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Simulating Narratives: What Virtual Creatures Can Teach Us

N. Katherine Hayles

Yearning for the light, the creatures struggle after it. In water they grow tails and learn to undulate like snakes. On land they clump along, relegated by fate and biology to rectangular shapes joined together with moveable hinges. They show extraordinary ingenuity in making the most of these limitations, crawling, hopping, jumping, always toward the light. Then their creator gives them a new goal, a colored cube reminiscent of a squared-off hockey puck. Put into competition with one another, the creatures learn to jostle and shove their opponents, to encircle the cube, to knock it out of the way so their opponents can't reach it. When they meet a new opponent, they develop counterstrategies to meet these challenges. I marvel at their adaptability, cleverness, and determination.

This passage describes my reactions while watching the videotape of Karl Sims's evolutionary simulation, *Evolved Virtual Creatures.* Judging from audiences with whom I have seen the tape, my responses are typical. Invariably viewers attribute to these simulated creatures motives, intentions, goals, and strategies. Even people who know perfectly well they are seeing visualizations of computer programs still inscript the creatures into

My thanks to Karl Sims for making his *Evolved Virtual Creatures* available to Nicholas Gessler and to Gessler for allowing me to view it. I am also indebted to Gessler for many of the ideas in this essay. He conveyed them to me over several years of ongoing discussions, and by now they are so woven into my own thoughts that I am no longer sure which started as his suggestions. Let me simply say, then, that this essay could not have been written without his help.

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narratives of defeat and victory, cheering the winners, urging on the losers, laughing at the schlemiels. Much more is going on here than simple anthropomorphic projection. *Evolved Virtual Creatures* is a laboratory not only in evolution (its intended purpose) but also in the impact of distributed cognitive systems on traditional modes of description, analysis, and understanding. Emerging from this laboratory are resources to rethink the divide between scientists and cultural critics, especially the conflict between seeing the body as an externally existing object with a more or less constant physical reality (the view of most biologists) and as a discursive construction produced by historically specific cultural formations. Virtual creatures can teach us that this divide is itself historically contingent, a result of the ongoing transition from the traditional liberal self to the contemporary posthuman subject.[1]

But I am getting ahead of my story. Let us return to the virtual creatures to explore their construction and dynamics. Compared to the world in which we live, the environment of *Evolved Virtual Creatures* is extremely simple, so simple it can be described almost completely.[2] How to define the boundaries of this world is a centrally important issue to which I will return. For now, let us consider the world to be the computer programs, the hardware on which the programs run, and the visualization routines that render these programs as pixelated images of embodied creatures. Even this simple world requires three different modes of interrogation: what it is (the material); what it does (the operational); and what it means (the symbolic). Feedback loops connect the material, operational, and symbolic into an integrated, recursively structured hierarchy. At the bottom of the hierarchy flash electronic polarities, joining the material and operational to create bits, the semiotic markers of one and zero. Logic

1. The transition from liberal humanist subject to the contemporary posthuman subject is described in N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago, 1999).

2. The world of *Evolved Virtual Creatures* is described in Karl Sims, "Evolving Virtual Creatures," ACM-0-89791-667-0/94/007/0015, paper presented at SIGGRAPH, Orlando, Fla., 24–29 July 1994. See also Sims, "Evolving 3-D Morphology and Behavior by Competition," unpublished manuscript. *Evolved Virtual Creatures* can be seen at www.biota.org/ksims/index.html, as well as an interview with Sims discussing his work.

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gates structure signals into bits; bit patterns are fashioned into compiler languages; compiler languages underlie programming languages; and programming languages such as LISP define functions. By the time we arrive at functions, the level at which Sims discusses his design for *Evolved Virtual Creatures,* we have reached a point where the patterns created by the programmer become explicit. Instantiated in these patterns are the programmer's purposes in creating this particular hierarchy of materio-semiotic codes.

Sims's design follows John Koza's proposal that evolutionary programs should take advantage of modular structures, which can be repeated over and over to create more complex structures.[3] The strategy appears often in nature; a fern, for example, displays a growth algorithm that uses the same basic shape for stems, branches, and leaves.[4] Like the fern, Sims's creatures are built using functions repeated with variations to create self-similar morphologies. One function specifies blocks that are multiplied and attached at various positions on a central rectangle to create a trunk with several limbs. Another function specifies the kind of articulation, or joint, between blocks; still another, the degrees of freedom through which a joint can move. Recursive loops *within* a function multiply the effects of that function to create more of the same, for example, more limbs of the same shape. Recursive loops *between* functions allow different parts of the creature to evolve together, so that the brain or central control circuits coadaptively change with the morphology. The advantages of these modular structures, achieved by using programs called directed graphs, are twofold. In addition to economy of description (because the same module can be used repeatedly with minor variations), the modules also ensure that some structure will persist in the midst of mutation and variation. If all of the programming elements were subject to mutation as independent entities, the resulting complexity would quickly become too chaotic to track effectively. When the elements are grouped and mutated as modules, the spectrum of possible variations is reduced to a manageable level.

The next step moves from the design of individual creatures to a population of creatures. With this step, the symbolic aspects of the program become apparent. The idea is to evolve creatures by introducing diversity into the population and defining fitness criteria that determine

3. See John R. Koza, *Genetic Programming: On the Programming of Computers by Means of Natural Selection* (Cambridge, Mass., 1992) and *Genetic Programming II: Automatic Discovery of Reusable Programs* (Cambridge, Mass., 1994), where Koza shows how genetic programming can itself dynamically evolve the functions it needs to evolve further. Koza calls these Automatically Defined Functions (ADFs) and remarks, "hierarchical organization and reuse [of ADFs] seem to be required if automatic programming is ever to be scaled up from small problems to large problems" (p. 4).

4. Benoit Mandelbrot, *The Fractal Geometry of Nature* (San Francisco, 1982) discusses how relatively simple computer algorithms can generate complex plant shapes.

which creatures get to reproduce. Diversity is accomplished through sexual reproduction that, following various schemes, combines portions of one creature's genotype with another's. Additional diversity is introduced through mutation. Behaviors take place within an environment governed by an artifactual physics, which includes friction, inertia, momentum, gravity, light, three-dimensional space, and time. Fitness values are determined according to how successful the creatures are in reaching various goals—following a light, moving through fluids and across terrains, cornering the puck while keeping an opponent away from it. (Figures 1 and 2 show evolving morphologies for swimming creatures, from a rudimentary beginning to a sinuous, snakelike creature.) To facilitate adaptation to these goals, the creatures are given photosensors that can neurologically evolve to respond to a beacon, the presence of the puck, and positions of competitors, each represented by a differently colored light source.

The designer's intentions, implicit in the fitness criteria he specifies and the values he assigns to these criteria, become explicit when he intervenes to encourage "'interesting'" evolutions and prohibit "inelegant" ones.[5] For example, in some runs creatures evolved who achieved locomotion by exploiting a bug in the way conservation of momentum was defined in the world's artifactual physics; they developed appendages like paddles and moved by hitting themselves with their own paddles. "It is important that the physical simulation be reasonably accurate when optimizing for creatures that can move within it," Sims writes. "Any bugs that allow energy leaks from non-conservation, or even round-off errors, will inevitably be discovered and exploited by the evolving creatures."[6] In the competitions, creatures evolved to exceptional heights and controlled the cube by simply falling over on it before their opponents could reach it.[7] To compensate, Sims used a formula that took into account the creature's height when determining its starting point in the competition; the taller the creature, the further back it had to start. (Figures 3 and 4 show creatures evolved through competition, from a simple beginning to the development of arms that can corner the puck or push away opponents.) The conjunction of processes through which we come to narrativize such images clearly shows that the *meaning* of the simulation emerges from dynamic interactions among the creator, the virtual world (and the real world on which its physics is modeled), the creatures, the computer running the programs, and, in the case of visualizations, the viewer watching the creatures cavort. In much the same way that the recursive loops between program modules allow a creature's morphology and brain to coevolve, so recursive loops allow the designer's intent, the creatures, the

5. Sims, "Evolving 3-D Morphology and Behavior by Competition," pp. 31, 29.
6. Sims, "Evolving Virtual Creatures," p. 18.
7. See Sims, "Evolving 3-D Morphology and Behavior by Competition," p. 29.

