N. KATHERINE HAYLES

HOW WE BECAME POSTHUMAN

VIRTUAL BODIES IN CYBERNETICS, LITERATURE, AND INFORMATICS

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For Nicholas
one of the world's great technology archivists
and much more besides

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Prologue

You are alone in the room, except for two computer terminals flickering in the dim light. You use the terminals to communicate with two entities in another room, whom you cannot see. Relying solely on their responses to your questions, you must decide which is the man, which the woman. Or, in another version of the famous "imitation game" proposed by Alan Turing in his classic 1950 paper "Computer Machinery and Intelligence," you use the responses to decide which is the human, which the machine.[1] One of the entities wants to help you guess correctly. His/her/its best strategy, Turing suggested, may be to answer your questions truthfully. The other entity wants to mislead you. He/she/it will try to reproduce through the words that appear on your terminal the characteristics of the other entity. Your job is to pose questions that can distinguish verbal performance from embodied reality. If you cannot tell the intelligent machine from the intelligent human, your failure proves, Turing argued, that machines can think.

Here, at the inaugural moment of the computer age, the erasure of embodiment is performed so that "intelligence" becomes a property of the formal manipulation of symbols rather than enaction in the human lifeworld. The Turing test was to set the agenda for artificial intelligence for the next three decades. In the push to achieve machines that can think, researchers performed again and again the erasure of embodiment at the heart of the Turing test. All that mattered was the formal generation and manipulation of informational patterns. Aiding this process was a definition of information, formalized by Claude Shannon and Norbert Wiener, that conceptualized information as an entity distinct from the substrates carrying it. From this formulation, it was a small step to think of information as a kind of bodiless fluid that could flow between different substrates without loss of meaning or form. Writing nearly four decades after Turing, Hans

Moravec proposed that human identity is essentially an informational pattern rather than an embodied enaction. The proposition can be demonstrated, he suggested, by downloading human consciousness into a computer, and he imagined a scenario designed to show that this was in principle possible. The Moravec test, if I may call it that, is the logical successor to the Turing test. Whereas the Turing test was designed to show that machines can perform the thinking previously considered to be an exclusive capacity of the human mind, the Moravec test was designed to show that machines can become the repository of human consciousness—that machines can, for all practical purposes, become human beings. You are the cyborg, and the cyborg is you.

In the progression from Turing to Moravec, the part of the Turing test that historically has been foregrounded is the distinction between thinking human and thinking machine. Often forgotten is the first example Turing offered of distinguishing between a man and a woman. If your failure to distinguish correctly between human and machine proves that machines can think, what does it prove if you fail to distinguish woman from man? Why does gender appear in this primal scene of humans meeting their evolutionary successors, intelligent machines? What do gendered bodies have to do with the erasure of embodiment and the subsequent merging of machine and human intelligence in the figure of the cyborg?

In his thoughtful and perceptive intellectual biography of Turing, Andrew Hodges suggests that Turing's predilection was always to deal with the world as if it were a formal puzzle.[2] To a remarkable extent, Hodges says, Turing was blind to the distinction between saying and doing. Turing fundamentally did not understand that "questions involving sex, society, politics or secrets would demonstrate how what it was possible for people to *say* might be limited not by puzzle-solving intelligence but by the restrictions on what might be *done*" (pp. 423–24). In a fine insight, Hodges suggests that "the discrete state machine, communicating by teleprinter alone, was like an ideal for [Turing's] own life, in which he would be left alone in a room of his own, to deal with the outside world solely by rational argument. It was the embodiment of a perfect J. S. Mill liberal, concentrating upon the free will and free speech of the individual" (p. 425). Turing's later embroilment with the police and court system over the question of his homosexuality played out, in a different key, the assumptions embodied in the Turing test. His conviction and the court-ordered hormone treatments for his homosexuality tragically demonstrated the importance of *doing* over *saying* in the coercive order of a homophobic society with the power to enforce its will upon the bodies of its citizens.

The perceptiveness of Hodges's biography notwithstanding, he gives a strange interpretation of Turing's inclusion of gender in the imitation game. Gender, according to Hodges, "was in fact a red herring, and one of the few passages of the paper that was not expressed with perfect lucidity. The whole point of this game was that a successful imitation of a woman's responses by a man would *not* prove anything. Gender depended on facts which were *not* reducible to sequences of symbols" (p. 415). In the paper itself, however, nowhere does Turing suggest that gender is meant as a counterexample; instead, he makes the two cases rhetorically parallel, indicating through symmetry, if nothing else, that the gender and the human/machine examples are meant to prove the same thing. Is this simply bad writing, as Hodges argues, an inability to express an intended opposition between the construction of gender and the construction of thought? Or, on the contrary, does the writing express a parallelism too explosive and subversive for Hodges to acknowledge?

If so, now we have two mysteries instead of one. Why does Turing include gender, and why does Hodges want to read this inclusion as indicating that, so far as gender is concerned, verbal performance cannot be equated with embodied reality? One way to frame these mysteries is to see them as attempts to transgress and reinforce the boundaries of the subject, respectively. By including gender, Turing implied that renegotiating the boundary between human and machine would involve more than transforming the question of "who can think" into "what can think." It would also necessarily bring into question other characteristics of the liberal subject, for it made the crucial move of distinguishing between the enacted body, present in the flesh on one side of the computer screen, and the represented body, produced through the verbal and semiotic markers constituting it in an electronic environment. This construction necessarily makes the subject into a cyborg, for the enacted and represented bodies are brought into conjunction through the technology that connects them. If you distinguish correctly which is the man and which the woman, you in effect reunite the enacted and the represented bodies into a single gender identity. The very existence of the test, however, implies that you may also make the wrong choice. Thus the test functions to create the possibility of a disjunction between the enacted and the represented bodies, regardless which choice you make. What the Turing test "proves" is that the overlay between the enacted and the represented bodies is no longer a natural inevitability but a contingent production, mediated by a technology that has become so entwined with the production of identity that it can no longer meaningfully be separated from the human subject. To pose the question

of "what can think" inevitably also changes, in a reverse feedback loop, the terms of "who can think."

On this view, Hodges's reading of the gender test as nonsignifying with respect to identity can be seen as an attempt to safeguard the boundaries of the subject from precisely this kind of transformation, to insist that the existence of thinking machines will not necessarily affect what being human means. That Hodges's reading is a misreading indicates he is willing to practice violence upon the text to wrench meaning away from the direction toward which the Turing test points, back to safer ground where embodiment secures the univocality of gender. I think he is wrong about embodiment's securing the univocality of gender and wrong about its securing human identity, but right about the importance of putting embodiment back into the picture. What embodiment secures is not the distinction between male and female or between humans who can think and machines which cannot. Rather, embodiment makes clear that thought is a much broader cognitive function depending for its specificities on the embodied form enacting it. This realization, with all its exfoliating implications, is so broad in its effects and so deep in its consequences that it is transforming the liberal subject, regarded as the model of the human since the Enlightenment, into the posthuman.

Think of the Turing test as a magic trick. Like all good magic tricks, the test relies on getting you to accept at an early stage assumptions that will determine how you interpret what you see later. The important intervention comes not when you try to determine which is the man, the woman, or the machine. Rather, the important intervention comes much earlier, when the test puts you into a cybernetic circuit that splices your will, desire, and perception into a distributed cognitive system in which represented bodies are joined with enacted bodies through mutating and flexible machine interfaces. As you gaze at the flickering signifiers scrolling down the computer screens, no matter what identifications you assign to the embodied entities that you cannot see, you have already become posthuman.

