Chapter 9

Future Imaginaries

Genome Scientists as Sociocultural Entrepreneurs

Joan H. Fujimura

Imagination is more important than knowledge.
ALBERT EINSTEIN

The image, the imagined, the imaginary—these are all terms that direct us to something critical and new in global cultural processes: the imagination as a social practice. No longer mere fantasy, no longer simple escape, no longer elite pastime, and no longer mere contemplation, the imagination has become an organized field of social practices, a form of work (in the sense of both labor and culturally organized practice), and a form of negotiation between sites of agency (individuals) and globally defined fields of possibility. The imagination is now central to all forms of agency, is itself a social fact, and is the key component of the new global order.
ARJUN APPADURAI

Imagination is a social practice deployed in the production of science and technology. Creating future imaginaries is a major part of scientists' work in the new biotechnologies that I study: genetics, artificial intelligence, and robotics research. Since these sciences are literally producing the future, I examine the social practices of imagining that form part of their work. I treat both imagining and laboratory experimentation as practices in which scientists are regularly engaged.

Science and technology have come to play increasingly important roles in defining the daily lives and bodies of people across the globe and defining the cultures and societies within which they live. The Human Genome Project, or more generally genomics, has triggered the imagination of scientists and society in ways that are not far from science fiction stories of the 1960s.

The term *genomics* refers to the new world created by molecular genetic sciences, information and computer sciences, and their institutional affiliates—the human genome projects in the United States, Japan, and Europe. This new world includes the transformation of genes into commodities in which biotechnology companies and venture capitalists have made major investments with the expectation of high profits; present and potential med-

ical applications; and social, legal, and ethical concerns about the consequences of these technologies.

In addition to dramatically changing the production of knowledge in biology, genomics has begun to transform understandings of life, bodies, disease, health, illness, relatedness, identities, "nature," and "humanness," as well as the practical handling of related affairs. Although they occur in a global context, these transformations happen in different ways in different locations. In this essay, I focus on these specificities of the locations of scientific production.

Genomic science is simultaneously a national and a transnational enterprise. It is transnational in its flow of ideas, information, materials, protocols and practices, and people. The initiation and shape of the science was a product of national competition and collaboration among the United States, Japan, and several European nations.[1] Here I portray two Japanese scientists who present two different imaginaries for the biology and culture of the twenty-first century. Their examples illustrate three main points: First, genome scientists are imagining the future and sometimes transfiguring nature and culture through their work. They are building roads to our future and choosing where and how to build them. Second, scientific imaginings often are engaged with *other* contemporary cultural discourses. Third, these images and efforts to reinvent nature and culture and related cultural discourses must be historically situated to be understood. To appropriate another oft-used metaphor about the genome project, but with a significant one-word modification, genome scientists are writing *a* book of life. The form, content, and interpretation of this book may differ in different historical periods and locations.

JAPANESE DISCOURSES ON WESTERN TECHNOLOGY AND JAPANESE CULTURE

In twentieth-century Japanese discourses, *science-technology* and *culture* have been distinct and even contradictory terms.[2] Debates about premodernity, modernity, postmodernity, and nonmodernity in Japan are intertwined with discussions of culture and technology and of Japan's relationship to the "West."[3] The set of discourses currently called Nihonjin-ron, or Japanese cultural uniqueness, represents Japanese culture as existing in its purest form in the period before Japan's modernization. Although technology and science were being imported from the West in the mid-nineteenth century, those technologies and sciences were said to have been carefully translated through Japanese culture so as to make the foreign "native." "Japanese culture" here is represented as the source of a firm, unshakable self-knowledge, and technology as the foreign, Western object that required translation through culture.

The modern period is often represented as a time when serious conflicts between modernization and Japanese culture arose. Debates about importation of Western science and ambivalence about modernization began in the late 1800s (Harootunian 1970; Najita 1989; Pyle 1969).[4] During the Meiji era (1868–1912), often marked as the time when Japan was transformed into a modern industrialized nation-state, Japanese intellectuals began to criticize the modernization of Japan and the attendant introduction of Western knowledge and technologies, and this criticism persisted. The critics argued that technological progress through increasingly efficient production came at a price: it took precedence over unique Japanese aesthetic and cultural forms. *Modernity* and *the West* are conflated here. Japanese novelists of the time wrote essays and novels that expressed their concerns over this loss of Japanese culture to modernization and the West. The writer Natsume Soseki (1911, cited in Najita 1989: 11) argued that the Western system of knowledge and production was overwhelming Japanese culture and was producing a pervasive "nervous exhaustion" in place of social well-being and happiness.[5] His conclusion was that Western technology had produced a crippled personality and a crisis of culture in Japan. The writer Tanizaki Junichiro (1933, cited in Najita 1989: 12) argued similarly that the laws and epistemologies accompanying Western technology had "distorted the ethical and aesthetic sensitivities of the Japanese" and produced a form of self-colonization. He argued that the Japanese "should be self-consciously identifying with culture as an internalized space of resistance."

After World War II, this earlier discourse was modified to argue that Japan was the first Asian nation to modernize, because Japanese culture was compatible with technological development and industrialization. For example, the sociologist Robert Bellah (1985 [1957]) argued that Japan's early modernization was aided by "authentic Japanese values" like group harmony and loyalty, and individual and collective achievement.[6] A description of Japan's vertical stratification system, by the sociologist Nakane Chie (1970), and a description of *amae* (psychological dependence in relationships) by psychologist Doi Takeo (1973, 1986), were used similarly to articulate a social organization well suited for modernization. These values and patterns purportedly made it possible for the Japanese to be effective in the organized processes of high-growth economics.

In contrast to these social scientists, cultural nationalist writers like Mishima Yukio (1969) argued that Japanese culture was epistemologically and ethically different from the politics and technologies of modernization. He invoked the prewar discourse's notion of Japanese culture as a pure, authentic sphere to criticize the new consumer culture of high-growth economics and its accompanying bureaucracies (Ivy 1995; Pincus 1996).

In the postmodern period, again the main question has been whether or not rapid modernization and economic growth have actually helped Japanese social and cultural life. Have they instead created a homogenized and harried consumer culture with few intellectual and social benefits?[7]

Controversial writers on civilization theory in Japan carry these criticisms one step further.[8] They challenge the scientific authority of Euro-American nineteenth-century positivist philosophies and their claims to universal relevance. They note that the West has had the special historical privilege of being able to appear at once unique and universal. Writers like the economic historian Kawakatsu Heita "define post-enlightenment western thought as the product of a particular society and era, and open up the possibility that the traditions of other societies may contain the seeds of new theories to fill the gap left by the withering of old certainties" (Morris-Suzuki 1995: 760). The cultural traditions of other societies can then be the source of "better" civilizations and societies.[9]

However, theories of Japanese cultural uniqueness have not gone unchallenged. Most recently both Japanese and American writers in anthropology, history, and literature have begun to question and complicate these early representations of Japanese culture and the Japanese self.[10] Their studies interrogate how what is assumed to be a coherent, unified Japanese culture has been and is being constituted, reconstituted, deconstructed, and challenged through history. They critique the earlier Japanese literature on the Japanese self as yet another example of Orientalism, where Japanese writers created *themselves* as the Other in response to Western culture.[11] In contrast to both premodern and modern discourses, these histories, ethnographies, and cultural studies discuss the located and contingent courses of events, actions, and practices rather than static generalizations about Japanese social, cultural, and identity categories.[12] These historical discourses of Japanese cultural uniqueness form part of the context within and against which images of the West, the East, and Japan, of science and culture, are being constituted and reconstituted in the imagination and entrepreneurship of genomic scientists in Japan.

