Makeover: Writing the Body into the Posthuman Technoscape Part One: Embracing the Posthuman

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The authors in this volume are rethinking one of the dominant metaphors of our time: the notion that digital information is disembodied. This urge to rethink stems from the quickening pace of an ongoing reconfiguration of almost all aspects of technical practice, as well as modes of communication and interaction, through smooth and unbroken articulation with intelligent machines: the transformation of the human into a new construction called the posthuman. N. Katherine Hayles has diagnosed this condition in her pathbreaking volume, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*:

> 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, regarded 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 be-

Configurations, 2002, 10:203–220

> tween bodily existence and computer simulation, cybernetic mechanism and biological organism, robot teleology and human goals.[1]

These developments have raised the specter—feared by many, celebrated by some—of the end of humanity. The fear that technological developments associated with computer technology, artificial intelligence, robotics, and (more recently) nanotechnology will succeed in displacing humanity through an evolutionary process leading first to a cyborg/human assemblage, and ultimately to the extinction and replacement of the human altogether, has been with us at least since the writings of André Leroi-Gourhan in the 1960s.[2] These ominous early speculations have been repeated in various forms throughout the intervening years and have been given added substance by authoritative figures such as Bill Joy of Sun Microsystems, who titled his April 2000 *Wired Magazine* essay "Why the Future Doesn't Need Us: Our most powerful 21st century technologies —robotics, genetic engineering, and nanotech—are threatening to make humans an endangered species."[3] Sounding a different note, Ray Kurzweil, an AI researcher and recipient of numerous awards (including the 1999 National Medal of Technology for his inventions in the area of text and speech recognition), has put a celebratory twist on this story with detailed timelines and imaginative narratives of how the posthuman transformation will take place over the next decades: by 2040, he predicts, fourth-generation robots will have human capabilities; and by 2099, human thinking and machine intelligence will have merged, with no meaningful distinction left between humans and computers.[4]

Kurzweil's enthusiastic prognosis has been challenged by critics who do not hold that human intelligence can be modeled on or ultimately subsumed by machine intelligence. These objections have been of two main types. Physicist Roger Penrose and philosopher Hubert Dreyfus, for example, have argued that while computers might perform comparably to human intelligence in some limited areas, the essential qualities of human intelligence need not fear being equaled or overtaken in a posthuman future of the sort that con-

1. N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999), pp. 2–3.

2. André Leroi-Gourhan, *Le geste et la parole: Dessins de l'auteur* (Paris: A. Michel, 1964–65); translated as *Gesture and Speech*, trans. Anna Bostock Berger (Cambridge, Mass.: MIT Press, 1993).

3. *http://www.wired.com/wired/archive/8.04/joy.html.*

4. Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (New York: Penguin, 1999), p. 280.

cerns Joy.[5] Principal reasons for resisting the comparison and reduction of brains to computers have been the physical limitations on buildable computers—despite the enormous successes of the past two decades—and the differences in architecture between the human brain (conceived as a computer) and computing machines. This class of objection becomes even more pertinent as we approach the end of the "silicon era" when increases in processor power are predicted to reach their limit, still with no equivalent of human consciousness *in silico* on the horizon.

Another type of objection has focused on issues of embodiment: on the inadequacy of the Cartesian conception of mind as an informational pattern separable from the body, at the heart of the conceptions espoused by Kurzweil, Marvin Minsky, and Hans Moravec. Contrary to such Cartesian assumptions, Antonio Damasio, Francisco Varela, and other neuro- and cognitive scientists have shown that human consciousness is not localized in a set of neural connections in the brain alone, but is highly dependent on the material substrate of the biological body, with emotion and other dimensions as supportive structure.[6] Similarly, philosophers George Lakoff and Mark Johnson have argued that metaphors for embodied interactions with the world are the sources of higher-level representations of language and thought.[7]

However, there are many computer scientists, roboticists, and engineers of artificial intelligence who have not regarded these objections as insurmountable obstacles to constructing autonomous intelligent agents. In fact, improving computing power, designing improved computing architectures, and recognizing embodiment as crucial to the design of intelligent agents have been top items on their agendas for the last decade. Opinions differ as to the definition of the technical goals to be achieved, the means for reaching them,

5. Hubert Dreyfus, *What Computers Can't Do* (1972; rev. ed., New York: Harper and Row, 1979); Roger Penrose, *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics* (Oxford/New York: Oxford University Press, 1989); Hubert Dreyfus, *What Computers Still Can't Do* (Cambridge, Mass.: MIT Press, 1992).

6. Antonio Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Putnam, 1994); idem, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (New York: Harcourt Brace, 1999); Francisco J. Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge, Mass.: MIT Press, 1991).

