Chapter 7
Process Ecology: Creatura at Large in an Open Universe

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Abstract Gregory Bateson maintained that access to the Sacred was being impeded by contemporary scientific attitudes. He urged that, in order to avoid a bad end, society must adopt an ecological vision. The conventional perspective can be described as the legacy of a Newtonian metaphysic, which consists of five postulates about how to view nature. Consideration of some aspects of ecosystem dynamics reveals, however, that they violate each of the five assumptions. In order that science may progress in its treatment of living systems, it thus becomes imperative that a new ecological set of assumptions supplant the former foundations. Nature is thus seen as open, contingent, historical, organic and granular. That these attributes allow more ready access to the Sacred is seen when one considers how they either obviate or mitigate former controversies such as free will, the origin of life, the possibility for Divine intervention and theodicy.

Keywords Autocatalysis, *creatura*, determinism, divine intervention, free will, newtonian metaphysics, origin of life, process ecology, radical chance, theodicy

[Au1] Introduction: An Occidental Pathway?

Should conventional scientific attitudes impede our approach to an "epistemology of the Sacred", the late Gregory Bateson would urge us to adopt in its place an "ecology of the mind". A deep and powerful idea! In reviewing Bateson's work, I have been amazed time and again by how prescient he was in so many ways. And yet, if one were to ask most ecologists to comment on Bateson's challenge to conventional science, the likely response would be a blank stare. Perhaps such ignorance would not have been a surprise to Bateson, who noted how the cybernetic nature of individuals and society induces them to be self-corrective against any disturbances to their

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worldview (Bateson 1972, p. 429).[1] Still, I am left to wonder whether Bateson's own eclectic vision didn't sometimes work against him. For example, he showed little reluctance to invoking sources from Gnosticism or Alchemy, but such allusions away from metaphysical naturalism often burden one's credibility among the bench ecologist – not to mention among those who set the trends for what is legitimate in science. I am reminded here of the overt disdain that most professional ecologists express for the concept of Gaia, due in large measure to the transcendental intimations evident in Lovelock's (1979) original formulation. And so with great and due respect to Bateson's genius, I will entertain the proposition that a more direct critique, posited within the Occidental framework that Bateson largely eschewed, might possibly have elicited a wider-ranging and longer-lasting response.

I note how Bateson hardly has been alone in invoking ecology to distinguish views that do not conform to conventional science. One encounters, for example, books on "the ecology of computational systems," (Huberman 1988) and entire institutes that are devoted to the "ecological study of perception and action" (Gibson 1979). Some have even accused ecosystem science of resting upon overtly theological underpinnings (Sagoff 1997). The latter allegation is hardly surprising, when one considers how Arne Naess (1988) purports that "deep ecology" affects one's life and perception of the natural world in a profound and ineffable way. Profound? Yes, and Bateson makes a good case for how language alone cannot convey all knowledge, but, as I hope to make apparent presently, maybe ecology need not be as ineffable as either he or Naess have contended.

I, therefore, entertain the proposition that the ways by which ecology affords *creatura* an escape from the mechanical shackles of mainstream science can be outlined in terms of a relatively straightforward metaphysics. For, in scrutinizing the assumptions that have sustained science over the last three or so centuries, one could conclude that, not only have they impeded access to the Sacred for many, but they have also blocked the road to full consideration of some very important natural phenomena as well. To heed Occam's Razor is all well and good, but to indulge in an exaggerated minimalism does a major disservice to our understanding of the natural world (Ulanowicz 1995a).

I will begin my parallel to Bateson's development by creating a "strawman" metaphysics that characterizes the consensus of scientific attitudes at the apogee of Newtonian science very early in the 19th century. I acknowledge that this framework has eroded considerably through the appearance of Thermodynamics, Darwinism, Relativity and Quantum Theories, but, depending on the particular field of endeavor, I would argue that various elements of the original structure remain solidly in place throughout almost all of contemporary science. I will then attempt to demonstrate how the phenomena particular to ecosystem behavior can violate each and every point of these conventional foundations. In a spirit of Postmodern Constructivism (Griffin 1996), I will try to outline a countervailing "ecological metaphysic", that poses far fewer barriers to the Sacred. In closing,

[1] All subsequent citations of Bateson 1972 will be denoted simply by the page number on which the material appears.

