Biomimicry and the Problem of Praxis

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ABSTRACT

Biomimicry can serve as a design template for an ecological civilisation by showing how cyclical, no-waste, mutually adaptive production systems designed 'after nature' could render human industry fully 'sustainable'. However, unless the modes of praxis involved in such a reformed industrial base are also redesigned, the value orientation fostered by the new order would remain anthropocentric. Biomimicry would accordingly result in an eco-modernist-type scenario in which society was 'decoupled' from nature, with dystopian consequences for the larger community of life. Drawing on Indigenous modalities, I explore ways in which modern industrial systems could include participatory modes of praxis that would emanate in genuinely bio-inclusive forms of consciousness and hence lay the ethical foundations for an ecological civilisation.

KEYWORDS

Biomimicry, eco-modernism, bio-synergy, Indigenous law, historical materialism, praxis, eco-civilisation

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Biomimicry can in many ways serve as a design template for an ecologically benign form of civilisation. It shows us how to design cyclical, no-waste, 'closed resource loop', manufacturing systems that can reuse resources indefinitely and eliminate wastes that are harmful to the natural environment, thereby at last rendering human industry genuinely sustainable. It affords a royal road to the 'circular economies' that are key to the idea of a 'global green shift' (Mathews 2017). In an initial formulation, Janine Benyus, the main populariser of the concept of biomimicry (Speck et al. 2017), defined it as 'a

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new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems, e.g., a solar cell inspired by a leaf' (Benyus 2002: xi). 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' (ibid.: xi).

However, there is a fatal ambiguity at the heart of biomimicry. This ambiguity lodges in the notion of 'mimicry' itself. For mimicry might be read in either of two ways. On the one hand it might imply a system that entirely *replaces* the elements or components of natural systems with engineered or fabricated ones that are nevertheless arranged in accordance with the design principles that shape and inform ecological systems. According to Benyus, these principles are as follows: nature runs on sunlight and uses only the energy it needs; it fits form to function, recycles everything, rewards cooperation and banks on diversity; it demands local expertise, curbs excesses from within and taps the power of limits (ibid.: 7). But a system could conform to such principles without including other-than-human species as either players or beneficiaries. Indeed such a system could entirely displace and replace 'original nature', the 'parliament of species' (ibid.: 8), whose myriad transactions currently contribute to the constitution of the biosphere. It could replace original nature with a human-made 'second nature', an engineered planetary simulacrum of nature created to service our own needs both exclusively and, being designed after nature, sustainably (Chu 2004).[1] On the other hand, however, mimicry might be read as pointing toward a schema that *imitates* original nature in the sense that it works towards the ecological reintegration of humanity into the larger community of life, following the synergistic patterns set by other species. This would represent a sustainable outcome not only in the sense of sustaining human civilisation but in the sense of sustaining all of earth-life.

Benyus herself clearly intended biomimicry to be understood in the latter sense. But logically there is no reason why it should not be construed in the former sense, as pertaining to the brave new world of a fully engineered, human-authored order – a 'second nature' – designed in accordance with principles that emulate original nature while at the same time replacing it. In practice, in biomimicry design circles, these two senses are not distinguished. I shall describe biomimicry in the 'second nature' sense as *human-focused*. (I use the term, *human-focused*, instead of the traditional term, *anthropocentric*, because I think it is more transparent to speak of biomimicry in this sense as having a human focus rather than to speak of it as being anthropocentric.) In order for biomimicry to avoid being understood in such a purely human-focused sense, it needs to be supplemented with a further, explicitly ethical principle of *bio-inclusiveness* – a principle that urges protection for *all* species. (Again, I here depart from the terminology – *biocentric* or *ecocentric*

1. Herein I shall occasionally use the contested term 'nature' as a short-hand descriptor for other-than-human life forms and systems.

– traditionally used in environmental ethics because these can be misconstrued as implying a privileging of non-human over human life.) Read simply in its own terms, as an ethically neutral principle of design, biomimicry does not entail, nor necessarily in any way motivate, bio-inclusiveness.

So, even supposing that industry and planning sectors in contemporary societies could be induced, in the interests of 'sustainability', to undertake the kind of design revolution implied by biomimicry, there is no reason to expect this revolution to be bio-inclusive in its effects unless those sectors are already committed to bio-inclusiveness, which they currently patently are not. The question I wish to explore here is: from whence can such a commitment come? Unless that commitment is present, biomimicry is in danger of merely furthering the Baconian dream of consolidating our own human imperium at the expense of nature by providing design templates whereby humanity can, by emulating the very nature that it is supplanting, secure its own exclusive existence in perpetuity.

It is instructive to note here how biomimicry intersects with the more recent project of eco-modernism, as promulgated by the Breakthrough Institute via their widely read 'Ecomodernist Manifesto'.[2] Eco-modernists are proposing definitively to 'decouple' human production systems from wider life systems in ways that resonate with biomimicry in its human-focused sense. By 'decoupling', eco-modernists mean that industrial systems should be closed-loop systems that run on sunlight and other clean forms of energy while requiring no material inputs other than those already available via the recycling of their own products and wastes.[3] In the process of such recycling, potential pollutants should be rendered either useful or harmless. Food production is included as a form of industrial production and is conducted intensively, in industrial hubs that likewise perpetually recycle resources and wastes. Meat is produced in industrial laboratories directly culturing living tissue rather than in factory farms engaged in animal husbandry. Waste and leftover outputs, including human wastes, would again cycle endlessly through literal and figurative food chains.[4]

The purpose of such systemic circularity is, from the eco-modernist point of view, to spare the biosphere the impacts of resource extraction and pollution as well as ensuring sustainability for the project of civilisation. Eco-modernists assume, as history testifies, that the Enlightenment project of industrial development – otherwise known as modernisation – is indeed, in political, social and economic terms, one that delivers 'progress', in the sense of vastly increasing

2. Ecomodernist Manifesto. Available at: http://www.ecomodernism.org/manifesto-english (accessed 7 September 2017).

3. Eco-modernists are, however, also very keen on nuclear power, which they regard as a potentially clean form of energy, and in this respect they diverge from biomimicry.

4. Eco-modernists have not, so far as I am aware, tackled the question of disposal as it pertains to human funerary practices. With a projected human population of 9 billion, and a vast proportion of planetary resources already committed to the support thereof, resource loops would not become properly closed until our human dead were incorporated into those loops.

levels of affluence in society. It is therefore assumed that, taken to its logical conclusion, this project will deliver global affluence, thereby eliminating poverty and the distinction between the developed and developing world. With the attainment of affluence, as history again testifies, the human population will plateau out and stabilise. Provided modernisation is carried to its logical conclusion then, cleanly, in circular fashion, it should relieve the twin pressures of over-population and over-consumption, and thereby ease the present burden on the natural environment. In other words, the problem with modernity as a project, as Bruno Latour (2011) observes, is not that it is in itself flawed, as so many environmentalists have argued, but that, as a project, it has not yet been completed: we have yet to modernise modernity – that is, to render it sustainable. Eco-modernists pour scorn, indeed astonishing vitriol, on those environmentalists who call for a return, in various guises, to pre-modern economic and aesthetic scenarios (Nordhaus and Shellenberger 2011).[5]

According to eco-modernists, completing the project of modernisation would involve not only closing resource loops but also intensifying the process of *urbanisation* that began at the time of the Industrial Revolution in Europe. Human populations are to be mainly accommodated in large-scale cities or city clusters. Such conurbations must become principal sites of production as well as accommodation for their populations, thereby hugely reducing all manner of transport and travel requirements. Populations of up to 100 million may be housed in such self-sufficient, geographically localised urban hubs. Human habitat requirements will thereby become contracted (Mathews 2017). As a result of this, and other strategies canvassed in the 'Ecomodernist Manifesto', parts of the planetary environment will become relatively freed of human impacts: a certain amount of land and sea will prove superfluous to human requirements, and hence available for *rewilding*.

