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Niche Construction and the Study of Culture Change in Anthropology: Challenges and Prospects

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ABSTRACT

Many North American anthropologists remain deeply suspicious of attempts to theorize the evolution of culture, given the legacy in our discipline of nineteenth-century stagist theories of cultural evolution that were shaped by scientific racism. In the late twentieth-century, some theorists tried to escape this legacy by using formal models drawn from neo-Darwinian population biology to reconceptualize cultural evolutionary processes, but these more recent approaches have been found unsatisfactory for reasons of their own. For example, gene-culture coevolution and dual inheritance theory have limited appeal to many contemporary cultural anthropologists because these theories rely on definitions of culture, and assumptions about human individuals and social groups, that many cultural anthropologists no longer find persuasive. Niche construction, by contrast, appears more promising as a framework for connecting cultural change with biological and ecological change. Nevertheless, the innovative features of niche construction coexist uneasily alongside the same problematic features that limit the usefulness of gene-culture coevolution and dual inheritance theory in cultural anthropology. This article discusses anthropological concerns about niche construction theory, but also suggests ways in which some of them might be reduced if niche construction theory were to incorporate insights from developmental systems theory and actor network theory.

Introduction

North American anthropology began as a discipline interested in explaining both biological and cultural evolution, but these early efforts have a checkered history, making many contemporary anthropologists suspicious of more recent efforts to theorize about cultural evolution. Toward the end of the nineteenth century, when our discipline was just taking shape, a perspective that is today called "scientific racism" mobilized ethnographic and historical data to argue that progressively more advanced stages of cultural evolution could be associated with progressively more advanced, phenotypically distinct human populations called "races." These

views had supporters both inside and outside anthropology, and would be called upon in the first third of the twentieth century to justify the tenets of Nazi biology. However, scientific racism was also resisted within anthropology. Franz Boas famously challenged the claims of those who connected different stages of cultural evolution with the biological attainments of different racial groups. He also took on the so-called "diffusionists," proponents of a rival perspective that associated cultural change with spreading waves of cultural innovation originating in a few unusually inventive societies. There was an implicit supposition of racial difference built into diffusionist views as well: as Alan Barnard points out, diffusionism rested on the assumption that most human populations were uninventive, inferior to the "culture-rich" peoples whose innovations they systematically copied (Barnard 2000, 47).

Boas and his students are credited for exposing the weaknesses both of the extreme unilineal cultural evolutionists and of the extreme cultural diffusionists, and for redirecting the focus of ethnography toward documenting the particular culture histories of specific peoples an approach that has been called "historical particularism." While Boas was highly critical of the physical anthropology of his day, which focused on racial classification, he did not give up an interest in patterns of biological development experienced by different human populations in different cultural and geographical settings. For example, his work documenting the changes in head shape experienced by children of immigrants undermined long-held assumption that head shape was a "hard" indicator of racial membership, and his results that have stood the test of time, in the face of challenges (Gravlee et al. 2003a, 2003b).

The legacy of nineteenth-century evolutionism in North American anthropology, and the Boasian critique of that legacy, has been interpreted differently by different anthropologists, both during Boas's lifetime and afterward. In particular, this legacy has influenced the willingness of many anthropologists even to consider that culture might evolve, fearing that any such consideration must inevitably be tainted by the stagism and racism of anthropological theorizing prior to the Second World War (e.g., Yanagisako 2005). After the war, many anthropologists followed Sherwood Washburn, rejecting the race-focused physical anthropology of the past, and embracing the new direction offered by the evolutionary synthesis. In keeping with the tenets espoused by authors of the synthesis like Theodosius Dobzhansky, the processes of evolution studied by population biologists were considered to be quite distinct from processes of culture change (Ingold 2007, 13). After 1975, however, the "new synthesis" of sociobiology attempted to explain culture in terms of gene selectionism. Although many anthropologists were attracted by sociobiology (or by its successor, evolutionary psychology) many others remained wary of these efforts, which seemed overly reductionist. In the 1980s and 1990s, dual inheritance theory and the theory of gene-culture coevolution persuasively used population-biology models to demonstrate the limitations of sociobiological reasoning about culture; as a result, the distinction between cultural processes and genetic processes no longer seems to be in doubt. At the same time, these moves have not mollified anthropologists who continue object that mathematical

models of cultural evolution incorporate outdated and problematic assumptions about culture, human individuals, and social groups.

For a long time, these concerns have caused many anthropologists to wrestle with an "anti-antievolutionism dilemma:" while they remain committed to evolution as a natural process, they find it difficult to affirm the currently hegemonic version of evolutionary theory (Schultz 2009). Tim Ingold helped find a way out of this dilemma with his pioneering exploration of "dissident" alternatives to gene selectionism in biology (2000, 2007, 2011). In recent years, more and more anthropologists are finding valuable approaches to evolution in areas of theoretical biology that go "beyond" the evolutionary synthesis of the 1930s and 1940s. Today, these fields include evolutionary development biology ("evo-devo"), plasticity and accommodation, niche construction, epigenetic inheritance, replicator theory, evolvability, multilevel selection and genomic evolution (Pigliucci and Müller 2010, 11, Figure 1.1). Especially attractive has been the "triple inheritance" model of niche construction originally set forth by Odling-Smee, Laland and Feldman (2003), which offers a way to connect cultural change with biological and ecological change in ways that do not harken back to the discredited views associated with scientific racism.

One widely appreciated feature of this model of niche construction is the way it brings *organisms* back into the picture as agents in evolution, a move that was long overdue and most welcome. However, equally significant for many anthropologists is the way this model of niche construction brings *artifacts* into the picture. Triple inheritance theory insists that artifacts play roles in evolutionary processes that are distinct from "informational" factors in evolution, such as genes and "memes" (i.e., unit-like cultural variants). Triple inheritance theory thus persuasively argues against extended phenotype accounts that would conceive of both organisms and the artifacts they create as outcomes of gene action. Triple inheritance theory also challenges dual inheritance models of cultural evolution, which handle material culture poorly and confine "culture" to beliefs, meanings, and values located "mostly in people's heads" (Richerson and Boyd 2005).

Triple inheritance theory resonates with the growing interest in material culture that has spread beyond archaeology into all fields of anthropology. Many anthropologists are adding niche construction to their theoretical toolkits, sometimes customizing it to do anthropological work of a kind not envisaged by the theory's originators. At the same time, some niche construction theorists in evolutionary biology have demonstrated interest in forging ties with scholars in disciplines like sociology and anthropology. One source of friction (Tsing 2005) will surely be the recent decision by originators of niche construction theory to back away from the triple inheritance model, a matter I address below. From an anthropological perspective, this move is disappointing, but ultimately it may not matter: if anthropologists find a triple inheritance model of niche construction helpful, they will continue to develop it in their own ways, not unlike the ways the anthropological concept of culture has been exapted and put to work in new ways by theorists in disciplines other than anthropology. But I do not rule out all possibilities of reconciliation. This article suggests ways in which niche construction theory

might be reformulated in order to overcome friction and establish awkward connections across difference.