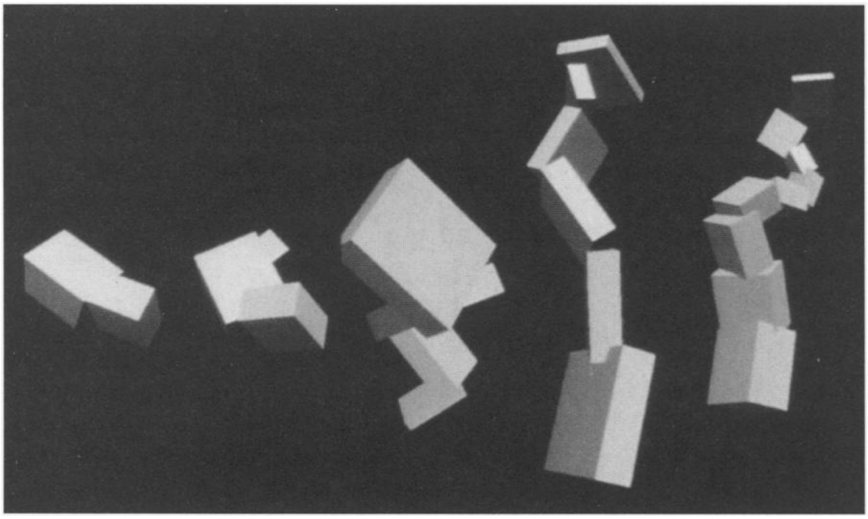

FIG. 1.—Evolutionary sequence of swimmers. A sequence, from left to right, showing creatures evolved by specifying as a fitness criterion how fast they could swim. From an initial two-block configuration that moved with difficulty, the creatures evolved to a multi-block configuration that undulates like a snake.

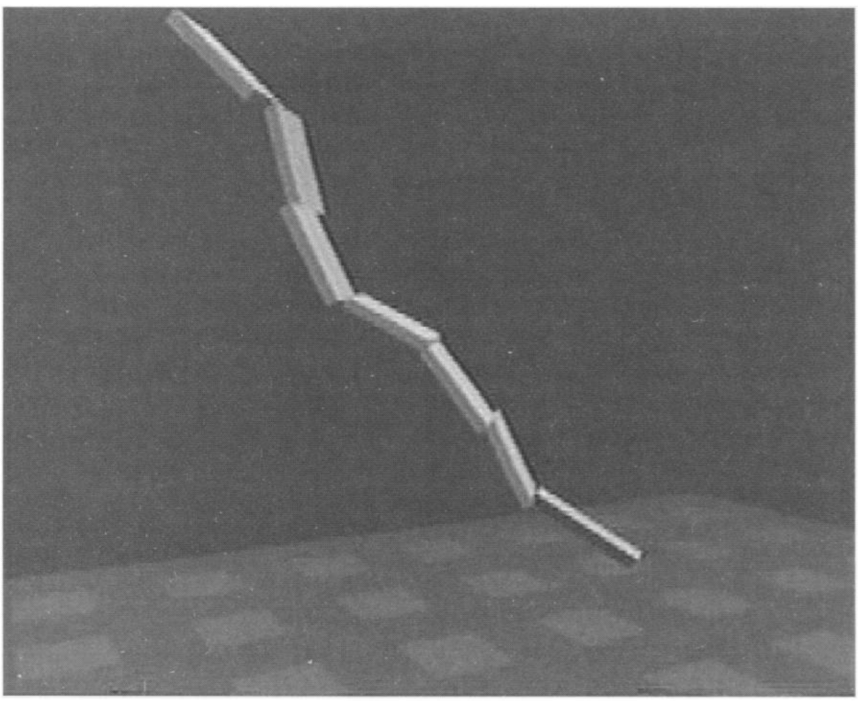

FIG. 2.—Evolved virtual snake. The end result of many generations of swimming creatures, this creature moves as gracefully through the virtual water as a water snake does through a river.

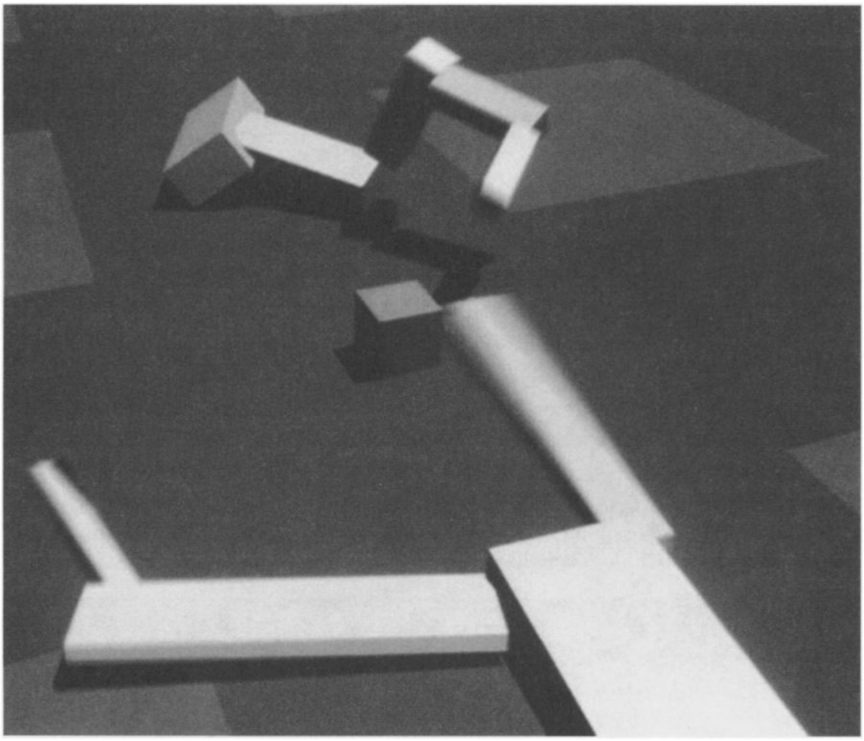

FIG. 3.—Creatures evolved through competition. The first creatures had only two limbs; after many generations, the blocks were manipulated to create arms capable of moving the puck.

virtual world, and the visualizations to coevolve into a narrative that viewers find humanly meaningful.

An adequate account of the simulation, then, requires expanding the boundaries of the system beyond the programs and computer to include the virtual world, the creator, and the viewer. The evolutionary dynamics of this larger world functions as a distributed cognitive system composed of human and nonhuman actors, each of which acts as an independent cognizer. As Michael Dyer has noted in another context, with distributed cognitive systems there is no free lunch; because all the parts interrelate, if one part of the system can only function as a relatively low-level cognizer, the slack has to be taken up somewhere else by making another part smarter.[8] Compared to artificial intelligence, artificial life simulations typically frontload less intelligence in the creatures and build more intelligence into the dynamic process of coadapting to well-defined envi-

8. See Michael G. Dyer, "Toward Synthesizing Artificial Neural Networks That Exhibit Cooperative Intelligent Behavior: Some Open Issues in Artificial Life," in *Artificial Life: An*