Most of the strategies proposed in the Ecomodernist Manifesto – with the exception of the emphasis on nuclear power – are more or less consistent with a biomimetic perspective, at least insofar as biomimicry is construed under its human-focused aspect. To this extent the manifesto might be viewed as something of a biomimicry manifesto as well, or an indicator of where biomimicry might lead. The eco-modernist movement has commanded attention from conservationists on account of its claim to pragmatism, its eschewal of retro-utopian scenarios and its moral insistence that conservation must not be prioritised, by 'first-world' advocates, over the issue of human poverty in the developing world. A conservation biologist of no lesser standing than E.O. Wilson has embraced an approach to development that essentially parallels that of eco-modernism (Wilson 2016). He argues that only by intensifying

5. Environmentalists have traditionally called for limits to population and consumption, for a return to voluntary simplicity or an ethos of frugality, and for devolution into bioregional economic and cultural units.

industrialism along basically eco-modernist lines can we hope both to free up and clean up sufficient habitat to assure the future of the world's biodiversity.

And yet, and yet. I, for one, harbour insistent doubts. As long as market economies remain in place – and there is emphatically no challenge to capitalism in either eco-modernist or biomimicry scenarios – the attainment of universal affluence cannot be expected to cap industrial production. Within capitalist economies, lands and waters will continue to be held within private tenure systems, and as such they will continue to represent exploitable resources. No intrinsic constraint on the drive to extract further profit or wealth from such resources exists within capitalist frames of reference: the quest for wealth knows no limits. Unless the economy is guided by a principle of bio-inclusiveness, 'left over' lands and waters will by no means be relinquished to 'biodiversity'; exploitative, wealth-generating uses will instead be found for them. Moreover, the assumption that universal affluence could be achieved by way of a technological revolution alone seems implausible. The roots of poverty lie as much in the politics of power, and in the consequences of conflict and war, as in a lack of resources: inegalitarianism, and with it inequality in the distribution of resources, will surely persist despite any technological potential for universal prosperity. Without a guiding principle of bio-inclusiveness then, it seems likely that, in the context of a mid-century human population of 9 billion, any 'leftover' lands and seas will continue to be squeezed, both by the already wealthy and by those rendered poor and disadvantaged by political contingencies.

In a socio-economic system entirely decoupled from nature however, from whence would such a principle of bio-inclusiveness come? What experiences would be available to people within such a system to suggest it? What would cause it to take root to such an extent that society would release 'half the earth' – Wilson's reckoning of what would be required for effective global conservation (Wilson 2016) – to allow for the flourishing of other species?

Societies do not arrive at the values that shape them simply by ratiocination. Certainly, we can discover and articulate a principle of bio-inclusiveness by reason alone. Indeed, articulation and philosophical defence of bio-inclusive forms of ethics have been going on apace in the academy, in the discourse of environmental philosophy and latterly more widely in the environmental humanities, for more than thirty years.[6] Categories foundational to that discourse, such as *anthropocentrism*, *biocentrism* and *intrinsic value*, quickly rippled out and permeated relevant scientific discourses, such as conservation biology.[7] But articulation and philosophical defence, no matter how cogent

6. For overviews of environmental ethics and environmental philosophy generally, see Brennan (2015) and Mathews (2014). For an introduction to the environmental humanities, see the journal *Environmental Humanities*.

7. See Soule (1985) for a foundational article. Environmental philosophers, such as Michael P. Nelson and his long-term collaborator, the conservation biologist John A. Vucetich, have also consistently leavened the conservation biology literature with ethical review and analysis.

and compelling, by no means translate into uptake by society at large. People seem rarely persuaded by reason alone to rearrange the norms that structure their institutions, let alone their own identities and consciousness. In the environmental context, such failure of uptake has to date prevailed. While there exists a minority tradition of bio-inclusiveness in conservation circles, modern civilisation at large continues to pivot ideologically around a resolutely anthropocentric axis. This ideology is currently coded as *development*.

If people habitually live in a state of radical dissociation from nature, I shall argue below, then a bio-inclusive stance can never be expected to gain real traction. Any such stance must grow out of practice.[8]

Inasmuch as advocates of biomimicry risk ending up decoupling society from nature, via the creation of a strictly engineered 'second nature', they face a similar impasse to that faced by eco-modernists: from whence, in the event of such decoupling, will the bio-inclusive mandate needed to motivate the conservation of other-than-human species arise? What will save either biomimicry or eco-modernism from serving simply to clinch the project of human supremacism? This is, in a sense, the 'hard problem' of environmentalism – hard, because it is the circularity into which programs for bio-inclusive reform always run. Sustainability per se, in a purely anthropocentric sense, is not really a hard problem. Modern civilisation has the technical and economic wherewithal to achieve it. But to bring about the shift in values that would be required to motivate transition to an ecological (in the sense of bio-inclusive) civilisation is another matter entirely. Experiences of deep engagement with nature would need to be widely available for such a value shift to occur, but such experiences are generally available only in cultural contexts that are already bio-inclusive. In other words, the hoped for bio-inclusive order would need to be in place already to motivate transition to that order. Circularity.

In fact there are two levels to this question of value shift in relation to biomimicry. Firstly, bio-inclusive values must already have significant currency in society in order to motivate large-scale investment in a new bio-inclusive economic order; and secondly, that new order will itself have to afford the kinds of experiences that will sustain and strengthen the hold of bio-inclusive values on society. In this article I shall argue that biomimicry under its bio-inclusive, as opposed to its purely human-focused, aspect can indeed prefigure an economic order that would afford the kinds of experiences that would sustain and strengthen those bio-inclusive values. In this respect biomimicry differs from eco-modernism, which, with its insistence on decoupling, could not sustain the kind of bio-inclusive values that ostensibly motivate it. But biomimicry cannot

8. To this argument an eco-modernist might respond that conurbations could include parklands and nature reserves that would enable residents to acquire first-hand experience of natural systems (John Mathews, personal communication.) But it is doubtful whether a merely recreational approach would have sufficient existential impact to shape fundamental normative attitudes. See my discussion of historical materialism, below.

of itself break the initial circularity: it cannot provide the kinds of experience that would give rise to bio-inclusive values before it has itself been taken up. To address this second problem fully would require a separate article. For the moment I wish merely to explore the question of the relation between an economic order designed in accordance with biomimicry principles and the values it might or might not be expected to serve.

Clearly, in order to tackle these questions of value, some theoretical account both of the origin of values and of their role in society is required: how do particular values arise and come to prevail in society and how do shifts in prevailing values occur? One theory that provides an explanation of these processes is the Marxist doctrine of historical materialism. I shall adopt a version of this framework here, not because I am a Marxist; I am not one. But historical materialism, which does not depend on other Marxist doctrines for its validity, is in my view far more persuasive than rationalist theories in its explanation of the ever-changing terrains of consciousness, identity and values within and across societies.