7. George Lakoff, *Women, Fire and Dangerous Things: What Categories Reveal about the Mind* (Chicago: University of Chicago Press, 1989); Mark Johnson, *The Body in the Mind: The Bodily Basis of Imagination, Reason, and Meaning* (Chicago: University of Chicago Press, 1987).

and the place of humans in a future heavily populated with intelligent agents. Not everyone on the frontlines of robotics research shares Moravec's optimism about mapping neural structures with sufficient completeness, and migrating consciousness to other media, such as silicon. For instance, Danny Hillis, designer of the world's fastest computer, the Connection Machine, on the one hand agrees with Moravec and Minsky about the lack of a dividing line between human beings and machines; he holds too that the brain is a kind of computer, and that thought is a complex computation.[8] On the other hand, he (like others) argues, we may never be able to understand and map natural intelligence into a wiring diagram. Nevertheless, for Hillis this ultimate limitation does not imply that we cannot engineer an artificial intelligence eventually superior to human intelligence. He asserts that intelligence is really an emergent phenomenon, a complex behavior that self-organizes as a consequence of billions of tiny local interactions. This conception of intelligence leads him to predict: "We will not engineer an artificial intelligence; rather, we will set up the right conditions under which an intelligence can emerge. The greatest achievement of our technology may well be the creation of tools that allow us to go beyond engineering—that allow us to create more than we can understand."[9] From this perspective the future direction in question is not elimination of the human, but coevolution with artificial agents.

Indeed, critics of the disembodied mind are very much at home in the AI community. Fundamentally in agreement with the views of Damasio, Lakoff, and Johnson, Rodney Brooks has made situatedness and embodiment the two fundamental principles of his construction of humanoid robots.[10] While he agrees in principle that it may be possible to computationally simulate the brain, creating a virtual version running on a computer, he sees the problem as getting it to run in a different medium, such as silicon and metal, and this transfer might take a hundred years just to figure out. Brooks

8. Danny Hillis, *The Pattern on the Stone* (New York: Basic Books, 1998), pp. 75–76.

9. Ibid., p. 138.

10. Brooks defines *situatedness* and *embodied* as follows: "A situated creature or robot is one that is embedded in the world, and which does not deal with abstract descriptions, but through its sensors with the here and now of the world, which directly influences the behavior of the creature.

An embodied creature or robot is one that has a physical body and experiences the world, at least in part, directly through the influence of the world on that body. A more specialized type of embodiment occurs when the full extent of the creature is contained within that body" (Rodney Brooks, *Flesh and Machines: How Robots Will Change Us* [New York: Pantheon, 2002], pp. 51–52).

agrees too with Damasio and others that Kurzweil's approach neglects the crucial role played by the bath of neurotransmitters and hormones in which our neuronal cells swim: "It neglects the role of our body in placing constraints and providing noncomputational aspects to our existence," he writes; "It may be completely missing the *juice*."[11]

But while Brooks agrees that humanoid intelligence requires situatedness and embodiment, and therefore must be evolved through interaction with the environment and other creatures, he sees nothing mystical about carbon-based matter: "My own beliefs say that we are machines, and from that I conclude that there is no reason, in principle, that it is not possible to build a machine from silicon and steel that has both genuine emotions and consciousness."[12] This statement expresses an ideology reinforced by several powerful technical advances in computing over the past decade, rich ideas about the nature of computation, and amazing progress in both biotechnology and nanotechnology. Brooks's view, not only representing those of AI scientists and engineers but also rapidly becoming the view we all silently share, fuses perspectives from computing, communications technology, biotechnology, and nanotech into a powerful new technoscience. In this view, there are only assemblages of machines, whether in the domain of consciousness, intelligence, or other biological and material systems, and these constructions are all to be understood as different forms of computation. According to this view, the world is a collection of machines—indeed, a computer.[13]

During the 1980s and 1990s, arguments rejecting a possible merger of human and machine intelligence were sustained by what seemed insurmountable differences between the reasoning capabilities of computers and humans, as well as by the limitations of silicon-based computer architectures. Given the physical limitations to etching the circuitry required in silicon below 0.1 microns, in the late 1990s it seemed that processing power would be stalled at 100,000 MIPS (a MIP is one million instructions per second), whereas emulat-

11. Ibid., p. 206.

12. Ibid., p. 180.

13. For a discussion of the computational view of nature, see Tommaso Toffoli, "Physics and Computation," *International Journal of Theoretical Physics* 21 (1982): 165–175; Norman Magolus, "Looking at Nature as a Computer," unpublished manuscript June 20, 2002. *http://www.ai.mit.edu/people/nhm/looking-at-nature.pdf*; Neil Gershenfeld, *The Physics of Information Technology* (Cambridge: Cambridge University Press, 2000), chap. 15, pp. 252, 282–284. Also Neil Gershenfeld, *When Things Start to Think* (New York: Holt, 1999); and, of course, Stephen Wolfram, *A New Kind of Science* (Champaigne, Ill.: Wolfram Media, 2002).