THE 1990S: THE JAPANESE HUMAN GENOME PROJECT AND GENOME INFORMATICS

In addition to physical and genetic linkage mapping, structural analysis, cDNA cloning and mapping, and sequencing, there has been a separate program set up to address computational aspects of biology in both the first and second five-year plans (1991–1996, 1996–2001) of the Japanese genome project.[13] The project called "Genome Informatics" has received a substantial portion of human genome funds, in part because of the efforts of a major architect of the Human Genome Project by Monbusho (the Ministry of Education, Sport, and Culture).[14] Professor Suhara (a pseudonym), a leading molecular biologist in Japan, was instrumental in making the Japanese Human Genome Project a reality in the late 1980s.[15] Suhara was influential in convincing the ministry to fund this research and, as head of the project in its first five-year period, in constructing the project in its initial and present format. Both before and during his directorship of the Japanese genome project, Suhara was involved in organizing the coordinated efforts of the Japanese, American, and European genome projects to map the human genome. He spent several years as a postdoctoral student in the United States and speaks excellent English, the de facto official language of genomics.

Suhara envisioned the genome project as more than the investigation of human genes. For him, it also represented the "installation" of a new science for twenty-first-century Japan. In his view, Japanese biological laboratories were not well integrated with scientific information networks in the United States and Europe. One of Suhara's primary missions was to create an infrastructure of "thick lines" of communication, both literally and figuratively. He accomplished this in the first phase of the genome project (1991–1996) by building into the funding and institutional structure of the genome project a major commitment to genome informatics, that is, biology using computer technology.[16] Suhara believed that traditional wet lab biology would decrease in importance in comparison to the emerging field of computational biology.[17] While many of his colleagues in Japan disagreed, he managed to persuade Monbusho officials to create a separate institutional and budgetary structure to fund genome informatics and computational genome analysis.[18]

Suhara's rationale was based on his view of Japan's noncompetitive position in the biological sciences. At the beginning of the 1970s, when molecular biology was becoming firmly established as the "new biology" in the United States and Europe, Japanese biologists were not interested. In Suhara's estimation, this indifference had left Japan behind in the field. He worried that the situation would repeat itself in genome informatics. Thus, in 1990, Suhara planned and argued for Japanese genomics to focus more resources on genome informatics, a field in which Japanese and American bioinformaticians were at about the same level of investment, expertise, and experience relative to their national budgets and personnel. Suhara believed Japan could make its mark in bioinformatics, in part because of its competitive position in the computing and information sciences.

Reinventing the East and the West via Genomics

Informatics includes techniques for comparing genetic and protein sequences and thus provides methods for comparing genomes of different species. These comparisons became Suhara's tool for promoting the genome project to the Japanese public and the basis of his imagined trans-

formation of the West by genomic knowledge. His vision is apparent in this assessment of the significance of the Human Genome Project:

> Too much stress has been placed on human dignity [in the West]. It's much easier for us [in Japan] to accept [man's place in nature] because we have not been brought up under the influence of Christianity. Most Japanese are either Buddhist or Shinto, and they have a much wider view of all living things. They don't put man as the representative of God to be placed above all the other living things.[19] This attitude is very firmly imprinted during our childhood.
>
> [The Japanese have a] much cooler concept of man. We look at man as one [among other] living creatures. By slowly changing the concept of life, I think . . . our attitudes toward technology [and toward] making use of the Human Genome Project will be slowly changed, particularly in Asian countries where the majority of people are not living under the influence of Christianity or [Islam], but under the influence of Buddhism or Confucius *[sic]* or Shinto.
>
> Everybody's bound to the contract [with one God] in the Christian community. You don't have to change this [Christian] social contract. But you do have to get better views on what man is by taking the flow of information from the Human Genome Project and extend[ing] the thought on evolution to man, [e.g., the idea] that a man is a result of a process of nature, has very close ties with other living things, and has to live together [with them] on earth. Culture plays the most important role in accepting evolution and the life of man among other lives.

In Suhara's narrative, culture is a set of values imprinted on us in our early years that then governs how we act in the world. For him, religious differences between Eastern and Western cultures explain why the Christian West values humans above other animals.[20] Suhara uses his notions of East and West as a basis for criticizing Western actions and attitudes and promoting his view of Asian values and attitudes, which he in turn uses to promote genomics research in Japan.

Suhara appeals to a view of the Japanese as sharing a common culture steeped in a Buddhism and a Shinto that are radically different from Christianity. But in contrast to Nihonjin-ron claims that the principles of science and freedom in modern industrial civilization have led to negative social and spiritual consequences, Suhara emphasizes the harmonious effects of science. He contends that a science that seems to represent the epitome of modernist interventions into nature—that is, genomics and its accompanying manipulations—will produce knowledge of the harmony and relatedness of all living animal species and, especially, of humans with other animals. This relatedness fits well with both Buddhist and Shinto views as he understands them.[21]

Unlike Japanese critics of the Meiji adoption of Western technologies, Suhara does not equate science and technology with the West. Therefore, the adoption of molecular biology technologies is not an adoption of Western cultural views. Indeed, in his view, these technologies are resisted in the West precisely because they (or at least their rhetorics) threaten to impose evolutionary biological knowledge over what he calls "cultural knowledge" or "the Christian social contract."[22]

In Suhara's future imaginary, once this truth is known, the West will eventually have to change its concept of humans and other animals. He envisions a turn, or return, to nature or immanence in the more animistic sense of a Buddhism that has been heavily influenced by Shinto.[23] Although Suhara is interested in the potential medical payoffs and products proclaimed by many American technocrats as *their* reason for promoting genomics, his imaginary engages more with the potential transformation of Western cultural values.

In order to realize this imaginary, Suhara had to persuade the Japanese public to accept and support genomics. In this effort, his narrative subverts the tropes of both Nihonjin-ron Orientalism and Western Orientalism, where tradition and religion are attributes of a premodern Orient, and science and modernity are attributed to a modern Occident. In Suhara's rhetoric, there is no Western or Eastern science. Instead, there is only science. It is not science that is the problem in the West; it is culture. Western culture does not allow it to benefit from the fruits of its own technologies. Indeed, culture and science are in direct conflict and contradiction in the West.

