Book Review

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Digital Biology: The Creation of Life Inside Computers and How It Will Affect Us.
Peter J. Bentley. (2001, Review). £7.99 paperback, 277 pages.

Physis kryptesthai philei—"Nature likes to hide itself"—says a fragment attributed to Heraclitus. After reading Peter Bentley's *Digital Biology* you may be tempted to think that, at least when it comes to biology, nature cannot hide much from an observant scientist equipped with a computer.

Peter Bentley, a research fellow at the Department of Computer Science, University College London, is well known for his activity in many areas of evolutionary computation. In this field he has recently edited two intriguing collections of essays: *Evolutionary Design by Computers* [2] and *Creative Evolutionary Systems* [3]; with *Digital Biology* he set outs to explain to a general readership "how biology and computers have become ... closely intertwined" and how this conjunction not only appears to benefit both technology and biology right now, but has the potential to change profoundly our lives in a not too distant future.

The starting point of Bentley's argument is the observation that the programmability of computers makes it possible to implement *universes* within them, where each universe is defined as a set of rules or laws. To prevent misunderstandings, in these days of widespread numerical modeling of physical systems, Bentley hastens to warn us that "this book is not about the *simulation* of nature or the creation of *virtual* or *artificial* nature. This book is about the use of concepts from nature in a *different universe*—a digital universe." In other words, Bentley is not primarily interested in describing the use of computers for the simulation of existing physical phenomena but rather in the definition of universes complex enough for "digital entities" to have some chance to evolve, grow, organize and, ultimately, live and think within them. These he calls "digital universes," and the emerging processes that they host constitute the "digital biology" of the title. In Gregory Bateson's terms [1], we could say that the research described in this book is not one leading to the computer implementation of a *pleroma* but one fostering the emergence of a *creatura*, a digital *creatura*. It is Bentley's belief, which inspires this popular science book, that we are already a good way toward this goal and that we should attribute to the universes and to the digital entities hosted by our computers a higher degree of reality than we are normally willing to. "Digital universes are not simulations"—he says—and those digital entities "may live and die within digital domains, but they are every bit as biological as you."

To develop his program, Bentley starts by defining and giving some example of the idea of a rule-based universe, along with a very elementary introduction to the concepts of computer hardware and software. In these opening pages the reader is

encouraged to "take a broader view of the computer" in order to see it not merely as a complicated device but, rather, as a "universe creator." The next chapter, "Evolution," introduces the main ideas of evolutionary theory, shows how they can be implemented in a digital universe, and explains how, in principle, they "form the basis of all the computing techniques described in this book." The evolutionary algorithms described in this chapter do not include the development process, since Bentley devotes a whole later chapter, "Growth," to that topic. The titles of the intermediate chapters—"Brains," "Insects," "Plants," and "Immune Systems"—will sound familiar to regular readers of *Artificial Life*. In each of these chapters Bentley relates briefly on the current state of our understanding of some aspect of the corresponding natural systems and proceeds to illustrate the efforts directed towards the implementation of their digital counterparts. Here and there, other researchers are introduced and asked to describe their work directly or comment on some of the issues raised by the book, but the reader is spared the colorful anecdotal descriptions of the their habits and milieu that often abound in this kind of literature.

The last chapter, "Answers," departs somewhat from the previous ones in that in it Bentley tries to stress the existence of a common theme behind the material presented in the preceding chapters, probably lest it be perceived by some reader as merely a collection of disparate and loosely related efforts. In fact, already in the introduction Bentley emphasizes that "all biological processes are aspects of a single, fundamental process." In this chapter that assertion is further motivated by interpreting all the examples presented in the previous chapters as instances of complex societies, that is—as Bentley puts it—collections of simple things that follow a set of rules. More precisely, Bentley suggests that the workings of all these systems can be understood in terms of the following general law: "Many things that interact with feedback and are perturbed create complexity." (A note does specify that "of course, multiple interacting things with feedback and perturbations may not always create *useful* complexity—they may get stuck in a stable state or fly off into chaotic randomness. But if you've got complexity—particularly the kinds of complexity we've seen in this book—you can be sure that it's because of our laws.") Bentley concludes the book by presenting a list of predictions, or "digital divinations," that in his view can be made to follow from that law.

