DATA MADE FLESH

BIOTECHNOLOGY AND THE DISCOURSE OF THE POSTHUMAN

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> *Then you could throw yourself into a highspeed drift and skid, totally engaged but set apart from it all, and all around you the dance of biz, information interacting, data made flesh in the mazes of the black market.*
>
> —William Gibson, *Neuromancer*

NEW BODIES, NEW MEDIA?

Over the past few years, it has become increasingly commonplace to come across a new vocabulary in mainstream media reportage: headlines about "genomes," "proteomes," "stem cells," "SNPs," "microarrays," and other mysterious biological entities have populated the many reports on biotechnology. The completion of human genome projects, policy decisions concerning the use of embryonic stem cells, controversies over genetic patenting, and the ongoing debates over human therapeutic cloning are just some of the issues that biotech research brings to public discussion. For many advocates as well as detractors, the so-called biotech century appears to be well underway.

But we might be a little more specific in describing biotech, which is for many becoming the new paradigm in the life sciences and medical research. This is to suggest that one of the main things that characterizes biotech currently is an intersection of bioscience and computer science or, to put it another way, an intersection between genetic and computer "codes." Within biotech research, this is known as the field of bioinformatics, which is simply the application of computer technology to life science research. Its products include on-line genome databases, automated gene-sequencing computers, DNA diagnostic tools, and advanced data-mining and gene-discovery software applications. When we consider advances in

these fields, it becomes apparent that biotech is a unique relationship between the biological and the informatic. As Craig Venter, CEO of Celera Genomics, states, "We are as much an infotech as a biotech company"; a notion reiterated by Ben Rosen, chairman of Compaq Computing, who states that "biology is becoming an information science."

The questions these mergers between biotech and infotech bring up are many: What does it mean to have a body, to be a body, in relation to genome databases? How is our notion of the body transformed when biotech research demonstrates the ability to grow cells, tissues, and even organs in the lab? How is the boundary between biology and technology reconfigured with the DNA chips commonly used in biotech labs? In biotech research, what happens to the referent of "the human" as it is increasingly networked through information technologies?

Between biology and technology, genetics and computer science, DNA and binary code is a more fundamental relationship between human and machine. I will take "posthumanism" as a wide-ranging set of discourses that, philosophically speaking, contain two main threads in its approach to the relationship between human and machine. The first thread I will refer to as "extropianism," which includes theoretical-technical inquiries into the next phase of the human condition through advances in science and technology. These are mostly technophilic accounts of the radical changes that leading-edge technologies will bring. The first part of this paper will be spent analyzing and critiquing the extropian branch of posthumanist thought, especially as it relates to the ways in which the term "information" is defined. The second thread is a more critical posthumanism, often in response to the first, and includes key texts by contemporary cultural theorists bringing together the implications of postmodern theories of the subject and the politics of new technologies. The second part will consider research in biotechnology in light of posthuman discourses. While biotech research raises many of the issues common to both the extropian and critical posthumanist discourses, it also elucidates unique relationships between human and machine, flesh and data, genetic and computer "codes." Both threads offer valuable insights into the ways in which notions of "the human" diversify, self-transform, and mutate as rapidly as do new technologies.

EXTROPIAN INVASION

There is a growing body of research, both theoretical and practical, on the ways in which advanced technologies—from nanotechnology to neural computing—will enhance, augment, and advance the human into a posthuman future. Scientist-theorists, such as Hans Moravec, Ray Kurzweil, Marvin Minsky, and Richard Dawkins, have all been associated with this line of thinking. Organizations such as the Extropy Institute and the World Transhumanist Organization have also been instrumental in creating networked communities based on transhumanist and extropian ideas.

One salient feature of such transformations includes the concept of "uploading," in which the parallels between neural pattern activity in the human mind and the capacity of advanced neural networking computing will enable humans to transfer their minds into more durable (read: immortal) hardware systems (Moravec 1988, 109–10). All of this is made possible via a view of the body that places special emphasis on informational pattern. Once the brain can be analyzed as a set of informational channels, then it follows that that pattern can be replicated in hardware and software systems. As Ray Kurzweil states:

> Up until now, our mortality was tied to the longevity of our hardware. When the hardware crashed, that was it. For many of our forebears, the hardware gradually deteriorated before it disintegrated.... As we cross the divide to instantiate ourselves into our computational technology, our identity will be based on our evolving mind file. We will be software, not hardware.... the essence of our identity will switch to the permanence of our software. (Kurzweil 1999, 128–29)

Other changes include the transformation of the material world, including the biological domain, through nanotechnology (the construction of organic and nonorganic objects atom by atom, molecule by molecule), new relationships to the environment through biotechnology, and the emergence of intelligent computing systems to enhance the human mind.

A key feature of this type of posthumanism—which I will generally refer to as "extropianism"—is that it consciously models itself as a type of humanism. That is, like the types of humanisms associated

with the Enlightenment, the humanism of extropianism places at its center certain unique qualities of the human—self-awareness, consciousness and reflection, self-direction and development, the capacity for scientific and technological progress, and the valuation of rational thought. As Max More's "The Extropian Principles: A Transhumanist Declaration" (1999) cites, key principles include "perpetual progress," "self-transformation," "practical optimism," "intelligent technology," "open society," "self-direction," and "rational thinking."