This rhetoric was useful to Suhara's advocacy efforts. Cognizant that it takes work to prepare "the community" for the introduction of new technologies, Suhara spoke to, and with, various Japanese public groups before and during his tenure as director of the genome project's first five years. As he describes it,

> Actually, I have spent four or five years working very hard in [arranging for] the Genome Project to be acceptable in the community. . . . It's important. You have to be prepared before the community or society raises its hand to ask questions. What are the implications? What good will it bring about? What bad will it create? You must be prepared beforehand. Our experience is still that, if we fail in doing this, none of the scientific activities will get real support from the community.

Suhara prepared this strategy after learning from the experience of those who had previously tried to promote organ transplants in Japan, which he says is one of the worst examples of improper introduction of new technologies: "In organ transplantation, we are twenty years behind the world, because they were not welcomed here at the time. When people began asking questions and brought up some problems, the medical people were not able to answer them." The anthropologist Margaret Lock (2001) has pointed to cultural factors—the fact that in Japan death is defined as the death of the heart, not of the brain—that have slowed the acceptance of organ transplantation in Japan. In contrast to Lock's cultural explanation, Suhara insists that "the medical community failed in preparing, at least in educating the community and preparing for the questions and the protests against having these activities." For Suhara, acceptance of, or resistance to, organ transplantation is changeable. It does not occupy his pantheon of cultural values that are "firmly imprinted during our childhood."

Suhara also prepared scientists to deal with opposition to the project:

> I have spent some time in preparing scientific communities [for] the questions and the oppositions from the communities to the introduction of DNA research. There has been much reluctance and fears, just like [Jeremy] Rifkin's work has [generated] in the States, in the community. Some people are still trying hard [to generate these fears], but after [the] spread of [information], particularly for the high school kids, the attitude has become more and more a minority.

Public education was one of Suhara's missions and a significant part of his work as director of the human genome project.[24] He lectured to the public, to other scientific communities, and to the press about genomics, often in the face of community and media criticisms.

More important for my argument, Suhara's linking of his cultural imaginary to his efforts at public education was strategic. When arguing for funding from the government ministry, Suhara promoted the medical and pharmaceutical (e.g., drug design) benefits of the project as well as the development of information infrastructures. But he was aware that describing scientific benefits was not as useful when addressing public concerns about the social and ethical implications of the project. For these audiences, Suhara spoke to how genomics would change our understandings of life: "People in general are not so much interested in the forthcoming change in basic science or [the] setting up of the infrastructure of the scientific community. They are more interested in life."

Anthropologists, historians, and literary scholars writing about invented traditions have argued that such traditions have been invented and manipulated toward particular ends (e.g., Hobsbawm and Ranger 1983). Recent scholarship has demonstrated that many prominent Japanese "traditions" were in fact created during the late nineteenth and early twentieth centuries as Japan underwent the arduous, and at times traumatic, experience of modernization. For example, the historian Takashi Fujitani (1996) informs us that the system of emperor worship, with its many spectacles and "traditional" displays in modern Japan, was not a holdover from feudal times but instead a very modern invention of monarchy in the late nineteenth and early twentieth centuries by a particular class of people. This invention served both to produce a national culture over and against the many different ways of living that had existed in Japan until that time and to promote the interests of a few people: a ruling aristocracy and its retainers. Monolithic notions of Japanese culture as constituted by imperial traditions here served the purposes of particular people and not others.

Suhara's campaigns wielded notions of Shinto and Buddhism that have been similarly rendered in Japanese society as traditionally Japanese. In a fashion similar to the building of an infrastructure for the imperial system (e.g., the spectacles of emperor worship) and the production of the nation-state, Suhara worked to lay the foundations for public acceptance of genome research, technologies, and therapeutics. He saw it as his task as the first director of the Japanese human genome project to educate and prepare the public for this new future. Using Nihonjin-ron-like rhetorics and invented traditions, Suhara promoted very modern ends. This cultural imaginary contested the idea that the new science was bad for Japan while it simultaneously ratified Nihonjin-ron claims of cultural uniqueness.

Contrary to Nihonjin-ron discourse, Suhara's imaginary inferred a congruence, and even a necessary bond, between modern science and traditional Japanese cultural values. In Suhara's rhetoric, these traditional Asian values are critical to the success of science, in which science and Asian values will be confederates in the transformation of the world. Japan and Asia will become the leaders of a modernity based on religious and scientific understandings that show the Christian West to be premodern, irrational, and "traditional." Ironically, this transformation will happen because of molecular genetic technologies first developed in the West. The cutting-edge technologies that will, in Suhara's eyes, be instrumental to this transformation were developed in a culture that will change as a result of the cutting-edge knowledge it has produced. Genomic knowledge will make Western culture consistent with Asian culture and sensibilities. In Suhara's future imaginary, "Christianity will have difficulties in changing the concept [of humankind] in the near future when we know about the basic structure of the human genome; but still, that time will come." Suhara's vision of Japanese culture transforming the world has some parallels with the philosopher Ueyama Shumpei's vision of Japanese and Asian cultures as the sources of the antidote for the ills of civilization.

Although Suhara's notion of culture appears at first to be undertheorized, he uses his notion in a rhetorical strategy of reversal to weave a representation of the West as the place of tradition and the East as the forefront of a scientific modernity. Suhara is promoting modernity through nostalgia. That is, he uses tropes like Japanese traditions of Buddhism, Shinto, and their attendant views of nature to promote science and modernity. Modernity and tradition are not binaries in Suhara's vision. Instead, they are concomitant productions. They can exist together; each can even create the grounds for the existence of the other.[25] Suhara's rhetoric uses these "authentic" productions to promote the emblem of modernity—that is, science.

KITANO HIROAKI, THE GLOBAL SCIENTIST-ENTREPRENEUR

The nostalgic literature, or Nihonjin-ron discourses of cultural purity and uniqueness, contradict the realities of multiple border crossings and transnational interchanges in people, trade, education, fashion, music, and technoscience. Indeed, they may even be a conservative nationalist reaction to these transnational interchanges. While Suhara promotes interchange, he uses a cultural nationalist rhetoric that resonates with Nihonjin-ron and civilizationalist discourses.[26] In contrast, Kitano Hiroaki—a physicist turned computer scientist, robotics entrepreneur, and systems biologist—is a prime exemplar of border crossing, yet his transnational enterprises are also useful to the nationalist agendas of Japanese government bureaucrats.

