Life as We Know It and/or Life as It Could Be: Epistemology and the Ontology/Ontogeny of Artificial Life
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Epistemology and the Ontology/Ontogeny of Artificial Life

Edward A. Shanken

Abstract

Artificial life researchers assert that their work can offer insight into "life as it could be." The author suggests that it can also shed light on "life as we know it." A complex series of decisions and presumptions precedes the selection of a given artificial entity as lifelike. For the artist, the processes of selection and representation bring into question what has been characterized by sculptor Michael Grey as "the relationship between ontology and ontogeny," or the interconnectedness of being and its formal embodiment. The work of biologists Humberto Maturana and Francisco Varela suggest that these two aspects of life are inseparable components of autopoiesis and are, moreover, environmentally determined and determining. If this is the case, then artificial life is not just a product of research but is structurally coupled with other natural and artificial life forms as part of a dynamic autopoietic system.

Nature as described by our scientists is indeed an artifact built in collaboration with a Being sufficiently complex to mock and, perhaps, punish materialists by responding to them in a crudely materialistic way.

—Paul Feyerabend, *Nature as a Work of Art* [1]

Feyerabend's point is not that materialists are dim-witted and circular and get what they deserve, but that any given scientific explanation will be partial at best. It will function well in certain domains and poorly in others—where alternative, perhaps incommensurable explanations, will do the trick. As a result, he likens the artwork of science to the constructions of Kurt Schwitters, such as the German artist's 1925 "merzbild" *Merzbau,* which the philosopher characterizes as an ad-hoc cobbling together of found objects in an amorphous structure. Noting that when "approached in different ways Nature gives different responses," Feyerabend concludes that universal explanations of nature-in-itself appear dubious. He proposes that science, which tends to search for unequivocal, unambiguous answers, could benefit from the arts, whose subtle understanding and appreciation of paradox and absurdity might complement what he calls the " 'objective' artifact *nature*" [2].

Implicit in the comments above is the idea that science is a hermeneutic rather than teleological endeavor. Artificial life, as the conjunction of biology and computational science, is likewise an interpretive discipline, one which—due to the domain of its inquiry and the nature and extent of its claims—raises many gnarly epistemological and ontological questions. For what is accepted as constitutive of life has great bearing on the understanding and experience of being.

Santa Fe Institute researcher Christopher Langton's definitions of artificial life assert that a-life research can not only offer insight into life-as-we-know-it but can also afford a glimpse into life-as-it-could-be [3]. I more than completely agree with Langton. For with regard to the understanding of life-as-we-know-it, I am concerned not just with his scientific goal of expanding insight into the physical, chemical, and biological qualities of life, but with the ways a-life research pushes the boundaries of metaphysics, and in so doing reveals insights into contemporary systems of value. A critical analysis of artificial life research programs may reveal as much about the epistemological and ontological biases of a particular cultural moment as the research itself does about the morphogenesis of prospective organisms. Nor are the two mutually exclusive, for combining these two levels of insight might create a self-reinforcing system of knowledge. In other words, a richer understanding of the constraints of current scientific and artistic methodologies affords more

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reasoned visions of the future, and these visions enable a subtler understanding of current constraints, and so on.

From Pygmalion to Artificial Life

As a segue into grappling with these ideas in the realm of art, Jack Burnham's *Beyond Modern Sculpture* of 1968 offers a useful history of the human infatuation with the creation of lifelike forms from nonliving matter [4]. The art historian begins a chapter entitled "Sculpture and Automata" with Ovid's myth of Pygmalion and works his way through the clockwork mechanisms of the Middle Ages and the Renaissance to the now legendary automata that Jacques Vaucanson created in the 18th century. These precursors set the stage for a section on "The Sociology of Modern Automata" and a later discussion of the fascination with machines and automata shared by artists before World War II, including Archipenko, Oskar Schlemmer, and Marcel Duchamp. Burnham concluded his book with the following prophecy:

> In retrospect, we may look upon the long tradition of figure sculpture and the brief interlude of formalism as an extended psychic dress rehearsal for the intelligent automata.... As the Cybernetic art of this generation grows more intelligent and sensitive, the Greek obsession with "living" sculpture will take on an undreamed reality. [5]