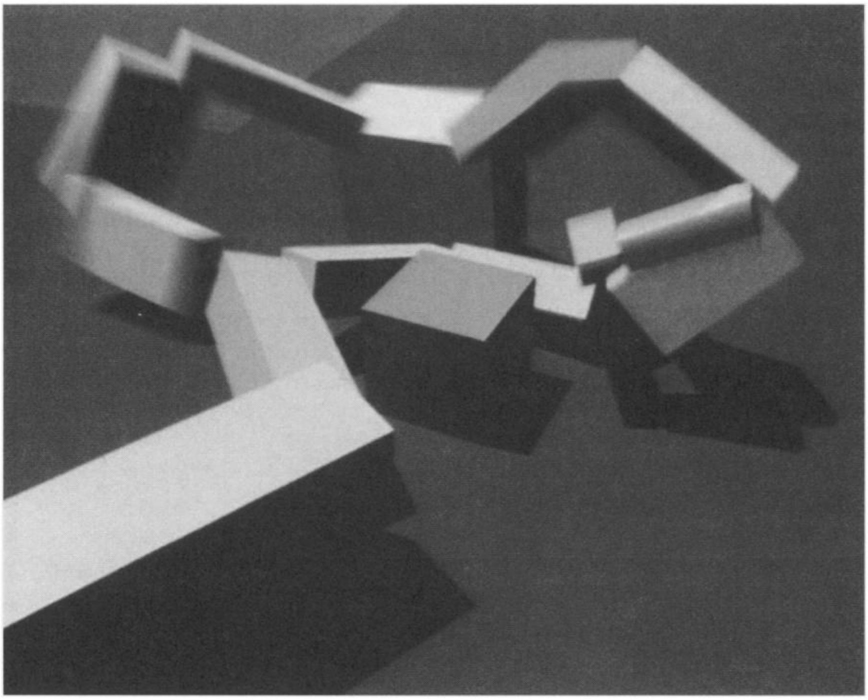

FIG. 4.—Evolving virtual tactics. The uppermost figure has evolved a strategy of ignoring the puck and heading straight for its opponent, a move I call the Schwarzenegger tactic. Notice that the lowermost creature is encircling the puck with its arm, another evolved behavior.

ronmental constraints. When the environment fails to provide the appropriate constraints to stimulate development, the creator steps in, using his human intelligence to supply additional adaptive constraints (for example, when Sims put a limit on how tall the creatures can get). But it would be a mistake to see the creator as the court of last resort. The point of such simulations is that the creator does not always need to be as smart as his creatures, for he is counting on their ability to come up with solutions that have not occurred to him. "When a genetic language allows virtual entities to evolve with increasing complexity," Sims observes,

> it is common for the resulting system to be difficult to understand in detail. In many cases it would also be difficult to design a similar system using traditional methods. Techniques such as these have the potential of surpassing those limits that are often imposed when

Overview, ed. Christopher G. Langton (Cambridge, Mass., 1995), pp. 111–34. I am also indebted to Dyer for conversations clarifying these issues for me.

human understanding and design is important. The examples presented here suggest that it might be easier to evolve virtual entities exhibiting intelligent behavior than it would be for humans to design and build them.[9]

Since distributed cognitive systems coevolve, the functioning of any one actor can be fully understood only in relation to that actor's interactions with all the other actors. It is in this context we should think about the narratives humans create for themselves when they watch *Evolved Virtual Creatures.* Spliced into a distributed cognitive system, we create these narratives not by ourselves alone but as part of a dynamic evolutionary process in which we are coadapting to other actors in the system, including pixelated images on a CRT screen and electronic polarities flickering beyond the scale of human perception.

Evolving Narratives

When we attribute to Sims's virtual creatures motives and intentions, we interpolate their behaviors into narratives in which events are causally related to one another and beings respond to their environment in purposeful ways. As Alex Argyros, among others, has suggested, the creation of narrative may itself be an evolutionary adaptation of remarkable importance.[10] Narratives, with their emphasis on causality, meaningful temporal sequence, and interrelation between behavior and environment allow us to construct models of how others may be feeling and acting, models that coevolve with our ongoing interior monologues describing and interpreting to ourselves our own feelings and behaviors. When narratives for some reason cannot be constructed, the result is likely to be a world without order, a world of inexplicable occurrences and bewildering turns of events. Simon Baron-Cohen describes such a world in *Mindblindness,* suggesting it is characteristic of how autistic people perceive their environment.[11] As Baron-Cohen points out, autism is associated with an inability to construct narratives that will make sense of the behaviors of others. Autistic people have no model in their minds for how others act, and, consequently, most actions are to them inexplicable and frightening. Another graphic description of what happens when narratives fail is rendered by Joan Didion in *The White Album.* Recounting a time in her life when she "began to doubt the premises of all the stories I have ever told myself," she lost her sense of living in a coherent world, for as she empha-

9. Sims, "Evolving 3-D Morphology and Behavior by Competition," p. 38.

10. See Alex Argyros, *A Blessed Rage for Order: Deconstruction, Evolution, and Chaos* (Ann Arbor, Mich., 1991).

11. See Simon Baron-Cohen, *Mindblindness: An Essay on Autism and Theory of Mind* (Cambridge, Mass., 1995).

sizes, "we tell ourselves stories in order to live."[12] What these accounts make clear is that narrative has an explanatory force that literally makes the world make sense. It is easy to see why the creation of narratives would confer evolutionary advantages on creatures who construct them. Without the presuppositions embedded in narratives, most of the accomplishments of *Homo sapiens* could not have happened.

When we construct narratives about virtual creatures, we use an evolved behavior to understand the evolved behaviors acted out in the simulation. It is no accident that in this scenario a feedback loop appears whose recursive structure resembles the recursive structures of the programs generating Sims's virtual creatures. Across a wide variety of research programs, from Stuart Kauffman's claims for the evolution of life at the edge of chaos to Koza's work with artificial life simulations and Francisco Varela and Humberto Maturana's theories of autopoiesis, recursive loops are associated with the emergence of complexity and consequently with life, consciousness, and intelligent behavior.[13] Maturana and Varela, for example, suggest that consciousness consists of the ability to make representations of representations (of representations of representations . . .). Luc Steels has named this phenomenon of spiraling recursions second-order (and higher) emergence and underscored its importance for artificial life simulations.[14] (First-order emergence, of course, is any behavior or property that cannot be found in a system's individual components or their additive properties but that arises, often unpredictably, from the *interaction* of a system's components. Emergent properties appear on the global level of the system, not the local level of the system's parts.) Second-order emergence arises when a system develops a behavior that enhances its ability to develop adaptive behaviors—that is, when it *evolves the capacity to evolve.*[15] The goal of most artificial life simulations is precisely to achieve such second-order (and higher) emergence, for then the simulation really takes off.

In addition to recursive structures, another important element in the creation of narrative is the ability to "see" a scene, either literally or metaphorically, in the mind's eye.[16] With training and experience, humans are able to translate a large variety of inputs into these imagined

12. Joan Didion, *The White Album* (New York, 1979), p. 11.

13. See Stuart A. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (Oxford, 1993); Koza, *Genetic Programming* and *Genetic Programming II;* and Humberto Maturana and Francisco Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht, 1980).

14. See Luc Steels, "The Artificial Life Roots of Artificial Intelligence," in *Artificial Life,* pp. 75–110.

15. A point made by Richard Dawkins in *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (New York, 1986).

16. I use *see* in quotations marks to imply not only the physical act of visual perception but also the culturally conditioned cognitive processes by which we invest what we see with meaning.

scenarios. No doubt an experienced programmer such as Sims can look at a program's functions and "see" the morphologies and behaviors of his creatures with no more difficulty than an experienced novel reader can "see" Isabel Archer in Henry James's tellingly entitled novel, *The Portrait of a Lady*. These translation processes draw upon and extend capabilities developed in evolutionary history. Our sophisticated perceptual-cognitive visual processing evolved coadaptively with our movement through three-dimensional spaces, so it is no surprise that the creation of narrative is deeply tied up with imagining scenes in which actions can take place. When Sims chooses some of his creatures for visual rendering, he taps into this evolutionary history by creating pixelated images that, through culture and training as well as biologically determined capacities, we recognize as representations of three-dimensional spaces. Articulated in this *lingua franca* of Western cultural perception, the images allow narrative to kick in with maximum force, for the action is "seen" in terms we can easily relate to our ongoing narrativizing of the world. (I recently came across an advertisement for an academic job encouraging "visible minorities" to apply, a phrase I had not heard before and that immediately evoked thoughts of Ralph Ellison's *Invisible Man*. Leaving aside the complex cultural history embedded in this phrase, it serves the purpose here of highlighting the importance of making bodies *visible* if they are to enter into the canonical narratives of a culture, a requirement that seems both strange and familiar when applied to visualizations of virtual creatures.)

