The New Biology

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THE EXPLORATION OF ECOSPACE: EXTENDING OR SUPPLEMENTING THE NEO-DARWINIAN PARADIGM?

by Niels Henrik Gregersen

Abstract. The neo-Darwinian paradigm, focusing on natural selection of genes responsible for differential adaption, provides the foundation for explaining evolutionary processes. The modern synthesis is broader, however, focusing on organisms rather than on gene transmissions per se. Yet, strands of current biology argue for further supplementation of Darwinian theory, pointing to nonbiotic drivers of evolutionary development, for example, self-organization of physical structures, and the interaction between individual organisms, groups of organisms, and their nonbiotic environments. According to niche construction theory, when organisms and groups develop, they not only adapt to their environments but modify their environments, creating new habitats for later generations. Insofar as ecological niches persist beyond the lifecycle of individual organisms, an ecological inheritance system exists alongside genetic inheritance. Such ecological structures may even facilitate the development of a cultural inheritance system, as we see in humans. The article discusses theological perspectives of such new developments within holistic biology.

Keywords: co-evolution; complexification; construction theory; exploration of ecospace; internal/external; the Modern Synthesis; neo-Darwinism; network causality; niche; panentheism; views of God

Since the discovery of the structure of DNA in 1953, neo-Darwinian theory has prevailed within evolutionary biology through population genetics and other gene-based theories of natural selection and differential adaption.

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While there is no reason to expect any displacement of the neo-Darwinian focus on genes, Darwinian biologists are today raising pressing questions about the assumption that the differential spread of genes, and their genetically derived traits, should be taken as the *sole explanans* of evolutionary biology. Neo-Darwinism does a great deal of explanatory work, but can it explain everything of importance with respect to evolution?

By comparison, the modern synthesis, developed before and during World War II by Theodosius Dobzhansky, Julian Huxley, and Ernst Mayr, entailed a broader explanatory program. Alongside the role of genetics, we also here find organism-centered views, emphasizing the creative (rather than just the pruning) role of natural selection, with some evolutionists even considering natural selection at the group level (Depew and Weber 2017).

Since the 1990s, other evolutionists have pointed to the importance of nonbiotic features in contributing to evolutionary processes. One such driver is the self-organization of physical structures underlying the formation of biological organisms; another driver is the interaction between individual organisms, groups and their nonbiotic environments. According to niche construction theory, when organisms and groups develop, they not only adapt to their environments, but modify their environments in systematic ways, thus creating new habitats for later generations. Insofar as ecological niches persist beyond the life cycle of individual organisms, an ecological inheritance system exists alongside genetic inheritance.

Expanding, Extending, Supplementing, or Replacing: Terminological Issues?

Within the philosophy of biology, there is no terminological consensus about what it means to expand, extend, supplement, or even replace standard Darwinian theory (Depew and Weber 2013). I here propose the following distinctions: *expanding* refers to the claim that a particular Darwinian theory is complete and self-sufficient in itself, capable of offering the ultimate explanation of biological and other forms of evolution. For example, speaking of a gene-centered Darwinism as "the universal acid," as Daniel Dennett does (1995, 63) is an expansionist maneuver. *Extending,* by contrast, means adjusting an existing evolutionary paradigm to "incorporate fields previously shunted aside" (Depew and Weber 2013, 405), thus broadening the scope of Darwinian theory, for example, by attuning it to features of epigenetic development. *Supplementing* goes a step further by pointing to aspects of reality, which are taken to be important for understanding biological evolution, but not reducible to the existing explanatory framework of evolutionary biology. Finally, *replacing* means arguing that evolution operates in a mainly non-Darwinian manner.

In what follows, I will argue that the real issue is not about expansionism, nor about replacement. The real issue is whether the nonbiotic features of biological evolution are to be seen as extensions of the existing repertoire of evolutionary explanations, or whether they add something fundamentally new to the standard repertoires of Darwinian theory. In an ideal world, the structural role of nonbiotic features would be absorbed into a broadened version of biological theory. If not, evolutionary biology would have to take note of the relevance of nonbiotic features for evolution, without wanting either to incorporate the physics of self-organization or ecological inheritance systems into a widened view of its own discipline. In the end, extending or supplementing represents a decision to be taken by theoretical biologists under pressure from empirical biologists. For philosophers and theologians, the question of extending versus supplementing is secondary to the more important issue of what is actually relevant for understanding the world of biology *in extenso*.

Does Neo-Darwinism Offer a Complete Account of Evolution, or Is There a Need for It to Be Supplemented?

The neo-Darwinian paradigm, focusing on the selective transmission of genes responsible for differential adaption, provides the basic foundation for explaining evolutionary processes. The question is not about whether neo-Darwinism needs to be replaced outright, but rather about whether this explanatory model of the differential spread of genes, and genetically derived traits, should be taken as the sole *explanans* of evolutionary biology. Neo-Darwinism does a great deal of explanatory work, but can it explain everything of importance with respect to evolution?

There is a particular burden of proof for anyone wanting to supplement the explanatory repertoires of the standard evolutionary biology. The burden on any contenders to the received view of neo-Darwinism is to show the causal effect of that which is beyond standard neo-Darwinian explanations, and to point to the conceptual strengths of seeking supplementary explanations that are structural and not only *ad hoc*. Typically, the argument regarding the need to draw a stronger line between standard neo-Darwinian assumptions and newer strands of evolutionary thinking makes reference to the manner in which neo-Darwinism relies on a number of problematic *dichotomies*, primarily between genotypic and phenotypic phenomena, that newer forms of evolutionary thinking destabilize.

Numerous examples of this breaking down of the standard dichotomies present themselves. The central dogma of Francis Crick, the co-discoverer of the DNA molecule, held that DNA informs RNA, and not the other way around. However, it is hard to be dogmatic in the world of biology. Indeed, "exceptions are so numerous by now that they cannot be ignored" (Depew and Weber 2013, 410). Also, DNA is not just DNA, but contains both coding sections and other sectors (some of which are sometimes referred to as junk DNA). But even the coding parts of the DNA are part of a molecular network that is co-responsible for the switching on and off of the DNA coding. The genome, in this sense, is always an epigenome, constantly re-shuttled and developed within the organism (Gadjev 2017). This allows for "epigenetic and phenotypic change to take the lead in evolution conceived as a cyclical process of gene–environment interaction in and through the developmental process" (Depew & Weber 2013, 410). If so, macroevolution cannot be accounted for exclusively by reference to micro-evolutionary processes.