HISTORICAL MATERIALIST ACCOUNTS OF CONSCIOUSNESS, IDENTITY AND VALUE

According to the doctrine of historical materialism, norms and values that genuinely inform consciousness originate not so much in discourse or debate as in the specific forms of *praxis* in which a given society, or a given class within a particular society, is engaged at any particular historical moment. Praxis consists of the practices whereby societies, or groups within societies, intentionally act upon the world in order to extract their livelihood from it. Humans, Marx wrote, 'begin to distinguish themselves from animals as soon as they begin to *produce* their means of subsistence' (Marx and Engels 1970: 42, original emphasis).[9] The concept of *production* is closely tied, for Marx, to that of praxis, where productive activity is the kind of activity by which we intentionally transform our environment to suit our own purposes. Although many creatures, such as bees and beavers, do engineer their own environments, only humankind, Marx thinks, does so with freedom to choose the end result. Bees have no choice but to build hives, and beavers dams, but the range of possibilities open to humans is limited only by our 'physical organisation', which predetermines the scope of our knowledge and the technologies available to us at any given point in time. Marx expands on the notion of historical materialism as follows:

9. Of course, interpretations of the Marxist notion of praxis vary widely. See e.g. Margolis (1989). I owe the way I am defining it here largely to feminist theory, specifically socialist and standpoint versions of feminism. For a classic feminist exposition of historical materialism, see Jaggar (1983: 51–82).

> In the social production of their life, men enter into definite relations that are indispensable and independent of their will, relations of production that correspond to a definite stage in development of their material productive forces. The sum total of these relations of production constitutes the economic structure of society, the real foundation on which rises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life constitutes the social, political and intellectual life process in general. It is not the consciousness of men that determines their being, but, on the contrary, their social being that determines their consciousness. (Marx 1968: 29)

While Marx defines praxis in terms of *productive* activity, I think the essential insight of historical materialism does not require such privileging of the category of production. Instead, historical materialism provides a method for demonstrating how human values, identity and consciousness arise out of the specific modes of livelihood that are practised in different societies. As a doctrine, historical materialism was intended to offer an alternative to theories that explained 'human nature' in terms of fixed essences, such as the inherent capacity for reason to which liberal philosophers of the eighteenth and nineteenth centuries so consistently appealed. Practices of livelihood vary, historically and geographically, across societies, and human nature and consciousness varies accordingly. But I would prefer to define practices of livelihood – or praxes – in terms of *provisioning* rather than production, because the Marxist privileging of production ties praxis to agrarianism and industrialism. This reflects Marx's own prejudice in favour of industrialism as the exclusive vector of progress. To define praxis in terms of provisioning rather than production extends the notion of praxis to hunter-gatherer societies as well as agrarian and industrial societies – a point that will be important for my overall argument.

Regardless of the type of society under consideration, the practices whereby a particular society, or groups within it, intentionally act upon the world in order to derive a livelihood from it are mediated by specific technologies – the scythe versus the combine harvester, for instance – and the social and economic relationships to which such technologies give rise. It is thus in our basic material and agentic orientation to reality, mediated by specific technologies and generative of specific forms of inter-species and intra-species social relations, that the distinctive tenor of consciousness and identity and different psychologies of selfhood in different societies are forged. From this perspective, the kinds of consciousness and identity found in hunter-gatherer societies will differ markedly from those found in, say, early agrarian societies, because the abilities, faculties and forms of knowledge and understanding of hunter-gatherers are shaped by the spear, the fire-stick and the digging-stick, and the kinds of relationships with other species and landscapes into which these implements draw them. The abilities, faculties and forms of knowledge and understanding characteristic of the subsistence farmer, by contrast, are shaped by the hand plough and by relationships with domestic animals into

which practices of animal husbandry draw the farmer. The requirements of different forms of praxis will also call forth distinctive structures of family and community and, concomitantly, distinctive social and political institutions – small, nomadic, non-hierarchical kinship bands versus sedentary villages organised around agrarian land tenure systems and headman forms of politics, for example. The consciousness of the forager and the subsistence farmer will be markedly different again from that of the factory worker, chained to an assembly line, while that of the factory worker will differ from that of, say, the white-collar worker, glued all day to a computer screen in an aseptic office setting, or to that of the corporate manager, coordinating operations from on high in an expensive board room.

Historical materialism is, clearly, dialectical. While humans intentionally modify their environment via praxis, the altered environment in turn acts upon them. The products we create to satisfy our wants act on our consciousness and indeed on our very bodies: our very anatomy can be modified by habituation to specific technologies, and it has become dramatically evident in recent years that the brain itself is the most responsive and plastic aspect of our anatomy in this respect: it rewires itself in accordance with our dedication to specific, often technologically mediated, tasks.[10] (The discovery of brain plasticity, and the effects of technologies – especially the new information and communication technologies – on neurology thus turns out to be a validation of dialectical materialism more compelling than Marx himself could possibly have imagined.) Such self-modification in turn gives rise to new needs, wants, aptitudes and imaginaries that will be satisfied and fulfilled via new forms of praxis – and so on unendingly. In this way, *Homo sapiens*, uniquely amongst species, according to Marx, creates its own nature, a nature that varies dramatically through time and across societies.

In short, our praxis constitutes our basic modality, our basic way of comporting ourselves in the world, and this basic modality will in turn colour our existential outlook, including our social and environmental relationships, and our sense of our own self-identity. Our existential outlook will consist in a vital tissue of moral, aesthetic, epistemological and utilitarian norms and values, which will inform, whether consciously or not, everything we do. To change such norms and values it is not enough to articulate and demonstrate the rational preferability of alternatives. One might give intellectual assent to such alternatives, but as long as one continues to engage in one's original form of praxis, or the forms of praxis that have shaped the normative status quo of one's society, one will not achieve any real or lasting normative reorientation or rearrangement of one's identity.

From the perspective of historical materialism then, there is no mystery in the failure of uptake to date of bio-inclusive values in modern societies, despite these values having been well articulated and compellingly defended,

10. See Doidge (2007) for a popular account of this revolution in neuroscience.

and despite widespread dismay at the accelerating crisis of biodiversity loss and ecological collapse. As long as people return to the business and administrative mills and shopping malls of an industrial economy subsequently to any exposure to the new values, their intellectual attachment to those values will soon be swamped by the resurgence of the forms of consciousness and identity constituted by their praxis, and by the forms of embodiment that grow out of it. Neither classroom discussions nor weekend workshops, nor even in-depth experiences such as wilderness treks, will long hold back the habits of consciousness and unconsciousness formed by our daily modalities. Serious and sustained recreational pursuits that train our faculties for engagement with natural forces or elements, such as surfing or rock climbing, or avocations that immerse us in the life worlds of other species, such as bird watching, may make inroads into these habits, but the existential investment we bring to practices associated with our livelihood and hence our survival will generally ensure that it is those which determine our basic existential orientation.

In affirming this, however, I do not wish to be understood as affirming that the values and forms of identity and consciousness that arise out of praxis are all equally valid, in a relativist or constructivist sense. Different praxes may serve to *reveal* certain aspects of reality while *occluding* others. I shall argue below, for example, that hunter-gatherer praxis tended to reveal *ecological* aspects of reality that do indeed objectively inhere in the world, while subsequent industrialist praxis occluded these. The damage that industrialist praxis has wrought on the natural environment demonstrates that such praxis – and the world view that accompanies it – is epistemologically deficient: it occludes vital features of reality in its pursuit of short-term advantage. The use of *reason* – reasoning from comparative world views and their actual impact on the world – can show us this. Reason can, in other words, validly critique or corroborate world views that emanate from praxis. But reason is not deep or pervasive enough as an influence on consciousness to enable us to *inhabit* a new-value outlook independently of praxis. It is not powerful enough to bring about large-scale value shifts in society, or even in the lives of individuals. Only praxis can achieve this, and it is in this sense, not in a relativist sense, that I wish here to affirm historical materialism.

