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The Construction of Emergent Order, Or, How to Resist the Temptation of Hylozoism

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Hylozoism, the doctrine that nature is imbued by life even in the apparently inert and lifeless, has as one of its "appealing" features the ability to duck the perplexing issue of how life originated. By so doing, hylozoism has generated even more conundrums such as why rocks, if indeed they are actually animated, don't appear alive. Hylozoism is not so much a resolution *as a way of* avoiding *the possibility of the emergence of the radically novel. But, hylozoism is not just a relic of the past since modern strains of its specific explanatory strategy can be detected in three examples from the study of complex systems, namely, May's and Feigenbaum's explanation of complexity and universality in "one-humped" maps, Maturana's and Varela's idea of autopoeisis, and Goertzel's notion of self-generating systems. These three explanatory strategies are analyzed as to their hylozoist cast with the result that the first is found to be appropriate to the mathematical nature of the inquiry while the second two are found wanting in the same way that hylozoism in general proves unsatisfactory as an explanation. To remedy the problems associated with a hylozoist strategy, a constructional view of the emergence of new wholes is proposed including intimations as to how this constructional process might proceed.*

KEY WORDS: autopoeisis; emergence; explanation; hylozoism; referential closure; self-generating systems; self-reference; self-transcending constructions.

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EMERGENCE, THE ORIGIN OF LIFE, AND THE APPEAL OF HYLOZOISM

Although the term "emergence" has become just about ubiquitous among those fields making up the study of complex systems, it comes with not a small measure of conceptual troubles, not the least of which has to do with its customary association with an *explanatory gap* between supposedly unpredictable, nondeducible, and irreducible "higher" level emergent phenomena and the "lower" level components from which they emerge (on gaps, see Silberstein, 2001; on levels, see Goldstein, 2002). Although elsewhere in science the presence of explanatory gaps has usually acted as a prod for researchers to discover how to close them, in the case of emergence explanatory gaps are precisely one of the chief ways emergence is recognized. This is a major reason why emergence has prompted a rethinking of reductionist strategies having as their objective the elimination of such gaps by collapsing "higher" level phenomena into "lower" level dynamics (see Van Gulick, 2001, for a discussion of the current emergence-versus-reduction debate).

When the idea of emergence was at the center of the loosely joined movement in the sciences and philosophy known as Emergent Evolutionism which lasted from approximately 1910 to 1935, it was typically exemplified by the emergence of life out of inorganic matter (Goldstein, 1999). This particular exemplification of emergence has continued down to the contemporary scene so that the artificial life researcher Adami (1998) asserts that only if life could emerge from nonlife would inquiry into computational emergence be a worthwhile endeavor. In fact, there has long been a close connection between the idea of emergence and research into the origin of life. Thus, Oparin, who almost singlehandedly established the biochemical underpinnings of the field, adhered to an emergence type of outlook and Wächterhauser, whose suggestion of a mineral-based scaffolding on which autocatalytic reactions might have gotten their start, admits the strong influence of Popper's explicitly emergentist idea of *retrodiction* (Fry, 2000).

Undoubtedly, the greatest theoretical puzzle facing research into the origin of life has been to account for the radically different properties contrasting living organisms from the inert matter from which they are supposed to have emerged. The disparity between the properties of life versus the lifeless is an issue that has long beguiled thinkers, e.g., Kant put it this way: "... [it would be] contradictory to reason [to believe] that life should have sprung from the nature of what is lifeless, that matter should have been able to dispose itself into the form of a self-maintaining purposiveness" (Kant quoted in Lenoir, 1982, p. 29). This is not to say, however, that there has not also been a traditional way out of this conceptual difficulty, namely, the antediluvian doctrine of *hylozoism* which, by supposing that nature is infused with life all the down even in the apparently inert, "resolves" the issue of the discrepancy between the organic and lifeless by essentially wiping it out. Hylozoism is commonly found along side the closely related notion of *panpsychism*, the tenet that mental qualities also pervade nature all the way down. Both doctrines have been held, in one form or another, by no less a set of philosophical and scientific luminaries than Aristotle, Descartes, Spinoza, Newton, Kant, James, and Whitehead, to name just a few. Indeed, although it's become quite popular to decry Newton for bequeathing a mechanical and thereby lifeless view of nature, Newton himself was actually committed to an opposite, hylozoist sentiment, "We cannot say that all nature is not alive" (Rae, 1981). Or, as the renowned 18th and 19th Century biologist Cuvier put it, ". . . life has always arisen from life. We see it being transmitted and none being produced" (Cuvier quoted in Farley, 1977, p. 39). A similar hylozoist disposition showed up in the influential dictum of Virchow who argued that a cell could not emerge from a noncell, his motto *omnis cellula e cellula* being a kind of cellular hylozoism (Farley, 1977).