Let us turn now from the structural preconditions for the creation of narratives to content. As Jerome Bruner has pointed out, one of the principal purposes narrative serves is to create a sense of *why* things happen.[17] The narratives we create typically inscript actions into a set of more or less canonical stories that invest actions with meaning. When Joan Lucariello studied which stories stimulated the most vigorous creation of narratives by young children, she discovered that nonexpected actions gave rise to the most stories in response, for example, a description that has Mary crying when she sees her birthday cake and dumping a glass of water all over the candles.[18] To make sense of these strange actions, the children invented a wide variety of stories that had the effect of suturing the actions back into a predictable and expected range of behaviors. In one small child's account, Mary was upset because her mother wouldn't let her wear the dress she wanted, and that's why she cried and ruined her cake. Presented with noncanonical actions, the children sometimes employed another narrative strategy of marking the behavior as unusual or deviant, which again allowed the social fabric of expectations to be

17. See Jerome Bruner, *Acts of Meaning* (Cambridge, 1990).

18. Joan Lucariello, cited in ibid., pp. 81–82, p. 157 n. 26, where the source is identified as "personal communication."

maintained by bracketing this behavior as an exception.[19] It is surely no accident that in his evolutionary simulations Sims designs programs that can be "seen" as creatures striving after a goal and winning against competitors, for these are among the most canonical narratives in traditional accounts of evolutionary history (not to mention in Western capitalist society). The banality of the narrative content suggests that what needs to be sutured here is not so much deviant action as the deviant actor. When we "see" the virtual creatures engaging in these activities, we have models in our minds for what these behaviors mean, and so the creatures, despite their odd shapes and digital insides, seem familiar and understandable.

At this point, some readers may object that however functional narrative may be for everyday social intercourse, it leads to serious mistakes when we use it to understand virtual creatures. Not only do these creatures have nothing in their heads; in a literal sense, they have no heads (because they are virtual and because their morphology is a series of blocks, the uppermost of which we "see" as the head). Attributing desires to these clumps of blocks is as ridiculous as thinking electrons have motives. Well, yes and no. Certainly the creatures are merely computer programs that have evolved certain behaviors (and therefore attributes we interpret as embodied action toward a goal) as a result of the fitness criteria used to select which genotypes will be allowed to reproduce or, more accurately, which coding arrangements will be replicated with what variations, since *genotype* and *reproduce* are themselves metaphors designed to reinforce the analogy with biological life forms. On the other hand, these programs are *designed* to simulate biological evolution and visually rendered so that narrative inscripting will take place. There is a sense in which we respond correctly, not mistakenly, when we attribute desires to these virtual creatures, for everything about them has been crafted to ensure such interpretations will occur.

One way to think about this situation is to note that distributed cognition also implies distributed causality. The creatures may not have motives and intentions, but the programmer does (at least in the conventional understanding of human actions). Remember that what we "see" in the visualization is the *global* result of present and past interactions among all the actors in this recursively structured complex adaptive system. When Sims decides which fitness criteria to use, which programs to eliminate, and which to render visually, he injects doses of his human intelligence into the system, along with the attributes we conventionally assign to humans, including desires and intentions. Moreover, his articles clearly show that his intentions affected virtually every aspect of the design, so it is not possible to bracket out his intentions by saying we should consider only the programs in themselves, not the global system.

19. See ibid., pp. 82–83.

Human intentionality, then, infects the creatures, marking them with a trace that cannot be eradicated. Recall that in this recursively structured complex adaptive system *all* of the actors are involved in and therefore affected by the interactions. Is it also the case that the blind operations of the programs infect the humans, marking them with a trace that cannot be eradicated? To entertain this hypothesis is to suppose that the human tendency to anthropomorphize the creatures has as its necessary and unavoidable supplement a countertendency to "see" human behavior as a computer program carrying out instructions. We may think we have desires and intentions (just as we think the creatures do), but our behaviors can be explained materially and operationally in terms similar to Sims's programs. This argument has been made by several researchers in artificial intelligence and artificial life, including Rodney Brooks and Marvin Minsky.[20] In their view, human behavior is the result of many semiautonomous agents running simple programs. To illustrate, Minsky suggests that "love" is a combination of one agent running an "attraction" program and another agent running a program that shuts off the "critical" agent.[21] Such proposals indicate that anthropomorphizing the creatures is accompanied by what I might call, for lack of a better term, computationalizing the humans. According to the logic of this relation, blind programs engaging in humanlike behaviors make plausible the interpretation of human behaviors as blind programs. We humanize the virtual creatures, they computationalize us, and the recursive loops cycling through the system bind both behaviors together in a network of complex coadaptations.

Which leaves us with an interesting question: what happens now to narrative and its function of making human sense of the world?

Computing the Human: Analogue and Digital Subjects

Following the work of Michel Foucault on the death of the author,[22] Mark Poster has expanded on Foucault's fourth and final stage of the author's disappearance to suggest that digital technologies and culture are bringing about a significant reconfiguration of contemporary subjec-

20. See Marvin Minsky, *The Society of Mind* (New York, 1986), and Rodney A. Brooks, "Intelligence without Representation," *Artificial Intelligence* 47 (Jan. 1991): 139–59. See also *The Artificial Life Route to Artificial Intelligence: Building Embodied, Situated Agents*, ed. Steels and Brooks (Hillsdale, N.J., 1995).

21. See Minsky, "Why Computer Science Is the Most Important Thing That Has Happened to the Humanities in 5,000 Years," paper presented in Japan, 15 May 1996. I am grateful to Nicholas Gessler for providing me with a transcript of this lecture.

22. See Michel Foucault, "What Is an Author?" *The Foucault Reader*, trans. Josué Harari, ed. Paul Rabinow (New York, 1984), p. 119.

tivity.[23] To illuminate this shift, Poster posits two different kinds of subjects: analogue and digital. The analogue subject is based on relations of resemblance.[24] Although Poster does not use this example, the mind-heart conjunction illustrates the concept. Consciousness is taken to resemble the soul or the heart, so that what is at the forefront of mind is also imagined to be deep inside. Similarly in the English Renaissance, a period dominated, as Foucault has shown, by cultural relations based on analogy,[25] human sperm was thought to contain a homunculus resembling the man who would grow from the sperm. Walnuts were considered to be "brain food" because walnut meat resembles the human cortex. Analogical relations require that the integrity of the units taken to resemble one another be preserved; otherwise, the correspondence is lost and the relation broken. If one tosses a handful of walnuts into a blender and turns it on, the walnuts are pulverized and no longer resemble a cortex. If walnuts were available only in this form, it seems unlikely they would have been considered good food for thought. Attributes of the analogue subject include, then, a depth model of subjectivity in which the most meaningful part of the self is seen to reside deep inside the body, and units with a natural integrity of form and scale that must be preserved if the subject is to be maintained intact.

Drawing on Mark Rose's work on copyright,[26] Poster focuses his discussion of subjectivity on the "cultural figure of the modern author," a figure that emerged in the eighteenth century in a "confluence of print technology, a book market, a legal status, and an ideology of individual as creator" ("WM," p. 6). In Poster's view, analogue subjectivity is deeply bound up with the dominance of print culture. At the same time alphabetic writing breaks the pictorial resemblance that connects an ideogram to the object represented, it forges a new connection between a sound and a mark. This connection differs from pictorial writing in that the association of sound with mark is entirely conventional, and the resulting

23. Mark Poster, "What's the Matter with the Internet," unpublished manuscript; hereafter abbreviated "WM." I am grateful to Poster for discussions clarifying his ideas in this manuscript.

24. Poster's discussion can be clarified by noting that analogue technologies do not necessarily rely on resemblance, only on morphological proportionality. A phonograph record, for example, does not look like the sound waves it captures and reproduces, but there is a morphological proportionality between the sound waves and the spacings of the record grooves. Analogue relations that depend on resemblance are more properly called analogies (or analogizing relations). Analogies are a subset of analogue relations, which also contain the relations, typical of analogue technologies, that depend on morphological proportionality.