Like the Enlightenment's view of science and technology, extropians also take technological development as inevitable progress for the human. The technologies of robotics, nanotech, cryonics, and neural nets all offer modes of enhancing, augmenting, and improving the human condition. As the "Transhumanist Declaration" states:

> Like humanists, transhumanists favor reason, progress, and values centered on our well being rather than on external religious authority. Transhumanists take humanism further by challenging human limits by means of science and technology combined with critical and creative thinking. We challenge the inevitability of aging and death, and we seek continuing enhancements to our intellectual abilities, our physical capacities, and our emotional development. We see humanity as a transitory stage in the evolutionary development of intelligence. We advocate using science to accelerate our move from human to a transhuman or posthuman condition. (More 1999, paragraph 3)

A key element in the extropian approach toward technology is that technological progress will necessarily mean a progress in "the human" as a species and as a society; that is, just as the human will be transformed through these technologies, it will also maintain, assumedly, something essential of itself. It is in this tension between identity and radical change, between visions of software minds and the realities of biological bodies, that extropianism reveals the inner tensions of posthumanist thinking. As a particular thread in the discourse of the posthuman, extropianism can be characterized along three main lines: as a technologically biased revision of European humanism, as an approach to technology as both self and not-self, and as a tendency to apply life science concepts toward social and political problematics. A further elaboration of these trends follows.

Humanism

The self-referential move of extropianism as an "upgraded" humanism is strategic; it enables posthumanism generally to replay the centrality of human forces in shaping the world through science and technology without any passive reliance on Luddite ideologies, "nature," or religious authority. Seen as a form of humanism, the posthuman puts leading-edge technologies in the hands of human subjects as agents of change. Historically, this moves beyond the control over the natural environment encapsulated by Western industrialism; it moves toward a wholesale transformation not only of the environment but of the human controllers of that environment.

The blind spot of this thread of posthumanism is that the ways in which technologies are themselves actively involved in shaping the world are not considered. To borrow a term from Bruno Latour, extropianism privileges the technologically enabled subject as the agent of change, without due consideration to the ways in which "nonhumans" and "actants" are also actively involved in the transformation of the world (Latour 1999, 122–23). This is not to suggest that we somehow invest our technologies with human subjectivity, but that the situated, contingent effects of technologies are indissociable from the subjects that "use" those technologies. While the humanist slant of extropian thinking clearly privileges a futuristic vision serving the human (postbiological life in hardware systems, intelligence-augmented minds, and, closer to the present, extended life span, genetically modified health, and smart drugs), what remains unclear for the extropians is the extent to which the human can be transformed and still remain "human."

Extropianism escapes this problem by claiming a universality to certain attributes, such as reason, intelligence, self-realization, egalitarianism, ethical thinking, and transcendence. By assuming that "intelligence" and "sentience" will remain constants over time and through successive transformations, extropianism smuggles humanist-based conceit into a technologically driven evolutionary paradigm. The conflicts arise when posthuman thinkers must consider the fate of the human or its history. What often goes unconsidered are the ways in which the human has always been posthuman and the ways

in which technology has always operated as a nonhuman actant
(Ansell-Pearson 1997, 123–50; Latour 1999, 174–216).

Tech Tools

One of the crucial requirements for the posthuman is that technology
be approached first and foremost as a tool. This technology-as-tool
motif—an investment in enabling technology—operates in several
ways. In one sense it presupposes and requires a boundary manage-
ment between human and machine, biology and technology, nature
and culture. In this way extropianism necessitates an ontological sep-
aration between human and machine. It needs this segregation in
order to guarantee the agency of human subjects in determining their
own future and in using new technologies to attain that future. It is
asymmetrical, in which the human subject is the actor and the technol-
ogy is the prosthetic that the human subject uses (Hayles 1999, 2–3).

This separation also provides the assurance of the neutrality of
technology. As Marshall McLuhan long ago argued, the most dan-
gerous position vis-à-vis technology is to assume its neutrality
(McLuhan 1995, 11–12). In this way, the safe, secure space of pure
research can provide for a range of utopian possibilities without
regard to the historical, social, and political contingencies that en-
frame each technological development. Thus the human—or rather a
humanist standpoint—becomes the safeguard against the threat of
technological determinism. It is the human user that guarantees the
right, beneficial use of otherwise value-neutral technologies.

Lastly, the ontological separation of human and machine is also
the establishment of a certain distance between the natural and tech-
nical domains, and this distance provides a source of security for the
ongoing development of the human as a product of evolution. By taking
technology as transparent, extropianism can suggest that it will change,
benefit, and improve the human in a manner totally amenable to the
norms of all institutional, governmental, and technological contexts.

Thus technology operates in a complex way for the extropian
branch of posthumanism. It is taken as a tool, one that is both trans-
parent and value-neutral, and thus abstracted from any sociohistorical
contingencies. But this ontological separation also hides a fantasy of

technology embedded in the posthuman generally: a fantasy about the anachronism of technology, in which the human advances so far that it doesn't need technology, that technology in effect disappears. The goal here is to attain a state of optimum self-sufficiency, autonomy, and self-realization such that the management of the human/machine divide is, in fact, no longer necessary. While in one sense this would seem tantamount to saying that the human becomes technology, the rhetoric of extropianism is—like that of most technophilic movements—about the world in the service of the human (be it the natural world, as in biotech, or the artificial world, as in AI).

SF Politics

A common political strategy in extropian texts when dealing with social concerns is to apply concepts from science and technology toward the political domain. The most common such trope used is that of biological evolution, in which the co-evolution of humans and machines will lead to a postevolutionary phase in which the abstract "emergence" of intelligent computers will dominate (that is, the democratization of biology-as-politics, from linear, hierarchical trees to planar, brainy complexity) (Kurzweil 1999, 40–51, 101–33).