In order then to address the question of how bio-inclusive values and consciousness could take root in society, rather than remaining as merely 'idealist' (albeit valid) critiques on the margins of mainstream discourse, I shall first consider in a little more detail the major historical precedent for such a system of values, and how tightly tied that system of values was to the praxis of the societies in question. I am referring of course to what have been termed until recently hunter-gatherer societies. I shall then review, very briefly, how the bio-inclusive consciousness of hunter-gatherer societies was overturned by the forms of praxis that defined subsequent – agrarian and modern (industrial

and, more recently, informational) – societies.[11] (This is very much a thumbnail sketch of certain types of society, intended just to illustrate the relation between different forms of praxis and different value systems rather than to explore either the praxes or the value systems in their empirical and variable detail.) In light of this brief account of praxical templates, I shall suggest certain forms of praxis that might be conducive to the development of bio-inclusive consciousness in a contemporary context. Finally, I shall conclude that biomimicry can hope to emanate in a bio-inclusive form of civilisation only if it entrains such praxes.

PRAXICAL TEMPLATES

Hunter-gatherer societies, or custodial societies

The basic praxis of hunter-gatherer societies of course consists of foraging for wild resources, where foraging includes the hunting of wild animals. Foraging may sound like a passive affair, a matter of merely browsing or predating on other species as one wanders around, but in fact to forage sustainably over the long term across a spatially bounded wild estate requires intimate knowledge of the ecology of that environment, highly developed powers of observation and a sophisticated ethos of adaptiveness and accommodation. The category of hunter-gatherer societies is a very broad one, and may include societies that have achieved sustainability in their way of life and societies that have not. Even so, there is currently increasing scholarly (and activist) discontent with the category as a blanket descriptor for pre-agrarian societies. Societies such as those of Aboriginal Australia, which were in the colonial period considered as paradigmatically hunter-gatherer, are now being redescribed in far more proactive terms as having engaged in large-scale landscape practices, such as patch-burning to promote grasslands for favoured herbivores – for example, kangaroos – and specific techniques of harvesting to promote the enhanced regeneration of staple plant species – such as yam daisies or species of lily with edible bulbs (Gammage 2011; Pascoe 2014). Such practices constitute active 'management' of ecological systems. However, although critics of the colonial representation of Aboriginal peoples as hunter-gatherers are increasingly speaking of Aboriginal people as having engaged systematically in *farming* in pre-colonial times, I think it is important to retain a distinction between the type of management practised by those pre-colonial societies and the type of management that characterises the agrarian forms of praxis we traditionally describe as farming. For the praxis of traditional Australian Aboriginal

11. This not an exhaustive typology of praxical templates. It does not include, for instance, a discussion of pastoralist societies or of the many societies that deploy praxes from more than one category – e.g. societies that practise village horticulture while also engaging in limited foraging. A separate article is required for a full discussion of this topic.

societies, insofar as it involved management (and it is not yet clear whether all pre-contact Aboriginal societies in Australia did engage in management), seems to have generally worked with what I would call the *conative* or self-actualising grain of existing ecosystems. 'Management' in this sense involved encouraging local ecosystems to develop in ways that increased their utility for humans but in no way interfered with their own ongoing flourishing – in something like the manner in which a gardener might 'guide' or 'train' a self-sown, otherwise wild, vine to climb a wall. Encouraging wild ecosystems to serve human ends in this manner without destroying the ecological integrity of the systems themselves is importantly – I would say categorically – different from management in the dominate-and-control mode associated with traditional agriculture. As traditionally understood, agriculture involved the carving out of dedicated spaces within which original ecosystems were removed and replaced by modified or 'domesticated' species of plants and animals – crops and livestock – often imported from elsewhere.

So while I think it is indeed crucial to recognise that many Indigenous societies previously described as hunter-gatherer in fact actively managed their environments, I also think it is important to recognise that differences of categorical significance did, at least in certain instances, exist between such Indigenous forms of management and the forms of management characteristic of agrarian societies that developed in, say, the Fertile Crescent during the Neolithic. For this reason it might be useful to introduce here a new category, that of *custodialism*, distinct from that of hunting and gathering, to denote the praxis of societies that managed their environments in what we might today call an ecological manner.[12] Custodialism might thus be understood to denote pre-agrarian forms of praxis that involved working collaboratively with ecosystems on a landscape scale to provision societies while also protecting and preserving the ongoing ecological integrity of those systems. Aboriginal Australia offers many instances of such custodialism (Gammage 2011; Pascoe 2014), but instances are coming to light in other parts of the world as well, such as South America (Balee 2013). Members of custodial societies do hunt and gather across their estates, but they are also custodians of those estates, ensuring by their praxis that those estates remain rich terrains of life for a multitude of species. It is an axiom of custodial praxis that a wealth of species is required to sustain the specific plant and animal populations on which such societies more directly depend.

The overall modality of custodial societies then might be pictured as one of accommodation to the interests of other species, not in the sense of abnegating

12. Many Indigenous commentators in Australia, influenced by Pascoe (2014), are currently spurning the 'hunter-gatherer' tag and claiming the tag 'civilisation' instead. I want to reserve the term 'civilisation' for agrarian societies, however, though not the pattern of valorisation that has traditionally accompanied it. By introducing the category 'custodialism' I have tried to signal a shift in valorisation away from civilisation towards custodialism while preserving what I think is the significant distinction between pre-agrarian and agrarian forms of praxis.

the human but rather in the sense of subsuming human interests under larger ecological ones. To succeed in this mode, an intimate knowledge of local ecosystems is required, and habitual attention to ecological patterns will form the background to everyday life. I have suggested elsewhere that these patterns may be codified in terms of two principles: firstly, the principle of conativity, viz. that every living thing is animated by a will to preserve and increase its own existence; and secondly, the principle of least resistance, viz. that living things best conserve their energy and hence preserve their own existence by acting in ways that least obstruct, and in that sense accommodate, the conativity of others, wherever such accommodation can also be turned to their own advantage (Mathews 2011). These are the principles that everywhere produce ecological patterns of mutual accommodation and synergistic morphogenesis amongst wild forms of life, if not at the level of the individual organism (which may be subject to predation or competition), then, more importantly, at the level of the species.

In Aboriginal societies in Australia, such principles may be normatively enshrined as Law. Law is the Law of life per se, life being the dynamic sum of interactive, mutually accommodating and co-constituting – in a word, *synergistic* – conativities. (This is not to say that new mutations producing life forms that fail to follow Law, in the sense of failing to conserve their energy, wherever possible, in accordance with the principle of accommodation, may not arise. But when they do they will in due course be selected out of existence.) Since Law is the touchstone of custodial truth, it is seen as textured into reality at large – the universe itself is seen as a normative terrain, charged with conativity and articulating itself in accordance with Law. Custodial peoples duly align themselves normatively with the grain of this larger unfolding, and manage both themselves and their environments in accordance with it (Black 2011; Rose 1992; Watson 2015).