ing the human brain would require a processing power of 100 million MIPS. But major breakthroughs in several areas—including single-electron transistors, quantum dots, quantum computing, and the beginnings of biological computing—have renewed the optimism of those who greet a posthuman future. Leonard Adelman launched the field of bio-molecular computing in 1994 with a demonstration that a DNA computer could be built which solved intractable mathematical problems, such as the traveling salesman problem.[14]

The first decade's work in this area offered no serious competition to silicon computing, but by 2003 a number of milestones marked the way for serious in vivo computing with biological cells. In 2001, Ehud Shapiro and colleagues at the Weizmann Institute in Israel implemented a Turing machine—a programmable finite automaton that converts information from one form into another according to a definite procedure—in a molecular "computer" consisting of a mixture of *Fok*I restriction nuclease, T4 DNA ligase, and ATP as "hardware," while the "software" consisted of eight short double-stranded DNA molecules used as input and transition rules. The DNA "software" was continuously ligated and cut by the enzymes, until it reached a final state—a defined sticky end—to which a "reporter" DNA was ligated, thus terminating the computation. This "device" was the first molecular computer to run autonomously without human-assisted protocols. While not practical as an alternative to silicon-based computing for desktop computers, this work makes palpable the idea of fusing biomolecular substrates with classical notions of computing, and it also points to the possibility of developing programmable control of intracellular processes to create molecular computing machines that can analyze situations in cells, and then synthesize molecules to deal with them. Cells can literally be programmed as input/output devices in order to harness the molecular self-assembly capabilities of DNA to build complex molecular structures for other purposes.

Similar work on chemical and biological computing has been pursued in many places. As part of an effort to learn how to control the chemical mechanisms of the cell for purposes of protein engineering, Tom Knight of the MIT Artificial Intelligence Laboratory and Ron Weiss of Princeton have worked on implementing digital circuits in DNA and inserting them into biological cells. The essential features of any digital logic implementation include the ability to

14. Leonard M. Adleman, "Molecular Computation of Solutions to Combinatorial Problems," *Science* 266: 5187 (1994): 1021–1024.

distinguish and maintain two distinct values of some physical representation of a signal. Knight and Weiss's approach is to co-opt existing biochemical machinery of DNA transcription and translation. Simple digital circuits are compiled as strings of DNA and inserted into *E. coli*. The naturally occurring mechanisms of controlled mRNA transcription, repressors, cooperative binding, and the degradation of mRNA and proteins provide a way to implement a logical inverter, the logical NOT gate. The "signals" in the logic system consist of concentrations of specific DNA-binding proteins, which act as repressors. These concentrations can be thought of as a simple integer count: how many protein molecules of a particular type exist within a single cell. By ensuring the appropriate nonlinear transfer curve in the inhibition (thus realizing two distinct values of the signal), the concentration of the transcribed protein is viewed as the logical inversion of the inhibitor protein. Other logical gates can be built on top of this one, giving rise to more complex computations performed within the cell. These molecular processes are quite slow and will not compete with silicon for speed, but the key point is that computation controls some internal processes of the cell. The resulting logic technology allows Knight and Weiss to engineer the chemical behavior of cells for use as sensors and effectors. By connecting these with cellular sensors and actuators, a cellular robot is born. Among the envisioned uses of such cellular robots is the construction of neural network modular implants for enhancing human capabilities in numerous areas such as vision or even reasoning.[15]

It is work such as this—the first building blocks of a controllable computation in biological substrates at nanoscale—that sustains confidence in a posthuman future already upon us. Rodney Brooks discusses the future of this merger of (nanoscale) robotic technology with biotechnology:

> We are on a path to changing our genome in profound ways. Not simple improvements toward ideal humans as is often feared. In reality, we will have the power to manipulate our own bodies in the way we currently manipulate the design of machines. We will have the keys to our own existence. There is no need to worry about mere robots taking over from us. We will be taking over

15. For examples of these directions of research, see Jessica O. Winter, Timothy Y. Liu, Brian A. Korgel, and Christine E. Schmidt, "Recognition Molecule Directed Interfacing Between Semiconductor Quantum Dots and Nerve Cells," *Advanced Materials* 13:22 (2001): 1673–1677; Nadrian C. Seeman and Angela M. Belcher, "Emulating Biology: Building Nanostructures from the Bottom up," *Proceedings of the National Academy of Sciences,* USA 99 (Suppl. 2) (2002): 6451–6455; Seung-Wuk Lee, Chuanbin Mao, Christine E. Flynn, and Angela M. Belcher, "Ordering of Quantum Dots Using Genetically Engineered Viruses," *Science* 296 (May 3, 2002): 892–895.