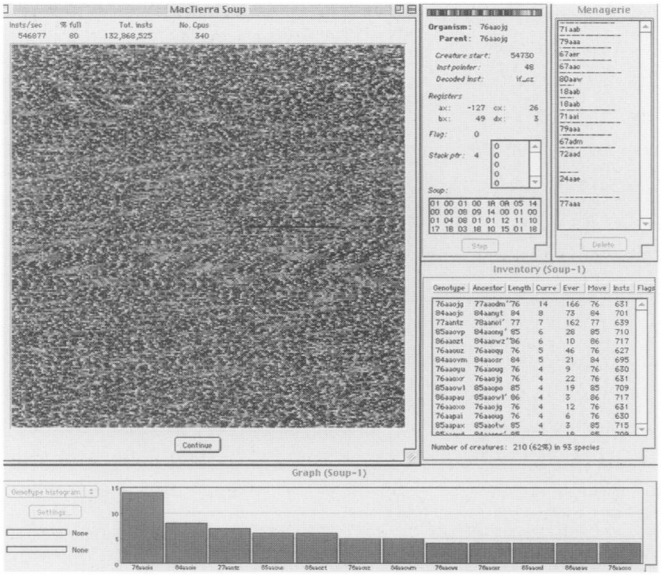

Fig. 1. A screen shot of the MacTierra artificial life program, which runs on a Macintosh computer. Originally, Tierra was conceived and written by a-life researcher Tom Ray; MacTierra (the Macintosh implementation of Tierra) was programmed by Simon Fraser.

A quarter century later, we may be in a better position to reflect on what has actually come to pass with regard to this prospective account of the future of art and its relationship to artificial forms of life and intelligence. Do the works of contemporary scientists and artists experimenting with artificial life possess the "undreamed reality" Burnham imagined? In Ovid's words, to what degree do these latter-day Galateas "redden at the kiss" or "return a kiss unripe"? Will they prove to be "an embarrassment" for our time, as art historian Barbara Stafford claims Vaucanson's "sleight-of-hand in the name of experiment...[was] to the Age of Reason" [6]? In what ways are the a-life images and artworks of Karl Sims, Michael Grey, or Ken Rinaldo compellingly lifelike? What of the famous a-life models like Thomas Ray's "Tierra" (Fig. 1; see Color Plate B) and Craig Reynolds' "Boids" or Rodney Brooks' massively parallel, situated-AI robots? [7] What, if anything (beside funding) is the difference between artificial life research done by artists and that done by scientists? In this regard, it is interesting to note that Brooks, whose scientific research at MIT's Artificial Intelligence Lab has consistently been funded by the US military, participated in the Ars Electronica Genetic Art—Artificial Life symposium in 1993. But he recognizes little in common between his work and art. In contrast, Rinaldo, an artist who teaches in the science and mathematics department at Columbia College in Chicago, and who along with Langton, Ray, and Sims also participated in that same Ars Electronica conference, understands Brooks' robots as continuous with his own artwork and would readily embrace them as art [8]. Ray, to his credit, collaborates with artists and has drawn parallels between art and evolution, noting in particular Sims' research on aesthetic selection [9].

I raise these questions rhetorically, for there are no simple answers. And the ramifications, more than the answers themselves, are of primary importance. I shall address these issues by first examining what I call the ontology of artificial life and then discussing the relationship of ontogeny and ontology in the work of artist-inventor Michael Grey. Finally, I shall inquire into the implications of contemporary narratives of artificial life, in order to suggest what that might tell us about the epistemological and ontological state of our own culture and future.

The Shoe/Fly Fallacy

What I mean by the ontology of artificial life is its quality and status of being. Strong a-life positions, such as those held by Langton and Ray, claim that artificial life research either already does, or is capable of, creating entities that are really alive, in the sense that they self-replicate and evolve in an open-ended manner [10]. Elliot Sober's Shoe/Fly Fallacy offers a critical perspective that reveals the potentially faulty logic of this position:

> Flies are alive.
> Flies are described by law L.
> Shoes are described by law L.
> Hence, shoes are alive.

