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Organization Environment published online 9 November 2011
DOI: 10.1177/1086026611425689

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Organization & Environment
XX(X) 1–24
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DOI: 10.1177/1086026611425689
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Towards a Deeper Philosophy of Biomimicry

Freya Mathews[1]

Abstract

Biomimicry as a design concept is indeed revolutionary in its implications for human systems of production, but it is a concept in need of further philosophical elaboration and development. To this end certain philosophical principles underlying the organization of living systems generally are identified and it is argued that not only our systems of production but also our psychocultural patterns of desire need to be reorganized in accordance with these principles if we are collectively to achieve the integration into nature to which biomimicry aspires. Even were this reorganization to be effected however, there is still an ethically momentous ambiguity in biomimicry that needs to be teased out before we can be assured that biomimicry will indeed produce the bioinclusive sustainability outcomes that it seems to promise.

Keywords

dualism, biomimicry, sustainability, *wu wei*, conativity, synergy, "genetic architecture," bioinclusive

The advent of the notion of biomimicry in design circles and the vision of a second industrial revolution based on it has, I shall argue, moved us closer to the goal of planetary ecological integrity than the traditional environment movement ever managed to do. Biomimicry is indeed a revolutionary concept. However, it is still relatively philosophically underdeveloped, descriptive, and ad hoc in its approach and accordingly piecemeal in its results. Moreover, critical ambiguities lurk in this concept. Until these are brought to light and resolved, biomimicry remains vulnerable to co-optation by as powerful an anthropocentric mentality as that which launched the original industrial revolution and ravaged, in our time, the living constituency of the biosphere. In short, a deeper *philosophy* of biomimicry is currently needed, and in this article I shall take some steps toward providing one.

But first, let me backtrack a little, and start by considering the traditional project of environmentalism. This was in its essence a project of protecting or preserving, restoring, or conserving the natural world or nature. This seems straightforward enough, and to this day just about everyone probably feels that they understand what is intended by it. But *nature* has turned out to be a very tricky concept. In the environmental context it was generally defined in contradistinction to the exclusively human domain of culture: "the natural" was contrasted with "the human" or "the cultural." Nature comprised those classes of living things or systems that had come into existence

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independently of human intention—those that lay, in other words, beyond the realm of artefact. Environmentalism traditionally sought to protect such things or systems.

Understood in this traditional sense, environmentalism had its roots in both the nature *conservation* movement of the early 20th century and the nature *preservation* movement of the 19th to 20th century (Rodman, 1995). Nature *conservation* sought to conserve "natural resources," such as timber, minerals, soil, and water, for the use of future as well as present generations of human beings. Environmental management, from the conservationist point of view, consisted in maintaining ecosystems in states productive for human purposes. Nature *preservation*, on the other hand, sought to save landscapes—sometimes described as wildernesses—that had not yet been unduly disturbed by human activity. From a preservationist perspective, environmental management consisted in maintaining undisturbed ecosystems in their original condition or restoring disturbed ecosystems to something resembling the condition they had been in prior to human intervention. In the West, both strands of environmentalism, and the forms of environmental management associated with them, continue to the present day. The resource conservation strand prevails in government agencies such as those concerned with forestry, soil conservation, water, fisheries, and mining. The preservationist strand persists in the ethos of national parks and nature reserves and, more latterly, in the notion of biodiversity conservation.

There has been much criticism of both strands, and each has roundly criticized the other (Devall & Sessions, 1985; Rodman, 1995) Resource conservationists are accused of valuing humanity to the exclusion of nature, treating nature as existing only to service humankind, devoid of interests of its own.[1] Such conservationists are described as *anthropocentric*, meaning that they regard humanity as the exclusive locus of moral significance. Preservationists are charged with the contrary error; inasmuch as they regard landscapes as of less value or as "spoilt" when modified by human activity, they are accused of valuing nature above humanity.[2] Preservationists are said to be *biocentric* in their ethical orientation, in the sense that the larger life system is for them as morally significant, in its own right, as humans are. They do not deny intrinsic moral significance to humans as anthropocentrists do to nature, but given that it is nature, at the present time, that is under grievous attack by humans, it is fair to say that biocentrists generally are on the side of nature.

It is clear from these remarks that there has been a split in traditional environmentalism between those who are truly for nature, in the sense of valuing it for its own sake, and those who are for humanity, valuing nature only as a resource—in Heideggerian terms, as a "standing reserve" for us. Those who are for nature may be said to uphold an *environmental ethic*, an ethic of and for nature. Those who are for humanity at the expense of nature may be said to lack such an ethic. This way of dividing up the moral field—between the anthropocentrists and the biocentrists—is, however, in many ways unsatisfactory. To take an unqualifiedly anthropocentric stand seems to bespeak moral deficiency—it is hard to deny that many, if not most, other living beings share moral qualities with us. Three decades of environmental philosophizing have made a very strong case that they do.[3] But if on the other hand one aligns oneself relatively unilaterally with nature, as some biocentrists do, one is strategically marginalized, doomed to fight a losing battle, since humanity clearly has the upper hand in the struggle for the earth today.[4]

This split between biocentric and anthropocentric approaches, which has structured but at the same time vitiated the traditional project of environmentalism, emanates from the notion of nature on which environmentalism has rested. The problem with this notion of nature lies, of course, in its crude dualism: Nature is defined as that which stands in contrast to humanity.[5] It is this crudely dualistic definition that sets us on one side or the other of the divide, lining us up as either for nature or for the human.

What seems to be needed to avoid this standoff is an inclusive conception of nature, one that accommodates both the human and the nonhuman components of the greater life system, without

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collapsing the distinction between them.[6] An environmental ethic which somehow places humans and nonhumans in the same moral camp might then be derivable from it. An environmental ethic such as this could be described as *bioinclusive* as opposed to biocentric, implying that even if it is conceded that our moral reasoning starts within the human circle, this circle needs to be expanded to include the interests of the members of the larger life system. A new definition of nature that resituated the human inside nature might help effect this moral inclusion.[7]

Under the banner of biocentrism, many ecological philosophers have already tried to resituate the human inside nature, but their attempts to do so have served to reinscribe, even while reversing, the old value dualisms. Such philosophers, including many deep ecologists, have re-visioned the human self, peeling away the layers of culture and the trappings of artifice to reveal the underlying condition of the human as animal, as organism, as species, enmeshed unavoidably in ecological relations with other species and with the biosphere at large. Such philosophers have emphasized that the human self is ultimately an ecological self.[8] The ecosystem is the ultimate moral community of the ecological self and ecocentrism is its appropriate moral orientation. But notice how this way of resituating the human quietly privileges the terms of the natural in an implicit differentiation of the natural and the cultural. In order to bring humanity inside the circle of nature it has been necessary, for these philosophers, to strip humans down to our ecological essentials, minimizing the impulse toward artifice—and by implication toward self-intentionality and self-meaning—that make us distinctively human. The ideal *modus vivendi* for the ecological self, from the perspective of biocentrism, is implicitly that of a primitive hominid living in small, technologically minimal communities immediately dependent on an otherwise untouched nature. In other words, the ecological self is a natural self on the far side of the culture/nature divide.

For most people in contemporary modern societies, such absorption into nature is—understandably and perhaps rightly—too high a price to pay for an environmental ethic, and they eschew biocentrism in practice even if they feel morally attracted to it in theory. If humanity is to be resituated inside nature, in the interests of bringing humans and nonhumans into the same moral camp, then this must be achieved without reducing the human to the terms of the dualistically defined natural. In other words, it must be achieved in a way which opens up the terms of the natural so that they can become inclusive of the artefactual.[9] Artefact must be seen as a potential expression of the natural. Nature will then no longer be understood as that which is untouched by us but rather as something deeper, something which can at least potentially be expressed in our handiwork just as it is expressed in the handiwork of the spider or the bee.[10]

To arrive at such a new, relatively nondualist conception of nature requires that we look beyond the traditional environment movement. But, as it happens, such a deeper conception of nature is already to hand in certain current notions of *sustainability*, which are in process of taking over from, and subsuming, older, more dualistic versions of environmentalism. Advocates of sustainability in this more recent sense argue not so much that we should *minimize* our artefactual production, so that its ecological impact is reduced, as that such production should be rendered consistent with the ecological fabric of the greater life system. Humanity should not merely curb consumption, reduce population, and generally adopt as far as possible a hands-off approach to nature, as earlier generations of biocentric environmentalists insisted, but rather should aim to integrate socioeconomic processes with ecological processes. Advocates of this particular notion of sustainability have been arguing that we should actually model all our production (artefacts, the built environment) and the organization of all our systems (agriculture, forestry, mining, manufacturing, architecture, and urban planning) on nature, understood in this new, less dualist sense. Our material culture should be created in accordance with the same design principles that shape the kind of natural entities and systems that have been naturally selected, in the course of evolution, for their adaptiveness vis-à-vis their environment. In this way human activities can be

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blended back into natural systems. The aim, again, is not so much to *reduce* our impact as to make that impact *generative* for nature.

