HOW WE BECAME POSTHUMAN

Virtual Bodies in Cybernetics, Literature, and Informatics

N. KATHERINE HAYLES

The University of Chicago Press
Chicago & London

CONCLUSION: WHAT DOES IT MEAN TO BE POSTHUMAN?

What, finally, are we to make of the posthuman?[1] At the beginning of this book, I suggested that the prospect of becoming posthuman both evokes terror and excites pleasure. At the end of the book, perhaps I can summarize the implications of the posthuman by interrogating the sources of this terror and pleasure. The terror is relatively easy to understand. "Post," with its dual connotation of superseding the human and coming after it, hints that the days of "the human" may be numbered. Some researchers (notably Hans Moravec but also my UCLA colleague Michael Dyer and many others) believe that this is true not only in a general intellectual sense that displaces one definition of "human" with another but also in a more disturbingly literal sense that envisions humans displaced as the dominant form of life on the planet by intelligent machines. Humans can either go gently into that good night, joining the dinosaurs as a species that once ruled the earth but is now obsolete, or hang on for a while longer by becoming machines themselves. In either case, Moravec and like-minded thinkers believe, the age of the human is drawing to a close. The view echoes the deeply pessimistic sentiments of Warren McCulloch in his old age. As noted earlier, he remarked: "Man to my mind is about the nastiest, most destructive of all the animals. I don't see any reason, if he can evolve machines that can have more fun than he himself can, why they shouldn't take over, enslave us, quite happily. They might have a lot more fun. Invent better games than we ever did."[2] Is it any wonder that faced with such dismal scenarios, most people have understandably negative reactions? If this is what the posthuman means, why shouldn't it be resisted?

Fortunately, these views do not exhaust the meanings of the posthuman. As I have repeatedly argued, human being is first of all embodied being, and the complexities of this embodiment mean that human awareness

unfolds in ways very different from those of intelligence embodied in cybernetic machines. Although Moravec's dream of downloading human consciousness into a computer would likely come in for some hard knocks in literature departments (which tend to be skeptical of any kind of transcendence but especially of transcendence through technology), literary studies share with Moravec a major blind spot when it comes to the significance of embodiment.[3] This blind spot is most evident, perhaps, when literary and cultural critics confront the fields of evolutionary biology. From an evolutionary biologist's point of view, modern humans, for all their technological prowess, represent an eye blink in the history of life, a species far too recent to have significant evolutionary impact on human biological behaviors and structures. In my view, arguments like those that Jared Diamond advances in *Guns, Germs, and Steel: The Fates of Human Societies* and *Why Sex Is Fun: The Evolution of Human Sexuality* should be taken seriously.[4] The body is the net result of thousands of years of sedimented evolutionary history, and it is naive to think that this history does not affect human behaviors at every level of thought and action.

Of course, the reflexivity that looms large in cybernetics also inhabits evolutionary biology. The models proposed by evolutionary biologists have encoded within them cultural attitudes and assumptions formed by the same history they propose to analyze; as with cybernetics, observer and system are reflexively bound up with one another. To take only one example, the computer module model advanced by Jerome H. Barkow, Leda Cosmides, and John Tooby in *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* to explain human evolutionary psychology testifies at least as much to the importance of information technologies in shaping contemporary worldviews as it does to human brain function.[5] Nevertheless, these reflexive complexities do not negate the importance of the sedimented history incarnated within the body. Interpreted through metaphors resonant with cultural meanings, the body itself is a congealed metaphor, a physical structure whose constraints and possibilities have been formed by an evolutionary history that intelligent machines do not share. Humans may enter into symbiotic relationships with intelligent machines (already the case, for example, in computer-assisted surgery); they may be displaced by intelligent machines (already in effect, for example, at Japanese and American assembly plants that use robotic arms for labor); but there is a limit to how seamlessly humans can be articulated with intelligent machines, which remain distinctively different from humans in their embodiments. The terror, then, though it does not disappear in this view, tends away from the apocalyptic and toward a more

moderate view of seriated social, technological, political, and cultural changes.

What about the pleasures? For some people, including me, the posthuman evokes the exhilarating prospect of getting out of some of the old boxes and opening up new ways of thinking about what being human means. In positing a shift from presence/absence to pattern/randomness, I have sought to show how these categories can be transformed *from the inside* to arrive at new kinds of cultural configurations, which may soon render such dualities obsolete if they have not already. This process of transformation is fueled by tensions between the assumptions encoded in pattern/randomness as opposed to presence/absence. In Jacques Derrida's performance of presence/absence, presence is allied with Logos, God, teleology—in general, with an originary plenitude that can act to ground signification and give order and meaning to the trajectory of history.[6] The work of Eric Havelock, among others, demonstrates how in Plato's *Republic* this view of originary presence authorized a stable, coherent self that could witness and testify to a stable, coherent reality.[7] Through these and other means, the metaphysics of presence front-loaded meaning into the system. Meaning was guaranteed because a stable origin existed. It is now a familiar story how deconstruction exposed the inability of systems to posit their own origins, thus ungrounding signification and rendering meaning indeterminate. As the presence/absence hierarchy was destabilized and as absence was privileged over presence, lack displaced plenitude, and desire usurped certitude. Important as these moves have been in late-twentieth-century thought, they still took place within the compass of the presence/absence dialectic. One feels lack only if presence is posited or assumed; one is driven by desire only if the object of desire is conceptualized as something to be possessed. Just as the metaphysics of presence required an originary plenitude to articulate a stable self, deconstruction required a metaphysics of presence to articulate the destabilization of that self.