Sober's point is not that it is impossible for artificial life forms to be synthesized, but that the method of creating them by virtue of their correspondence with the laws that describe acknowledged living entities is not a sufficient criterion for judging their vitality, but rather permits for "an overly liberal conception of life" [11].

In response to philosophers like Sober, a-life researchers like Langton and Ray argue that restricting the definition of "life itself" to carbon-chain phenomena

on Earth—a sample size of one—results in an overly conservative conception of life, a form of cosmic "parochialism" (to use Ray's term). They take issue with the notion of "life itself" and posit the possibility of a pluralism of life phenomena developing along different evolutionary chains, what might be called "life themselves" [12]. They claim that their studies on artificial life expand understanding of how life might come into being and evolve in extraterrestrial conditions (life as it could be) not limited to the characteristics of life particular to the environment of the fourth rock from the sun (life as we know it.). Ray has recently stated that he prefers to avoid the semantic question "Is it alive?" Instead, he is more concerned with the degree to which an artificial system manifests a "'genuine' instance of some property that is a signature of living systems (e.g., self-replication, evolution, flocking, consciousness)" [13].

The working method of artificial life research, in contrast to that of the life sciences, is also a source of ontological confusion that is emblematized in the field's self-proclaimed and semantically imprecise title. In general, science has historically taken understanding natural phenomena as its goal. To do so it develops propositional theories and undertakes experiments to determine the extent to which nature corresponds to those theories. So, for example, biology takes expanding the understanding of life as the general goal of its inquiry.

Research on artificial life proceeds in a somewhat different fashion. A-life begins with pre-existing explanations of life and complex systems from biology and mathematics and seeks to reproduce variations on those themes. While it may claim to seek an expanded understanding of life, it does not perform experiments on living matter, but rather on theories about life. This is a crucial distinction. For it follows then that Ray's Tierra experiment, for example, takes expanding understanding of evolutionary biology—and not, it might be argued, life itself—as the subject of its inquiry. In this sense, artificial life is a misnomer because the phenomena being reproduced and studied are not life phenomena, but scientific theories [14].

In terms of the Shoe/Fly Fallacy, a-life takes as its base material neither shoes nor flies, but law L. This reveals an inherent circularity of a-life: take a biological theory or law L, model it on a computer, and lo and behold, behavior resembling that of biological organisms described by law L emerges. It's a neat trick; however, it's not necessarily life that is emulated, but biological theory. A more accurate appellation for artificial life might be "synthetic biology," a term used by Ray and others, though of course, that's not quite as catchy [15].

Similarly, artists who utilize artificial life in their work are not creating life but are creating art that either is informed by, emulates, or amounts to visual models of biological theory. Now, I'm not saying this is a good or a bad thing. Nor do I believe that it denigrates the accomplishments of artificial life research to understand its product as synthetic biology rather than life itself. To draw an artistic parallel, while Burnham criticized the vitalist sculpture of Jean Arp and Henry Moore for what he interpreted as its inevitably doomed dreams, he nonetheless attributed great value to the work itself; not as the abstract embodiment of the essence of life, but as an aesthetically and metaphorically rich artistic statement [16]. Similarly there may be potentially great value in art that utilizes artificial life; but again, such value cannot be attributed to the life it purports to embody. My point is that it is important to be clear-headed about what artificial life research does and does not do, and not to be confused by ontological misconceptions and misleading terminology.

There is another troubling matter that has to do with the difference between art and life. Feyerabend asserts that Nature is an artifact built by science, but he also claims that there is such a thing as "Nature as [it] is in and for [it]self" [17]. With regard to art, however, there is arguably no such a thing as "Art as it is in and for itself." What then is the difference between the scientific claim that artificial life forms are alive and the aesthetic claim that artificial life forms are art? To what extent is life a semantic construction, the meaning of which—like art—is subject to negotiation and reformulation?