> from ourselves with manipulatable body plans and capabilities easily able to match that of any robot.[16]

Brooks's admonition that we are machines on a continuous path of coevolution with other machines prompts reflection on what we mean by "posthuman." If we are crossing to a new era of the posthuman, how have we gotten here? And how should we understand the process?

The papers in this volume begin from the assumption that the emergence of the "posthuman" is not a matter of technological determinism, of the needs and necessities of computer processor improvements anastomosing the unwitting aid of human agency with biotechnology to produce a new life form. As Kate Hayles has reminded us, the posthuman, like the human, is a hybrid entity constructed through networks that are materially real, socially regulated, and discursively constructed.[17] The startlingly different ways of describing humans as machines offered by Brooks, Hillis, Moravec, and Minsky remind us that our notion of the body is a cultural construct, a historical conception both contested and negotiated. This conception is not an inevitability springing from either technologically determined processes or our immediate experience; rather, it is an interpretive frame we coconstruct along with our machines and the worlds they inhabit. Thinking about how we became—and are still becoming—posthuman in these terms allows us to deconstruct the process, to understand and to contest its meaning.

Important opportunities and consequences are at stake in this investigation. One of the central threads of discourse constructing the posthuman is the notion that information is disembodied, a pattern independent of a specific material medium, capable of being rewritten into different substrates. As Hayles shows in *How We Became Posthuman*, this notion grew in tandem with deep concerns about preserving the liberal humanist subject dear to the creators of the first wave of cybernetics. The liberal humanist subject was conceived as a rational, self-regulating, free, and autonomous individual with clearly demarcated boundaries and a sense of agency linked with a belief in enlightened self-interest. Cybernetics was envisioned by scientists and engineers such as Norbert Wiener, Warren McCulloch, and their colleagues at the Macy Conferences as a way to maximize human potential in a chaotic and unpredictable postwar world. They wanted to ensure a position of mastery and control for the liberal subject removed from the noise and chaos. The vision of the

16. Brooks, *Flesh and Machines* (above, n. 10), p. 236.

17. Hayles, *How We Became Posthuman* (above, n. 1), p. 291.

posthuman emerging from the work of Moravec, Minksy, and others, Hayles has argued, simply reinscribes that liberal humanist subject—indeed, seeks to immortalize it in future generations of software and hardware. For those convinced that this view of the subject underpins a sense of manifest destiny to dominate and control nature that has been detrimental to women, to other (particularly non-Western) cultures, and to other life-forms, engaging the techniques through which the posthuman is emerging offers an opportunity to contend for a different vision. We need not simply acquiesce in a view of the posthuman as an apocalyptic erasure of human subjectivity, for the posthuman can be made to stand for a positive partnership between nature, humans, and intelligent machines.[18]

In order to explore the processes at work constituting the posthuman, the essays in this volume can best be situated in a framework of analysis proposed both by Hayles in *How We Became Posthuman*, and by Elizabeth Grosz in *Volatile Bodies: Toward a Corporeal Feminism* and *Architecture from the Outside*. Hayles and Grosz both advocate a distinction between the body as a cultural construct and the experiences of embodiment that individual people within a culture feel and articulate.[19] "The body" is an abstraction, implied by heterogeneous, overlapping systems of discourse and material practices; it is produced by medical, legal, political, and economic regulations, norms, and conceptualizations applied to actual physical bodies as objects to be ordered, organized, and interpreted. On the other side of these concepts and schemas for action are the individual material body and its experiences, which, though interpreted by the individual him- or herself and society in terms of "the body," are never fully captured and assimilated into discourse. The two poles stand in tension and are constantly interacting with one another. Discursive constructions of the body are constantly applied to embodied action, while inadequacies of fit among abstraction, intention, and individual experience open fissures that motivate efforts to modify or build different discursive regimes.

18. For a similar discussion of the body as the primary sociocultural product and engagement with virtual reality as an opportunity for feminist rethinking of the production of alternative models, registers, alignments, perspectives, and corporealities other than the functioning male body under the name of the "neutral human," see Elizabeth Grosz, *Architecture from the Outside: Essays on Virtual and Real Space* (Cambridge, Mass.: MIT Press, 2001), esp. ch. 2, "Lived Spatiality (The Spaces of Corporeal Desire)," pp. 31–47.