A caption on the cover of the January 13, 1999, issue of *Japan Newsweek* reads, "The 21st Century's 100 Leaders: These are the stars who are opening the New Era in Politics, Business, and Art" (Seiki no riidaa hyakunin: Seiji, Business, Art shinjidai o kirihiraku shuyaku wa karera da). Among the thirty or so faces of political and media stars on the cover, a few spots to the right of Cameron Diaz and George W. Bush, is Kitano Hiroaki. In summer 1999, Kitano received an award from the Science and Technology Agency for his work on robotics. The governors of two Japanese prefectures were at the awards ceremony to speak about their RoboFesta events, inspired by Kitano's RoboCup. They were sponsoring RoboFesta to try to reverse the drop in interest in science among Japanese schoolchildren. In October 2000, one of Kitano's robotics designs was installed in the Venetian Biennaire Exhibition (2000), and it won the Prix Ars Electronica (Austria, 2000). In November 2000, under the auspices of the Science and Technology Corporation, Kitano organized the first international conference on systems biology. In February 2001, the editor of the Japanese business magazine *President* commissioned a writer to follow Kitano and write a portrait article on his various projects around the world. In June 2001, Kitano appeared on a Japanese television game show, where he talked about his lab's robotics research. Miniature dolls modeled on the lab's humanoid walking robot, PINO, went on sale in August 2001 at KiddyLand, the most famous toy store in Japan.

Who is Kitano Hiroaki and how has his vision of the future captured the attention of the popular media and the Japanese government? He was educated in Japan in particle physics. He worked in software engineering at NEC Corporation, a Japanese electronics company, and then moved to Carnegie Mellon University in Pittsburgh to conduct research in artificial intelligence. In 1993, he moved back to Japan to work at Sony Corporation on virtual reality modeling language and entertainment robotics (including Sony's AIBO; see below). In 1999 he established his own research institute. Meanwhile, he has created an international organization, RoboCup, to organize matches between soccer-playing robots in the interest of developing artificial intelligence.

Kitano is still officially employed by Sony but spends most of his days at his own not-(yet)-for-profit research institute in the cosmopolitan Harajuku section of Tokyo. In the middle of Tokyo, Kitano has built an institute that is combining research on advanced robotics, artificial intelligence, and systems biology. The institute is located on Omotesando Street, also home to the chic fashion houses of Issey Miyake, Yooji Yamamoto, and Rei Kawakubo, but its members and laboratories are located in other institutions both in Japan and across the Pacific, at the California Institute of Technology in Pasadena.

The Kitano Symbiotic Systems Project was funded by the Japan Science and Technology Corporation under the auspices of the Exploratory Research for Advanced Technology (ERATO) program. Kitano wrote not a single grant proposal for this project. Instead, ERATO officials, who had followed his work for some time, offered him a grant to conduct whatever research interested him. ERATO annually selects several scientists to receive their substantial awards. The agency's unofficial goal is to show that Japanese science can be innovative, in response both to intimations in American and European research institutions that Japanese science is merely mimetic and to direct statements that Japan exploits the innovations of the West to produce lucrative technologies—that it does not fund enough fundamental research. ERATO scientists also seem to be charismatic, creative, and imaginative people with an international orientation.

Kitano's research focuses on the designing and modeling of symbiotic systems—simulated biological and intelligence systems. On his web page at Sony, the description of his personal project states that the unified theme of his research is the "emergence and evolution of intelligence."

> Diverse approaches must be taken to tackle this grand problem. As a basic researcher, I am focusing on computational aspects of the evolution of neurogenesis and morphogenesis. Research on high-level intelligence is based on the genetic supervision theory and active perception, so that phenomena such as emotion and selective attention can be incorporated. In the long run, these issues will be integrated as "Symbiotic Systems Theory." A robust real-time translation of closed-caption and entertainment applications are expected fruits of these basic researches.

The following statement by the agency funding Kitano's research, and which appears on his web page, summarizes Kitano's project:

> Biology, unlike physics, has yet to find a unifying way to deal with its diverse subject matter. Hence, it has so far been impossible to use the great power of mathematical simulations to help overpower the inherent complexity and to gain greater predictive power.

> Kitano . . . is trying to recapture the essence of "complexity" and "symbiosis." "Complexity" is used concerning phenomena involving a very large number of elements interacting in a very non-linear complex way; "symbiosis" is well-known through work in cellular evolution and the Gaia hypothesis, that Earth is a self-regulating cybernetic system in which all of the many species interact to maintain homeostasis (Japan Science and Technology Corporation and ERATO 1999: 6)

Kitano's rhetoric combines the cultural capital that physics and mathematics have accrued as a result of their high positions in the hierarchy of scientific disciplines, with the literal capital that computer science holds in Japanese government, academia, and private industry, as well as with the cultural capital that the Gaia hypothesis holds in international popular culture. The Gaia theme is compatible with the Shinto theme of the harmony of all living things.[27] But by using Gaia rather than Shinto in his rhetoric, Kitano avoids Japanese cultural nationalism. It has public appeal without being nationalistic.

Kitano's rhetoric has worked because the funding agencies are based in government ministries. These ministries have been mandated to increase Japan's international presence in the world. In response to accusations from outside Japan that it has not been a sufficiently responsible international citizen, the Japanese government has instituted a campaign to internationalize at all levels of society.[28] As noted earlier, Kitano's rhetoric convinced these bureaucrats of the usefulness of his project because of its international appearance and appeal and because of its novelty.

There are two parts to Kitano's strategies for tackling the grand problem of "the emergence and evolution of intelligence." The first part is to model development in organisms using techniques from artificial intelligence and computer science research. The second is to use the results of molecular developmental biology and molecular neuroscience research to develop novel methods for building intelligent robotics systems.

Systems Biology

Using bioinformation databases, computer modeling and simulation, artificial intelligence tools, and complexity theory, Kitano is attempting to model organic developmental systems. He wants to establish methodologies and techniques that enable scientists to understand (1) the structure of the biological system, such as gene-metabolic-signal transduction networks and physical structures, (2) the dynamics of such systems, (3) methods to control systems, and (4) methods to design and modify systems for desired properties (Kitano 2002: 1662).

Many computational researchers moving into biology believe that the field has become too complex for biologists to handle. They argue that the mass of information now stored in databases primarily in the United States, Europe, and Japan must be analyzed by people experienced with masses of complex data. One proposed approach is to build and use simulations to understand the dynamical properties of biological systems—for example, developmental systems. This approach may yield answers to questions such as: How does the body develop from its original single cell? How do cells differentiate into lung and heart and muscle cells when they all have the same DNA in their nuclei? Another approach is to develop software to mine the data for nuggets of knowledge that can be used to produce pharmaceuticals and other therapeutics. The first approach could be used in the long run to produce therapeutics, while the hope of the latter is to develop products in the short term. Kitano is interested in the former.