The Production of Meaning

Such questions surround the work of Michael Grey. A complex and self-conscious series of presumptions, decisions, calculations, and fine-tunings precedes his creation and identification of a lifelike artificial entity and its representation in visual form, as in *Jelly Cycle* (1994; Fig. 2; see Color Plate B) [18]. For the artist, the processes of selection and representation bring into question what he has characterized as "the relationship between ontogeny and ontology" or the interconnectedness of the emergence of life and theories of being [19]. In his research on artificial life, he has questioned the transit between the mathematical codes that function metaphorically as the genetic blueprints for the formal ordering of digital information, and the perceptual codes of observation that enable the interpretation of the emergent artificial life forms as scientifically and/or aesthetically relevant.

Fig. 2. A detail of Michael Grey's *Jelly Cycle* (1991–92), a neural network animation in 56 cells on eight mixed media panels (8 ft. x 11 in. each) with Mylar, wax, and Plexiglas. (Photo: Stephen White; courtesy of Lisson Gallery, London)

Grey is especially interested in the epistemological threshold that attends the process of recognition; for of the literally millions of possible morphogenetic chains that he and his collaborator, Randolph Huff, produced on a supercomputer from

algorithmic models they specified, no more than a few bear an apparently uncanny resemblance to known forms of life. But here I must place emphasis on the words "apparently uncanny resemblance," for what is at issue is fundamentally a question of epistemology and hermeneutics, of the systems of knowledge that form the basis for the interpretation of an emergent form or behavior as similar or related to a known one, and that enable the logical transference of qualities of the latter to the former. If, for example, Grey's algorithms model the gestation and maturation of a jellyfish, then the mysteries of phenotypic development from the genome appear to unravel before our very eyes. Similarly, if Karl Sims' algorithms for his *Evolved Virtual Creatures* (Fig. 3; see Color Plate A) act in a predatorial manner, then those artificially generated forms can be seen to behave like forms of life, for apparently only living organisms have need for such intentional, survivalist behavior. But while only living forms would have need to act in a predatorial manner, conversely, only living forms would have need not to. Note that both cases reveal a prejudice for intentionality and the perpetuation of life; a prejudice which, though it has much to recommend it from the human perspective, is not, a priori, either a necessary or desirable thing. Again, what must be emphasized here is that a-life confronts observers with a fundamentally hermeneutic problem—one that demands particular caution—for the embeddedness of human perception and interpretation in limited systems of knowledge makes observers prone to falling for the Shoe/Fly Fallacy.

Grey's jellyfish are the aesthetic product of the confluence of a computational process (which generates the simulated morphogenesis of forms) and an interpretive process (which ascribes meaning and significance to them from the perspective of a human observer). Are they alive? No. Do they emulate biological organisms? No. Do they emulate biological theories? Yes. Do they question the relationship between the science of biology, the creation of artistic form, and the systems of meaning and significance that constitute those fields of endeavor? Most definitely.

The Progeny of A-Life

In *The Tree of Knowledge,* developmental biologists Humberto Maturana and Francisco Varela suggest that the interconnectedness of being and its formal embodiment are inseparable components of autopoiesis—the necessary, integral unity of living forms—and are, moreover, both environmentally determined and determining [20]. Such close interrelationships obtain from the cellular to the social level. In this light, artificial life can be seen not as an autonomous product of research, but as "structurally coupled" with other natural and artificial life-forms as part of a dynamic autopoietic system. It follows then that the artistic process of visualizing and contextualizing artificial life forms can play a critical role in determining not just the qualities of life-as-it-could-be but those of life-as-we-know-it. In other words, regardless of the extent to which one believes a-life is alive, there is a field of scientific and artistic inquiry that has brought the concept of artificial life into being; that has, in Feyerabend's terms, contributed to the "'objective' artifact nature." And those fields and concepts and the people who developed them are structurally coupled with all the other fields and concepts and people who developed them— together, as part of a dynamic system, like the interwoven parts of Schwitters' *Merzbau.*

Because of the complex cultural valences that surround life, were I to believe that I, or Thomas Ray, had actually created life in a computer, I might think of myself, my human community, and our relationship to the cosmos somewhat differently than I actually do, given my current belief that what has actually been created is a graphic representation of biological theory. I am not changed in the ways that I imagine Ray and Langton are. But that does not mean I am unchanged, for my understanding of life, biology, knowledge, and being has been altered by the metaphorical resonance and cultural mythology of artificial life research [21]. Regardless of the ontological status one grants a-life, one is changed and changing as a result of one's encounters with and considerations of it. It is, perhaps, part of Burnham's "psychic dress rehearsal" for things to come.