19. Hayles, *How We Became Posthuman* (above, n. 1), esp. chap. 8, "The Materiality of Informatics," pp. 192–207; Elizabeth Grosz, *Volatile Bodies: Toward a Corporeal Feminism* (Bloomington: Indiana University Press 1994), esp. p. 19; idem, *Architecture from the Outside*, pp. 49–54.

Understanding how discursive constructions relate to embodiment requires the examination of another set of processes poised in dynamic tension: namely, processes of inscription and incorporation. If the scientists, engineers, philosophers, and media theorists we have been discussing are correct that we are crossing to a posthuman era characterized by a seamless articulation of intelligent machines and human being, major transitions will be required in our material practices, schemas of action, behavior, bodily habits—indeed, in our material bodies themselves. We need to explore not only the content of inscription (philosophical debates and abstract ideologies, along with representations of the posthuman in fiction, film, videogames, and other media), but also the technologies of inscription: computer code, object-oriented languages, algorithms, chips, "smart" fabrics, nanodevices, radio frequency ID tags, and molecular assemblages—all the means for incorporating representations of the posthuman and improvising new repertoires of physical gesture and performance. We need to understand how the posthuman "gets under our skin," to use Bernadette Wegenstein's metaphor—both figuratively, in the sense of images and advertising campaigns attempting to shape our cultural imaginary, and literally, in the interfaces of machinic relays with the body.

As examples of how these processes of inscription and incorporation might work in the generation of a posthuman future, we need not look to distant cellular robots. A shift in the habits of professional communities, such as surgeons, is already well under way. In the field of telesurgery, for instance—a "field" that a decade ago seemed like utter science fiction—surgeons work collaboratively with intelligent agent technology and surgical robots to perform complex procedures beyond the capabilities of earlier advanced surgical technique. A prominent recent example is the completely closed-chest endoscopic bypass surgery performed with a telesurgical system manufactured by Intuitive Surgical of Palo Alto, California. While not currently widely available, such systems are working their way into broad areas of medical practice. Effectively, such fusions of computer technology and surgical technique transform the skills, perceptions, and material practices of surgeons, eventually becoming the modus operandi of their everyday work.[20]

Such arenas in medicine are developing today, but even these are too exotic to capture the pervasive nature of computer inscriptions

20. See Timothy Lenoir and Sha Xin Wei, "Authorship and Surgery: The Shifting Ontology of the Virtual Surgeon," in *From Energy to Information: Representation in Science, Art, and Literature*, ed. Linda Henderson and Bruce Clarke (Stanford: Stanford University Press, 2002), pp. 283–308.

and incorporations. We might consider the ordinary bar code, the universal identifier for nearly every manufactured item on the planet. Today's familiar bar codes are passive, registering information only when scanned by a laser that transmits the bar code's digital information. Large-scale initiatives are under way to introduce enhanced versions of bar codes that will actively transmit all sorts of data, a system called radio frequency identification (RFID) tagging.[21] An RFID "tag" is a wireless semiconductor integrated circuit that stores an ID number in its memory and transmits that ID, as well as potential access to other information, through networked databases when accessed by, for instance, a Web browser. Standards have been agreed upon for manufacturing these devices, which are currently being produced at the size of 0.44 mm square, about the size of a large grain of dust. Hitachi Corp., for instance, is producing an RFID chip called the mu-chip. The mu-chip uses the frequency of 2.4 GHz—the same as cell phones, wireless computers, and handheld personal digital assistants. It has a 128-bit ROM for storing the ID. Its unique ID numbers can be used to identify individually trillions of objects, with no duplication. Moreover, with a size of 0.4 mm square, the mu-chip is small enough to be attached to a variety of minute objects; it can even be embedded in paper. Manufacturing, distribution, and tracking systems can be built or enhanced using the mu-chip with an event-driven accumulation of, and on-demand access to, information stored in a database through the network.

A number of major corporations are experimenting with these technologies as a means for generating ubiquitous computing environments. One of the most interesting experiments is Hewlett-Packard's project "cooltown." Cooltown's creators greet visitors in this manner:

> Welcome to cooltown, our vision of a technology future where people, places, and things are first class citizens of the connected world, wired and wireless—a place where e-services meet the physical world, where humans are mobile, devices and services are federated and context-aware, and everything has a web

21. For detailed information on this ongoing initiative see the website of the collaborative MIT/Cambridge University project, AutoID, the goals of which are described on the project homepage *http://www.autoidcenter.org/*:

> We are on the brink of a revolution of "smart products" that will interconnect everyday objects, consumers, and manufacturers in a dynamic cycle of world commerce. In October 1999, the Uniform Code Council (creators of the UPC) joined with MIT, Procter & Gamble, and The Gillette Company to make their vision of forming one seamless global commerce network a reality. Corporate and industrial sponsors have invested their participation and funding on a variety of levels in recognition of their integral role in helping develop a technology that will shape a new world of optimally efficient and beneficial global commerce.

