©2016. *Environmental Philosophy* 13:2 pp. 195–214

ISSN: 1718-0918
doi: 10.5840/envirophil201692035

Biomimicry and the Materiality of Ecological Technology and Innovation: Toward a *Natural* Model of Nature

Vincent Blok

Abstract: In this paper, we reflect on the concept of nature that is presupposed in biomimetic approaches to technology and innovation. Because current practices of biomimicry presuppose a *technological* model of nature, it is questionable whether its claim of being a more ecosystem friendly approach to technology and innovation is justified. In order to maintain the potentiality of biomimicry as ecological innovation, we explore an alternative to this technological model of nature. To this end, we reflect on the materiality of natural systems and explore a natural model of nature, which is found in the responsive conativity of matter. This *natural* model of nature enables us to conceptualize biomimicry as conative responsiveness to the conativity of the biosphere.

Key words: biomimicry, ecological innovation, philosophy of technology, eco-innovation

No philosopher followed popular thought in
making earth the primary form of body
—Aristotle, *The Metaphysics*, 989a5

1. INTRODUCTION

As an alternative to the ecosystem-destructing technologies of the industrial age, ecological approaches to technology and innovation have increasingly been receiving attention over the years. Biomimicry or biomimetics is an

Dr. Vincent Blok, MBA, Assistant Professor, Social Sciences Group, Wageningen University, Rozenboomlaan 27, 2271VR Voorburg, Nederland/The Netherlands. E-mail: info@vincentblok.nl

example of such an ecological approach to technology and innovation to which environmental philosophers and scientists have been paying more and more attention. It studies the design of natural systems—a termite hill for example—and then imitates these designs to solve human problems; air conditioning in large buildings for instance (see Forbes 2005; Myers 2012; Harman 2014). Nature is seen here as an inspiring source of knowledge that enables nature-based technological innovations. For Benyus, the "hand-in-glove harmony" of natural systems, in which "organisms are adapted to their places and to each other" (Benyus 2002, 4), is the main lesson that we can learn from nature and that can inspire future developments of a more ecological and more responsible type of technology and innovation.

A similar approach can be found in McDonough and Braungart's (2002) cradle to cradle approach and in Peter Sloterdijk's call for a homeotechnological turn in technology and innovation. *Homeo* is derived from the Greek *homoios*, which means 'the same like' or 'resembling,' and homeotechnology therefore articulates a type of technology and innovation that is embedded in, and co-operates with, nature; in homeotechnology, "the 'materials' are conceived in accordance with their own stubbornness, and are integrated into operations with respect to their maximum aptitude" (Sloterdijk 2001, 227 [my translation]). Like the concept of biomimicry, homeotechnology also is founded on an *imitatio naturae* (Sloterdijk and Heinrichs 2006) and is considered to be an ecosystem friendly approach to technology and innovation that is no longer characterized by domination and exploitation of nature, but by learning and exploration. In this respect, they can be conceptualized as biomimetic types of technology and innovation.

Because the concept of biomimicry itself and its implications are still philosophically underdeveloped (see Mathews 2011), earlier work has explored the concept of nature, technology, and mimesis presupposed in the literature on biomimetic practices (Blok and Gremmen 2016). One of the problems that arose was that the ambition of biomimicry is to mimic natural systems, and biomimicry can only claim to be a more ecological type of technology and innovation because of its imitation of nature, but that nature is a priori understood in technical terms—i.e., as "natural technology" (Vincent and Mann 2002)—in biomimetic practices. Because biomimicry in fact often mimics a *technological* model of nature, it becomes questionable whether it can claim to be an ecological—i.e., a more ecosystem friendly—and more responsible type of technology and innovation.

Because we are sympathetic toward the ambition of biomimicry and see its potential as a more ecological and responsible type of technology and innovation, in this article we explore an alternative to the technological model of nature, i.e., a *natural* model of nature. In this respect, our effort is contrary to philosophers like Adorno, who conceived nature as a *social* category of the natural (see Nelson 2011). In this article, on the contrary, we reflect on the materiality of natural systems and on the principles that govern natural systems in §3. On the basis of our findings, in §3.3 we develop a natural model of nature as an alternative to the technological model presupposed in biomimetic practices. In §4, we reflect on the consequences of this natural model of nature for our concept of biomimicry and its claim to be a more ecosystem friendly type of technology and innovation. With this, we open a radical new perspective on the concept of ecological technology and innovation. It is argued that biomimicry has to be understood as conative responsiveness to the conativity of the biosphere. Biomimicry is conative *and* responsive, and its ecosystem friendliness precisely consists in this responsiveness to the conativity of the biosphere. In order to set the stage, however, in §2 we first briefly show the extent to which biomimetic practices presuppose a technological model of nature.

2. THE RELATION BETWEEN NATURE AND TECHNOLOGY IN THE LITERATURE ON BIOMIMETIC PRACTICES

Over the past decades, several scientists have conceptualized nature in their work on biomimicry. According to Ball (2001, 413), biomimetics "decodes and elucidates the cell's molecular machinery piece by piece"; this means that nature is understood here already in a technological way, i.e., as a machine. The same holds for Forbes's conceptualization of nature in terms of its "engineering skills" (Forbes 2005, 4). In a similar vein, Vincent (2001, 321) conceptualizes nature as "four billion years' worth of R&D" and insists on "considering life as one technology among others" (Bensaude-Vincent, Arribart, Bouligand, and Sanchez 2002, 2). And Aizenberg introduces biomimetics as a strategy "to mimic high-tech solutions that nature can give us, reformulate natural materials, natural strategies and to create new materials and devices that outperform anything that we have today" (Aizenberg 2012). In a historical study of the concept of biomimicry, Bensaude-Vincent et al. (2002) even argue that nature is seen as an engineer in biomimetic practices.