By contrast, pattern/randomness is underlaid by a very different set of assumptions. In this dialectic, meaning is not front-loaded into the system, and the origin does not act to ground signification. As we have seen for multiagent simulations, complexity evolves from highly recursive processes being applied to simple rules. Rather than proceeding along a trajectory toward a known end, such systems evolve toward an open future marked by contingency and unpredictability. Meaning is not guaranteed by a coherent origin; rather, it is made possible (but not inevitable) by the blind force of evolution finding workable solutions within given parameters. Although pattern has traditionally been the privileged term (for example, among the

electrical engineers developing information theory), randomness has increasingly been seen to play a fruitful role in the evolution of complex systems. For Chris Langton and Stuart Kauffman, chaos accelerates the evolution of biological and artificial life;[8] for Francisco Varela, randomness is the froth of noise from which coherent microstates evolve and to which living systems owe their capacity for fast, flexible response;[9] for Henri Atlan, noise is the body's murmuring from which emerges complex communication between different levels in a biological system.[10] Although these models differ in their specifics, they agree in seeing randomness not simply as the lack of pattern but as the creative ground from which pattern can emerge.

Indeed, it is not too much to say that in these and similar models, randomness rather than pattern is invested with plenitude. If pattern is the realization of a certain set of possibilities, randomness is the much, much larger set of everything else, from phenomena that cannot be rendered coherent by a given system's organization to those the system cannot perceive at all. In Gregory Bateson's cybernetic epistemology, randomness is what exists outside the confines of the box in which a system is located; it is the larger and unknowable complexity for which the perceptual processes of an organism are a metaphor.[11] Significance is achieved by evolutionary processes that ensure the surviving systems are the ones whose organizations instantiate metaphors for this complexity, unthinkable in itself. When Varela and his coauthors argue in *Embodied Mind* that there is no stable, coherent self but only autonomous agents running programs, they envision pattern as a limitation that drops away as human awareness expands beyond consciousness and encounters the emptiness that, in another guise, could equally well be called the chaos from which all forms emerge.[12]

What do these developments mean for the posthuman? When the self is envisioned as grounded in presence, identified with originary guarantees and teleological trajectories, associated with solid foundations and logical coherence, the posthuman is likely to be seen as antihuman because it envisions the conscious mind as a small subsystem running its program of self-construction and self-assurance while remaining ignorant of the actual dynamics of complex systems. But the posthuman does not really mean the end of humanity. It signals instead the end of a certain conception of the human, a conception that may have applied, at best, to that fraction of humanity who had the wealth, power, and leisure to conceptualize themselves as autonomous beings exercising their will through individual agency and choice.[13] What is lethal is not the posthuman as such but the grafting of the

posthuman onto a liberal humanist view of the self. When Moravec imagines "you" choosing to download yourself into a computer, thereby obtaining through technological mastery the ultimate privilege of immortality, he is not abandoning the autonomous liberal subject but is expanding its perogatives into the realm of the posthuman. Yet the posthuman need not be recuperated back into liberal humanism, nor need it be construed as antihuman. Located within the dialectic of pattern/randomness and grounded in embodied actuality rather than disembodied information, the posthuman offers resources for rethinking the articulation of humans with intelligent machines.

To explore these resources, let us return to Bateson's idea that those organisms that survive will tend to be the ones whose internal structures are good metaphors for the complexities without. What kind of environments will be created by the expanding power and sophistication of intelligent machines? As Richard Lanham has pointed out, in the information-rich environments created by ubiquitous computing, the limiting factor is not the speed of computers, or the rates of transmission through fiber-optic cables, or the amount of data that can be generated and stored. Rather, the scarce commodity is human attention.[14] It makes sense, then, that technological innovation will focus on compensating for this bottleneck. An obvious solution is to design intelligent machines to attend to the choices and tasks that do not have to be done by humans. For example, there are already intelligent-agent programs to sort email, discarding unwanted messages and prioritizing the rest. The programs work along lines similar to neural nets. They tabulate the choices the human operators make, and they feed back this information in recursive loops to readjust the weights given to various kinds of email addresses. After an initial learning period, the sorting programs take over more and more of the email management, freeing humans to give their attention to other matters.

If we extrapolate from these relatively simple programs to an environment that, as Charles Ostman likes to put it, supplies synthetic sentience on demand, human consciousness would ride on top of a highly articulated and complex computational ecology in which many decisions, invisible to human attention, would be made by intelligent machines.[15] Over two decades ago, Joseph Weizenbaum foresaw just such an ecology and passionately argued that judgment is a uniquely human function and must not be turned over to computers.[16] With the rapid development of neural nets and expert programs, it is no longer so clear that sophisticated judgments cannot be made by machines and, in some instances, made more accurately than by humans. But the issue, in Weizenbaum's view, involves more

than whether or not the programs work. Rather, the issue is an ethical imperative that humans keep control; to do otherwise is to abdicate their responsibilities as autonomous independent beings. What Weizenbaum's argument makes clear is the connection between the assumptions undergirding the liberal humanist subject and the ethical position that humans, not machines, must be in control. Such an argument assumes a vision of the human in which conscious agency is the essence of human identity. Sacrifice this, and we humans are hopelessly compromised, contaminated with mechanic alienness in the very heart of our humanity.[17] Hence there is an urgency, even panic, in Weizenbaum's insistence that judgment is a uniquely human function. At stake for him is nothing less than what it means to be human.