I will touch upon a few particular implications of this new metaphysic for some abiding issues in philosophy and theology, such as free will, the possibility of divine intervention, the origin of life and theodicy.

Barriers to the Sacred

Although books on the Scientific Method are legion, summaries of the fundamental assumptions which underlie the scientific endeavor are comparatively few. One such synopsis is by Depew and Weber (1994), who enumerated four fundamental postulates about nature according to which Newtonian investigations were pursued:

1. Newtonian systems are causally *closed*. Only mechanical or material causes are legitimate. Other forms of action are proscribed from consideration, especially any reference to Aristotle's "final", or top-down causality, which Thomas Aquinas later identified with God. The publication of Newton's *Principia*, after all, had been quite decisive in showing how the movements of the planets could be accurately described and predicted without any reference whatsoever to supernatural agencies.[2]
2. Newtonian systems are *atomistic*. They are strongly decomposable into stable least units, which can be built up and taken apart again. This property is ineluctably bound up with the notion of reductionism, whereby only those agencies at the smallest scales are of any importance. Whence, Carl Sagan, in wrapping up his television show on biological evolution that highlighted such megafauna as dinosaurs saw no inconsistency whatsoever in declaring, "These are some of the things that *molecules* do!" Another tacit implication of atomism is that in breaking any system apart nothing of essence is thereby lost. Thus, when atomism is combined with closure, the outcome is akin to the dictum of Lucretius (1st century BCE), "There are atoms, and there is the void." – nothing more!
3. Newtonian systems are *reversible*. Laws governing behavior work the same in both temporal directions. This is a consequence of the symmetry of time in all Newtonian laws. Although the obvious irreversibility of biological phenomena might give one pause, it should be pointed out how Aemalie Noether (1983) demonstrated that symmetry in time and the notion of conservation (of material and energy) are inextricably linked, and virtually all scientific endeavors rely on some assumption about conservation. One should note as well that in a reversible, conservative world nothing essentially new can possibly arise.

[2] Eddington's original warning read, "If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations – then so much the worse for Maxwell's equations. If it is found to be contradicted by observation, well, these experimentalists do bungle things sometimes. But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation".

4. Newtonian systems are deterministic. Given precise initial conditions, the future (and past) states of a system can be specified with arbitrary precision. So enamored of their own successes were the mechanists of the early 19th century that Pierre Laplace (1996) was able to exult in the unlimited horizons of the emerging mechanical worldview. Any “demon” or angel, he proclaimed, that possessed a precise knowledge of the positions and momenta of all particles in the universe at any single instant could invoke Newtonian-like dynamics to predict all future events and/or hindcast all of history.

In addition, I have elsewhere (Ulanowicz 1999) suggested a fifth article of faith, namely that

5. Physical laws are *universal*. They apply everywhere, at all times and scales. The keyword here is “everywhere”. In combination with determinism, universality says that nothing occurs other than what is elicited by a fundamental physical law. Or, as Philip Hefner (2000), former director of the Zygon Center for Religion and Science, once wistfully expressed his doubts by saying that God just doesn’t have enough “wiggle-room” to act in the world.

As I mentioned earlier, nobody fully accedes to all five postulates. Almost every scientist, however, clings to one or more of the tenets. Thus it is that closure is strictly applied to the neo-Darwinian scenario of evolution. The theory is scrupulous in making reference to only material and mechanical causes (Dawkins 1976, Dennett 1995). Atomism (reductionism) still dominates biology – witness the preponderance of molecular biology today. A substantial fraction of scientists even continue to deny the reality of chance in the world. “If only the depth and precision of one’s observation were not so limited”, they maintain, “one could in principle predict what now appear to be random behaviors.” So it is not surprising that for many, science appears as an ostensible refuge from having to confront questions of faith.