My argument has two parts. In Part I, I defend the original, bold claims of the triple inheritance model of niche construction that gives artifacts their due. Using examples from biological anthropology, archaeology, and sociocultural anthropology, I show how anthropologists are making use of niche construction theory, not always in ways its originators intended, but in ways that retain parity for artifacts while expanding the theory in both scale and scope. In Part II, I consider efforts made by some niche construction theorists to respond to concerns that anthropologists and other social scientists have raised about niche construction theory. I then offer my own proposal about what an "extended" niche construction theory linking anthropology and evolutionary biology might look like, suggesting that the two theoretical frameworks best suited to realize this alliance are *developmental systems theory* (which resonates with Boasian-style investigations into human biocultural development currently being pursued in contemporary biological anthropology) and *actor-network theory* (which has already had a significant impact in many areas of anthropological research). Should the collaboration succeed, whether the outcome should be qualified as "development," as "evolution", or as something else entirely, remains to be determined.

Part I

As noted above, many contemporary anthropologists criticize current efforts to theorize cultural evolution because they worry about the resurrection of some version of the cultural stagism associated with scientific racism. Mindful of this legacy, proponents of dual inheritance theory and gene-culture coevolution carefully constructed their accounts of cultural evolution from materials provided by the Modern Evolutionary Synthesis. In this way, dual inheritance theory was famously able to use mathematical models from population biology to demonstrate that under certain environmental conditions, culture (conceived as units of cultural variation analogous to genes) could be favored by natural selection (Boyd and Richerson 1985). But while these efforts made it possible to talk about cultural evolution in ways that did not revive scientific racism, they remained problematic because of the ways in which human cultural practices—and human beings—were distorted to fit the demands of mathematical models. For these reasons, philosopher of biology Tim Lewens calls dual inheritance theory "the kinetic theory of culture" by analogy with the kinetic theory of gases, and he observes—correctly, in my judgment—that anthropologists and others remain hostile to this theory *not* because they have doubts about the validity of evolutionary theory in general, but because they object to the way this particular use of evolutionary theory atomizes culture and represents human action in simplified, idealized ways (2013). Such accounts appear to deal only with superficial cultural processes, and are unable to account for the emergence and stabilization of large-scale sociocultural structures and networks over the course of human (pre)history. As I show below,

some anthropologists interested in these phenomena have not only found the triple inheritance version of niche construction theory helpful, but have drawn attention to ways in which it might be expanded to better suited to anthropological purposes.

Biological anthropologist Agustín Fuentes, for example, writes that "niche construction is the altering, building, and/or destroying of niches via the mutual interaction of organisms and their environments and is an important force in structuring evolutionary change, alongside natural selection (Odling-Smee et al. 2003)" (Fuentes 2012, 110). Fuentes subscribes to the view all of us on earth today live in the Anthropocene, a geological epoch in which the activities of human beings exert a major influence on global landscapes and climates (2012, 102):

> Anthropogenic habitats emerge via human niche construction … Humans engage in both intentional and by-product ecological change, which in turn affects the evolutionary pressures on the other species inhabiting human-occupied ecosystems (and adjacent ones). At the global level, humans are ecosystem engineers on the largest of scales, and these altered ecologies are inherited not only by subsequent generations of humans but by all the sympatric species residing within them (2012, 110).

Fuentes has been instrumental in the development of a research specialty called "ethnoprimatology," which studies relationships between nonhuman primate species ("alloprimates") and human populations in a range of different settings around the world. Niche construction plays an important role in ethnoprimatological research, which investigates not only the impact of human activities on traditional primate habitats, but which also highlights those places where particular alloprimates and humans have a long history of mutually sustaining relationships. In all these settings, moreover, the distinctive role played by many kinds of humanly constructed artifacts cannot be ignored:

> The construction and expansion of urban spaces, the alteration of forest landscapes, for agricultural or other uses, the creation of roads and other transportation systems, and the rapid increase in human population numbers, and our dietary needs, affect local and regional ecologies, changing aspects of their structure and function. Alloprimates can find themselves completely intertwined in such systems. The expansion of human residential areas into areas of overlap with other primates, especially high-density urbanizations, increases the type and intensity of interaction opportunities with alloprimates and simultaneously alters primate ranging, foraging, and behavior. Increased human building, road construction, forest clearance, and industrial output can affect local microclimates in both temperature and rainfall regimes, shifting patterns and types of plant growth and fruiting in addition to changing the structural landscape. Alloprimates must then adapt their behavior to human structures (Houses, roadways, sewage systems, etc.) and the local climatic and phenological shifts, move away from the impacted area,

> or perish … thus, there appears to be a pattern of ecological selection for those alloprimates that are best able to coexist with humans (e.g. macaque monkeys in South and Southeast Asia, baboons in sub-Saharan Africa) and selection against those who cannot (e.g. apes and leaf monkeys). Human niche construction and its concomitant climate change likely constitute the main selection pressures on other primates today (Fuentes & Wolfe 2002, Strier 2011)" (Fuentes 2012, 110-111).

At the same time, Fuentes is comfortable adopting a more conventional definition of niche construction to address questions in biological anthropology where formal mathematical modeling seems appropriate. For instance, he and his colleagues used data on fossil hominins from Africa and formal models incorporating niche construction to test a hypothesis about the factors responsible for extinction of the genus *Paranthropus* and survival of the genus *Homo* (Fuentes et al. 2010). Both hominin lineages coexisted in eastern and southern Africa between about 2.5 and 1 million years ago, and both appear to have been targets of the same predators. However, *Paranthropus* disappeared from the fossil record after about 1 million years ago, while the *Homo* lineage has persisted until today. Fuentes and his colleagues hypothesized that niche construction, in the form of social cooperation, might have protected populations of *Homo* from predation, shifting more of the predation burden onto *Paranthropus.* And *Paranthropus*, subject to increased predation levels, but without the buffering provided by a cooperative constructed niche, would eventually been driven to extinction. The authors concluded that "the underlying concepts behind this model are supported via theoretical and fossil evidence" (Fuentes et al. 2010, 440). In describing their methods, they have this to say (Fuentes et al. 2010, 436):

> Niche construction is defined as the modification by organisms of the functional relationship between themselves and their environment through an active change of one of the factors of that environment. "Through niche construction organisms not only influence the nature of their world, but also in part determine the selection pressures to which they and their descendants are exposed, and they do so in a nonrandom manner" … Approaching human evolution using a feedback model perspective in the context of niche construction theory (Odling-Smee et al. 2003) can provide a strong conceptual tool and support the notion that ameliorating predation pressures may have been a boon to *Homo* but a bane to *Paranthropus*.