TOWARD EMBODIED VIRTUALITY

We need first to understand that the human form—including human desire and all its external representations—may be changing radically, and thus must be re-visioned. We need to understand that five hundred years of humanism may be coming to an end as humanism transforms itself into something that we must helplessly call post-humanism.

Ihab Hassan, "Prometheus as Performer: Towards a Posthumanist Culture?"

This book began with a roboticist's dream that struck me as a nightmare. I was reading Hans Moravec's *Mind Children: The Future of Robot and Human Intelligence,* enjoying the ingenious variety of his robots, when I happened upon the passage where he argues it will soon be possible to download human consciousness into a computer.[1] To illustrate, he invents a fantasy scenario in which a robot surgeon purees the human brain in a kind of cranial liposuction, reading the information in each molecular layer as it is stripped away and transferring the information into a computer. At the end of the operation, the cranial cavity is empty, and the patient, now inhabiting the metallic body of the computer, wakens to find his consciousness exactly the same as it was before.

How, I asked myself, was it possible for someone of Moravec's obvious intelligence to believe that mind could be separated from body? Even assuming such a separation was possible, how could anyone think that consciousness in an entirely different medium would remain unchanged, as if it had no connection with embodiment? Shocked into awareness, I began noticing he was far from alone. As early as the 1950s, Norbert Wiener proposed it was theoretically possible to telegraph a human being, a suggestion underlaid by the same assumptions informing Moravec's scenario.[2] The producers of *Star Trek* operate from similar premises when they imagine that the body can be dematerialized into an informational pattern and rematerialized, without change, at a remote location. Nor is the idea confined to what Beth Loffreda has called "pulp science."[3] Much of the discourse on molecular biology treats information as the essential code the body expresses, a practice that has certain affinities with Moravec's ideas.[4] In fact, a defining characteristic of the present cultural moment is the belief that information can circulate unchanged among different material substrates. It

is not for nothing that "Beam me up, Scotty," has become a cultural icon for the global informational society.

Following this thread, I was led into a maze of developments that turned into a six-year odyssey of researching archives in the history of cybernetics, interviewing scientists in computational biology and artificial life, reading cultural and literary texts concerned with information technologies, visiting laboratories engaged in research on virtual reality, and grappling with technical articles in cybernetics, information theory, autopoiesis, computer simulation, and cognitive science. Slowly this unruly mass of material began taking shape as three interrelated stories. The first centers on how *information lost its body*, that is, how it came to be conceptualized as an entity separate from the material forms in which it is thought to be embedded. The second story concerns how *the cyborg was created as a technological artifact and cultural icon* in the years following World War II. The third, deeply implicated with the first two, is the unfolding story of how a historically specific construction called *the human is giving way to a different construction called the posthuman.*

Interrelations between the three stories are extensive. Central to the construction of the cyborg are informational pathways connecting the organic body to its prosthetic extensions. This presumes a conception of information as a (disembodied) entity that can flow between carbon-based organic components and silicon-based electronic components to make protein and silicon operate as a single system. When information loses its body, equating humans and computers is especially easy, for the materiality in which the thinking mind is instantiated appears incidental to its essential nature. Moreover, the idea of the feedback loop implies that the boundaries of the autonomous subject are up for grabs, since feedback loops can flow not only *within* the subject but also *between* the subject and the environment. From Norbert Wiener on, the flow of information through feedback loops has been associated with the deconstruction of the liberal humanist subject, the version of the "human" with which I will be concerned. Although the "posthuman" differs in its articulations, a common theme is the union of the human with the intelligent machine.

What is the posthuman? Think of it as a point of view characterized by the following assumptions. (I do not mean this list to be exclusive or definitive. Rather, it names elements found at a variety of sites. It is meant to be suggestive rather than prescriptive.)[5] First, the posthuman view privileges informational pattern over material instantiation, so that embodiment in a biological substrate is seen as an accident of history rather than an inevitability of life. Second, the posthuman view considers consciousness, re-

garded as the seat of human identity in the Western tradition long before Descartes thought he was a mind thinking, as an epiphenomenon, as an evolutionary upstart trying to claim that it is the whole show when in actuality it is only a minor sideshow. Third, the posthuman view thinks of the body as the original prosthesis we all learn to manipulate, so that extending or replacing the body with other prostheses becomes a continuation of a process that began before we were born. Fourth, and most important, by these and other means, the posthuman view configures human being so that it can be seamlessly articulated with intelligent machines. In the posthuman, there are no essential differences or absolute demarcations between bodily existence and computer simulation, cybernetic mechanism and biological organism, robot teleology and human goals.

To elucidate the significant shift in underlying assumptions about subjectivity signaled by the posthuman, we can recall one of the definitive texts characterizing the liberal humanist subject: C. B. Macpherson's analysis of possessive individualism. "Its possessive quality is found in its conception of the individual as essentially the proprietor of his own person or capacities, *owing nothing to society for them*. . . . The human essence *is freedom from the wills of others*, and freedom is a function of possession."[6] The italicized phrases mark convenient points of departure for measuring the distance between the human and the posthuman. "Owing nothing to society" comes from arguments Hobbes and Locke constructed about humans in a "state of nature" before market relations arose. Because ownership of oneself is thought to predate market relations and owe nothing to them, it forms a foundation upon which those relations can be built, as when one sells one's labor for wages. As Macpherson points out, however, this imagined "state of nature" is a retrospective creation of a market society. The liberal self is *produced* by market relations and does not in fact predate them. This paradox (as Macpherson calls it) is resolved in the posthuman by doing away with the "natural" self. The posthuman subject is an amalgam, a collection of heterogeneous components, a material-informational entity whose boundaries undergo continuous construction and reconstruction. Consider the six-million-dollar man, a paradigmatic citizen of the posthuman regime. As his name implies, the parts of the self are indeed owned, but they are owned precisely because they were purchased, not because ownership is a natural condition preexisting market relations. Similarly, the presumption that there is an agency, desire, or will belonging to the self and clearly distinguished from the "wills of others" is undercut in the posthuman, for the posthuman's collective heterogeneous quality implies a distributed cognition located in disparate parts that may be in only tenuous

communication with one another. We have only to recall Robocop's memory flashes that interfere with his programmed directives to understand how the distributed cognition of the posthuman complicates individual agency. If "human essence is freedom from the wills of others," the posthuman is "post" not because it is necessarily unfree but because there is no a priori way to identify a self-will that can be clearly distinguished from an other-will. Although these examples foreground the cybernetic aspect of the posthuman, it is important to recognize that the construction of the posthuman does not require the subject to be a literal cyborg. Whether or not interventions have been made on the body, new models of subjectivity emerging from such fields as cognitive science and artificial life imply that even a biologically unaltered *Homo sapiens* counts as posthuman. The defining characteristics involve the construction of subjectivity, not the presence of nonbiological components.