In the posthuman view, by contrast, conscious agency has never been "in control." In fact, the very illusion of control bespeaks a fundamental ignorance about the nature of the emergent processes through which consciousness, the organism, and the environment are constituted. Mastery through the exercise of autonomous will is merely the story consciousness tells itself to explain results that actually come about through chaotic dynamics and emergent structures. If, as Donna Haraway, Sandra Harding, Evelyn Fox Keller, Carolyn Merchant, and other feminist critics of science have argued, there is a relation among the desire for mastery, an objectivist account of science, and the imperialist project of subduing nature, then the posthuman offers resources for the construction of another kind of account.[18] In this account, emergence replaces teleology; reflexive epistemology replaces objectivism; distributed cognition replaces autonomous will; embodiment replaces a body seen as a support system for the mind; and a dynamic partnership between humans and intelligent machines replaces the liberal humanist subject's manifest destiny to dominate and control nature. Of course, this is not necessarily what the posthuman *will* mean—only what it *can* mean if certain strands among its complex seriations are highlighted and combined to create a vision of the human that uses the posthuman as leverage to avoid reinscribing, and thus repeating, some of the mistakes of the past.

Just as the posthuman need not be antihuman, so it also need not be apocalyptic. Edwin Hutchins addresses the idea of distributed cognition through his nuanced study of the navigational systems of oceangoing ships.[19] His meticulous research shows that the cognitive system responsible for locating the ship in space and navigating it successfully resides not in humans alone but in the complex interactions within an environment that includes both human and nonhuman actors. His study allows him to give an

excellent response to John Searle's famous "Chinese room." By imagining a situation in which communication in Chinese can take place without the actors knowing what their actions mean, Searle challenged the idea that machines can think.[20] Suppose, Searle said, that he is stuck inside a room, he who knows not a word of Chinese. Texts written in Chinese are slid through a slot in the door. He has in the room with him baskets of Chinese characters and a rulebook correlating the symbols written on the texts with other symbols in the basket. Using the rulebook, he assembles strings of characters and pushes them out the door. Although his Chinese interlocutors take these strings to be clever responses to their inquiries, Searle has not the least idea of the meaning of the texts he has produced. Therefore, it would be a mistake to say that machines can think, he argues, for like him, they produce comprehensible results without comprehending anything themselves. In Hutchins's neat interpretation, Searle's argument is valuable precisely because it makes clear that it is not Searle but the entire room that knows Chinese.[21] In this distributed cognitive system, the Chinese room knows more than do any of its components, including Searle. The situation of modern humans is akin to that of Searle in the Chinese room, for every day we participate in systems whose total cognitive capacity exceeds our individual knowledge, including such devices as cars with electronic ignition systems, microwaves with computer chips that precisely adjust power levels, fax machines that warble to other fax machines, and electronic watches that communicate with a timing radio wave to set themselves and correct their date. Modern humans are capable of more sophisticated cognition than cavemen not because moderns are smarter, Hutchins concludes, but because they have constructed smarter environments in which to work.

Hutchins would no doubt disagree with Weizenbaum's view that judgment should be reserved for humans alone. Like cognition, decision-making is distributed between human and nonhuman agents, from the steam-powered steering system that suddenly failed on a navy vessel Hutchins was studying to the charts and pocket calculators that the navigators were then forced to use to calculate their position. He convincingly shows that these adaptations to changed circumstances were evolutionary and embodied rather than abstract and consciously designed (pp. 347–51). The solution to the problem caused by this sudden failure of the steering mechanism was "clearly discovered by the organization [of the system as a whole] before it was discovered by any of the participants" (p. 361). Seen in this perspective, the prospect of humans working in partnership with intelligent machines is not so much a usurpation of human right and responsi-

bility as it is a further development in the construction of distributed cognition environments, a construction that has been ongoing for thousands of years. Also changed in this perspective is the relation of human subjectivity to its environment. No longer is human will seen as the source from which emanates the mastery necessary to dominate and control the environment. Rather, the distributed cognition of the emergent human subject correlates with—in Bateson's phrase, becomes a metaphor for—the distributed cognitive system as a whole, in which "thinking" is done by both human and nonhuman actors. "Thinking consists of bringing these structures into coordination so they can shape and be shaped by one another," Hutchins wrote (p. 316). To conceptualize the human in these terms is not to imperil human survival but is precisely to enhance it, for the more we understand the flexible, adaptive structures that coordinate our environments and the metaphors that we ourselves are, the better we can fashion images of ourselves that accurately reflect the complex interplays that ultimately make the entire world one system.

This view of the posthuman also offers resources for thinking in more sophisticated ways about virtual technologies. As long as the human subject is envisioned as an autonomous self with unambiguous boundaries, the human-computer interface can only be parsed as a division between the solidity of real life on one side and the illusion of virtual reality on the other, thus obscuring the far-reaching changes initiated by the development of virtual technologies. Only if one thinks of the subject as an autonomous self independent of the environment is one likely to experience the panic performed by Norbert Wiener's *Cybernetics* and Bernard Wolfe's *Limbo*. This view of the self authorizes the fear that if the boundaries are breached at all, there will be nothing to stop the self's complete dissolution. By contrast, when the human is seen as part of a distributed system, the full expression of human capability can be seen precisely to *depend* on the splice rather than being imperiled by it. Writing in another context, Hutchins arrives at an insight profoundly applicable to virtual technologies: "What used to look like internalization [of thought and subjectivity] now appears as a gradual propagation of organized functional properties across a set of malleable media" (p. 312). This vision is a potent antidote to the view that parses virtuality as a division between an inert body that is left behind and a disembodied subjectivity that inhabits a virtual realm, the construction of virtuality performed by Case in William Gibson's *Neuromancer* when he delights in the "bodiless exultation of cyberspace" and fears, above all, dropping back into the "meat" of the body.[22] By contrast, in the model that Hutchins presents and that the posthuman helps to authorize, human

functionality expands because the parameters of the cognitive system it inhabits expand. In this model, it is not a question of leaving the body behind but rather of extending embodied awareness in highly specific, local, and material ways that would be impossible without electronic prosthesis.