The understandings of niche construction employed in these two examples of research in biological anthropology vary in scale and in scope, and the first highlights the role of humanly constructed artifacts while the second does not. But while this variation might trouble some formal theorists, I believe that it illustrates how niche construction theory is being exapted in ways that render it suitable to address matters of concern to anthropologists. In fact, it illustrates a prediction made by the originators of niche construction theory, who argued that "niche-

constructing activity will frequently generate multiple forms of feedback over a range of temporal scales" (Laland et al. 2005, 39).

Because material culture is imbricated in human evolution from before the origin of our species, *Homo sapiens*, a triple inheritance model of niche construction also seems well suited to research in anthropological archaeology. After all, archaeology is a field in which "artifacts" are central (e.g., Olsen et al. 2012), and in which they are conceived broadly to include not only portable objects but also remodeled features of the landscape at different scales. In a recent collection of papers that includes applications of niche construction outside evolutionary biology, archaeologist Felix Reide explicitly drew on the triple-inheritance model of niche construction (NC) (Reide 2011, 793-794):

> The NC model recognizes three domains of inheritance … genetic, ecological, and cultural—and archaeology can provide proxy information on all three domains. Archaeological data on craft traditions can be used to track cultural inheritance, thereby plotting the historical relationships among past communities of teachers and learners … In addition, much archaeological data pertains directly to human modification of the biotic and abiotic environments, both locally and transiently as well as at larger geographical and temporal scales.

In his paper, Reide sought to address the question of whether the domestication of dogs was regularly associated with the emergence of specialized reindeer economies in southern Scandinavia at the end of the last Ice Age (some 15,000 years ago). He sorted the components of archaeological data sets from this period into the three domains of inheritance recognized by niche construction theory, and then used quantitative methods incorporating niche construction to test for correlations among these domains. His analysis showed "limited positive support for … a correlated evolution of the use of domesticated dogs as hunting/herding/transport aids and the repeated emergence of specialized reindeer economics. Both traits can be understood as a constructed niche dimension and interpreted within the NC framework" (2011, 801). In other words, Reide's results suggested that "the fragmentary record of domesticated dogs in the northern European Late Glacial may not be the result of poor preservation, but rather of the fact that dog domestication/use was not a core part of the cultural repertoire at the time," with the consequence that earlier groups who attempted to domesticate reindeer without dogs eventually contracted and disappeared (2011, 801). However, things were very different for later human groups who moved into this environment with domesticated dogs, and who succeeded in developing early forms of reindeer domestication (2011, 802).

On one hand, archaeologists regularly apply quantitative analyses of their data when this seems appropriate, and Reide's use of niche construction theory in this study simply adds to the number of quantitative theories at his disposal. On the other hand, Reide also observes that archaeologists are interested in matters that stretch well beyond the scope encompassed by conventional quantitative models of niche construction. He points out that archaeologists have

long differentiated between what Wendell Oswalt called "weapons/instruments" and "facilities" (Oswalt 1976). "In this view, material culture that reflects personal transmission of information and use, such as projectile points, basketry or pottery (weapons/instruments), provides information on cultural inheritance in the strict sense" (Reide 2011, 794). This "strict" interpretation models niche construction as activity initiated by *individual* organisms that pass on a modified selective environment to future generations. Such an interpretation has been favored, for instance, in discussions of niche construction by philosophers of biology Kim Sterelny (e.g. 2003), although he has recently begun to move away from this view (Sterelny 2012), a point to which I will return below.

However, confining niche construction to the narrow scope of individual niche modification does not encompass Oswalt's category of "facilities": "material culture that reflects a collective transmission of information and use, such as tents, and housing structures, fishing platforms, fortifications as well as field systems," which Reide feels ought to be distinguished as belonging to "the ecological inheritance passed from generation to generation" (2011, 794). Reide agrees with Odling-Smee et al. 2003 that attempts to view facilities as extended phenotypes is misguided:

> Alternatively, such features could be viewed as part of the human extended phenotype … but their selective relevance is via modified environments, particularly in subsequent generations born into a niche that already is modified in a given way…. Furthermore, facilities often have a use life longer than a single human generation, and are continuously or periodically modified and changed. These evident ecological modifications cannot be readily related to the genotypes of those who played no part in putting them in place. Instead, they reference the collectively held stock of ecological knowledge and its implementation: a modified environment that constitutes the ontogenetic niche for subsequent generations. (2011, 794)

Nevertheless, from an anthropological perspective, this *collective* dimension of human niche construction is underdeveloped in niche construction theory; as Lewens observed for dual inherence theory, "collective" seems to refer to the aggregate sum of all individual niche-constructing activity, and no principled account is offered to explain the varied ways in which human social labor must have been mobilized to remodel features of the physical environment, in different places and times, to produce Oswalt's "facilities."

In the meantime, anthropologists have explored this matter on their own. Stephen Lansing, for instance, is an environmental anthropologist who has worked for many years on the Indonesian island of Bali, combining ethnographic research and joint investigations with colleagues from different disciplines, in an ongoing project to trace the historical development and stabilization of the irrigated rice terrace agriculture for which the island has long been famous. Unlike discussions of niche construction that focus on foraging or herding peoples, the

study of niche construction in Bali involves "niche construction in a complex society" (Lansing and Fox 2011, 927). Anthropologists generally define complex societies as those with a permanent division into social strata, and which are also characterized by craft specialization of various kinds (pottery, metallurgy, textile manufacture). Members of complex societies also construct permanent dwellings and other structures that support habitats engineered to sustain and protect the domesticated species of plants and animals on which they depend for survival. Bali's irrigated rice agriculture depends on a network of water temples and their associated canals, tunnels, aqueducts and terraces. Its origins go back a thousand years. Lansing and Fox ask: Is this an example of niche construction (2011, 927)?

The question must be posed because, as they point out, "Presently, there is little role for conscious planning in the theory of niche construction, which explains the intricate architecture of environments like termite mounds as products of Darwinian selection. But in cases like the rice terraces, the role of conscious intention cannot be ignored" (2011, 927). Philosophers like Hegel and Marx, by contrast, did explain human architectural achievements as the product of conscious intention. And so the challenge is this: "If human niche construction is to account for historical phenomena like the Balinese case, the analytical focus must be broadened to include the global-scale consequences of conscious innovation as well as the transmission of existing repertoires of cultural information" (2011, 927-928). Note that Lansing and Fox are unwilling to limit culture to that which exists "mostly in peoples heads." Indeed, their test case would fit comfortably within Fuentes' definition of niche construction as "the altering, building, and/or destroying of niches via the mutual interaction of organisms and their environments."