Moreover, standard evolutionary biology, across its spectrum, is more concerned with *temporal evolution* rather than the exploration and co-construction of *ecospace*. The relationships between genes and cultural/ecological expressions are complex, and arguably not sufficiently well described in gene-centric terms (more on this later). For example, population-community ecology and ecosystem ecology are relatively unrelated to the research covering the standard paradigms (Odling-Smee, Laland, and Feldman 2003, 4).

Indeed, even strong proposals for a co-evolution of genes and cultures continue to speak of cultures and genes as "two distinct but interacting systems of information inheritance within human populations" (Durham 1991, 419–20). Hence the standard distinctions between "genes versus memes," "cell nuclei versus the brain," and "sexual versus social intercourse." This reflects a prior assumption of a nature–culture divide. But, of course, animals other than humans have brains and, likewise, cultures have developed in species with relatively small brains (e.g., birds). So, what are the mediating structures linking the DNA and the central nervous system? And what is the role played by abiotic structures in and around organisms? These sorts of questions seem to demand approaches which go beyond simply taking the package of genes, selection, and mutation as the sole explanatory device.

The question for those arguing that these newer theories are merely extensions of existing paradigms is whether this breaking down of the genotypic/phenotypic dichotomy can be adequately described by means of terms already existing within standard evolutionary theory. Equally, there is a case to be made for saying that the very breaking down of such distinctions constitutes a novel way of theorizing about evolutionary phenomena, something that should be thought of as a discrete supplement to existing discourse. And, as such, even if it is possible to re-describe such thinking in the gene-centric terms of a neo-Darwinian approach, there is the question of whether this is practicable or appropriate. A more holistic approach, observing a reciprocity between genotypic and phenotypic products, might be a more appropriate way of describing the evolutionary interactions here than simply juggling the existing terms to preserve the already existing gene-centric model.

Darwinian Expansionism: Darwinian Theory as a "Universal Acid"

Putting aside questions of extension or supplementation, what is highly questionable is the view, espoused by some popular proponents of evolutionary theory, that Darwinism is "a universal acid" so corrosive that it will penetrate through, and eat away everything, on its way towards explaining everything about the physical and social universe (*downwards* and *upwards*, as it were). In *Darwin's Dangerous Idea*, Daniel C. Dennett advocates this view of a universalized Darwinism; he writes:

> Darwin's idea had been born as an answer to questions in biology, but it threatened to leak out, offering answers—welcome or not—to questions in cosmology (going in one direction) and psychology (going in the other direction). If redesign could be a mindless, algorithmic process of evolution, why couldn't that whole process itself be a product of evolution, and so forth, *all the way down*? And if mindless evolution could account for the breathtakingly clever artefacts of the biosphere, how could the products of our own "real" minds be exempt from an evolutionary explanation. Darwin's idea thus threatened to spread *all the way up*, dissolving the illusion of our own authorship, our own *divine* spark of creativity and understanding. (Dennett 1995, 63)

This idea of a "universal Darwinism" is particularly over-ambitious regarding its "downwards" application to physical theory. In *The God Delusion*, Richard Dawkins argues that Darwinism "raises our consciousness outside its original territory of biology" (Dawkins 2006, 114). When he uses Darwinian theory to champion a selectionist multiverse theory (Dawkins 2006, 146), he seems to be putting things upside down. After all, it is physics and chemistry that give rise to the emergence of biological organisms, and not the other way around.

This does not mean that Darwinian theory cannot be inspirational for physicists. A group of scholars, following Wojciech Zurek, have argued for a "quantum Darwinism" with reference to the selection and proliferation of states of quantum entanglement (Zurek 2009). Yet, so far it has been difficult to identify stable lineages in quantum reality comparable to the robust transmission and recombination of distinct genes in living organisms. So, such ruminations are somewhat speculative, and they threaten to inappropriately overextend the meaningful application of Darwinian mechanisms. Similarly, Lee Smolin (1997) has hypothesized about lineages of universes over time, each with different laws and parameters. But apart from the (again) speculative nature of the hypothesis of successive universes, we only happen to know of a single universe, with some definite physical constants, and a few universal laws of nature. Darwinian features, such as competition for scarce resources, and adaption to external environments, are features which are absent on the cosmic scale. It is difficult to imagine a selection theory without a variety of contenders for the selection race. This problem is admitted by Smolin (1997, 105): "Of course, the principle of natural selection will be more difficult to apply in cosmology than it is in biology, as we have access to only one member of the collection." That is, we have only access to the actual universe, while collections of other universes are only imagined universes.

All physicists agree that we only know of one universe, even if some physicists do theorize about the possibility of multiverses (serially or spatially arranged), with respect to which, in the future *perhaps,* one *might* be able to reach indirect empirical information that *might* be interpretable in terms of physical multiverse theory thereof. Cambridge physicist Martin Rees, a contender of multiverse theory, offers this candid description of the empirical status of a multiverse theory (here in terms of spatially co-existing multiverses): "The question plainly cannot be settled by direct observation, but relevant evidence can be sought, which could lead to an answer" (Rees 2001, 166).

On the other hand, extending the Darwinian paradigm *upwards*, so to speak, into the social and psychological sciences offers more plausible explanatory potential, given that cultural artifacts (for example, libraries and the Internet) rest on the constructive powers of biological organisms (in this case, human beings). Thus, the parsimonious nature of strict Darwinism (variation + selection → differential spread) is not necessarily restricted to genetics. Hence, Donald T. Campbell (1960) proposed the Darwinian mechanism of "blind-variation-and-selective-retention" (BVSR) as a model for epistemology. Similarly, pan-selectionist theories of culture have been developed, from Dawkins's concept of viral memes to Dan Sperber's epidemiology of representations (Sperber 1996).

However, it seems to me that there is something *un-biological* about speaking of memes having a life of their own, just as there is something *dematerialized* about speaking of genes apart from the organisms they are a part of. In the world of the living, all things are in flow and in interaction with their environments. Likewise, no brain exists apart from its body, and no culture exists apart from its natural surroundings. In the world of biology, there are no simple one-way causal-effects (not even at RNA-DNA level). It is notable that proponents of evolutionary psychology have not been able to evidence any genetic basis for the supposed ancestral brain *modules* so far. Here, we have returned to the observation that no evolution nor any development can take place abstracted from the wider ecospace within which genes are transmitted to the next generation.