This use of technological language to understand nature is not only metaphorical. First of all, language structures the way we self-evidently see and understand the world around us. An analysis of the language in which biomimetic practices are formulated reveals how nature is self-evidently conceived in biomimetic practices. An example is the following statement by Vincent: "We routinely fail to recognize the similarities between our technical problems and the solutions to similar problems in other technologies. In particular, we routinely fail to tap into the four billion years' worth of R& D in the natural world" (Vincent 2001, 321). In this quote, it becomes clear that scientists involved in biomimicry actually understand human technologies as *similar* to natural technologies.

A second reason why the technological language to understand nature is not metaphorical can be found in the explicit ambition of these scientists to overcome the fundamental dichotomy between nature and technology, which is embedded in history and reinvigorated in current debates on GMOs for instance (see Bensaude-Vincent et al. 2002). The ambition of these scientists is precisely to overcome these dichotomies and "close the gap between our technology and nature" (Forbes 2005, 1). The following quote makes clear why more is at stake than just metaphorical use of technological terms: "So the nature/technology antithesis breaks down in the face of the new science and technology. This is surely a good omen for the future. It signals a culture less divided, less neurotic about the natural and the synthetic, less timid and backward looking" (Forbes 2005, 232). In the literature on biomimetic practices, nature is seen as an engineer involved in an enduring R&D program in order to solve natural problems (see Blok and Gremmen 2016 for a full discussion).

Something similar can be found in the concept of bionics, which concerns the supplementation or duplication of neurophysiological characteristics of the human body by the integration of electronic devices and mechanical parts. Nature is seen here as a "system that uses information to achieve heightened regulation and control," and is understood "in terms of the concepts of feedback, information, control, regulation, teleonomy" (Dicks 2015, 10). If nature is understood as a regulation and control system like in bionics, the "paradigm of the artificial machine" is applied to nature (Dicks 2015, 10).

This brief consultation of the literature on biomimetic and related practices (e.g., bio-inspiration) reveals that nature is understood in technological terms, i.e., as natural technology (Vincent and Mann 2002). In this conceptualization of nature in technological terms—natural technology or nature as artist, *tektoon*, *techne*, technology—the traditional dichotomy between nature and technology is removed. Or as Ball puts it, in biomimetic methods of technology and innovation, "this disparity between the natural and synthetic art of manufacture begins to diminish" (Ball 2001, 413). This raises the question of what, in the end, the difference is between biomimetic technologies that claim to *explore* and *learn* from nature, and traditional technologies that are considered to *exploit* nature. In fact, there are many examples of biomimetic technologies that just pretend to mimic nature in order to safeguard the future of planet Earth, but can be characterized by the exploitation of nature (see Myers 2012 for examples).

This ambiguity between nature and technology is not an issue in current literature on biomimetic practices only; it is also rooted in the philosophical tradition. Aristotle uses examples from the domain of the *techne*—the vase, the statue—to understand *phusis*. This becomes clear also in his equation of technology with nature in his *Physics*. According to Aristotle, both technology (*techne*) and nature (*phusis*) are seen as productive (*poiesis*). The difference between *techne* and *phusis* is that natural beings have the principle of their productivity in themselves, whereas artefacts are produced by an external agent such as an artist or engineer (Aristotle 192b8–34); *techne* is human production or *poiesis* by an external agent and *phusis* is natural production or self-making (*auto-poiesis*). Because both *techne* and *phusis* are rooted in *poiesis*, both are essentially the same according to Aristotle (see Aristotle 199a10–20).

However, *techne* and *phusis* are essentially the same not only because both are rooted in *poiesis*, but also because technology *mimics* nature (Aristotle 194a20–25). The *techne* either—on the basis of the *phusis*—accomplishes or *perfects* what *phusis* is not capable of effectuating itself, or imitates (*mimeitai–mimesis*) *phusis* (Aristotle 199a20–25). There are, therefore, two types of technological *mimesis* of nature according to Aristotle. First of all, there is the mimetic copy or reproduction of the naturally given. The second type of mimicry is based on the *deficiency* of nature; nature is not capable of producing or effectuating everything, and mimicry productively *supplements* the capabilities of nature (see Lacoue-Labarthe 1998).

These two types of mimicry are also present in current biomimetic practices. One can argue that, in a biomimetic or bio-inspired building, the natural air conditioning system in termite hills is *copied.* This does not mean that biomimicry consists in a "slavish copying" of nature (Forbes 2005, 18). In fact, it uses "nature's principles to create things that evolution never achieved" (Forbes 2005, 1). For that reason, some scientists reject the term biomimicry and prefer to speak of bio-inspiration. It is all about understanding the underlying principles of how nature works—for instance spider silk—and their application in engineering something that may be different to the natural version; bio-inspired nylon for instance.

Consultation of Aristotle's concept of nature, technology, and mimesis makes two things clear. On the one hand, the conceptualization of mimicry as the *perfection* of nature presupposes already the *imperfection* or *deficiency* of nature itself. In today's world, this deficiency can be conceptualized as Earth's incapability of accommodating an increasing world population *and* ensuring the sustainability of Earth's life support systems at the same time, which calls for technological interventions. On the other hand, the conceptualization of nature as *poiesis* already implies that nature is understood in technological terms, namely, in terms of its productivity or makeability (see Heidegger 1999).[1]

1. For example, "In spite of, or even on the basis of the priority of, *phusis* and of *phusei on*, the *thesei on* and *poioumenon* become precisely that which now furnishes what is *understandable* for the receiving interpretation and determines the understandability of beingness itself (as *hule–morphe*) . . . Does all of this not indicate that even *phusis*, too, has to be interpreted in conformity with the *poioumenon* of *poiesis* (cf. finally Aristotle) and that *phusis* is not powerful enough to demand and sustain the unfolding of its truth over and above the *parousia* and *aletheia*?" (Heidegger 1999, 129). For Heidegger, the technological understanding of nature, namely, as *poioumenon*, means not only that

Contrary to the technological production of artefacts, which is characterized by *poiesis* by an external agent, nature is characterized by *auto-poiesis* or *self-making*.