While it may sound far-fetched, the interconnectedness of artificial and natural forms of life may extend beyond the metaphysical transformation of consciousness and affect the development of physical matter as well. Applying Rupert Sheldrake's theory of causative formation to the project of artificial life suggests that once an artificial life-form comes into being in a certain configuration, it is more likely that, through the principle of morphic resonance, the same conuration will recur in the future [22]. While Sheldrake claims that morphic resonance is most

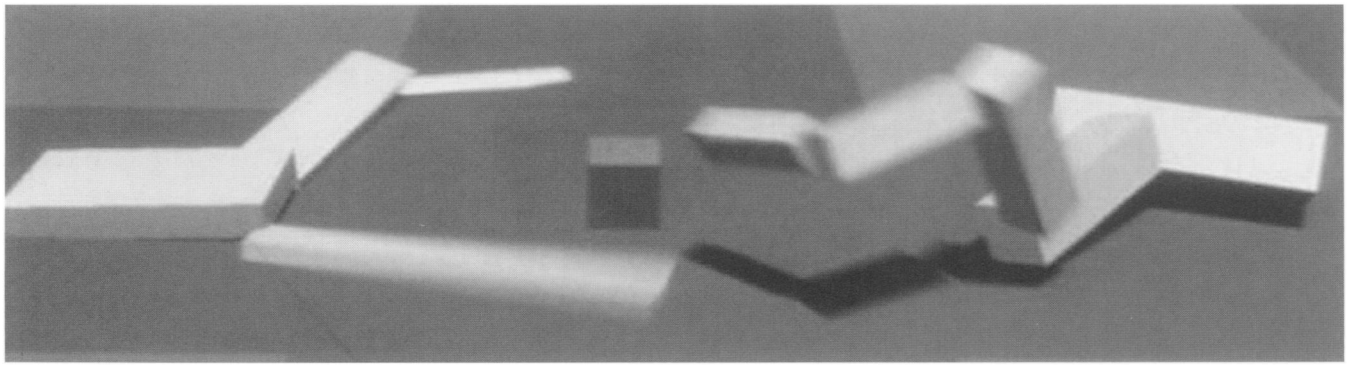

Fig. 3. Karl Sims, *Evolved Virtual Creatures,* artificial life forms, 1994. Here the creatures are competing for possession of a cube. (Courtesy of Karl Sims, ©1994)

potent within a species, he also claims the same principle is at work at the quantum level. Thus, certain aspects of causative formation may influence development between species, and perhaps between natural and artificial forms of life. The artist who gives rise to new forms of artificial life may, by morphic resonance, influence the development of other artificial and natural life-forms [23].

The artificial creation of autonomous communities that successfully self-reproduce evolving entities, and the success of bottom-up, massively parallel situated robotics in producing intelligent behavior, lend credibility to materialist explanations of life and intelligence. One can see these developments, and the parallel ontological shifts, as part of a continuum of increasingly materialistic explanations of nature between the 17th and 20th centuries, from Descartes to Julien Offray De La Mettrie and from Darwin to Watson and Crick, or as part of an even larger shift from ancient, religious creationism to secular, evolutionary functionalism.