The Extropy Institute's emphasis on "open society" and "self-realization" (among other terms) illustrates this tendency to conflate the stratifications between the discourse of science and political discourse. This is indicated by the common absence of the issues of race and ethnicity, gender and sexuality, public policy, governmentality, warfare, and global economics in most extropian texts. Similarly, Kurzweil applies evolutionary thinking to technological development, arguing that human societies are currently undergoing a kind of exponential evolution—what he terms "the law of accelerating returns" (1999, 29–30). In the domain of the life sciences, such formulations are analogous to Richard Dawkins's sociobiological theories of "memes," or the DNA of culture—units that replicate, hybridize, and spread throughout a cultural context (such as concepts, fashion, songs, and so on) (Dawkins 1976, 189–202).

The bottom line for extropian thinking is the human subject as a biological animal, the individual or population as a species. Yet the vision of a posthuman future is predicated on the (technical) capacity

to surpass this "merely" material foundation. From this biopoliti-
cal stance, scientific and technological concepts are completely trans-
parent, and it is from these models (such as molecular genetics and
evolution) that the capacities, constraints, and mobilities of human
beings in social and political contexts are measured.

What warrants a critique of extropianism's particular use of sci-
entific concepts as political platforms is that, quite simply, they don't
hold water. Any critical interrogation of the relationships between
scientific and political discourses needs to pay attention to the con-
tingencies involved in producing scientific concepts and artifacts,
while not simply denouncing scientific discourse as pure construction.
In the best-case scenario, scientific concepts can transform politics,
just as such applications will reveal the limitations of the ideologies
embedded in scientific concepts.

OTHER POSTHUMANISMS

One of the most resonant aspects of Donna Haraway's 1985 "Cyborg
Manifesto" was that its appropriation of the terminology of the
cyborg was itself a performative gesture against the necessity of ori-
gin stories (Haraway 1991, 180–81). By strategically borrowing the
figure of the cyborg from space-race-era NASA research into enabling
astronauts to survive in "alien" or extraterrestrial environments,
Haraway shows how the doubled contingency of humans and tech-
nologies will always require critical gestures, ironic gestures, even
ludic gestures, which will turn upside down, and render impure and
noninnocent, our views of the human condition.

This move is also a key element to the more critical threads of
posthumanist thinking, which are often interventions in the overtly
utopic postulations of thinkers like Moravec and those associated
with extropianism above. Theorists such as Haraway, Katherine
Hayles, Rosi Braidotti, Scott Bukatman, and Keith Ansell-Pearson
have shown how any critical perspective on the human-technology
relationship will have to pay special attention to the underlying
assumptions in place in declarations such as those by the Extropy
Institute. While not denying the significance and transformative pos-
sibilities of new technologies, these critical takes on the posthuman

offer a more rigorous, politically and socially rooted body of work from which the difficult task to imagining the future may begin.

For instance, Haraway's focus after the "Cyborg Manifesto" has been on the ways in which the technosciences (especially immunology, molecular genetics, and ecoscience) are constantly producing new "material-semiotic nodes" in the ongoing debate of what counts or what matters as human. These unique, hybrid objects—the transgenic mouse, the genome map, AIDS—challenge our conceptions of the sharp division between active subjects and passive objects. Indeed, such developments in genetics challenge us to find the supposedly definite boundary of the human at all.

While Haraway's focus has primarily been the life sciences, Katherine Hayles has offered several pointed, detailed analyses of posthumanist thinking (in its extropian vein) (1999). Focusing on research in advanced computing and cybernetics (AI, robotics, emergence, cognition), Hayles shows that the posthuman is founded on a strategic definition of "information." This modern notion of information—most notably in the extropian concept of uploading—does not exclude the body or the biological/material domain from mind or consciousness, but rather takes the material world as information. This powerful ideology not only informs research in cognitive science but in the life sciences as well. Hayles's critical point is that informatics is a selective process, and those things that are filtered or transformed in that process—such as a notion of the phenomenological, experiential body, or "embodiment"—simply become by-products of an informatic economy.

Both Haraway and Hayles have taken up the discourse of the posthuman and have provided articulate analysis and critique while not totally denouncing posthumanism itself. The result, as with Haraway's strategic appropriation of the cyborg, is a new hybrid discourse that emphasizes the productive tensions between contingency and emergence. For Haraway, the posthuman can thus become a unique type of politics, challenging the ways in which the relationships between humans and nonhumans, and biology and technology, are all regulated. As Judith Halberstam and Ira Livingston state:

> The posthuman does not necessitate the obsolescence of the human; it does not represent an evolution or devolution of the human. Rather it participates in re-distributions of difference and identity. The human

functions to domesticate and hierarchize difference within the human (whether according to race, class, gender) and to absolutize difference between the human and nonhuman. The posthuman does not reduce difference-from-others to difference-from-self, but rather emerges in the pattern of resonance and interference between the two. (1995, 10)

It is this processual character of the posthuman that Haraway, Hayles, and Halberstam and Livingston highlight, a zone of transitionality, which does not take its legitimation from any origin, and which interrogates the technological determinism implicit in extropian-type thinking. But for all this, the transitional, transformative, mutating potential of the posthuman is not simply a free-floating, abstract "rhizome." As Haraway makes clear, the posthuman can only work as a biopolitics if it constantly questions what comes to us as "second nature." Part of this work means interrogating and creating the possibilities for the emergence of new relationships between human and machine, biology and technology, genetic and computer information.

