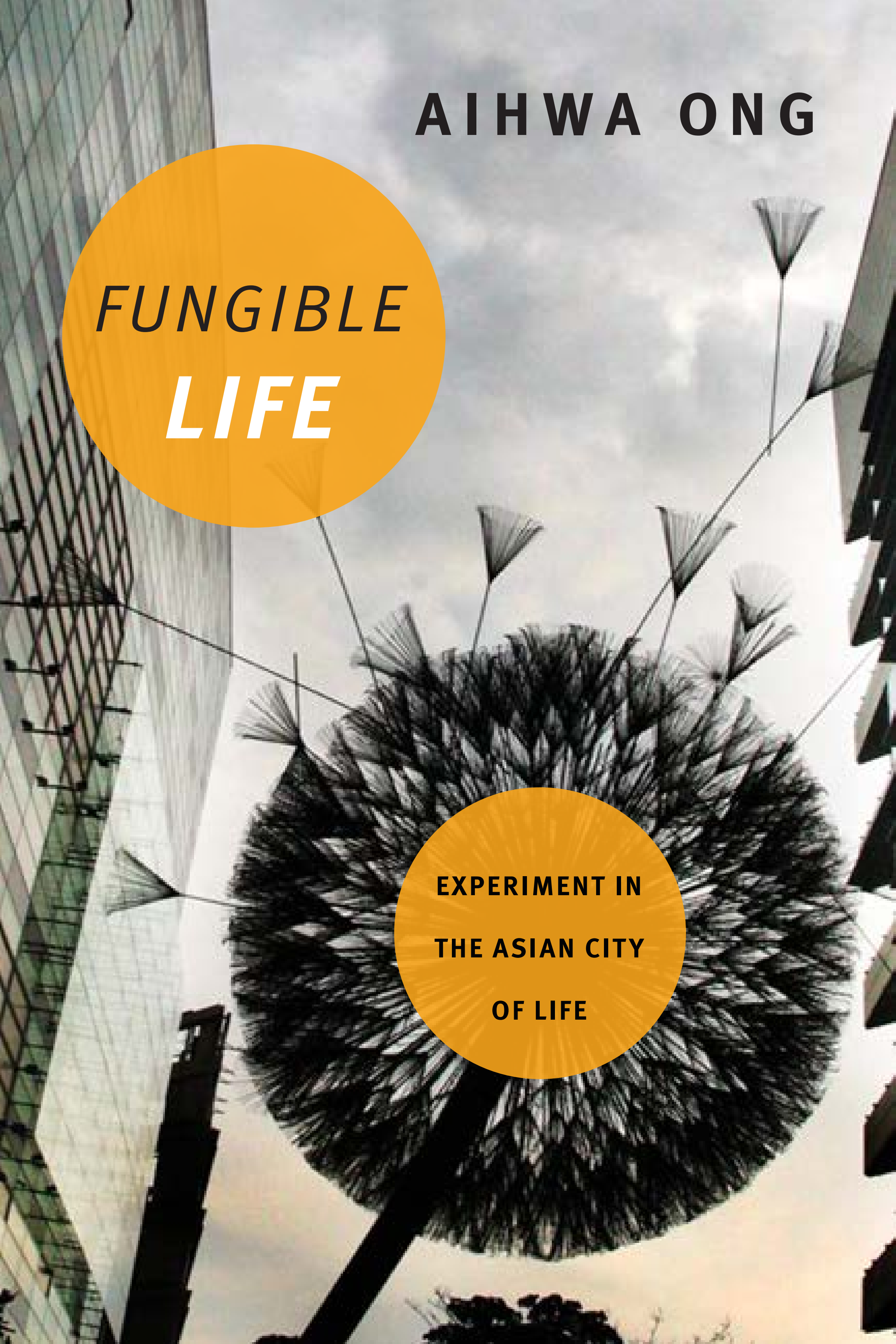

AIHWA ONG

FUNGIBLE **LIFE**

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Cover art: A sculpture at Biopolis, 2003. AP Photo / Wong Maye-e.

In memory of my parents
Ong Chin Seng and P'ng Hooi Kean

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PROLOGUE

ENIGMATIC VARIATIONS

Beyond Fortune-Cookie Genetics

In September 2013, an invitation to order a "your 23andMe kit today" arrived at my home in Berkeley. 23andMe is a personal genome service company that was cofounded by Anne Wojcicki (who is related to a founder of Google) in the heart of Silicon Valley. The letter claims that "the service reports on more than 240 health conditions and traits, including carrier status, disease risk and how your DNA may impact your overall health."[1] Furthermore, it added, "You can also learn about your ancestral history." This marketing gimmick underlines that "preventive health information should be accessible to everyone," thus combining a democratizing accessibility with a sunny injunction to self-management.

23andMe celebrates the dream of making DNA technology relevant to personal health, educational benefits, and cultural self-discovery. At UC Berkeley, some administrators were inspired to adopt this user-friendly approach to spark student interest in modern science. In the fall of 2010, the campus initiated a voluntary Bring Your Genes to Cal program. Incoming freshmen were invited to send in their saliva samples to be tested for different kinds of enzyme intolerance.[2] Meanwhile, 23andMe has been promoted in American popular culture for its power and potential to help individuals search for unknown ancestors. A television show on PBS hosted by the Harvard historian Henry Louis Gates Jr. used 23andMe kits to trace the genetic ancestry of famous individuals, stirring widespread interests among African American people seeking to rediscover family lines disrupted by the kinship-shattering cataclysm of slavery. But despite concerns that exposing personal features to the public may lead to social discrimination,[3] personal genetics, packaged and exemplified by 23andMe's merging of consumer empowerment and genomic self-knowledge, is publicly touted as the intertwining of American ingenuity, democracy, and individualism, all mined through individual bloodlines and genomes.