Kitano's interest in developmental biology derives from his interest in developing models of intelligent systems: "To develop artificial intelligence, you need to know about the actual reality of the brain. You need to know how the brain evolved, how it functions, how it grows. I was particularly interested in evolution and growth, so my primary interest was in developmental biology."[29]

The Kitano project combines work in computer simulations, dynamic systems, and molecular biology. Kitano states, "It aims to establish a new comprehensive methodology, systems biology, which emphasizes an understanding of a biological system as a system." Using systems theory, Kitano's group is creating software that simulates a developmental process in order to identify the dynamics of genes and proteins. He observes, "Ideally, it should be possible to predict a certain gene X having a specific location and function [using the simulation model]. If the result is not consistent with reality, this method also includes automatic hypothesis generation and a mathematical model to suggest the shortest research path to identify the gene. This process shows great promise to obtain a better basic understanding of biology while providing improved predictive and preventive medicine."

Kitano's group is currently working on three projects, including studies of human cell aging, developmental systems (eye, wing, leg, segmentation) in *Drosophila*, and embryogenesis and neural systems of the worm *Caenorhabditis elegans*. According to Kitano and his colleagues, "The goal of this research program is to establish a new paradigm of biological research. . . . We propose that computer simulation which models mechanisms of biological processes should be used together with actual biological experiments, instead of using abstract mathematics describing average behavior of the system, so that results of simulation[s] (which are virtual experiments), can be verified by tangible experiments" (Kitano et al. 1997: 275). The "virtual cell laboratory" is creating detailed simulations of intracellular genetic interactions and metabolic cascades. It involves modeling and analyzing aging, differentiation, and the cell-cycle regulation of human cells.

More specifically, in one experiment, the researchers are trying to model aging by first translating it into a problem of cell senescence. Kitano and the microbiologist Imai Shin-Ichiro worked together to study cell aging by building a probability model that used computer simulations of the cell aging process. Even though they did not believe that cellular processes are random, their model is based on random generation of cellular events. The researchers attempted to match the results from the computer model with results of wet lab experiments. For example, they produced graphed curves of life spans of cells produced by their computer algorithm and compared these to curves produced in the wet lab experiments. Their comparison showed that their simulated curves matched the wet lab experimental results better than curves produced by other models.[30] More important, their results suggested to them an innovation in aging research: the idea that cellular senescence involves two independent regulatory processes (Kitano and Imai 1998).

Kitano and Imai jointly created this model of aging. In 1996, they had produced interesting simulation results that identified a particular gene as critical to aging and had sent a paper reporting these simulation results to a well-regarded biology journal. The journal editor returned the paper, saying that they needed wet lab proof that the gene was important in aging processes. Imai's laboratory did the experimental work of isolating and testing the gene, and they then resubmitted the paper for publication. The journal editor then said that, since they had located the relevant gene, the theoretical and simulation work was irrelevant.

This journal's response was not unusual. Until recently, theoretical or computational biologists have had a difficult time convincing wet lab scientists that their work is worthy of regard, funds, and publication. While neural network research has received some support from psychologists and molecular biologists like Francis Crick, theoretical biology generally has not been held in high regard since the advent of molecular biology.[31] Some researchers in the field call this "the other two-culture problem." Dry lab versus wet lab competitions in biology usually have been won by wet lab molecular biologists, in part because wet lab biologists have controlled the means of production in biology. But computational biology slowly has managed to make its presence felt in recent years. Biologists have been willing to have computer scientists and mathematicians help them figure out how to map and locate genes and how to search for similarities, but they have been loath to grant computational biology status equal to that of molecular biology. But the other side has its own version of elitism. For the past several years, I have studied computational biologists doing what they call data extraction or data mining. Some of them have argued that their methods allow them to produce better, unbiased knowledge than the molecular biologists who, according to their computational rivals, work in such great detail with one gene or protein or part of a protein that they cannot see the forest for the trees.

Kitano decided to bypass the battle in order to get his work done. He enrolled several wet and dry lab scientists in his project to study developmental pathways and to design software systems to assist in this process. However, most of the project's early articles were published in artificial intelligence journals and in biology journals like *Experimental Gerontology*, which the researchers consider less prominent than *Cell*, *Nature*, and *Science*.

Another hurdle for Kitano's project was, in his view, the present state of biology in Japan. Like Suhara, Kitano recognizes the lead that the United States has held in molecular biology and the competitive position that Japan has held in computer science. Japan has excelled in the production of robotics, imaging techniques, cybernetics, artificial intelligence, and simulation technologies like virtual reality.[32] But rather than engage in a competitive response to this situation as Suhara did, Kitano takes advantage of the situation by organizing research teams that are transinstitutional and transnational. He says,

> If U.S. research is more advanced, we can create a team with American researchers. It's not completely conflict-free, but we can team up with the top American biologists, because what they are doing and what we are doing are usually complementary. It's not competitive. So if we come up with a very good model, they can take advantage of that, if we make a team.

Kitano's team currently includes computer scientists, biologists, and engineers from several institutions in Japan and California. Kitano has built a new laboratory at the California Institute of Technology that incorporates molecular biology, computing, artificial intelligence, and robotics research in one physical laboratory.

Artificial Intelligence

The second part of Kitano's imaginary includes a plan to use systems biology to reanimate artificial intelligence and robotics research:

> Current research is aiming at the development of novel methods for building intelligent robotics systems, inspired by the results of molecular developmental biology and molecular neuroscience research. Symbiotic intelligence . . . incorporates a new type of robotics system having many degrees of freedom and multimodal sensory inputs. The underlying idea is that the richness of inputs and outputs to the system, along with the coevolving complexity of the environment, is the key to the emergence of intelligence. As many sensory inputs as possible, as well as many actuators, are being combined to allow smooth motion and then [are] integrated into a functional system. The brain is an immense system with heterogeneous elements that interact specifically with other elements. It is surprising how such a system can create coherent and simple behaviors which can be building blocks for complex behavioral sequences, and actually [can] assemble such behaviors to exhibit complex but consistent behavior.

Aiding this symbiotic systems design for both biology and artificial intelligence is Kitano's global venture, RoboCup, a trademarked nonprofit organization registered in Switzerland in 1997. RoboCup organizes and coordinates a World Cup series of soccer matches played annually by teams of robots (both real and simulated) from thirty-five countries. Kitano has also worked to develop the AIBO, a robotic pet, developed by Sony. The AIBO plays soccer, kicks and heads the ball, rolls over, and stands up after being tackled. At the Third Robot World Cup, AIBO dogs played in three-member teams. Sony has also claimed that the AIBO has instincts and emotion, and that it can autonomously act on these capabilities. But RoboCup and the AIBO are not just fun and games. They are part of an effort to use the collaboration and competition between robots and robot teams to study and then improve the interactive capabilities of robotics systems. Kitano has also proposed developing robotic systems for use in large-scale disaster rescue operations. The 1995 Kobe earthquake demonstrated the vulnerability of human rescue systems. Rescue personnel themselves were victims of the disaster and unable to carry out their responsibilities. Rescue robots that can be controlled from afar, and computerized systems for simulating possible disaster and rescue scenarios, are the serious work of and rationale for these robots, while play and entertainment are what animates them. Work and play produce a powerful synthesis. For Kitano, these robotic and artificial intelligence systems also provide an immediate practical benefit for his systems biology project: he can attract top robotics engineers and designers to work on developing artificial intelligence and engineering systems to assist in designing his biological systems.