Philosophers like Heidegger criticized such a technological conceptualization of nature, because *poiesis* or *making* concerns the making *present* of natural entities, while nature as the movement of coming forth or rising up *and* the self-closing and self-withdrawal of nature is neglected (see Heidegger 1998, 183–230). This presupposition of the presence of nature is also at stake in biomimetic practices. Any perfect or imperfect *mimesis* of nature presupposes that nature reveals itself to us in such a way that we understand nature's principles sufficiently to imitate these principles in biomimetic or bio-inspired practices (see van der Hout 2014). According to Forbes, it is only because we now have access to nature on the nano-level that true biomimicry or bio-inspiration is possible.[2] At the same time, we do not even need Heidegger's concept of nature as revealing–concealing to understand that nature is primarily a *terra incognita*, in this respect withdraws from revealing, and, as a consequence, limits any biomimetic effort (see Clark 2011).

We can conclude that both the Aristotelian tradition and current biomimetic practices conceptualize nature in technological terms. How can we, under these circumstances, claim that biomimicry is a more *ecological* type of technology and innovation? Contrary to the technological conceptualization of nature in current biomimetic practices, we are in need of a natural concept of nature. Because of our sympathy toward the ambition to mimic *nature's* models and because we see the potential of biomimicry as a more ecological type of technology and innovation, in the next section we explore an alternative to the technological model of nature, i.e., a *natural* model of nature.

3. EXPLORING A NATURAL MODEL OF NATURE

In this section, we look for a *natural*, rather than a technological, principle of nature in order to provide a philosophical basis for biomimicry as a more ecological type of technology and innovation. In this effort, we have one important predecessor in the work of Freya Mathews (2011). In her work, she identifies two philosophical principles underlying the organization of living systems on Earth and argues that biomimicry reorganizes technology and innovation in

---

nature *appears* as self-making, but also that this is how it is understandable by *human for-grasping* (Heidegger 1999, 129). What is beyond human for-grasping—and according to Heidegger, that is the truth of being as the essence of *phusis* (see Blok 2016)—*is* not in the actual sense of the word.

2. "And how we don't just stare at creatures in amazement, wondering 'How do they do it?' Thanks to genetic engineering and a host of new techniques, we can now start to unravel nature's nanoengineering and produce engineered equivalents for it. This is bio-inspiration" (Forbes 2005, 5).

accordance with these principles in order to produce the bio-inclusive and sustainable outcomes that it promises (Mathews 2011).

The first principle of nature is called 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" (Mathews 2011, 368). She associates this conativity principle with the "*will* wherewith everything strives to persevere in its own existence" and takes it as a defining characteristic of all living things (Mathews, 2011, 368). Other theorists associate this will with the concept of *auto-poiesis*, like Dicks (2015, 6), Maturana and Varela (1980, 85–87), and Capra (1997, 95–97). According to Maturana and Varela, the notion of *auto-poiesis* "is necessary and sufficient to characterize the organization of living systems" (1980, 82).

The second principle of nature is found in 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" (Mathews 2011, 369). This means that organisms will pursue their conativity without provoking resistance by 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" (Mathews 2011, 369). Whereas the first principle of conativity can still be understood as an ego-centric principle of self-assertion at the expense of others, with the addition of the second principle of least resistance, together they explain the hand-in-glove harmony of natural systems, in which organisms live in harmony with other species in Earth's ecosystems (see §1).

At the same time, we can criticize the two principles as proposed by Mathews and others. If the conativity of nature is understood in terms of *auto-poiesis*, it is questionable whether we can escape a technological model of nature. Although Mathews herself does not speak in terms of *auto-poiesis*, her efforts to develop a biomimetic *ethos* presupposes the *presence* of nature for this *ethos*, just like the technological model of nature. Without this presence of nature for human understanding, it is not possible that "our ends as well as our means, our designs" are *shaped* by nature, not possible that "nature designs *us* as well as our instruments," not possible that nature "dictates our desires," and that we "borrow from the large life system (Mathews 2011, 373–375) (see §2).

One can also question whether the second principle is in fact a principle of nature. First of all, one can fulfil one's conativity not only by accommodating the conativity of others, but also by *destroying* the conativity of others. Secondly, the principle of least resistance neglects the fact that organisms not only *adapt* to their environment, but also *manipulate* and *adjust* their environment to them. Thirdly, every species would grow exponentially and suffocate the conativity of others without any resistance by these others, as evolution already shows us. There is no hand-in-glove harmony among organisms in the ecosystem, but rather conflict and tensions that can increase but also decrease one's conativity. We can question Mathews's second principle of least resistance because it is questionable whether it is a principle of nature, but we can also question her first principle of conativity because it presupposes that nature reveals itself to us and that we understand nature's principles sufficiently to imitate them in our biomimetic practices.

It is not necessary, however, for the concept of conativity to be understood as *auto-poiesis* and presence. In the remainder of this section, we argue that conativity has to be understood as the movement in which the being or identity of nature is performatively constituted.

3.1. The Conativity of Matter

Spinoza was the first philosopher to develop a full concept of conativity and derived the term from ancient philosophers like Lucretius and Cicero (see Groome 1998). According to Spinoza, "each thing, as far as it can by its own power, strives [*conatur*] to persevere in its own being" (Spinoza 1992, part 3, proposition 6). For Spinoza, this conativity is not an *ontic* will or impulse of living systems toward self-preservation, but an *ontological* principle of all beings: "The conatus to preserve itself is the very *essence* of a thing" (Spinoza 1992: part 3, proposition 7 [emphasis added]); conativity articulates and establishes the being or *identity* of beings. Furthermore, for Spinoza, this conativity is not limited to *living systems* as Mathews (2011) suggests, because *every* body is conative according to Spinoza, even a stone (cf. Bennett 2010). On the one hand, we can argue that conativity is not only a principle of living nature, but primarily a principle of matter, i.e., of each material body on Earth.[3] On the other hand, we can argue that this concept of conativity of material entities extends the domain of the 'living' from the traditional animate to the 'in-animate,' i.e., 'living matter' as key element in Earth's generation and self-regulation as a dynamic system (Vernadsky 1998; Lovelock 2006; Clark 2011, 14).[4]