As Bateson might underscore here, these postulates all pertain to the *pleroma* in nature (p. 481). They are set up to describe the world in terms of eternal and unchanging fundamental *objects*. Change at higher levels is thereby only illusory or epiphenomenal. And so we confront the first major question, “How can things change?”

The Aleatoric in Nature

Bateson (p. 427) was fond of pointing to Lamarck as the first to interject change into biology, and the evolutionary theorist would immediately (and correctly) interject that Wallace and Darwin introduced both change and history with their description of evolution. Later Mendel demonstrated how change could be discrete, as opposed to gradual. This is all well and good, but it needs to be emphasized how, at the beginning of the 20th century, none of these individuals enjoyed widespread approbation among scientific circles; primarily because their narratives evoked too much discord with the Eleatic view of Newtonians that the universe is essentially unchanging. Evolutionary theory began to gain ground only in the 1930s, after Fisher and Wright had borrowed the probabilistic approach of Boltzmann and Gibbs to show that the genie of chance could be pushed back into the bottle. Although there might be small departures from the grand continuum, these deviations were simple and regular in nature and could be predicted in the aggregate using probability theory.

This reconciliation by Fisher and Wright, commonly call the "Grand Synthesis", conveniently ignored the potentially radical nature of some events in a complex world. Actually, consideration of radical chance came well before the advent of what we today call "Complexity Theory", Walter Elsasser (1969) elaborated it about the same time that Bateson was actively preaching the Ecology of Mind (although in my brief survey of Bateson I encountered no evidence that he was aware of Elsasser).

In brief, Elsasser argued for the existence of unique events – events that occur once and never again. He began by introducing the concept of an "enormous number" – numbers so large that they defy physical reality. In order to approximate the threshold of enormous numbers, he attempted to estimate an upper limit on the number of simple events that possibly could have occurred since the Big Bang. Elsasser reckoned the number of simple particles in the known universe to be about 10^{85}, give or take a few orders of magnitude. He then noted as how the number of nanoseconds that have transpired since the beginning of the universe is about 10^{25}. Hence, his rough estimate of the upper limit on the number of conceivable events that could have occurred in the physical world is about 10^{110}. Any number of possibilities much larger than this value simply loses any meaning as regards physical reality.

Bateson's eschewal of the Big Bang notwithstanding, anyone familiar with combinatorics immediately will realize that it doesn't take very many identifiable elements or processes before the number of possible configurations among them becomes enormous. One doesn't need Avagadro's Number of particles (10^{23}) to produce combinations in excess of 10^{110} – a system with merely 80 or so distinguishable components will suffice. In probabilistic terms, any event randomly comprised of more than 80 separate elements is almost certain never to have occurred earlier in the history of the universe. Such a constellation is unique once and for all time. It follows, then, that in ecosystems with hundreds or thousands of distinguishable organisms, one must reckon not just with the occasional unique event, but with legions of them. Unique, singular events are occurring all the time, everywhere!

In the face of this reality, any consideration of determinism as a universal characteristic seems absurd. All hope of probabilistic prediction fails, because probability theory cannot deal with singular events. In order to define a probability for an event, it must re-occur a sufficient number of times. Suddenly, the entire ground has shifted. The dominant question no longer is how can things change, but rather how can any pattern persist in the face of such radical indeterminacy?

A Cybernetic World

This shift in leading question throws us back into Bateson's home territory – that of cybernetics, for now one must ask what elicits and sustains order in the midst of a world full of noise? In formulating a response, we note Bateson's opinion (p. 404) that a causal circuit generates non-random response to random stimuli. I, therefore, wish to concentrate on a particular form of causal circuit – that of autocatalysis. My definition of autocatalysis is any manifestation of a positive feedback loop whereby the direct effect of every link on its downstream neighbor is positive. Without loss of generality, let us focus our attention on a serial, circular conjunction of three processes A, B, and C (Figure 7.1) Any increase in A is likely to induce a corresponding increase in B, which in turn elicits an increase in C, and whence back to A.

