Neocybernetic Gaia Theory

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Neocybernetic systems theory (NST) refers to a range of *second-order* cybernetic concepts—recursion, reentry, closure, autonomy, cognition, self-reference, and self-referential systems. The designation "first-order" is a back formation denoting the original cybernetic logic centered on operational circularity in natural and technological systems, in which, for instance, output effects are fed back as causal inputs, thus superseding a strictly linear description. As far back as one cares to trace it, cybernetic discourse has attended to entities, such as Gaia in Isabelle Stengers's description, "breaking the general linear relation between causes and effects" (Stengers 2015: 137). In his first book on Gaia, James Lovelock's first-order description of cybernetic non-linearity applies to both cybernetic orders: "The over-long delay in the understanding of cybernetics is perhaps another unhappy consequence of our inheritance of classical thought processes. In cybernetics, cause and effect no longer apply; it is impossible to tell which comes first, and indeed the question has no relevance" (Lovelock 1979: 52).

Neocybernetics arose when Heinz von Foerster forged a "cybernetics of cybernetics" by turning the logic of operational circularity upon itself. Following his account, the development of second-order cybernetics generalized circularity in the concept of recursion. Recursion was now explored in its own right as formal self-reference in those systems capable of rising to cognitive operations, to wit, "observing systems." This description pressed living systems to the forefront: biological systems' self-referential maintenance of self-produced organizations and cognitive boundaries between internal operations and external environments received a formal blueprint in the theory of autopoiesis.

In *Autopoiesis and Cognition* (1980) Maturana and Varela published their definitive case for considering autopoietic systems, such as living cells, as cognitive, or as restated in second-order cybernetic parlance, not merely as observed but more fundamentally as *observing* systems producing life-maintaining, self-making cognitions of their environments. Maturana and Varela coined the term *autopoiesis* to denote this group of interrelated concepts—circular organization, operational closure, and self-referring processes. The discourse of autopoiesis named the self-referential or recursive form of the "organization of the living" as coupled to a self-referential description of the cognitive processes that produce the discourse. Biotic autopoiesis is recursive self-constitution applied to the observation of cells and organisms. Observed both *as* and *by* an autopoietic operation, the minimal organization of life, the cell, takes the form of a closed circular process of self-production (autopoiesis) within a system open to selective environmental interaction (cognition).

Lynn Margulis would appropriate the concept of autopoiesis as an explicit component of her own Gaia discourse, to the extent of presenting Gaia as the autopoietic planet: "Autopoiesis of the planet is the aggregate, emergent property of the many gas-trading, gene-exchanging, growing, and evolving organisms in it" (Margulis and Sagan 2000: 23). Margulis also drew on the discourse of autopoiesis in countering the neo-Darwinist worldview. Her strategy was to ally autopoiesis with symbiosis as a pervasive form of living organization and—in instances of

"symbiogenesis"—as a source of evolutionary variation. In concert with the discourse of autopoiesis, symbiosis per se is *not* about reproduction or the supposed vagaries of genetic mutation. It is precisely about "the organization of the living" as that also takes the form of communal assemblies over and above the recursive formalisms of individual living systems. What her mantra "Gaia is symbiosis seen from space" foregrounds for any particular case of symbiosis, from the microcosm on up, is the *living* part of the living-together of extant organisms. Ongoing life co-maintains itself in ever-varied ensembles established by hazard and stabilized by mutual viability.

Lovelock's initial Gaia hypothesis took shape before Maturana and Varela brought the theory of autopoiesis forward. As he was writing *Gaia: A New Look at Life on Earth*, the concept of autopoiesis was still relatively unknown. He would lament what appeared to be the absence of a scientific definition of life, cybernetic or otherwise. "Even the new science of cybernetics has not tackled the problem, although it is concerned with the mode of operation of all manner of systems from the simplicity of a valve-operated water tank to the complex visual control process which enables your eyes to scan this page. Much, indeed, has already been said and written about the cybernetics of artificial intelligence, but the question of defining real life in cybernetic terms remains unanswered and is seldom discussed" (Lovelock 1979: 4). In fact, until the introduction of autopoiesis as a neocybernetic definition of the form of the living, Lovelock's own Gaia discourse was among the most notable prior efforts to "define real life in cybernetic terms." It would be Margulis who eventually annexed autopoiesis to the cybernetics of Gaia.

Simply put, first-order cybernetics is about control, second-order cybernetics is about autonomy. NST takes recursive processes beyond mechanical and computational control processes toward the formal autonomy of natural systems. Neocybernetics aims in particular at natural systems in which *circular recursion constitutes the system*. In Varela's terms, circular causality constitutes a systemic identity. This finer appreciation of recursive self-constitution refines the choices of systemic observation. Neocybernetic Gaia theory posits a description of *metabiotic Gaia* by taking Margulis's conception of autopoietic Gaia beyond the biotic occasion toward Lovelock's mature geobiological description. The systems thinker who comes the closest to limning this redescription of the Gaia concept turns out to be Francisco Varela.

References

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