puter models addressing evolutionary, ecological, and morphological aspects and led to what is nowadays officially perceived as a-life—a field defined, for all practical purposes, by a conference organized by Chris Langton in 1987. It is a measure of Langton's success that the rapid subsequent development has essentially followed the same themes. A spate of popular science books, more conferences, and a new journal have done much to keep the subject in the limelight. A-life's other thread runs mostly out of sight but has potentially an even larger effect upon public awareness: this is the sorry tale of computer viruses.

Claus Emmeche's book gives good, if sometimes a bit short, descriptions of a-life's favorite pets, such as John Conway's game of Life, Langton's self-reproducing loops, John Holland's genetic algorithms, Stuart Kauffman's Boolean networks, Craig Reynolds's flocks of "boids," and Kristian Lindgren's chronicles of the Prisoner's Dilemma. All these have been well described in other recent books, but it ought to be stressed that the original, Danish, version of *The Garden in the Machine* appeared some three years ago.

So far, a-life is a branch of experimental mathematics dominated by computer scientists. Only a handful of true-life biologists have ventured onto this new playground (Tom Ray, for instance, with his Tierra world, or Richard Dawkins with his biomorphs). A silent majority either remains blissfully unaware of the discipline or just waits for it to fade away, convinced that artificial life will soon meet natural death. Such an attitude of "business as usual" is unfortunate: if—as may well be possible—a-life has nothing much to contribute to biological theory, this ought to give rise to some lively scientific polemics.

Emmeche, who is a theoretical biologist himself, stakes out the claims for such a debate in a fairly nonpartisan way. His own perspective is closer to semiotics—the science of signs and meaning—than to computer science. This allows him to survey the field in a very broad philosophical context but leads him possibly to overemphasize the formal aspects of a-life's creatures. To be sure, they are not slimy little things based on a carbon cycle but computer programs. Some are, however, able to reside in a fairly real way in a computer's memory, at least in principle. That they are actually relegated to the memory of a simulated computer because of fears that they might spread ought not to be held against them. All too real experience with electronic worms make such a "computational containment" most advisable.

In a spirit of friendly skepticism, *The Garden in the Machine* describes artificial life as a postmodern activity "which leads toward what one may call a deconstruction of biological science." Such deconstruction—a current buzzword in discussions of art and literature—combines, as we are told, internally opposing tendencies in novel ways; this is today's equivalent of creating chimeras, artificial beings obtained by juxtaposing disparate parts of different animals, a pursuit that may constitute the oldest tradition of a-life.

The investigation of virtual realities is a respectable endeavor in mathematics, and it seems indisputable that research on artificial life has led, especially through its "bottom-up" approach, to the emergence of a wide range of fascinating and still largely unsolved problems relating to dynamical systems, information processing, and complexity theory. The question remains whether a-life will also enrich biology. Emmeche's discussion of this issue is even-handed and thoughtful, and his cautious conclusion—namely, that it is too early to decide—is doubtless correct. But he refers—to my taste—slightly too much to philosophers and not enough to biologists. We can learn more from J. B. S. Haldane and John Maynard Smith, skilled explorers of alternate realities in biological thought-experiments, than from the ponderings of Aristotle and Maturana. Actually, most a-lifers are philosophical enough and quite adept at discussing definitions of life. But such well-worn debates tell more about us than about life. Biologists will need more substantial fare if they are to take a-life seriously. One sometimes fears that this will be provided not by any refined biological argument but by the brain-child of some ill-advised hacker flouting computational containment.

This being said, Emmeche's book is a serious, sensible introduction to an exciting new field. It is not every day that one can see science fiction clash with natural philosophy in such a civilized fashion.

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Vignettes: Shifts in Biology

Biologists have often employed a range of metaphors to describe the real nature of organisms, and the metaphors have typically been borrowed from the technology that happened to be most fashionable at the moment. An ant, for example, can be viewed as a mechanical piece of clockwork, with precise, finely tuned parts, each with its distinct function. From a subsequent perspective, the ant can be viewed as a piece of energy technology: a thermodynamic design that—in analogy to a steam engine—consumes chemically bound energy by combustion and performs work while developing heat. Today we might view the ant as a little computer with associated sensory and motor organs: it processes a mass of information about the external world and reacts by feeding back various responses.

—*Claus Emmeche*, in *The Garden in the Machine: The Emerging Science of Artificial Life* (Princeton University Press)

Much of the history of biology can be expressed metaphorically as a dynamic tension between unit and aggregate, between reduction and holism. An equilibrium in this tension is neither possible nor desirable. As large patterns emerge, ambitious hard-science reductionists set out to dissolve them with nonconforming new data. Conversely, whenever empirical researchers discover enough new nonconforming phenomena to create chaos, synthesizers move in to restore order. In tandem the two kinds of endeavors nudge the discipline forward.

—*Edward O. Wilson*, in *The Biological Century: Friday Evening Talks at the Marine Biological Laboratory* (Robert B. Barlow, Jr., John E. Dowling, and Gerald Weissmann, Eds.; Marine Biological Laboratory and Harvard University Press)

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