Among other reasons for its adoption, hylozoism has offered the advantage of being able to skirt the entire enigmatic issue of the emergence of life from the lifeless since according to it, there is no nonanimated matter to begin with and, therefore, life need not emerge from what it is not! Thus, from the hylozoist perspective, the emergence of life from the nonliving need not be any more mysterious than the unfolding of what has already been enfolded. Furthermore, although hylozoism sounds very much like a vitalist perspective, it can actually avoid the vitalist notion that a special life force must be added to the living—since this life force exists all the way down in nature, life and its unique properties do not require the addition of a new life force.

Although offering the promise of demystifying the origin of life, the doctrine of hylozoism has had to pay two very high prices. First, it must deny the possibility of the coming into being of radically new properties for, if even the most nonlife like aspects of nature are nevertheless imbued with life, then consequently the radical discrepancy between life and nonlife disappears. The second price, stemming from the first, is that hylozoism thereby replaces one enigma with another, that is, the conundrum of origin of a radically new property, i.e., life, with the conundrum of why the inorganic, although supposedly endowed with life, does not exhibit what it is supposed to be endowed with. Why does a rock appear and behave inert and not life-like? Thus, no matter how hard hylozoism has tried to rid radical discontinuity from the origin of life, it winds up with another equally problematic discontinuity, that between appearance and reality. In the words of Juarrero

(1999), this type of explanation cannot possible explain the emergence of real novelty, "unless that seemingly novel, emergent, and original event is really neither truly novel, nor emergent, nor a radical, new beginning, but instead is already there, folded into the dynamics, just waiting to be unfolded and made actual" (p. 106).

These fundamental conceptual limitations of hylozoism are not simply quaint relics of our philosophical and scientific past for similar hylozoist-like explanatory strategies can also be found among those contemporary complexity theories which appeal to a seminal kernel as a means for explaining the later instantiation of this nascent form, that is, explicating what appears enigmatic by first positing a primordiality to the enigmatic feature and then understanding the exhibition of that feature at a later time as the result of the unfolding of its primordial nature. Like hylozoism, these explanations must then pay the conceptual price of not only replacing one conundrum by another, namely, the enigma of the emergence of the radically novel with the enigma of why this radical novelty is not evident, but also disavowing the possibility that anything really new could come about at all.

I want to focus on three exemplifications of this sort of hylozoist-like strategy in complexity theory—the first one which is unproblematic since its explanatory thrust is consonant with its subject matter, the second two because they're not. The first concerns the understanding of complexity and universality in nonlinear dynamical systems put forward respectively by May (1976) and Feigenbaum (Feigenbaum, 1983), which, I will argue, do not present a conceptual difficulty since they remain within a purely mathematical framework where dynamics are seen to naturally emerge out of innate structure. However, in the next two examples—the idea of autopoeisis as developed by Marturana and Varela but especially as it was formulated by Varela, and the idea of self-generating systems put forward by Goertzel—although consisting, in part, of appeals to mathematical structures per se, then extrapolate from this mathematical structure to apply to the nonmathematical realm of naturally occurring complex systems. These two extrapolations of mathematics, though, do *not* take place within the context of a typical empirical use of mathematics, but, instead, not only proceed with little philosophical or scientific warrant but actually serve to hinder further scientific understandings of emergence.

There is a further aim, however, behind discerning the hylozoist cast of these three approaches in the study of complex systems, namely, to point out how the idea of emergence, if it is to have any teeth in it at all, must face up to the really difficult challenge of accounting for the coming into existence of the radically novel, a difficulty facilely dodged by hylozoist-like strategies. In this regard, I offer several hints as to what would need to be taken into consideration if the emergence of the radically novel does actually take place.

EXPLAINING COMPLEXITY AND UNIVERSALITY IN NONLINEAR DYNAMICAL SYSTEMS

As is well known to the readers of this journal, much of the credit for sparking the chaos and complexity revolutions is due to the investigations of the complexity and universality of the logistic map and similar nonlinear dynamical functions conducted respectively by May and Feigenbaum. May's (1976) pioneering study of first-order difference equations revealed the presence of "an extraordinary spectrum of dynamical behavior, from stable points, through cascades of stable cycles, to a regime in which the behavior (although fully deterministic) is in many respects 'chaotic,' or indistinguishable from the sample function of a random process" (p. 459). Among the explanatory strategies employed by May was his analysis of the emergence of mathematical complexity during bifurcation by appealing to the mathematical structure of the derived map relating the differenced variable two generations apart, i.e.,

$$X_{t+2} = F[F(X_t)]$$

The graphic depiction of this map showed that the fixed point attractors became unstable when the parameter value steepened the curve, what May called "turning" the nonlinearity." Here May was appealing to the specific nonlinear structure of the map to account for the ensuing complexity. Thus, as in the hylozoist strategy described above, May explained the emerging complexity by turning to the actualization of a primordial, innate structure.