This is the design philosophy currently going under the name of *biomimicry* or biological design, associated with thinkers such as biologist, Janine Benyus and economists, Amory and Hunter Lovins. Benyus defines biomimicry as "a new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems, eg a solar cell inspired by a leaf." She adds that biomimicry is also "a new way of viewing and valuing nature. It introduces an era based not on what we can *extract* from the natural world, but on what we can *learn* from it" (Benyus, 2002a, front pages). According to Benyus, nine principles can be identified as underlying nature's designs. Nature, she argues, (i) runs on sunlight, (ii) uses only the energy it needs, (iii) fits form to function, (iv) recycles everything, (v) rewards cooperation, (vi) banks on diversity, (vii) demands local expertise, (viii) curbs excesses from within, and (ix) taps the power of limits (Benyus, 2002a). If we designed our industry and our built environment in accordance with these principles, Benyus suggests, we would be well on the way to living within the ecological limits of nature, and thus achieving our goal of sustainability.

Examples, cited by Benyus and others, of products and systems designed along biomimetic lines include the self-fastening fabric, Velcro, designed in 1948 by a Swiss engineer who observed, when brushing his dog, the mechanism by which burrs clung to the dog's fur; a "smart" clothing fabric composed of "scales," which open in warm conditions and close in cold conditions, where this fabric is modelled after pine cones, which open and close according to temperature; external paints that, once applied, are self-cleaning, modelled after the lotus leaf, the bumpy surface structure of which is such that dirt particles cannot stick but are rolled off by rain drops; buildings that imitate the structure of termite mounds in order to cool themselves, termite mound temperature being maintained at a constant 87°F by an internal chimney effect, so that funguses can be farmed by the termites inside the mounds; fabric that can be stuck to furniture and peeled off when in needs of replacement, the adhering mechanism being inspired by geckos, whose foot pads adhere to surfaces without glue, using small doses of static electricity.

Benyus points out that it is not enough that products themselves be designed from nature. The infrastructure and processes by which products are produced likewise need to follow natural design. So, for instance, industrial plants and large engineered systems, such as sewerage treatment plants, should generate their own energy and convert their waste streams into resources either for ecosystems (waste water, for instance, can be purified by wetland systems that can provide habitat for birds and aquatic organisms) or for industry.

An example of such an industrial plant is a brewery near Tsumeb in Namibia that has been designed for zero emissions. Breweries traditionally have three inputs: water, hops, and barley and four outputs: beer, spent mash, waste water, and carbon dioxide. Normally the mash goes to landfill or is used as low-grade cattle fodder with high methane outputs. In the Namibian case, however, it is used to grow mushrooms. In the process of growing mushrooms, the spent beer mash is converted from indigestible cellulose into protein, which is then used to cultivate earthworms, which are in turn fed to chickens. The waste water, which is alkaline and would normally have to be chemically treated, is used for the cultivation of spirulina algae, which is a high-grade 70% protein foodstuff. The residual water is then channelled to fish ponds for fish production. Multiple species of fish and other aquatic life are cultivated to mimic an ecosystem and ensure pond health. The fish are nourished by the mushroom/earthworm/chicken waste-streams. Moreover, the chicken manure goes through a digester and produces methane gas, which is used to fuel the brewery operations. In a country desperately short of water and food, the brewery produces not only beer but also mushrooms, chicken, spirulina algae, and fish; it generates fuel

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for its own operations and wastes not a drop of water. It has higher revenues and employs more people than comparable companies (Mshigeni, 2001; Saunders, 2000).

All these processes, as Benyus says, are "sweetening" the earth: "Life creates conditions conducive to life in everything it does, besides just meeting its own needs" (Benyus, 2002a)

This principle is also illustrated by designer, William McDonough, who points out that the total biomass of ants on earth is greater than the total biomass of humans, yet no "pollution" or ecological degradation results from their activities (McDonough, 2002). Ant activities feed back nutritiously into the ecosystems that support them. McDonough is confident that human productive activity can be designed to achieve the same end. The scale of human consumption is not the problem, so reducing industrial output is not the solution. The *redesign of industrial production*, so that it regenerates nature rather than depleting and degrading it, is the solution.

Now this surely is a turning point in Western thinking. Benyus, McDonough, Lovins, and Lovins all describe it as the "next industrial revolution," and this is hardly an exaggeration. For though the moral regard for nature it presupposes preserves the thrust of earlier biocentric philosophies, this new thinking no longer implies a return to preindustrial, small-scale forms of society, as earlier biocentric moralities often implicitly did, but rather renders a bioinclusive ethic compatible with the industrialism of modern mass societies. If implemented, it would change our world beyond recognition.

However, at its present stage of development the notion of biomimicry is still relatively ad hoc. Nature is identified in terms of the design strategies of particular plants and animals and their life systems, and we are enjoined to emulate those strategies in our own design practice. The nine principles that Benyus enumerates are descriptive but not explanatory. Observations such as that "nature runs on sunlight," for instance, and that nature "banks on diversity," are handy rules of thumb for designers, but in no way render nature intelligible to us—they do not fit together into an intelligible order. Only when we have understood *why* nature runs on sunlight and *why* it banks on diversity can we truly get inside the mind-set of nature, so to speak, and start designing our world, nondualistically, from inside that mind-set.

Principles Underlying Biomimicry

So can we identify any deeper, necessary principles in nature that in some sense render the design principles enumerated by biomimicry theorists intelligible? There may be many such principles, but I can think of two. The first I would call the *principle of conativity*. It asserts that all living beings and living systems act in accordance with a will or impulse to maintain and increase their own existence. In contemporary systems theory the capacity for self-actualization is referred to as *autopoiesis*, but I prefer the term *conatus* or *conativity*, as it has a longer philosophical lineage and is not confined to the terms of reference of any particular branch of science, such as systems theory. The Jewish philosopher, Benedict de Spinoza, for instance, writing in the 17th century, defined *conatus* as the will wherewith everything strives to persevere in its own existence. Conativity directs the activity of organisms and larger life systems, and it is this directed activity, within the context of particular environments, that gives specific shape to organisms and living systems.[11]

Such striving, or self-directed effort to resist inroads into one's integrity and preserve one's own existence, may be taken as a defining characteristic of all living things. To impute conativity to living systems, however, need not imply that conativity antedates the mechanism of natural selection in determining the form and functionality of organisms. The conativity of organisms may itself be understood as a primal product of natural selection though also thereafter as a sine qua non thereof: Without the intentionality implied in conativity—the *will* to preserve their own

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existence (however dependent on prior causes that will might be)—organisms would no more evolve than rocks and stones do. (Whether or not intentionality must be understood as entailing consciousness is a question that does not need to be resolved in the present context. Certainly it entails more than can be analysed in purely extensional terms but this need not imply full-fledged consciousness. For an account of intentionality that partakes of the mental but not necessarily of the conscious, see Plumwood, 1993.)[12]

However, there is another hallmark of living systems. It pertains to the very particular *manner* in which they pursue their conative ends. They do so in a way that involves the least expenditure of effort on their part. I propose to call this the *principle of least resistance*. Whenever organisms meet resistance they are inclined, if circumstances permit, to turn aside, seeking to avert obstacles rather than meeting them head-on. Of course, there will be circumstances where the conative goal of an individual is itself to engage in combat—with a sexual or territorial rival, for instance. In such cases, the organism will not turn aside, but will still be likely to observe the principle of least expenditure of effort in its manner of fighting: Like a good martial artist, it may, for example, seek to turn the manoeuvres of its opponent against it. Generally though, an organism will pursue its ends in ways that least provoke resistance to its activities. Ways that least provoke resistance are logically likely to be ways that least thwart the conativity of others. The path of least resistance is thus a path by which one seeks to fulfil one's own conativity while, as far as possible, accommodating the conativity of others.

That living systems are shaped by the twin principles of conativity and least resistance can be asserted with some confidence because their doing so is a matter of logical necessity rather than mere empirical contingency. This is a necessity arising from the logical dynamics of evolution. Organisms endure because they make active (conative) efforts to endure, and are hence not dissolved by the causal processes that would otherwise continuously make inroads into their physical integrity. And organisms that succeed in fulfilling their conative ends while least provoking resistance on the part of others will be those best able to conserve their own energy, leaving them with greater energy to invest in other forms of self-maintenance and self-increase relative to organisms whose activity provokes greater resistance. They will also best conserve their environment, in the sense that their activities will least compromise the conativities of the other elements of their life-support system. The path of least resistance is in this sense the logical path for conative entities to follow, so it is the path that will be naturally selected for them: They evolve an existential disposition that leads them to favour this modality.