A didactic example of autocatalysis in ecology is the community that forms around the aquatic macrophyte, *Utricularia* (Ulanowicz 1995b). All members of the genus *Utricularia* are carnivorous plants. Small bladders, called utricles, are scattered along its feather-like stems and leaves (Figure 7.2a). Each utricle has a few hair-like triggers at its terminal end, which, when touched by a feeding zooplankter, opens the end of the bladder, and the animal is sucked into the utricle by a negative osmotic pressure that the plant had maintained inside the bladder. In nature the surface of *Utricularia* plants is always host to a film of algal growth known as periphyton. This periphyton serves in turn as food for any number of species of small zooplankton. The autocatalytic cycle is closed when the *Utricularia* captures and absorbs many of the zooplankton (Figure 7.2b).

In chemistry, where reactants are simple and fixed, autocatalysis behaves just like any other mechanism. As soon as one must contend with organic macromolecules and their ability to undergo small, incremental alterations, however, the game alters considerably. Whenever the effect of any catalyst on the downstream element is fraught with contingencies (rather than being deterministic and obligatory), a number of decidedly non-mechanical behaviors can arise (Ulanowicz 1997). For the sake of brevity, I will discuss only a few:

Perhaps most importantly, autocatalysis is capable of exerting selection pressure upon its ever-changing, malleable constituents. To see this, one considers a small spontaneous change in process B. If that change either makes B more sensitive to A or a more effective catalyst of C, then the transition will receive enhanced stimulus from A. Conversely, if the change in B either makes it either less sensitive to the effects of A or a weaker catalyst of C, then that perturbation will likely receive

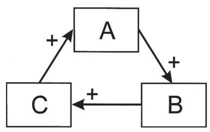

Fig. 7.1 A simple example of autocatalysis

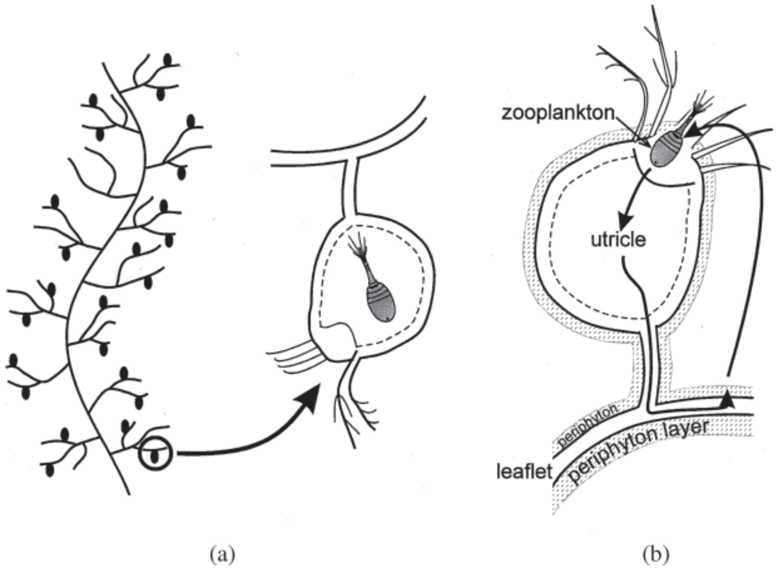

Fig. 7. 2 (a) *Utricularia*, a carnivorous plant. (b) The cycle of rewards in the *Utricularia* system

diminished support from A. That is to say that there is a preferred direction inherent in autocatalysis – that of increasing autocatalytic participation. This preferred direction can be interpreted as a breaking of symmetry, and such asymmetry violates the assumption of reversibility. Furthermore, as elements increasingly engage in autocatalysis, or mutually adapt to the cycle, they lose the capability of acting on their own. They may even become unable to persist in isolation, or if they do, it would be with behavior radically different from what they exhibited as part of the autocatalytic scheme. That is, the full cycle manifests an organic nature that belies the assumption of Atomism.