INFORMATIC NEGOTIATIONS

In her work on the technical genealogies of cybernetics and posthumanism, Hayles locates the emergence of a technologically derived episteme associated with the information theory of Claude Shannon and the cybernetics of Norbert Wiener. In *The Mathematical Theory of Communication* (first published in 1949), Shannon and Warren Weaver provide the technical foundations for modern communications technologies by conceiving of a unilinear transmission line (a message transmitted from A to B). Likewise, in his equally technical treatise *Cybernetics* (first published in 1948), Norbert Wiener established a mode of thinking of machines or organisms as relay systems that incorporate feedback, input, output, and noise (Shannon and Weaver 1965; Wiener 1996). It is in this tradition that Hayles proposes a shift from more traditional, modern notions of subjectivity, based on presence and absence (we are reminded here of Descartes's criteria of a mind present to itself), to an episteme based on a related dichotomy between "pattern" and "randomness" (1999, 39–40).

At issue in each dyad (presence-absence, pattern-randomness) is a hierarchical valuation, but central to the shift itself is an increasing

acceptance of a worldview based on an essentializing of information as the source of an object. For Hayles, the danger with the shift to pattern and randomness is that it contains the potential to simply replay the ideologies and anxieties of the presence/absence dyad, resulting in a devaluation of the body and materiality and a valuation of the manipulability, replicability, and disembodiedness of information.

In looking at the genealogy of information theory and cybernetics, we see a network of impelling factors that collectively and situationally contribute to the kinds of questions asked by researchers. Military research, general telecommunications research, cryptography, developments in mainframe computers in military and business applications, all play a significant role in the formation of the technical concept of information. Though Wiener (often referred to as the father of cybernetics) and Shannon (often credited with the development of information theory) worked separately on the problems of informational communication, both contributed to a solidification of information as a concept within engineering, communications, computer science, and a range of other fields.

First, we might take Shannon's model for communication to distinguish several elements involved in the processing of information. Shannon depicts information not as an object but as a resultant measurement from processes, and each of these processes is a differential between some two values. Information thus passes through a sender, is encoded into a particular technological format appropriate for communication (e.g., telephone, telegraph, the Internet), is transmitted via a given technological medium (electrical wire, fiber optic cable), is decoded as it arrives at its destination, and then goes to the receiver (Shannon and Weaver 1965, 31–35). Using this model, we can distinguish three elements at work: a "message" or content, information, and the medium. This distinction is important to note because Shannon's model shows us that we are not simply dealing with a form/content dichotomy. The quantity "information" is situated between the meaning or content it codes for and the medium that supports it. The distinction is also important because neither Shannon nor Wiener make much mention of the medium or the hardware involved in the information transmission process. Just as the quantity "information" is assumed to unproblematically signify the message, so is the medium assumed to unproblematically mediate information. As will be

suggested later, this downplaying of the medium, and this assumption of information technology as transparent, will significantly affect the ways in which subjects and bodies are or are not mediated through newer fields such as biotechnology.

Second, this emphasis on information as a quantitative unit does not mean that there is an object called "information" that is qualitatively different from the message. Ironically, the rhetorical emphasis of Shannon and Weaver on information as a value irrespective of the content or meaning implies that information is indissociable from content/meaning. Although Shannon and Weaver explicitly state that information is not the content or meaning, they do not say that information can be separated from content/meaning (Shannon and Weaver 1965, 8–95). This is an important distinction because it suggests that what is of primary concern in information theory and cybernetics is to develop a means by which a "message" (Wiener's preferred term) or "content" (the term Weaver, Shannon's collaborator, uses) may be quantified so that it may be transmitted through a feedback system (in cybernetics) or along a transmission line (in telecommunications). Thus, it is not exactly accurate to state that Wiener and Shannon want to simply encode meaning, if by this we mean that they want to take meaning as a completely separate unit, which is then translated from a language of quality into a language of quantity (in short, into a language of mathematics). Wiener and Shannon do, however, separately attempt to conceive of a kind of quantifiable signifying system whereby the message or content is always already accounted for by its status as information. In other words, information, while not an object or a thing, is nevertheless the constantly varying, quantitative value of a message or content at a given point within either the cybernetic system or the line of communication. Information, then, as a quantifiable value, must always account for the message or content, even if the message is incomplete, scrambled, or distorted (noise).

Finally, there is a working assumption in cybernetics and information theory that the informational system's goal is always a state of stability and order, and, to borrow a term that is used both in cybernetics and biology, directed toward a state of homeostasis (Hayles 1999, 7–8; Wiener 1996, 8–16). What distinguishes information from noise is the stability and internal order of information as it

travels across informational channels. Although this foundational assumption of the homeostatic system was modified by later developments in cybernetic theory, it still provides a technical basis for the ways in which information is distributed to this day, and it is here that the links with modern biology make themselves evident. A homeostatic system, be it biological or informatic, continues to maintain its operational mode with a minimum of deviation from that mode—be it a pathology or static, disease or error. What both Wiener and Shannon establish for later conceptualizations of information is an identity between information and stasis, such that the primary effects of information on a system reinforce that system's stable congruity through time. In the systems mapped out by Wiener and Shannon, information does not so much alter the system's mode of operation as it primarily serves as a regulatory process that triggers the maintenance of a normative mode of operativity of a system.