Similarly, Feigenbaum utilized a corresponding explanatory strategy in regards to the emerging complexity as well as the universality he discovered in such maps. To refresh the readers, Feigenbaum's constant is the ratio of successive parameter values, λ_n, of the nth iterates of so-called "one-hump" maps, i.e., quadratic difference equations as well as coupled nonlinear differential equations:

$$f = \lim_{n\to\infty} \frac{\lambda_{n+} - \lambda_n}{\lambda_{n+2} - \lambda_{n+1}} = 4.6692016\ldots$$

The Feigenbaum number is universally present in all "one-humped" maps, a "unique and hence *universal* solution" or in other words, is "...*predetermined*" and "must appear as a natural rate in oscillators, populations, fluids, and all systems exhibiting a period-doubling route to turbulence" (Feigenbaum, 1983, p. 17; his emphasis). Moreover, according to Feigenbaum, universality is due to the fact that in functional iteration the function is applied to itself recursively, so it is plausible that only a few, select self-consistent patterns would emerge, determined more by the iterative operation itself than the particular one-hump function involved. Again, we see an appeal to an innate, seminal mathematical structure in order to account for the ensuing dynamical behavior.

Feigenbaum (1983) resorts to this hylozoist-like strategy in explaining how complex behaviors arise in such an apparently simple operation as functional iteration: "A monotone f, one that always increases, always has simple behaviors, whether or not the behaviors are easy to compute. A linear f is always monotone. The f's we care about always fold over and so are strongly nonlinear. This folding nonlinearity gives rise to universality. Just as linearity in any system implies a definite model of solution, folding nonlinearity in any system also implies a definite method of solution" (p. 21). Notice that Feigenbaum, akin to May, identifies a "folding" nonlinearity in the graphic depiction of the function on a coordinate plane so that f reaches a maximum and then decreases, thereby forming a hump or a fold. This folding nonlinearity is crucial since it introduces a kind of symmetry whereby the fold is operated on by the function, being stretched and folded over and over again (I am endebted to Jim Frank-Saraceni for this insight). Thus, the fold can be understood as the nonlinear seed of the complexity later exhibited during the operation of functional iteration. From that folded nonlinearity many things are possible, most importantly, the emergence of new attractors at bifurcation and universality. Furthermore, the ensuing complexity and universality, according to Feigenbaum, *must*, by the necessity of the mathematical structures involved, occur. This reveals again how the entire explanation is of a hylozoist cast in being about a necessary actualization of preexisting, nascent complexity which is innate in the mathematical structure itself of the functions.

It must be noted here that what May and Feigenbaum had discovered was of a purely mathematical nature in spite of applications to the study of turbulence and so on. Within that purely mathematical context, later behavior is "predetermined," a matter of the unfolding of what's innate in the structure. Such, however, is the nature of mathematical explanations in general where an appeal to innate structure is used to explain dynamics. This is a mode of explanation perfectly appropriate for its subject matter. Indeed, it is more than likely that May's and Feigenbaum's dynamical explanations were a main inspiration for Prigogine's protege, Nicolis, in his description of self-organizing physical systems as the *activation of a hidden nonlinearity* (Prigogine and Nicolis had by then pretty much appropriated a nonlinear dynamical systems scheme for understanding self-organization—see, e.g., Nicolis, 1989).

PUSHING SELF-REFERENCE ALL THE WAY DOWN

Unlike May's and Feigenbaum's hylozoist-like mathematical explanations of mathematical phenomena, the next two examples, explain *naturally occurring systems* by a similar recourse to the unfolding of innate mathematical structures. In both of these cases, the mathematical structure appealed to is that of self-referentiality. Both theorists hinge their explanations on, first, pushing self-referentiality down to the foundations of mathematics and logic, and, next, appealing to this primordial self-referentiality as the conceptual underpinning of their two perspectives. However, by so doing, both approaches thereby open themselves up to the conceptual snags associated with hylozoism described above.

The Case of Autopoeisis

During the mid-phase period of emergentist thought, running approximately from 1935 to 1980, emergent wholes were characterized and formulated as *referentially closed*, that is, as being constituted by causal loops reinforcing each other, the circular kind of causality Kant had originally called for in order to distinguish life from nonlife (see McFarland, 1970). Later, Waddington (1978) attributed the idea of self-referential causality in its modern garb to Whitehead's conception of organic unity. Perhaps the apotheosis of referential closure was Maturana's and Varela's (1980) notion of *autopoeisis* which held organic wholes to be those entities which seek to maintain the very organization of which they are the embodiment. Living wholes are self-referential in their very essence by consisting of a network of production processes of components which, through their interactions, regenerate and realize the network that produces them. This self-referential, circular causality operates to create an invariant self-contained identity, a boundary-circumscribed state of *closure*, the term favored by Varela (1979, 1984), to distinguish his approach from the then standard information theoretic input/output model.