25. See Foucault, *The Order of Things: An Archeology of the Human Sciences*, trans. pub. (New York, 1970).

26. See Mark Rose, *Authors and Owners: The Invention of Copyright* (Cambridge, Mass., 1993).

arbitrariness makes alphabetic writing much more economical than ideograms (thousands of ideograms versus some thirty letters of the Greek alphabet).[27] There is also another shift, for now the resemblance is not between word and thing but, as Poster puts it, between "a written symbol and its utterance, between two forms of language, writing and speech. The relation between the word and thing becomes conventional, arbitrary, whereas the relation within language between trace and voice is stronger, more direct" ("WM," p. 22). Thus to the extent that print can be considered an analogue medium, it connects voice to mark and thus author as speaker to the page.

Reinforcing the sense that print texts are "voiced" by an individualistic creator is the uniformity, stability, and durability of print. "The reader could return time and again to the page and re-examine the words it contained," Poster writes. "A readerly imaginary evolved which paid homage to this wonderful author who was always there in his or her words. . . . The world of analogue authors was leisurely, comforting, reassuring to the cognitive function and expanding through continuous exercise of the visual function" ("WM," p. 26). Although literary history is largely outside the scope of Poster's analysis, the role of the novel in reinforcing the depth model of interiority and the stability and individuality of the analogue subject has long been recognized in literary studies. The legal fight to insure copyright, the cult of the author, print technology, and print culture worked hand in glove to create a depth model of subjectivity in which analogue resemblances guaranteed that the surface of the page was matched by an imagined interior within the author, which evoked and also was produced by a similarly imagined interior in the reader.

In contrast to this dynamic are the correspondences producing the digital subject. Digital technologies employ hierarchical program structures similar to those we saw at work in *Evolved Virtual Creatures.* Unlike the depth model of meaningful interiority in the analogue subject, the further down into the coding levels the programmer goes, the less intuitive is the code and the more obscure the meaning. Speaking as someone who has programmed in machine language, I can testify how murderously difficult it is to translate thoughts into binary code. Programming in C++ is a breeze by comparison. Moreover, with genetic algorithms and programs the important developments are *emergent* properties that appear at the global level of the system once the programs are set run-

27. Robert K. Logan, *The Alphabet Effect: The Impact of the Phonetic Alphabet on the Development of Western Civilization* (New York, 1986), argues that the switch from pictorial representations to alphabetic representation, in its much greater economy, is a move toward the digitalization of language. In this view, alphabetic writing is not primarily analogue but digital. See also his interesting arguments about computational language as an advance on natural languages in Logan, *The Fifth Language: Learning a Living in the Computer Age* (Toronto, 1995).

ning. The mantra for such programs is "simple rules, complex behaviors," which implies that the further down into the system one goes, the less interesting it is.

Although the digital subject has depth, the structures governing the relation of surface to interior differ dramatically from the analogue subject. The digital subject—say, one of Sims's virtual creatures—instantiates hierarchical coding levels operating through a dynamic of fragmentation and recombination.[28] Unlike analogue subjectivity, where morphological resemblance imposes constraints on how much the relevant units can be broken up, the digital subject allows for and indeed demands more drastic fragmentation. This difference can easily be seen by comparing the analogue aspects of print media to the fragmentation of digital technologies. Each letter of the alphabet must be treated as a distinct unit for writing to be legible, and the corresponding phoneme also acts as an intact unit. In contrast are digital sampling techniques, where sound waves may be sampled some 40,000 times a second, digitally manipulated, and then recombined to produce the perception of smooth analogue speech ("WM," p. 20). In fact emergence depends on such fragmentation, for it is only when the programs are broken into small pieces and recombined that unexpected adaptive behaviors can arise. Instead of a depth model of meaningful interiority, the digital subject manifests global behaviors that cannot be predicted by looking at the most basic levels of code when the program begins running. Complexity becomes visible first on the surface, not deep inside. Moreover, the complex surface bears no analogical resemblance to the mind-numbing simplicity of ones and zeros.

To summarize: the analogue subject implies a depth model of interiority, relations of resemblance between the interior and surface that guarantee the meaning of what is deep inside and the kind of mind-soul correspondence instantiated by and envisioned within the analogue technologies of print culture. The digital subject implies a surface complexity that is related through hierarchical coding levels to simple underlying rules, a dynamic of fragmentation and recombination that gives rise to emergent properties, and a disjunction between surface and interior instantiated by and envisioned within the digital technologies of computational culture.

What happens when we become part of a complex adaptive system by "seeing" the virtual creatures? I suggested earlier that two processes are at work simultaneously: on the one hand humans anthropomorphize the virtual creatures, and on the other hand the virtual creatures computationalize the humans. The narratives we construct as we watch the

28. William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (Cambridge, Mass., 1995), highlights the importance of fragmentation and recombination across a variety of architectural sites and social practices in the digital age.

virtual creatures inscript their behaviors into an analogue world, but observant viewers will notice details that cannot be explained by supposing the complex surfaces are matched analogically with equally complex interiors. One creature, for example, moves in a way that indicates it samples the position of the puck and opponent once at the beginning of the competition and thereafter ignores all cues about position.[29] Clearly, here is an instance of a relatively simple program creating an impression of surface complexity that contrasts with the simplicity of the underlying rules. Another example is provided by a small mobile robot made by Lego that, on the surface, appears to be capable of following a black line on a white ground.[30] A viewer might suppose that inside the robot is an intelligent program that has an internal representation of a line and can so accurately match this representation with what it sees that it can distinguish many different kinds of lines, including ones that are curved and even looped. Underlying the surface complexity, however, are three simple rules: if from white to black, turn right; if from black to white, turn left; if no change, continue straight. Although the robot *globally* follows the line, this is an emergent behavior. In fact, it simply swerves right when it first comes across a black line on a white background and then, as it begins to veer off the line, immediately turns again, so its line-following behavior consists of a series of small swerves that a viewer may interpret as corrections the robot initiates to make sure it follows the line. Simple rules, complex behavior.

On the global level, our narratives about the virtual creatures can be considered as devices that suture together the analogue subjects we still are as we move in the three-dimensional spaces in which our biological ancestors evolved with the digital subjects we are becoming as we interact with virtual environments and digital technologies. In fact, this essay can be read as a narrative designed to accomplish just such a suturing. Hence my insistence on using the plural first person, despite the risk of indulging in oppressive universalisms, for I want to insist that my readers, like me, participate every day of our lives in the distributed cognitive complex adaptive systems created by digital technologies in conjunction with global capitalism. So pervasive have these technologies become that it would be difficult to find anyone who remains completely outside their reach. Certainly, here in the U.S. their presence is ubiquitous. In this sense, we do not need to slot Sims's videotape into the VCR to watch virtual creatures. We see them all the time, all around us, including when we look into the mirror.

29. This behavior was pointed out to me by Nicholas Gessler.

30. The robot was displayed in an art show featuring images, simulations, and installations created by artificial life techniques, entitled *The Art and Aesthetics of Artificial Life,* exhibited at the UCLA Center for Digital Arts, 22 June–23 July 1998, curated by Nicholas Gessler.

Reconfiguring the Material/Discursive Divide

Let me return to the suggestion that the material/discursive divide is a historically contingent formulation characteristic of a moment that may already be passing. To develop this idea, I will find it useful to review accounts that scientific realists and cultural critics give in their respective projects. For the realist, the flow of structuring information about physical reality moves from the material (say, a field of morning glories of varied colors) through the operational (experiments in breeding that operate upon the plants and plant genomes to isolate colors from one another) to the symbolic (graphs and charts showing how the colors migrate back to an equilibrium distribution after being separated). The closer the researcher is to the embodied reality of the plants, the fuzzier the picture is likely to be as various sources of "noise" and "contamination" complicate the regularities presumed to be revealed by such inscriptions as graphs and charts. The idea is to remove the noise or, failing that, compensate for it as much as possible in the experimental design and subsequent analysis, so the form of the underlying regularities becomes sharp and well defined.