---

3. The distinction between *living* nature and *dead* matter is already questioned as a typical *modern* distinction (Jonas 1966). According to Folz, the distinction between *phusis* (nature) and *zoe* (life) consists in the fact that *zoe* "designates a particular character of *phusis* within which self-emergence is intensified" (Folz 1995, 132). Nature, however, is often identified with life, or as Whitehead puts it: "Neither physical nature nor life can be understood unless we fuse them together as essential factors in the composition of 'really real' things whose interconnections and individual characters constitute the universe" (cited in Folz 1995, 131). Contrary to Folz, we claim that the expansion of our concept of 'life' to include nature at large provides a concrete principle of nature that can be used in biomimetic practices. In this article, we conceive conativity as a principle of Earth's materiality, thus including nature.

4. Peter Forbes, one of the proponents of bio-inspiration, argues that "what makes bio-inspiration possible is the miracle that nature's mechanisms do not have to be 'alive' to

To what extent can we consider conativity to be *essential* for materiality, i.e., to what extent does conativity articulate the identity of material entities? In Spinoza's view, only one common substance—*Deus sive Natura*—constitutes the universe. All separated material entities that we encounter in the world are *modes* or *modifications* of this one substance.[5] As such a mode, each material entity is resistant to everything that can take its existence away, and this resistance is precisely the conativity or striving to preserve oneself as such a mode of the common substance (Spinoza, part 3, proposition 6). Conativity is essential then because it *differentiates* the identity of material entities from the common but undifferentiated substance—it articulates and establishes the self or identity of the tree and the stone for instance *as* modes of matter (*self*-perseverance)—and prevents at the same time their relapse in this common substance (self-*perseverance*).

If we frame Spinoza's idea of a common substance in more profane terms and highlight the 'naturalistic' framework that he introduces, we can say that all material entities we encounter in the world—the stone, the tree, human beings—are modes or modifications of matter. As such a modification of matter, each material entity strives to preserve itself (self-perseverance). If, however, this striving is *essential* for each material entity, conativity cannot be understood at an ontic level as a struggle for the existence of these entities, but at an ontological level as the impulse[6] in undifferentiated matter—whether this materiality is conceptualized as a flux of matter (Heraclitus), as *Primordia* (Lucretius), or as unshaped materiality (Aristotle)—to differentiate and establish material entities like stones and trees as modes of this undifferentiated materiality.[7]

---

work" (Forbes 2005, 5), but we argue here that we have to extend the domain of the 'living' to the in-animate or materiality in our concept of biomimicry.

5. This conception of material entities as modes of a common substance originates in pre-Socratic philosophy: "And this is why some have said that it was earth that constituted the nature of things, some fire, some air, some water, and some several and some all of these elemental substances. For whichever substance or substances each thinker assumed to be primary he regarded as constituting the substantive existence of all things in general, all else being mere modifications, states, and dispositions of them" (Aristotle 193a20–30).

6. *Conatio* is a translation of the Greek *horme*, impulse or onset.

7. Levinas conceptualized *conatus* at an ontological level as "ontological right to existence," i.e., as struggle for existence (cited in Toadvine 2012, 179; see Levinas 1985). It is not necessary, however, to conceptualize this struggle in a negative sense. Hans Jonas for instance took this struggle as a positive indication, namely, as a struggle to maintain oneself. This struggle is characteristic of all entities according to Jonas. The fact that nothing in the world is indifferent toward its own existence is the starting point of ethics according to Jonas, because it makes us responsible for the maintenance of this existence (Jonas 1984). Further elaboration of Levinas's and Jonas's view on the struggle for existence is beyond the scope of this article.

The essentiality of conativity for material entities shows in other words that conativity is not a will or power of material entities to preserve themselves (*auto-poiesis*) but primarily a principle of the appearance of matter *as* stone, tree, and so forth. Conativity is literally an endeavoring, an effort, and the essentiality of conativity consists in its endeavor to articulate and establish the differentiated identity of material entities *as* modes of undifferentiated matter. On the one hand, conativity is needed to differentiate and establish these material entities from the undifferentiated materiality in which they are embedded (*self*-perseverance). On the other hand, conativity is needed to maintain and persevere in these modifications and prevent their relapse into undifferentiated matter again (self-*perseverance*).

A first round of reflection on a naturalist concept of conativity makes therefore clear, first of all, that conativity is not an ontic will or impulse of material entities, but primarily consists in the articulation and establishment of the identity of material entities as differentiations from this undifferentiated materiality. Contrary to philosophers like Timothy Morton, who argue that there are only discrete entities and no matter as such—an argument that inspired his "ecology without matter" (Morton 2013, 150; see also 44)—we rehabilitate a materiality that articulates and establishes the identity of material entities as differentiations from this undifferentiated materiality. This is the first characteristic that we can discern of the conativity of matter. Consequently, 'I' am not primarily conative, but 'I' am the performative constituent of the conativity of matter. This means that conativity as a principle of matter consists in the endeavor to differentiate and preserve material entities like stones and trees, me and you, from undifferentiated matter as modes of this materiality, which remain embedded in this conative or 'vibrant' materiality (see Bennett 2010). This reveals a second characteristic of the conativity of matter: undifferentiated matter itself is a non-identity that articulates the identity of material entities without the possibility of being identified itself. Matter itself is always heterogeneous to, and always transcends, actual material entities as differentiations from undifferentiated matter (we return to this in §3.3). If, however, we conceive conativity as a principle of matter, rather than as a principle of material entities, the question is why undifferentiated matter differentiates material entities like stones, trees, and human beings that build Earth's ecosystems.