Realizing his appeal to self-referentiality lacked support as such in science and mathematics, Varela (1974, 1979a, 1979b) turned to the controversial work of the English mathematician Spencer-Brown whose novel approach to Boolean algebra incorporated self-referentiality as a fundamental element. According to Robertson (1999), Spencer-Brown found problem-solving advantage in using equations where a variable was forced to refer to itself, a step not unlike how imaginary numbers were first used to solve equations and then later incorporated into a consistent theoretical framework. For Spencer-Brown the self-referential value functioned like a self-referential paradox, e.g., the infamous *Liar* where true and false are forced to oscillate in an endless circle. Working with the mathematician Louis Kauffman, Varela (Robertson, 1999) developed an abstract algebra which placed self-referentiality on the same logically primordial level as true and false thereby making it able to ground the type of autopoeitic dynamics found in living systems. Varela's self-referential logic can be considered a sort of "*pan*-self-referentialism" since it, like the explanatory strategies found in hylozoism and pan-psychism, posited what was ultimately in need of explanation as a primordial, ubiquitous characteristic which then unfolded into later manifestations.

That such autopoietic wholes could be mathematically formalized was a consequence of, as pointed out later by Ostolaza and Bergareche (Helmreich, 2000), a critical difference between *organization* and *structure* in the theory of autopoiesis: *organization* being that whose objective is the preservation of itself; and, *structure* being the material substrate which the organization utilizes for its purpose of survival. Since autopoeisis is primarily a matter of organization and not structure, and since organization refers to itself, an autopoeitic whole is amenable to a purely formal account wherein the structure as such can be effectively disregarded. This point is similar to the idea, popular among computer scientists, concerning a radical disjunction between software and hardware so that the purely formal construction of software can putatively be implemented in virtually an unlimited number of different hardwares.

Varela, by buttressing his notion of autopoiesis through an algebra of self-reference, effectively adopted a hylozoist strategy since self-reference was pushed all the way down to the foundation of logic, and, through implication, into the core of nature herself. Like the above mentioned "benefit" of hylozoism, Varela was thereby able to pretty much duck the issue of how autopoeitic self-referential invariance arose to begin with since there was no longer a pre-self-referential condition. That's probably why Varela was, for the most part, reticent in regard to morphogenetic transformation during evolution and tended to avoid the term "emergence." A similar hush concerning transformation and how it can come about is also apparent among those who have appropriated autopoeisis in other contexts (see Ulrich and Probst, 1984).

This is not to say that the idea of autopoeisis does not possess some intriguing suggestions for understanding organic wholeness. But, as an explanation for referential closure, it suffers from the same serious lack as hylozoist strategies do in general. Even those who do get some important mileage out of the concept, for example, Lemke (2000), do so by, in my estimation, so changing the notion of Varela's *closure* that it no longer carries the sense of being closed! Indeed, the autopoietic stance on emergent wholes pushes the focus of inquiry away from how the parts (i.e., "structure") can function in making up wholes and instead overemphasizes the autonomy of emergent wholes in relation to the parts (i.e., "organization"). One result is the impression that such wholes are disconnected from that from which they emerge, as organization supposedly is from structure, a sense of having a life of their own separate from and lifted out of causal processes—so we are unfortunately back with more enigmas.

The Case of Self-Generation

Influenced in part by the idea of autopoiesis but more directly building on Kampis' (1991) idea of self-modifying component systems is Goertzel's (1994) notion of cognition as a *self-generating system* consisting of a set of stochastically computable processes which operate on one another to generate new processes of the same basic nature. Like Kampis' component systems, self-generating systems are emergent systems because new, unpredictable observables are continually being created. These processes are established as autopoeitic, cross-referential webs, which Goertzel terms "magicians," each magician possessing transformational "spells" for changing other magicians or group of magicians into other magicians. In a self-generating system, each collection of components can act on each other with a certain probability, thereby yielding new components with different probabilities. As a result, a new collection of components can then be fed back into the previous system like functional iteration or artificial life updating, thereby being used as "fodder" for further ongoing modifications. In addition, there is some kind of filtering procedures for these modifications, which appears to be along the lines of fitness functions in genetic algorithms. Goertzel holds that cognition is basically a matter of such self-generating webs plus capacities for pattern recognition.