Self-Organization Both Propels and Constrains Biological Selection

What other drivers of evolution might there be to persuade us to speak of the need for supplementing neo-Darwinism? Here, the role of self-organization is a strong candidate (Gregersen 2006a). We can begin by considering the strict neo-Darwinian explanation of the evolution of complex lifeforms. By *strict neo-Darwinism*, I am referring to a specific theoretical development within Darwinism, which aims to explain biological evolution solely by the principle of natural selection, according to which only genes are transgenerational. Neo-Darwinism came into being with the German evolutionist August Weismann (1834–1914). Weismann deliberately sought to erase all elements of Lamarckism in Charles Darwin's work, while at the same time renouncing any notion of teleological development in evolution. The title of Weismann's work, *The Omnipotence of Natural Selection: A Rebuttal of Herbert Spencer,* reveals both Weismann's central thesis and the fierceness of his attack. The so-called *Weismann's barrier* between genetic and somatic cells entailed the dogma that, since the germ line is "sequestered" (Weismann 1893, 63–64) from the body early in the development, there is no possible causal route from body cells to germ line cells. Weismann's view of "hard inheritance" ruled out Lamarck's and Spencer's presupposition of the inheritance of acquired characteristics. Weismann thus excluded cultural factors as carriers of evolution. But he also took issue with the so-called developmentalist school within contemporary evolutionary theory, which took recourse to internal physical–chemical blueprints for explaining the course of evolution.

Controversies between today's varieties of Darwinism still gravitate around the question of whether evolution can be explained by natural selection alone, or whether it needs to embrace mathematical and physical aspects of reality in explaining the trajectories of evolution. A historical or externalist adaptationism stands over against a structuralist or internalist explanation.

If we are looking for a more comprehensive position within holistic biology, we might look for a combined approach in which historical contingencies and biological selection pressures are seen as processes always teamed together within a wider physico-chemical framework capable of *self-organization*. In this view the externalist view of adaptionism meets the internalist view of informational structures underlying evolution, both in its temporal and its spatial development. How, if *selection* and *self-organization* are to be related to one another at all is a scientific question, the answer to which today remains open. I will outline three possible responses (for more options, see Depew and Weber 1995, 479–90):

(1) Natural selection and self-organization may not be related at all. According to this view, the physical organization of matter has nothing, or very little, to do with biological selection processes. The electrostatic forces and the differentiation of chemical compounds, and so on, are processes going way back into evolutionary prehistory, and may not influence the later trends of evolution. This

is probably the standard assumption among practicing biologists, if only for reasons of economy.

(2) Evolution, however, may also be seen as a single complementary process of selection-and-self-organization, in which self-organization offers not only the general phase space in which selection can operate, but also presents to selection the specific areas between too much order and too much disorder (poised between chaos and order), within which the possibilities for increased organization may take place.

(3) A third option is that self-organization constrains natural selection, which drives evolution. This view, in fact, retains the commonsense picture that biological life is fueled by a reliable physical and chemical world. It also reminds us of the fact that the array of biological evolution is not infinite but depends on that which is physically possible. As argued by a former editor of *Nature,* Philip Ball, physics is all-over constraining the palette of possible evolutionary futures: "Once you start to ask the 'how?' of mechanism, you are up against the rules of physics, chemistry, and mechanics, and the question becomes not just 'is the form successful?' but 'is it physically possible?'" (Ball 1999, 6).

This third way of relating propensities, self-organization, and natural selection is, according to David Depew and Bruce Weber, a well-established position supported by scholars working within different evolutionary paradigms. Specific physico-chemical solutions seem to channel evolution within a rather a small window of what is physically feasible. Nonetheless, once the small window has been opened, it is rich in its possibilities for the exploration not only of further chemical combinations, but also of the ecospace, and still more intense forms of sentience, communication, and collaboration.

Complexification and the Exploration of Ecospace

Evolution is usually envisaged as a temporal process, and more often than not as something somehow progressive. In the context of neo-Darwinian theory, however, it can be problematic to speak of a drive towards complexification in evolution. Some would argue that the concept of complexification smacks too much of the idea of *progress,* which (supposedly) was not part of Darwin's original idea, but something foisted onto Darwinism by unorthodox evolutionists such as Herbert Spencer. Dennett writes: "Global, long-term progress, amounting to the view that things in the biosphere are, in general, getting better and better and better, was denied by Darwin, and although it is often imagined by onlookers to be an implication of evolution, it is simply a mistake—a mistake no orthodox Darwinians fall for" (Dennett 1995, 299).

Dennett admits that evolution exhibits occasional trends towards complexity, but not persistent trends that can be valued as "progress." However, Darwin himself saw progress, and even the development towards perfection, as an implication of natural selection: "And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection" (Darwin [1859]1964, 489). Based on a review of Darwin's views on evolutionary progress, Robert J. Richards points out that, even though Darwin acknowledges that "progress is no invariable rule" (Darwin 1871, 177), he believed in progress as a general rule. Richards therefore concludes that "if we take Darwin whole, we see that his view of progress in evolution does not differ from that of Spencer" (Richards 1988, 145–46).

That being so, Dennett may be right that neo-Darwinian theory does not in itself entail a predictive theory of a steady universal progress. Nonetheless, it is hard to disregard the empirical fact that evolution, at least retrospectively, shows evidence of an overall trend towards biological complexity. Ernst Mayr, one of the doyens of post-WWII philosophy of biology, proposes a distinction between an idea of evolutionary progress ascribed to teleological or finalistic causes and the idea of progress as a by-product of natural selection: "to designate as progress the series of changes from simplest prokaryote to a large angiosperm tree or a primate is descriptively legitimate. How else could we designate the successive, innovative acquisitions of photosynthesis, eukaryoty (development of a nucleus), multicellularity (metaphytes, metazoans), diploidy, homeothermy, central nervous system, and parental care?" (Mayr 1982, 532).

It seems that such aspects of evolutionary growth include several parameters, including morphological complexity and functional complexity, both of which facilitate the exploration of *ecospace*. As argued by Holmes Rolston, morphological complexity is intimately linked to the complexification of the *functional complexity* provided by sentience, self-control, mobility and communication:

> [I]ncreases in capacities for centralized control (neural networks with control centers, brains surpassing mere genetic and enzymatic control), increases in capacities for sentience (ears, eyes, noses, antennae), increases in capacities for locomotion (muscles, fins, legs, wings), increases in capacities for manipulation (arms, hands, opposable thumbs), increases in capacities for acquired learning (feedback loops, synapses, memory banks), increases in capacities for communication and language acquisition—all these take increased complexity. (Rolston 1999, 11–12)

All other things being equal, *functional complexity* offers advantages for survival. Prey that can quickly detect a predator, and quickly move away, are better off than duller and slower prey. And vice versa: the group of predators who communicate and collaborate in catching the prey fare better overall than the lonely predator (although the latter will not need to share meat with others). A *top-down* causality (from awareness, communication, and collaboration to survival-and-reproduction) is thus fully comprehendible within the principle of natural selection. As a consequence, the causal nexus "from below"—from genes to organisms and groups—is causally constrained, and selectively modified, by the "top down" influence of the cultural patterns within groups, of the communication between the members of the group, and of the sensitivity of the individuals. In all cases, we notice that evolution is not just about temporal development, but also about the exploration of *ecospace*.