According to Spinoza, material entities are not only conative but also *associative* (see Bennett 2010); this means not only that the conativity of matter articulates and establishes material entities as modes of matter that can affect other entities in the environment, but also that these entities are in this at the same time *affected* by other entities, which are in their turn also performatively constituted by the conativity of matter. According to Spinoza, each mode of matter is already a composition of simple modes that affect and are affected by one another, i.e., that are primarily *responsive* to one another and form the relatively stable bodies that we encounter in the world, ranging from simple bodies like stones to complex bodies like human beings for instance.[8] Or as Bennett puts it: “because each mode suffers the actions on it by other modes, actions that disrupt the relation of movement and rest characterizing each mode, every mode, if it is to persist, must seek new encounters to creatively compensate for the alterations or affections it suffers. What it means to be a ‘mode’, then, is to form alliances and enter assemblages: it is to mod(e)ify and be modified by others” (Bennett 2010, 22).

If we conceptualize this associativity at an ontological level, i.e., at the level of the materiality that articulates and establishes the identity of material entities, these entities are not only the product of the conativity of matter, because this conativity is at the same time responsive to the conativity of (other) matter.[9] This responsive conativity of matter articulates the relatively stable bodies like stones, trees, and human beings that we encounter in the world. In the differentiation of material entities by the conativity *of* matter, these entities are at the same time constituted by their responsiveness *to* the conativity of (other) matter and build the relatively stable bodies and complex systems in which entities are interconnected and interdependent.[10] A second round of reflection on a naturalist concept of conativity reveals the responsiveness of conativity as a third characteristic of the conativity of matter.

The problem with this conceptualization of three characteristics of the conativity of matter is, however, that it remains abstract and is disconnected from our daily experience of nature. Contrary to philosophers like Deleuze and Bennett, who tried to articulate conativity in terms of assemblages and actants, we choose an ecological perspective to understand the conativity of matter in this article and, in the next subsection, propose to conceptualize the responsive conativity of matter as responsiveness to a mutual *affordance* of matter.

---

8. This responsiveness does not imply a hand-in-glove harmony as Mathews (2011) suggests, but can also involve destruction, manipulation, and resistance (see §3.). See Braidotti (2006), cited in Bennett (2010), for the role of conflict and tension in Spinoza’s concept of conativity.

9. One can argue that, as long as matter is undifferentiated, it cannot respond to anything other because, prior to difference, there is nothing other for it to respond to. Although we can argue that the traditional concept of causality is inappropriate to conceptualize the *event* of responsive conativity, the question makes clear that future research should be dedicated to this event character of responsive conativity.

10. With this, we receive a first answer to the question of what incentive undifferentiated matter has to differentiate material entities like stones and trees; this incentive can be found in matter’s responsiveness to the conativity of (other) matter (to which we return in §3.3).

3.2. The Responsive Conativity of Matter and the Affordance Ontology[11]

According to James Gibson, one of the most influential psychologists in the field of visual perception in the twentieth century, we do not perceive stimulus information from the outside world, which we process consciously or unconsciously, but rather *affordances* in the environment. The word *affordance* indicates the meaning of a thing or organism in the environment, which is detected or picked up by the perceiver and allows him to perform a specific kind of action; air affords breathing and water affords drinking for example, a chair affords sitting and a hammer affords hammering. According to Gibson, “the affordance of anything is a specific combination of the properties of its substance and its surfaces taken with reference to an animal” (Gibson 1977, 67). If a substance is rigid, horizontal, and extended for instance, then it affords support; it is the ground or floor on which we are walking.

Not only the physical environment, but also animals harbor affordances, according to Gibson. Their sexual, predatory, nurturing, fighting, cooperating, and communicating interactions for instance harbor a complex set of affordances: A beautiful butterfly affords her predator to hunt for her and dispatch her, for instance. Although the butterfly affords hunting, this does not mean that the meaning of the butterfly for the predator is a characteristic of the butterfly. The affordance arises *with reference to an animal*: A rigid and horizontal surface affords support for the butterfly for instance, but not for fish. In the same way, air affords flying for butterflies but not for a cat as their predator. This relativity of the affordance does not mean that the meaning of the butterfly depends on the valuation of this object by the subject. In the case of inanimate objects, affordances stem from the environment, and in the case of animate objects, affordances arise in the reciprocity of animals and other animals. Gibson provides the example of a mother and her child and a prey and her predator: What the child affords the mother is reciprocal to what the mother affords the child; and what the prey affords the predator—hunting—is reciprocal to what the predator affords the prey—hiding.

As argued elsewhere, we have to conceive affordances at an ontological level (see Blok 2014). This means that the predator for instance does not first see the prey and then take action. On the contrary, prey and predator are constituted by their mutual affordances; in the mutual affordances of prey and predator, the prey affords hunting and the predator affords hiding, and, in their actual behavior in response to the affordance, their identity *as* prey and *as* predator is performatively constituted; in their mutual affordance, the prey becomes the one who is hiding for the predator and is looking for shelter in holes and caves, and the predator becomes the one who is hunting for the prey. With this, it

11. This section is a summary of a more extended introduction to Gibson’s affordance theory and its ontological interpretation (see Blok 2014).

becomes clear how the affordance has to be understood. The affordance is the (non-subjective) *meaning* of the prey and of the predator. This sense or meaning arises in the reciprocity between prey and predator; both butterfly and predator live already in a meaningful world in which they are what they are, i.e., they *perform* hiding and seeking. The ontological status of the affordance is that it articulates a meaningful world (ecosystem) for an organism and allows him to perform his specific behavior *as* prey, *as* predator, and so forth.