To see how another very important attribute of living systems can arise, one notes in particular that any change in B is likely to involve a change in the amounts of material and energy that are required to sustain process B. As a corollary to selection pressure we immediately recognize the tendency to reward and support any changes that serve to bring ever more resources into B. Because this circumstance pertains to any and all members of the feedback loop, any autocatalytic cycle becomes the epi-center of a *centripetal* pattern of flows towards which as many resources as possible will converge (Figure 7.3). In a way of speaking, an autocatalytic loop *defines its own selfhood* by virtue of being the focus of centripetal flows. It is what Bateson refers to as the unit of evolutionary survival that he identifies with "mind" (p. 483).

Bateson (p. 402) noted a proclivity in cybernetic systems to exert top-down influence, and the selection pressure inherent in autocatalysis acts in exactly this

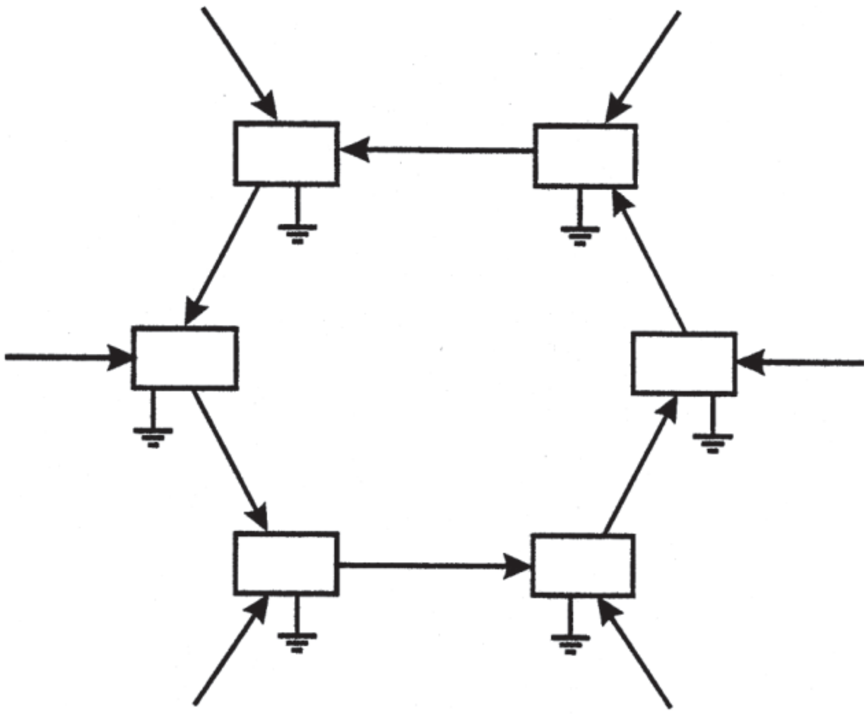

Fig. 7.3 Centripetal action as engendered by autocatalysis

fashion. It is an agency proper to the macroscopic ensemble that actively orders its constituent elements. When viewed at the level of the entire loop, centripetality appears as an agency originating *at* the focal level. Both of these modes of action violate the rule of causal closure, which allows only mechanical actions at smaller levels to ramify *up* the hierarchy of scales.

A common consequence of centripetality is that whenever two or more autocatalytic loops exist within the same system and draw from the same pool of finite resources, *competition* among the foci usually ensues.[3] In particular, whenever two loops share pathway segments in common, the result of this competition is likely to be the exclusion or radical diminution of one of the non-overlapping sections. For example, should a new element D happen to appear and to connect with A and C in parallel to their connections with B, then if D is more sensitive to A and/or a better catalyst of C, the ensuing dynamics should favor D over B to the extent that B will either fade into the background or disappear altogether (Figure 7.4). That is, the

[3] The focus here upon competition is to demonstrate how centripetality can order dynamical structures. One must always bear in mind that such competition does not act in exclusion of mutuality, which constitutes the very foundation of centripetality.