What to make of this shift from the human to the posthuman, which both evokes terror and excites pleasure? The liberal humanist subject has, of course, been cogently criticized from a number of perspectives. Feminist theorists have pointed out that it has historically been constructed as a white European male, presuming a universality that has worked to suppress and disenfranchise women's voices; postcolonial theorists have taken issue not only with the universality of the (white male) liberal subject but also with the very idea of a unified, consistent identity, focusing instead on hybridity; and postmodern theorists such as Gilles Deleuze and Felix Guattari have linked it with capitalism, arguing for the liberatory potential of a dispersed subjectivity distributed among diverse desiring machines they call "body without organs."[7] Although the deconstruction of the liberal humanist subject in cybernetics has some affinities with these perspectives, it proceeded primarily along lines that sought to understand human being as a set of informational processes. Because information had lost its body, this construction implied that embodiment is not essential to human being. Embodiment has been systematically downplayed or erased in the cybernetic construction of the posthuman in ways that have not occurred in other critiques of the liberal humanist subject, especially in feminist and postcolonial theories.

Indeed, one could argue that the erasure of embodiment is a feature common to *both* the liberal humanist subject and the cybernetic posthuman. Identified with the rational mind, the liberal subject *possessed* a body but was not usually represented as *being* a body. Only because the body is not identified with the self is it possible to claim for the liberal subject its notorious universality, a claim that depends on erasing markers of bodily

difference, including sex, race, and ethnicity.[8] Gillian Brown, in her influential study of the relation between humanism and anorexia, shows that the anoretic's struggle to "decrement" the body is possible precisely because the body is understood as an object for control and mastery rather than as an intrinsic part of the self. Quoting an anoretic's remark—"You make out of your body your very own kingdom where you are the tyrant, the absolute dictator"—Brown states, "Anorexia is thus a fight for self-control, a flight from the slavery food threatens; self-sustaining self-possession independent of bodily desires is the anoretic's crucial goal."[9] In taking the self-possession implied by liberal humanism to the extreme, the anoretic creates a physical image that, in its skeletal emaciation, serves as material testimony that the locus of the liberal humanist subject lies in the mind, not the body. Although in many ways the posthuman deconstructs the liberal humanist subject, it thus shares with its predecessor an emphasis on cognition rather than embodiment. William Gibson makes the point vividly in *Neuromancer* when the narrator characterizes the posthuman body as "data made flesh."[10] To the extent that the posthuman constructs embodiment as the instantiation of thought/information, it continues the liberal tradition rather than disrupts it.

In tracing these continuities and discontinuities between a "natural" self and a cybernetic posthuman, I am not trying to recuperate the liberal subject. Although I think that serious consideration needs to be given to how certain characteristics associated with the liberal subject, especially agency and choice, can be articulated within a posthuman context, I do not mourn the passing of a concept so deeply entwined with projects of domination and oppression. Rather, I view the present moment as a critical juncture when interventions might be made to keep disembodiment from being rewritten, once again, into prevailing concepts of subjectivity. I see the deconstruction of the liberal humanist subject as an opportunity to put back into the picture the flesh that continues to be erased in contemporary discussions about cybernetic subjects. Hence my focus on how information lost its body, for this story is central to creating what Arthur Kroker has called the "flesh-eating 90s."[11] If my nightmare is a culture inhabited by posthumans who regard their bodies as fashion accessories rather than the ground of being, my dream is a version of the posthuman that embraces the possibilities of information technologies without being seduced by fantasies of unlimited power and disembodied immortality, that recognizes and celebrates finitude as a condition of human being, and that understands human life is embedded in a material world of great complexity, one on which we depend for our continued survival.

Perhaps it will now be clear that I mean my title, *How We Became Posthuman,* to connote multiple ironies, which do not prevent it from also being taken seriously. Taken straight, this title points to models of subjectivity sufficiently different from the liberal subject that if one assigns the term "human" to this subject, it makes sense to call the successor "posthuman." Some of the historical processes leading to this transformation are documented here, and in this sense the book makes good on its title. Yet my argument will repeatedly demonstrate that these changes were never complete transformations or sharp breaks; without exception, they reinscribed traditional ideas and assumptions even as they articulated something new. The changes announced by the title thus mean something more complex than "That was then, this is now." Rather, "human" and "posthuman" coexist in shifting configurations that vary with historically specific contexts. Given these complexities, the past tense in the title—"became"—is intended both to offer the reader the pleasurable shock of a double take and to reference ironically apocalyptic visions such as Moravec's prediction of a "postbiological" future for the human race.

Amplifying the ambiguities of the past tense are the ambiguities of the plural. In one sense, "we" refers to the readers of this book—readers who, by becoming aware of these new models of subjectivity (if they are not already familiar with them), may begin thinking of their actions in ways that have more in common with the posthuman than the human. Speaking for myself, I now find myself saying things like, "Well, my sleep agent wants to rest, but my food agent says I should go to the store." Each person who thinks this way begins to envision herself or himself as a posthuman collectivity, an "I" transformed into the "we" of autonomous agents operating together to make a self. The infectious power of this way of thinking gives "we" a performative dimension. People become posthuman because they think they are posthuman. In another sense "we," like "became," is meant ironically, positioning itself in opposition to the techno-ecstasies found in various magazines, such as *Mondo 2000,* which customarily speak of the transformation into the posthuman as if it were a universal human condition when in fact it affects only a small fraction of the world's population—a point to which I will return.

The larger trajectory of my narrative arcs from the initial moments when cybernetics was formulated as a discipline, through a period of reformulation known as "second-order cybernetics," to contemporary debates swirling around an emerging discipline known as "artificial life." Although the progression is chronological, this book is not meant to be a history of cybernetics. Many figures not discussed here played important roles in that

history, and I have not attempted to detail their contributions. Rather, my selection of theories and researchers has been dictated by a desire to show *the complex interplays between embodied forms of subjectivity and arguments for disembodiment throughout the cybernetic tradition.* In broad outline, these interplays occurred in three distinct waves of development. The first, from 1945 to 1960, took homeostasis as a central concept; the second, going roughly from 1960 to 1980, revolved around reflexivity; and the third, stretching from 1980 to the present, highlights virtuality. Let me turn now to a brief sketch of these three periods.

During the foundational era of cybernetics, Norbert Wiener, John von Neumann, Claude Shannon, Warren McCulloch, and dozens of other distinguished researchers met at annual conferences sponsored by the Josiah Macy Foundation to formulate the central concepts that, in their high expectations, would coalesce into a theory of communication and control applying equally to animals, humans, and machines. Retrospectively called the Macy Conferences on Cybernetics, these meetings, held from 1943 to 1954, were instrumental in forging a new paradigm.[12] To succeed, they needed a theory of information (Shannon's bailiwick), a model of neural functioning that showed how neurons worked as information-processing systems (McCulloch's lifework), computers that processed binary code and that could conceivably reproduce themselves, thus reinforcing the analogy with biological systems (von Neumann's specialty), and a visionary who could articulate the larger implications of the cybernetic paradigm and make clear its cosmic significance (Wiener's contribution). The result of this breathtaking enterprise was nothing less than a new way of looking at human beings. Henceforth, humans were to be seen primarily as information-processing entities who are *essentially* similar to intelligent machines.

The revolutionary implications of this paradigm notwithstanding, Wiener did not intend to dismantle the liberal humanist subject. He was less interested in seeing humans as machines than he was in fashioning human and machine alike in the image of an autonomous, self-directed individual. In aligning cybernetics with liberal humanism, he was following a strain of thought that, since the Enlightenment, had argued that human beings could be trusted with freedom because they and the social structures they devised operated as self-regulating mechanisms.[13] For Wiener, cybernetics was a means to extend liberal humanism, not subvert it. The point was less to show that man was a machine than to demonstrate that a machine could function like a man.