Although we cannot explore the full meaning of the affordance ontology in the context of this article, this brief introduction enables us to open an ecological perspective on the responsive conativity of matter. In §3.1, we saw not only that the conativity of matter articulates material entities that can affect other entities, but also that these entities are at the same time constituted by their responsiveness to the conativity of (other) matter and build relatively stable bodies that are interdependent and interconnected, like different organs in a human body for instance. The affordance ontology enables us now to conceptualize the responsive conativity of matter as responsive to a mutual *affordance* of matter. The mutual affordance of prey and predator affords actual behavior that constitutes their identity *as* prey and *as* predator, and this actual behavior can be understood as a conativity of matter to differentiate material entities like prey and predator in response to a mutual affordance of matter. This means that the differentiation of material entities consists in their performance of actual behavior *as* prey and *as* predator, in which their identity is performatively constituted. This performance of actual behavior is not only due to the conativity of matter (first characteristic of the conativity of matter), but is at the same time responsive to the conativity of (other) mater, or, seen from the ecological perspective of the affordance ontology, responsive to an affordance of (other) matter (third characteristic of the conativity of matter). An affordance of matter affords (other) matter to differentiate material entities in response to this affordance—conativity of matter—and this responsiveness consists in the actual differentiation of material entities that are interdependent and interconnected and build the ecosystem in which the prey hides for the predator, and vice versa. Ecological examples of such a responsive conativity can be found in the performative constitution of a mother as responsive to her child and vice versa, a bird and its nest, a spider and its web, and so on.[12]

The affordance ontology enables us to open an ecological perspective on the responsive conativity of matter and to deepen our understanding of the conativity and the associativity of matter. By understanding the responsive conativity of matter as responsiveness to an affordance of matter to differentiate

12. From the perspective of the conativity of matter, this implies that matter offers affordances not only to an animal, for instance the affordance of the web to the spider, but also the other way around (for the limits of this mutuality, see Blok 2014).

material entities from undifferentiated matter that are interdependent and interconnected, we are able to reconnect abstract concepts like the conativity and the associativity of matter with our daily experience of Earth's ecosystems. The advantage of such an ecological perspective is that the affordance ontology provides an ecological explanation of abstract concepts like conativity and associativity.

3.3. The Responsive Conativity of Matter as a Natural Model of Nature

The critical question now is: Does our ecological conceptualization of the responsive conativity of matter provide an alternative to the technological model of nature in biomimetic practices? With the responsiveness of the conativity of matter, we receive an indication of a *natural* model of nature, which may inspire a more ecological type of technology and innovation embedded in nature. The conative differentiation of material entities by undifferentiated matter consists first of all in the articulation and establishment of the *identity* of material entities as differentiations from undifferentiated matter, and this articulation is secondly primarily *responsive* to an affordance of (other) matter, in which the prey for instance is performatively constituted as the one who is hiding for the predator (responsive conativity), while the predator is the one who is hunting for the prey (responsive conativity).[13] Thus, the responsive conativity of matter opens an ecological perspective on the concept of conativity that can be seen as a *natural* model of nature.

A consequence of this natural model of nature is, however, that we have access only to the material entities articulated by the responsive conativity of matter (identity) and not to matter itself (non-identity) (see §3.1). If 'I' am not conative but the performative constituent of the conativity of matter (not I) in response to a mutual affordance of matter, and as such interconnected and interdependent with the other entities that build the ecosystem in which I live and act, 'I' am primarily reciprocal to other material entities and not to matter itself. This does not make 'me' a "mere surface effect of some deeper force," as Harman would argue (2011, 6), precisely because 'I' am at the same time reciprocal to other material entities in the environment. The responsive conativity of matter has a twofold nature, namely, the performative constitution of material entities in response to an affordance of matter (identity) on the one hand—and this is the origin of the generativity of matter—and the origin of actual and

13. Although we may speak of a *material* model of nature, we prefer the term natural as opposed to a technological model of nature in this article. This seems to be legitimate, because philosophers like Aristotle also articulate matter in terms of nature: "For what I mean by matter is precisely the ultimate underlying subject, common to all the things of Nature, presupposed as their substantive, not incidental, constituent" (Aristotle 192a30–35). At the same time, it raises questions about the precise relation between matter and nature. This question is, however, beyond the scope of this article.

possible differentiations of material entities on the other: the limitlessness, heterogeneity, or non-identity of matter.

The affordance ontology enables us to open an ecological perspective on this twofold nature of the responsive conativity of matter. Gibson points to the "independent existence of an unlimited environment" beyond our actual responsiveness to affordances in the environment (Gibson 1977, 69). This means that nature is always *extended* beyond our responsiveness to the actual affordances in the environment; the limitlessness and complexity of nature consists in the fact that nature is never exhausted by its affordances, is always richer and more complex than any actual affordance in the environment, and transcends all actual and possible affordances of nature (see Blok 2015). This concept of the limitlessness of nature beyond our responsiveness to the affordances in the environment helps us to open an ecological perspective on the heterogeneity or non-identity of matter (second characteristic of the conativity of matter). From an ecological perspective, the conativity of matter is responsive to a mutual affordance of matter and differentiates multiple interconnected and interdependent material entities in Earth's ecosystems, which remain embedded in undifferentiated matter (non-identity), and is always heterogeneous to, and transcends, actual material entities as differentiations from undifferentiated matter.

With this indication of the twofold nature of the responsive conativity of matter, we can also return to the question raised in §3.1. There, we asked why undifferentiated matter differentiates material entities like stones and trees, prey and predator in Earth's ecosystems. Heraclitus argued that nature has the tendency to conceal itself (Heraclitus 1951, fragment 22B123), and Aristotle's *hule* is conceived as *steresis* or *absencing* that belongs to the presencing of the *physis* (see Heidegger 1998, 227). This tendency to concealment is also confirmed in modern quantum theory: "Objects withdraw from each other at a profound physical level" (Morton 2013, 41). From this perspective, we can argue that the ultimate conativity of undifferentiated matter consists in the differentiation of material entities *in order to* preserve itself *as* undifferentiated matter. Contrary to Ian Grant and Graham Harman, who object to the idea that 'brute matter' should give rise to life (Clark 2011, 24), we argue that undifferentiated matter *should* differentiate natural entities, although not for us humans, but rather for its own perseverance. Matter differentiates multiple interdependent and interconnected material entities that are responsive *to one another* in the ecosystem (identity), in order to preserve in its own existence as concealed, undifferentiated matter (non-identity).[14]