As we have seen, cybernetics was born in a froth of noise when Norbert Wiener first thought of it as a way to maximize human potential in a world that is in essence chaotic and unpredictable. Like many other pioneers, Wiener helped to initiate a journey that would prove to have consequences more far-reaching and subversive than even his formidable powers of imagination could conceive. As Bateson, Varela, and others would later argue, the noise crashes within as well as without. The chaotic, unpredictable nature of complex dynamics implies that subjectivity is emergent rather than given, distributed rather than located solely in consciousness, emerging from and integrated into a chaotic world rather than occupying a position of mastery and control removed from it. Bruno Latour has argued that we have never been modern; the seriated history of cybernetics—emerging from networks at once materially real, socially regulated, and discursively constructed—suggests, for similar reasons, that we have always been posthuman.[23] The purpose of this book has been to chronicle the journeys that have made this realization possible. If the three stories told here—how information lost its body, how the cyborg was constructed in the postwar years as technological artifact and cultural icon, and how the human became the posthuman—have at times seemed to present the posthuman as a transformation to be feared and abhorred rather than welcomed and embraced, that reaction has everything to do with how the posthuman is constructed and understood. The best possible time to contest for what the posthuman means is now, before the trains of thought it embodies have been laid down so firmly that it would take dynamite to change them.[24] Although some current versions of the posthuman point toward the antihuman and the apocalyptic, we can craft others that will be conducive to the long-range survival of humans and of the other life-forms, biological and artificial, with whom we share the planet and ourselves.

Notes

Chapter One

1. Hans Moravec, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge: Harvard University Press, 1988), pp. 109–10.

2. Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society,* 2d ed. (Garden City, N.Y.: Doubleday, 1954), pp. 103–4.

3. Beth Loffreda, "Pulp Science: Race, Gender, and Prediction in Contemporary American Science" (Ph.D. diss., Rutgers University, 1996).

4. Richard Doyle discusses the "impossible inversion" that makes information primary and materiality secondary in molecular biology in *On Beyond Living: Rhetorical Transformations in the Life Sciences* (Stanford: Stanford University Press, 1997). See also Evelyn Fox Keller's analysis of the disembodiment of information in molecular biology in her *Secrets of Life, Secrets of Death: Essays on Language, Gender, and Science* (New York: Routledge, 1992), especially chapters 5, 8, and the epilogue. Lily E. Kay critically analyzes the emergence of the idea of a genetic "code" in "Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity," *Configurations* 5 (winter 1997): 23–92. For a discussion of how this disembodied view of information began to circulate through the culture, see Dorothy Nelkin and M. Susan Lindee, *The DNA Mystique: The Gene as a Cultural Icon* (New York: W. H. Freeman and Company, 1995).

5. Michel Foucault famously suggested that "man" is a historical construction whose era is about to end in *The Order of Things: An Archaeology of the Human Sciences* (New York: Vintage Books, 1973), a few years earlier than Ihab Hassan's prescient announcement of posthumanism cited in the epigraph to this chapter. Since then, the more radical idea of the posthuman (as distinct from posthumanism) has appeared at a number of places. Among the important texts defining the posthuman in cultural studies are Allucquére Roseanne Stone, *The War of Desire and Technology at the Close of the Mechanical Age* (Cambridge: MIT Press, 1995); Judith Halberstam and Ira Livingston, eds., *Posthuman Bodies* (Bloomington: Indiana University Press, 1995); Scott Bukatman, *Terminal Identity: The Virtual Subject in Postmodern Science Fiction* (Durham: Duke University Press, 1993); and Anne Balsamo, *Technologies of the Gendered Body: Reading Cyborg Women* (Durham: Duke University Press, 1996). A number of scien-

tific works, detailed in chapters 3, 6, and 9, also figure importantly in delineating this list of characteristics.

6. C. B. Macpherson, *The Political Theory of Possessive Individualism: Hobbes to Locke* (Oxford: Oxford University Press, 1962), p. 3 (emphasis added).

7. Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1990), especially "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," pp. 149–82; Homi Bhabha, *The Location of Culture* (New York: Routledge, 1994); Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia,* translated by Brian Massumi (London: Athlone Press, 1987).

8. Lauren Berlant, in *The Anatomy of National Fantasy: Hawthorne, Utopia, and Everyday Life* (Chicago: University of Chicago Press, 1991), discusses the white male body of the ideal citizen, including its tendency toward disembodiment.

9. Gillian Brown, "Anorexia, Humanism, and Feminism," *Yale Journal of Criticism* 5, no. 1 (1991): 196.

10. William Gibson, *Neuromancer* (New York: Ace Books, 1984), p. 16.

11. Arthur Kroker, *Hacking the Future: Stories for the Flesh-Eating 90s* (New York: St. Martin's Press, 1996).

12. Five of the Macy Conference transactions were published: Heinz von Foerster, ed., *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems,* vols. 6–10 (New York: Josiah Macy Jr. Foundation, 1949–55). From the seventh conference on, Margaret Mead and Hans Lukas Teuber are listed as "assistant editors." The best study of the Macy Conferences is Steve J. Heims, *The Cybernetics Group* (Cambridge: MIT Press, 1991). In addition to discussing the conferences and doing extensive archival work, Heims also conducted interviews with many of the participants who have since died.

13. See Otto Mayr, *The Origins of Feedback Control* (Cambridge: MIT Press, 1970), for a full history of the concept of the feedback loop.

14. Walter Cannon is usually credited with working out the implications of homeostasis for biological organisms in *The Wisdom of the Body* (New York: W. W. Norton, 1939). Claude Bernard originated the concept in the nineteenth century.

15. Mayr, *The Origins of Feedback Control.*

16. Nancy Armstrong, *Desire and Domestic Fiction: A Political History of the Novel* (New York: Oxford University Press, 1987).