It is on account of this necessity that conativity and the modality of least resistance are, I am suggesting, key features of living systems. To recapitulate, living systems actively strive to persevere in their own existence and they choose to do so, logically enough, in those ways that least deplete their self-energies. These will generally be those ways that least provoke resistance from others—ways, in other words, that are most consistent with the conativity of others. Indeed, the most effective way of preserving one's own existence is to weave one's own conative ends into the conative goals of others: By making oneself integral to the existence of others, one induces them to do at least part of the work of preserving one's own existence, thereby further conserving one's own energy. The two principles—of conativity and least resistance—are beautifully orchestrated in living systems, and are particularly exquisitely exemplified in stable ecosystems.

As living systems ourselves, we humans are also essentially conative beings: Our fundamental impulse is to strive to preserve the integrity of our own existence and maintain ourselves in existence. In this respect, we are inalienably "part of nature." However, because we are endowed with reflexive awareness, we can reflect on our own nature, and, by reflecting on it, modify it. Conativity—the will to realize and preserve our own existence—will remain our fundamental impulse, but the "existence" to which we are dedicated will now be conceptually mediated rather than merely corporeally given. We can choose our ends in accordance with our discursive

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systems, where these of course vary from culture to culture. This means that the ends appointed by specifically human (i.e., conceptually mediated) conativity may not conform to the principle of least resistance: These ends may clash with the ends of others. Our *ways* of pursuing these ends may also depart from the path of least resistance. So even if it is natural for us, as living systems, to follow the path of least resistance, as living systems with reflexive awareness we do not have to do so. We may, in accordance with our discursive frames of reference, conceive of and commit to ends quite inconsistent with the ends of others. And we might choose to pursue our ends in ways that, far from accommodating others, cut directly across their conativity, trading off the effort needed to deal with resistance, on one hand, against immediacy of gratification, for example, on the other. In this respect then, humans, as living systems endowed with reflexive awareness, can choose to depart from the principle of least resistance and act instead in an "impose and control" mode, that effectively places us "outside nature."

It is worth noting that humans, and any other beings on earth or in the cosmos endowed with reflexive awareness, are in this sense distinct from the rest of nature, as dualism averred. However, *dualism* is scarcely an appropriate term for the kind of distinctness that is indicated here, since dualism connotes the division of a prior whole into two substance- or attribute-parts, such as mind and body or mentality and physicality. Reflexivity does not have this connotation. The peculiar characteristic of the reflexive being is not *mind*, which may be distributed widely, indeed universally, across the original whole to which the being belongs, but the capacity to reflect on the mind's representation of that original whole. The reflexive being "lifts," so to speak, its representation of the world out of the world, in order to examine it. Its reflexivity is like a transparent layer of mind that can be peeled back and in this sense separated from the original unity of mind and world. Once thus peeled back, the ideal representation of world can be mentally manipulated—negated, rearranged, embellished. In this process new possibilities come into view. The reflexive being can envisage alternative orders of things, and, in due course, act to actualize those alternatives, thereby departing from the conative template laid down by nature.

Reflexivity then confers a certain freedom from nature while not signifying a real separation from nature. The universe which allows of reflexivity would perhaps better be described as an *iterative* universe than a *dualistic* one, intrinsically mental as well as physical in nature but affording successive mental repetitions of itself. Such iterativity is not incompatible with unity, but instead reproduces that unity at different levels of abstraction.

Nonetheless, the freedom that reflexivity confers translates ultimately into a capacity to choose either to preserve the physical structure of the existing world or destroy/replace it. In the course of human history, societies have by and large conformed to the conative template laid down by nature, recognizing the wisdom of the way of least resistance, and developing modes of practice more or less in accord with it. Deviations from this norm have also occurred however, whenever societies, or elites in societies, have been able to collar forces external to themselves to do their will. So, for instance, civilizations have sometimes been built on the labour of slaves, who have been treated as external to the social corpus, as a kind of battery for powering activities which are accordingly undertaken very much in the imperial, impose-and-control mode rather than the mode of least resistance.[13] In modern civilization, science has provided, at least until the present time, virtually unlimited supplies of energy—in the shape of electricity and nuclear power, for example—that have made it p]ossible for us to act in the impose-and-control mode with apparent impunity. We have been able to afford massive expenditures of energy in pursuit of even the most trivial of ends. Since that power has been derived from external energy supplies, and has not been drawn from our own life-force, we have not been corporeally self-depleted or self-decreased by expending it. Hence, this pattern of action has not so far been eradicated by natural selection despite cutting against the grain of nature-as-least-resistance. We have managed to impose on other species and systems in pursuit of our human goals without corporeally depleting ourselves—and

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hence without suffering the usual selective consequences of impose-and-control behaviour—only because the energy we have been using to do this has not been our own. However, self-depletion was only one of the selective consequences of the impositional mode; the other was the depletion of the environment that sustains the imposer. The imposer selects itself out of existence by thwarting the conativities of the systems that support it. In modern societies, such thwarting is indeed taking place, continuously and on a grand scale, and the larger life systems that support us are indeed becoming gravely depleted. This is the explicit face of the crisis we face today.

As reflexive beings we can grasp the logical force of the conative template laid down by nature and choose to reconform to it. We can seek—after observing how modern departures from this template have deranged our environment—to realign ourselves to the conative contours of the original psychophysical unity to which we manifestly belong. We can do this, I am suggesting, not merely in an ad hoc way, via strategic imitations of biological specimens, but rather by seeking in our activities generally to direct our conativity along the channels of least resistance.

When least resistance becomes our habitual modality in every circumstance, we can trust that it will continue to be our modality in "environmental" contexts. And we can trust that in environmental contexts, any exercise of our agency that follows the path of least resistance will be environmentally optimal, whether or not it reproduces the specific design features of any existing life system or is explicitly directed toward environmental ends. It is in fact important that we try to get rid of the distinction between environmental and other ends, or environmental and other contexts. The need for "environmentalism" is the end-result of a process that began with a fundamental modification of our agency. At the moment we chose to release our agency from the requirement of least resistance, we departed from the way of nature. To realign ourselves with nature, as sustainability ultimately demands, is to rediscover, in a contemporary context, the pathways of least resistance, and to commit our agency, quite generally, to them.[14]

Benyus gestures toward the path of least resistance in her second principle, "nature uses only the energy it needs." That this is a fundamental principle, one which provides an explanatory key to the others and to the modus operandi that defines nature generally, needs to be emphasized. Conativity, the impulse toward self-existence and self-increase, is absent from Benyus's list. Together however, these two principles, properly understood, provide a *philosophical* basis for biomimicry and hence for sustainability.

Wu Wei

Many traditional societies, lacking inexhaustible external supplies of energy, tended, as I have remarked, to be attuned to the way of least resistance. This "way" was particularly enshrined in ancient Chinese society via the tradition of Daoism (Girardot, Miller, & Xiaogan, 2001), "Dao" of course meaning precisely "Way," and the modality of Daoism, *wu wei*, being a way of least resistance. In order to enrich our present understanding of the notion of least resistance, let us take a look at Daoist cosmology.

According to the early texts in which the foundations of philosophical Daoism were laid down (the *Daodejing* and the *Zhuangzi*), the Way is a way of flow. The elements of nature (the "Ten Thousand Things") are really patterns in an underlying flow. These patterns form and re-form under the influence of the patterns forming and re-forming around them. This is, in other words, an order of mutual arising, a symbiosis in which no particular form or pattern can emerge independently of the forms or patterns resolving and dissolving all around it. Moreover, when the Ten Thousand Things are left to arise spontaneously in this way, under the mutual influences of one another, the universe assumes *its* own proper pattern or form—it follows *its* proper course.

The kind of order that Dao manifests then is an order of flow patterns. The flow patterns that are observable in water or wind or indeed in any field of energy are always graceful and beautiful

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and somehow effortless, regardless of what disturbances or obstacles are introduced into the field of flow. This is because such flows always follow the lines of least resistance. Water flows downhill. It fills the lowest places first. It flows around obstacles rather than trying to surmount them. If trapped it waits patiently until an opening occurs and then it starts to flow again. It makes no judgments or discriminations about where it will go. It just goes where the going is easiest. This is a theme to which the *I Ching* returns again and again:

> It flows on and on, and merely fills up all the places through which it flows; it does not shrink from any dangerous spot nor from any plunge, and nothing can make it lose its own essential nature. It remains true to itself under all conditions. (Wilhelm, 1964, p. 115)

It makes no effort, which is why the idea of flow is equated with effortlessness. Flowing into whatever spaces are available, finding a way around obstacles rather than contending with them, insisting on nothing, but nevertheless, by dint of continuous adaptation to whatever presents, unwaveringly achieving its end, the river makes its way down to the sea. In wending its way thither and thereby achieving its own destination, it simultaneously assists others in achieving their ends, sustaining the entire landscape with its waters, giving life to all things. "Doing nothing" then, the river ensures that everything is done, that its work of sustaining the world is accomplished. (As Laozi observes, "the thousands of things depend on it for life, it rejects nothing. . . . It clothes and feeds the thousands of things, but does not act the ruler" (Lafargue, 1992, p. 138.)