(It is worth noting that, while consciousness of Law in this sense has long been lost to most civilisations, an echo of it remains within at least one of the major civilisations still extant today, namely that of China. The notion of *Dao*, one of the deepest and still living taproots of Chinese thought, presents striking parallels to that of Law, especially in the fundamental modality it prescribes, viz. *wu wei*, or 'inaction'. Inaction is intended in this context to prescribe not passivity but rather a mode of getting things done that does not rely on effortful striving or the kind of dominate-and-control mentality that seeks to impose its own will forcibly upon the world, where this latter mentality is arguably the hallmark of Western civilisation, at least in its modern form.[13] Accommodation

13. This has been the burden of a vast range of eco-philosophical literature, particularly ecofeminism and deep ecology.

constitutes a mode of getting things done which does not rely on such effortful striving.)[14]

For custodial peoples there are not, as there are for farmers, two worlds, that of the human and that of nature, where the human is the enclosed world of hearth, home and meaning, and hence of communication, while nature is the wild world that lies beyond the hearth, bereft of meaning for humans and hence beyond the reach of communication. Pre-agrarian reality is a single world, a world that is a seamless tapestry of both culture and nature, mind and matter, human and animal, all in intercommunication and all engaged in incessant exchanges of meaning (Viveiros de Castro 1998). In the midst of this communicative cosmos of meaning and cross-species multiculturalism, pre-agrarians are inalienably at home – 'inalienably', because there is nowhere outside this cosmos into which they might fall into meaninglessness. There is thus, amongst such peoples, an existential groundedness, a sense of at-homeness in existence, that contrasts with a certain edginess or anxiety that prevails under agrarian and subsequent conditions and that might give rise to a search for security in transcendent domains (Jackson 1995).

In the context of the 'one world' metaphysics of pre-agrarian societies, just one law prevails, a law that applies equally to humans, animals, plants and ecosystems – in a word, to all things. It is the law of the universe itself, and everything is beholden to it, which is why it is generally written in texts today as Law. Although richly elaborated narratively and philosophically across many different cultures, it might arguably be seen as revolving around the two earlier mentioned principles, those of conativity and least resistance/accommodation. Law in this sense forms the axis around which consciousness and identity and every aspect of culture in pre-agrarian societies takes shape. Members are constrained by normative and legal principles not regarded as of merely human provenance but as having their origin in the very structure of the universe.

Agrarian societies: the advent of civilisation and the descent into anthropocentrism

At different times in different parts of the world, custodial societies started to transition towards agrarianism as their basic praxis. Often already adept at regenerative techniques of harvesting (Pascoe 2014), they settled into areas where tubers, grains or other staples could be cultivated more intensively. Animals were domesticated for meat, milk, wool, fur, labour and transport. More intensive food production allowed for the growth of permanent settlements, and, in favourable circumstances, these expanded into towns and cities. Production and storage of food surplus in turn gave rise to social

14. I have written elsewhere on the parallels between wu wei and hunter-gatherer praxis (e.g. Mathews 2011).

specialisation: artisans together with military and religious workforces could be spared from the fields to dedicate themselves to specialised services. The availability of food surpluses, together with the emergence of specialised crafts and eventually manufacture, also gave rise to possibilities of wealth and hence to social stratification and political hierarchy.[15] Hierarchy and the consequent centralisation of power laid foundations for the rise of states, and, with the administrative functions of states, literacy and civil law. All the elements of civilisation, in other words, appeared and started to constellate with the advent of agriculture.[16]

Key to our present concerns is the fact that agriculture, as foundational praxis, split people's experience into the two above-mentioned spheres: first, an exclusively human space, in which all that was wild, self-sustaining and self-regenerating was eliminated or replaced by human handiwork or domesticated to serve human ends; and second, a backdrop to that human space, the sphere of the wild, no longer intimately known or understood, no longer inhabited. The origins of human/nature dualism, and hence of anthropocentrism, lie deeply buried in this split of the unitive cosmos of pre-agrarian societies into the two ontological spheres of the farmer (Mathews 1994).

If the praxical template of agrarian societies was agriculture, then their root category would seem to have been *production*. Where custodials engaged in *provisioning*, obtaining food and other necessities by collaborating with rather than subjugating local ecosystems and by allowing those systems to do for them the high-energy work involved in providing, agrarian societies *produced* what they needed – by replacing those ecosystems and performing themselves the arduous work of providing: selecting, clearing, tilling, sowing, domesticating, genetically altering – in a word, farming. This attitude of self-sustenance found expression not only in agriculture but in a much intensified disposition to build, weave, spin, fire pots, engage in metalwork and crafts, and generally to replace the natural environment locally with a human-manufactured one. As a basic praxical category, I shall take *production* to signify the intentional bringing forth of preconceived products from materials and elements that have been stripped of their original conativity – in the process losing their place in larger conative,ecological systems – and rendered into raw materials for human designs. Production may be seen as the praxical condition for the split of the unitive cosmos of custodials into the dual spheres – culture and nature – of farmers. Farmers discovered that they could, by productive activities, bring forth their own world from nature, and in this, their own world, they were no longer constrained by Law.

The shift from pre-agrarian societies to agrarian ones was, I think, the epochal one (Diamond 1987). Industrialism, and its present-day offshoot,

15. Frederick Engels (1968) was the first to explore these developments from a historical materialist perspective.

16. For a parallel account of the social corollaries of agriculture, see Ian Morris (2015).

informationalism, were already inherent as potentialities in the category of production. It may thus be from the normative logic of this category that we shall need to depart if we wish to recover a genuinely ecological and bio-inclusive form of civilisation today.

Industrialism: the advent of modernity

The inclination to replace that which is given by nature with the arbitrary artefactualities that we contrive for ourselves eventually led, in Europe, to an efflorescence of mechanical technology in the late medieval period. The elaborate machinery that started to make its appearance in the artisan workshops of this period provided prototypes of the mechanical model that filtered into contemporary imagination and came to intellectual fruition in the mechanical consciousness of the seventeenth century (Bernal 1969). This new mechanical way of understanding the world provided both a grand blueprint for taking reality apart and reconfiguring it as human artefact and a legitimation for thus instrumentalising it: with nature represented as nothing but an oversize machine, there could be no moral objection to converting it into resources for production. The new science thus served as a final, logical refutation of the custodial law (Law) that had long been in abeyance in agrarian societies. From the viewpoint of science, the cosmos could no longer be regarded as charged with life, meaning and normative significance of its own but was normatively null, a blank slate for the inscription of human meanings.

The rapid intensification of production that occurred under these conditions resulted in the establishment of large-scale 'manufactories', which in due course devolved into mere 'factories', as the handicraft aspect of manufacture disappeared altogether and mechanised mass production ensued. This coincided of course with the industrial revolution of the eighteenth and nineteenth centuries, which, together with the scientific revolution of the seventeenth century, marks the advent of modernity. Modernity has subsequently spread, in differently culturally modulated forms, from Europe to most parts of the globe. Its signature in every cultural context is indeed the priority it gives to production – its extreme preference for fabricated environments over those which are natural or given. As the presumed hallmark of human-ness, production is morally subject to no limits. It has accordingly constantly to renew itself – its means, its methods, its content – thus giving rise to incessant change. It may be expected eventually to convert the entire natural environment into its raw materials and fill the world up with its output.

We are today of course still very much in the grip of industrialism. However, as industry is digitised and information systems overtake manufacturing ones as the praxical environment of our societies, we are beginning to sense a new trajectory.