One theory of the history of the water temple system attributes its origin to the work of Balinese kings; another theory (the "budding model"), supported by Lansing's previous research, argues that irrigation on Bali expanded *without* the involvement of a powerful elite. According to this second model, from at least the eleventh century BCE, groups of farmers began organizing themselves into community-level institutions called *subaks*, "associations of farmers who managed irrigation water from a common source, such as a spring or irrigation canal" (Lansing and Fox 2011, 928). In this article, Lansing and Fox propose a new test for the "budding model" of the water temple system: "if the expansion of irrigation was accomplished by the farmers themselves … the budding model would predict the formation of small communities located along irrigation systems, with the oldest settlements located at the irrigation outtakes nearest to the most ancient weirs or springs" (2011, 928). Because settlements are organized around groups of related men, Lansing and Fox compared Y-chromosome and mtDNA data collected from subaks located in two regions of Bali, as well as with a control group of randomly selected men from each of geographical regions of Bali The results showed a strong correlation between Y-chromosome and mtDNA data for the set of subaks in one region (Sebatu) but not for the set of subaks in the other region (Tabanan) or for the random Balinese sample (2011, 928). The Sebatu results, they argue, provide genetic evidence that is consistent with results from Lansing's earlier work on the water temple system, which provided evidence for evolutionary feedback and

ecological inheritance connecting the timing of irrigation and risks to the rice harvest from pests. This also adds to evidence from a "natural experiment" in the 1970s that occurred when Green Revolution rice was introduced to Bali, along with new procedures for planting and harvesting. These changes disrupted irrigation patterns, and rice pest populations were out of control within two years. "It was only when farmers spontaneously returned to synchronized planting schemes that harvests began to recover" (Lansing and Fox 2011, 931).

The "budding model" thus assigns subaks a central role in the agricultural system. Lansing and Fox hypothesize a historical process in which "incremental feedback learning becomes consolidated in the social norms of the subak institution that encourage cooperation among farmers" creating "an ecological inheritance of modified selection pressures for descendant populations, and is thus consistent with a process of niche construction" (2011, 931). Lansing and Fox also draw attention to ongoing forms of social labor that are required to maintain and repair the irrigation canals and tunnels that bring water to rice terraces. But the most important cultural achievement that makes the water temple system function is a hybrid agricultural calendar that lets "groups of subaks manage irrigation using complex interlocking schedules" (2011, 933). Lansing further argues that over the course of Balinese history, the patterns of nesting cycles associated with this calendar have been repeatedly applied in many domains of Balinese culture, "contributing to a mental and physical landscape of pleasing harmonies and perceptible coherence"—producing what he calls "perfect order" (Lansing and Fox 2011, 933; Lansing 2006).

The role of the construction and maintenance of artifacts—temples, canals, aqueducts, and terraces—is central to Lansing's account of the water temple system. But if niche construction in the form of synchronized planting schemes may be accounted for using traditional Darwinian methods, these are insufficient to account for the origin and operation of the agricultural calendar, which reliably sets the many features of this engineered landscape into motion. What is needed is a way to account for "the emergence of meaningful patterns in social institutions" and "the historical process by which social institutions facilitate or impede the spread of ideas and processes of social learning" (Lansing and Fox, 2011, 933). Lansing and Fox conclude that if the engineered landscape of Balinese rice terraces are to be considered an example of niche construction, then the theoretical apparatus of niche construction will need to expand to include the insights of philosophers like Hegel and Marx.

To sum up, a theory of niche construction suitable for anthropologists must have at least three key features. First, it should retain (and build on) the triple inheritance focus that accords artifacts parity alongside genes and ideational forms of culture. For some, the key virtue of this formulation is that it prevents artifacts from being merged either with ideational culture "mostly in people's heads" or with abiotic features of the physical environment. Second, niche construction needs to be seen as operating on multiple scales, including theoretical tools appropriate for studying the niche-constructing behaviors of individual organisms, but also incorporating theoretical tools appropriate for studying niche construction on scales up to and

including global processes of the Anthropocene. Finally, in conjunction with this second feature, niche construction must be conceived more broadly in scope, ranging from unconscious interventions by individual organisms to the consciously planned and jointly realized efforts of ecological engineering and maintenance carried out in complex societies. It is therefore unfortunate, from an anthropological perspective, that more recent formulations of niche construction theory have found the "triple inheritance system unnecessarily complicated and constraining" and that the replacement version proposes collapsing cultural and ecological inheritance systems "into a single ecological inheritance system consisting of informatic as well as physical material and energy resources " (Kendal et al. 2011, 787). In view of the foregoing discussion, this reformulation makes niche construction theory less, rather than more, appealing to anthropologists. And it may well not matter to anthropologists who seem inclined to build on the insights present in triple inheritance theory as they forge new tools for studying human evolutionary history. But there may be another way forward, which I explore in Part II.

Part II

As we have seen, many anthropologists and other scholars in the social sciences and humanities have resisted attempts to explain human cultural processes, such as the evolution of culture, in ways that disregard contributions made by their own disciplines in addressing such matters. Objections may include the worry that niche construction theory, like dual inheritance theory, is just another "kinetic theory of culture." This worry may not be misplaced, given the recent revision of niche construction theory that was noted above. But niche construction theorists have not been insensitive to the concerns of critics from outside evolutionary biology. One notable attempt to respond to critics in the social sciences and the humanities is found in a recent paper by Jeremy Kendal (2011). This response was motivated, he tells us, by a critique of niche construction theory by psychologist Mary Gauvain, who found its account of psychological development "underspecified," and who insisted that any account of human psychological development required "'the critical examination and incorporation of … the mind as a symbol generating, meaning-making, artifact-devising, socially transmitting system that is simultaneously an individual, social, and historical (cross-generational) phenomenon'" (Kendal 2011, 242). Kendal takes up Gauvain's challenge: "This article makes a start by summarizing four pertinent theories developed by sociologists, cognitive scientists, and sociocultural anthropologists: *situated learning, activity theory, practice theory,* and *distributed cognition*" (2011, 242).

These theories are likely to be familiar to many contemporary sociocultural anthropologists, and Kendal's effort to explore developments in social theory that postdate Durkheim is welcome (cf. Wilson 2002). However, the fact that he is responding to the critique of a psychologist is significant, not because anthropologists do not study individual cultural development (which we have done since the middle of the last century), but because

anthropology, unlike psychology, is equally interested in studying cultural structures and processes that do not center on individuals (as illustrated by the three case studies reviewed in Part I). Moreover, the goal of Kendal's theoretical summary is equally significant: he is setting out *only* to identify "points that are particularly relevant in a cultural niche-construction approach" (2011, 242). And so Kendal's review is highly selective: he emphasizes only those features of these four theoretical perspectives that can be fit into a version of niche construction understood as "a quantitative framework to account for historical contingency on patterns of culture change" (2011, 242).

As a result, anthropologists who are familiar with Jean Lave's work on situated learning may be surprised that Kendal's discussion of legitimate peripheral participation by apprentice tailors in Monrovia in the 1970s says nothing about the larger political context in which these activities were situated. But as Lave has recently emphasized, the centrality of relations of power must always be included in accounts of apprenticeship: "If you block issues of force, power, and conflict, it is all too easy to see learning and teaching as completely benign processes, making unaskable question about the conflicts and tensions, the relations of mutual need and potential threat, that masters and apprentices represented for each other" (2011, 89). Similarly, anthropologists familiar with the work of Lev Vygotsky, and his influence on later generations of cultural psychologists (and linguists), may be surprised to read how narrowly the effect of cultural and historical contexts on individual learning are conceived, in order to make them suitable for embedding in a quantitative model of cultural niche construction that measures "within-individual learning dynamics in an evolutionary framework" (2011,244).