Relying on Kampis' components systems however presented Goertzel with a problem since the former utilize mathematical functions which operate on themselves, i.e., self-referentially belong to their own domain or range, operations which are usually considered mathematical no-no's. To get around this difficulty, Goertzel turned to Aczel's theory of hypersets which are sets having the nonorthodox property of being allowed to contain themselves, a property going against conventional standards of logic and set theory. Here, Goertzel is relying on the graph theoretic understanding of Aczel's hypersets recounted in Barwise and Etchemendy (1988). Finding

Aczel's hypersets as "incredibly liberating" "for the mathematically indoctrinated mind," Goertzel feels confident in applying them since not only had Aczel shown that if ordinary set theory was consistent, so was set theory supplemented by hypersets, L. Lòfgren's (1968) had demonstrated that the axiom of complete self-reference is independent from set theory and logic. Like Varela's hylozoist strategy of explaining organic referential closure by appeal to an algebra of self-referentiality, Goertzel hylozoistically explains cognitive referential closure through the positing of a primordial self-referentiality in the form of hypersets.

Saying It Is So Does Not Make It So

Both autopoeisis and self-generation rely on a similar hylozoist-like explanatory strategy: first situating a primordial self-referentiality as a fundamental logical/mathematical element and then understanding the referential closure of organic wholes or cognition as manifestations of this primeval self-referential structure. The only difference with hylozoism is that in both cases, rather than organicity as such being pushed all the way down in nature, it is self-referentiality that is pushed down to a primordial logical status. The justification for the explanations offered in both cases, then, hinge on a mathematical foundation for a natural phenomena, the latter being somehow the result of the unfolding of the former. Note, that in neither case is the mathematical foundation put forward as a means for empirically validating their proposals. In fact, there are no empirical tests suggested for either idea at all. Whereas in the previous examples of May's and Feigenbaum's explanations of complexity and universality in nonlinear dynamical systems, the appeal to mathematical structure was totally consonant with the arena and direction of explanation, in the case of autopoeisis and self-generation, naturally occurring phenomena are explained by recourse to a purely mathematical foundation. There lies the rub for both the notions of autopoeisis and self-generating systems, since by following a hylozoist cast for their approaches, they both wind-up dodging the really baffling issue of the coming into being of the quality of referential closure.

There is a problematic metaphysics going here similar to the puzzling situation found in Escher's famous drawing of two hands drawing each other. Although Escher's fascinating drawing vividly depicts the structure of a cross-referential system, it, at the same time, evokes the enigma of how these two hands could have arisen to being with for they require each other's already existing presence. Escher's drawing suggests that unless the macroscopic image is a macromanifestation of a microseed of cross referentiality, that is, a manifestation of some kind of hylozoist self-referentialism at the primordial level, there is no way the hands could have emerged in the first place! Hence, although both autopoeisis and self-generation may be plausible models of referentially closed systems, as far as viable models of emergence go, they are seriously deficient for they amount to emergents emerging by their own bootstraps! Again, we see that hylozoist strategies carry with them the unfortunate feature of explaining one obscurity by something equally or even more obscure.

Now it might turn out to be the case that self-reference does indeed pervade nature, even rocks, just as hylozoists say life pervades nature, even rocks. However, just saying it is so does not make it so, even though saying it is so happens to be expedient. Goertzel, for example, does not worry about this issue since, as he proclaims, hyperset theory has been a totally liberating experience from the "stifling preconceptions" of orthodox set theory where sets have been forbidden to be members of themselves so as to avoid set-theoretical and semantic paradoxes. To be sure, Russell (Cocchiarella, 1987) introduced his type theory, one of whose proscriptions was the inadmissibility of such things as hypersets, in order to rid set theory of paradoxes. Type theory, of course, has its own problems, e.g., it has been criticized for the *ad hoc* way it adds new axioms to keep set theory free from paradox. But neither Lòfgren's nor Aczel's proposals for self-referentiality entail the kind of justification for self-generation that Goertzel thinks they do. After all, although Cohen had proven Cantor's Continuum Hypothesis was itself independent from set theory, this did not entail that the Continuum Hypothesis was true—in fact, Cohen himself doubts its veracity (Tiles, 1989)! Indeed, there is something suspiciously facile about being able to do all sorts of wonderful things by simply positing self-referentiality as a primordial mathematical element and then going on from there. Here, Goertzel's approach is reminiscent of a similar glib approach to set theoretical paradoxes found in Hellerstein's (1997) "Diamond Logic," where, by the simple positing of two paradoxical foundational elements, seemingly all the beguiling paradoxes encountered in the history of logic are *ipso facto* resolved! To paraphrase Russell, self-generation, like Hellerstein's paradoxical logic, has all the advantages of parthenogenesis over sexual reproduction in explaining an actual birth!

