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Reckoning the nonexistent: Putting the science right

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ABSTRACT

Patten (2014) focuses upon some obvious conflicts between environmental action and the science of ecology and asks whether either should be revised to achieve better accord. It appears that both need to be reconsidered, but it is the conventional notion of science that seems more in need of emendation. The materialist/mechanist metaphysics of conventional science renders it unsuitable for the interpretation of ethics and inadequate to the full treatment of the phenomenon of life. Fortunately, the study of ecological networks provides a natural introduction of the apophatic (that which does not exist) into science, because it makes possible the quantitative parsing of the organization inherent in a network from its residual flexibility (an apophasis, or lack of constraint). Data suggest that both are necessary for sustainability, and methods for achieving a balance between the opposing attributes are outlined. The conventional mechanistic picture of the ecological world as a noisy clockwork must be transformed into the metaphor of a dialectic between the buildup of autocatalytic constraints and the entropic decay of system organization. Enduring configurations of mutualistic contingencies appear more relevant to the explanation of ecosystem behavior than is classical dynamical theory. With this transition to a more encompassing metaphysics, most of the inconsistencies observed by Patten evaporate. For example, the full picture reveals that there are contexts under which maximum power should be allowed full reign, while other conditions call for the environmentalist's conservative approach.

1. Major disconnects

Bernard Patten, earlier in this Special Edition identifies several points of major dissonance between key projects of the environmental movement and the science of ecosystem behavior. He notes, for example, that considerable efforts around the globe have been mounted to conserve biodiversity, while the theoretical support for such action is very tenuous, at best. The principle of maximum power generation is purported to be driving much of ecosystem dynamics (Odum, 1971), and the dissipation it generates is often quite destructive locally. He argues, however, that such local upsets often contribute to greater welfare at the next higher level. Why, then, work to inhibit local instances of maximum power generation (e.g., eutrophication)? The dynamics of maximum power apply as well to Neoliberal economics, where it is almost axiomatic that local maximization of profit will contribute to the common good. Why do so many organizations work to achieve peace, when wars create ever larger alliances within which conflict is significantly mitigated? Why aim to make human society sustainable, when the scientific consensus is that biological systems are never in equilibrium?, etc.

Patten makes it very clear that he is not advocating abandonment of environmental and humanitarian initiatives. Rather, he is pointing to how value-free science does not square with many human concerns. He aims more toward putting both science and public consensus to the test – much in line with Popper's call for continued attempts to falsify hypotheses. Falsification is a notion to which everyone pays lip-service, but very few ever practice. Patten, then, is courageously following Popper's exhortation to seek out and confront inconvenient dissonance.

To paraphrase Patten's questions: "Is environmentalism misguided, or is science inadequate to evaluate the benefits of contemporary environmental action?" To be sure, one can cite examples that speak to either side of this issue, but because the subject of this Special Edition is ecological science, I wish to focus on the shortcomings of contemporary theory. Regarding the adequacy of science, I begin by recalling the answer that Augustine of Hippo gave when he was asked if miracles violated natural laws? In effect he said, "No, we just don't know enough about natural laws!" Of course, miracles remain outside of science, but the point I wish to make is that we are still in need of Augustine's Fourth Century humility, despite our advanced notions of natural laws

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and the enormous benefits wrought by science over the past three centuries.

To allay any possible misgivings on the part of the reader, let me affirm now that I do not think that contemporary science is necessarily wrong – just that it remains (perpetually) incomplete, and that accepted metaphysics greatly exaggerate the role of universal laws in the origins of natural living systems.

2. Observing with one eye only

It is central to the scientific method that our body of knowledge always remains incomplete and evolving. With a slight touch of irony, I wish to suggest that, although most scientists do recognize the incompleteness of their own field, the greater majority remain unaware that nature itself is incomplete. Were it otherwise, science would not remain almost exclusively positivistic (material/mechanical) in scope. As it is, contemporary science is didactic and focuses narrowly on the palpable, on observable regularities. It pays scant regard to the arbitrary and virtually none at all to that which is absent. Bateson (1972), for example, remarked on the preoccupation of physics with the palpable, and that it is only rare exceptions, like the Pauli Exclusion Principle, that mention what is not or cannot be. More recently, Deacon (2011) underscored Bateson by highlighting the role that the missing plays in initiating and sustaining change.