Yet the cybernetic perspective had a certain inexorable logic that, especially when fed by wartime hysteria, also worked to undermine the very lib-

eral subjectivity that Wiener wanted to preserve. These tensions were kept under control during the Macy period partly through a strong emphasis on *homeostasis.*[14] Traditionally, homeostasis had been understood as the ability of living organisms to maintain steady states when they are buffeted by fickle environments. When the temperature soars, sweat pours out of the human body so that its internal temperature can remain relatively stable. During the Macy period, the idea of homeostasis was extended to machines. Like animals, machines can maintain homeostasis using feedback loops. Feedback loops had long been exploited to increase the stability of mechanical systems, reaching a high level of development during the mid-to-late nineteenth century with the growing sophistication of steam engines and their accompanying control devices, such as governors. It was not until the 1930s and 1940s, however, that the feedback loop was explicitly theorized as a flow of information. Cybernetics was born when nineteenth-century control theory joined with the nascent theory of information.[15] Coined from the Greek word for "steersman," cybernetics signaled that three powerful actors—information, control, and communication—were now operating jointly to bring about an unprecedented synthesis of the organic and the mechanical.

Although the informational feedback loop was initially linked with homeostasis, it quickly led to the more threatening and subversive idea of *reflexivity.* A few years ago I co-taught, with a philosopher and a physicist, a course on reflexivity. As we discussed reflexivity in the writings of Aristotle, Fichte, Kierkegaard, Gödel, Turing, Borges, and Calvino, aided by the insightful analyses of Roger Penrose and Douglas Hofstader, I was struck not only by the concept's extraordinarily rich history but also by its tendency to mutate, so that virtually any formulation is sure to leave out some relevant instances. Instructed by the experience, I offer the following tentative definition, which I hope will prove adequate for our purposes here. *Reflexivity is the movement whereby that which has been used to generate a system is made, through a changed perspective, to become part of the system it generates.* When Kurt Gödel invented a method of coding that allowed statements of number theory also to function as statements *about* number theory, he entangled that which generates the system with the system. When M. C. Escher drew two hands drawing each other, he took that which is presumed to generate the picture—the sketching hand—and made it part of the picture it draws. When Jorge Luis Borges in "The Circular Ruins" imagines a narrator who creates a student through his dreaming only to discover that he himself is being dreamed by another, the system generating a reality is shown to be part of the reality it makes. As these examples illustrate, reflexivity has subversive effects because it confuses and entangles

the boundaries we impose on the world in order to make sense of that world. Reflexivity tends notoriously toward infinite regress. The dreamer creates the student, but the dreamer in turn is dreamed by another, who in his turn is dreamed by someone else, and so on to infinity.

This definition of reflexivity has much in common with some of the most influential and provocative recent work in critical theory, cultural studies, and the social studies of science. Typically, these works make the reflexive move of showing that an attribute previously considered to have emerged from a set of preexisting conditions is in fact used to generate the conditions. In Nancy Armstrong's *Desire and Domestic Fiction: A Political History of the Novel,* for example, bourgeois femininity is shown to be constructed through the domestic fictions that represent it as already in place.[16] In Michael Warner's *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-Century America,* the founding document of the United States, the Constitution, is shown to produce the very people whose existence it presupposes.[17] In Bruno Latour's *Science in Action: How to Follow Scientists and Engineers through Society,* scientific experiments are shown to produce the nature whose existence they predicate as their condition of possibility.[18] It is only a slight exaggeration to say that contemporary critical theory is produced by the reflexivity that it also produces (an observation that is, of course, also reflexive).

Reflexivity entered cybernetics primarily through discussions about the observer. By and large, first-wave cybernetics followed traditional scientific protocols in considering observers to be outside the system they observe. Yet cybernetics also had implications that subverted this premise. The objectivist view sees information flowing from the system to the observers, but feedback can also loop *through* the observers, drawing them in to become part of the system being observed. Although participants remarked on this aspect of the cybernetic paradigm throughout the Macy transcripts, they lacked a single word to describe it. To my knowledge, the word "reflexivity" does not appear in the transcripts. This meant they had no handle with which to grasp this slippery concept, no signifier that would help to constitute as well as to describe the changed perspective that reflexivity entails. Discussions of the idea remained diffuse. Most participants did not go beyond remarking on the shifting boundaries between observer and system that cybernetics puts into play. With some exceptions, deeper formulations of the problem failed to coalesce during the Macy discussions.

The most notable exception turned out to hurt more than it helped. Lawrence Kubie, a hard-line Freudian psychoanalyst, introduced a reflexive perspective when he argued that every utterance is doubly encoded,

acting both as a statement about the outside world and as a mirror reflecting the speaker's psyche. If reflexivity was already a subversive concept, this interpretation made it doubly so, for it threatened to dissolve the premise of scientific objectivity shared by the physical scientists in the Macy group. Their reactions to Kubie's presentations show them shying away from reflexivity, preferring to shift the conversation onto more comfortable ground. Nevertheless, the idea hung in the air, and a few key thinkers—especially Margaret Mead, Gregory Bateson, and Heinz von Foerster—resolved to pursue it after the Macy Conferences ran out of steam.

The second wave of cybernetics grew out of attempts to incorporate reflexivity into the cybernetic paradigm at a fundamental level. The key issue was how systems are constituted as such, and the key problem was how to redefine homeostatic systems so that the observer can be taken into account. The second wave was initiated by, among others, Heinz von Foerster, the Austrian émigré who became coeditor of the Macy transcripts. This phase can be dated from 1960, when von Foerster wrote the first of the essays that were later collected in his influential book *Observing Systems.*[19] As von Foerster's punning title recognizes, the observer of systems can himself be constituted as a system to be observed. Von Foerster called the models he presented in these essays "second-order cybernetics" because they extended cybernetic principles to the cyberneticians themselves. The second wave reached its mature phase with the publication of Humberto Maturana and Francisco Varela's *Autopoiesis and Cognition: The Realization of the Living.*[20] Building on Maturana's work on reflexivity in sensory processing and Varela's on the dynamics of autonomous biological systems, the two authors expanded the reflexive turn into a fully articulated epistemology that sees the world as a set of informationally closed systems. Organisms respond to their environment in ways determined by their internal self-organization. Their one and only goal is continually to produce and reproduce the organization that defines them as systems. Hence, they not only are self-organizing but also are autopoietic, or self-making. Through Maturana and Varela's work and that of other influential theorists such as German sociologist Niklas Luhmann,[21] cybernetics by 1980 had spun off from the idea of reflexive feedback loops a theory of autopoiesis with sweeping epistemological implications.

In a sense, autopoiesis turns the cybernetic paradigm inside out. Its central premise—that systems are informationally closed—radically alters the idea of the informational feedback loop, for the loop no longer functions to connect a system to its environment. In the autopoietic view, no information crosses the boundary separating the system from its environ-

ment. We do not see a world "out there" that exists apart from us. Rather, we see only what our systemic organization allows us to see. The environment merely *triggers* changes determined by the system's own structural properties. Thus the center of interest for autopoiesis shifts from the cybernetics of the observed system to the cybernetics of the observer. Autopoiesis also changes the explanation of what circulates through the system to make it work as a system. The emphasis now is on the mutually constitutive interactions between the components of a system rather than on message, signal, or information. Indeed, one could say either that information does not exist in this paradigm or that it has sunk so deeply into the system as to become indistinguishable from the organizational properties defining the system as such.