Together with such functional complexity comes the capacity for *niche construction*, that is, the formation of new niches, adaptive for given organisms, and providing an ecological inheritance of importance for later generations. This niche construction, therefore, forms an additional evolutionary driver that needs to be considered when discussing the question of extending or supplementing the neo-Darwinian paradigm.

What is Promising About Niche Construction Theory, and How it Fits into Wider Paradigms of Evolutionary Theory

Self-organizing physico-chemical processes are constantly undergirding biochemical evolution, putting some constraints on what is evolutionarily possible. Evolutionary processes, however, also alter the physical environment of relevance for the organisms, sometimes in a haphazard manner, sometimes in a systematic (and even dramatic) manner. A famous example, highlighted by Charles Darwin himself, is earthworms, which alter the soil chemistry in which they live, stimulating increased fitness of future generations. Other examples are the caves dug out by foxes and other mammals, or the more conspicuous case of beavers constructing impressive beaver dams, creating long-term changes in the environment (to the benefit or disadvantage for other species). The most dramatic example of niche construction is that performed by the human species. So profound and prolific is human niche construction that some have suggested that our geological epoch should be called the *Anthropocene* (Waters et al. 2016).

Niche construction takes different structural forms. For example, it may be "inceptive"—initiating systematic changes in the environment—or it may be "counteractive"—responding to particular environmental challenges. But more importantly, niche construction is not always functional for long-term survival. An example is the deforestation caused by agricultural practices in tropical West Africa. The purpose of creating more fertile soil has had the side-effect of creating of small ponds that have given rise to malaria and sickle cell anemia (Durham 1991, 103–53). A more positive example, also unintentional, is the development of a lactose tolerance in human populations resulting from the domestication of cows and other animals (Durham 1991, 154–225).

The concept of "niche construction" was originally developed by Richard Lewontin in the 1980s. Since the beginning of the millennium, the literature surrounding the topic has burgeoned, both among proponents and by critics (e.g., Laland 2000, with open peer commentaries). The general discussion has been stimulated in particular by F. John Odling-Smee, Kevin N. Laland, and Marcus W. Feldman's book *Niche Construction: The Neglected Process in Evolution* (2003) and by Eva Jablonka and Marion J. Lamb's *Evolution in Four Dimensions: Genetic, Epigentic, Bahavioral, and Symbolic Variation in the History of Life* (2014). The concept of niche construction has also proven important among anthropologists and theologians (Mühling 2014; Deane-Drummond, Arner, and Fuentes 2016). What is promising about niche construction theory, in particular, is the fact that it seems to offer a genuine supplement to standard evolutionary thinking by

(1) focusing on the evolutionary relationships between biota and abiota, thus bringing the exploration and construction of ecospace to the foreground within evolutionary theoretical frameworks;
(2) avoiding standard dichotomies between organisms and their environments, in which the latter are seen merely as passive templates for evolutionary processes while organisms are seen as responding to such templates and never the other way around;
(3) focusing on the *creative* aspects of evolution rather than only on the responsive or defensive aspects of evolution; and
(4) giving an impetus to a broader *network* view of evolutionarily relevant causes rather than postulating one single universal explanation behind all processes.

However, what seems more unclear (at least at present) is the exact explanatory scope and added value of niche construction in relation to other prominent proposals within evolutionary theory, not least with regard to other theories of co-evolution. Once again, discussion here constitutes a tussle between those wanting to present niche construction as a distinct kind of explanation over and above standard theorizing and others who think it simply describes phenomena in ways that can adequately be redescribed in terms of existing explanatory frameworks. It seems to me beyond doubt that niche construction theory has conceptual advantages in focusing on the relevance of both modifying natural environments and creating new artifacts during evolution, for which no single gene traits can be responsible. But how far the concept of niche construction brings us in terms of an extended causal understanding of evolution is still subject to debate.

One needs to ask about the relation between niche construction theory and the established theories within current biology concerning the interactions between organisms and their environments. Similarly, one needs to ask what the status of niche construction theory is with respect to current paradigms in ecology which also focus on the interaction between biota and abiota. While the theory of niche construction has gained a rather safe ground in studies of hominization and paleoanthropology, the question is more open as to what niche construction theory offers to the understanding of pre-human evolution.

Thus, the jury is still out as to whether niche construction is a substantial supplement to inheritance-based views of Darwinian evolution, or whether something like niche construction is already implicit within standard evolutionary explanation, and only grossly overlooked so far. It seems clear to me, however, that the causal impact of niche construction, performed in a continuous and systematic way throughout evolution, cannot be easily accommodated within a strict neo-Darwinian paradigm of biological evolution. Whether it can, or could, be accommodated within the richer paradigm of the modern synthesis is a more open question. As Dobzhansky famously said, "nothing in biology makes sense except in the light of evolution" (1973, 125). To this might be added the friendly corollary that *nothing makes sense in evolution except in the light of ecology.*

Theological Issues and Possibilities

In public and academic contexts, scholars in the *science-and-religion* field are often asked about the implications of evolutionary theory for understanding religion, and even God. However, there are reasons for rejecting the widespread view that evolution theory has implications for concepts of theology, in a strictly logical sense of the term. With that in mind, I will address some potential theological responses arising out of a biological understanding of *nature as an interacting network of causes*.

Why There Is No Entailment Relation Between Evolutionary Theory and Concepts of God

First, unlike the physical sciences, the biological sciences are not *fundamental sciences* digging down into ultimate reality. Rather, the biological sciences belong to the category of domain-specific sciences, concerned with explaining resilient structures and formative developments of living organisms once life has emerged on planet Earth (and on other sites for life, if they exist). If it is true that concepts of God are intrinsically related to the question of ultimate reality, the biological sciences cannot logically be their ultimate arbiter, even though evolutionary theory, in many ways, may be connected to religious self-reflection. Yet, one also needs to note, as Fraser Watts and Michael Reiss (2017) do in their introductory article to this section of the issue, that scientific theories are never *free-floating* but stand in need of philosophical elucidation and interpretation. In the philosophy of biology we do find notions that may be of relevance for understanding theological concepts, without the former entailing the latter.

Second, the social and experiential aspects of religion seem to escape a too direct empirical grasp. Religious practices as well as religiously relevant concepts of God build on a vast repertoire of religious experiences, linguistic traditions, and religious reflections. Religious approaches to reality, and the existential questions that religion deals with in its idiosyncratic ways—such as doubt and certainty, fear and trembling, longing and desire, and intimations of horizons of what is ultimately real—are not easily transported into data amenable for a subsequent empirical classification. As we will see below, this does not mean that *all* aspects of religious experience necessarily fall beyond the scope of evolutionary explanation, but regarding concepts of God and ultimate reality, they do.