17. Michael Warner, *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-Century America* (Cambridge: Harvard University Press, 1990).

18. Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1987). Malcome Ashmore explores this feature of science studies in *The Reflexive Thesis: Wrighting Sociology of Scientific Knowledge* (Chicago: University of Chicago Press, 1989).

19. Heinz von Foerster, *Observing Systems,* 2d ed. (Salinas, Calif.: Intersystems Publications, 1984).

20. Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living,* Boston Studies in the Philosophy of Science, vol. 42 (Dordrecht: D. Reidel, 1980).

21. Niklas Luhmann has modified and extended Maturana's epistemology in significant ways; see, for example, his *Essays on Self-Reference* (New York: Columbia Uni-

versity Press, 1990) and "The Cognitive Program of Constructivism and a Reality That Remains Unknown," in *Self-Organization: Portrait of a Scientific Revolution*, edited by Wolfgang Krohn, Guenter Kueppes, and Helga Nowotny (Dordrecht: Kluwer Academic Publishers, 1990), 64–85.

22. Edward Fredkin, "Digital Mechanics: An Information Process Based on Reversible Universal Cellular Automata," *Physica D* 45 (1990): 245–70. See also the account of Fredkin's work in Robert Wright, *Three Scientists and Their Gods: Looking for Meaning in an Age of Information* (New York: Times Books, 1988). Also central to this theory is the work of Stephen Wolfram; see his *Theory and Applications of Cellular Automata* (Singapore: World Scientific, 1986).

23. Marvin Minsky, "Why Computer Science Is the Most Important Thing That Has Happened to the Humanities in 5,000 Years" (public lecture, Nara, Japan, May 15, 1996). I am grateful to Nicholas Gessler for providing me with his transcript of the lecture.

24. See Jennifer Daryl Slack and Fred Fejes, eds., *The Ideology of the Information Age* (Norwood, N.J.: Ablex Publishing Company, 1987), for essays exploring the implications of the contemporary construction of information. The tendency to ignore the material realities of communication technologies has been forcefully rebutted in two important works: Friedrich A. Kittler's *Discourse Networks, 1800–1900*, translated by Michael Metteer (Stanford: Stanford University Press, 1990), and Hans Ulrich Gumbrecht and K. Ludwig Pfeiffer, eds., *Materialities of Communication*, translated by William Whobrey (Stanford: Stanford University Press, 1994).

25. The relation of molecular biology has been explored in Keller, *Secrets;* the centrality of World War II to the development of cybernetics is demonstrated by Peter Galison in "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (1994): 228–66. Relevant here also is Kay, "Cybernetics, Information, Life" and Andy Pickering, "Cyborg History and the World War II Regime," *Perspectives on Science* 3, no. 1 (1995): 1–48.

26. Norbert Wiener, *Cybernetics; or, Control and Communication in the Animal and the Machine* (Cambridge: MIT Press, 1948), p. 132.

27. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2d ed. (Chicago: University of Chicago Press, 1970); Foucault, *The Order of Things*. Both Kuhn and Foucault substantially revised their theories in later years. The vision of historical change in Michel Foucault's *The History of Sexuality*, translated by Robert Hurley (New York: Vintage Books, 1980), is much closer to seriation than are his earlier works.

28. The simulation is the creation of Gregory P. Garvey of Concordia University. An account of it can be found in Thomas E. Linehan, ed., *Visual Proceedings: The Art and Interdisciplinary Programs of Siggraph 93* (New York: Association for Computing Machinery, 1993), p. 125.

29. "A Magna Carta for the Knowledge Age" can be found (along with skeptical commentaries, mine among them) at the FEED Web site,< http://www.emedia.net/feed>.

30. Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).

31. Doyle, *On Beyond Living*, makes the point that the construction of information as primary, with materiality as supplemental, is a rhetorical rather than an experimental

accomplishment. He argues that the discourse of molecular biology functions as "rhetorical software," for it operates as if it were running a program on the hardware of the laboratory apparatus to produce results that the research alone could not accomplish. See also Kay, "Cybernetics, Information, Life."

32. Donald M. MacKay, *Information, Mechanism, and Meaning* (Cambridge: MIT Press, 1969).

33. Carolyn Marvin, "Information and History," in Slack and Fejes, *The Ideology of the Information Age*, pp. 49–62.

34. In response to a presentation by Alex Bavelas at the eighth Macy Conference, Shannon remarked that he did not see a "close connection" between the semantic questions that concerned Bavelas and his own emphasis on "finding the best encoding of symbols." Foerster, Mead, and Teuber, *Cybernetics* (Eighth Conference, 1951), 8:22.

35. Xerox PARC has been at the forefront of developing the idea of "ubiquitous computing," with computers embedded unobtrusively throughout the home and workplace environments. See Mark Weiser, "The Computer for the 21st Century," *Scientific American* 265 (September 1991): 94–104. For an account of how computers are transforming contemporary architecture and living patterns, see William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (Cambridge: MIT Press, 1995).

36. Sherry Turkle discusses the fascination of VR worlds in *Life on the Screen: Identity in the Age of the Internet* (New York: Simon and Schuster, 1995). Stone, *The War of Desire and Technology*, proposes that VR technologies undo the commonsense notion that one person inhabits one body. She suggests instead that we think of the subject "warranted by" the body rather than contained within it.

37. For an account of the extensive connections between cybernetics and the military, see Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge: MIT Press, 1996), and Les Levidow and Kevin Robins, eds., *Cyborg Worlds: The Military Information Society* (London: Free Association Books, 1989).

38. Don Ihde develops the full resonances of "lifeworld" from his grounding in phenomenology in *Technology and the Lifeworld: From Garden to Earth* (Bloomington: Indiana University Press, 1990), showing how the contemporary world is marked by a double attraction toward technology and toward the "natural" world simultaneously.