The third wave swelled into existence when self-organization began to be understood not merely as the (re)production of internal organization but as the springboard to emergence. In the rapidly emerging field of artificial life, computer programs are designed to allow "creatures" (that is, discrete packets of computer codes) to evolve spontaneously in directions the programmer may not have anticipated. The intent is to evolve the *capacity* to evolve. Some researchers have argued that such self-evolving programs are not merely models of life but are themselves alive. What assumptions make this claim plausible? If one sees the universe as composed essentially of information, it makes sense that these "creatures" are life *forms* because they have the form of life, that is, an informational code. As a result, the theoretical bases used to categorize all life undergo a significant shift. As we shall see in chapters 9 and 10, when these theories are applied to human beings, *Homo sapiens* are so transfigured in conception and purpose that they can appropriately be called posthuman.

The emergence of the posthuman as an informational-material entity is paralleled and reinforced by a corresponding reinterpretation of the deep structures of the physical world. Some theorists, notably Edward Fredkin and Stephen Wolfram, claim that reality is a program run on a cosmic computer.[22] In this view, a universal informational code underlies the structure of matter, energy, spacetime—indeed, of everything that exists. The code is instantiated in cellular automata, elementary units that can occupy two states: on or off. Although the jury is still out on the cellular automata model, it may indeed prove to be a robust way to understand reality. Even now, a research team headed by Fredkin is working on showing how quantum mechanics can be derived from an underlying cellular automata model.

What happens to the embodied lifeworld of humans in this paradigm? In itself, the cellular automata model is not necessarily incompatible with

recognizing that humans are embodied beings, for embodiment can flow from cellular automata as easily as from atoms. No one suggests that because atoms are mostly empty space, we can shuck the electron shells and do away with occupying space altogether. Yet the cultural contexts and technological histories in which cellular automata theories are embedded encourage a comparable fantasy—that because we are essentially information, we can do away with the body. Central to this argument is a conceptualization that sees information and materiality as distinct entities. This separation allows the construction of a hierarchy in which information is given the dominant position and materiality runs a distant second. As though we had learned nothing from Derrida about supplementarity, embodiment continues to be discussed as if it were a supplement to be purged from the dominant term of information, an accident of evolution we are now in a position to correct.

It is this materiality/information separation that I want to contest—not the cellular automata model, information theory, or a host of related theories in themselves. My strategy is to complicate the leap from embodied reality to abstract information by pointing to moments when the assumptions involved in this move were contested by other researchers in the field and so became especially visible. The point of highlighting such moments is to make clear how much had to be erased to arrive at such abstractions as bodiless information. Abstraction is of course an essential component in all theorizing, for no theory can account for the infinite multiplicity of our interactions with the real. But when we make moves that erase the world's multiplicity, we risk losing sight of the variegated leaves, fractal branchings, and particular bark textures that make up the forest. In the pages that follow, I will identify two moves in particular that played important roles in constructing the information/materiality hierarchy. Irreverently, I think of them as the Platonic backhand and forehand.

The Platonic backhand works by inferring from the world's noisy multiplicity a simplified abstraction. So far so good: this is what theorizing should do. The problem comes when the move circles around to constitute the abstraction as the originary form from which the world's multiplicity derives. Then complexity appears as a "fuzzing up" of an essential reality rather than as a manifestation of the world's holistic nature. Whereas the Platonic backhand has a history dating back to the Greeks, the Platonic forehand is more recent. To reach fully developed form, it required the assistance of powerful computers. This move starts from simplified abstractions and, using simulation techniques such as genetic algorithms, *evolves* a multiplicity sufficiently complex that it can be seen as a world of its own. The two moves thus make their play in

opposite directions. The backhand goes from noisy multiplicity to reductive simplicity, whereas the forehand swings from simplicity to mulilicity. They share a common ideology—privileging the abstract as the Real and downplaying the importance of material instantiation. When they work together, they lay the groundwork for a new variation on an ancient game, in which disembodied information becomes the ultimate Platonic Form. If we can capture the Form of ones and zeros in a nonbiological medium—say, on a computer disk—why do we need the body's superfluous flesh?

Whether the enabling assumptions for this conception of information occur in information theory, cybernetics, or popular science books such as *Mind Children,* their appeal is clear. Information viewed as pattern and not tied to a particular instantiation is information free to travel across time and space. Hackers are not the only ones who believe that information wants to be free. The great dream and promise of information is that it can be free from the material constraints that govern the mortal world. Marvin Minsky precisely expressed this dream when, in a recent lecture, he suggested it will soon be possible to extract human memories from the brain and import them, intact and unchanged, to computer disks.[23] The clear implication is that if we can become the information we have constructed, we can achieve effective immortality.

In the face of such a powerful dream, it can be a shock to remember that for information to exist, it must *always* be instantiated in a medium, whether that medium is the page from the *Bell Laboratories Journal* on which Shannon's equations are printed, the computer-generated topological maps used by the Human Genome Project, or the cathode ray tube on which virtual worlds are imaged. The point is not only that abstracting information from a material base is an imaginary act but also, and more fundamentally, that conceiving of information as a thing separate from the medium instantiating it is a prior imaginary act that constructs a holistic phenomenon as an information/matter duality.[24]

The chapters that follow will show what had to be elided, suppressed, and forgotten to make information lose its body. This book is a "rememory" in the sense of Toni Morrison's *Beloved*: putting back together parts that have lost touch with one another and reaching out toward a complexity too unruly to fit into disembodied ones and zeros.

Seriation, Skeuomorphs, and Conceptual Constellations

The foregoing leads to a strategic definition of "virtuality." *Virtuality is the cultural perception that material objects are interpenetrated by informa-*

tion patterns. The definition plays off the duality at the heart of the condition of virtuality—materiality on the one hand, information on the other. Normally virtuality is associated with computer simulations that put the body into a feedback loop with a computer-generated image. For example, in virtual Ping-Pong, one swings a paddle wired into a computer, which calculates from the paddle's momentum and position where the ball would go. Instead of hitting a real ball, the player makes the appropriate motions with the paddle and watches the image of the ball on a computer monitor. Thus the game takes place partly in real life (RL) and partly in virtual reality (VR). Virtual reality technologies are fascinating because they make visually immediate the perception that a world of information exists parallel to the "real" world, the former intersecting the latter at many points and in many ways. Hence the definition's strategic quality, strategic because it seeks to connect virtual technologies with the sense, pervasive in the late twentieth century, that all material objects are interpenetrated by flows of information, from DNA code to the global reach of the World Wide Web.

Seeing the world as an interplay between informational patterns and material objects is a historically specific construction that emerged in the wake of World War II.[25] By 1948, the distinction had coalesced sufficiently for Wiener to articulate it as a criterion that any adequate theory of materiality would be forced to meet. "Information is information, not matter or energy. No materialism which does not admit this can survive at the present day."[26] Wiener knew as well as anyone else that to succeed, this conception of information required artifacts that could embody it and make it real. When I say virtuality is a cultural perception, I do not mean that it is merely a psychological phenomenon. It is instantiated in an array of powerful technologies. The perception of virtuality facilitates the development of virtual technologies, and the technologies reinforce the perception.