We conclude this section by highlighting the three characteristics that we found of the responsive conativity of matter as a natural model of nature: 1) the conativity of matter consists in the articulation and establishment of the

14. See Blok 2014 for the relation between matter (identity) and matter (non-identity).

identity of natural entities as differentiations from undifferentiated matter; 2) the conativity of matter is at the same time responsive to a mutual affordance of matter to differentiate material entities in response to this affordance, and build complex entities like human beings, complex networks of interrelated entities like a flock of birds or a termite hill, and in the end, complex systems like Earth's ecosystems in which we live; 3) the conativity of matter consist in the end in the differentiation of interconnected and interdependent entities which build the ecosystems in which we live (identity), *in order to* preserve itself as undifferentiated matter (non-identity). The twofold nature of the responsive conativity of matter consists in the self-concealment of matter by the performative constitution of responsive bodies in Earth's ecosystems.

4. THE CONSEQUENCES OF THE RESPONSIVE CONATIVITY OF MATTER FOR OUR CONCEPT OF BIOMIMICRY

What now are the consequences of our natural principle of nature for our concept of biomimicry? Do the three characteristics of our natural principle of nature provide guidelines for future biomimetic innovations? Although this article focused on the development of a natural model of nature that may inspire biomimetic practices, and although the exploration of its applicability in practice is subject to future research, we draw some theoretical implications in this final section.

We started this article with the Aristotelean conception of nature as *imperfect*, which has to be perfected by a technological *biomimesis*. We can reframe this imperfection of nature now in terms of the non-identity of matter, which is the origin of the responsive conativity of matter. On the one hand, it is clear that biomimicry cannot be understood as the mimesis of this non-identity of matter, as this non-identity is not accessible to us, and 'we'—including our biomimetic innovations and technologies—are primarily responsive to an affordance of matter in which both my biomimetic behavior and the natural entities I try to mimic are performatively constituted. On the other hand, this means that the affordance of matter limits the possibility of biomimicry, as my biomimetic efforts have to be seen as behavior performatively constituted by the conativity of matter in response to an affordance of matter. In this responsive conativity of matter, I am performatively constituted as the one who is mimicking matter (responsive conativity), while matter becomes the twofold of the self-concealment of matter by the performative constitution of interconnected entities in Earth's ecosystems. If we take the responsive conativity of matter seriously as a natural model of nature, we have to conclude that mimicry itself is performatively constituted by matter in response to an affordance of matter, and that it is this responsive conativity of biomimicry that constitutes the materiality of ecological innovations and technologies.[15]

As a principle of biomimetic practices, our natural model of nature ensures that biomimicry does not primarily consist in the imitation of an esthetic form of natural entities in our design, like in the case of a sharkskin-inspired swimsuit, nor in the inspiration taken from natural technology at macro-, micro-, or even nano-level. On the contrary, it mimics precisely the self-perseverance in conativity, i.e., the self-perseverance that can be associated with the articulation of the self or identity of technological entities (self-organization and self-design), the autonomy, adaptability, and headstrongness in their growth, and their self-perseverance, which can be associated with self-regulation and self-healing/self-repairing of natural entities. What is primarily mimicked of nature in biomimicry is conativity as self-perseverance of nature.

Such a natural concept of biomimesis has some advantages over the technological conceptualization found in current biomimetic practices (see §2).[16] We asked how biomimicry can claim to be a more ecological type of technology and innovation as long as it presupposes a technological model of nature. Our natural model of nature enables us in the first place to claim that biomimicry explores and learns from nature: biomimicry is no longer reproducing nature in a natural technology, but has to be seen as performatively constituted by the conativity of matter in response to an affordance of matter. This means that, in the word biomimicry, mimicry has to be understood as this responsiveness to an affordance of matter, and that bio has to be understood as the twofold nature of matter. Only if we conceptualize biomimicry as performatively constituted by the conativity of matter in response to an affordance of matter, are both claims of biomimicry—that it is exploring nature, rather than exploiting it, and that it is embedded in nature—legitimized. This *natural* concept of biomimicry is non-dualist—biomimicry itself is performatively constituted by the responsive conativity of matter and therefore interdependent and interconnected with the ecosystems it tries to mimic—and eco-centric—biomimicry itself is responsive to an affordance of matter, in which matter conceals itself. It is this natural concept of biomimicry that can claim to be a more ecological—i.e., a more ecosystem friendly—and more responsible type of technology and innovation.[17]

---

15. In this respect, we confirm Morton's observation "that I am unable to go beyond . . . *ecomimesis*, the (often) first-person rendering of situatedness 'in'" (Morton 2013, 5), which is at the same time "an ecology without the present" (92).

16. We leave the question open as to what extent not only the natural concept but also the technological concept of biomimicry can be seen as responsive to an affordance of matter (see Blok 2015).

17. I would like to thank Freya Mathews and the anonymous reviewer of *Environmental Philosophy* for the fruitful comments on an earlier draft of this article.

REFERENCES

Aizenberg, J. 2012. *Extreme Biomimetics.* Ted Talk, 2 March 2012.

Aristotle. 1980. *The Physics*. Trans. P. H. Wicksteed and F. M. Cornford. Cambridge/London: Loeb Classical Library/Harvard UP.

Aristotle. 1989. *The Metaphysics*. Trans. H. Tredennick. Cambridge/London: Loeb Classical Library/Harvard UP.

Ball, P. 2001. "Life's Lessons in Design." *Nature* 409: 413–16. doi: https://doi.org/10.1038/35053198

Bennett, J. 2010. *Vibrant Matter. A Political Ecology of Things.* Durham: Duke UP.

Bensaude-Vincent, B., H. Arribart, Y. Bouligand, and C. Sanchez. 2002. "Chemists and the School of Nature." *New Journal of Chemistry* 26: 1–5. doi: https://doi.org/10.1039/b108504m

Benyus, J. M. 2002. *Biomimicry: Innovation Inspired by Nature.* New York: Harper Perennial.