These two points—taken each individually, or in concert—lead us to the conclusion that neither theism nor atheism can legitimately be said to be "implied" by evolutionary theory. It is, for example, fully possible to believe in a timeless personal deity, and still be an uncompromising Darwinian in biology. Martin A. Nowak, a Harvard professor of biology working on mathematical game theory, recently concluded an essay on "God and Evolution" with the following sentences: "In my opinion, an atemporal Creator and Sustainer of life lifts the entire trajectory of the world into existence. For the atemporal God, who is the creator and sustainer of the universe, the evolutionary trajectory is not unpredictable but fully known" (Nowak 2014, 51).

Certainly, the theological view here offered by Nowak expresses only minimal contact between theology and evolutionary biology. Below I wish to draw up some options for finding stronger connections between evolutionary theory and the way we may think about God. But it should be noted that Nowak's view is in no way incoherent, since in general there are no one-way implications from Darwinian theories to concepts of God, or vice versa.

Co-Evolution and Theology

Of relevance for theology and philosophy of religion, in addition to clarity about the philosophical status of selection and adaptation theory, is the question of the grounding of biological process in physics and chemistry. The observed overall trend towards increasing hierarchical orders over time, and the corresponding growth of capacities, may be anchored in universal physical laws such as gravity (responsible for material clumping) and thermodynamics (responsible for the arrow of time). And, for all, the natural propensities for self-organization and information are responsible for the proliferation and growth of patterns in evolution.

Such wide-ranging discussions have been touched upon above, and it should suffice to say that, insofar as a principle of self-organization is active both in the pre-biotic and the biotic world, the selection of genetic material cannot be the only principle of evolution. As was noted above, another candidate is the self-organizational capacities of material configurations underlying the world of the living, which can be shown both to constrain and propel evolutionary and co-evolutionary process. Likewise, information may be added to the furniture of the world of matter, so that information, or structure, is a currency on par with mass and energy at matter's most basic level (Davies and Gregersen 2014). In such an informational universe, the emergence and proliferation of life from nonlife is less improbable than otherwise imagined. Living in a biofriendly universe means living in a hospitable world (Kaufman 1995, 47–70). For obvious reasons, this view of our biophysical conditions is more open for a religious interpretation of the sort envisaging humans as somehow *desired* or *welcome* inhabitants of the cosmos (in contrast to the pan-selectionist view that all life is about warfare).

This raises a question about the relationship between contingency and the elements of continuity that exist between the world of physics and biology. In contemporary biology, one finds *externalist* views being raised over against *structuralist* or *internalist* explanations, particularly when explaining the trajectory of evolution (Sterelny 2001). The late Harvard biologist Stephen Jay Gould famously argued that if we were able to rewind the tape of evolution from 500 million years ago up to today, evolution would take an entirely different route. As a result, Gould suggested that natural selection, on its own, is not able to explain the actual history of evolution in any robust sense. Evolution is too historical to be put into the general scheme of natural selection (Gould 1989).

Indeed, in Gould's view, the world we see around us is a large-scale result of numerous adaptations and historical *contingencies*. Other biologists, however, point to the *convergence* of the evolutionary trajectories. Cambridge paleontologist Simon Conway Morris points out an overall trend towards the emergence of properties such as feeling and consciousness. After all, intelligence has dawned both among mammals and among mollusks. One finds the same camera-like eye in the octopus and mammals, even though their genetic lines departed from each other some half billion years ago, long before eyes had developed. Similarly, compound eyes (of the sort possessed by insects) have developed independently at least three times. Conway Morris states, "Put simply, contingency is inevitable, but unremarkable. It need not provoke discussion, because it matters not. There are not unlimited ways of doing something. For all its exuberance, the forms of life are restricted and channeled" (Conway Morris 1998, 13).

The argument for evolutionary convergence is not only provided by the fact that properties such as feeling, perception, and consciousness are advantageous in the game of selection. Conway Morris also argues that a common genetic structure underlies very different building plates and phenotypic expressions in animals. Much research has been done, for example, on the class of genes called the Hox genes, which control the embryological development in many species. A fruit fly, a mouse, and a human being are indeed different creatures, but both the symmetry of their body plans and the sequence of their body parts, from front to end, seem to be uniquely determined by the sequence of the Hox genes. The sheer *repetition* in evolution is profoundly significant. If we take the feature of evolutionary recurrence seriously in interpretations of reality, we might learn to see ourselves as having friends (such as bacteria and gene-elements) far back in evolutionary time.

Deep History and the Recurrence of Cultural Forms

The recent proposal of *deep history*, coming out of the collaboration between Harvard prehistorians Daniel Lord Smail and Andrew Shyrock, questions the standard dichotomy between history and prehistory. Smail takes the lesson of "interactionist approaches to genes and environment" when suggesting that "many social skills and social pathologies have both genetic and environmental components" (Smail 2008, 136). Smail and Shyrock thus propose a variety of governing metaphors and theoretical perspectives such as kinshipping, family trees, co-evolutionary webs and spirals, extensions of social relations, fractal repetitions of patterns going from deep time into human civilizations, and scalar integration provided by the general insight that emergent systems may generate punctuations and nonlinear trends at any scale of analysis (Shyrock and Smail 2011, 19).

Not only do we share many of the same genes with our forebears, but quite a few of our basic cultural practices reveal a deep evolutionary presence in the midst of our civilization. Thinking of the importance of energy exchanges with our environments, Shyrock and Smail write: "Ecological systems are the products of the organisms that inhabit them" (Shyrock and Smail 2011, 78). Thinking of the role of the body as a means of communication far below the threshold of intentional consciousness, they invite us to observe that "bodies also extend over space" (58). Thinking of patterns of sharing of food that are similar to that of birds and mammals, or of new ritualized forms relating food to domination, they draw attention to the way that "food became a social differentiator" (151). One might think about the role of *deep kinshipping*—for kinship is not only defined by genetic lines, but also by adoptions, household regulations, and cultural affinities, including differentiations between male and female, incest taboos between brothers and sisters, rules for food sharing, and so on. Kinshipping evolves as "a gradual thickening of social kinship," but may even be widened to "include relations among species and environments" (187). Think, for example, of the domestication of dogs which become part of the household, or of the kinship relations established between groups of humans and animals in totemism.