The feedback loops that run between technologies and perceptions, artifacts and ideas, have important implications for how historical change occurs. The development of cybernetics followed neither a Kuhnian model of incommensurable paradigms nor a Foucauldian model of sharp epistemic breaks.[27] In the history of cybernetics, ideas were rarely made up out of whole cloth. Rather, they were fabricated in a pattern of overlapping replication and innovation, a pattern that I call "seriation" (a term appropriated from archaeological anthropology). A brief explanation may clarify this concept. Within archaeological anthropology, changes in artifacts are customarily mapped through seriation charts. One constructs a seriation chart by parsing an artifact as a set of attributes that change over time. Suppose a researcher wants to construct a seriation chart for lamps. A key attribute is

the element that gives off light. The first lamps, dating from thousands of years ago, used wicks for this element. Later, with the discovery of electricity, wicks gave way to filaments. The figures that customarily emerge from this kind of analysis are shaped like a tiger's iris—narrow at the top when an attribute first begins to be introduced, with a bulge in the middle during the heyday of the attribute, and tapered off at the bottom as the shift to a new model is completed. On a seriation chart for lamps, a line drawn at 1890 would show the figure for wicks waxing large with the figure for filaments intersected at the narrow tip of the top end. Fifty years later, the wick figure would be tapering off, and the filament figure would be widening into its middle section. Considered as a set, the figures depicting changes in the attributes of an artifact reveal patterns of overlapping innovation and replication. Some attributes change from one model to the next, but others remain the same.

As figure 1 illustrates, the conceptual shifts that took place during the development of cybernetics display a seriated pattern reminiscent of material changes in artifacts. Conceptual fields evolve similarly to material culture, in part because concept and artifact engage each other in continuous feedback loops. An artifact materially expresses the concept it embodies, but the process of its construction is far from passive. A glitch has to be fixed, a material exhibits unexpected properties, an emergent behavior surfaces—any of these challenges can give rise to a new concept, which results in another generation of artifact, which leads to the development of still other concepts. The reasoning suggests that we should be able to trace the development of a conceptual field by using a seriation chart analogous to the seriation charts used for artifacts.

In the course of the Macy Conferences, certain ideas came to be associated with each other. Through a cumulative process that continued across several years of discussions, these ideas were seen as mutually entailing each other until, like love and marriage, they were viewed by the participants as naturally going together. Such a constellation is the conceptual entity corresponding to an artifact, possessing an internal coherence that defines it as an operational unit. Its formation marks the beginning of a period; its disassembly and reconstruction signal the transition to a different period. Indeed, periods are recognizable as such largely because constellations possess this coherence. Rarely is a constellation discarded wholesale. Rather, some of the ideas composing it are discarded, others are modified, and new ones are introduced. Like the attributes composing an artifact, the ideas in a constellation change in a patchwork pattern of old and new.

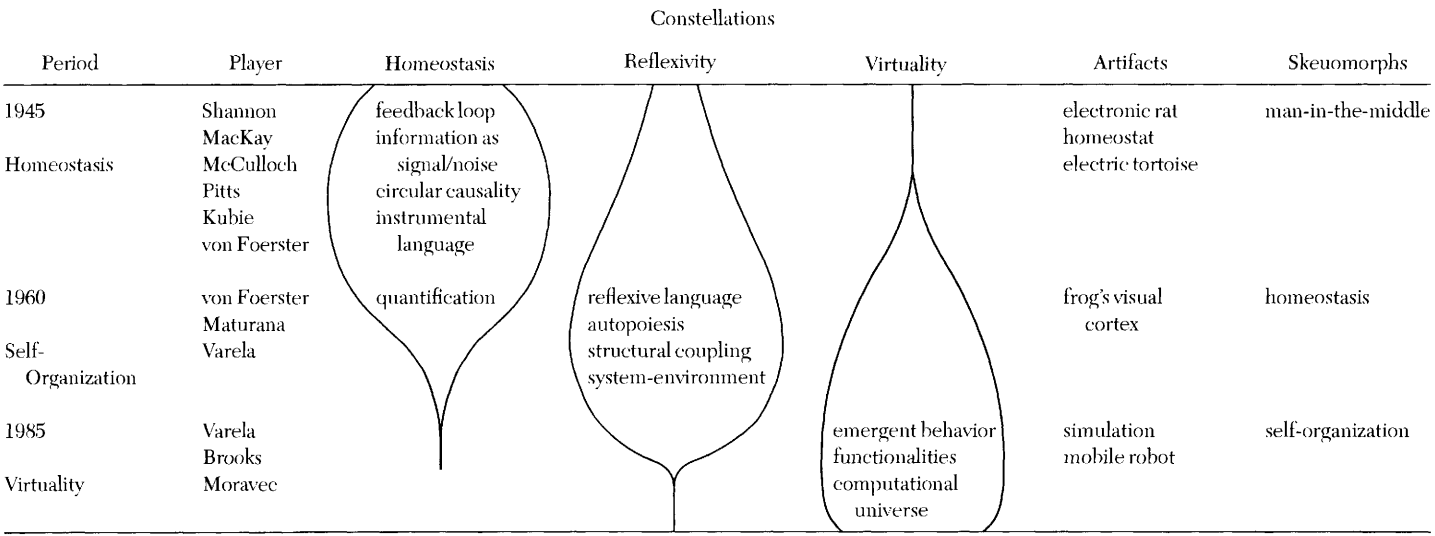

FIGURE 1 The three waves of cybernetics

Here I want to introduce another term from archaeological anthropology. A *skeuomorph* is a design feature that is no longer functional in itself but that refers back to a feature that was functional at an earlier time. The dashboard of my Toyota Camry, for example, is covered by vinyl molded to simulate stitching. The simulated stitching alludes back to a fabric that was in fact stitched, although the vinyl "stitching" is formed by an injection mold. Skeuomorphs visibly testify to the social or psychological necessity for innovation to be tempered by replication. Like anachronisms, their pejorative first cousins, skeuomorphs are not unusual. On the contrary, they are so deeply characteristic of the evolution of concepts and artifacts that it takes a great deal of conscious effort to avoid them. At SIGGRAPH, the annual computer trade show where dealers come to hawk their wares, hard and soft, there are almost as many skeuomorphs as morphs.

The complex psychological functions a skeuomorph performs can be illustrated by an installation exhibited at SIGGRAPH '93. Called the "Catholic Turing Test," the simulation invited the viewer to make a confession by choosing selections from the video screen; it even had a bench on which the viewer could kneel.[28] On one level, the installation alluded to the triumph of science over religion, for the role of divinely authorized interrogation and absolution had been taken over by a machine algorithm. On another level, the installation pointed to the intransigence of conditioned behavior, for the machine's form and function were determined by its religious predecessor. Like a Janus figure, the skeuomorph looks to past and future, simultaneously reinforcing and undermining both. It calls into a play a psychodynamic that finds the new more acceptable when it recalls the old that it is in the process of displacing and finds the traditional more comfortable when it is presented in a context that reminds us we can escape from it into the new.

In the history of cybernetics, skeuomorphs acted as threshold devices, smoothing the transition between one conceptual constellation and another. Homeostasis, a foundational concept during the first wave, functioned during the second wave as a skeuomorph. Although homeostasis remained an important concept in biology, by about 1960 it had ceased to be an initiating premise in cybernetics. Instead, it performed the work of a gesture or an allusion used to authenticate new elements in the emerging constellation of reflexivity. At the same time, it also exerted an inertial pull on the new elements, limiting how radically they could transform the constellation.

A similar phenomenon appears in the transition from the second to the third wave. Reflexivity, the key concept of the second wave, is displaced in

the third wave by emergence. Like homeostasis, reflexivity does not altogether disappear but lingers on as an allusion that authenticates new elements. It performs a more complex role than mere nostalgia, however, for it also leaves its imprint on the new constellation of virtuality. The complex story formed by these seriated changes is told in chapters 3, 6, and 9, which discuss cybernetics, autopoiesis, and artificial life, respectively.