Informational societies

Since we are at the very beginning of this new stage, it is too soon to make any definitive pronouncements. But for present purposes it may be enough to observe that while informational societies presuppose and rest upon a high level of technological sophistication, and in that respect remain tied to the same industrial praxis as industrialism, they stand in a complex relationship with industrialism, and in some ways reveal a new trajectory for modernity. For while production was unquestionably a root category for industrialism, and underpinned the materialism and consumerism that has characterised industrial societies to date, that root category is now, in informational societies, being joined by a new one: communication. Communication, not merely for the sake of production but for its own sake, is a new imperative of the informational era: communication is what we *do* with information. In the context of this new imperative, the immense tide of commodities that was generated by modernity in its initial, industrialist stage may be about to recede, leaving a sleeker, more streamlined, high-tech, information-based culture in its wake. However, such an information-based culture in no way represents a turning back to a pre-industrial, pre-modern era, as, for instance, the anti-consumerist counter-culture of the late twentieth century did. Rather, it signals a further evolution of modernity itself, inasmuch as it enables a further defection or escape of the human from the messy materiality of 'nature'. From an informational perspective, we no longer see 'nature' – the realm of sentient, suffering, fleshly earth-life – in mechanical terms as merely a machine, inert but at least still material. We now see it in positively Pythagorean terms as information – as information in its most abstract, digital (that is, numerical) sense: in other words, as sheer ideality. This represents the ultimate triumph of dualism and hence of anthropocentrism: 'nature', as background to the human, is not only devoid of life or mind; it is not even in its essence material but ideal. Ruthless extractivism, serving now a 'higher', information-oriented level of technological sophistication, is accordingly in no way abated. Communication in this techno-informational context represents a further turning in of the human onto itself rather than a turning outward, communicatively, to a larger context of life. Modernity, the apotheosis of anthropocentrism, is, in other words, in this emerging informational guise, undergoing a new iteration.

BIOMIMICRY AS A TOOL OF ECO-MODERNISM

Enter biomimicry. As a design-led solution to the now almost universally acknowledged global environmental crisis that industrialism has spawned, biomimicry is a natural fit with informationalism. As an approach, it represents life systems in terms of abstract design templates, transcribable as information, that may be technologically reproduced. We can follow these design blueprints

in crafting circular economies that will enable us to live independently of the larger lifeworld indefinitely. Biomimicry thus holds a key, both ideologically and physically, to the decoupling of human production systems from nature that eco-modernism prescribes. In doing so it is aligned with the new but already dominant digital consciousness of informationalism.

As universal affluence is achieved courtesy of digitalised but sustainable industrial technologies, we shall, according to this scenario, be able to live happily ever after in our clean, spare, smart, photosynthesising, self-air-conditioning, closed-cycle, rain-harvesting, water-reticulating, waste-consuming, fully self-contained, biomimetic plastic bubbles, absorbed presumably in obsessive techno-mediated communication and entertainment, without ever giving a thought to what may be going on outside our plastic shells.

Eco-modernists, as I mentioned at the outset, assume that lands and seas freed by this closing of economic loops will revert to nature. No longer needed by us for industry, these areas will have a chance to become rewilded, as are some marginal lands and waters even today (Fraser 2009). But with humanity thus conclusively decoupled, both ideologically and physically, from nature, the anthropocentrism that had its origins in agrarianism and came to maturity as modernity will, as I have suggested, presumably reach its final apotheosis. Why would those inside the bubble retain the faintest interest in or concern for other forms of life? Why would they be inclined to leave *anything* for nature? As I argued earlier, the eco-modernist assumption that development would result in parts of the biosphere becoming surplus to human requirements is flawed. Human 'requirements' will never be capped without an ethos, a normative orientation, that aspires to prosperity for *all* life. Without such an ethos, the prospects for the larger community of life on earth remain desperately bleak. From the perspective of a historical materialist view of consciousness, such a bio-inclusive orientation will have no chance of developing in a society decoupled from nature. If people's daily praxis fosters a preference for built environments over natural ones, and latterly even for digital ideality over corporeality, thereby sealing people off from the lived and vulnerable particularity of life in nature, how can they possibly come to care about other-than-human lives in any genuine way?

So biomimicry in the service of eco-modernism is likely to lead, in my view, not to an ecological form of civilisation but to the final human rout of nature. For biomimicry to serve bio-inclusive ends, as Janine Benyus intended, and for it to become the basis for a genuinely ecological civilisation, it must prescribe, as our root praxis, neither *production*, the replacement of the natural with the human-made, nor *communication* in an exclusively digital mode, but forms of *participatory* engagement with natural systems that will give rise to participatory consciousness, just as the praxis of custodial peoples did and does. In other words, biomimicry will have to show how we can, by serving the interests of other species and systems, at the same time satisfy our own

desires – though our desires may have to be revised in this process for such an outcome to occur. I would prefer to describe the new praxis in terms of *synergy* rather than mimicry, although the fact that synergy is the norm in nature does imply that in practising synergy we are indeed imitating nature. But we are imitating nature not in its particulars, as many biomimetic design scenarios do (the classic example being that of Velcro, designed after observation of the little hooks by way of which burrs lodge in dog fur), but in its deepest logic, which I have here suggested consists in a law of accommodation and least resistance. I have elsewhere defined bio-synergy as a mode of engagement that allows us to use natural systems in the service of our own ends but only in ways that are compatible with, and ideally enhance, theirs. Where ends of ours contradict the conative tendencies of natural systems, those systems may not be conscripted by us. Instead our ends must be adapted to accommodate theirs (Mathews 2011). In our implied willingness, in the name of bio-synergy, to allow the world to 'do the doing', rather than undertaking to do all the doing ourselves, our practice also recapitulates the modality of *wu wei*.

The transition to bio-synergy as our primary mode of praxis would involve a reversion from production, as our root category, back to the kind of category that prevailed in custodial societies, viz. a collaborative or participatory mode of provisioning.

PRAXIS IN A BIO-SYNERGY MODE

But how might new forms of such provisioning, congruent with our twenty-first-century setting, be envisaged? How might we reconfigure our relationship with natural systems in ways that respect their integrity and serve their ends, as pre-agrarian cultures did, while yet supporting our own massively increased numbers, which can by no means now be sustained by older forms of custodialism?

In order to tackle this conundrum, let us eschew the usual starting point – the question of our own needs – and begin instead with the needs of the rest of earth-life. If we consider the question of these needs first, and then calibrate our own needs in light of how we answer it, we might begin to decipher the forms that bio-synergy could take today.