German anatomist Ernst Haeckel's dictum that "ontogeny recapitulates phylogeny" (that fetal, or ontogenetic, development recapitulates phylogenetic stages of human evolution) has been restated in a work of art by Ken Rinaldo as *Technology Recapitulates Phylogeny* (see p. 372) [24]. I suggest further that ontology recapitulates technology. Indeed, we not only make machines in our own image, but make ourselves—psychically and metaphysically—in the image of our machines. At the risk of oversimplification, Renaissance and Enlightenment world views were deeply spiritual: human beings and machines alike were seen as continuous with the divine. In contrast, the world view of artificial life is comparatively materialistic: human beings and machines alike are seen as so much matter and energy of varying degrees of organizational complexity. As Margaret Boden, Simon Penny, and others have noted, it calls for the familiar postmodern evacuation of epistemological absolutism [25]. Enlightenment claims of transcendent values of truth, beauty, and the good must be replaced by values that emerge artificially, organizing themselves autopoietically from the bottom up, evolving open-endedly through a process akin to natural selection.

While I am skeptical of the epistemological and ontological claims of strong artificial life positions, I nonetheless believe that ultimately forms of life will be able to be synthesized from nonliving matter in the lab and studio. Indeed, if replicable, the purported cloning of sheep and monkeys from living genetic material is a major step in that direction. If, as Christopher Langton suggests, it is presumptuous to restrict life to carbon-chain phenomena on Earth; if life is, as Thomas Ray has claimed, the inevitable, computational result of the formal organization of matter; if moreover, as Stuart Kauffman has proposed, the likelihood of its incidence is much more common than previously believed [26]; then the privileging of organic life as more or less unique and precious, to say nothing of divine, needs to be reconsidered. Bruno Latour has argued that the rights commonly reserved for humans may have to be extended to nonhumans—including technology—because our inextricably mutual codependence defies the possibility of coherently asserting the autonomy of either as a discrete entity [27]. As for artificial forms of life and intelligence, one can imagine that the life, liberty, and the pursuit of happiness of such entities may be protected by virtue of their birthright as citizens. Science fiction or constitutional law, artificial life breeds strange bedfellows indeed!

Acknowledgments

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References and Notes

1. Paul Feyerabend, "Nature as a Work of Art," in *Common Knowledge* **1**, No. 3, 8 (1992). All further citations of Feyerabend refer to this article.

2. While Feyerabend [1] rightly offers the proviso that science is no monolith, and that as a result his discussion is circumspect, his assertion on behalf of the contribution artists could make in the creation of the "'objective' artifact *nature*" is troubling for it either fails to recognize the fields of science dedicated to understanding paradox, or implies that their contributions are somehow severely limited by the educational and/or other institutional constraints imposed on scientists as opposed to artists. At the same time, there is reason in the position that the training and practice of individuals in highly specialized disciplines does create practitioners and fields of differential expertise; that while, for example, scientists can think creatively and lawyers scientifically, training in particle physics could no more prepare one to defend an alleged murderer in court than training in capital law would prepare one to split atoms—though each area of training might conceivably offer insights into the other.

3. Christopher Langton, "Artificial Life," in Margaret A. Boden (ed.), *The Philosophy of Artificial Life* (Oxford: Oxford University Press, 1996) pp. 39–94.

4. Jack Burnham, *Beyond Modern Sculpture: The Effects of Science and Technology on the Sculpture of This Century*, 1st Ed. (New York: George Braziller, 1968).

5. See Burnham [4] 376. Note that in the second and third printings of *Beyond Modern Sculpture* the text was revised. See also Joe Davis, "Microvenus," in Ellen K. Levy with Berta M. Sichel, eds., *Art Journal* **55**, No. 1, 70 (Spring 1996). I am grateful for Davis's assistance in helping me to clear up this discrepency between printings.

6. Barbara Maria Stafford, *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education* (Cambridge, MA: MIT Press, 1994) pp. 194–95. According to Stafford, the makeshift metabolism of Vaucanson's Duck (ca. 1733–34) was intended to prove Hecquet's hydraulic model of the digestive system. Fifty years later, after the maker's death, it was revealed to be a hoax because seeds actually only entered the breathing tube and not the stomach. The degree to which this was an embarrassment to the Age of Reason is, of course, a matter of interpretation.