If one is to follow Dao, allowing everything to take its own course, it is necessary to adopt the modality apposite to Dao, namely that of *wu wei*, meaning nonaction. *Wu wei*, as set forth by Laozi in the *Daodejing*, proceeds by harnessing forces or patterns of energy already at play in the world, and letting them carry us to our destination: "Nonaction" denotes not inactivity but activity taken with rather than against the grain of existing conativities. One who is committed to *wu wei* in this sense seeks to solve problems not by confronting them head-on but by allowing himself or herself to be carried along by ambient conativities. Zhuangzi illustrates *wu wei* via the story of an old man who falls into a river and is carried by the rapids to emerge downstream unscathed, having rolled with the waves and currents (Giles, 1889).

However, there is an ambiguity in the Daoist notion of *wu wei* that is worth teasing out here. In the first sense—which we might call the passive sense—the agent takes the world as he finds it. He harnesses conativities already at play in the world in order to achieve his own conative ends: The old man crosses the river by riding currents that are already flowing toward the opposite bank. In the second sense—which we might call constructive—the agent creates a setup (*shi*, in Chinese), such that, relative to the setup, events will spontaneously unfold—of their own volition—toward the agent's desired ends. The idea here—explained at length in a brilliant study of *shi* by Francois Jullien, *The Propensity of Things*—is that if one gets the setup right, one will not have to *impose* on things in order to achieve one's desired outcomes. Things will proceed toward those ends or outcomes of their own accord, out of their own nature. So, for instance, according to the ancient military strategist, Sunzi, a good general's strategy is put in place so far ahead of battle it is not even visible to the enemy and makes actual fighting unnecessary, or, if battle is waged, victory inevitable. As Jullien explains, Sunzi likens *shi* to the disposition of stones: Stones placed on flat ground do not move of their own accord, nor do square stones placed on a slope. But round stones placed on a slope roll of themselves. So *shi* here includes the shape of the object and the gradient of the ground. A military strategy must work like the round stones on the slope: Once put in place, the outcome of the strategy is inevitable. No further effort will be required on the part of the general's force (Jullien, 1999).

Both these modalities are modalities of least resistance, and hence qualify as versions of *wu wei*. However, it is clear that *wu wei* in the second sense is, indirectly, a modality of control: The

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agent actively manipulates initial conditions so as to bring about the end-result he desires. But this is a form of manipulation which, unlike the impose-and-control modality that has prevailed in the modern West, does no violence to the things manipulated. In setting things up to unfold according to their own conative ends, the agent does not oppress or obstruct or distort the things in question. Indeed, it is important to his or her purpose that they are unaware that they are being set up. So no harm is done.

In an environmental context, the distinction between the passive and constructive versions of *wu wei* might be illustrated as follows: One might feed oneself by *wu wei* in the passive sense simply by gathering the provender of wild forests or fields. To feed oneself by *wu wei* in the constructive sense, one might instead engage in horticulture but in accordance with organic principles that rely on natural processes of fertilization, germination, pest control, and so forth, thereby minimizing the further human input required. Most instances of biomimetic design exemplify *wu wei* in this latter, constructive sense.

Synergy

Although *wu wei*, even in the constructive sense, is environmentally vastly preferable to the modality of impose and control, it may not enable us finally to attain our goal of full sustainability. *Wu wei* enables us, as free riders on the life system, to make use of that system without harming it and at minimal energic cost to ourselves. However, the system itself would not survive as a system if all its elements were free riders in this way. In order for the system to cohere as a system it is necessary not merely that no element harm the system in the course of its activities, but that each element contribute something to it. In other words, the conativity of each element must be such that, in seeking its own ends, it simultaneously helps other elements achieve theirs. There is a *mutuality* of conativity amongst the elements of the system: In pursuing its own desires, each element seeks also to accommodate the desires of others. At the limit this mutuality attains a degree of codetermination that could properly be termed *synergy*, synergy being the process whereby two parties join their conativities to create a new end which subsumes, but at the same time enlarges, the respective conativities of each party.[15] Synergy is a *recursive* function: Each element of a synergistic system does indeed harness forces or patterns of energy already at play in its environment in order to achieve its conative ends, but its ends are in turn shaped by those forces or patterns. True, there are generic ends: All organisms have to eat, for instance, and most have to mate. But *what* each organism eats, and *how* and *with whom* it mates, will be determined by who and what is out there in its environment. The specificities of its conatus will be dictated by the specificities of the conativities of the other elements of its context. In the larger life system it is thus not a matter of the design of an organism being selected, in accordance with the principle of least resistance, to serve that organism's preestablished ends. It is rather that both ends and design are dictated by the opportunities and limitations afforded by the specific environment of the organism.

If we as human beings are to "act from within nature," as the ethos of biomimicry implies we ought, then the requirement of recursiveness applies to us, to our agency. We must allow our ends as well as our means, our designs, to be shaped by who and what is out there in our environment. Under current interpretations however, biomimicry takes our ends as it finds them in our consumer society, and merely looks to "nature" for the "design solutions" that will enable us to attain those ends with less rather than more disruption to the life systems of planet-earth. From the present point of view, this is far from enough: Nature is not merely a storehouse of readymade designs available for us to mix and match to our consumer purposes. Nature is a fully recursive modality, and if we want to fit in with nature, we need to let nature design *us* as well as our

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instruments. That is to say, we need to allow the wider life systems to *dictate our desires*, as well as provide design blueprints for the means we use to achieve those desires.

To take this further step, from the nonintrusiveness of means implied in *wu wei* to the mutuality of ends implied in synergy, is not to depart from Daoism, but only to embrace Dao in its larger contours. As the pattern of enfolding and unfolding that flows through all things, *Dao* is internalized in each individual as *de*, the power or potentiality of that particular individual to manifest in accordance with Dao. That is, while Dao denotes the unfolding of things at the cosmological level, *de* denotes the power of a particular thing to unfold itself in accordance with Dao. The *de* of an individual is the specific form of its desire when that desire has been shaped by reference to the larger life system.[16] Our task then is not merely to observe the workings of Dao in the world but to discover our specifically human *de*. This involves making ourselves available for conative reconfiguration in synergy with the conativity of the larger life system.

Degrees of Sustainability

It is possible then to understand "nature" not substantivally, in terms of things which exist independently of human intention, but modally, as the collective pursuit of conative ends in accordance with the principle of least resistance. To imitate nature then, as biomimicry requires, is to adopt this modality. A certain sensitivity to the self-directed patterns-of-unfolding of others is needed if we are to follow the principle of least resistance. This sensitivity can operate at different levels. The greater the sensitivity, the less resistance the agent will encounter, and consequently the more fully he or she will, by definition, be integrated into nature. These different levels of attunement correlate with different modes of agency and these modes of agency define different levels of biomimetic attainment and hence different levels of sustainability. The modes of agency we have identified so far are letting-be, *wu wei*, mutualism, and synergy. Let us review these modes and the level of sustainability represented by each of them.

In the letting-be mode, the agent pursues his or her ends in ways that simply do not intersect with the self-directed unfolding of others. In the environmental context, this correlates with preservationism, which advocates a hands-off approach to the greater life system, seeking both to preserve undisturbed ("wild") ecosystems and to restore disturbed ones. As I have explained, this older stream of environmentalism emanates from a deeply dualist conception of nature, which has been philosophically superseded by the sustainability movement. (This is not to say, however, that in rejecting preservationism, on grounds that its assumption that nature is only truly nature when untouched by us is illusory, we should not adopt a protective stance toward certain biotic environments. There are many other reasons, apart from the untenable valorization of nature as that which is untouched by human hands, for locking up the few uncompromised ecosystems that still exist on earth—as absolutely vital biodiversity reserves and gene banks, for instance, and as last refuges for the many species on this planet that, though possessing as much right to live and blossom as humanity does, have been driven with relentless injustice from most of their native ranges. Such protectionism, where it is called for, however, is a small (though crucial) part of the sustainability project.)

