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How Does Architecture Affect the Evolution of Other Species?

As much as other species, humans modify the environment, affecting both the evolution of their own species and the evolution of others. Take a species that we happen to know quite a lot about: the German cockroach (*Blattella germanica*). One of 51 species of the genus *Blattella*, the German cockroach has become so specialized in the human-built environment that it is not known to occur anywhere else (Roth 1995). Recent studies have demonstrated that some populations of German cockroach have evolved an adaptive behavioral aversion to glucose in the poison baits set by apartment residents. In this essay, I explore how the spaces closest to us, our own buildings, affect the evolution of other species. I also discuss how the small spaces of human houses allow us to approach larger questions about the Anthropocene and how humans affect Earth itself. After all, no species exists in a vacuum (even the cockroaches we may vacuum up).

In "Evolution of the Indoor Biome" (Martin et al. 2015), my coauthors and I estimated that the human-constructed indoor biome—a formation of plants and animals that have common characteristics—occupies somewhere between 1.3 percent and 6 percent of global ice-free land area, an area as extensive as other small biomes such as flooded grasslands and tropical coniferous forests. Together with the German cockroach, thousands of species—perhaps hundreds of thousands—live in this large indoor biome, many of them preferentially or even obligately. In just one study of 40 houses in North Carolina, USA, researchers documented more than 8,000 bacterial and archaeal taxa (simple, single-celled organisms) (Dunn et al. 2013). And yet, we have studied only a small fraction of those species found indoors, mainly those we consider pests. Just as in rainforests, most taxa (microbes) of the indoor biome have yet to be discovered.

In preparing for this paper, I found myself thinking about how the niche construction framework maps onto recent efforts of environmental historians and anthropologists to study the role of nonhuman species or materials in history-making. One particularly influential framework for doing this has been "actor-network theory" (Latour 2005), which insists that human and nonhuman agency are to be treated on an equal footing. Many people object to the way actor-network theory employs agent similarity on the

Figure 1: Our homes, like this one in New Orleans, often provide pests with the perfect environment in which to flourish (courtesy of the author).

grounds that human actions are propelled by intentions, whereas those of machine tools or microbes are not. To address this concern, Andrew Pickering (1993) suggests that we turn our attention to the moments when human agency confronts the "contours of nonhuman agency." He conceptualizes this process as a dialectic of resistance and accommodation, "the struggle between the human and material realms in which each is interactively restructured with respect to the other."

The indoor biome challenges us to consider the roles of both humans and nonhumans in historical and evolutionary change and at the same time complicates the question of intention. Humans do intentionally build structures to differentiate indoor and outdoor environments, but they do not intend for species other than humans to inhabit them (with the exception of pets, some food animals, and sometimes plants). We do not build houses for the sake of cockroaches, or cellar spiders, or the molds that live on showerheads. And yet, these species occupy the places we build. They even evolve to live in them. In some cases, we notice these species and change our building practices; in others, we don't. Whether humans notice them or not, these species constitute our environment, too, and play their part in our own evolutionary trajectories. Physical and biological environments do much more than simply resist our intentions—as human niche construction suggests, these environments might even shape them—and yet, many environmental historians describe nonhuman actors, or nature, as simply "resisting" or "pushing back on" human activities. Similarly, science and technology studies (STS) scholars often focus on the resistance of the material world to human agency. What would it mean to write a history in which the environment is a collaborator rather than an obstacle?

The indoor biome challenges us to think beyond the limited metaphor of resistance. There is a poverty to the view that nature acts only by helping or hindering human action—resistance and accommodation are only the extremes of a spectrum. Nature does act, despite its lack of a human voice or political incorporation. The natural world and human culture exist in a relationship that exceeds a structure/agent relationship, as nature and culture are intertwined and are continuously constructed. The indoor biome is a human creation whose novel environment influences the ecology and the evolution of humans, but also hosts many other (overlooked) species that create their own novel environments. By combining actor-network theory's interest in carefully identifying how actor networks are continuously reshaped—which things interact with one another—and human niche construction theory's careful attention to describing evolutionary processes—i.e., which things influence each other's development—we can begin to decipher the puzzle that is history.

If ecology is the study of the relationships between organisms and environments, and evolutionary biology is the study of how organisms change over time, then how do we understand the relationship *among* organisms, environments, and evolution? Richard Lewontin's *The Triple Helix* (2000) is a particularly useful tool for thinking about this relationship, whether in the indoor biome or elsewhere. With this book, Lewontin unearthed a set of questions that had fallen between the cracks of disciplinary walls. The triple helix is Lewontin's symbolic rejection of the division between ecology and evolutionary biology. With this rejection, he complicates the linear narrative that genes determine organisms, which then adapt to their environments. The triple helix metaphor suggests that organism, environment, and evolution are three intertwined elements that must be studied together: geneticists may pull apart DNA's *double* helix to read

Figure 2: Creating indoor environments that reflect the outdoors—cacti viewed from inside a house in the Sonoran desert, Arizona (courtesy of the author).

its code, but we can only understand DNA's function by considering it whole, in action at multiple scales. Lewontin contends that organisms, influenced in their development by their surroundings, in turn change and even create the environments they live in.

Niche construction theory similarly explores these feedback actions and draws attention to historical processes. Through the metaphor of construction, organisms, including humans, shape their environments and, in part, their evolutionary trajectories. Niche construction theory is especially compelling because it specifically challenges the distinction between evolutionary causes and evolutionary effects. A human creates shelter by building a home, and that environment in turn exerts selective pressure on the human, say, by protecting it from extreme cold—but hurricanes still come through. This illustrates that while organisms create opportunities, such as shelter, in their worlds—or at least, some of them—they also have to adapt to selective pressures in the process, some of which are a result of their own actions and others which are beyond their control. What links the triple helix and niche construction is their common attempt to describe relationships that traditional academic boundaries have rendered invisible.

These relationships are the key to understanding both how architecture affects the evolution of other species and how, on a larger scale, human actions affect the earth itself. Unlike Lewontin's triple helix or niche construction theory, much scholarship on the recent concept of the Anthropocene still emphasizes its effects and overlooks the processes involved (but see Ellis 2015). Proponents of the term "Anthropocene" argue that we live in a geological age of our own making, an epoch that began at the moment when human activities started to have a significant global impact. They believe that the signature of human activity in sediments and ice cores justifies the distinction of an Anthropocene from the preceding geological epoch, the Holocene. Their overarching question is whether aluminum, concrete, and plastic "technofossils," or the detonation of thermonuclear weapons, will define our times. It is a question of the physical record of history, and not how that record was laid down. Consequently, those who seek to define the "age of humans" elide fundamental questions of human agency, equity, and responsibility. Not all humans equally participated in the development and detonation of thermonuclear weapons; the average human does not emit five metric tons of carbon per person per year—the average US American does. And even the average American is a statistical artifact, a technofossil, if you will, given that the distribution of resources in the United States is spectacularly skewed. In flattening the impact of humans, the Anthropocene provides absolution to some. But it fails to point to political solutions as it views history as a determined past and not a dynamic process. This is where niche construction theory, actor-network theory, and other process-oriented methods have much to offer Anthropocene studies.

Studying the influence of the human-built environment on the evolution of other species opens up new questions for biologists, anthropologists, architects, and environmental historians. Perhaps buildings—and the interactions they reveal—allow us a new way of thinking about human niche construction and the Anthropocene. Rather than treating today's environments as though they were the inevitable outcomes of history, we should seek to understand the contingency of historical paths, the ways in which we seek to systematically exclude some humans (and, yes, most nonhumans) from history-making, and the diversity of other worlds that were and that continue to be possible.

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