time $t + 1$. Panel B shows the niche construction perspective in which natural selection and genetic inheritance play the same role but there now exists feedback between the environment and the organism's gene pool and ecological inheritance (changes shown in red). Adapted from Laland et al. (2000).

The earthworm is a commonly cited example of a powerful niche constructor (see [Sultan, 2015](#), pages 103-104). Earthworms, like other annelids, are extremely susceptible to desiccation in dry environments.

How, then, can they survive on land? When burrowing through soil, earthworms alter the soil structure and leave behind a layer of mucus. These changes create a moist and nutrient-dense environment where the earthworm, even with its ostensibly aquatic physiology, can thrive. The point here is that, in many ways, earthworms have not adapted directly to a terrestrial environment. Rather, they have, through their own actions, adapted the environment to their own physiology.

Questions, controversies, and new developments

The idea of niche construction as an evolutionary process has been contentious. Standard evolutionary theory views adaptation as a one-way process in which species improve their fit to existing environmental conditions. Niche construction theory suggests that this is not typically the case and that, through their own actions, many organisms actively change their environments in ways that facilitate adaptation or change evolutionary dynamics in important ways, for example, by creating evolutionary feedback between organisms and their environments (see [Figure 1](#)). Although few researchers would argue that organisms do not actively change their environments, a great deal of controversy surrounds the evolutionary significance of such changes.

As a result, researchers in the field of evolutionary biology differ greatly in their opinions on whether processes such as niche construction (and also, to some extent, evolutionary developmental biology, epigenetic inheritance, and cultural inheritance) necessitate changes to existing evolutionary theory (see [Pigliucci & Müller, 2010](#), pages 3-18, for an accessible primer; [Uller & Laland, 2019](#)). Sharp debates on the topic can be found in the literature (e.g., [Laland et al., 2014](#)).

The evolutionary significance of niche construction, breadth of its applicability, and its status as an evolutionary process remain open theoretical and empirical questions. However, there exist many empirical examples and theoretical treatments of niche construction, which suggest significant evolutionary effects across a wide range of biological systems ([Odling-Smee et al., 2003](#)).

Broader connections

Niche construction theory is more broadly a part of evolutionary theory and overlaps with existing fields of study in ecology and evolution such as ecosystem engineering, population genetics, quantitative genetics, and indirect genetic effects.

Much work has focused on ecological niche construction, in which changes are made to ecological environmental conditions. A similar process, *cultural* niche construction [see [Animal Culture](#)], is thought to be particularly important in the study of human evolution and behavior. Human culture is pervasive and cumulative; both features make its effects on evolutionary change significant compared with those in other animals. Cultural niche construction occurs when cultural practices alter natural or cultural selective pressures. The response to such changes can either be genetic (in which case the system involves *gene culture coevolution*) or purely cultural ([Odling-Smee et al., 2003](#), page 338). Cultural niche construction

has been used as a framework to understand and address pressing human social issues (e.g., [Denton et al., 2023](#)) and questions about the cultural evolution of human social structure ([Fogarty et al., 2019](#)).

Cultural niche construction can link biological and cultural evolution and is of particular use in fields commonly concerned with human evolution and behavior such as archaeology, human behavioral ecology, anthropology, sociology, and psychology.

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