Kendal's treatment of Antony Giddens' practice theory may surprise some anthropologists the most. His analysis focuses on *The Constitution of Society* (1984), in which Giddens develops his theory of structuration. Kendal finds many instances where concepts developed by Giddens may be matched to concepts developed within niche construction theory. Most significant seems to be the fact that structuration sets forth a model of reciprocal causation between agency and structure that resonates with the reciprocal causation between niche-constructing organisms and the environment that is central to niche construction theory. It is quite correct, therefore, for Kendal to describe structuration theory as pertinent for his purposes, but much has changed in the thirty years since Giddens' book was written, not only in theory in sociocultural anthropology but also in the work of Anthony Giddens. The forms of social and cultural closure that structuration theory presupposes (sometimes called "holism") became less helpful for many sociocultural anthropologists after the Cold War ended in 1989, when societies that had been presumed separate and self-contained, each equipped with its own culture, began to loosen up. Borders softened, and new flows of people, wealth, commodities, ideas, and ideologies began to sweep across the globe, provoking intense processes of deterritorialization, reterritorialization and cultural hybridization (Appadurai 1996). Anthropologists searched for theoretical tools that could help make sense of these unruly movements, and structuration theory was not a strong contender, given its modernist assumptions about both "structure" and

"agency." Nevertheless, in light of the theoretical challenges facing niche construction theorists from within evolutionary biology (see, e.g., Laland et al. 2013), a field in which unidirectional causation leading from selection on genes to everything else still has many adherents, reciprocal causation must appear radical indeed—perhaps as radical as structural-functionalism first appeared in British social anthropology at the beginning of the twentieth century. From an anthropological perspective, therefore, it is an encouraging move, despite its limitations.

Kendal's treatment of distributed cognition, however, is especially interesting. He cites cultural psychologist Michael Cole's important observation (1995, 190) that "the species specific characteristic of human beings is their need and ability to inhabit an environment transformed by the activity of prior members of their species. Such transformations and the mechanism of the transfer of these transformations from one generation to the next are the result of the ability/proclivity of human beings to create and use artifacts—aspects of the material world that are taken up into human action as modes of coordinating with the physical and social environment" (Kendal 2011, 246). He also cites the work of Wheeler and Clark (2008) who "consider aspects of structured learning environments as *extended cognitive systems*: ' Non-organic props and aids, many of which are either culturally inherited tools or structures manipulated by culturally transmitted practices, might themselves count as proper parts of extended cognitive processes'" (2011, 246). As Kendal points out, these kinds of theoretical tools invite niche construction theorists to consider "a large range of cultural phenomena that may be subject to cumulative cultural evolution and effects of developmental niche construction, but for which there has been negligible enquiry from within the field of cultural evolution, including the consideration of cultural traits that could not be invented by a single individual" (2011, 246). More than any of the other perspectives Kendal reviews, this perspective pays attention to artifacts, and breaks with many of the assumptions taken for granted in standard cognitive science approaches.

Kendal also approvingly refers to the work of anthropologists Bonnie Nardi (1996) and Will Hutchins (1995), and to the work of philosopher Andy Clark (2011), all of whom emphasize that cognition is not something that takes place inside our heads, but is the product of the changes in relational structures of biotic and abiotic components that are both internal and eternal to the mind (2011, 247). I find these arguments extremely persuasive. But taking them seriously would mean that we needed to abandon once and for all the presumption that our insides and our outsides are fully external to one another. Surely echoing many others, Kim Sterelny once stated that "There is probably a reasonably principled organism-environment boundary" (2005, 31). To make the most of a version of niche construction rooted in distributed cognition, however, it will be necessary to reconsider this opinion.

Kendal himself suggests the directions to explore: developmental systems theory and actor network theory. Developmental systems theory offers a principled way to negotiate the organism-environment boundary to which Sterelny refers. As we have seen, Kendal's focus is on the scaffolding of *individual* learning by a constructed learning environment, and he writes:

"*developmental systems theory* also recognizes the importance of this type of interaction [between learner and constructed learning environment], noting that 'the unit of both development and evolution is the developmental system, the entire matrix of interactants involved in a life cycle' (Griffiths and Gray 2001, 206)" (2011, 247). Thinking about developmental systems as units may ease the discomfort of those who take boundaries seriously, simultaneously highlighting the heterogeneous assemblage of biotic and abiotic interactants that make up such a system, while suggesting that this assemblage is not too unruly to be identified as a unit. Indeed, I found this way of thinking about developmental systems helpful when I first encountered developmental systems theory. But it does seem a retreat from full parity between organism and environment, and therefore is somewhat contradictory to niche construction theorists' own declaration of a "desire to focus on the *symmetry* between organism and environment," which was one of the reasons they came to reject the notion of extended phenotypes: "The extended-phenotype approach retains the notion of organismal adaptation to environment rather than the coevolutionary dynamics of both" (Laland, Odling-Smee and Feldman 2005, 52).

As Kendal observes, developmental systems theorists Paul Griffiths and Russell Gray are also committed to a *parity thesis* (Kendal 2011, 247):

> the roles played by the many causal factors that affect development do not fall neatly into two kinds, one exclusively played by DNA elements the other exclusively played by non-DNA elements…. Instead there are numerous important distinctions to be drawn amongst the causal roles played by developmental factors" (Griffiths and Gray 2005, 420)

Kendal compares this parity thesis with the *Parity Principle* proposed by theorists of distributed cognition (Kendal 2011, 247). Andy Clark (2008, 77) defines the Parity Principle as follows:

> If, as we confront some task, a part of the world functions as a process which, were it to go on its head, we would have no hesitation in accepting as part of the cognitive process, then that part of the world is (for that time) part of the cognitive process. (Clark and Chalmers 1998, 8).

Clark explains that the Parity Principle provides "a 'veil of ignorance' style test meant to help avoid biochauvinistic prejudice" (2008, 77). Although Clark's focus is individual cognition, he is has no difficulty conceiving of cognitive systems as "hybrid systems displaying novel cognitive profiles that supervene on more than the biological components alone" (2008, 99). Clark seems willing to reach fairly far into the world outside the skull as he traces connections between components of hybrid cognitive systems: "the parity claim was specifically meant to *undermine* any tendency to think that the shape of the present-day, human inner-processes sets some bar … on what should count as part of a genuinely cognitive process" (2008, 114; emphasis in original).