From the perspective of deep history, evolution is a broad category because it takes place in the continuous exchange between individual brains/minds and their social and natural environments. The importance of the social processes referred to above are instantaneously understood by human persons, even by children in the schoolyard. At the same time, there is nothing deterministic about such bio-cultural processes, since they demand a constant reinterpretation and social negotiation. A sort of semi-automaticity and a self-aware mode of interpretation here seem to walk together in the creation of eco-cultural nexuses.

Something similar may be the case in the development of religious ideas, which are always, in one sense, spontaneous and easy to go with, *natural* so to speak, yet in another sense molded by specific linguistic and cultural contexts, in which religious practices are reinterpreted. In this view, human minds are not operating within closed modular boxes, which then become activated by external triggers, but rather achieve a flow of awareness, from something almost instinctual to something far more evaluative, interpretative, and potentially self-reflective.

God in a World of Laws, Guiding Principles and Networks of Causal Capacities

Whether or not Darwin himself believed in progress continues to be a matter of controversy among today's Darwinians. But more importantly, the concept of selection is often taken to be a *law of nature*, comparable, say, to the law of gravity. American biologists, such as Edward O. Wilson (2006), often refer to *the law of selection*, while German biologists more appropriately speak about *das Prinzip der Selektion*.

Yet, and this is a crucial point to note, selection does not explain anything in causal terms, but simply describes *the collective net effect of a variety of type-different causes* of relevance for differential survival (for example, physical background conditions, chemical constraints, genes, organisms, niches, environments, etc.). Elliott Sober has helpfully termed the principle of selection as a statistical "equilibrium law" (Sober 1986, 140), since it is interested in an overall understanding of the "ultimate" effects of genetic inheritance, whilst being disinterested in the detailed "proximate" causes that lie behind the net equilibrium effects. As Sober puts it: "Equilibrium explanation [such as natural selection] shows why the actual cause of an event is in a sense, explanatorily *irrelevant*. It shows that the identity of the actual cause doesn't matter, as long as it is one of a set of possibilities of a certain kind" (Sober 1986, 140). Natural selection may thus be gruesome, or take the form of collaborative helping. What matters, from the point of view selection, is the statistical outcome. Or, as already formulated by Ernst Mayr, the so-called laws of biology are to be seen as *higher level generalizations* rather than as laws in the sense of prescriptive laws. As such, the very idea of the existence of laws is seriously weakened in current philosophy of science, and sometimes challenged altogether.

What, then, is the status of the so-called laws of biology (cf. Gregersen 2013)? I suggest that it is better to speak of principles and *regularities*, rather than to use the term *law* as imported from physics, and loaded with various meanings taken therefrom. Some have argued, for example, that such things as ontologically distinct laws do not apply to the world of evolution. John Beatty's *evolutionary contingency thesis* states this view uncompromisingly: "All generalizations about the living world are just mathematical, physical, or chemical generalizations or deductive consequences of mathematical, physical, or chemical generalizations plus initial conditions, or are distinctively biological, in which case they describe contingent outcomes of evolution" (Beatty 1995, 46–47).

Other biologists endorse the *contingent regularity thesis*, according to which the character of experimental evolutionary biology can best be made sense of as a search for contingent regularities. Robert Brandon (1997) is here keenly aware of the difference between physics and biology. Whereas the discipline of physics knows of some constants, such as the velocity of light or Planck's constant, the situation is very different in biology:

> These parameter values [in physics] are called constants because they are supposed to hold everywhere and everywhen. When measured accurately once, they need not be measured again. In evolutionary biology, on the other hand, there are no fundamental constants. The most important parameter values in evolution, things like the strength of selection, mutation rate, migration rate, are not at all constant. Even when measured accurately at one place and time, they must be constantly remeasured for different populations in different environments. Thus it makes sense that much more time and energy is spent measuring parameters in evolutionary biology than in contemporary physics. Again this is because biological parameters seem to lack the projectibility, or the lawlikeness, of the fundamental constants of physics. (Brandon 1997, 453)

What, then, do biologists focus on if not laws? It seems that experimental biology explores contingent regularities, or the causal capacities of natural organisms. Just as Brandon noted above, causal capacities change over time, and such regularities do not really have the invariance associated with the deep-seated physical laws of nature. Think of the constant changes that take place in organisms' immune systems in the face of ever new challenges to the organism. Here we can hardly speak of well-defined capacities, such as those relating to the capacities of the sodium-potassium pump in cells (for whose discovery Jens Christian Skou was awarded the Nobel Prize in Chemistry in 1997).

Therefore, in complex self-developing systems we would need to refer to historically actualized natural propensities rather than to inherent natural capacities of a more resilient nature. Many complex systems exemplify a *synchronous* holistic influence, according to which the parts are co-determined by the whole so that "more is different," as was famously stated by the physicist Philip Anderson (1972, 393). But things are more complex than this synchrony describes. Certainly, the behaviors of individual lymphocytes are dependent on the behaviors of other lymphocytes within the organism. But there is also an undeniably *diachronous* aspect to the formation of an immune system. The many types of proteins, cells, organs, and tissues that comprise the dynamic network of an immune system adapt over time to recognize specific pathogens more efficiently, and immunologists therefore routinely speak of the acquired immunity in terms of an *immunological memory*.

Since such systems produce themselves (*autopoietically*) over the course of time, and since the rules for self-formation are built into the systems themselves (they do not have the status of Platonic formative principles), the probability rates are mutable across history (Gregersen 1998). As pointed out by Karl Popper in his book *A World of Propensities,* if we want to take probabilities seriously from an ontological point of view, they should be seen as being "as real as forces" and not merely as a set of abstract possibilities (Popper 1990, 12). Hence, when situations change the relevant probabilities change too. The pathways of evolution are, as it were, built in the course of exploration and use. As was argued by the ecologist Robert E. Ulanowicz, in order for the propensities of self-developing biological systems to be able to proceed they must always "exhibit a porosity that lends a degree of flexibility or malleability" (Ulanowicz 2009, 56) to their future development. Furthermore, since evolutionary systems never work in isolation but usually in co-evolution with other self-developing systems, we may speak of a "juxtaposition of propensities" (Ulanowicz 2009, 58). Seen from this perspective, even the reference to resilient structures in biological systems should be taken with some caution, since resilience too is a matter of degree and circumstance. If anything, the clause of "all other things being equal" does not apply to the world of the living.

However, not only do biologists measure and re-measure the ever-changing propensities of biological systems; there is also a certain logic in evolution as formulated in the principle of natural selection. Indeed, it seems more appropriate to use the term "principle" (as is usual among Nordic and German biologists). If anything, the guiding law of selection may be termed a formal *equilibrium law.* Without having any interest in the concrete biochemical processes at work in the biological past, the principle of selection describes the eventual outcome of myriads of causal interactions. The principle of selection is a formative principle that explains the overall result, without identifying the triggering causes behind the outcome.