In the *wu wei* mode, agents pursue their ends in ways that use, without disrupting, the self-directed unfolding of others (classical *wu wei*). As we have seen, *wu wei* can take either a passive form, consisting in a benign kind of free riding on the world-as-it-is (e.g., a seed designed for dispersal by riding on the wind), or a constructive form, consisting in setting things up so that they will unfold toward one's desired end by their own volition (e.g., erecting a windmill on a hill and letting the wind do the work of pumping water out of a dam). Passive *wu wei* seems to correlate with a simplified conception of a hunter-gatherer way of life, and as such may seem

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impractical, except in incidental ways, as a praxis for today's urbanized and industrialized mass societies. (It should be noted however that proposals for the commercial culling of feral wildlife in preference to farming may be instances of this approach, and such proposals may assume real economic significance in certain countries, such as Australia, as we shall see below.) Constructive *wu wei*, on the other hand, is the modality underlying many of the key strategies of the sustainability movement. It is exemplified in the use of renewable sources of energy, such as solar and wind, that are not depleted by being used; in organic and permacultural methods of farming and forestry; and in the so-called "passive design" in architecture, which allows buildings to benefit from the light and heat and rainfall that would pass over or through them anyway. Much biological or biomimetic design also follows the lines of such constructive *wu wei*: The design principles and actual designs it borrows from the larger life system often cleverly exploit, without fracturing, forces or patterns or processes already at play in the environment.

Constructive *wu wei* is thus an indispensable modality in sustainability design, but, as noted earlier, it will not ultimately integrate us into nature, as it is basically a free-rider mode which, though it does no harm, does little or nothing actively to regenerate and contribute to the cohering of the life system. This is obviously not only true of instances of constructive *wu wei* such as renewable energy systems or passive architectural design, but it is also true of permacultural or organic horticulture systems which, on the face of it, seem precisely dedicated to "putting something back" into natural systems, replenishing soils, recycling water, and conserving fertility, for instance. Although such horticultural systems ideally do no harm the ecosystems within which they are located, they typically also do little or nothing to support the native fauna and flora of those ecosystems. Catering as they do to our existing tastes rather than observing the native affordances of a given ecosystem, they generally dedicate the biological resources of that ecosystem to exotic crops that do not contribute to the native profile. In this sense then they remain instances of the ecologically free-riding mode.[17]

For fuller integration into nature we need to proceed to the *mutualistic* mode. In this mode, agents not only pursue their ends in ways that use, without unduly disrupting, the self-directed unfolding of others, but they also ensure that the benefit they derive from others is reciprocated: That is, in seeking one's own ends one chooses means that contribute to the conditions others need in order to attain their ends (mutual *wu wei*).

Such mutualism is, I would suggest, a principal key to the aforementioned "next industrial revolution." William McDonough is a clear exponent of mutualism in design philosophy, so let us return to him. McDonough, like Benyus, the Lovins and other biodesign theorists, argues that products and the built environment should be designed not merely to satisfy needs of ours without impacting negatively on larger life systems but that they should also be designed to create opportunities for those life systems. Our designs will achieve this by imitating functional aspects of these systems. The desires of consumers are in this way turned to ecological advantage. It is not necessary to reduce our industrial output; rather, that output should be designed to give the environment what it wants while also satisfying the wants of consumers. McDonough offers many examples of products that satisfy consumer demand while at the same time nourishing and supporting biological systems. The key to his design philosophy is the elimination of waste, or the conversion of "waste" into resource. Products are designed so that they, and by-products of the production process, can either be returned to the ecosystem as biological nutrient or recycled back into the industrial system as manufacturing "nutrient," that is, resource for further manufacturing. The problem with our economy at present, according to McDonough, is not the mere fact of human production or even capitalist consumerism in itself. It is not human conativity. The problem is that we do not design our products and our systems of production so that they actively contribute to the interests of the natural environment (McDonough, 2002).

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McDonough emphasizes that products should be designed for return not only to "the environment," in a generic sense, but also to the particular local environments in which they will be used. So, for example, if a manufacturer is designing a hair gel, he should ask himself not only "What does the consumer want from this hair gel?" nor only "What does the environment want from this hair gel?" but also "What does the river into which this hair gel will eventually be discharged want from it?" In other words, the designer should think about where the hair gel will eventually end up, and how the hair gel can make a positive contribution—via a pollution-dispersing agent, for example—to this site of disposal.

McDonough is, I think, definitely asking the right question here—what does the *river* want from the hair gel? But his question does not go far enough. The question that needs to be asked is not merely what by-products does the river want from the commodities we desire, but what does the river want us to desire in the first place? What contribution does it need us to make if it is to attain its own creative unfolding? Clearly, the river cares nothing for the way we look and hence for our hairstyle. To the fish, as Zhuangzi pointed out long ago, we all look weird, whatever we do with our hair. ("All men consider Mao Chiang and Lady Li [contemporary ladies of the imperial court] to be eternal beauties," Zhuangzi remarks drily, "but when fish see them, they dive quickly to the bottom; when birds see them, they fly off; and when deer see them, they bolt and run" [Hamill & Seaton, 1998, p. 15].) If we take seriously the question McDonough did not ask—what does the river want its people to want—and start to think about our desires as a condition for the river's self-realization, the desire for hair gel and other such commodities might give way to an altogether different suite of desires. What a river, a world, wants of its people may be not merely pollution-dispersing agents but, I would suggest, an entire culture of engagement, whereby our sense of our own meaning becomes suffused with the meanings that the river, as a living system in its own right and a conative strand of the biosphere, has for itself. Such a culture of engagement is achieved when, in synergy with the river, we no longer think of it merely as *ours* but also think of ourselves as *its*—when we take our place in the river's world, and build our desires, our ends, on that premise.

It is crucial to address the question of what the life system wants us to want if we wish to achieve environmental sustainability, because in the longer term we will simply not be able to devise means which systematically nourish the greater life system unless our ends are cross-referenced to the ends of the other elements of that system. If our ends do not change, if they remain unreferenced to the ends of the environment, it would ultimately be impossible to devise the mutuality of means that McDonough and others envisage. To achieve environmental sustainability then, we need to let the river shape not only our means but also our ends. This brings us to *synergy*.

In the synergistic mode, an agent's conativity is adapted to the conativity of others, so that, in wanting what she wants, she is already wanting something that will directly or indirectly benefit them. This kind of mutual accommodation of ends makes it possible to systematize the mutualism of means I have already described. Without adjusting our ends in this way, it would not be possible to create a systematic mutuality of means: The more arbitrary or ad hoc a set of ends becomes, the more difficult it is to satisfy those ends in mutually enabling ways.

Synergy, or adaptation to the conativities of others and consequent enlargement of the agent's own conativity, can take place in either purely *causal* or *intentional* ways.

In the *causal* case, adaptation to the conativities of others occurs via natural selection or coevolution, as when an animal evolves to want what its environment needs it to want. So, for example, a forest-dwelling bettong (miniature kangaroo) develops a taste for truffles (underground fungus); its digging for truffles aerates the forest soil, thereby benefiting the forest, where this in turn ensures the continued conditions for the flourishing of the fungus. In this case, the

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bettong has evolved to want the very thing that will lead it to do what the forest needs it to do, namely, dig amongst the roots of the trees. It does not want watermelons or chocolate, neither of which could be readily secured in ways that would benefit the forest. It wants what the forest needs it to want.

In the *intentional* case, adaptation to the conativity of others takes place either as a result of deliberation or, spontaneously, as a result of communicative encounter or exchange. The deliberating agent may use the methods of science or natural history to discern the conativity of the forest by closely observing the patterns of its self-directed unfolding. So, for example, ecologists might study forest systems and discover the successional stages—the different vegetation profiles—that characterize the forest's advance to climax or old-growth status. An ecologist who concedes the conative status of ecosystems might infer that this is the end that the forest seeks to realize. It should be noted however that to understand biological systems to the degree necessary for gaining insight into their conative tendencies would require a significant expansion of traditional biological and ecological sciences along more holistic lines. It might also mean the addition of new kinds and methods of "science," kinds and methods that would enable us to discover the conative "signature" of a thing, the particular *style* of self-realization that it brings to the synergistic encounter. Traditional sciences, basically reductive in their thrust, neither recognize nor have the resources to reveal such signatures. The wholesale objectification of natural systems that science entrains leaves no room for the dimension of self-reference in systems that is brought into play in synergy. However we configure this self-reference, it is an essential element in the dynamics of synergy, without which the whole project of adapting our own ends to the ends of the larger life system would make little sense.[18]

Communicative exchange rather than scientific deliberation is likely to provide a more immediate route to synergy: We may discover the conativity of another entity, and adapt our own conativity to its, by direct communication with that entity. By engagement with it, in other words, we might induce it to disclose to us its own sense of itself. This might be achieved via some form of self-expression or self-revelation intrinsic to that entity. So, for example, with vocal species such as birds or whales one might initiate a *musical* encounter. In such an encounter the other party—the bird or the whale—may begin to express its sense of itself, and as the encounter proceeds to the level of synergy, cross-species patterns of sound may be created that express but enlarge the musical signatures of both parties. In this sense, each party will be moulded via the encounter. Our own human conativity will not henceforth be the same as it was. It will have been bent toward the conativity of our musical confreres.