There is another problem, however, besides the set theoretical one, with basing a theory of emergence on a self-referential foundation. This is the fact that pure self-reference is entirely enclosed, hence, Varela's term "closure." Indeed, Kampis (1995) points out that a completely self-referential object approaches something like Leibniz's monads or Kant's *Ding an sich*. This implies that a completely self-referential entity would not be open to change or evolution or any sort of environmental affect at all. Recursion or feedback loops per se are not purely self-referential which is why models including them can represent systems undergoing change.

THE EMERGENT CONSTRUCTION OF EMERGENT WHOLES

The Emergence of Wholes

If the hylozoist strategies described above are insufficient for explaining the emergence of the radically novel, including the emergence of wholes characterized by referential closure, then what theoretical strategies might offer more? Simon once put forward a methodological principle that has since become something of a working guideline among complexity theorists, "... in the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist (Simon quoted in Wimsatt, 1972, p. 174). Notice Simon's careful phrasing: he simultaneously affirmed the reductionist underpinning of scientific research while acknowledging a heuristic value accrued from paying attention to the whole as such. Although Simon could thereby be seen as opening a door for taking emergence *scientifically* seriously, ardent advocates of emergence have tended to adhere to an *in principle* holism and a strident *anti*reductionism. Indeed, the theory of autopoeisis, by emphasizing the distinction between organization and structure as described above, comes down on the side of the inviolability of the whole and thereby tends to subordinate the importance of parts even to the point of gainsaying their explanatory significance at all. Such an attitude to parts falls-out from the holist conceptualization of wholes as pregiven, foundational structures of reality, a conceptualization found at least as far back as Aristotle but emerging in a pronounced form in the scientific work of Goethe and others whose perspectives form the backdrop of much of contemporary holism (Harrington, 1996). Indeed, there is a connection between the *Naturphilosophisch* conception of wholes as pregiven and their self-referential structure, the most telling example, as mentioned above, being found in the work of Kant (see Lenoir, 1982; and McFarland, 1970). As soon as wholes, however, are considered ontologically pregiven, they partake of the same fate as hylozoism's animation of nature, i.e., they are pushed all the way down into the primordial substance of nature. As a result, the coming into being of wholes loses its bewildering character just as the origin of life does for hylozoism.

What is needed instead is an approach which, instead of shirking it, looks squarely at the difficult issue of what must be involved in the coming into existence of wholes. Previously, I (Goldstein, 2000, 2002) have offered an approach to emergence which characterizes the processes of emergence in terms of construction, more specifically, *self-transcending constructions*. The basic idea was to offer a fresh approach to the study of emergence given the fact that even in spite of the great amount of research devoted to it in such areas of complexity theory as far-from-equilibrium thermodynamics, dynamical systems, and artificial life, emergence has remained an elusive concept primarily due to the lack of suitable constructs for investigating structure and patterns (see, e.g., Cructhfield, 1993; Hartman, 200; Holland, 1998). I sketched out a constructional approach that took quite seriously the claims made for emergent phenomena, and then backing in, so to speak, from the characteristics of such phenomena to how they might come about. That is, what kinds of constructional processes might be capable of bringing about emergent phenomena. It must be noted that "construction" is not being used in its customary sense where it carries the connotation of an "external constructor." Rather, those processes at the heart of evolution, namely variations and natural selection, as well as the genetic operators of artificial life can be included under the rubric of "construction" in this sense. A *self-transcending* construction is one precisely leading to an outcome that is radically transcendent with respect to that from which it emerges. This concurs with Dobzhansky's (1978) observation on the course of evolution, ". . . cosmic evolution transcended itself producing life, and biological evolution did so when there emerged mind" (p. 21) and that, "Between potentiality and realization there intervenes a process or development or evolution" (p. 19). To the degree that emergents are not pregiven as a hylozoist perspective would have it, but, instead, dynamically arise over time, then they must be in one way or another *constructed* in our specific sense of the term. Furthermore, if referential closure is a critical property of such wholes, then there must also be a cogent account for the coming into being of the self-referential nature of wholes.

Although it is not possible here to go into any great detail of such an approach, what I can offer are some hints as to what might be involved in the self-transcending construction of new emergent wholes. In particular, several hints can be culled from areas of study devoted to the specific nature of *wholes* as such: first, Gestalt Psychology's principles of the organization of perceptual wholes; second, principles from the design of aesthetic wholes; and, third, insights into how the self-referential structure associated with wholes may be constructed.