Focus upon the palpable is, of course, natural and understandable. The arbitrary and the missing tend to be unattractive and difficult to describe, much less to quantify. With simple systems, it usually has been possible to isolate and ignore irregularities by creating artificial laboratory situations (Popper, 1990). But with complex systems like ecological communities, there simply is no ignoring that which is absent. If, for example, a particular resource or predator of a given population is absent, it becomes a matter of life or death to that species. The conventional way of accounting for the missing is to relegate it to the boundary statement for the problem. If, however, the arbitrary or the missing happens to be integral to the system dynamics, it becomes a significant distortion of reality to remove it to the exogenous world.

3. Engineering – a different metaphysics

My point is that it is entirely possible to quantify the indeterminate and/or the absent as *endogenous* aspects of complex systems. At first, such a task strikes one as absurd and oxymoronic – to quantify that which is not?! Such quantification might seem especially perplexing to those trained always to approach problems in reductionistic fashion, which has been the experience of most biologists. Engineers, however, feel no compulsion always to invoke reductionism. Their role in society does not permit them to wait for reductionist explanations. They are forced daily to confront practical problems by searching for quantitative regularities that appear and persist in the absence of any knowledge about detailed events – an approach they have labeled "phenomenology" (which biologists frequently disdain as empiricism). It is through phenomenology, however, that that which is absent becomes apparent.

Perhaps phenomenology is most frequently encountered in the guise of engineering "black-box" methods of problem solving. The most significant example of phenomenological science, however, is thermodynamics. The basic laws and relationships of thermodynamics were discovered without any knowledge whatsoever about the actions of individual molecules. In fact, it was not even necessary to know that atoms and molecules exist! By way of example, if during my own training as an engineer, I should use either the word "atom" or "molecule" in response to any question on thermodynamics, that answer would categorically be marked incorrect. My mentors imposed this restriction to emphasize that the laws and inter-variable relationships of thermodynamics remain solidly and wholly entailed by phenomenology.

Many remain unaware of how the development of thermodynamic principles during the 19th Century placed the atomic theory at risk. How could small particles, presumably obeying reversible dynamics, behave irreversibly in the aggregate? This enigma underscored a dictum that many would prefer to ignore: If a theory contradicts established phenomenology, it is always the theory that is at risk, not the phenomenology. To operate otherwise would be to engage in ideology, not science. That thermodynamics is portrayed today by physicists as a form of molecular statistical mechanics represents an attempt by physicists to maintain the ascendancy of a reductionist physics that many engineers know is helpful at times, but is by no means necessary.

Of course, the macroscopic approach is not foreign to ecology. All ecologists recognize the obligate role of genes in ontogeny, and many projects in autecology deal with the expression of genetic characteristics. It would be foolhardy, however, to predicate the behavior of whole ecosystems on genomes (Stent, 1981).

It will come as a further surprise to many non-engineers to learn that one can uncover significant factors in a system's operation in the absence of any knowledge about its specific dynamics. The "Buckingham-Pi Theorem", which undergirds the discipline of "dimensional analysis", allows the engineer to sift through the characteristic parameters of a system and identify key system processes without having any knowledge of the dynamical form of those processes (Buckingham, 1915; Long, 1963).

4. Reckoning the indeterminate

This empirical mindset of the engineer provides an avenue toward quantifying that which is missing. The approach, however, is indirect and relativistic, because quantifying what is missing is not possible in any absolute sense. A relative measure of what is missing is nonetheless almost always feasible.[1] Thus, we begin by focusing not on what is absent, but rather on how much of an attribute is present. For example, we derive a metric of the extent to which the internal processes of a system are constrained by one another. We then calculate this metric for two different system configurations. By difference, then, it becomes possible to calculate how much constraint is *lacking* from the lesser organized system with respect to the more organized form.

To illustrate such relativistic computation, I turn to the metaphor of the network. Conventionally, a network is assumed to represent the constraints that bind various elements into a functioning system – and this it does. The metaphor does not end there, however. The network also portrays the ways in which *indeterminacy* is amalgamated with the constraints that bind the system. Consider, for example, the web in Fig. 1 depicting energy transfers in an oyster reef community (Dame and Patten, 1981). Medium at any node of the network cannot flow directly to all other nodes. For example, if energy is resident in the deposited detritus, it can proceed only to the deposit feeders, the microbiota or the meiofauna, and not anywhere else. Implicit and unspecified constraints prohibit energy from flowing directly to the remaining compartments.

But such constraint is only half the story. At the same time, it is not determined to which of the allowable consumers the next quantum of energy will flow. For example, it seems impossible to say whether a fish predator will next consume a filter feeder or a deposit feeder. Most probably believe that, although one remains

[1] Some thermodynamicists will recognize this sentence as a restatement of the third law of thermodynamics.