7. See Thomas S. Ray, "An Approach to the Synthesis of Life," in Margaret A. Boden, ed., *The Philosophy of Artificial Life* (Oxford: Oxford University Press, 1996) pp. 111–45; Craig Reynolds, "Flocks, Herds, and Schools: A Distributed Behavioral Model," in *Computer Graphics* **21**, 25–34; Rodney A. Brooks, "Intelligence Without Reason," in *Proceedings of the 1991 International Joint Conference on Artificial Intelligence*, pp. 569–95; and Brooks and Lynn Andrea Stein, "Building Brains for Bodies," in *Autonomous Robots* **1** (1994), pp 7–25.

8. Author's interviews with Brooks (April 1996) and Rinaldo (September 1996).

9. See the Web sites www.hip.atr.co.jp/~ray/pubs/art/art.html and www.hip.atr.co.jp/~ray/pubs/fatm/node9.html. Ray has also collaborated with artists Christa Sommerer and Laurent Mignonneau on *A-Volve*, on the Web at www.ntticc.or.jp/preactivities/gallery/a-volve/explan_v_e.html.

10. See Langton [3] and Ray [7].

11. Elliot Sober, "Learning from Functionalism: Prospects for Strong Artificial Life," in Boden [8] p. 372.

12. The term "life themselves" is my own.

13. See Tom Ray, "Recognizing Life," on the Web at www.hip.atr.co.jp/~ray/pubs/zen/node2.html.

14. According to Simon Fraser, a Santa Fe Institute postdoctoral fellow who developed MacTierra, a Macintosh implementation of Ray's artificial life program (originally written for the DOS operating system), "Tierra aims to study the evolutionary process by the instantiation of evolution in another form, namely in an ecosystem of interacting and competing machine code programs living in the Tierra environment, which emulates a massively parallel computer."

15. More on synthetic biology can be found on the Web at www.hip.atr.co/jp/~ray/pubs/zen/node1.html.

16. Burnham [4] pp. 49–109.

17. Feyerabend [1] p. 7. I have taken the liberty of neutering the philosopher's poetic gendering of "Nature as she is in and of herself—and this lady, we shall never know..."

18. See Michael Joaquin Grey, "Jelly Lovers: Dreams of Causality," in *Art Journal* **55**, No. 1, 36. Grey collaborated with artist and computer programmer Randolph Huff on the creation of the algorithms for these and other works. *Jelly Cycle* is on the Web at www.aec.at/prix/1994/grafik94/94gn-jelly1.jpeg.

19. For an excellent and in-depth discussion of these and related matters, see Susan Oyama, *The Ontogeny of Information: Developmental Systems and Evolution* (New York: Cambridge University Press, 1985).

20. Humberto Maturana and Francisco Varela, *The Tree of Knowledge: The Biological Roots of Human Understanding* (Boston: Shambala Publications, 1992).

21. For more on this topic, see N. Katherine Hayles, "Narratives of Artificial Life," in George Robertson, Melinda Mash, Lisa Tickner, Jon Bird, Barry Curtis, and Tim Putnam, eds., *FutureNatural: Nature, Science, Culture* (New York: Routledge, 1996) pp. 146–64.

22. See Rupert Sheldrake, *A New Science of Life: The Hypothesis of Formative Causation* (London: Blond & Briggs, 1981). Sheldrake's theory of causative formation by morphic resonance is by no means widely accepted, so my own theorization based on his ideas is admittedly highly speculative.

23. See Roy Ascott, "Nature II: Telematic Culture and Artificial Life," *Convergence* **1**, No. 1, 22–30 (Spring 1995).

24. I am indebted to Ken Rinaldo's artwork *Technology Recapitulates Phylogeny* (1993) and his discussion of it, including his reference to Haeckel, for my thinking on these matters. See pp. 371–376 in this issue.

25. See Margaret Boden's introduction to *The Philosophy of Artificial Life* (Oxford: Oxford University Press, 1996) pp. 1–31, and Simon Penny, "The Darwin Machine: Artificial Life and Art," on the Web at www-art.cfa.cmu.edu/www-penny/texts/Darwin_Machine_.html.

26. Stuart Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (Oxford: Oxford University Press, 1993).

27. Bruno Latour, "On Technical Mediation: Philosophy, Sociology, Genealogy," in *Common Knowledge* **3**, No. 2, 29–64.

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