Gestalt Psychology's Principles of Wholes

If emergent wholes are constructed out of the interaction of their parts in such a manner that these wholes become more than a mere amalgam of the parts, then a sensible starting place to come to grips with this constructional process would not be to jump to a presumed transcendental source of pregiven wholes as a hylozoist oriented holism would have it, but, instead, ask first what exactly it is about wholes that summons the label of wholeness. In other words, what does the wholeness of a whole consist in? It is this and other closely related questions which have shaped the investigations into perception on the part of Gestalt Psychology which grew out of a tradition of German holism. But whereas this holistic background posited wholes as pregiven, ontological facts, Gestalt Psychology's focus has been more on how parts are organized in such a way as to "construct" a perceptual whole (Köhler, 1947). Although some of Gestalt's insights into perception are now considered outdated, it is being turned to here not for what it says about perception per se, but rather its value in the construction of wholes as such—as Koffka (1935) once presciently put it, "It has been said: the whole is greater than the sum of its parts. It is more correct to say that the whole is something else than the sum of its parts, because summing up is a meaningless procedure, whereas the whole part relationship is meaningful" (p. 176). The "meaningfulness" of the whole part relationship was described by Koffka in terms of parts which "fit" each other or possess a "good continuation" or "joining" with each other and adumbrated according to principles of organization or "grouping," e.g., figure/ground, closure, proximity, similarity, symmetry, continuity, uniformity, and internal and external "forces" of organization.

Each of these principles point to ways in which parts relate to other parts so that wholes are thereby formed. Here is not the place to assess the merits of any of these principles, but merely to point out that it is principles such as these that serve to make wholes wholes, thus forestalling the need to invoke some pregiven wholeness which is then unfolded as a hylozoist type of strategy would do. Similarly, emergent wholes could be said to acquire their sense of wholeness by their parts being congruent to one another in a corresponding manner. Hence, the constructional process leading to such wholes would need to follow something like these organizing principles for wholeness.

The Construction of Aesthetic Wholes

The wholeness of artistic products has been a primary concern of artists. Consider, for instance, these three quotes from famous artists: Delacroix—"before knowing what the picture represents you are seized by its magical accord" (quoted in Dewey, 1934, p. 145); Klee—"the aim of our theoretical work is always in one form or another, the organization of differences into unity, the combination of organs into an organism . . ." (quoted in Barratt, 1980, p. 282); and, Mattisse—"the relationships between tones [colors] must be instituted in such a way that they are built up instead of knocked down.

A new combination of colors will succeed to the first one and will the give the wholeness of my conception" (quoted in Dewey, 1934, p. 136). These remarks on the design of the sense of aesthetic wholeness could be added to the above list of organizational principles from Gestalt Psychology. Again, the issue is how wholeness as such is built-up out of the right combination and juxtaposition of parts.

The concern for aesthetic wholeness has perhaps had its most intense commitment and expression in Islamic design which turned to abstract geometrical shapes to depict the quality of divine unity due to the Quranic injunction against pictorial representations of the divine and the Prophet (Burckhardt, 1976). This use of geometrical forms to portray unity and wholeness is another door into abstract principles of design about wholeness which parallels the Gestaltist's views on the organization of perceptions into unities. The principles of the Islamic representation of wholeness can be summarized as follows (derived from Burckhardt, 1976; and, Critchlow, 1976). First, there is the copresence of a center, periphery, and in-between regions. Second, there is a heterogeneity of sizes and shapes linked by common "threads" as well as a mix of repetition and the unexpected. Third, regions are concentrically layered from the center outwards. Fourth, there is the use of various symbols for the unity of oppositions, e.g., circles, squares, crosses, six pointed stars, octagons, and so on. Fifth, local regions are connected with much interlocking and interweaving. Sixth, one finds the use of modularity and scaling, including the golden proportion and its fractal scaling. And, seventh, there is much evidence of diverse symmetries which serve to generate a sense of harmony between simplicity and complexity. Furthermore, the overt design can, on analysis, be discerned to rely on covert patterns acting as a sort of blueprint for wholeness (see Critchlow, 1976).

It is crucial to emphasize that the organization of the design which exhibits the sense of wholeness is not something apart from the parts but is precisely how the parts are made to fit together with each other. This indicates that wholeness need not be seen as some sort of pregiven state but, instead, can be understood as that which is constructed out of the right arrangement of parts, that is, is constituted by the parts in their interrelationships. As the famous geneticist Wright (1978) said in regard to biological wholes, "The whole can dominate only in ways that involve concurrence of the parts" (p. 79). Such wholeness consists in a "unity in multiplicity" where each part has an indispensable function and in that sense, at least, is not downplayed in relation to the whole. Again, the point is that the emergent construction of emergent wholes would presumably follow something like these principles of wholeness construction.