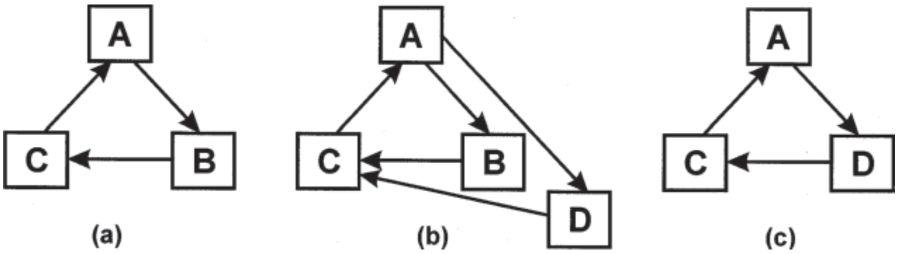

Fig. 7.4 The selection of new element D to replace B [Au3]

selection pressure and centripetality generated by complex autocatalysis (a configuration of processes) is capable of influencing the replacement of elements.

In the conventional view, agency is considered to originate only with objects, but we now perceive yet another inversion of affairs. A *configuration of processes* strongly influences which objects remain and which pass from the scene. I would suggest that such configurations are at the crux of Bateson's "*creatura*". Processes participate in the creation of their own elements, a fact which also underscores Whitehead's (1978) emphasis on process over objects and laws.

Bateson posits as how creatural description is always hierarchical (p. 457), and so it is worthwhile to note how autocatalytic selection sometimes acts to stabilize and regularize behaviors across the hierarchy of scales. Unlike the rigidity of Newtonian universality, the effects of a chance event anywhere in the realm of "process ecology" rarely will propagate up and down the hierarchy without attenuation. The consequences of noise at one level are usually mitigated by autocatalytic selection at higher levels and by energetic culling at lower levels. Nature as a whole takes on "habits" (Hoffmeyer 1993) and exhibits regularities, but the universality and uniformity of all Newtonian laws are replaced by a *granularity* of the real world. That is, models of events at any one scale can explain matters at another scale only in inverse proportion to the remoteness between them. Obversely, the domain within which irregularities and perturbations can damage a system remains circumscribed. Under the more flexible scenario of process ecology chance does not necessarily unravel a system.

Finally, it should be pointed out that the overall autocatalytic configuration will tend to persist, even as constituents *and associated mechanisms* come and go under its aegis.

A Transactional Ecology

In the years following Bateson's participation in the series of Macy Conferences, those in the discipline of information theory made strides in extending Claude Shannon's measure of information to apply to Bayesian or conditional probabilities

(Rutledge et al. 1976). As a result, it is now possible to identify Shannon-like indices capable of decomposing the overall complexity of a configuration (or network) of processes into separate components that represent organized or coherent structure on the one hand and disorganized flexibility, on the other. As a result we now have the capability to quantify Bateson's "economy of flexibility" (p. 349ff) in terms of two measurable and complementary terms called the network ascendancy and overhead, respectively (Ulanowicz 1980).

Those cybernetic tendencies that reinforce autocatalytic performance and thereby create order contribute quantitatively towards an increasing system ascendency (Ulanowicz 1986). It is tempting to think that an ever-higher ascendency would always benefit an ecosystem. It appears, however, that systems can acquire a surfeit of order and constraint to the point of growing "brittle" (Holling 1986). Too low a proportion of overhead represents a deficiency of flexibility in the system that would otherwise allow it to adapt to novel challenges. In Bateson's terminology, the system comes to lack a "defense in depth" (p. 351), and such brittle systems become candidates for collapse (p. 495).

In keeping with the complex nature of the biological world, changes in ecosystem structure do not appear to move toward a single goal (p. 500). Not only do ecosystems appear to respond to a multiplicity of "orientor" functions (Mueller & Leupelt 1998), but a major division of trends into order-enhancing or ascendant directions as opposed to entropic or diversifying dispersions becomes visible. The interplay between the contributions to ascendency and overhead resembles nothing other than a classical dialectic (although a "transactional exchange" might describe the situation with fewer distracting connotations). Contributions to either side of this transaction tend to subtract from its complement, and vice versa. Over the longer term (at a higher level), however, only systems that retain appropriate amounts of *both* attributes can persist (Ulanowicz 1986, 1997).