In the movement from embodied reality to inscription, much is gained and some things are lost. The most important gains, of course, are the regularities revealed through the inscriptions, a point to which I will return. Also important is the implication that once these regularities are durably inscribed, they can circulate through different media without affecting their meaning. If I xerox the chart showing morning glory color distribution and discuss it with my research seminar, everyone assumes we are seeing the *same* graph that appeared in the scientific journal, even though the method of producing the image and the materials comprising it (toner ink and copier paper) differ from the original. Similarly, if the researcher illustrates a lecture on her work with slides, these count the same as the graphs printed on the journal pages. The case would be otherwise if we examined morning glory plants. Say I buy morning glory plants at Home Depot and take them into my seminar. Since they are obviously not the same plants the researcher examined in her test fields some months earlier, questions would inevitably arise about material differences that may exist between our plants and hers. Material embodiments do not circulate effortlessly because they are always instantiated, specific, and located in a certain time and place. By contrast, inscriptions can circulate because cultural conventions privilege the forms expressed by the inscriptions over their instantiations in particular media such as print, xerox, and photographic negative, which are regarded as passive vehicles for the transmission of the forms.

Normally one says inscriptions are transportable or transmissible, but perhaps a more appropriate term to describe their circulation is *transmigration.* Just as the soul, conceived as a disembodied entity, is thought to move from one corporeal body to another in transmigration, so the abstract form of the inscription is counted as moving from one incorporation to another, despite differences between material instantiations. (A partial exception to this convention is the signature, which is presumed to embody the signer's material presence and so not to be transmigratable from one medium to another. A photocopy of a will does not count the same as the original signed document. This presumption of embodiment appears to be giving way with the spread of new communication technologies; faxes, for example, are increasingly accepted as legally binding documents. Even here, however, there continues to be some whiff of embodiment, for a fax occupies a different legal position than email, which cannot carry a signature linked with embodiment.)

Inscription, then, is crucially important to the transformation of embodied reality into abstract forms. Bruno Latour and Steve Woolgar, posing as naive anthropologists visiting a biological laboratory, emphasize that what would first strike such observers is the "strange mania for inscription" that obsesses the scientific workers, from laboratory technicians scribbling in laboratory notebooks to senior scientists writing journal articles.[31] Defining an inscription device as "any item of apparatus or particular configuration of such items which can transform a material substance into a figure or diagram," Latour and Woolgar note that "inscriptions are regarded as having a direct relationship to 'the original substance.'"[32] For our purposes, it is worth noting that many, perhaps most, scientific instruments produce inscriptions through morphological proportionality to physical properties. Sound waves hit a membrane and the vibrations capture an analogue resemblance, which is conveyed through a linking mechanism to a pen tracing a line on a graph paper, which in turn bears an analogue resemblance to the vibrations. Even though scientific instrumentation increasingly uses digital technologies for analysis and imaging, there usually remain some portions of the chain that employ analogue representation, typically at the beginning and end of the process. I call this analogue-digital-analogue structure the *Oreo,* for like the two black biscuits sandwiching a white filling between them, the initial and final analogue representations connected with embodied materialities sandwich between them a digital middle where fragmentations and recombinations take place.

An example of an Oreo structure is positron emission tomography, or PET images. The process begins with the ingestion of radioactive substances by the patient. An instrument senses the decay products using analogue proportionality, and the results are inscribed as an array of nu-

31. Bruno Latour and Steve Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (London, 1979), p. 48. See also Timothy Lenoir's excellent introduction, "Inscription Practices and the Materialities of Communication," in *Inscribing Science: Scientific Texts and the Materiality of Communication,* ed. Lenoir (Stanford, Calif., 1998), pp. 1–19.

32. Latour and Woolgar, *Laboratory Life,* p. 51.

merical data. These data are then digitally analyzed and manipulated to create lifelike analogical resemblances that humans interpret as metabolic processes occurring within the cortex. These images are often read as showing thinking in action, but they may more accurately be understood as showing the Oreo effect in action. Analogue resemblance appears at the bottom of the Oreo because the embodied materiality of radioactive decay connects to the apparatus of inscription through relations of resemblance. Only after this resemblance has been captured as a number indicating the level of radioactivity at a certain position in the brain can it be digitized and manipulated as part of a data array. Similarly, at the top end, analogue resemblance is the mode best suited to our sophisticated visual-cognitive perceptual skills. Compare the accessibility of a PET image with looking at a data array displaying numbers standing for radioactivity levels. It would take hours or days to extract from this display the intuitive understanding we gain from a glance at the image. Where linkages between embodied materialities are key, analogue resemblances are also likely to be crucial.

By contrast, the digital middle of the Oreo also offers distinctive advantages. Moving from analogue resemblance to coding arrangements opens possibilities for leveraging unthinkable with analogue resemblance, which by virtue of *being* a resemblance must preserve proportional similarity. The difference can be illustrated with a typewriter and computer word processing program. To make a letter darker on a typewriter, proportionately more ink and/or pressure must be applied for each letter, whereas to make a screen of letters bold, a single keystroke will suffice. Coding arrangements have powerful transformative properties precisely because they have been freed from the morphological resemblances of analogue technologies. The power of codes should not, however, obscure the fact that the bold letters on screen also have a material basis; at the point where the embodied materiality of electronic polarities is transformed into binary code, analogue resemblance necessarily reenters the picture.

To clarify this point, let us consider in more detail how electronic polarities are fashioned into a bit stream. The polarities are rarely or never captured in their initial phase as the discrete step function we are accustomed to call one and zero. Rather, the polarities as initially inscribed have a "fall-off" error, a trailing off that represents the noise of embodiment as it is registered by the electronic inscription apparatus. Sophisticated electronics are necessary to rectify this "error" to make it into the binary signals of one and zero. Although we may think of the computer as the digital middle of the PET scan, in fact it too has an analogue bottom and, insofar as humans need to interact with its processes, an analogue top as well. Wherever different embodied materialities are linked, analogue resemblance is likely to enter the picture, for it is the dynamic that mediates between the noise of embodiment and the clarity of form.

Let me return now to inquire about the status of the forms transmigrating through inscriptions, an issue that goes to the heart of the differences between realist and constructivist viewpoints. From a realist point of view, the forms are always already instantiated in the embodied reality and the inscriptions merely reveal their true nature. From a constructivist point of view such as that articulated by Latour in *Science in Action,* the forms do not precede the inscriptions but are produced by them.[33] In making this argument, constructivists point toward the contingencies and local conditions that always accompany embodied reality. The air pump cannot produce the same results in Holland as in England;[34] two equivalent scientific instruments cannot be calibrated to produce the same results unless someone who knows how to calibrate the first instrument physically travels to the second one.[35] Few doubt that regularities exist in nature, but the problem comes when these regularities are seen as laws that can be abstracted from embodied contexts and expressed as the transmigrating forms of scientific inscriptions. As Evelyn Fox Keller wittily puts it, every scientist knows what hard work it is to get nature to obey the laws of nature. Does nature count as the abstracted form or the embodied materiality, which is always more complex than the form allows?

While the realist assumes the flow of structuring information moves from material through the operational to the symbolic, the constructivist often assumes it goes from the symbolic (Enlightenment ideas about clarity of vision as an enactment of rationality) through the operational (Bentham's plans for a model prison) to the material (the construction of the Panopticon). Notice that the two positions are symmetrical with one another, each tracing the flow in the opposite direction from the other. To break open the hegemony of scientific realism, no doubt it was helpful to take the strong counterposition that truth effects are produced by social processes rather than experimental apparatus. But such strategies are limited in their options by the very assumptions they resist. Defining himself by what he revolts against, the revolutionary ends up looking like his opponent reflected in a mirror.

The last decade or so of work in the cultural and social studies of science has been marked by various strategies to escape the limitations imposed by the realist/constructivist symmetry. The Latour of *We Have Never Been Modern* differs significantly, it seems to me, from the Latour of *Science in Action,* for in the later work Latour, acknowledging the limitations of earlier constructivist arguments, insists that the objects of scien-

33. See Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, Mass., 1987).

34. See Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J., 1985), pp. 235–44.

35. See H. M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (London, 1985).

tific research are at once discursively constructed, socially produced, *and* materially real.[36] I want to put Sims's virtual creatures into conversation with these ongoing debates, for I think they have something important to contribute. They suggest other ways to skew the symmetry relations of the materialist/discursive divide and to rethink the transmigrations of forms through inscriptions that have the effect of leaving embodied reality behind.