> presence. In cooltown, technology transforms human experience from consumer lifestyles to business processes by enabling mobility. Cooltown is infused with the energy of the online world, and web-based appliances and e-services give you what you need when and where you need it for work, play, life.[22]

Don't mistake this for the scene from the 2002 film *Minority Report*, where characters in a futuristic world are personally greeted by the smart walls of a department store. That scene could happen today in cooltown, or even in one of the new Rem Koolhaas–designed Prada stores. Through the use of RFID tagging, as well as other types of "smart" materials, persons with network access in places like cooltown will be able to "surf" reality. The virtual world of cyberspace and the physical environment are seamlessly connected. Soon the increasing numbers of AI agents that assist us in a variety of Web-related tasks will be physically present to us as companions as we start the day at our local Starbucks.

Many of the papers in this volume investigate such areas of inscription and incorporation, redefining both the body and our experience of embodiment. In so doing, they contest the widely held notion that information itself is disembodied. There have been, of course, many sources for this notion, but they share a general sense that digital media entail a loss of reference. One of the most prevalent disseminators of this idea was Jean Baudrillard's periodization of the present as the age of simulacra, an age that he characterized by a liquidation of reference, truth, and objectivity: "an age in which the hyperreal—the generation of models of a real without origin or reality—replaces the real."[23] During the 1980s such notions were promoted and reinforced by the rise of digital imaging and computer graphics that disrupted the traditional relationship of observer and representation—and indeed, digital image-processing in relation to photography was a major source for Baudrillard's ideas on the age of simulacra.[24] Whereas photographs adhere to reality by virtue of their physical modes of production, digital images are fabricated through layers of algorithmic computer processing, with no trace of the materially mimetic qualities of film, (predigital) photography, or television. Citing 1989 as the dawn of the postphotographic era when digital recording and processing began to replace photography, William Mitchell claims that the connection of images to solid substance has become tenuous: "The currency of the great bank of nature has left

22. http://cooltown.hp.com/.

23. Jean Baudrillard, *Simulations* (New York: Semiotext(e), 1983), pp. 2–4.

24. See Andrew Darley, *Visual Digital Culture: Surface Play and Spectacle in New Media Genres* (New York: Routledge, 2000), pp. 59–64.

the gold standard. Images in the post-photographic era can no longer be guaranteed as visual truth—or even as signifiers with stable meaning and value."[25]

From the loss of reference in the production of images, another step in this line of reasoning directs concern to a profound shift in the institutions constituting the subjectivity of the viewer, and indeed, even the dematerialization of the observer altogether. The works of architect/philosopher Paul Virilio and art historian Jonathan Crary are among those expressing this line of reasoning.[26] While Crary does not claim that familiar modes of seeing are completely disappearing, he has argued that new technologies of image production have become broadly institutionalized within the military, medicine, science, media, and the arts, with a concomitant restructuring of traditional institutions, transformation of social practices, and instantiation of new belief structures. According to Mitchell, "A worldwide network of digital imaging systems is swiftly, silently constituting itself as the decentered subject's reconfigured eye."[27] For Crary, the shift taking place in visual culture due to computer-based image processing signals that important functions of the human eye are being supplanted by practices in which visual images no longer have any reference to the position of an observer in a "real," optically perceived world:

> If these images can be said to refer to anything it is to millions of bits of electronic mathematical data. Increasingly, visuality will be situated on a cybernetic and electromagnetic terrain where abstract visual and linguistic elements coincide and are consumed, circulated, and exchanged globally.[28]

For Crary, as for Mitchell, in the shift to digitality the embodied human observer with her repertoire of techniques for decoding sensations is displaced by a new abstract regime of computer code, where standards of vision are set by machinic processes of pattern recognition and statistical sampling. With the advent of computer tech-

25. William J. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* (Cambridge, Mass.: MIT Press, 1992), p. 57. Mitchell noted that in 1989, the sesquicentennial year of the invention of photography, 10 percent of all photographs were touched up by digital processing: "And the opening of the 1990s will be remembered as . . . the time at which the computer-processed digital image began to supersede the image fixed in silver-based photographic emulsion" (ibid., p. 20).