The assumption that Shannon and Wiener work from is that meaning is and should be stable with regard to information. However, in order to secure such stability, the transmission of meaning must also be stable: the carriers of information, the transmission of information, must also be stable, constant, and thus transparent. This is not a theoretical question, but a technical question, a question of operationality and systematicity. Ironically then, in order to secure the stability of information as meaning, researchers in computer science, information theory, and cybernetics must also focus on the transmission, carriers, and the encoding/decoding processes of information. The question for Shannon and Wiener is "how can we keep such and such a medium from affecting the meaning of the information signal?" and not "how will such and such a medium affect the meaning of the information signal?"

The very language of computer science contains within it this assumption; signals may be encoded, transmitted, and decoded across a range of media, as long as the media are technically able to facilitate the transmission of information that is self-identical. Thus the questions that Shannon and Wiener separately ask result in their theoretical formulations: for Shannon and Weaver working on telecommunications problems at Bell Labs, information is a quantitative measure of the accuracy of the reproduction of a signal from point A to point B (Shannon and Weaver 1965, 8–16). For Norbert

Wiener, working at MIT and for the military, information is the range of choices available at a particular instant, within a cybernetic system composed of inputs/sensors, outputs/effectors, and a central mechanism of feedback (Wiener 1996, 6–9). Both researchers grounded their research in a notion of information as (1) concurrent with meaning but stabilized through a medium, (2) a quantitative value independent of qualitative changes or changes in meaning, and (3) a value thus stable across media and independent of media.

These characteristics, which form what we might call a "classical theory of information," are directly related to the ways in which the posthuman has traditionally equated information with disembodiedness (Hayles 1999, 4–5, 47–48). The medium of information (to be distinguished from the message and from information) is transparent with respect to information, so that information is taken to be abstracted and self-identical across different media, or across different technological platforms. As the central unit operating within systems that work toward a homeostatic state, information is seen to play a central role in maintaining, restoring, or producing a normative, regulatory operational state for the system, a system that constantly works toward a state of stasis and self-identity.

While these are not problematic implications in themselves, when taken within the larger context of the relationship between information technologies and technoscience, they replay the association between disembodiedness and information characterized by Hayles. The reason information can be a self-identical value, across media, across signifying processes, and across systemic contexts, is precisely because it is conceived, from the beginning, as a value independent of material instantiation. When information is regarded as information, no matter what medium "carries" it, it then becomes a universal, disconnected from the material-technical necessities of the medium, the processes, and the context. It is this universalizing and decontextualizing of information that enables Wiener to conceive of machines and organisms as the same, from the perspective of cybernetic systems operating through feedback loops. I do not want to imply here a critique of Wiener's overall suggestions regarding cybernetic systems; it is the particular way in which information—the central unit of Wiener's and Shannon's theories—is or is not intimately constrained by the contingencies of embodiedness that provides

the point of problematization: the theory of information that these foundational texts present to us is one in which information is universalized, decontextualized, and disconnected from the necessities of technological contingency.

We might refer to this process of making a certain definition of "information" foundational to considerations of the body—which I am locating in the work of Wiener and Shannon—as "informatic essentialism." Informatic essentialism is not a repression, denial, or effacement of the body; it proposes that the relationships between the biological body and information technology is such that the body may be approached through the lens of information. In other words, by making informatics a foundational worldview, the body can be considered as "essentially" information. This position—which can be ascribed to the extropian branch of posthumanism with which we began—is not, of course, exclusive to concerns over the body-technology relationship; however, it is in this relationship that the tensions inherent in informatic essentialism become clearer.

Informatic essentialism makes the primary move of suggesting that the body—as a material substrate more often than not defined by the biological sciences—can be successfully interpreted and thus reconfigured through an informatic worldview. This also implies that, as information, this body—the body regarded through the lens of informatics—is therefore subject to the same set of technical actions and regulations as is all information. In short, when the body is considered as essentially information, this opens onto the possibility that the body may also be programmed and reprogrammed (and whose predecessor is genetic engineering). Understood as essentially information, and as (re)programmable, the body in informatic essentialism increasingly becomes valued less according to any notion of materiality or substance (as we still see in modern biology) and more according to the value of information itself as the index to all material instantiation—a kind of source code for matter.

The complexity in the posthuman position outlined here is that, on the one hand, it does not necessarily deny materiality or the body, but on the other hand, in equating information with the body it interprets materiality and body in terms of an informational pattern—an asymmetrical, strategic move. With a view of materiality as

information, materiality is, again, not denied by the posthumanist position; materiality is now a programmable informational pattern with real effects in a variety of social, political, and scientific contexts. The key to informatic essentialist thinking is not disembodiment, but something more along the lines of file conversions and data translation.

To condense our analysis thus far, we might suggest that the logic of informatic essentialism is as follows: information equals the body, which by extension implies that information equals biology and/or materiality, which leads from the contingency of the biological body to the emancipation of the biological body through the technical potential of informatics. Change the code, and you change the body.

FROM POSTHUMANISM TO BIOTECH

What the extropian branches of the posthuman, as well as the critiques of the posthuman, divert their attention from are the ways in which an informatic essentialism is not something exclusive to the fields of computer-based, cybernetic, and information technology research. Especially when considering notions of the body, informatic essentialism becomes a powerful source of speculation, having as much to do with embodiment as with disembodiment. The model of the posthuman outlined thus far, focusing on the body-technology relationship, has been asymmetrical. It has provided a more or less linear narrative, whereby certain prevalent new research fields (computer science, cybernetics, and information technologies), through a logic of informatic essentialism, reinterpret the natural, biological body as information and then move on to incorporate all notions of materiality and body into an abstract, disembodied level of operativity based on some notion of consciousness or intelligence.