Constructing Self-Reference by Diagonalization

As discussed above, organic wholeness has been thought of in terms of referential closure from Kant through Whitehead, Maturana and Varela, and on into the neo-emergentist focus on autocatalytic networks. However, in contrast to the presumption that such self-referentiality must be somehow ontologically pregiven, it can be shown that self-reference can actually be constructed. One access into how this can take place is afforded by a look at self-reference grammatical constructions of sentences. This will show that self-reference is not achieved by the facile move of simply stipulating its existence as a fundamental logical/mathematical element, but, instead, consists of a rather convoluted construction.

A self-referential sentence is by definition one that refers to itself, e.g, the following four sentences:

This sentence is written in English. (1)

This sentence has five words. (2)

This sentence is grammatically correct. (3)

This sentence is a sentence. (4)

In each case, it is the opening phrase "This sentence" which is the marker that indicates that what the sentence is referring to is itself. There is nothing particularly significant in using the phrase "This sentence" to construct a self-referential sentence since it could be replaced by some other device, e.g., putting a box around the sentence:

The sentence in the box is in English.

Sentence 4 is a bit more complicated since it is not only referring to itself, it also referring to *what* it is, i.e., a sentence, whereas what the previous sentences, 1, 2, and 3, are referring to themselves about is not the *fact* of being a sentence but, instead, *about* the language, *about* the number of words, or *about* its grammatical status. Again, there is nothing particularly unusual about such grammatical constructions and accordingly, there should not be any controversy about whether such sentences are semantically meaningful. (By the way, cross-reference is an indirect form of self-reference in that it includes two or more things referring to each other in a circular fashion, so that ultimately the circle comes back to from where it started—see Grim, Mar, St. Denis, 1998; and, Hellerstein, 1997).

In mathematical logic, the *construction* of self-reference is often understood in terms of *diagonalization* in which, for an expression ("*ex*" for short) of the sentence, substitute for *ex* the literal quotation of the *whole* statement (Smullyan, 1994). For example, start with sentence (5):

John is reading *Moby Dick*. (*"Moby Dick"* = *ex*) (5)

and substitute the whole sentence (5) for *ex* to yield:

John is reading "John is reading *Moby Dick*." (6)

Strictly speaking, sentence (6) is not yet self-referential for it merely asserts John is reading sentence (5), not itself, sentence (6).
Now consider the sentence:

John is reading the diagonalization of sentence (6). (7)

Since the diagonalization of (6) is {John is reading "John is reading 'John is reading Moby Dick'"}, sentence (7) is {John is reading "John is reading 'John is reading 'John is reading Moby Dick''"}, or:

John is reading the diagonalization of "John is reading
'John is reading Moby Dick.'" (7A)

The diagonalization of expression (7A) then would be:

John is reading the diagonalization of (7) or {"John is reading the
diagonalization of 'John is reading *Moby Dick*.'"}. (8)

Sentence (8) then asserts that John is reading the diagonalization of (7), but the diagonalization of (7) is (8) itself! Therefore, sentence (8) asserts that John is reading the very same sentence itself (8)! Accordingly, sentence (8) is purely self-referential.

Whatever the construction process necessary for the self-referential structure of emergent wholes would be, it would need to mimic, in some sense, diagonalization in order to possess the property of completely turning back on itself. Our brief review of diagonalization shows that achieving pure self-reference is difficult since the action of referring has to be completely bent back around to itself, a complete, not partial, fulfillment of circularity. That is why neither self-reproduction nor recursion are purely self-referential, the former because what is being reproduced is not itself but a facsimile thereof, the latter because the feeding back consists of a new value not just the same old value (unless, of course, the recursive function has become a fixed point, for example, a fixed point attractor in the logistic map at certain ranges of the parameter value. Indeed, fixed points show that a recursive function have become self-referential in regards to the variable).

CONCLUSION

Hylozoist strategies are certainly a temptation for the way they manage to avoid the really "hard problem" of emergence. It might seem that we are also falling into a hylozoist cast by presenting what could be taken as a form of "pan" self-transcending constructionalism by positing a ubiquity of self-transcending processes. However, self-transcending constructions are by their very nature not pregiven, but refer, instead, to dynamical processes involved with the coming into being of the radically original. Therefore, they are not being offered as an easy way out of the dilemma as to what is necessitated with the latter but rather as admitting that accounting for the emergence of wholes requires difficulties that hylozoist perspectives merely shun. Several hints were offered as to what such a self-transcending constructional process would need to consist in, namely hints concerning the construction of the wholeness of a whole and the construction of authentic self-reference. If there really is the emergence of new, integrated, correlated wholes then somehow or other the construction of such wholes during the course of emergence would need to resemble the construction of wholes outlined here.

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