Future Possibilities?

Is the goal of systems biology just knowledge and understanding? No, says Kitano: "Overall, the project aims to obtain a breakthrough in the methodology for understanding, controlling, and creating biological systems." Kitano imagines cloning human organs from human cells in a precisely controlled manufacturing system. Simulation technologies, control technologies, and instrumentation could be used to clone organs customized for each person: manufactured life. Projects in the United States aimed at cloning human organs from stem cells have yet to devise the precise technologies for growing organs from an individual's cell or DNA. Kitano's idea is to simulate such growth and development before ever moving into the production stage. As noted above, organ donation is still a rare event in Japan. When transplantation has occurred, the organs have come from outside Japan—which has also produced criticism from both within and outside the country. In this climate, cloning organs to order is a provocative offer, despite the uneasiness that many people might have about cloning.

Long-range imaginings are part of Kitano's rhetoric. Systems biology will allow humans to intervene in the natural workings of bodies to prevent problematic outcomes and to build organs that can be transplanted when the natural ones are frail or damaged.

Kitano's visions are not universally shared. Researchers in computational biology criticize his particular framing of the project, although they like his use of the name *systems biology*. And it is not clear that his visions can be realized. Nevertheless, he has created a demand, audience, and resources for himself, his visions, and his work.

CONCLUSION

These instances of technosocial design for the future serve as examples of the social practice of imagination. These future imaginaries are distinct from fantasy, especially in the sense that fantasy refers to "thoughts disconnected from projects and actions" (Appadurai 1996: 7). Indeed, the imaginaries presented here are visions of future possibilities around which scientific practices and communities are organized. They are collective enterprises and not simply an individual's dreams. They are the products and producers of networks of humans that include cultural intellectuals and writers, government bureaucrats and politicians, molecular biologists, artificial intelligence researchers, robotics engineers and designers, business executives and long-range planners and the public. These networks also can be said to include technologies—nonhuman actors, in Bruno Latour's words—without which scientific imaginaries cannot be made into projects and actions.

Technosocial imagining is serious work done by serious people. The work of the two scientists I discuss here has led to enterprises that have enrolled and engaged many people, funds, and government agencies, and much public and consumer interest. Through their work we see new possible futures in the making.

But are such visions merely hyperbole, the rhetorical strategies of persuasion that lead to nothing but a waste of good resources? Should we not wait to see what actually happens before we study such projects? I argue that if we wait for the future to become the past, we leave the design of the future to others. *Especially* if one does not support the possibilities being imagined today, it is critical to study them. I am arguing for a sociology of the future.

In the design of the future, rhetorical strategies of persuasion are in part

a requirement of imagination as a social practice because the future is being imagined as *a new possibility*, as something that does not already have a constituency. Hyperbole is part of the very process of persuading people to support that new possibility and, thus, of convincing them to change their present ways. For example, when Kitano projects into the future his vision of what systems biology, robotics, and artificial intelligence could become, he relies on an imagined vision of future possibilities to win people's support. Kitano's imaginary is a world where simulated biological and intelligence systems help us understand and emulate the emergence and evolution of intelligence, which in turn can be used to solve complex problems, build intelligent robotics systems, produce disaster rescue systems, clone human organs for transplantation, and otherwise provide improved predictive and preventive medicine. Kitano's vision provides both animated machines and manufactured life. To achieve his goals, Kitano must create cultural capital literally from the imagination. Hyperbole can be seen as a means to that end.

Future imaginings also have to be located in their present contexts. Appadurai's concept of "globally defined fields of possibility" refers to the fact that possible futures never before imagined by people in one locality are now available to them because of the influence and reach of global media. But these fields of possibility are also produced and consumed within particular contexts, particular locations.

For example, Suhara uses Nihonjin-ron and civilizationalist discourses in Japan to produce an image of genomics that will reshape Western culture to be more in line with Eastern cultural values. Genomics will transform the assumptions of the "Christian West." Suhara has turned cultural nationalist arguments around and used them to attempt to convince the Japanese public that new genomic technologies are more congruent and even harmonious with traditional Japanese and Asian cultural values than they are with Western cultures.

Suhara uses nationalism to promote a transnational, even postnationalist, project. Kitano's supporters use an internationalist agenda to promote a national agenda, while Kitano uses their nationalist agendas to promote his transnational project. Contradictions and complications abound—and can become resources.

Both of these scientists are imagining what they might create with DNA, amino acids, and other biological information collected in databases around the world. And by doing so, they and their colleagues are participating not merely in the practice of science but also in redesigning culture and society. Genomic scientists are building maps of genomes, national and transnational identities, notions of culture, new institutions, and future realities. Although one could argue that genomic maps, cloned organs, and visions of nature are first-order products, and that notions of national identities, culture, and institutions are by-products, these aspects of nature and culture are inseparable. Social and cultural organization may not be first-order objects of the everyday practice of scientists, but they are clearly tools manipulated in their efforts to produce genomes and other such scientific knowledge and medical technologies. Both their manipulation of these tools and their specifically scientific products have consequences for the constitution of society and culture. It is critical to pay attention to the practices of scientists as social actors and to the future worlds they are imagining. Politicians, political philosophers, sociologists, and anthropologists may mark off their territories, and may designate themselves as the makers and keepers of society and culture, but science and technology have already demonstrated their powers in making and remaking culture and society.

NOTES

This paper has benefited from many readers and audiences, of whom I can list only a few. I thank my colleagues at the Wenner-Gren International Symposium on "Anthropology in the Age of Genetics," my colleagues in the School of Social Science at the Institute for Advanced Study, and the Princeton University and University of Pennsylvania Joint Workshop in History of Science who heard and read different versions of this paper. For their detailed comments, I also thank Adam Ashforth, Troy Duster, Clifford Geertz, Ken George, Alan Goodman, Marta Hanson, Deborah Heath, Deborah Keates, Claire Kim, Dorothy Ko, Rob Kohler, Roddey Reid, Danilyn Rutherford, Joan W. Scott, and Sharon Traweek. I am grateful to the respondents who took the time and effort to talk with me about their work and allowed me to observe their activities. Finally, I thank the Social Science Research Council, the Abe Foundation, the Henry R. Luce Foundation, and the Institute for Advanced Study for their support of this research and writing.

1. See Cook-Deegan 1994 and Fujimura 2000 for stories of the international competition that led to the development of the American Human Genome Initiative.

2. The two terms are complex and paradoxical, and their interrelations are intertwined. Morris-Suzuki (1995) discusses "some of the paradoxes of the concept [civilization] by examining its evolution in the work of a few Japanese scholars who have reflected particularly deeply on the meaning of 'culture' as a framework for analysis."