As an anthropologist who sometimes (but not always) focuses on individual human cognition, I am intrigued by Clark's observation that "The Parity Principle was meant to engage

our rough sense of what we might intuitively judge to belong to the domain of cognition—rather than, say, that of digestion—but to do so without the pervasive distractions of skin and skull (2008, 114). If we follow out this observation fully, I contend, we might well discover that seemingly far-flung strands of the heterogeneous "web" spun and maintained by the cognizing organism (Clark 2008, 123) may (counterintuitively) turn out to belong in the domain of cognition. Consider, for instance, how nourishing food is an external resource that contributes to a well-functioning brain, but that it may be unavailable in sufficient amounts to particular cognizing individuals because of political economic arrangements in the wider society that make it too expensive for these individuals to purchase. Thus do matters of digestion link back to cognition. And some anthropologists might find these political economic arrangements so important and complex as to merit research focus in their own right, while still acknowledging the threads that link these arrangements back to individuals who cognize (and eat).

This kind of open-endedness—in which developmental systems are entangled with wider features of the world, including biotic and abiotic resources whose availability maybe affected by economic and political institutions—is explicitly provided by Susan Oyama's concept of developmental system. Oyama defines a developmental system (DS) as "an organism (or other developing entity) *and its developmentally relevant environments*, all approachable on multiple temporal and spatial scales" (2011, 1). Oyama observes that "Depending on how they are observed, DSs can demonstrate great regularity (certain metabolic cycles and behavioral routines, say) but such orderliness is not criterial. Their workings run the gamut from well-protected reliability to extremely loose, variable associations among their *interactants* (participants in the DS, abiotic and biotic, including the organisms itself)" (2011, 2). This suggests that conceiving of a DS as a *unit*, as indicated in the definition offered by Griffiths and Gray above, might be better understood as the consequence of observing a DS from a particular point of view, perhaps when it is at its most orderly. If such unit-like orderliness is not criterial, however, there is nothing to stop interested researchers (anthropologists, perhaps) from tracing the threads that interweave the development of cognition in a human individual with political economy and digestion.

Oyama insists that a developmental system, conceived in the open-ended way she favors, "integrates organisms with their developmental worlds, pressing academic specialties to achieve a kind of collaboration that does justice to that relation… DSs virtually demand a multi-disciplinary approach (2011, 3). Paying this kind of attention to developmental processes has proved valuable in recent anthropological work that emphasizes the importance of distinguishing between "genetics" and "biology" in investigations of connections between "race" and disease. Clarence Gravlee, for example, has developed an approach that brings together what anthropologists have learned about "race": first, race does not line up with patterns of genetic variation in human populations; second, race is a sociocultural and historical construct that shapes the circumstances of people's lives; and third, awareness of the consequences for health of living under racist conditions constitutes "a mandate for ethnographic research on the social

reality of race and racism … to identify … the experiences and exposures that shape the emergence and persistence of racial inequalities in health" (2013, 41).

Gravlee and his colleagues used this approach to carry out research in Puerto Rico, attempting to explain why darker skin pigmentation was associated with higher blood pressure. They discovered that skin color had two dimensions that needed to be distinguished: "the phenotype of skin pigmentation and the cultural significance of skin color as a criterion of social status" (2013, 38). Measurement of skin pigmentation was carried out using the method of reflectance spectrometry, which reliably estimates the concentration of melanin in the skin. Measurement of the cultural relationship between skin color and social status required ethnographic methods. This "biocultural" (or "biosocial") approach revealed that Puerto Ricans with darker skins and higher socioeconomic status actually experienced higher blood pressure than other Puerto Ricans. This was interpreted as resulting from the fact that such individuals were likely to experience more intense racism as their social status increased, thereby producing increasingly frustrating social interactions that contributed to higher blood pressure (2013, 38). When Gravlee and his colleagues later included genetic-based estimates of African ancestry, they found that

> adding sociocultural data to the model revealed a statistically significant association between blood pressure and a particular candidate gene for hypertension—an association that was not evident in the analysis including only African ancestry and standard risk factors. This finding suggests that taking culture seriously may both clarify the biological consequences of social inequalities and empower future genetic association studies" (2013, 39).

"DSs are open-ended, " Oyama writes, "yet constrained and constraining … An ontogeny—a developmental course—conceived in these terms integrates organisms with their developmental worlds" (2011, 2-3). Gravlee's work illustrates the promise of taking this openness seriously. Oyama's approach to developmental systems theory also resonates with actor network theory, a connection Oyama has herself recognized (2000, 126; 2011, 22, n57). Actor network theory studies the properties of heterogeneous assemblages of humans and nonhumans, living and nonliving, as these emerge and stabilize (or destabilize) over time and space. It has been influenced in particular by the writings of Michel Callon (1986, 1991) and Bruno Latour (1987, 2005). Latour has recently defined an actor-network as follows (2011, 797-798):

> In its simplest but also in its deepest sense, the notion of network is of use whenever action is to be redistributed…. Take any object: At first, it looks contained within itself with well-delineated edges and limits: then something happens, a strike, an accident, a catastrophe, and suddenly you discover swarms of entities that seem to have been there all along but were not visible before and that appear in retrospect necessary for its sustenance. You thought the Columbia shuttle was an object ready to fly in the sky, and

> then suddenly, after the dramatic 2003 explosion, you realize that it needed NASA and its complex organizational body to fly safely in the sky…. The action of flying a technical object has been redistributed throughout a highly composite network where bureaucratic routines are just as important as equations and material resistance… What was invisible becomes visible, what had seemed self-contained is now widely distributed…. The search for the production of object and of objectivity is totally transformed now that they are portrayed simultaneously in the world and inside their networks of production.

Actor-network theory has been influential in many fields of contemporary anthropological research, particularly in the anthropology of science, technology and medicine. It has close ties to the "cyborg anthropology" based on the work of Donna Haraway, whose interests expanded from biology to include in the possibilities and dangers associated with assemblages of humans and high technology in fields from weapons development to biomedicine (Haraway 1991, Gray et al. 1995). Additionally, Haraway's work on cross-species relations (Haraway 1989, 2008) has informed research in fields like ethnoprimatology.

Once the organism-environment boundary dissolves, heterogeneous assemblages of many kinds are revealed. In a recent article, I highlighted many similarities between actor-network theory and the triple-inheritance model of niche construction, arguing that reconceiving of niche construction in actor-network terms could facilitate multidisciplinary connections to disciplines outside biology where actor-network theory has become established, such as anthropology (Schultz 2013). For example, I show how anthropologist Paige West's account of economic development in highland New Guinea (West 2006) depends on recognizing a variety of actants (i.e., living and nonliving participants in an actor network). West draws readers' attention to the "biotic" and "abiotic" artifacts that sustained life in her field settings. The cultural mediations she describes involved not just "humans" in the lump, but a specific heterogeneous community of humans composed of indigenous Gimi people and outsiders from Australia, the United States, and elsewhere in Papua New Guinea; and they were connected not just to "the environment" in the lump, but to specific mountains and forests, to birds of paradise and trees with harpy eagle nests, to game animals, and to swiddens. These heterogeneous living actants intertwined with heterogeneous nonliving actants: the tools of the hunters and farmers, such as bush knives; imported tinned fish that replace the pork they no longer eat; dwellings for residents, five church buildings, a health post perennially out of medicine, and a school. Particularly salient were a village airstrip and planes run by the Seventh Day Adventist Church that provided the community of Maimafu with its sole link to the outside world. The significance of this link became apparent when West pointed out that villagers grew cash crop coffee that needed to be flown out on these planes before it could be sold. "The airfreight charges paid to the mission planes fluctuate according to the price of fuel, thus tying Maimafu and other rural places that grow 'airstrip coffee' to the global political economy of oil" (2006, 106).