What we have not accounted for are the ways in which current developments in the life sciences are equally active in the material transformations of notions of the body and life itself. This inquiry, this investigation into the informatic qualities of the biological body, is already taking place in contemporary molecular biotechnology through the immanently practical means of research, clinical trials, product pipelines, and medical applications. In press releases from

biotech corporations, in articles in science publications, in interviews with researchers, one increasingly hears a refrain: as Nobel laureate and genomics pioneer Leroy Hood puts it, "biology is information."[1] Emerging fields, from proteomics to regenerative medicine, are employing computer technology and computer science research into the "wet lab."[2] Such practical transformations assumedly bolster the biotech industry by making genome mapping, gene targeting, and product development more efficient. But on the research side, such intersections between bioscience and computer science may also significantly transform some of the foundational concepts in molecular genetics. For instance, the initial report of the human genome map revealed, among other things, that the number of human genes was far less than researchers had expected, thus prompting many within the research community to call for more complex approaches to studying gene expression, biopathways, and biological systems. Similarly, the controversies over a number of population-genome projects (most notably in Iceland) have raised issues over how ethnicity and race are assumed to smoothly overlap with culture—all of which is being interpreted through genetic data.

Without a consideration of the ways in which the current life sciences are reinterpreting the organism, the body, and life, we risk assuming that, in the epistemological changes brought about by the posthumanist position, the only danger is that of disembodiment. Biotechnology research presents us with a turbulent zone in which the questions that concern posthumanist thinking are brought to a tensioned pitch, in which research seems more science fictional than science fiction itself ("neo-organs" grown on demand), and in which a range of issues have attracted public controversy (governmental regulations over human cloning). Biotech research is unique in that, on the one hand, it employs technologies common to other posthuman fields (principally, computer/information technologies), but on the other hand, its constant "object" of study is the domain of the biological (a domain traditionally set apart from the technological). Instead of being focused on disembodiment and virtuality, biotech research's approach to informatics is toward the capacities of information to materialize bodies (bodies amenable to current paradigms of medicine and health care).

BIOMEDIA IS THE MESSAGE

In contradistinction to the discourses of posthumanism that seek to dematerialize the body (into software Minds, into informational networks), research in biotechnology presents us with a case in which informatic essentialism is utilized to redefine biological materiality. Biotech assumes the classical definition of "information" and "informatic essentialism," but instead of using this definition to direct itself toward the immanence of disembodied pattern (to borrow Hayles's terms), biotech begins to reconfigure the materiality of the body through the lens of technology. In doing so, it is formulating and renegotiating new norms concerning how bodies will be approached by the life sciences and medical practice. That norm takes different forms in different contexts, but in general it has to do with (1) a body that can be effectively approached on the level of information; (2) a body that, as information, can be technically manipulated, controlled, and monitored through information technologies; and, most important, (3) a body that is viewed as fundamentally information (genetic codes), where its being viewed as information does not exclude its being material. This last point is crucial, because it points to the disconcerting ways in which biotech demands that bodies be both informatic and material.

To put it another way, biotech has no body-anxiety; in fact, it is based on a deep investiture and revaluation of the body as a materiality, and one that can be understood and controlled through information. Biomedical science frames this as the recuperated, healthy, homeostatic body—a return to its state of health. But the process is less a circle than a kind of spiral—the body returning to itself is fundamentally different from itself, because it has been significantly retranslated through genetics, gene therapy, stem cell engineering, and so forth. The upward part of this spiral is a self-sufficient, autonomous, immortal body—the dream of the liberal-humanist subject as black box. The downward part of the spiral is the expendable, unstable body—the fears of the loss of autonomy associated with differentiation, otherness, and expendability. Biotech is, above all, a discourse of production and materialization with respect to the scientific body.

As a way of analyzing this further, we can take one particular field as a kind of case study, a field within biotech research known as regenerative medicine.[3] Primarily a response to the overwhelming demand for tissue and organs in transplantation, regenerative medicine encompasses research in tissue engineering and stem cells, as well as borrowing techniques from therapeutic cloning, gene therapy, and advanced surgical techniques. Its goal is to be able to regenerate and synthesize biological tissues and even entire organs in the lab. This new horizon of what researchers call "off-the-shelf organs" has prompted many in the medical community to envision a future in which the body's natural capacity to heal itself is radically enhanced through molecular genetics and cellular engineering. Already several products, including a bioengineered skin graft, are being marketed by biotech companies under FDA approval, and laboratory animal experiments involving the synthesis of a tissue-engineered kidney, liver, and even heart are currently underway. Recently, regenerative medicine has made headlines for its discovery of "adult stem cells," cells within the adult body that contain the potential to differentiate into a wide range of cell types, pointing the way for further research into diseases such as Parkinson's and Alzheimer's.[4]

On the one hand, the notion of growing organs in the lab evokes the kind of medical horror often seen in science fiction, from Mary Shelley's *Frankenstein* to the early films of David Cronenberg. On the other hand, regenerative medicine is promising to be among the first medical fields to be able to turn the knowledge (and data) generated by biotech into practical medical applications. Using the techniques of regenerative medicine as our example, we can see three primary moments that characterize this intersection between biotech and infotech.

The first has to do with the "translatability" between flesh and data, or between genetic codes and computer codes. In order for a patient to receive a bioengineered skin graft, blood vessel, or cartilaginous structure, a biopsy or cell sample must first be taken. Using genetics diagnostics tools such as DNA chips and analysis software, DNA samples are translated into computer codes that can be analyzed using bioinformatics software. That is, once the biological body can be effectively interpreted through the lens of informatics, a unique type of encoding can occur between genetic and computer codes. This first step of "encoding" the biological into the informatic

is one of the defining moments in the posthuman, allowing the necessity of material instantiation to give way to the mutability of computer code.