In short, the practice of synergy rests on the assumption that there is more to nature than can be revealed by traditional analytical science. New cultural practices may be needed if we are to find the "fit" with nature that synergy—and, I would argue, sustainability—requires (Mathews 2011). It is not necessary that we be converted in advance to a particular dogmatic metaphysics of nature in order to take up such practices. It is enough that we recognize that sustainability requires some kind of rapport with living systems that is lacking in our current scientistic approach. New communicative practices can be embraced in a spirit of open-minded experiment. If there is indeed a new metaphysics of nature, key to sustainability, to be discovered, then such practices will reveal it.[19]

In conclusion then, synergy represents a new horizon in biomimicry thinking because in the transition to synergy we are moving from a mutualism of means, as proposed by theorists such as McDonough, to a rapprochement of ends: Instead of thinking merely about how to devise technological means for achieving our current consumer ends consistently with the interests of nature, we start thinking about our ends themselves. What should we want? What does the rest of nature want us to want? To practise biomimicry in the deepest sense is, first and foremost, I would venture to suggest, to fathom this. We will never act from within nature until such synergy

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of desires is attained: As long as we retain our current ends we can no more design our society so that it fits into the greater life system than a bettong who wanted watermelon or chocolate instead of truffles could fit into the forest system.

Biosynergy as a Basis for Civilization: A Brief Outline

In broadest outline then, how is a civilization based on synergy with biospherical systems to be envisaged? If biosynergy is defined as the form of synergy proper to biomimicry—namely, productive synergy with ecosystems or communities of species—a biosynergistic system would be one which depended on ecosystems to fulfil our own human purposes though without reducing those systems, instrumentally, to mere means of ours. In other words, biosynergy would involve arranging for existing life systems to serve our ends but only to the extent that their doing so was compatible with their also continuing to unfold toward ends of theirs. Where ends of ours contradicted the conative tendencies of such life systems, those systems could not be conscripted by us. Instead our ends would have to be adapted to theirs.

The details of such a biosynergistic civilization are still far from being worked out. As we have seen, such a civilization was—very faintly—foreshadowed by premodern forager societies, or those of them at any rate that adhered to proto-ecological guidelines. And although it is not entirely clear how the biosynergistic principles of earlier forager societies could be reinvoked in the context of modern mass societies, certain aspects of such a civilization might be as follows.

For provisioning purposes a biosynergistic civilization would rely on bioenergy systems already available in the biosphere rather than replacing these systems with systems of its own. This would presumably mean, first and foremost, as Benyus foreshadowed, a solar economy, since solar energy animates the entire fabric of planetary life systems and can be gathered with little cost to those systems. It would also mean that instead of practising traditional agriculture a society running on biosynergistic principles should as far as possible allow native ecosystems to serve as its primary producers. "Bush foods" (or, in the Australian context, "bush tucker") would in this sense constitute staples in a biosynergistic economy, though it is imperative to qualify this statement with the condition that bush foods would only be harvested to the degree required for the regulation of ecosystems. In other words, the role of human consumers in the ecosystem would replicate that of omnivorous predators, routinely reducing populations of consumed plant and animal species to ecologically optimal levels. (The reason it is paramount to state this qualifier is that the commercial harvesting of "bush meat" in economies, such as those of certain African nations, in which nature is already under attack, is often the last nail in the ecological coffin.[20])

As I remarked earlier, in countries such as Australia where feral and/or exotic species—plant and animal alike—pose major threats to native biological systems, ferals would be the appropriate first targets of any biosynergistic regime of organized foraging. Bypassing such species as objects of consumption is one of the most striking anomalies of present bioantagonistic economies. Australia, for instance, is host to vast populations of invasive feral animals, such as rabbits, goats, pigs, and camels, yet these animals almost never appear on the national table. Instead further ecological damage is incurred, on an even vaster scale, to deliver traditional farmed animals—sheep, pigs, chickens, and cattle, for instance—to the table. Readiness on the part of consumers to switch from traditional meats to feral meats, in much reduced quantities, provides an example of the kind of adaptability required of consumers in a biosynergistic economy, in which two-way accommodation of ends is expected. Biosynergy, we recall, is a two-way street—it not only allows us to act on nature but also permits nature to act on us, trimming our ends to the conative contours of ecosystems.

Clearly an economy even partly reliant on ecology for its primary production will be one in which human demand will have been adjusted to ecological carrying capacity. Ecological

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carrying capacity is here understood to mean the capacity of ecological systems to support human populations without compromising other-than-human constituencies. Biosynergy in this respect is patently incompatible with current levels of human population and, therefore, prescribes the setting of optimal ecological targets for human population.

Insofar as we rely for provisions on bioenergy systems already operating in the biosphere rather than replacing those systems with agricultural and manufacturing systems of our own, we exemplify the forager aspects of biosynergistic economies. But biosynergy is not exclusively a forager modality. It allows us not only to gather produce from preexisting biological systems but also proactively to modify those systems, at least to the extent that such modifications represent a further self-unfolding of those systems rather than their thwarting. So, for instance, we might vary the physical conditions that define the parameters of particular ecosystems, thereby changing those systems, but in a direction we judge to be consistent with their conative tendency.

An arresting example of this approach in land management has been provided in Australia recently by grazier, Peter Andrews (2008). Responding to the devastating degradation of pastoral and farm lands in southeastern Australia, degradation made visible in recent years by unprecedented drought and climate change but invisibly in the making for many decades prior to that as a result of poor land practices, Andrews has startled both farmers and environmentalists with his land management philosophy. His argument is that ecological systems evolve to maintain and increase overall fertility, the capacity continuously to generate and regenerate themselves. Plants are the main instrument of this (in my terms, conative) project of self-maintenance and self-increase: "Plants are in charge," Andrews says. When disturbed and degraded by clearing, draining, or overgrazing, land reacts quickly by growing "weeds." Environmentalists rush to remove weeds and replace them with indigenous vegetation; farmers rush to replace weeds with productive species. Both are wrong, according to Andrews. In growing weeds, he argues, the land protects its groundwater reticulation systems and increases its depleted biodiversity and hence ultimately restores its fertility. We should allow this process to occur, only intervening to slash and mulch the weeds. When, as a result, soil fertility is eventually restored, species useful to humans such as grasses will again appear, though they may not be the same species as those that characterized the original biotic regimes. The new biotic regimes will however be as "natural" as the originals, because they express the conativity of the original ecosystem in altered circumstances.

In arguing that degraded land systems may be repaired in ways that result in biotic regimes that, though altered, are still in a sense a continuation of the original ecosystems, Andrews is not of course condoning practices that degrade land. But it was the fact of land degradation that forced him to ask, what does the land want? Instead of taking as the conative end of the ecosystem the particular biotic profile it happened to exhibit prior to human disturbance, as environmentalists do, he took this conative end to be something more open, more evolving and dynamic, though still organic. That end was, he concluded, basically *fertility*—the water, soil, and atmospheric conditions necessary for the continued and preferably increased re-creation of mutually enfolded, place-inflected forms of life. The land is in this sense, from Andrew's point of view, open to our interventions. It can benefit from interaction with us if our interventions increase its fertility. In short, Andrews argues that we can serve the land even while we are altering it for our own productive purposes, provided our interventions are in accordance with the land's own conative tendencies.[21]

Although primary production in a biosynergistic economy might thus be figured as a responsive but proactive custody of ecological systems, industrial production is more difficult to prefigure. It is hard to see how natural biological systems could, even in synergy with us, produce books and kettles, let alone aeroplanes and computers. For the time being then ad hoc biodesign of commodities, together with the progressive tailoring of our desires to the capacities of natural systems, might have to suffice: We might have to be content with a manufacturing system that

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takes its design blueprints piecemeal off nature's shelf and operates, without further waste or extraction, on a material resource base already carved out by industry, rather than looking to the agency of actual biological systems to take the place of industry. In future, however, we might indeed achieve the purposes currently served by articles such as aeroplanes and kettles by harnessing the agency of natural systems more immediately and processually, without the need for clunky permanent articles of this kind. Or, even more likely, we might find that in a society shaped synergistically by rich cultures of communication with other-than-human forms of life the purposes served by such articles give way to other, more expressive purposes. In either case, from the vantage point of a biologically sophisticated future we might look back on our present era of manufacture as a kind of Dark Ages, an age of obtuse unnecessary clutter, blocking, short-circuiting, and destroying the elegant pathways of agency and efficacy already available in the shape of natural biological processes and systems.