Internal Versus External Views of Divine Creativity

What theological reflections might be raised in relation to the evolution of causal capacities and the principle of selection? Some more general theological concerns come to the fore here. On the one hand, there is a concern that God should not be thought of as being absent from creation, nor as being merely passively present in it. On the other hand, theology has been worried, with good cause, about presenting a picture of God as controlling every step of creaturely self-development, thereby jeopardizing the self-organizing powers of creaturely existence.

One might suggest that the single most important issue here is whether divine creativity is to be seen as being *internal* or *external* to the world of creation, with its laws, guiding principles, and evolving capacities. If divine activity is seen as external to creation, then God is an other-power, regardless of whether God compels his creatures as a monarch (as in old-style theism), or just gently persuades them, so to speak, to move forwards (as in the new-style theism of *process thought*). God may, for example, be thought of as imposing necessitarian laws of nature on the world, which would then eventually provide fruitful results in the long run (one sees this in Friedrich Schleiermacher's uniformitarian view of divine action). On top of this general divine action, God may then sometimes do something extraordinary by imposing exceptions from the otherwise necessitarian laws (*supernatural miracles*)—this is the classic form of the monarchical model of God. Others, like process theologians, choose to mitigate divine power by confining divine activity to more formative suggestions about how creatures may proceed if they wish to follow a more divinely attuned path.

In both cases, however, divine creativity is imagined as a separate power, one existing apart from nature. Here, theologians have to negotiate between the extent of divine power versus the extent of creaturely power. Whether one opts for a sovereign God or for a God of limited power, God is imagined to exist alongside the world of creation. Accordingly, divine action is itemized as a particular portion of the total power of *God + creation*, as it were. In both cases, we have a *fixed-pie* view of the God-world interaction. In the monarchical case we ascribe to God the whole pie; in the process view we divide it more equally between divine power and creaturely power. But in both cases we have a series of contrasts: *there* is God, *here* is the world; *that* is divine action, *this* is natural causation; *here* is God's part of the equation, *there* is ours. This is, as I see it, the unfortunate result of an incompatibilist view of divine action and the laws, principles, and capacities of nature, and it is a view that has been taken issue with (see Gregersen 2006b).

An alternative theological view is possible if, as I advocate, one envisages divine creativity as being *internal* to creation. In this view, the world of creation can be understood as being God's dwelling-place or habitat, as it were, and God can be envisaged as creating from within creation, in the bosom of God-given creaturely capacities, in tandem with the rest of creation, and in the guise of creation (in, with, and under). In this scenario, *the unity of God and nature would be the primary fact*. Put differently, one might say that there is no nature without God, and no creator without creation.

It seems to me that this internal understanding of creation is far closer to that found throughout Biblical traditions. One can cite many examples: that the blessings of divine creativity are to be found *in* creatures themselves, in the juiciness of the grape (Isaiah 65: 8 NRSV), as well as *in* the powers of Gideon (Judges 6:12–14 NRSV); that the wisdom of old reaches from one end of the world to the other (Wisdom 8:1 NRSV), yet is still to this day inviting anyone to eat his or her fill of her fruits (Sirach 24:26 NRSV); that eventually She will be vindicated by all her children who do her deeds (Luke 7:35; Matthew 11:19 NRSV). As such, the Reign of God is not a place to be identified here or there, but is in the midst of us (Luke 17:21 NRSV). God's creative Logos, full of grace and truth, is the true light that enlightens anyone who comes into the world (John 1:9 NRSV), which finally became flesh in Jesus (John 1:14 NRSV). Accordingly, the promise is that the Spirit of God, without whom there is no life (Psalms 104:28–30 NRSV), shall be poured over all flesh, as was envisioned from times of old (Acts 2: 17; Joel 3:1 NRSV).

There is no shortage of such thinking to be found in the New Testament and the Hebrew Bible. Over and over again, we see the pattern of a divine presence that is somehow (a) present in advance; and yet also (b) coming into the world in order to bring its capacities into flow and fruition. Divine power, wisdom, form, and bliss elicit creaturely power, wisdom, form, and bliss, and there is no hint of a conflict between them. What we see here is a differentiated union (not a collapse) between divine activity and creaturely activity. God is the source, as it were, the creation of the world is the river, and the water comes from God, and *is* the exercise of divine creativity (Gregersen 2005).

There is no opposition here between up and down on the vertical or spatial axis. There is, however, another tension, which is on the temporal axis between *now* and *then*. For God's creativity has not yet been fully completed or exhausted in the world of creation. The Kingdom of God has not yet come; the Wisdom has not yet been received by all; the shining power of the divine Logos has not yet been received by his own people, who did not accept him; and the fire of the Spirit has not yet fully vivified all people with faith, hope and love. As an impatient Jew, Jesus prayed to his Father to finish the work of creation. Creation is still under construction. And Christians are still praying to the Father of Jesus Christ, who is the Father of all (Ephesians 4:4 NRSV): "Thy Kingdom come" (Matthew 6:9–10 NRSV).

A note of clarification is needed here. The idea of the union of divine creativity and creaturely creativity is not a matter of simply equating God and world. God is transcendent exactly in and through the self-consistent quality of divine immanence in creation. The theological motive for speaking of divine transcendence is not to place God outside of the universe, but to emphasize *divine self-consistency in and through the flux of times and circumstances*. In the Christian view, for example, God is the everlasting communion of love between Father, Son and Holy Spirit. The theological reason for speaking of God's transcendence is thus centered on God's identity, not on God's location *vis-à-vis* the world (Gregersen 2014). Likewise, the term *transcendence* is used to remind us that not even the revealed God can be fully conceptualized by human language. *Un dieu defini est un dieu fini*!

The Relevance of Panentheism

Certainly, questions of internal activity, and what might be natural to that idea, raise numerous other questions, often encapsulated in the idea of *panentheism*. For example, there are numerous senses in which the universe might be appropriately thought of as being *in* God. A person might be thought of being *in* another person's heart. Or, when the members of a symphony orchestra are playing sensitively with one another, it can be said that each member of the orchestra *becomes one of many* in the unified experience of the symphony. Here the experience of *resonance* (Rosa 2016, 435–514) stands in the forefront.