Unlike experiments in the natural world that must abstract the forms out of embodied materiality, often with great effort and ingenuity, the forms underlying the virtual creatures are easily accessible and open to view. At the bottom of the hierarchy are the ones and zeros of binary code. Some see the emergence of complexity out of these simple elements as confirming the Platonic nature of reality. In this interpretation, eloquently articulated by Christopher Langton, a prominent researcher in artificial life, conventional science abstracts the forms by starting with complex phenomena and using analysis to break them down into simpler components. Artificial life starts from the opposite end and uses synthetic methods to build complex phenomena out of simple components.[37] In the view of Langton and others, the analytical and synthetic approaches are symmetrical and work together to confirm that the ultimate nature of reality is mathematical in form and computational in process.[38] Edward Fredkin, for example, has an ongoing research project dedicated to demonstrating that underlying quantum mechanics and particle physics are cellular automata, ultimately simple units governed by a small set of simple rules.[39] Reality in this view is a program run by a universal computer, and computational code is the true language of nature. These interpretations do not contest the received view that forms transmigrate through inscriptions. Rather, they extend transmigration to computational processes and enlarge its domain to include biological and artificial life.

There are other ways to look at the success of artificial life simulations in creating virtual creatures. Instead of placing the emphasis on the simplicity of the underlying forms, some researchers point to the importance of recursive structures in generating complexity, the input of

36. See Latour, *We Have Never Been Modern,* trans. Catherine Porter (Cambridge, Mass., 1993).

37. See Christopher Langton, "Artificial Life," in *Artificial Life: The Proceedings of an Interdisciplinary Workshop on the Synthesis and Simulation of Living Systems,* ed. Langton (Reading, Mass., 1989), p. 1.

38. Stefan Helmreich, a cultural anthropologist who spent several months at the Santa Fe Institute, in *Silicon Second Nature: Culturing Artificial Life in a Digital World* (Berkeley, 1998) records the views of many artificial life researchers then working at the Santa Fe Institute. He discusses particularly those researchers who feel that computational techniques are in some deep sense *natural* because they reflect the mathematical nature of reality.

39. See Edward Fredkin, "Digital Mechanics: An Informational Process Based on Reversible Universal Cellular Automata," *Physica D* 45 (1990): 254–70.

the observer in attributing life to the creatures, and the novelty and unpredictability of emergent phenomena.[40] In these viewpoints, it matters that complexity *disappears* at the beginning of traditional scientific modeling and *appears* at the end of artificial life simulations. Whereas the complexity of the real world—which is to say, the messiness of embodied materiality—is left behind in the (necessary and useful) analytical division of an environment into discrete components and the abstraction of form out of these components,[41] complexity is precisely what is produced by the recursively structured adaptive systems of artificial life. Although this complexity is generated from simple elements, it is not reducible to their combined properties, nor it is predictable from them, for it emerges dynamically from their interactions. That is, if you have only the simple rules and transmigrating forms, the most interesting part of reality may have slipped through your fingers. When the emphasis falls on complexity, the effect is not to create symmetrically interlocking accounts in which the synthetic procedures of artificial life confirm the analytical insights of traditional science. Rather, foregrounding complexity reminds us what is missing when embodied materiality is reduced to inscription.

In the case of virtual creatures, it is difficult or impossible to think of forms transmigrating from embodied materiality to the electronic inscriptions we see on the CRT screen, for the complex structure of the Oreo necessarily complicates that picture. The complexity the creatures display is not inherent in the binary code; rather, it is *produced* as the program runs. "But you have forgotten," the realist objects, "that the creatures are simulations. As such, they occupy a different ontological niche than an inscription emerging from an embodied materiality that is the object of an experiment. It is no wonder that forms do not transmigrate, for the images do not represent preexisting reality." To this, I would respond that the simulations, although they do not represent a preexisting reality, nevertheless are themselves real, in the sense that they exist as objects in the world. Moreover, the evolutionary processes by which they are generated are no less real than the evolutionary processes that produced us as viewers. In Latour's terminology they are quasi-objects, hybrid entities produced through nature-culture.[42] They differ from the inscriptions of a biological laboratory not in being purely "artificial" in

40. Helmreich also notes that some researchers focus on the effect of the observer. He notes that a European biologist told him that the "fundamental distinction between programs and organisms rested on the notion of autonomy and argued that programs do not have autonomy because they need an interpreter to work, a thinking subject who continually enacts a correspondence principle between symbol manipulation and the context within which these manipulations are relevant" (Helmreich, *Silicon Second Nature,* p. 225).

41. Nancy Cartwright in *How the Laws of Physics Lie* (Oxford, 1983) clearly analyzes the kinds of complexities that are left behind when a holistic interactive environment is divided into separate components.

42. See Latour, *We Have Never Been Modern,* p. 50.

contrast to the "natural" organisms of the laboratory, but rather in the processes that produce them. When we see them, they are images on a CRT screen. Beneath that, they are functions in a LISP program, on down through the coding levels to the bottom layer where electronic polarities are being fashioned into bit streams. Their "bodies" have a material instantiation, but this material instantiation differs radically from the inferences we make when we "see" them as creatures moving in three-dimensional space. To bridge the gap between our narrative inscription of the creatures and the materio-semiotic apparatus producing them, I find it useful to think of them as processes rather than bodies. For their bodies literally are processes—electron beams scanning across the screen, functions being run in the computer—and their morphological and neurological properties are the result of generations of processes congealed and expressed in what we "see" as their bodies.

And how do we "see" the creatures, or anything else for that matter? We "see" them through the same processes that bring the world into existence for us. As Brian Massumi elegantly argues in "The Brightness Confound," there is a sense in which the world is not a collection of preexisting objects but rather a continuing stream of processes.[43] Although we customarily assume the world preexists the processes, from a perceptual point of view the processes come first, and the objects we take as the world emerge from them. It is precisely this flux, this ongoingness of process from which the world emerges, that the realist in effect erases by privileging the underlying forms as the essential reality. Hence the significance of the virtual creatures, for they make this move impossible. There are no forms underlying them adequate to account for their emergence, no mechanisms that can be seen as allowing preexisting forms to transmigrate out of embodied materiality to become the complex inscriptions we see. When I suggest that we are virtual creatures, I mean to foreground the importance of processes for us as well. Processes connect the embodied materiality of the creatures with the bodies we see, processes connect our visual-cognitive perceptions of them with the narratives we construct, and processes are reinscribed and reinterpreted as narrative representations when we tell stories about the creatures of defeat and victory, evolution and development. In the distributed cognitive environments like those created when humans and nonhuman actors collaborate to create and understand the virtual creatures, embodied materialities interacting through complex processes disrupt the story of transmigrating forms and instead stimulate narrative inventions that foreground emergence and flux, perception and process.

The shift, then, is not merely from analogue to digital subjectivity,

43. See Brian Massumi, "The Brightness Confound," *Body Mécanique: Artistic Explorations of Digital Realms* (exhibition catalogue, Wexner Center for the Arts, Columbus, Ohio, 19 Sept. 1998–3 Jan. 1999), p. 81.

both of which could be described as realist entities. Rather, the more profound change is from form to process, from preexisting bodies to embodied materialities linked to one another by complex combinations of processes based both in analogue resemblances and coding relationships. When we inscript ourselves as actors in these distributed cognitive environments, we become neither the interiorized analogue subject of print culture nor the binary code of the digital subject, but rather a hybrid entity whose distinctive properties emerge through our interactions with other cognizers within the environment, including the congealed processes embodied in such mundane objects as the chair I am sitting on, the keyboard I tap, and the yellow legal pad on which I scribble notes as I peer at the screen. Print culture and print subjectivity do not disappear but rather mutate as distributed cognitive environments stimulate new kinds of narratives, including this one on the page you are reading.