39. The notorious case is Autodesk's initiative to develop VR software that cited *Neuromancer;* see John Walker, "Through the Looking Glass: Beyond 'User' Interfaces," *CADalyst* (December 1989), 42, and Randall Walser, "On the Road to Cyberia: A Few Thoughts on Autodesk's Initiative," *CADalyst* (December 1989), 43.

40. An important work linking postmodern fiction with cybernetic technologies is David Porush, *The Soft Machine: Cybernetic Fiction* (New York: Methuen, 1985). Porush defines cybernetic fiction as self-reflexive fictions that look to cybernetics both for their themes and for the literary machinery of their texts.

41. Jean-François Lyotard, *The Postmodern Condition: A Report on Knowledge*, translated by Geoff Bennington and Brian Massumi (Minneapolis: University of Minnesota Press, 1984); Linda Hutcheon, *A Poetics of the Postmodern: History, Theory, Fiction* (New York: Routledge, 1994); and Brian McHale, *Constructing Postmodernism* (New York: Routledge, 1992) and *Postmodern Fiction* (New York: Methuen, 1981).

42. Bernard Wolfe, *Limbo* (New York: Random House, 1952).

43. Philip K. Dick: *We Can Build You* (London: Grafton Books, 1986), first pub-

lished in 1969; *Do Androids Dream of Electric Sheep?* (New York: Doubleday, 1968); *Dr. Bloodmoney; or, How We Got Along after the Bomb* (New York: Carroll and Graf, 1988), first published in 1965; and *Ubik* (London: Grafton Books, 1973), first published in 1969.

44. Neal Stephenson, *Snow Crash* (New York: Bantam, 1992); Greg Bear, *Blood Music* (New York: Ace Books, 1985); Richard Powers, *Galatea 2.2: A Novel* (New York: Farrar Straus Giroux, 1995); and Cole Perriman, *Terminal Games* (New York: Bantam, 1994).

Chapter Two

1. The paradox is discussed in N. Katherine Hayles, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* (Ithaca: Cornell University Press, 1990), pp. 31–60.

2. Self-organizing systems are discussed in Grégoire Nicolis and Ilya Prigogine, *Exploring Complexity: An Introduction* (New York: Freeman and Company, 1989); Roger Lewin, *Complexity: Life at the Edge of Chaos* (New York: Macmillan, 1992); and M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon and Schuster, 1992).

3. Friedrich A. Kittler, *Discourse Networks, 1800–1900*, translated by Michael Metteer (Stanford: Stanford University Press, 1990), p. 193.

4. The fluidity of writing on the computer is eloquently explored by Michael Joyce in *Of Two Minds: Hypertext Pedagogy and Poetics* (Ann Arbor: University of Michigan Press, 1995).

5. Howard Rheingold surveys the new virtual technologies in *Virtual Reality* (New York: Summit Books, 1991). Also useful is Ken Pimentel and Kevin Teixeira, *Virtual Reality: Through the New Looking Glass* (New York: McGraw-Hill, 1993). Benjamin Woolley takes a skeptical approach toward claims for the new technology in *Virtual Worlds: A Journey in Hyped Hyperreality* (Oxford, England: Blackwell, 1992).

6. Allucquère Roseanne Stone, *The War of Desire and Technology at the Close of the Mechanical Age* (Cambridge: MIT Press, 1995).

7. Sherry Turkle, *Life on the Screen: Identity in the Age of the Internet* (New York: Simon and Schuster, 1995).

8. In *The Age of the Smart Machine: The Future of Work and Power* (New York: Basic Books, 1988), Shoshana Zuboff explores, through three case studies, the changes in U.S. workplaces as industries become informatted.

9. Computer law is discussed in Katie Hafner and John Markoff, *Cyberpunk: Outlaws and Hackers on the Computer Frontier* (New York: Simon and Schuster, 1991); also informative is Bruce Sterling, *The Hacker Crackdown: Law and Disorder on the Electronic Frontier* (New York: Bantam, 1992).

10. Turkle documents computer network romances in *Life on the Screen*. Nicholson Baker's *Vox: A Novel* (New York: Random House, 1992) imaginatively explores the erotic potential for better living through telecommunications; and Rheingold looks at the future of erotic encounters in cyberspace in "Teledildonics and Beyond," *Virtual Reality*, pp. 345–77.

11. Among the studies that explore these connections are Jay Bolter, *Writing Space: The Computer, Hypertext, and the History of Writing* (Hillsdale, N.J.: Lawrence Erl-

At Home in the Universe: The Search for the Laws of Self-Organization and Complexity (New York: Oxford University Press, 1995).

39. Jerome H. Barkow, Leda Cosmides, and John Tooby, *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (New York: Oxford University Press, 1992), especially the chapter by Tooby and Cosmides: "The Psychological Foundations of Culture," pp. 19–136. Tooby and Cosmides have also been instrumental in forming the Human Behavior and Evolution Society (HBES), which holds annual conferences centered on the ideas of evolutionary psychology. In some ways the HBES is a successor to sociobiology, although with a more flexible framework of interpretation.

40. Steven Pinker makes this point in *The Language Instinct* (New York: W. Morrow, 1994). This model provides an interesting corrective to Maturana's largely passive model of "languaging" between "observers."

41. Steels, "The Artificial Life Roots."

42. Marvin Minsky, *The Society of Mind* (New York: Simon and Schuster, 1985), especially pp. 17–24.

43. Marvin Minsky, "Why Computer Science Is the Most Important Thing That Has Happened to the Humanities in 5,000 Years" (public lecture, Nara, Japan, May 15, 1996). I am grateful to Nicholas Gessler for providing me with his transcript of the lecture.