26. See Paul Virilio, *The Vision Machine,* trans. Julie Rose (Bloomington: Indiana University Press, 1994).

27. Mitchell, *Reconfigured Eye* (above, n. 25), p. 85.

28. Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, Mass.: MIT Press, 1992), p. 2.

nology that allows a satellite, MRI scanner, or tunneling microscope to capture and process an image, and then send it to another computer where the image is analyzed and interpreted in terms of other algorithms and data-processing techniques, vision becomes machinic; and in the process, human observers are placed on the same plane as machines of vision.[29]

The work of Crary, Virilio, Mitchell, and others has directed attention to the power of manipulation inherent in new visualization technologies, and the tendency of digital imaging to detach the viewer from an embodied, haptic sense of physical location and being-there. Reflections on problems of reference connected with digital imaging were magnified and extended to other senses with the introduction of early work on Virtual Reality in the mid-1980s and early 1990s. But even prior to the development of practical VR systems, critical and popular discourse around Virtual Reality and its representation in literature and film coded the perception of new electronic media as abstract, disembodied, and decontextualized information. Ivan Sutherland, who constructed the first head-mounted display in the 1960s preparing the way for experimentation with VR, discussed the potential of VR in his 1965 paper, "The Ultimate Display." Sutherland emphasized the power of a digital display connected to a computer to explore mathematical simulations and concepts not realizable in physical space: "There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality," he wrote: "The ultimate display would, of course, be a room within which the computer can control the existence of matter."[30] Picking up on the notion of Virtual Reality as providing access to an abstract transcendent realm, in the first cyberpunk novel, *Neuromancer,* William Gibson defined cyberspace as "a consensual hallucination" and as "the nonspace of the mind."[31] Such ideas were given powerful visual presentation in numerous popular films from 1982 to 1992, bracketed by *Tron* (1982) and *Lawnmower Man* (1992), in which protagonists are uploaded through the net

29. See John Johnston, "Machinic Vision" *Critical Inquiry* 26 (Autumn 1999): 27–48. Johnston urges us to consider machinic vision as broader than simply reduction to technological image processing: "Machinic vision, . . . presupposes not only an environment of interacting machines and human-machine systems but a field of decoded perceptions that, whether or not produced by or issuing from these machines, assume their full intelligibility only in relation to them" (p. 27).

30. Ivan Sutherland, "The Ultimate Display," *Proceedings of the International Federation of Information Processing Congress 1965* (New York, [May]1965), vol. 2, pp. 506–508.

31. William Gibson, *Neuromancer* (New York: Ace, 1984), p. 51.

into cyberspace, and where bodies as informational patterns fuse in the ecstasy of virtual sex.

The papers in this volume all address the issues of inscription and incorporation, and they are all concerned with issues of embodiment in posthuman media-rich environments. They all begin from the premise that a posthuman future is already upon us, and—affirming a call made by Donna Haraway over a decade ago that, as "[a]nthropologists of possible selves, we are technicians of realizable futures"[32]—these papers all argue that the time to intervene actively in the metamorphoses of our posthuman futures is now. Both Bernadette Wegenstein and Colin Milburn examine semiotic techniques and narrative strategies by which constructions of desire and fictions of a posthuman imaginary "get under the skin" and are made to appear transparent expressions of the natural world and our experience. Key to their work is the dissolution of boundaries between bodies and machines, the blurring of hardware and life. Wegenstein argues that beyond Deleuze and Guattari's call for "bodies without organs," the body at the turn of the millennium has turned into an "organ without a body," or better yet into an "organ instead of a body." Analyzing examples from cosmetic advertising, media art, and other sources of popular culture, she concludes that in this move "under the skin" organs adopt (inter)faces turning the body into a "flattened" screen, a surface of reflection, in other words, a medium in itself. It is no longer just that we construct machines to model aspects of biological function: the new nanomachines shaping the posthuman depend on utilizing the biological machine as the model for the nanomachine—achieving, as Milburn notes, a terminal circularity.

Focusing on both scientific and science-fictional writing connected with nanotechnology, Milburn articulates a narrative strategy he calls "nanologic." In this logic, science and science fiction negatively define each other, and though each is required for the other's structural existence, science fiction is the diminished and illegitimate term, the parasitical simulation of science. Within the technoscapes and dreamscapes of nanotechnology, Milburn argues, the biological and the technological interpenetrate, science and science fiction merge, and our lives are rewritten by the new "nanological" way of seeing that results from that splice. Milburn contends that

32. Donna J. Haraway, "The Biopolitics of Postmodern Bodies: Constitutions of Self in Immune System Discourse," in idem, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), p. 230. Chris Hables Gray reiterates this need for "participatory cyborg evolution" in his recent political mapping of posthumanism, *Cyborg Citizen: Politics in the Posthuman Age* (London/New York: Routledge, 2001).

embodiment is central to nanonarratives. Rather than purveying a posthumanism in which the subject is in danger of losing the body, nanonarrative reduces everything to pure materiality, demolishing metaphysical categories of identity. Accordingly, nanologic does not support any sort of abstracted, theoretical construction of the body because nanotech puts the body's surfaces and interiors into constant flux. The posthuman bodies conditioned by nanologic are therefore always individuated experiences of embodiment in an endless array of possible bodily conformations, where all borders are fair game.