The hybrid subjectivity emerging from distributed cognitive environments is playfully enacted in Jim Campbell's art installation *I Have Never Read the Bible*. The viewer sees a book on the wall from which issues a voice whispering letters while unrecognizable music plays in the background. To make the installation, Campbell recorded his voice articulating the twenty-six letters of the alphabet while Mozart's *Requiem* played in the background. He then took a digital version of the Bible, available on CD-ROM, converted it to his own simpler coding scheme, and burned it into ROM chips. Using a simple circuit involving only a few memory chips and electronic chips, he then devised an arrangement that associated his voice recording of the letters with the corresponding letters in the digitized Bible. The result is a "reading" of the Bible letter by letter from beginning to end, a process that the installation takes thirty-seven days to complete, running twenty-four hours a day. Meanwhile, the background music that in the original recording was a coherent performance of the *Requiem* has also been scrambled, with a bit of music playing for only as long as it takes to articulate the letter, then switching to another bit associated with the next letter. This musical soup serves as an audible reminder that we should not mistake the analogue reproduction of sound for the coherent original, for the digital has intervened and left tangible evidence of its process of fragmentation and recombination.

In the installation, the voice and scrambled music issue from a nineteenth-century edition of *Webster's Dictionary*. Heavy with materiality, the dictionary testifies to the anarchic status of the book as it hangs on the wall, whispering to the viewer "I-N—T-H-E—B-E-G-I-N-N-I-N-G—W-A-S—T-H-E—W-O-R-D . . . ." Performing the "voiced" text of analogue subjectivity, the installation simultaneously hybridizes this subjectivity by embedding it in a new content. Visibly testifying to this new context is the cable running out of the dictionary to an electronic (and presumably digital) device below (see fig. 5). The choice of the dictionary as the "voiced" text foregrounds the issue of meaning, for the dictionary's

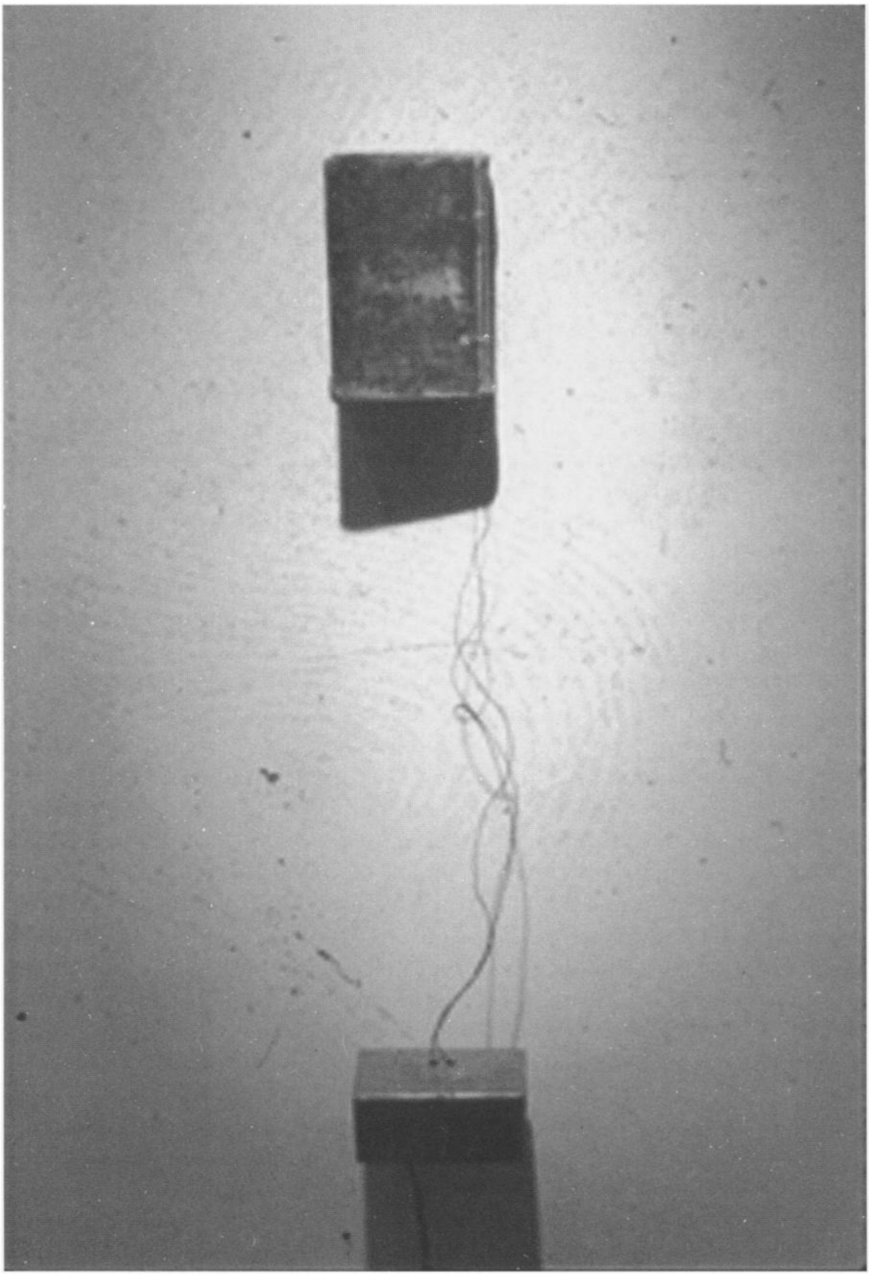

FIG. 5.—Jim Campbell, *I Have Never Read the Bible* (1994). The installation is largely conceptual art. The interest of the work is not primarily visual. Rather, the intriguing qualities lie in the interaction between the work and the listener/viewer as reading is enacted and performed as a cyborg practice.

function is to define words, to match one signifier with other signifiers in correspondences that clarify meaning through the kind of recursive looping typical of print culture. In Campbell's installation, however, the signifier is not the flat mark of print culture, nor does it work by recursive looping with other flat marks. As if testifying to this change, the *Webster's Dictionary* that hangs on the wall cannot be opened, for it has been hollowed out to conceal the electronic gear within. The signifier has become a complex chain of digital codes and analogue resemblances with rich internal structures articulated together through a series of dynamic processes in a configuration I have elsewhere called a flickering signifier.[44] Meaning emerges not through correspondences between the flat marks but rather through the interactions of human and nonhuman cognizers distributed throughout the environment. The hybridity of the situation is highlighted in the installation's title. The point, after all, is that *I Have Never Read the Bible,* that is, the artist as a singular subject has not read it. Rather, "reading" here is a distributed activity taking place partly in the articulations of the artist, partly in the "voiced" text, partly in the Oreo structures of the scanner, computer, and synthesizer, and partly in the perceptions of the viewer who not only makes words out of the voiced letters but also makes meaning out of her interpolation into this distributed cognitive environment.

What kind of subject am I as I stand musing before this installation? I certainly am not the autonomous liberal self who located identity in consciousness and rooted it in my ability, first and foremost, to possess my own body. Rather, as I think about my connection to virtual creatures, I am tempted to fashion myself in their images, seeing myself as a distributed cognitive system comprised of multiple agents running the programs from which consciousness emerges, even though consciousness remains blissfully unaware of them. I am one kind of material embodiment, the virtual creatures are another, but we are connected through dynamic processes that weave us together in a web of jointly articulated cognitive activities. I think, therefore I connect with all the other cognizers in my environment, human and nonhuman, including the dynamic processes that are running right now as you decode these letters and all the dynamic processes that have run in the past and congealed to create this paper, this ink, this old language made of nouns and verbs that I am trying to fashion to new purposes that will allow you to see my body, your body, the bodies of the virtual creatures, not as nouns that enact verbs, but first and foremost as dynamic processes that weave together the embodied materialities of diverse life forms to create richly complex distributed cognitions. That is what virtual creatures can teach us.

44. See Hayles, "Virtual Bodies and Flickering Signifiers," *How We Became Posthuman,* pp. 25–49.