Throughout the book Bentley maintains a lively and entertaining style and comes up often with engaging and imaginative excursions to introduce a theme or illustrate a point. Despite the fact that the general readership he has in mind forces him to devote a good part of each chapter to the (usually excellent) description of some aspects of natural biological processes and systems, thus limiting the space devoted to their digital counterparts, Bentley succeeds in giving a good account of the ongoing activities and in conveying the spirit that animates this field of research. Undoubtedly, not all of his statements would be subscribed to by the bulk of the research community, especially when it comes to attributing reality and biological status to the processes and phenomena taking place within present-day computers. Some readers may feel the lack of a more profound discussion of the culture-transforming potentialities announced in the subtitle or may have a hard time recognizing the results described in the book as a beginning of the realization of the extraordinary developments announced in the introduction. Finally, striving to illustrate actual applications of the ideas presented, the central chapters of the book tend to focus on the implementation of models mimicking processes occurring in nature, to the detriment of the space devoted to the more creatively defined universes that characterize artificial life endeavors. In any case, it remains true that the book is well written, very readable, and essentially correct (apart from the consistent misspelling of "autopoiesis") given the constraints imposed by the popularization objective, and that it reflects well the excitement, enthusiasm, and ex-

pectations of the research community whose efforts it describes. In this sense it makes good reading for the nonspecialist that wants to have a general idea of what the fields of evolutionary computation, artificial life, complex systems, and biologically-inspired modeling are about and what's going on in them.

Going now back to the remark that opens this review, we can maybe regret, paradoxically, that Bentley's gift for presentation tends to make things seem simpler than they really are. I have often noticed that people with a non-technical background appear sometimes to entertain the belief that engineers and technicians find the solution to all their problems ready-made in some sort of cookbook and that creative effort is not normally required from them. Correspondingly, it might be that from Bentley's presentation someone could end up believing that from the simple observation of nature one can infer the essence of its workings, or that in the field of universe creation "anything goes" in the sense that any set of rules, once implemented on a computer, gives some interesting behavior and has the potential to lead to the emergence of some form of life.

As Bentley puts it, "[a] computer has an infinite number of different behaviors," and it is indeed reflecting on this fact that, when computers were much less powerful than today, Howard Pattee noted [5]: "We must remember ... that the potential variety of programs is indeed infinite, and that we must not consume our experimental talents on this endless variety without careful selection based on hypotheses which must be tested." On the other hand, we also know that the construction of models is not a task to be approached absentmindedly. Referring to the scientific enterprise, Richard Feynman once told the following story [4]:

> In the South Seas there is a cargo cult of people. During the war they saw airplanes land with lots of good materials, and they want the same thing to happen now. So they've arranged to make things like runways, to put fires along the sides of runways, to make a wooden hut for a man to sit in, with two wooden pieces on his head like headphones and bars of bamboo sticking out like antennas—he's the controller—and they wait for airplanes to land. They're doing everything right. The form is perfect. It looks exactly the way it looked before. But ... they're missing something essential, because planes don't land.

Feynman gives the name "cargo-cult science" to pseudo-scientific practice that captures the form but misses something essential. Correspondingly we could use the name "cargo-cult models" for models that replicate some aspects of nature's processes but miss something essential. Note that some partial success does not guarantee that something essential is not missing. (Assuming that the cargo cult was really intended to bring back the planes, we could hypothesize that, following its discovery, anthropologists and ethnologists flocked to study it; if so, the practitioners of the cult could rightly report to local funding agencies "some promising preliminary results" in bringing back planes and goods.)

The members of the research community are hopefully aware of the need to move carefully between the Scylla of the infinity of fabricable digital universes and the Charybdis of cargo-cult models. Given the intended audience of this book, probably it would have been wise on Bentley's part to state explicitly that the job of the researcher consists, among other things, in complying with the method and discipline that enables one to stay away from those two perils—perils that the very existence of the computers that are bringing forth the predicted revolution, with the almost effortless implementation of models they allow, makes more acute as time goes on.

References

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4. Feynman, R. P. (1985). *"Surely you're joking, Mr. Feynman!": Adventures of a curious character*. New York: W.W. Norton.

5. Pattee, H. H. (1969). How does a molecule become a message? *Developmental Biology Supplement, 3*, 1–16.