3. These debates assumed that there was and is an essential, bounded Japanese culture that would be violated by "Western" ideas. This discourse also assumed a desire to maintain Japanese culture as it had been conceived collectively by these intellectuals. In contrast, recent work in anthropology, history, and cultural studies has demonstrated that culture is not synonymous with nation-state. For a discussion of these recent arguments, see Gupta and Ferguson 1992.

4. However, the discourse of certainty in the "inviolate" Japanese culture continued in the language of Japanese exceptionalism until circa 1910.

5. Names of Japanese authors living and writing in Japan are given in this essay with family name first.

6. Bellah partially recanted on this claim in the revised version of his book *Tokugawa Religion* (1985).

7. Miyoshi and Harootunian (1989) point out that this question applies to Europe and America as well.

8. For Western versions of this kind of civilization theory, see Huntington 1996.

9. The philosopher and cultural theorist Ueyama Shumpei has similarly argued that modern industrial civilization, based on the principles of science and freedom, has produced great benefits for humanity but has also produced negative social and spiritual consequences—"poisons" to which it is necessary to seek an antidote. Ueyama credited Western culture for the origin of industrialization and argued that Japan, with its roots in Chinese civilization, was, therefore, a more promising source for this antidote (Ueyama 1990, as discussed in Morris-Suzuki 1995: 740). For critiques of Kawakatsu's and Ueyama's work, see Fujii 1998 and Morris-Suzuki 1995.

10. These include Befu 2001; Field 1993; Fujii 1993; Fujitani 1996, 1998; Ivy 1995; Kondo 1990, 1997; Morris-Suzuki 1995; Ohnuki-Tierney 1993; Sakai 1997; Tanaka 1993; Traweek 1992; Vlastos 1998; Yoneyama 1995.

11. For example, immersed in the discourse of Japanese cultural uniqueness, authors like Doi (1973) have created an image of a Japanese self as interdependent in contradistinction to the image in the West of a self that is individualist and independent. Both images are cultural productions, and the image of Japanese interdependence was viewed as one of Japanese Orientalizing themselves. For critiques on Nihonjin-ron literature, see especially Kondo 1990; Ivy 1995; and Sakai 1997; see Said 1979 on Orientalism.

12. Some historians and anthropologists use these histories and anthropologies of Japan to question the organization of area studies in the American academy (e.g., Harootunian and Sakai 1999).

13. The acronym cDNA refers to DNA in the genome that actually codes for genes in more complex organisms such as humans. The cDNA for a particular gene appears as split fragments in the genome. In the laboratory, cDNA can be produced from mRNA (messenger RNA). Scientists are interested in cDNA because it allows them to study the expression of human genes in tissues.

14. The Japanese genome projects have been undertaken on a scale much smaller than those in the United States; the research was organized into five different projects, each belonging to a different government ministry. Japanese ministries are organized in a top-down fashion, and each ministry is highly competitive with other ministries, although this traditional division of labor recently has begun breaking down. (For example, several agencies now fund different aspects of the research being conducted at the Monbusho-funded Human Genome Center at the University of Tokyo.) Aside from Monbusho, the ministries involved in genomics research include the Science and Technology Agency, the Ministry of Agriculture, Koseisho (the Ministry of Health and Human Welfare), and the Ministry of International Trade and Industry. Monbusho and the Science and Technology Agency have recently been combined to form Monkasho (the Ministry for Education, Science, and Culture). Although Monbusho's genome project was the largest, with researchers and facilities in universities throughout Japan, other agencies have been expanding their projects. In the face of recent financial crises, the Japanese government has also decided to boost the economy by putting more money into the development of biotechnology. As a result of this decision, competition between ministries is beginning to take second place to coordinating the expertise for developing biotechnol-

ogy and competing with the biotechnology industries of the United States and Europe.

15. Professor Suhara's comments throughout the essay are from several interviews I conducted with him, the first in summer 1994, the last in summer 1999.

16. Genome informatics, or bioinformatics, is the study of biological information at all scales, from the study of submolecular functional groups and bond lengths to that of molecules, especially DNA and proteins. Bioinformatics researchers aspire to include other kinds of information on organisms and environments, but most of the information collected in databases to date pertains to the molecular level.

17. "Wet lab" biology refers to the research done on living biological materials, in contrast to "dry lab" research, which uses computational tools to examine and manipulate biological information.

18. Walter Gilbert, a molecular biologist at Harvard University and winner of the Nobel Prize, was thinking along the same lines at that time. In 1991, he published an article in the journal *Nature* titled "Toward a Paradigm Shift in Biology," which was subtitled "Molecular Biology Is Dead—Long Live Molecular Biology." In it, he argued that molecular biology would have to reinvent itself as an information science to have relevance in the future.

19. This representation ignores, among other things, the exploitation of forests and marine life around the world by Japanese companies.

20. In contrast, the discipline of anthropology has been entangled in controversies over its central organizing concept, culture. The notion of culture has been criticized, articulated, rearticulated, rejected, defended, and embraced. Suhara elides these agonistic struggles.

21. I qualify this statement because there are many different versions of both religions in many different countries and throughout history.

22. Suhara refers not only to creationism but also to other Christian views.

23. See Ketelaar (1990) on the conflicts between Buddhism and Shinto in Japan. Through this process, Buddhism transformed into a more immanent view of spirituality.

24. See Fujimura 1996 (chapter 7) on articulation work. Scientific work takes many different forms, including public education. Experiments at the laboratory bench are just one kind of work practice.

25. Indeed, for Foucault, tradition was an effect of the discourse of modernity.

26. See n. 8 on civilization theory, which promotes a view of the world as being divided into several major civilizations that are incommensurable.

27. Lovelock's Gaia hypothesis describes the earth as a complex, self-regulating cybernetic system. However, New Agers have understood this to mean a Goddess-guided system, and this spiritual definition has traveled far. Kitano subscribes to the Lovelock definition but benefits from the wide appeal of the term.

28. James Fujii (1998) and Marilyn Ivy (1995) discuss the Japanese state-sponsored *kokusaika* (internationalization) as an effort to domesticate the foreign, not as an actual opening of Japanese industry and education to the outside. Jennifer Robertson argues that internationalization is both a product of and central to the ongoing (since the Meiji period) formation of a Japanese national cultural identity (1998: 129).

29. Kitano Hiroaki, interview by author, 19 July 1999, 54. Except where otherwise attributed, all quotes by Kitano are from this interview.

30. Other projects include the attempt to model the genetic and enzyme cascades of yeast. Kitano says they "will [also] study the development of neural systems in order to understand how very large complex systems can be evolved and developed." In another project, Kitano and his colleagues are building a detailed simulation of the embryogenesis and neural system of *C. elegans*, with a focus on "a detailed model of a gene regulatory network for cell fate determination."

31. Francis Crick and James Watson won the Nobel Prize for proposing the double-helix structure of DNA.

32. Indeed, the translation of this technological advantage into commercial success during the 1980s produced both the trade wars and the praise and criticisms of Japan that accompanied them. See Morley and Robins (1995) for the effect of these wars on discussions of Japanese culture.