Since the biggest challenge currently facing earth-life is that of climate change, let us address this challenge first. It is clear that even with a shift away from fossil fuels, global warming will continue to occur for decades, possibly centuries. Clunky industrial-consciousness solutions to this problem of course abound. Geo-engineering proposals – such as the pumping of sulphate particles into the atmosphere, the erection of giant mirrors in space or the artificial whitening of clouds to increase albedo – all appeal to the industrialist imagination that seeks to supplant natural systems with human-made ones. But how

might a bio-synergy approach respond? It would involve first acknowledging the conativity of the earth system, then considering how that system, left to itself, would correct the problem. What does the biosphere want? What would its own response be to the crisis? Undoubtedly, left to its own devices, the biosphere would simply revegetate itself. Vegetation is the basis of earth-life; maintaining and if necessary increasing vegetation cover is the conative imperative of the biosphere. Revegetation would draw down carbon and hence in due course rebalance the composition of the atmosphere. A synergy approach to climate change would thus consist simply in removing obstacles that currently prevent the biosphere from getting on with its own business, while also assisting its process of recovery by way of limited strategic interventions, similar in principle to those proposed in the philosophy of rewilding. These might include reafforestation and revegetation projects as well as the protection of existing wild lands. However, bio-synergy as praxis requires deep and intricate understanding of life systems, so a bio-synergistic approach to climate change would also take its cues from the study of these systems and their histories. One such cue is the recent discovery that, 50 million years ago, an early version of the fast-growing freshwater Azolla fern precipitated a rapid episode of global cooling. During the so-called Arctic Azolla event, Azolla spread across a land-locked Arctic sea and in the process sequestered so much carbon that it converted the greenhouse climate that prevailed at the time to an icehouse one (Appenzeller 2005; Brinkhuis and Schouten 2006).

As practitioners of bio-synergy, we might wonder whether the Azolla event offers a clue to our current situation. Remarkably, climate scientists have now, to all appearances independently of the Azolla discovery, come up with an Azolla-type intervention to address the climate crisis. The species that precipitates the cooling in this case is not a freshwater fern like Azolla but seaweed, specifically giant kelp, which, like Azolla, grows very fast – up to thirty times faster than terrestrial plants.[17] According to Tim Flannery, Australia's chief commissioner at the Climate Commission, the large-scale, open-ocean encouragement of kelp and other seaweeds would draw down massive amounts of CO_2, while also providing a wholesale alternative to fossil fuels:

> The stupendous potential of seaweed farming as a tool to combat climate change was outlined in 2012 by the University of the South Pacific's Dr Antoine De Ramon N'Yeurt and his team. Their analysis reveals that if 9% of the ocean were to be covered in seaweed farms, the farmed seaweed could produce 12 gigatonnes per year of biodigested methane which could be burned as a substitute for natural gas. The seaweed growth involved would capture 19 gigatonnes of CO_2. A further 34 gigatonnes per year of CO_2 could be taken from

17. The modern, super-fast-growing fern *Azolla filiculoides* nevertheless remains pretty exciting in its own right. Its capacity to draw down nitrogen and carbon is impressive, and its potential as feedstock is yet to be explored. See Bradley (2012).

> the atmosphere if the methane is burned to generate electricity and the CO_2 generated captured and stored. (Flannery 2017: 140–141)

Flannery adds, quoting research by N'Yeurt and colleagues, that this 'could produce sufficient biomethane to replace all of today's needs in fossil-fuel energy, while removing 53 billion tonnes of CO_2 per year from the atmosphere' (ibid.).

Further synergistic benefits of kelp 'farming' include the de-acidification of surrounding sea water (as a result of the removal of CO_2) and, as a consequence, restoration of an ideal environment for shell growth and hence for shellfish – to the extent, according to Flannery, that kelp farms on the scale indicated above could support sustainable fisheries capable of yielding 200 kilogrammes of seafood per year, per person, for 10 billion people (ibid.: 141). Kelp itself also has some value as feedstock, while other seaweeds are suitable for human consumption. Of course, the benefits that would accrue from climate change mitigation would apply not only to ourselves but to all species, and the reduction in ocean acidification would increase ocean primary productivity and biodiversity generally (ibid.).

By approaching the question of climate change from the point of view of the biosphere itself then, we find that, through a relatively minor set of interventions to stimulate free-range seaweed growth in the open oceans, without nets, we could witness massive global cooling and ocean de-acidification, the restoration of habitat for ocean biodiversity plus provision of both high-grade protein for the world's human population and supply of a renewable alternative to fossil fuels. The level of technology required to encourage the biosphere to heal itself in this way is laughably minimal – arrays of ropes on which seaweed and mussels can grow are floated a little way below the surface of the ocean, and from these are suspended baskets filled with scallops and oysters. Pipes are needed to bring water up from the ocean depths to provide nutrients for the seaweed arrays, as are platforms of solar panels to assist in harvesting as well as floating docks for ships to transport seafood to ports.

This seaweed scenario provides a perfect instance of bio-synergy: by offering a little assistance for the biosphere to 'do the doing' – that is, for it to get on with its own business – we find that we can incidentally take care of our own needs, provided we are able to adapt our desires to the cut of the biospheric cloth – by settling for seafood as our staple, for example, rather than insisting on, say, beef.

I am reminded, by the mention of ropes and baskets, of my favourite example of a synergistic hydrological system, the ancient Dujiangyan irrigation scheme, established in 256 BCE on the Min River in the Chinese province of Sichuan. The system was built to protect local people from the dangerous annual flooding of the river. Instead of constructing a *dam* that would literally *block* the flow of the river, the Daoist governor, Li Bing, devised a series of channels, held in place by bamboo baskets filled with stones, that harmlessly

and productively dispersed the flood waters across the flood plain, making that flood plain the richest agricultural area in China. In contrast to the massive dams that were an unfortunate hallmark of China's 'scientific' development in the latter half of the twentieth century, the Dujiangyan system does not damage the ecology of the river, even though it reconfigures it: fish and other aquatic life have free passage through the system. Where dams generally succumb to ecological death and silt-up in a matter of decades, and are thought to contribute to geological instability, Dujiangyan is still as benignly functional and productive today as it was more than two thousand years ago, and it emerged almost unscathed from the catastrophic Sichuan earthquake of 2008 (Watts 2010).

Returning to the issue of climate change, it is clear that, in the same way that we can delegate much of the work of climate repair to vegetation, we can also recruit animals to play their part in that repair. Sea otters, for example, have been found to protect wild coastal kelp communities by feeding on the sea urchins that, in the absence of otters, decimate the kelp. Since, as we have just seen, kelp is a major sequester of carbon, provision for the recovery of sea otter populations, after severe depletion by hunting and habitat loss, makes a significant contribution to carbon drawdown (Duarte et al. 2013). A deeper understanding of the ecology of climate dynamics would reveal innumerable other ways in which restoring ecological functionality and thereby addressing biodiversity loss would ameliorate current climate distress (Wilmers et al. 2012).

On the question of adapting our own nutrient requirements to ecological affordances, consider another case study, that of the Veta La Palma aquaculture farm in southern Spain. This 8,000 acre fish farm is part of a larger estate on a marshy island in the Guadalquivir River. Badly degraded by inappropriate beef cattle farming in the first half of the twentieth century, the estate was taken over in the 1970s by a new company, which, under the direction of conservation biologist Miguel Medialdea, asked the question: what does this island want? In response to the demonstrable inclination of the island to revert to marshlands, the marshy parts of the estate were allowed to recover. An 'extensive' (as opposed to intensive) form of fish farming was subsequently initiated. Extensive farming relies on the natural ecology of an environment to provide for the species farmed. In the case of Veta La Palma, this has meant that a diversity of fish species is sustained by abundant crustaceans and other naturally occurring aquatic life. Optimal habitat health is ensured by large populations of waterfowl, numbering up to 600,000 at times, and comprised of up to 250 species. Instead of regarding birds as competitors for fish, Medialdea sees them, in classic *wu wei* style, as allies, as assistant farmers helping to do the hard work of maintaining conditions conducive to fish flourishing. Human input into the farm is minimal. Staff regulate the hydrology of the marshlands by way of a network of fish ponds that are artificially flooded to ensure the

physical and microbiological quality of the water. More than a hundred islands have also been created for the nesting of waterfowl and 93 miles of earthen banks have been revegetated, while 12,000 acres of the estate have been set aside as a marshland habitat reserve. The end result of this edifying exercise in bio-synergy is the provision of some of the most sought-after seafood in the world and the creation of the largest waterfowl sanctuary in Europe.[18]

Numerous other examples of a synergistic approach to provisioning could be cited here. Making full use of 'ecosystem services' and taking advantage of, without harming, ecological relationships, has long been central to alternative farming and horticultural philosophies, from the 'one straw revolution' of Masanobu Fukuoka to companion planting, from organics to permaculture synergies between selected plant and animal species that deliver outcomes that farmers themselves would otherwise have to labour to achieve. Indeed many variously named intimations of a synergistic agricultural paradigm are currently coming into view: ecological agriculture (Soule and Piper 1992), restorative agriculture (Massey 2017) and natural sequence farming (Andrews 2014), as well as the older farming traditions of China, Japan and Korea (King 2004). These all represent ecologically oriented challenges to the prevailing philosophy of agribusiness.