44. Marvin Minsky, "How Computer Science Will Change Our Lives" (plenary lecture, Fifth Conference on Artificial Life, Nara, Japan, May 17, 1996).

45. Antonio R. Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: G. P. Putnam, 1994), p. 226.

Chapter Ten

1. Ihab Hassan, "Prometheus as Performer: Towards a Posthumanist Culture?" in *Performance in Postmodern Culture*, edited by Michael Benamou and Charles Caramella (Madison, WI: Coda Press, 1977), p. 212. See also Judith Halberstam and Ira Livingston, "Introduction: Posthuman Bodies" in *Posthuman Bodies*, edited by Judith Halberstam and Ira Livingston (Bloomington: Indiana University Press, 1995): "Posthuman bodies are the causes and effects of postmodern relations of pleasure, virtuality and reality, sex and its consequences" (p. 3).

2. For a discussion of the semiotic square, see Ronald Schleifer, Robert Con Davis, and Nancy Mergler, *Culture and Cognition: The Boundaries of Literary and Scientific Inquiry* (Ithaca: Cornell University Press, 1992). See also A. J. Greimas, *Structural Semantics: An Attempt at a Method*, translated by Daniele MacDowell, Ronald Schleifer, and Alan Velie (Lincoln: University of Nebraska Press, 1983). I do not claim for the semiotic square the inevitability with which Greimas, its inventor, invested it. Rather, for my purposes it is useful as a stimulus to thought and as a way to tease out relationships that might not otherwise be apparent.

3. Jean Baudrillard, *Simulations*, translated by Paul Foss, Paul Patton, and Philip Beitchman (New York: Semiotext(e), 1983).

4. Greg Bear, *Blood Music* (New York: Ace Books, 1985) (hereafter cited in the text as *BM*); Richard Powers, *Galatea 2.2: A Novel* (New York: Farrar Straus Giroux, 1995) (hereafter cited in the text as *G2*); Cole Perriman, *Terminal Games* (New York: Bantam, 1994) (hereafter cited in the text as *TG*); Neal Stephenson, *Snow Crash* (New York: Bantam, 1992) (hereafter cited in the text as *SC*).

5. Fredric Jameson cogently makes the connection between an information society and late capitalism in *Postmodernism; or, The Cultural Logic of Late Capitalism* (Durham: Duke University Press, 1991).

6. Darko Suvin, "On Gibson and Cyberpunk SF," *Foundation* 46 (1989): 41.

7. Daniel Dennett, *Consciousness Explained* (Boston: Little, Brown and Co., 1991), notes, "The voice the schizophrenic 'hears' is his own" (p. 250 n).

8. Elaine Scarry, *The Body in Pain: The Making and Unmaking of the World* (New York: Oxford University Press, 1985).

9. Veronica Hollinger, "Cybernetic Deconstructions: Cyberpunk and Postmodernism," *Mosaic* 23 (1990): 42.

10. Mark Johnson, *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason* (Chicago: University of Chicago Press, 1987).

11. Judith Butler, *Gender Trouble: Feminism and the Subversion of Identity* (New York: Routledge, 1990); J. L. Austin, *How to Do Things with Words,* edited by J. O. Urmson and Marina Sbisa (Oxford, England: Clarendon Press, 1972).

12. Andrew Hodges, in his excellent biography *Alan Turing: The Enigma* (New York: Simon and Schuster, 1983), comments, "To Alan Turing, the multiplier was a rather tiresome technicality: the heart [of the Universal Turing Machine] lay in the logical control, which took the instructions from the memory, and put them into operation" (p. 320).

13. For a discussion of the deep structure of VR programming languages and their relation to utterances that can *perform* the viewpoint they instantiate, see Robert Markley, "Boundaries: Mathematics, Alienation, and the Metaphysics of Cyberspace," in *Virtual Reality and Their Discontents,* edited by Robert Markley (Baltimore: Johns Hopkins University Press, 1996), pp. 55–77.

14. David Porush, "Hacking the Brainstem: Postmodern Metaphysics and Stephenson's Snow Crash," *Configurations* 3 (1994): 537–71.

15. Mary Catherine Bateson, *Our Own Metaphor: A Personal Account of a Conference on the Effects of Conscious Purpose on Human Adaptation* (1972; Washington, D.C.: Smithsonian Institution Press, 1991).

16. Richard Dawkins develops the concept of memes as the ideational analogue to selfish genes in *The Selfish Gene* (New York: Oxford University Press, 1976).

17. In the introduction to *Posthuman Bodies,* Halberstam and Livingston note: "You're not human until you're posthuman. You were never human" (p. 8).

18. Veronica Hollinger, in "Feminist Science Fiction: Breaking Up the Subject," *Extrapolation* 31 (1990): 229–39, makes a similar argument regarding the diversity of feminist science fiction. Some texts want to recuperate some aspects of the subject, whereas others aim for a more subversive and far-reaching deconstruction. Those who have never experienced a strong and unified subjectivity, Hollinger observes, might want to have a chance to articulate such subjectivity before they deconstruct it. Anne Balsamo, in "Feminism for the Incurably Informed," *South Atlantic Quarterly* 92 (1993): 681–712, takes issue with Hollinger's conclusion, arguing that what is needed is not so much diversity among texts and readings as articulations that can escape from the dualism of anti/pro-humanism by offering a vision of "post-human existence where 'technology' and the 'human' are understood in contiguous rather than in oppositional terms" (p. 684).

Chapter Eleven

1. I am grateful to Marjorie Luesebrink for conversations that stimulated me to think further about the ideas in this conclusion.