N. Katherine Hayles's essay in this volume extends the treatment of posthuman embodiment begun in *How We Became Posthuman*. In reflecting on that earlier text, she states that she has come to feel that while rejecting the Cartesian conception of a disembodied mind, she did not elaborate clearly enough what the alternative would be. Here, drawing further upon the work of Damasio, and especially upon Edwin Hutchins's thesis from *Cognition in the Wild* that human reasoning should be considered as situated and distributed, she argues that reasoning is heavily context-dependent, using the environment as prop and affordance in negotiating its intentions.[33] Carrying this idea further, Hayles applauds Andy Clark's notion of extended mind, where body boundaries are treated as fluidly intermingled with technological affordances, and she adopts Clark's notion that we are cyborgs: "not in the merely superficial sense of combining flesh and wires, but in the more profound sense of being human-technology symbiots: thinking and reasoning systems whose minds and selves are spread across biological brain and non-biological circuitry."[34] Like Hutchins and Clark, Hayles argues that in the world of smart appliances it becomes harder and harder to say where the world stops and the person begins.

Crucially in this essay, Hayles illustrates how we might embrace the posthuman as the occasion to rethink the mind/body split and the premise that mind and body, like the rest of the world, preexist our experiences of them. She draws upon several Virtual Reality installations from the summer of 2001, each of which illustrates aspects of her critique of the rhetoric of disembodiment and demonstrates what "incorporation" of distributed cognition implies. "Traces," "Einstein's Brain," and "NØtime" provide rich experiential instances of the claim that bodies and subjects are constituted in an

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

34. See Andy Clark, "Natural Born Cyborgs?" The Edge: Third Culture, 12.29.2000, p. 4: *http://www.edge.org/3rd_culture/clark/clark_p4.html*.

emergent dynamic involving multiple agencies—including the desires of the subject, the cultural formations within which identities can be enacted and performed, and the social interactions that circulate through networks such as the World Wide Web. Rather than a pregiven static platform for the self, Hayles uses these provocative installations to explore the meaning of emergent selves.

In two recent books and several essays, Mark Hansen has addressed the issues of embodiment and visuality.[35] In contrast to the views of early theorists of digital media who focused on visual media as sites of disembodiment, he has developed a new phenomenology, elaborated in dialogue with the works of Henri Bergson and Gilles Deleuze, which emphasizes the role of the affective, proprioceptive, and tactile dimensions of experience in the constitution of space. For Hansen, visuality is shaped in terms of these more visceral bodily elements rather than by the abstract power of sight, and he maintains that the body continues to be the active framer of the image, even in a digital regime.

In the essay included here, Hansen explores these issues in connection with digital design in architecture. The *Blur Building* of Diller + Scofidio, a massive fog-installation on Lake Geneva, is particularly powerful in illustrating Hansen's point. He shows that what is at stake in the *Blur Building* is not simply a "seeing that can no longer interpret,"[36] but a wholesale short-circuiting of the role of vision, such that the affective body is literally compelled to "space the void." The *Blur Building* displaces the visible, planimetric enclosure we are accustomed to experience as architectural space by an amorphous, atmospheric fog enclosure. By interrupting the visual sense with the dynamic amorphous fog mass, Diller + Scofidio engage an alternate spatial sense and with it an entirely different kind of space. Through effective use of electronic media, the experiment catalyzes a fundamental shift in the sensory economy of the body—from a frontal, visually dominant modality to a longitudinal modality that draws heavily on both hearing and touch, as well as specifically bodily senses such as proprioception—and in doing so, it generates a profoundly intensive spatial experience. Hansen argues that this shift in the body's sensory economy cannot be solely a projection from within the body; rather, it results from an encounter between the body and the dimensions of space released through the crossover of

35. See esp., Mark Hansen, *New Philosophy for New Media* (Cambridge, Mass.: MIT Press, forthcoming).

36. Peter Eisenman, "Visions Unfolding: Architecture in the Age of Electronic Media," in Luca Galafaro, *Digital Eisenman: An Office of the Electronic Era* (Basel: Birkhäuser, 1990), p. 84.

architecture and the electronic technologies employed in the *Blur Building*. As in the case of the media art installations that Hayles discusses, space becomes an emergent, deeply embodied phenomenon. This encounter of bodily affectivity and interstitial spacing is immediate and can be experienced explicitly within the confines of the bodily inhabitation of the Blur: indeed, in the *Blur Building*, digital electronics become palpable as "habitable medium," and space, according to Hansen, becomes wearable.