Susan Oyama asks, "When we are told it takes a village to sustain a child, we could wonder, And what does it take to sustain a village?" (2011, 27). Paige West provides one answer,

and her answer emphasizes what actor network approaches in anthropology can add to discussions of organism-focused studies of niche construction. Niche construction, explicitly informed by actor network theory, would pay attention to "the social" in the production of space, but the "the social" would be reconceptualize in terms of "collectives," in which humans are attached to nonhumans, living and nonliving, physical and nonphysical (Latour 2005). Acknowledging this would mean, among other things, that organisms, cultures, and environments would need to be approached as emergent hybrid products of "natureculture" (Haraway 2008, 6-7); Latour 1993, 7). For example, it would mean acknowledging the naturalcultural heritage of Gimi country itself: as West argues, "The biodiversity that exists in and around Maimafu, through the subsistence patterns that the NGO wishes to curtail, produced the landscape in which they live. So there is, therefore, no 'pristine condition' to preserve" (2006,178).

Actor network theory also shows how to fill the gaps that always open up in discussions of distributed cognition, when analysts refer to the items that cognizing individuals "co-opt" from the world outside their bodies. In these accounts, the pencil and paper a person relies on to carry out a math calculation pop in and out of existence, cut off from those parts of the wider world that make them available to the cognizing individual in the first place. Actor network theory would not rule out a focused analysis of distributed cognition, but it would not cut the threads that entangle pencils and paper to stationary stores and paper processing plants and the cutting down of forests for wood pulp, or to the settings in which graphite and wooden cylinders were first brought together centuries ago. Incorporating actor network thinking into discussions of developmental systems, of organisms with distributed cognition, and of organisms that engineer parts of their own (and others) ecological niches would be, I submit, a serious move toward doing justice to all of them. Kendal cites the early work of Bonnie Nardi in connection with activity theory, but her more recent work also incorporates actor network thinking (e.g., Nardi 2010; Leonardi et al. 2012). Kim Sterelny may be incorporating actor network thinking into his own views (Schultz 2013b).

My 2013 article also examined connections between niche construction and archaeology. To that discussion, I would only add here that conversations between niche construction theorists and archaeologists like Reide are already taking place, and more conversations should be encouraged, especially with archaeologists who take actor network theory seriously (e.g. Hodder 2012, Olsen et al. 2012, Olsen 2010). For these archaeologists, symmetrical treatment for artifacts and people is noncontroversial (see, for example, Olsen et al. 2011, 11-14). Similar views can also be found in studies of material culture by sociocultural anthropologists (e.g. Miller 2005).

Archaeologist Ian Hodder has recently proposed a "distributed" account of the Neolithic transition from hunting and gathering to agriculture in Southwest Asia (2006, 18-19). His proposal has many features that can be found in archaeologists' use of actor network theory. First, he steps away from conventional explanations that rely on single events or causes. Using

rich materials from sites like Çatalhöyük in Turkey, where he has worked for many years, Hodder argues instead that the Neolithic transition is better viewed as "a process dispersed through many areas of life" and "spread over a very long period of time," involving conscious and unconscious practices that draw in people, artifacts, and habitats, give rise to new challenges, and provoke new responses from human populations (2006, 19). Recently, Hodder has compared this approach (now called "entanglement") to niche construction:

> The concept of niche construction brings evolutionary approaches closer to entanglement as defined here, and yet the notion of niche remains rather passive, a background to change, rather than engaging with the dialectical tensions between all the dependencies and dependences within the full realm of entanglement. There remains the potential, however, for exploring the ways in which an evolutionary approach can contribute to understanding the transformations of entanglements. (2012, 151).

Hodder's conclusion is encouraging. There is no question that niche construction theory has had a remarkable stimulating effect on research in anthropology, and that good prospects exist for overcoming many of the awkward features that currently inhibit fuller cooperation between its advocates in evolutionary biology and its enthusiastic promoters in anthropology. Attention to the rich possibilities of entwining open-ended accounts of development with open-ended accounts of actor networks may intimidate some, but the risk is worth taking. Connecting the innovative potential of the triple inheritance model of niche construction with insights from developmental systems theory and actor network theory points the way to fresh and powerful ways of theorizing the cultural, biological and ecological linkages—the naturalcultural linkages—that characterize human evolutionary history.

REFERENCES CITED

Barnard, Alan. *History and Theory in Anthropology*. Cambridge: Cambridge University Press, 2000.

Boyd, Robert, and Peter J. Richerson. *Culture and the Evolutionary Process*. Chicago: University of Chicago Press, 1985.

Callon, Michel. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay." In *Power, Action and Belief: A New Sociology of Knowledge*, John Law (ed), 196–233. London: Routledge. 1986.

Callon, Michel. "Techno-Economic Networks and Irreversibility." In *A Sociology of Monsters: Essays on Power, Technology and Domination*, John Law (ed), 132–65. London: Routledge. 1991.

Clark, Andy. "Supersizing the Mind: Embodiment, Action, and Cognitive Extension.", 2008: xxix, 286 p.

Clark, Andy. "Precis of Supersizing the Mind: Embodiment, Action, and Cognitive Extension (Oxford University Press, NY, 2008)." *Philosophical Studies* 152, 2011: 413–16.

Fuentes, Agustin. "Monkeys, Humans and Politics in the Mentawai Islands: No Simple Solutions in a Complex World." In *Primates Face to Face: The Conservation Implications of Human and Nonhuman Primate Interconnections*, Agustín Fuentes, and L. D. Wolfe (eds), 187–207. Cambridge: Cambridge University Press. 2002.

Fuentes, Agustin. "Ethnoprimatology and the Anthropology of the Human-Primate Interface." *Annual Review of Anthropology* 41, 2012: 101–47.

Fuentes, Agustin, and L. D. Wolfe. *Primates Face to Face: The Conservation Implications of Human and Nonhuman Primate Interconnections*. Cambridge: Cambridge University Press, 2002.

Fuentes, Agustín, Matthew Wyczalkowski, and Katherine C. MacKinnon. "Niche Construction Through Cooperation: A Nonlinear Dynamics Contribution to Modeling Facets of the Evolutionary History in the Genus Homo." *Current Anthropology* 51, no. 3, 2010: 435–44.

Gravlee, Clarence. “Race, Biology, and Culture: Rethinking the Connections.” In *Anthropology of Race*, John Hartgan (ed), 21–41. Santa Fe, NM: School for American Research. 2013.