An Ecological Metaphysic

The astute reader may have noticed that I have offered at least one reason why each of the five Newtonian postulates does not pertain to the realm of ecosystem development. In order to make further progress in understanding the realm of *creatura*, it becomes necessary to formulate an ecological counterpoint to each of the five Newtonian postulates (Ulanowicz 1999):

1. Ecosystems are not closed but *open* to the influence of non-mechanical agency.
2. Ecosystems are *contingent* in nature.
3. The realm of ecology is *granular*, rather than uniform and universal.
4. Ecosystems, like other biotic systems, are not reversible but *historical*.
5. Ecosystems are not easily decomposed; they are *organic* in composition and behavior.

Fading Issues

As Bateson proposed, not only does an ecological vision help us to perceive reality more clearly than the procrustean Newtonianism it supplants, it also places far fewer barriers to encountering the Sacred. Perhaps the Newtonian impediments should not be too surprising, seeing as how they had precipitated during a time of secular–clerical strife. But those conflicts are now behind us (at least in the Western World), and so we should now reconsider a few of the issues that until rather recently have been regarded as conflicts between science and theism (Ulanowicz 2004):

Take, for example, the controversy surrounding free-will. In a deterministic Newtonian world there simply is no place whatsoever for free-will. To paraphrase the Newtonianist Sagan, thinking is just one of the things that *molecules* do, and molecules do not swerve from their lawful course. But the world of ecology is an open theatre, replete everywhere with legions of singular events. Nor is it any longer necessary to confine the search for free will to the vicissitudes of quantum phenomena (Penrose 1994). Contingencies can arise anywhere among the many layers of patterns that separate the firing of neurons from conscious thought, and the top-down influences of mind cannot be discounted (Juarrero 1999).

Then there is the matter of prayer, so central to the religions of the Book. While most believers acknowledge that the highest form of prayer should concern attitude rather than supplication, the latter retains its place among all such denominations. But why pray, if the Deity cannot interfere with its ordained laws? Such was the conundrum for the Deists, who sprang up in the wake of Newton. As Philip Hefner once opined, God just doesn't have the "wiggle room" to answer entreaties. The ecological world, however, is a far more supple place. Singular events are occurring everywhere, all the time. Most amount to nothing in the long run; a few damage the system and elicit a response; a miniscule few take the configuration into new and more effective (autocatalytically speaking) modes of operation and become incorporated into the history of the system. As mentioned, the fabric of causality is porous at all levels, and one cannot exclude a priori the possibility that a Deity might execute a coordinated action across several levels that need not propagate to the rest of the universe. God is not to be iced-out of the natural world, nor need small miracles defy rationality.

These last few statements most certainly will be rejected summarily by some as just another "God of the Gaps" argument. For those critics, I have special words: First, I would emphasize the sheer ubiquity of singular events in this complex world. One is not pointing to just rare and occasional gaps through which a God can tinker with nature. The entire fabric is *full* of holes. Secondly, as John Polkinghorne has noted, there are gaps and there are gaps (Davis 1998). It is rational to *believe* in the universality of scientific law, both those derived in the past and those yet to be formulated. It is contrary to that belief, however, to deny that limits to our knowledge, such as the natural ones posed by, say, the Heisenberg Principle, cannot exist. The gaps which I have described are of this latter nature, and one ignores them at peril to one's own rational integrity. With all due apologies to Arthur Eddington (1930) and the late Karl Popper (1990), I would dare to say to those who cannot accommodate causal openness:

> If someone points out to you that your pet theory of evolution is in disagreement with Fisher's equations, then so much the worse for Fisher's equations. And if your theory contradicts the facts, well, sometimes these experimentalists make mistakes. But if your theory cannot accommodate gaps in the causal structure of living systems, I can give you no hope; there is nothing for it but to fall grievously short of providing you full knowledge of how living systems evolve. [Au4]

Evolutionary theory sidesteps circumstances leading to the origin of life, although there is no paucity of theories concerning life's beginnings. Given the emphasis in conventional science, however, upon attaching agency solely to objects, the focus of most of these theories is upon those structural elements that could lead to life. That is, most infer that once the right chemical structures appear, they will immediately spring to life, somewhat akin to Ezekiel's dry bones taking on flesh and dancing. Process ecology bids us instead to entertain a more consistent scenario.