2. Warren McCulloch, quoted in Mary Catherine Bateson, *Our Own Metaphor: A Personal Account of a Conference on the Effects of Conscious Purpose on Human Adaptation* (1972; Washington, D.C.: Smithsonian Institution Press, 1991), p. 226.

3. Hans Moravec, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge: Harvard University Press, 1988).

4. Jared Diamond, *Guns, Germs, and Steel: The Fates of Human Societies* (New York: Norton, 1997), and *Why Sex Is Fun: The Evolution of Human Sexuality* (New York: Basic Books, 1997).

5. Jerome H. Barkow, Leda Cosmides, and John Tooby, eds., *The Adapted Mind: Evolutionary Psychology and the Generation of Culture* (Oxford: Oxford University Press, 1992).

6. Jacques Derrida, *Of Grammatology,* translated by Gayatri C. Spivak (Baltimore: Johns Hopkins University Press, 1976).

7. Eric A. Havelock, *Preface to Plato* (Cambridge: Harvard University Press, 1963).

8. Chris G. Langton, "Computation at the Edge of Chaos: Phase Transition and Emergent Computation," *Physica D* 42 (1990): 12–37; Stuart A. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution* (New York: Oxford University Press, 1993).

9. Francisco J. Varela, "Making It Concrete: Before, During, and After Breakdowns," in *Revisioning Philosophy,* edited by James Ogilvy (Albany: State University of New York Press, 1992), pp. 97–109.

10. Henri Atlan, "On a Formal Definition of Organization," *Journal of Theoretical Biology* 45 (1974): 295–304. Michel Serres has a provocative interpretation of how this noise can give rise to human language, in "The Origin of Language: Biology, Information Theory and Thermodynamics," *Hermes: Literature, Science, Philosophy,* edited by Josué V. Harari and David F. Bell (Baltimore: Johns Hopkins University Press, 1982), pp. 71–83. See N. Katherine Hayles, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* (Ithaca: Cornell University Press, 1990), pp. 56, 204–6, for a discussion of Atlan and Serres.

11. Gregory Bateson, quoted in Bateson, prologue to *Our Own Metaphor,* pp. 13–16.

12. Francisco J. Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge: MIT Press, 1991).

13. In Neal Stephenson's *Snow Crash* (New York: Bantam, 1992), his young white heroine, "Y.T.," is kidnapped, dumped aboard the Raft, and assigned to mess detail. She then has an insight into how small the fraction of the world's population is who ever believed they had a liberal humanist self. Once she gets over the shock and settles into a routine, she starts looking around her, watching the other fish-cutting dames, and realizes that this is just what life must be like for about 99 percent of the people in the world. "You're in this place. There's other people all around you, but they don't understand you and you don't understand them, but people do a lot of meaningless babble anyway. In order to stay alive, you have to spend all day every day doing stupid meaningless work. And the only way to get out of it is to quit, cut loose, take a flyer, and go off into the wicked

world, where you will be swallowed up and never heard from again" (pp. 303–4).

14. Richard Lanham, *The Electronic Word: Democracy, Technology, and the Arts* (Chicago: University of Chicago Press, 1994).

15. Galen Brandt, "Synthetic Sentience: An Interview with Charles Ostman," *Mondo 2000,* no. 16 (winter 1996–97): 25–36. See also Charles Ostman, "Synthetic Sentience as Entertainment," *Midnight Engineering* 8, no. 2 (March/April 1997): 68–77.

16. Joseph Weizenbaum, *Computer Power and Human Reason: From Judgment to Calculation* (New York: W. H. Freeman, 1976).

17. Gilles Delueze and Felix Guattari of course celebrate this very alienness in their vision of the phylum and "body without organs" in *Anti-Oedipus: Capitalism and Schizophrenia* (Minneapolis: University of Minnesota Press, 1983). For an ecstatic interpretation of the posthuman, see Judith Halberstam and Ira Livingston, eds., *Posthuman Bodies* (Bloomington: Indiana University Press, 1995).

18. Donna J. Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective,"in *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1990), pp. 183–202; Evelyn Fox Keller, "Baconian Science: The Arts of Mastery and Obedience," *Reflections on Gender and Science* (New Haven: Yale University Press, 1995), pp. 33–42; Sandra Harding, *The Science Question in Feminism* (Ithaca: Cornell University Press, 1986); and Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper, 1982).

19. Edwin Hutchins, *Cognition in the Wild* (Cambridge: MIT Press, 1995).

20. John R. Searle, "Is the Brain's Mind a Computer Program?" *Scientific American* 262, no. 1 (1990): 26–31; see also John R. Searle, *Minds, Brains, and Science* (Cambridge: Harvard University Press, 1986), pp. 32–41, for the "Chinese room" thought experiment. Searle attempts to answer the analysis that it is the whole room that knows Chinese, saying there "is no way to get from syntax to semantics" (p. 34).

21. Hutchins, *Cognition,* pp. 361–62.

22. William Gibson, *Neuromancer* (New York: Ace Books, 1984). The narrator, after relating how Case has been exiled from cyberspace, comments: "For Case, who'd lived in the bodiless exultation of cyberspace, it was the Fall. . . . The body was meat. Case fell into the prison of his own flesh" (p. 6).

23. Bruno Latour, *We Have Never Been Modern,* translated by Catherine Porter (Cambridge: Harvard University Press, 1993). Latour's important argument is that quasi-objects operate within networks that are at once in material real, socially regulated, and discursively constructed. Using different contexts, I have argued in this book for a very similar view regarding the history of cybernetics.

24. Dynamiting the system here alludes to Bill Nichols's seminal article on cybernetics, "The Work of Culture in the Age of Cybernetics," in *Electronic Culture: Technology and Visual Representation,* edited by Timothy Druckrey (New York: Aperture, 1996), pp. 121–44.