Gravlee, Clarence, H. Russell Bernard, and William Leoard. “Boas’s *Changes in Bodily Form:* The Immigrant Study, Cranial Plasticity, and Boas’s Physical Anthropology.” *American Anthropologist* 105, no. 2, 2003: 326–32.

Gravlee, Clarence, H. Russell Bernard, and William Leonard. “Heredity, Environment, and Cranial Form: A Re-Analysis of Boas’s Immigrant Data.” *American Anthropologist* 105, no. 1, 2003: 125–38.

Gray, Chris Hables. *The Cyborg Handbook*. New York: Routledge, 1995.

Griffiths, Paul, and Russell Gray. “Darwinism and Developmental Systems.” In *Cycles of Contingency: Developmental Systems and Evolution*, Susan Oyama, Paul Griffiths, and Russell Gray (eds), 195–218. Cambridge, MA: MIT Press. 2001.

Haraway, Donna. *Primate Visions*. New York: Routlege, 1989.

Haraway, Donna. *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge, 1991.

Haraway, Donna J. *When Species Meet*. Minneapolis: University of Minnesota Press, 2008.

Hutchins, Will. *Cognition in the Wild*. Cambridge, MA: MIT Press, 1995.

Ingold, Tim. *The Perception of the Environment: Essays on Livelihood, Dwelling & Skill.* London ; New York: Routledge, 2000.

Ingold, Tim. *Lines : A Brief History*. London ; New York: Routledge, 2007.

Ingold, Tim. *Being Alive : Essays on Movement, Knowledge and Description*. London ; New York: Routledge, 2011.

Ingold, Tim. “The Trouble With ‘Evolutionary Biology’.” *Anthropology Today* 2 23, 2007: 13–17.

Kendal, Jeremy. “Cultural Niche Construction and Human Learning Environments: Investigating

Sociocultural Perspectives." *Biological Theory* 6, 2011: 241–50.

Kendal, Jeremy, Jamshid Tehrani, and F. J. Odling-Smee. "Human Niche Construction in Interdisciplinary Focus." *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* 366, 2011: 785–92.

Laland, Kevin, F. J. Odling-Smee, and Marcus W. Feldman. "On the Breath and Significance of Niche Construction: A Reply to Griffiths, Okasha and Sterelny." *Biol. Phil.* 20, 2007: 37–55.

Laland, Kevin, F. J. Odling-Smee, W. Hoppitt, and Marcus W. Feldman. "Proximate and Ultimate: A Debate." *Biology and Philosophy* 28, no. 5, 2013: 719–810.

Lansing, J. Stephen. *Perfect Order: Recognizing Complexity in Bali*. Princeton, N.J.: Princeton University Press, 2006.

Latour, Bruno. *Reassembling the Social: An Introduction to Actor-Network-theory*. Oxford ; New York: Oxford University Press, 2005.

Latour, Bruno. "Networks, Societies, Spheres: Reflections of an Actor-Network Theorist. International Journal of Communication." *International Journal of Communication* 5, 2011: 796–810.

Latour, Bruno. *We Have Never Been Modern*. Harvard University Press, 1993.

Latour, Bruno. *Science in Action : How to Follow Scientists and Engineers Through Society*. Cambridge, Mass.: Harvard University Press, 1987.

Leonardi, Paul M., Bonnie Nardi, and Jannis Kallinikos, eds. *Materiality and Organizing* Oxford: Oxford University Press, 2012.

Lewens, Tim. "The Kinetic Theory of Culture." Paper presented at the meetings of the International Society for the History, Social Studies, and Philosophy of Biology, 2013:

Nardi, Bonnie A. "Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition." In *Context and Consciousness: Activity Theory and Human-Computer Interactions*, Bonnie Nardi (ed), Cambridge, MA: MIT Press. 1996.

Nardi, Bonnie A. *My Life as a Night Elf Priest*. Ann Arbor: University of Michigan Press, 2010.

Odling-Smee, F. John, Kevin N. Laland, and Marcus W. Feldman. *Niche Construction : The Neglected Process in Evolution*. Princeton: Princeton University Press, 2003.

Oswalt, Wendall. *An Anthropological Analysis of Food-Getting Technology*. New York: John Wiley and Sons, 1976.

Oyama, Susan. "Sustainable Development: Living With Systems." Paper presented at meetings of the International Society for History, Philosophy, and Social Studies of Biology, 2011:

Pigliucci, Massimo, and Gert Miller. *Evolution: the Extended Synthesis*. Cambridge, MA: MIT Press, 2010.

Reide, Felix. "Adaptation and Niche Construction in Human Prehistory: A Case Study From the Southern Scandinavian Late Glacial." *Phil. Trans. R. Soc. B* 366, 793–808.

Richerson, Peter, and Robert Boyd. *Not By Genes Alone: How Culture Transformed Human Evolution*. Chicago: University of Chicago Press, 2005.

Schultz, Emily. "Resolving the Anti-Antievolutionism Dilemma: A Brief for Relational Evolutionary Thinking in Anthropology." *American Anthropologist* 111 2, 2009: 224–37.

Schultz, Emily. "Backing Into the Actor Network? Wrestling With the Implications of Niche Construction and Human Cultural History." Paper presented at meetings of the International Society for the History, Philosophy, and Social Studies of Science, 2013:

Schultz, Emily. "New Perspectives on Organism-Environment Interactions in Anthropology." In *Entangled Life*, Gillian Barker, Eric Desjardins, and Trevor Pearce (eds), 79–102. Dordrect: Springer. 2013.

Sterelny, Kim. "Made By Each Other: Organisms and Their Environment." *Biology and Philosophy* 20, 2005: 21–36.

Sterelny, Kim. *The Evolved Apprentice*. Cambridge, MA: MIT Press, 2012.

Strier, Karen. "Conservation." In *Primates in Perspective, 2nd ed*, Christina J. Campbell,

Agustin Fuentes, Katherine C. MacKinnon, Melissa Panger, and Simon K. Bearder (eds), 664–75. Oxford: Oxford University Press. 2011.

Tsing, Anna Lowenhaupt. *Friction: An Ethnography of Global Connection*. Princeton, NJ: Princeton University Press, 2005.

West, Paige. *Conservation is Our Government Now: The Politics of Ecology in Papua New Guinea*. Durham, NC: Duke University Press, 2006.

Wheeler, M, and A. Clark. "Culture, Embodiment, and Genes: Unraveling the Triple Helix." *Philos Trans R Soc B* 363, 2008: 3536–75.

Wilson, David Sloan. *Darwin's Cathedral: Evolution, Religion and the Nature of Society*. Chicago: University of Chicago Press, 2002.

Yanagisako, Sylvia. "Flexible Disciplinarity: Beyond the Americanist Tradition." In *Unwrapping the Sacred Bundle: Reflections on the Disciplining of Anthropology*, Daniel Segal, and Yanagisako, Sylvia (eds), 78–98. Durham, NC: Duke University Press. 2005.

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