Howard Odum (1971), for example, proposed that *proto-ecological* systems had to already be in existence before proto-*organisms* could arise. His scenario was that at least two opposing (agonistic) reactions (like oxidation–reduction) (Fiscus 2001) had to be physically separated and their reactants be actively transported across a spatial domain that consisted of one region where a source of energy dominates and another where the residuals of that energy (entropy) can be conveyed out of the system. Such a cyclical configuration of processes, via scenarios involving selection like those just discussed, could readily engender more complicated but smaller cyclical configurations (proto-organisms). Unlike the warm soup hypothesis, such transition poses no enigma. In irreversible thermodynamics processes are assumed to engender (and couple with) other processes all the time. Large cyclical motions spawn smaller ones as the normal matter of course, as when large-scale turbulent eddies shed smaller ones (Ulanowicz 2002). Corliss (1992) has suggested that an Odum-like scenario might have played out in proximity to archaen thermal springs – an idea that recently has found new enthusiasts in Harold Morowitz and Robert Hazen (Cody et al. 2001). Thus, process ecology, with its notion that objects can be created by configurations of processes, provides a far more consistent narrative of the origin of life.

One barrier to the Sacred that did not originate with the Newtonian worldview is the problem of evil in the world, or theodicy, as the theologians call it. To be sure, this vexing issue does not simply disappear from the ecological vision, but it does take on a different form. Bateson, for example, was prescient in recognizing the necessity of noise in the creative process (p. 410). Unfortunately, few have come to share his insight, and most prefer instead to concentrate on the necessity of the right "machinery" to carry out creative acts. But all the machinery in the world will not result in creative change, absent some form of participation by the aleatoric. Efficiency and performance may be necessary for creativity, but they are insufficient to guarantee it. For this reason a healthy ecosystem must always retain a modicum of inefficient, incoherent and disorganized repertoires that could be implemented in the face of novel perturbation to generate an effective response to the threat (Ulanowicz 1990). Any system that is so finely honed in its performance so as to exclude too much such insurance is doomed to extinction. Similarly, a society that seeks to purge itself of all petty evil will collapse. Just like weeds among the wheat, some tolerance for minor evils must be allowed in order for society to progress. The problem of theodicy, therefore, is no longer why any evil exists (ontology), but becomes rather a question of magnitude – why are *excessive* evils allowed to persist?

Conclusion: New and Renewed Dialogs

I would like to close by supporting Bateson's approbation of a Buberian I–Thou relationship between humanity and the living world (p. 446). Bateson prefigured by at least a decade Ilya Prigogine's (and Stengers 1984) call for a new dialogue between "man and nature". Indeed, the metaphor of a dialog is an encouraging replacement for the timeworn notion that competition and struggle between humankind and the rest of the universe constitute a necessary state of affairs. Speaking as a conventional theist, I would like to venture even further and suggest that the ecological vision does not proscribe a renewed hope in a continuing exchange between humanity and the Divine, as has been described over the centuries by the religions of the Book. Perhaps ironically, by delving ever deeper into the natural world, both scientists and theists are discovering that ostensible conflicts between them are beginning to pale (which is not to say that they will ever completely disappear). Nevertheless, the inevitable but necessary decay of order into the void that has made a "cosmology of despair" (Haught 2003) so fashionable among academics is now being countered in the ecological vision by the cybernetic pull towards more organized living configurations, so that a growing number of scientists no longer need abandon rationality in order to begin to entertain a countervailing "cosmology of hope".

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