Ethical Ambiguities in Biomimicry

It has to be admitted that the philosophical analysis of biomimicry that I have offered here retains, on closer examination, ambiguities that could render it inconsistent with bioinclusive outcomes. For while I have analysed biomimicry in terms of synergy, it is conceivable that modern societies could develop technical and economic systems that were indeed characterized by internal synergy—an intricate internal cross-referencing and intercoherence of ends—without those ends being the ends of the greater life system. Cities and industries and transport systems designed in accordance with principles of internal synergy and synergy with the geophysical environment might function independently of ecological systems. Indeed they might themselves ultimately come to equate sociofunctionally with ecological systems, with the result that ecological systems might eventually, as mechanisms of planetary self-regulation, become superfluous. Solar cities that photosynthesized might take the place of forests, for example, and industrial "plants" that purified and reticulated water might take the place of wetlands. Manufacturing processes that included food in their outputs and confined production inside closed resource loops might replace traditional agriculture and bypass the need for resource extraction and hence the need for a "natural environment" as a quarry for resources. The physical conditions for life, generically, might, in other words, ultimately be renewed and maintained by artificial, biomimetic global systems that rendered superfluous the biological systems they imitated, with the result that the "planetary life" which these conditions safeguarded would become vested exclusively in us.[22]

This is a real issue in the field of sustainability design: Under the banner of biomimicry or biodesign, diametrically opposed tendencies are visibly in play. On one hand, theorists such as Janine Benyus envisage biomimicry as enabling us to resituate industrial civilization within the ecological limits of the biosphere. She calls for a change of heart, a change in the story we tell ourselves about who we are in the universe—a surrender, in other words, of the Western claim to human transcendence of nature. We have to learn to think of ourselves as "one vote in a parliament of 30 million (perhaps even 100 million), a species among species" (Benyus, 2002a, p. 8), Clearly Benyus assumes that biomimicry is in the service of a bioinclusive ethic, an ethic which assigns moral standing to all the members of this "parliament," as sentient beings with meanings and purposes of their own that deserve our respect and moral consideration.

On the other hand however, there are theorists, particularly in the field of architectural design, who are proclaiming, as key to sustainability, a different kind of nature-inspired design. Termed *organic architecture* or "genetic architecture" rather than biomimicry but nevertheless biomimetic in essence, this is a movement which is biased toward the human and even more promethean in its implications than anything we have yet witnessed in the history of modernity. Armed with

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technologies of morphogenesis derived from genetics, information theory, and computational theory, these theorists prefigure an "autonomous" architecture which self-constellates and self-replicates in adaptation to its environment. The structures emanating from such an architectural practice would be genuinely organic, built from the inside out in accordance with the morphogenetic principles of life itself. They would accordingly be sensitive to context and coadaptive and in this sense internally synergistic—and therefore in principle as sustainable as the life world. There is thus no reason why an entire global urban-industrial civilization designed in accordance with such principles should not usurp the "parliament of 30 million species" altogether, and replace it with a "new nature," a simulated but fully sustainable "nature" exclusively human in its provenance and constituency.

One leading exponent of the new "genetic architecture," Karl Chu, puts the vision this way:

> The morphogenetic approach, which is based on the logic of an internal principle or code that generates morphology, seeks to establish the autonomy of architecture . . . the notion of autonomy that I am proposing with genetic architecture is based on genetic code: a two-fold logic of recursion and self-replication founded upon the principles of computation. It is predicated on recursive unfolding of the morphogenetic potential implicit within a genetic code. . . . Genetic architecture is perhaps the clearest example of the emergence of the will to existence, an unequivocal affirmation of life, including artificial life, in, perhaps, all its modalities. (Chu, 2009)

This will to existence, which Chu describes approvingly as messianic, is a will to actualize "possible worlds"—worlds as coherent and self-subsisting as the original one though disjoint from it, radically alternative to it. It is evidently the mission of genetic architecture to make such alternative worlds—worlds which re-create "nature" from scratch—actual. Genetic architecture then is clearly a new manifestation of the old Baconian dream of autonomy from a pregiven nature, a manifestation more deeply Baconian than Francis Bacon himself. It is the Baconian dream at last rendered properly realizable by the fact that science has now succeeded in "vexing" from nature (as Bacon would have put it) her inmost secret—the genetic code.

This then is a profound ethical ambiguity lurking within the discourses of biomimicry. For some theorists, biomimicry is a vehicle by which we can save the parliament of species; for others it is a vehicle by which we can replace that parliament with a "new nature" of our own design. Both parties agree that we need to resituate ourselves inside nature, but for the former party this translates into moral respect for the beings and systems that currently constitute the biosphere whereas for the latter it translates into respect for abstract principles of self-genesis and regeneration that can clinch the claims of an anthropocentric triumphalism. Both positions seem equally biomimetic: They agree on the generative principles that shape nature and hence underpin biodesign. Both announce themselves, justifiably, as models of sustainability. But, on closer inspection, a difference is indeed discernible between them, a difference that makes the all-important moral difference. Nature, according to the particular philosophy of biomimicry outlined earlier in this article, is a realm of both conativity and least resistance. Conativity is the impulse of living things to preserve and increase their own existence. As such, conativity must be understood as a function of the ontological autonomy and self-directedness of living systems: Living things exist to serve their own ends. It is this self-directedness that, according to prevalent forms of environmental ethics, confers moral considerability on them: Living things are ends in themselves rather than merely ends for others (Fox, 1990; Mathews, 1991; Rolston, 1991; Taylor, 1986). They matter to themselves. On account of doing so they are accredited with intrinsic value or inherent worth, where moral considerability is understood to supervene on this.

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A "new nature" created via human agency might contain systems that are in certain respects self-maintaining and self-replicating, but ultimately such systems would inevitably be designed with human ends in view, or would slot into larger systems so designed. Any conative element of such systems would accordingly ultimately defer to an "extrinsic teleology," to use Keekok Lee's term—the teleology imposed on anthropogenic systems by their instrumentally motivated designers (Lee, 1999, p. 2). Being externally directed in this way, such systems would neither qualify as ends in themselves nor hence as morally considerable, or not at any rate in the same way that genuinely conative systems do.

In this sense, nature, defined in terms of conativity and least resistance, *cannot* be fully replaced by human-designed systems. Natural systems by definition unfold toward their own ends and their moral significance accrues from this essential characteristic. We can simulate nature in respect of least resistance, but we cannot, or have no reason to, simulate it in respect of conativity. From the perspective of the present philosophy of biomimicry then, strategies of biomimesis must start from within nature. Biomimicry affords (synergistic) ways of interacting with natural systems that imitate the ways of nature by reconciling, as far as possible, our own interests with those of the elements of biological systems. Since this is also the aim of an environmental ethic premised on acknowledgment of the self-directedness of natural systems, biomimicry, properly understood in terms of its philosophical fundamentals, essentially implicates such an environmental ethic.

In conclusion, I have argued in this article that biomimicry will not furnish a key to sustainability until we act not only in imitation of nature but also from within, so to speak, the mind-set of nature, where this means allowing nature to "redesign" not only our commodities but also our own desires. Until we, like all other elements of the ecosystem, weave ourselves into nature's synergistic net of desire, wanting what our eco-others need us to want, no amount of clever biomimetic design of our products will ensure the integration of those products into nature. Moreover biomimicry, less-than-fully understood, retains ambiguities that could render it inconsistent with bioinclusive outcomes. If it is not to degenerate into the Baconian nightmare of a "new nature," the ethical import of biomimicry must be acknowledged, the ethical entailment that follows from a philosophical analysis of nature in terms of conativity and synergy. This is an entailment that translates into an ethical commitment to the community of species that currently constitutes the biosphere. To commit to this community of species is not to fix it in time absolutely, to allow it no fluidity of membership around the edges. It is however to declare that our loyalty is to *this* earth community, the one that has myriad ends of its own, ends that it enlarges us to intuit and serve precisely because they are, and remain, other than ours.

Acknowledgments

Many thanks to two anonymous referees for insightful comments on an earlier draft of the present article.

Author's Note

This article contains several passages adapted from Mathews (2006).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Notes