I have already suggested that living in a condition of virtuality implies we participate in the cultural perception that information and materiality are conceptually distinct and that information is in some sense more essential, more important, and more fundamental than materiality. The preamble to "A Magna Carta for the Knowledge Age," a document coauthored by Alvin Toffler at the behest of Newt Gingrich, concisely sums up the matter by proclaiming, "The central event of the 20th century is the overthrow of matter."[29] To see how this view began to acquire momentum, let us briefly flash back to 1948 when Claude Shannon, a brilliant theorist working at Bell Laboratories, defined a mathematical quantity he called information and proved several important theorems concerning it.[30]

Information Theory and Everyday Life

Shannon's theory defines information as a probability function with no dimensions, no materiality, and no necessary connection with meaning. It is a pattern, not a presence. (Chapter 3 talks about the development of information theory in more detail, and the relevant equations can be found there.) The theory makes a strong distinction between message and signal. Lacan to the contrary, a message does not always arrive at its destination. In information theoretic terms, no message is ever sent. What is sent is a signal. Only when the message is encoded in a signal for transmission through a medium—for example, when ink is printed on paper or when electrical pulses are sent racing along telegraph wires—does it assume material form. The very definition of "information," then, encodes the distinction between materiality and information that was also becoming important in molecular biology during this period.[31]

Why did Shannon define information as a pattern? The transcripts of the Macy Conferences indicate that the choice was driven by the twin engines of reliable quantification and theoretical generality. As we shall see in chapter 3, Shannon's formulation was not the only proposal on the table. Donald MacKay, a British researcher, argued for an alternative definition that linked information with change in a receiver's mindset and thus with meaning.[32] To be workable, MacKay's definition required that psychologi-

cal states be quantifiable and measurable—an accomplishment that only now appears distantly possible with such imaging technologies as positron-emission tomography and that certainly was not in reach in the immediate post–World War II years. It is no mystery why Shannon's definition rather than MacKay's became the industry standard.

Shannon's approach had other advantages that turned out to incur large (and mounting) costs when his premise interacted with certain predispositions already at work within the culture. Abstracting information from a material base meant that information could become free-floating, unaffected by changes in context. The technical leverage this move gained was considerable, for by formalizing information into a mathematical function, Shannon was able to develop theorems, powerful in their generality, that hold true regardless of the medium in which the information is instantiated. Not everyone agreed this move was a good idea, however, despite its theoretical power. As Carolyn Marvin notes, a decontextualized construction of information has important ideological implications, including an Anglo-American ethnocentrism that regards digital information as more important than more context-bound analog information.[33] Even in Shannon's day, malcontents grumbled that divorcing information from context and thus from meaning had made the theory so narrowly formalized that it was not useful as a general theory of communication. Shannon himself frequently cautioned that the theory was meant to apply only to certain technical situations, not to communication in general.[34] In other circumstances, the theory might have become a dead end, a victim of its own excessive formalization and decontextualization. But not in the post–World War II era. The time was ripe for theories that reified information into a free-floating, decontextualized, quantifiable entity that could serve as the master key unlocking secrets of life and death.

Technical artifacts help to make an information theoretic view a part of everyday life. From ATMs to the Internet, from the morphing programs used in *Terminator II* to the sophisticated visualization programs used to guide microsurgeries, information is increasingly perceived as interpenetrating material forms. Especially for users who may not know the material processes involved, the impression is created that pattern is predominant over presence. From here it is a small step to perceiving information as more mobile, more important, more *essential* than material forms. When this impression becomes part of your cultural mindset, you have entered the condition of virtuality.

U.S. culture at present is in a highly heterogeneous state regarding the condition of virtuality. Some high-tech preserves (elite research centers

such as Xerox Palo Alto Research Center and Bell Laboratories, most major research universities, and hundreds of corporations) have so thoroughly incorporated virtual technologies into their infrastructures that information is as much as part of the researchers' mindscapes as is electric lighting or synthetic plastics.[35] The thirty million Americans who are plugged into the Internet increasingly engage in virtual experiences enacting a division between the material body that exits on one side of the screen and the computer simulacra that seem to create a space inside the screen.[36] Yet for millions more, virtuality is not even a cloud on the horizon of their everyday worlds. Within a global context, the experience of virtuality becomes more exotic by several orders of magnitude. It is a useful corrective to remember that 70 percent of the world's population has never made a telephone call.

Nevertheless, I think it is a mistake to underestimate the importance of virtuality, for it wields an influence altogether disproportionate to the number of people immersed in it. It is no accident that the condition of virtuality is most pervasive and advanced where the centers of power are most concentrated. Theorists at the Pentagon, for example, see it as the theater in which future wars will be fought. They argue that coming conflicts will be decided not so much by overwhelming force as by "neocortical warfare," waged through the techno-sciences of information.[37] If we want to contest what these technologies signify, we need histories that show the erasures that went into creating the condition of virtuality, as well as visions arguing for the importance of embodiment. Once we understand the complex interplays that went into creating the condition of virtuality, we can demystify our progress toward virtuality and see it as the result of historically specific negotiations rather than of the irresistible force of technological determinism. At the same time, we can acquire resources with which to rethink the assumptions underlying virtuality, and we can recover a sense of the virtual that fully recognizes the importance of the embodied processes constituting the lifeworld of human beings.[38] In the phrase "virtual bodies," I intend to allude to the historical separation between information and materiality and also to recall the embodied processes that resist this division.

Virtuality and Contemporary Literature

I have already suggested that one way to think about the organization of this book is chronologically, since it follows the three waves of seriated changes in cybernetics. In this organization of the textual body, each of the three chronologically arranged divisions has an anchoring chapter discussing the scientific theories: on the Macy Conferences (chapter 3); on autopoiesis

(chapter 6); and on artificial life (chapter 9), respectively. Each section also has a chapter showing specific applications of the theories: the work of Norbert Wiener (chapter 4); tape-recording technologies (chapter 8); and human-computer interactions (chapter 10). Also included in each of the three divisions are chapters on literary texts contemporaneous with the development of the scientific theories and cybernetic technologies (chapters 5, 7, and 10). I have selected literary texts that were clearly influenced by the development of cybernetics. Nevertheless, I want to resist the idea that influence flows from science into literature. The cross-currents are considerably more complex than a one-way model of influence would allow. In the *Neuromancer* trilogy, for example, William Gibson's vision of cyberspace had a considerable effect on the development of three-dimensional virtual reality imaging software.[39]

A second way to think about the organization of *How We Became Posthuman* is narratively. In this arrangement, the three divisions proceed not so much through chronological progression as through the narrative strands about the (lost) body of information, the cyborg body, and the posthuman body. Here the literary texts play a central role, for they display the passageways that enabled stories coming out of narrowly focused scientific theories to circulate more widely through the body politic. Many of the scientists understood very well that their negotiations involved premises broader than the formal scope of their theories strictly allowed. Because of the wedge that has been driven between science and values in U.S. culture, their statements on these wider implications necessarily occupied the position of ad hoc pronouncements rather than "scientific" arguments. Shaped by different conventions, the literary texts range across a spectrum of issues that the scientific texts only fitfully illuminate, including the ethical and cultural implications of cybernetic technologies.[40]

Literary texts are not, of course, merely passive conduits. They actively shape what the technologies mean and what the scientific theories signify in cultural contexts. They also embody assumptions similar to those that permeated the scientific theories at critical points. These assumptions included the idea that stability is a desirable social goal, that human beings and human social organizations are self-organizing structures, and that form is more essential than matter. The scientific theories used these assumptions as enabling presuppositions that helped to guide inquiry and shape research agendas. As the chapters on the scientific developments will show, culture circulates through science no less than science circulates through culture. The heart that keeps this circulatory system flowing is narrative—narratives about culture, narratives within culture, narratives

about science, narratives within science. In my account of the scientific developments, I have sought to emphasize the role that narrative plays in articulating the posthuman as a technical-cultural concept. For example, chapter 4, on Wiener's scientific work, is interlaced with analyses of the narratives he tells to resolve conflicts between cybernetics and liberal humanism, and chapter 9, on artificial life, is organized by looking at this area of research as a narrative field.