REFERENCES

Appadurai, A. 1996. *Modernity at large: Cultural dimensions of globalization.* Minneapolis: University of Minnesota Press.

Befu, H. 2001. *Hegemony of homogeneity: An anthropological analysis of Nihonjinron.* Honolulu: TransPacific Press.

Bellah, R. 1985 [1957]. *Tokugawa religion: The cultural roots of modern Japan.* New York: Free Press.

Cook-Deegan, R. 1994. *The gene wars: Science, politics, and the human genome.* New York: W. W. Norton.

Doi, T. 1973. *The anatomy of dependence.* Tokyo: Kodansha.

———. 1986. *The anatomy of self.* Tokyo: Kodansha.

Field, N. 1993. *In the realm of a dying emperor: Japan at century's end.* New York: Vintage Books.

Fujii, J. A. 1998. Internationalizing Japan: Rebellion in Kirikiri and the International Center for Japanese Studies. *Journal of Intercultural Studies* 19:149–69.

Fujimura, J. H. 1996. *Crafting science: A socio-history of the quest for the genetics of cancer.* Cambridge: Harvard University Press.

———. 2000. Transnational genomics in Japan: Transgressing the boundary between the "modern/West" and the "pre-modern/East." In *Cultural studies of science, technology, and medicine,* ed. R. Reid and S. Traweek, 71–92. New York: Routledge.

Fujitani, T. 1996. *Splendid monarchy: Power and pageantry in modern Japan.* Berkeley: University of California Press.

———. 1998. Minshushi as critique of orientalist knowledges. *Positions* 6, no. 2:303–22.

Gilbert, W. 1991. Toward a paradigm shift in biology: Molecular biology is dead—long live molecular biology. *Nature* 349:99.

Gupta, A., and J. Ferguson. 1992. Beyond culture: Space, identity, and the politics of difference. *Cultural Anthropology* 7:6–23.

Harootunian, H. D. 1970. *Toward restoration: The growth of political consciousness in Tokugawa Japan.* Berkeley: University of California Press.

Harootunian, H., and N. Sakai. 1999. Dialogue: Japan studies and cultural studies. *Positions* 7, no. 2:593–647.

Hobsbawm, E., and T. Ranger. 1983. *The Invention of tradition.* Cambridge: Cambridge University Press.
Huntington, S. P. 1996. *The clash of civilizations and the remaking of world order.* New York: Simon and Schuster.
Ivy, M. 1995. *Discourses of the vanishing: Modernity, phantasm, Japan.* Chicago: University of Chicago Press.
Japan Science and Technology Corporation and Exploratory Research for Advanced Technology (ERATO). 1999. *Japan Science and Technology Corporation and ERATO program bulletin.* Tokyo: Japan Science and Technology Corporation.
Ketelaar, J. E. 1990. *Of heretics and martyrs in Meiji Japan: Buddhism and its persecution.* Princeton: Princeton University Press.
Kitano, H. 2002. Systems biology: A brief overview. *Science* 295:1662–64.
Kitano, H., S. Hamahashi, J. Kitazawa, K. Tako, and S-I. Imai. 1997. The virtual biology laboratories: A new approach to computational biology. *Proceedings of the Fourth European Conference on Artificial Life,* 274–83.
Kitano, H., and S-I. Imai. 1998. The two-process model of cellular aging. *Experimental Gerontology* 33:381–91.
Kondo, D. K. 1990. *Crafting selves: Power, gender, and discourses of identity in a Japanese workplace.* Chicago: University of Chicago Press.
———. 1997. *About face: Performing race in fashion and theater.* New York: Routledge.
Lock, M. 2001. *Twice dead: Organ transplants and the reinvention of death.* Berkeley: University of California Press.
Lovelock, J. 1998. *Ages of Gaia: A biography of our living earth.* New York: W. W. Norton.
Mishima, Y. 1969. *Bunka oei ron* [Discussion on the defense of culture]. Tokyo: n.p.
Miyoshi, M., and H. D. Harootunian. 1989. Introduction to *Postmodernism and Japan,* ed. M. Miyoshi and H. D. Harootunian, vii–xx. Durham, N.C.: Duke University Press.
———, eds. 1989. *Postmodernism and Japan.* Durham, N.C.: Duke University Press.
Morley, D., and K. Robins. 1995. *Spaces of identity: Global media, electronic landscapes, and cultural boundaries.* New York: Routledge.
Morris-Suzuki, T. 1995. The invention and reinvention of "Japanese culture." *Journal of Asian Studies* 54, no. 3:759–81.
Najita, T. 1989. On culture and technology in postmodern Japan. In *Postmodernism and Japan,* ed. M. Miyoshi and H. D. Harootunian, 3–20. Durham, N.C.: Duke University Press.
Nakane, C. 1970. *Japanese society.* Berkeley: University of California Press.
Natsume, S. 1965 [1911]. Gendai Nihon no kaika [The enlightenment of modern Japan]. In *Han kindai no shiso,* ed. Fukuda Tsuneari, 53–72. Gendai Nihon shiso taikei 31. Tokyo: n.p.
Ohnuki-Tierney, E. 1993. *Rice as self: Japanese identities through time.* Princeton: Princeton University Press.
Pincus, L. 1996. *Authenticating culture in imperial Japan: Kuki Shuzo and the rise of national aesthetics.* Berkeley: University of California Press.
Pyle, K. B. 1969. *The new generation in Meiji Japan: Problems of cultural identity, 1885–1895.* Stanford: Stanford University Press.
Robertson, J. 1998. It takes a village: Internationalization and nostalgia in postwar

Japan. In *Mirror of modernity: Invented traditions of modern Japan,* ed. S. Vlastos, 110–29. Berkeley: University of California Press.
Said, E. 1979. *Orientalism.* New York: Vintage.
Sakai, N. 1997. *Translation and subjectivity: On "Japan" and cultural nationalism.* Minneapolis: University of Minnesota Press.
Tanaka, S. 1993. *Japan's orient: Rendering pasts into history.* Berkeley: University of California Press.
Tanizaki, J. 1965 [1933]. In'ei raisan [In praise of shadows]. In *Han kindai no shiso,* ed. Fukuda Tsuneari, 114–46. Gendai Nihon shiso taikei 31. Tokyo: n.p.
Traweek, S. 1992. Border crossings: Narrative strategies in science studies and among physicists in Tsukuba Science City, Japan. In *Science as Practice and Culture,* ed. A. Pickering, 429–65. Chicago: University of Chicago Press.
Vlastos, S., ed. 1998. *Mirror of modernity: Invented traditions of modern Japan.* Berkeley: University of California Press.
Yoneyama, L. 1995. Memory matters—Hiroshima's Korean Atom Bomb Memorial and the politics of ethnicity. *Public Culture* 7, no. 3:499–527.