1. This has been the thrust of the deep ecology discourse and comparable strands of ecological philosophy, as found, for example, in the work of Holmes Rolston III, J. Baird Callicott, and Richard Sylvan.
2. Critiques of deep ecology have often charged deep ecologists with misanthropy and with seeking to protect nature at the expense of humanity. For a discussion of these charges, see Fox (1990).
3. There is a huge literature addressing the question of the moral considerability of other-than-human systems and beings. A small selection of classic or particularly useful articles arguing the case would include the following: Routley (1973), Goodpaster (1978), Taylor (1981), Rolston (1991), Leopold (1949), Callicott (1989), Schmidtz (1998).
4. This divide between anthropocentric and biocentric approaches in environmental philosophy did not go unchallenged by scholars in the field. Bryan Norton (1984, 1992), for instance, argued that these perspectives "converge" in the actual practice of policy making since an enlightened anthropocentrism is likely to lead in practice to the same policy decisions as would concern for the moral considerability of nonhuman forms of life.
5. For a classic analysis of dualism in an environmental context, see Plumwood (1993).
6. Authors who have in recent times argued for such an approach to the natural include Thomas Heyd and Val Plumwood. Heyd proposes the idea of a "culture of nature" that would consist of cultural practices designed specifically to enable the flourishing of natural processes in contexts in which these were under threat from anthropogenic processes. One example of such a culture of nature would be the creation of national parks and nature conservation reserves which permitted the continuation of traditional hunting and horticultural activities of indigenous communities. Such activities, Heyd points out, often increase the flourishing of nature, if such flourishing is measured by, for example, biodiversity indicators. Heyd's basic idea is that culture itself may become a tool for the protection and further "cultivation" of nature, and as such, while it may be conceived as distinct from nature, it need not be conceived as in opposition to nature. See Heyd (2007, pp. 123-127). Val Plumwood likewise details ways in which culture can become an instrument for the protection and cultivation of nature. She theorizes this cultural turn to the natural in terms of developing "ecological reason" in place of the "instrumental reason" that has driven the project of modernity (see, Plumwood, 2004). For a different approach to a notion of culture premised on communicative engagement with nature, see Mathews (2005).
   Proposals such as these are to be distinguished from a line of argument favoured by Marxists among others, which sees human praxis generally as inevitably and inescapably embedded in nature even while it also modifies nature. From this point of view all human production and hence culture, no matter whether sustainable or unsustainable, is an expression of nature. In other words, nature/culture dualism is collapsed from this point of view. Callicott (1994) seems also to have taken up such a position. In the pages of *Organization & Environment*, Aidan Davison (2007, p. 263) seems to be pointing toward this kind of view in his discussion of the city as a site for the "re-naturing" of sociological perspectives and the "re-socializing" of ecological perspectives. This is not the position of the "culture of nature" authors considered above, nor is it the position advanced in the present article, which argues precisely for the development of an environmentally sensitive culture through activation of the commonalities between humanity and nature. The latter position leaves entirely open the possibility—and indeed affirms the actual prevalence—of cultures that are in opposition to nature.
7. Val Plumwood and Anthony Weston have suggested replacing the biocentrism/anthropocentrism divide with an inclusive concept of *multicentrism* (see, Weston, 2004).
8. See, for example, Naess (1985, 1987), Devall (1988), and Mathews (1991). Please note that the present critique is directed at my own work on the notion of the ecological self as much as that of others.
9. One author who has advanced a line of argument consistent with this position is Piers Stephens. In an article titled "Nature, Purity, Ontology," he wrestles with the human/nature, culture/nature, artifice/nature dilemma, acknowledging that "[g]reens need an ontology which may defend nature as natural

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without collapsing back into claims of dangerous purity" (Stephens, 2000, p. 272). By claims of dangerous purity, he means hyperdualized notions of nature as untouched—unadulterated, uncontaminated—by human agency, as are sometimes found in the pronouncements of wilderness aficionados. Against such dualism, Stephens develops a notion of culture as *cultus*. In explication of *cultus* he appeals to Erazim Kohak:

> [c]ulture is a matter of cultivation, echoing the Latin *cultus*, the yielding of respect, honouring the sacredness of all that is. The man of culture is one who cultivates, who honours the nobility of being. . . . His task . . . is not an arbitrary one, displacing nature. *Nature is his guide in the task of cultivation*. That is *cultus*—and in that sense, culture is not the contradiction of nature but rather the task of humans within it. (Kohak, 1984, pp. 20, 91, italics added by Stephens)

Stephens takes up the notion of culture as the condition of being guided by nature, and identifies a long Western tradition of such "truth to nature" in art and the rest of cultural practice. Noting that this tradition was displaced by the Baconian Enlightenment project of the instrumentalization of nature, he goes on to distinguish two modes of artefacticity, that which emanates in *cultus artefacts* on one hand and that which results in *artificiality* on the other:

> *Cultus* artefacts, though finally defined by human purpose, are generated and produced through processes which embodied the spirit of utilising and respecting nature's own dynamics and possession of some independence, incorporating the domain of emotive care in the human process of production; the artificial, by contrast, is informed by a rationale of separation, objectification and the subjugation of nature's own dynamics by feelingless application of abstract principles. (Stephens, 2000, p. 287)

Stephens's argument is highly compatible with the argument of the present article, though it is theorized in very different terms—the radical empiricism of William James. His article can however, I think, be fruitfully read in conjunction with the present argument from biomimicry.

10. There are of course perils in this approach. If artefact can become an expression of nature, there is a danger that nature could become fully artefactualized. In other words, artefacts designed to imitate nature could in due course come to replace the natural environment altogether. This is a danger explored at length by Keekok Lee (1999). To avoid this danger she argues for the retention of certain "vital distinctions" even while she eschews dualism. The distinction she defends is an "ontological dyadism" between the natural and the artefactual, defined initially in terms of internal and external teleology: The teleology of nature is internal to natural systems themselves whereas the teleology of artefacts is external, imposed on them by their makers. Internal teleology is of value in its own right. Ultimately this "vital distinction" is made in terms of dependence on/independence of human agency: Even the abiotic (and hence non-telos-bearing) aspects of the natural environment are intrinsically valuable insofar as they are created and maintained independently of human purpose. The distinction between the human and the natural then must be reworked rather than rejected, according to theorists such as Lee, precisely because the defence of the natural ultimately depends on it. (Other environmental philosophers, such as Robert Elliot, have also argued that it is the independent provenance of nature that is the source of its intrinsic value [see, Elliot, 1997].) I address this other side of the argument against dualism in the final section of this article, "Ethical Ambiguities in Biomimicry."
11. For a thorough explanation of conativity in this sense, see Mathews (1991).
12. Conativity may be interpreted as originating in the processes of biological evolution: It is perfectly consistent with strictly materialist Darwinian theory to suppose that conativity was generated as part of the phenomenon of life as it emerged from its physical origins. But it is also possible to assume a different starting point, imputing aspects of mind to the larger geophysical processes that shape evolution

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and tracing the conativity of life back to these, even while allowing that conativity in this generic sense is configured into species-specific drives by the processes of natural selection. See, for instance, Mathews (2003).

13. Instances of subordination are not unknown in nature either, as the well-known case of ants farming aphids illustrates. Such instances are necessarily rare however, since systematic subordination of one species by another across the ecological board would, for reasons already explained, impair the fabric of the environment.
14. Least resistance thus provides an informing principle for the kind of social structure, or "habitus," that is likely to produce "environmental" attitudes in its members. For a discussion of the habitus approach to sociology, and its sources in the work of Norbert Elias and Pierre Bourdieu, see Kasper (2009).
15. See Mathews (2006).
16. For a beautiful account of this—very systems-theoretic—interpretation of the relation between Dao and *de*, see Ames (1989).
17. Of course, organic and permacultural systems can also become a liability for native ecosystems if the species cultivated are not very carefully selected to avoid "escapes" into the surrounding environment, producing potentially ecologically destructive weed and feral problems.
18. A promising alternative to the reductive method of traditional analytical science in this connection is the method of Goethean science. Goethe, the 18th-century poet and naturalist, outlined a four-step procedure (exact sense perception, exact sensorial imagination, seeing-in-beholding, and being one with the object) which started with contemplative observation of an entity but opened out into a form of communicative engagement with it that involved the exercise of carefully disciplined faculties of intuition and imagination as well as perception in order to discover the distinctive "gesture" of the entity that was expressed, but never entirely articulated, in the appearances it presented to observers (Bortoft, 1996; Brook, 2009).
19. For a range of suggestions as to such practices, see Mathews (2005, 2008, 2011).
20. For an account of the bush meat crisis—the catastrophic large-scale commercial butchering of wildlife, including gorillas, chimpanzees, bonobos, and elephants—and for domestic and export markets, see the Canadian Ape Alliance website as well as Anthony Rose's website, http://bushmeat.net.
21. In other words, if I am reading Andrews aright, he is suggesting that we ought to identify the agency of the land—what I am calling its conativity—and work with it. If we give the land what it wants, it can give us what we want—but only if we want what it needs us to want. Because Andrews is himself a pastoralist who has eschewed land management orthodoxies and proceeded by trial and error for more than 30 years, posing question after question to his own land and sensitively observing its responses, he seems genuinely attuned to the land's conativity. He does not reify as "nature" the vegetation profile that happened to exist at the time of settlement in Australia. He argues that at the time of settlement the indigenous vegetation profile was already degraded as a result of Aboriginal firing practices, which had resulted in a virtual eucalyptus monoculture that sustained a very low level of soil fertility.
22. This is a tendency in modern technology clearly identified in the work of Keekok Lee. Writing in the late 1990s about "deep" technologies, such as biotechnology and nanotechnology, that reshape matter at a molecular level in the service of human interests, she observes that such technologies may have low environmental impact, in the sense that they may not pollute or destroy the environment, but that there is a danger that they might in time replace nature, artefactualizing not only the biotic but the abiotic environment: "The threat then posed by modern *homo faber* is the systematic elimination of the natural, both at the empirical and the ontological levels, thereby generating a narcissistic civilization" (Lee, 1999, p. 2).

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Bio

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