What does this emphasis on narrative have to do with virtual bodies? Following Jean-François Lyotard, many theorists of postmodernity accept that the postmodern condition implies an incredulity toward metanarrative.[41] As we have seen, one way to construct virtuality is the way that Moravec and Minsky do—as a metanarrative about the transformation of the human into a disembodied posthuman. I think we should be skeptical about this metanarrative. To contest it, I want to use the resources of narrative itself, particularly its resistance to various forms of abstraction and disembodiment. With its chronological thrust, polymorphous digressions, located actions, and personified agents, narrative is a more *embodied* form of discourse than is analytically driven systems theory. By turning the technological determinism of bodiless information, the cyborg, and the posthuman into narratives about the negotiations that took place between particular people at particular times and places, I hope to replace a teleology of disembodiment with historically contingent stories about contests between competing factions, contests whose outcomes were far from obvious. Many factors affected the outcomes, from the needs of emerging technologies for reliable quantification to the personalities of the people involved. Though overdetermined, the disembodiment of information was not inevitable, any more than it is inevitable we continue to accept the idea that we are *essentially* informational patterns.

In this regard, the literary texts do more than explore the cultural implications of scientific theories and technological artifacts. Embedding ideas and artifacts in the situated specificities of narrative, the literary texts give these ideas and artifacts a local habitation and a name through discursive formulations whose effects are specific to that textual body. In exploring these effects, I want to demonstrate, on multiple levels and in many ways, that abstract pattern can never fully capture the embodied actuality, unless it is as prolix and noisy as the body itself. Shifting the emphasis from technological determinism to competing, contingent, embodied narratives about the scientific developments is one way to liberate the resources of narrative so that they work against the grain of abstraction running through the teleology of disembodiment. Another way is to read literary texts along-

side scientific theories. In articulating the connections that run through these two discursive realms, I want to entangle abstract form and material particularity such that the reader will find it increasingly difficult to maintain the perception that they are separate and discrete entities. If, for cultural and historical reasons, I cannot start from a holistic perspective, I hope to mix things up enough so that the emphasis falls not on the separation of matter and information but on their inextricably complex compoundings and entwinings. For this project, the literary texts with their fashionings of embodied particularities are crucial.

The first literary text I discuss in detail is Bernard Wolfe's *Limbo*.[42] Written in the 1950s, *Limbo* has become something of an underground classic. It imagines a postwar society in which an ideology, Immob, has developed; the ideology equates aggression with the ability to move. "Pacifism equals passivity," Immob slogans declare. True believers volunteer to banish their mobility (and presumably their aggression) by having amputations, which have come to be regarded as signifiers of social power and influence. These amputees get bored with lying around, however, so a vigorous cybernetics industry has grown up to replace their missing limbs. As this brief summary suggests, *Limbo* is deeply influenced by cybernetics. But the technical achievements of cybernetics are not at the center of the text. Rather, they serve as a springboard to explore a variety of social, political, and psychological issues, ranging from the perceived threat that women's active sexuality poses for Immob men to global East-West tensions that explode into another world war at the end of the text. Although it is unusually didactic, *Limbo* does more than discuss cybernetics; it engages a full range of rhetorical and narrative devices that work both with and against its explicit pronouncements. The narrator seems only partially able to control his verbally extravagant narrative. There are, I will argue, deep connections between the narrator's struggle to maintain control of the narrative and the threat to "natural" body boundaries posed by the cybernetic paradigm. *Limbo* interrogates a dynamic that also appears in Norbert Wiener's work—the intense anxiety that erupts when the perceived boundaries of the body are breached. In addition, it illustrates how the body of the text gets implicated in the processes used to represent bodies within the text.

Several Philip K. Dick novels written from 1962 to 1966 (including *We Can Build You, Do Androids Dream of Electric Sheep?, Dr. Bloodmoney,* and *Ubik*) provide another set of texts through which the multiple implications of the posthuman can be explored.[43] Chronologically and thematically, Dick's novels of simulation cross the scientific theory of autopoiesis. Like Maturana, Varela, and other scientific researchers in the

second wave of cybernetics, Dick is intensely concerned with epistemological questions and their relation to the cybernetic paradigm. The problem of where to locate the observer—in or out of the system being observed?—is conflated in his fiction with how to determine whether a creature is android or human. For Dick, the android is deeply bound up with the gender politics of his male protagonists' relations with female characters, who ambiguously figure either as sympathetic, life-giving "dark-haired girls" or emotionally cold, life-threatening schizoid women. Already fascinated with epistemological questions that reveal how shaky our constructions of reality can be, Dick is drawn to cybernetic themes because he understands that cybernetics radically destabilizes the ontological foundations of what counts as human. The gender politics he writes into his novels illustrate the potent connections between cybernetics and contemporary understandings of race, gender, and sexuality.

The chapter on contemporary speculative fictions constructs a semiotics of virtuality by showing how the central concepts of information and materiality can be mapped onto a multilayered semiotic square. The tutor texts for this analysis, which include *Snow Crash, Blood Music, Galatea 2.2,* and *Terminal Games,* indicate the range of what counts as the posthuman in the age of virtuality, from neural nets to hackers, biologically modified humans, and entities who live only in computer simulations.[44] In following the construction of the posthuman in these texts, I will argue that older ideas are reinscribed as well as contested. As was the case for the scientific models, change occurs in a seriated pattern of overlapping innovation and replication.

I hope that this book will demonstrate, once again, how crucial it is to recognize interrelations between different kinds of cultural productions, specifically literature and science. The stories I tell here—how information lost its body, how the cyborg was created as a cultural icon and technological artifact, and how humans became posthumans—and the waves of historical change I chart would not have the same resonance or breadth if they had been pursued only through literary texts or only through scientific discourses. The scientific texts often reveal, as literature cannot, the foundational assumptions that gave theoretical scope and artifactual efficacy to a particular approach. The literary texts often reveal, as scientific work cannot, the complex cultural, social, and representational issues tied up with conceptual shifts and technological innovations. From my point of view, literature and science as an area of specialization is more than a subset of cultural studies or a minor activity in a literature department. It is a way of understanding ourselves as embodied creatures living within and through embodied worlds and embodied words.

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-

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N. Katherine Hayles is professor of English at the University of California, Los Angeles. She holds advanced degrees in both chemistry and English. She is the author of *The Cosmic Web: Scientific Field Models and Literary Strategies in the Twentieth Century* and *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* and is the editor of *Chaos and Order: Complex Dynamics in Literature and Science*, the last published by the University of Chicago Press.

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