Any event may be experienced as a finite realization of some wider options placed within an even more comprehensive set of possibilities (the phase-space of creation, as it were). As Schleiermacher has suggested in his famous *On Religion: Speeches to Its Cultured Despisers* in 1799, anything finite is perceived in religion as if carved out and allowed to exist out of the whole raft of what is possible. This is a suggestive way of understanding the world's being in God, especially if it is made clear that natural events are not simply *parts* of the divine, but creaturely *realizations* made possible by a continuous divine creativity, which in itself is infinite. Hegel's logic of *das wahre Unendliche* (the true infinity as including and not excluding finite beings) can be interpreted as a philosophical version of this view, similar to that of Karl Jaspers's concept of God as *das Umgreifende* (the Comprehensive One) in relation to situated human beings. Philip Clayton (2004, 88) also takes a metaphorical stance regarding the 'en' in panentheism too, interpreting it as "a logical inclusion rather than (primarily) one of location. Conceptually it's much closer to the (Hegelian) case for finite being included within the infinite."

Elsewhere, I have argued that if we wish to have a more stable, generic notion of panentheism, we should set up two requirements (Gregersen 2004; 2016). Not only does God contain the world so that the world belongs to God (a widespread view in Christian tradition), but in panentheism there is also a feeding back from the world into divine life. In other words, there is *a two-way interaction* between God and world. For K. C. F. Krause, who coined the term *panentheism*, all divine activity is motivated by the divine love, which promotes otherness and brings the world back into the divine life. As Krause put it: "Love is the living form of the inner organic unification of all life in God. Love is the eternal will of God to be lovingly present in all beings and to take back the life of all his members into Himself as into their whole life" (Krause 1900, 117).

In *The World in the Trinity: Open-Ended Systems in Science and Religion,* Joseph Bracken's neo-Whiteheadian view of panentheism employs a thorough use of a spatial as well as a qualitative concept of higher order and lower order systems within the all-comprehensive system of the divine life (Bracken 2014) I am sympathetic to Bracken's emphasis on the spatial aspects of panentheism in his use of systems theory. For, as we have seen above, if we do not address the spatial configurations of ecospace but only the temporal aspects of evolution, we do not really address the full repertoire of contemporary evolutionary theory, and we miss some potentially quite fruitful connections between the biological sciences on the one hand and philosophy of religion and theology on the other. Creativity most often comes up in the interface between loosely coupled systems, such as concrete bodies situated in, and actively relating to, particular ecological and cultural settings. This applies also to human beings as self-interpreting animals: in the process of self-reflection, we always have to negotiate the interactions between biological needs, our desires, and the cultural norms or priorities embodied in communities within our wider societies.

If one is prepared to follow a systems-theoretical perspective in this vein, the next step is to determine which types of systems theory are to be used in elucidating those notions of panentheism that one can live by. Here, it seems, the critical question concerns the *pan* in panentheism. Is it sufficient to speak about "the world as a harmonious whole," as philosophers have done since antiquity, be it Plato in his *Laws* (Book 10), or Cicero, the Roman Stoic, in *On the Nature of the Gods* (Book 3)? We seem to live not just in one comprehensive system of all-that-is (the *pan* of panentheism). Rather, we live in a world with highly differentiated *type-different systems* (for example, economics, politics, knowledge, art, morality, religion, and so on), each with their system-specific environment. And again, it is in the interpenetration of these different systems that something new and creative emerges, and where new cultural niches open up. Philosophy of religion as a discipline, for example, is placed in the critical zone between the codes of the knowledge system (valid/non-valid, true/not true), and the codes of religious systems (immanence/transcendence, authentic/inauthentic). We need to pay attention to the interactions between such specialized systems rather than only attending to the bigger picture of *the world as one systemic whole*.

As such, panentheism is a highly stimulating concept, which speaks to what may well be some deep-seated natural propensities for understanding oneself as belonging to something more comprehensive than ourselves. Potentially, panentheistic views of God may therefore relate more easily to aspects of the exploration and co-opting of ecospace so central to current developments within evolutionary theory than they relate to concepts of a purely transcendent, dislocated God. At the same time it should be acknowledged that the idea of panentheism is not a philosophically stable concept in itself. It is always to be re-specified in the light of particular philosophical theologies or systematic theologies, and reframed with respect to particular reference problems that come up within a fractured world—a world not very often experienced as a harmonious whole.

Are Humans Ultimate or Penultimate Niche Constructors?

The ugly fact of evolution is that all life is lived at the expense of other life, and that it will remain so. This does not mean, however, that all life is bound to be greedy, for what is covered by the term *natural selection* (seen as a statistical principle) is not only the red in claw, but also the collaborative exploration of ecospace. This exploration of the ecospace entails the possibility of exploring the ecospace for the sake of others. Particularly for humans, there may be such a call, not only for actively changing the world (in human terms, to take up God's call for adopting the mantle of wise stewardship over creation), but also for restraining oneself against seeing the environment as existing only for human purposes, as a resource for humans, instead of seeing creation as having value and worth in and for itself.

From the perspective of the internalist model of divinity developed above, God apparently chooses to pass on power to his creatures. Creating means not only producing but also letting-be. Hence, if human beings really have a special role to play in participating in divine creativity, they should also participate in the divine enjoyment of what is, and what comes to flourish. In the biblical traditions, this duality of the human situation is expressed by the divine call to subdue *and* tend the garden (Genesis 1 vs. Genesis 2). The point may be that a blessing not passed along soon dries out; that the light which does not radiate dims and dies out; and the joy that will not be shared becomes dull.

This reflection casts a light on the widespread reference to human beings as the "ultimate niche constructors" (Odling-Smee et al. 2003, 3). From a theological point of view, humans are only penultimate niche constructors, and they are to be seen as niche constructors in principle on a par with earthworms and beavers—only with a wider scope of niche constructing capacities, and also with a wider call for self-restraint on behalf of others. Exploring the ecospace should go hand in hand with a self-limitation for the sake of other forms of niche construction. In this way, the power to create by intentional design brings with it the responsibility to constrain oneself so that human creativity is practiced wisely, not just for humans, but for creation's sake in and for itself—accordingly, giving it room to be, and to create, itself. After all, culture matters.

This is so, at least from a theological perspective. If God is creating the universe by letting it be, and if humans are somehow still called to be living images of the divine, there should be a similar sense of caring for others, also by letting others be what they are. Otherwise human beings may look more like zombies than images of God. Zombies are mindless in their consumption. They eat and eat without ever being satisfied, without enjoying, and without ever being still. The zombie never reflects on its consumption, its consuming is compulsive and knows no limit. It reaches no equilibrium with its environment, and it recognizes no limits to its consuming. This is the kind of consuming that not only eats up its own nourishment, but it eats up the nourishment of everything around it, until there is nothing left for anything to eat, including itself. Similarly, humans, who self-designate as the ultimate niche constructors, could well end up being the ultimate self-destructors. After all, nature could do well without humans. But humans can't do without nature.

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