The second manner in which biotech integrates itself with infotech is through a technique of programming or "recoding." One of the main breakthroughs that have enabled tissue engineering to regenerate tissues and organs has been the research done into stem cells. Briefly, stem cells are those cells that exist in a state of pluripotency, prior to cellular differentiation in which they may become, for instance, bone, muscle, or blood cells. Researchers can target specific gene clusters that might be activated or deactivated for regeneration to occur. All of this takes place through software applications and database tools that focus on the multiple genetic triggers that take a stem cell down one route of differentiation or another.[5] Once the biological body can be effectively "encoded" through informatics, then it follows that the reprogramming of that code will effect analogous changes in the biological domain.

Finally, regenerative medicine mobilizes these techniques of encoding and recoding toward its output—or "decoding"—which is the use of an informatics-based approach to generate or synthesize biological materiality. This is the main goal of tissue engineering—to be able to use the techniques of biotech to actually generate the biological body on demand. Once a patient's cells can be prompted to regenerate into particularized tissue structures, they can then be transplanted back onto the body of the patient, in a strange kind of biological "othering" of the self. From the perspective of medical research, this process is purely "natural," in the sense that it involves the integration of no nonorganic components and in the sense that it utilizes biological processes—in this case, cellular differentiation— toward novel medical ends.

In the research of regenerative medicine, this tripartite process of encoding, recoding, and decoding the body operates through a kind of informatic protocol in which, at each step, information comes to account for the body. It is this process that I would like to refer to as "biomedia." Put briefly, biomedia establishes an equivalency between genetic and computer codes such that the biological body gains a novel technics. The significance of this technical mobility has been described by Donna Haraway:

> [T]he genome is an information structure that can exist in various phys-
> ical media. The medium might be the DNA sequences organized into
> natural chromosomes in the whole organism. Or the medium might be
> various built physical structures, such as yeast artificial chromosomes
> or bacterial plasmids, designed to hold and transfer cloned genes.…
> The medium of the database might also be the computer programs
> that manage the structure, error checking, storage, retrieval, and distri-
> bution of genetic information for the various international genome
> projects that are under way. (1997, 246)

While research into both artificial intelligence and biotechnology par-
ticipates in the assumptions regarding an informatic basis to the
body, the primary difference is that biotech research directs its re-
sources toward an investment in generating materiality, in actually
producing the body through informatics. If areas such as genomics
and bioinformatics are predominantly concerned with programming
the (genetic) body, other areas such as tissue engineering and stem
cell research are predominantly concerned with being able to grow
cells, tissues, and even organs in vitro, in silico, and in vivo. The tra-
jectory of biotech's informatic essentialism completes a loop, from an
interest in encoding the body into data to an interest in programming
and reprogramming that genetic-informatic body, and finally to an
investment in the capabilities of informatics to help synthesize and
generate biological materiality.

Biotech is not about the reaffirmation of the body and materiality
over and against the dematerializing tendencies of digital technology.
Instead, it is about the mediation of this body-information episteme
in a variety of concrete contexts crisscrossed by social, scientific, tech-
nological, and political lines. Biotech thus accomplishes this process
through its tactical deployment of biomedia—the technical and prag-
matic utilization of informatic essentialism toward the rematerializa-
tion of a range of biotechnical bodies.

What are the implications for this biotechnological investment in
the body? For one, the fact of mediation is not being taken into con-
sideration; the ways in which these various biotechnologies are not
only intending to cure but are significantly reformulating what is
meant by "body" and "health" are not under the main arena of con-
sideration. "Health"—as a normative term—is never questioned in
these contexts as to how it changes in different technological and

political instances. Along with this, the technologies in biotech are not simply objects or things, but rather liminal techniques for intervening in the body; they operate not mechanically (as does a prosthetic), externally (as does surgery), or through engineered foreign elements (as does gene therapy), but by harnessing biological (read: biological-as-natural) processes and directing them toward novel therapeutic ends. In such instances technology is indirect and facilitative; it is kept completely separated from the body of the (biomedical) subject: thus regenerative medicine's claim for a less technological, more natural approach to creating the context for advanced health.

In this way nature remains natural, the biological remains biological, plus the natural and biological can now be altered without altering their essential properties (growth, replication, biochemistry, cellular metabolism, and so on). The capacity of these technologies, and their aforementioned invisibility, enables researchers to conceive of a body that is not a body—a kind of lateral transcendence. The technologies of therapeutic cloning, tissue engineering, and stem cell research all point toward a notion of the body that is purified of undesirable elements (the markers of mortality, disease, instability, unpredictability), but that nevertheless still remains a body (a functioning organic-material substrate). The problems Hayles outlines—how to deal with the contingency of embodiedness—are here resolved through a revaluation and production of a body purified through a combination of informatics and bioscience.

POSTORGANIC LIFE

As we've seen in the hard science examples of AI and the "wet science" examples of regenerative medicine, posthumanism takes technological development as a key to the inevitable evolution of the human. However, it might be more accurate to call posthumanism a means of managing the human and the technological domains. Posthumanism is, in a sense, an ambiguous form of humanism, inflected through advanced technologies. A range of conflicted responses to the ways in which the human is changing can be seen in different posthumanist thinkers. For instance, there is the deep anxiety expressed by Bill Joy, CEO of Sun Microsystems, in an article in

Wired magazine (2000). Joy expresses a concern over the potential of such technologies as cloning, nanotech, and AI to render the human obsolete through their capacity for self-replication. Responses can also have a sacrificial tone, as in Hans Moravec's book *Robot* (1999), in which Moravec, despite his commitment to humanist values, can't help but foresee a future in which the human becomes geriatric, respectfully retiring as a new generation of intelligent computers takes over. Finally, others are more celebratory, even ecstatic, in their future visions, as is Ray Kurzweil, in which the human and the intelligent computer inevitably head toward a fusion under the common theme of computational networks.