My own favourite example of small-scale synergy is bee keeping as it was practised before the advent of industrial apiaries. I have written elsewhere about this tender art (Mathews 2010), but in the present connection the gist of these reflections is that, by the eighteenth and nineteenth centuries in Europe, bee keepers had so divined what honey bees most set their hearts upon (yes, bees do have circulatory systems!) that they built hives designed to enchant those housewifely hearts, thereby creating conditions not only of security but of delight for their small charges. If the keepers commandeered some of the honey for their own use, still the bees, so richly fulfilled, thrived. As the glorious nineteenth-century writer Maeterlinck, to whom I owe this information, puts it:

> Man truly became the master of the bees, although furtively, and without their knowledge; directing all things without giving an order, receiving obedience but not recognition … [H]e does with them what he will, he obtains what he will, provided always that what he seeks be in accordance with their laws and their virtues. (quoted in ibid.: 356)

This is the *wu wei* of bio-synergy indeed: the keeper is the ruler who does not rule, whose 'rule' is invisible, and a source of fulfilment, to the 'ruled'. Maeterlinck goes on to tell a story of an old man, a 'recluse and sage', who first introduced him, as a child, to bee keeping. The sage's apiary, set in a garden

18. See the Veta La Palma website (http://www.vetalapalma.es, accessed 7 September 2017). The Veta La Palma approach to fish farming was popularised by celebrated American chef Dan Barber (see Barber, 'How I fell in love with a fish', 2010. Available at: https://www.ted.com/talks/dan_barber_how_i_fell_in_love_with_a_fish, accessed 7 September 2017).

brimming with blooms beloved by bees, consisted of neat straw domes painted in bright floral hues, particularly blue, since the old man had noticed the bees' fondness for this colour (ibid.).

All such bio-synergistic strategies exemplify the *wu wei* tendency: by accommodating other species or systems, by recruiting them into synergy with us via the creation of conditions that answer to their interests, we can enlist them as allies in the provision of our livelihood, allocating to them the major burden of effort required for such provisioning. For them, such effort is not an imposition because it is made with, rather than against, the grain of their conativity.

So biomimicry in the Velcro mode is not enough. It is not enough for advocates of biomimicry merely to represent nature as a manifold of abstract design scenarios that may be adapted to the requirements of industrialism. To proceed in this manner would be to import all the underlying anthropocentric and dualistic values associated with modernity into the new order. This would result at best in a human-focused articulation of biomimicry. Instead, advocates of biomimicry need to depart from the forms of praxis that underwrite modernity and recover earlier modes of cooperating with natural systems, serving the conativities of those systems so that they in turn can serve our needs. Of course, in order to serve those conativities, we must first attune to them, and then, if necessary, adapt our own ends to them. This might result in many products currently hailed as instances of biomimicry design, such as Velcro, proving superfluous.

To adopt such a bio-synergy approach to providing for our needs would require of us a deep understanding of the multi-layered and interlocking intricacies of life systems. To practise 'extensive' farming and to make strategic interventions into disturbed ecosystems on scales both small (as in bee keeping) and grand (as in marine revegetation via kelp) would require us, as workers and planners, to immerse ourselves in the life of ecosystems. Such immersion would consist in close attentiveness not only to the nuts and bolts of these systems, their genetic profiles and the mechanisms by which their components interact, but to their conative contours, the inner patterns that shape their outward forms. Such systems have, in other words, to be approached as living flows with interior ends and meanings of their own. To discover these flows, it is not enough to adopt the natural scientist's stance of being a detached observer. Rather, one must engage communicatively with one's biotic environs, divining conative tendencies by inviting responses, and always respecting the autonomy of living things: they will divulge their self-meanings only if they choose to do so, and they will choose to do so only to the extent that one's overture is respectful and appropriate.

In this sense, bio-synergy requires a return to a vastly enlarged world of multilateral, trans-species communication lost until now to post-agrarian societies. The disposition to engage in such communication, however, is our birthright – it is part of an evolutionary heritage resulting from tens of thousands of years

of pre-agrarian praxis. It is for this attentiveness to the detail and particularity of natural systems, and attunement through communicative engagement to the intelligences at work in myriad life forms, that our brains and bodies have arguably evolved (Shepard 1998). If our species has taken with such alacrity to the informational era, and has displayed such a compulsive urge to engage in the communicative exchanges that information technology encourages, then we might speculate that this is because anthropocentrism has robbed us of opportunities for the kind of highly sophisticated and multivocal communicativity for which evolution has prepared our brains. Neurologically deprived in this manner – deprived of opportunities to exercise our brains in their biologically intended mode – we resort to the chatter of our present-day techno-mediated 'communiculture', which, ironically, locks us, reiteratively, harder and harder into the ever-contracting circles of anthropocentrism. Within this trivialised communiculture, however, may lie a clue to a deep human disposition that can be tapped to motivate bio-synergistic forms of praxis.

CONCLUSION

Whether bio-synergy as a mode of provisioning can fully meet the needs of human societies in the twenty-first century is a question that awaits further exploration. My aim in this article has only been to show that unless biomimicry is interpreted in terms of something approximating to bio-synergy – however this is figured – it will not serve the bio-inclusive values that early proponents, such as Benyus, intended it to do. It is likely instead to follow the kind of course prefigured by eco-modernism, with anthropocentric results potentially catastrophic for the rest of earth-life. In arguing this I have examined the intimate way in which the normative orientation of any society is shaped by its prevailing forms of praxis. Environmental thinkers in industrial societies, in which consciousness is rooted in the category of production, may propose, on strictly philosophical grounds, that bio-inclusive values are preferable to the anthropocentric orientation that productivism entrains. But it will not be possible for either those thinkers themselves or anyone else genuinely to inhabit such values until our praxis transitions to a post-productivist, more participatory mode. Hollow appeals to the need for 'value shift' that ignore this relationship between values and praxis are bound to lead to frustration. So biomimicry, if it is to serve bio-inclusive values, must likewise offer post-productivist, participatory modes of praxis.[19]

19. We might concur that bio-synergy as praxis would ensure a bio-inclusive orientation in society, but in the absence of an economic order that already provides consistent experiences of bio-synergy, the normative commitment needed for initial investment in such a new order will be lacking. This is, as I mentioned at the start, the 'hard problem' that bedevils all proposals for deep environmental reform. Space, however, precludes any treatment of this problem here.

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