Blok, V. 2014. "Reconnecting with Nature in the Age of Technology. The Heidegger and Radical Environmentalism Debate Revisited." *Environmental Philosophy* 11(2): 307–332. doi: https://doi.org/10.5840/envirophil20149913

Blok, V. 2015. "The Human Glanze, the Experience of Environmental Distress and the 'Affordance' of Nature: Towards a Phenomenology of the Ecological Crisis." *Journal of Agricultural and Environmental Ethics* 28(5): 925–938. doi: https://doi.org/10.1007/s10806-015-9565-8

Blok, V. 2016. "Thinking the Earth: Critical Reflections on Meillassoux' and Heidegger's Concept of Earth." Working Paper.

Blok, V., and B. Gremmen. 2016. "Ecological Innovation: Critical Reflections on Biomimicry as a New Way of Thinking and Acting Ecologically." *Journal of Agricultural and Environmental Ethics* 29(2): 203–217. doi: https://doi.org/10.1007/s10806-015-9596-1

Capra, F. 1997. *The Web of Life: A New Scientific Understanding of Living Systems.* New York: Anchor Books.

Clark, N. 2011. *Inhuman Nature: Sociable Life on a Dynamic Planet.* Los Angeles: Sage.

Dicks, H. 2015. "The Philosophy of Technology." *Philosophy and Technology* (in press).

Folz, B. 1995. *Inhabiting the Earth. Heidegger, Environmental Ethics, and the Metaphysics of Nature.* New York: Humanity Books.

Forbes, P. 2005. *The Gecko's Foot. Bio-inspiration—Engineered From Nature.* London: Fourth Estate.

Gibson, J. 1977. "The Theory of Affordances." In *Perceiving, Acting and Knowing*, ed. R. Shaw and J. Bransford. Hillsdale: LEA.

Groome, T. H. 1998. *Sharing Faith: A Comprehensive Approach to Religious Education and Pastoral Ministry: The Way of Shared Praxis*. Eugene: Wipf and Stock.

Harman, G. 2011. *The Quadruple Object.* Washington: Zero Books.

Harman, J. 2014. *The Shark's Paintbrush.* Ashland: White Cloud Press.

Heidegger, M. 1998. *Pathmarks*. Trans. W. McNeill. Cambridge: Cambridge UP. doi: https://doi.org/10.1017/CBO9780511812637

Heidegger, M. 1999. *Contributions to Philosophy (from Enowning)*. Trans. P. Emad and K. Maly. Indiana: Indiana UP.

Heraclitus. 1951. *Die Fragmente der Vorsokratiker.* Trans. and ed. H. Diels and W. Kranz. Berlin: Weidmannische Verlagbuchhanglung.

Jonas, H. 1966. *The Phenomenon of Life*. New York: Harper and Row.

Jonas, H. 1984. *The Imperative of Responsibility. In Search of an Ethics for the Technological Age.* Chicago: University of Chicago Press.

Lacoue-Labarthe, P. 1998. *Typography.* Trans. C. Fynsk. Stanford: Stanford UP.

Levinas, E. 1985. *Ethics and Infinity. Conversations with Philippe Nemo.* Pittsburgh: Duquesne UP.

Lovelock, J. 2006. *The Revenge of Gaia: Why the Earth is Fighting Back—And How We Can Still Save Humanity.* New York: Penguin.

Mathews, F. 2011. "Towards a Deeper Philosophy of Biomimicry." *Organization and Environment* 24(4): 364–387. doi: https://doi.org/10.1177/1086026611425689

Maturana, H. R., and F. J. Varela. 1980. *Autopoiesis and Cognition.* Dordrecht/Boston: Reidel. doi: https://doi.org/10.1007/978-94-009-8947-4

McDonough, W., and M. Braungart. 2002. *Cradle to Cradle. Remaking the Way We Make Things.* New York: North Point Press.

Morton, T. 2013. *Hyperobjects. Philosophy and Ecology after the End of the World.* Minneapolis and London: University of Minnesota Press.

Myers, W. 2012. *Biodesign: Nature, Science, Creativity.* London: Thames & Hudson.

Nelson, E. S. 2011. "Revisiting the Dialectic of Environment: Nature as Ideology and Ethics in Adorno and the Frankfurt School." *Telos* 155: 105–126. doi: https://doi.org/10.3817/0611155105

Sloterdijk, P. 2001. *Nicht Gerettet. Versuche nach Heidegger.* Frankfurt a.M.: Suhrkamp.

Sloterdijk, P., and H-J. Heinrichs. 2006. *Die Sonne und der Tod. Dialogische Untersuchungen.* Frankfurt a.M.: Suhrkamp.

Spinoza, B. 1992. *Ethics: Treatise on the Emendation of the Intellect, and Selected Letters*. Trans. S. Shirley. Indianapolis: Hackett.

Toadvine, T. 2012. "Enjoyment and its Discontents. On Separation from Nature in Levinas." In *Facing Nature. Levinas and Environmental Thought*, ed. W. Edelglass, J. Hatley, and C. Diehm. Pittsburgh: Duquesne.

Van der Hout, S. 2014. “The Homeotechnological Turn: Sloterdijk’s Response to the Ecological Crisis.” *Environmental Values* 23: 423–442.

Vernadsky, V. 1998. *The Biosphere*: New York: Copernicus. doi: https://doi.org/10.1007/978-1-4612-1750-3

Vincent, J. 2001. “Structural Biomaterials and Biomimetic Strategies.” In *Biomimétisme et Matériaux*, ed. C. Sanchez. Paris: OFTA.

Vincent, J., and D. Mann. 2002. “Systematic Technology Transfer from Biology to Engineering.” *Philosophical Transactions from the Royal Society A* 360(1791): 159–173. doi: https://doi.org/10.1098/rsta.2001.0923