It seems that the posthuman wants it both ways: on the one hand, the posthuman invites the transformative capacities of new technologies, but on the other hand, the posthuman reserves the right for something called "the human" to somehow remain the same throughout those transformations. This contradiction enables posthuman thinkers to unproblematically claim a universality for attributes such as the faculty of reason, the inevitability of human evolution, or individual self-emergence. But many of the implications of posthuman technologies—distributed computing, computational biology, and intelligent systems—fundamentally challenge any position that places the human at its center.

Beyond this, what we find in contemporary biotech is a technically advanced, "thick" investment in the ways in which the body and information are directly related. Biotech is perhaps unique because it is one of the few information sciences that is also a life science; its continued interest is not in the anachronisms of the biological domain, but in the ways in which biology is itself a technology. Indeed, as science historian Robert Bud shows, the very meaning of the term "biotechnology" has, at least since the nineteenth century, indicated the industrial uses of naturally occurring processes (such as fermentation, agriculture, livestock breeding) (Bud 1993). Contemporary molecular biotech follows in this tradition. Biotech is not to be confused with bioengineering or prosthetics; that is, biotech is not about interfacing the human with the machine, the organic with the nonorganic. Rather, biotech is about a fundamental reconfiguration of the very processes that constitute the biological domain and their use toward a range of ends, from new techniques in medicine to new

modes of agricultural production, and to deterrence programs in biowarfare. As Bud states, biotech has always been about "the uses of life."

The culmination of these elements points to the fact that the condition for the future success of biotechnology will be the integration of information technology into the biological domain while maintaining the ontological separation between human and computer under the ideology of the posthuman. In the biotech future, the body is approached as information, medicine becomes an issue of technical optimization, and "life" becomes a science of informatics.

However, it would be too easy to fall into a position of either technophilia (where a more advanced biotechnology is the answer) or technophobia (where biotech carries the total burden of dehumanization). As one suggestion, we might look to those research endeavors within biotech that are adopting more sophisticated theoretical approaches to the intersections of bioscience and computer science, genetic and computer codes. For instance, research institutes such as the Biopathways Consortium and the Institute for Systems Biology are focusing not on the centrality of genes or DNA, but rather on biological systems, biochemical pathways, and gene expression arrays.[6] With a view to a systems-wide approach that would not reduce divergence or difference, one is reminded of Jorge Luis Borges's story "The Garden of Forking Paths" or the material uses of computer networks in communications. Similarly, unique collaborations between art and science in the domain of new media art are exploring the cultural, scientific, and political dimensions of fields such as cloning, new reproductive technologies, and connections between genetics and race. Artist groups such as Critical Art Ensemble and Biotech Hobbyist collaborate with scientists to create projects that deny a reactionary, reductive stance while maintaining the importance of critique.[7] These are, certainly, not unproblematic approaches to thinking about the technoscientific body, and there is still much to be considered within research on the cultural valences of technoscience. But such examples may begin to demonstrate the ways in which technology is more than a tool and that elusive materiality called the body is something other than the sum of its parts.

As genome projects are completed, genomic databases are assembled, and biotech becomes increasingly networked into mainstream

health care, there needs to be a sustained, transformative intervention into the ways in which flesh is made into data as well as the ways in which data is made flesh.

Notes

1. Leroy Hood, "The Human Genome Project and the Future of Biology," at http://www.biospace.com.

2. For more, see Ken Howard, "The Bioinformatics Gold Rush," *Scientific American* 283, no. 1 (July 2000): 58–63; Aris Persidis, "Bioinformatics," *Nature Biotechnology* 17 (August 1999): 828–30.

3. Lawrence Bonassar and Joseph Vacanti, "Tissue Engineering: The first Decade and Beyond," *Journal of Cellular Biochemistry* 30/31 (1998): 297–303; David Mooney and Antonios Mikos, "Growing New Organs," *Scientific American* 280, no. 4 (April 1999): 60–67; Sophie Petit-Zeman, "Regenerative Medicine," *Nature Biotechnology* 19 (March 2001): 201–6.

4. Stephen Hall, "The Recycled Generation," *New York Times Magazine*, January 30, 2000, 35–45; Roger Pedersen, "Embryonic Stem Cells for Medicine," *Scientific American* 280, no. 4 (April 1999): 68–73; David Stocum, "Regenerative Biology and Medicine in the 21st Century," *E-biomed* 1 (March 7, 2000): 17–20.

5. For more, see the textbook *Principles in Tissue Engineering*, ed. Robert Lanza et al. (New York: Landes, 1997).

6. For more, see the Institute for Systems Biology's Web site, at http://www.systemsbiology.org, and the group's proof-of-concept article, Troy Ideker et al., "Integrated Genomic and Proteomic Analyses of a Systematically Perturbed Metabolic Network," *Science* 292 (May 4, 2001): 929–34.

7. Critical Art Ensemble's Web site is at http://www.critical-art.net; Biotech Hobbyist's Web site is at http://www.biotechhobbyist.org.

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