This popular image of genomic science was dismissed as "fortune-cookie genetics" by Dr. Edison Liu, then the lead scientist at Biopolis, Singapore's ecosystem of bioscience institutions. He explained that the growth of personalized genetics companies in the United States has generated the private misuse of genetic information for clues to personal ancestry and health. While 23andMe, for Liu, a U.S. citizen, represents a typically American genomic preoccupation with individualistic conceptions of kinship and descent, he had some reservations. The fact that most people are unable to interpret the data without the intervention of physicians means that the self-knowledge acquired from a cheek swab is not useful from a medical point of view, and indeed it might even encourage individuals to make health decisions without consulting with medical specialists. Indeed, Liu's position was echoed by U.S. doctors and the American Food and Drug Administration (FDA), which disapproved of individuals learning about their own DNA for these reasons. In 2013, the FDA sought to curb the misuse of commercialized, personalized test kits that had led some individuals, on their own, to seek out serious medical procedures such as a radical mastectomy.[4] For Liu, the market packaging of user-friendly DNA is a neoliberal capitalization on individual desires for fortune-telling that only contributes to the fortune of companies and perhaps to the detriment of falsely empowered individual patients.

By invoking 23andMe, Liu seized the opportunity to differentiate an American use of genomics, which seems to project rugged individualism and valorized self-care,[5] from Biopolis, where genomics are managed by scientists for collective health needs. Although the Biopolis hub is closely informed by American scientific administration and practice, as the hub's spokesman, Liu sought to highlight a defiantly Asian difference. As a state-funded project, the Singapore genomics initiative began earlier (2003), intending not to promote personal genetics, but rather to connect genetic data and tissues already stored in hospitals and clinics in Singapore and other sites, especially in China. A community of scientists, not private companies, will supervise the work of linking multiple existing data sources in research institutions and filling in the gaps in genomic knowledge about peoples in Asia.

The Singapore biomedical initiative also challenges the fortune-telling belief that the inheritance story is told exclusively by DNA. Liu explains: "We are in a 'new risk genomics' moment because new research shows that our inheritance is infinitely more mysterious than previously assumed in Mendelian genetics." At the turn of the century, the Human Genome Project was intended to usher in a DNA-focused approach to personalized medicine. Soon after, the focus shifted from a narrow focus on genetics to epigenetics, or the study of gene–environment effects on the performance of genes.

Scientists realize that while the genome evolves slowly through centuries, the epigenome, which turns a gene on or off, can change very quickly, within a few generations. The new science is called post-genomics. Liu prefers the term "new risk genomics," which describes a highly interdisciplinary field that includes genetics, epigenetics, biostatistics, proteomics (protein studies), and metabolomics (the study of cellular metabolites). Liu believes that, as a center for the study of new risk genomics, Biopolis has the potential to generate a tremendous amount of digital information that will revolutionize diagnostic and therapeutic methods. The high ambition of this interdisciplinary ecosystem is architecturally rendered as well in the design of Biopolis itself as a network of interconnected research towers.

Yet, despite Liu's rhetorical dismissal of recreational fortune-cookie genomics, some kind of fortune-telling is involved in genomic science, albeit in the abstract language of DNA and mathematics that still manages to work in "Asian" cultural elements. In the post-genomic landscape that Biopolis configures, and indeed mimetically hails through its architecture, it is precisely the attempt to design and then harness the "experimental future"[6] and its fortunes in Asia that is at stake. This book attempts to illuminate what is cosmopolitan science and what are the variations and differences that become coded in Asian post-genomics.

Biotechnologies today are involved in decoding the secret workings of the genome and recoding it in relation to other systems of codes and information (e.g., ethnicity, disease, nationality, geography). Genetic technologies can be likened to the Enigma machine used during World War II, a device for coding and decoding secret messages.[7] As in the mid-twentieth-century coding industry, the contemporary biomedical enterprise is resolutely multidisciplinary, driven by biological research and bioinformatics. The research milieu is a strange place where mathematicians, biologists, engineers, and other scientists work in tension and in concert across different fields.

The work of unlocking the enigma of life—the double helix of science and passion—now includes research venues in Asia. At Biopolis, DNA databases are coded to "Asian" ethnicities and other elements, thereby redefining what "Asian" means in variations of genes, identity, disease, and space. As a supplement to the American paradigm of the new genomics, researchers in Singapore are amassing and gathering for the first time millions of data points on Asian vulnerabilities and variations, so that other scientists can develop drugs and therapies tailored to the needs of bodies within Asia. I seek to illuminate one of the latest iterations of a century-long migration of scientific and technological knowledges originating in Europe and the United States to Asia, and the situated discovery of new findings within particular biomedical assemblages that transform contemporary science.

Asia, Anthropology, and Science Studies

The path for the study of post–World War II science, technology, and medicine in East Asia was blazed by anthropologists conducting research on Japan, arguably the most scientifically advanced nation in the region. In a pathbreaking study of high-energy physicists in Japan and the United States, Sharon Traweek examined the social and discursive construction of scientific communities.[8] Margaret Lock's award-winning studies of aging and menopause, as well as of organ transplantation, also situated biomedical innovations within a Japan–North American framework.[9] Arthur Kleinman pioneered the cross-cultural study of health practices by contrasting Western and Chinese-style approaches to psychological illness in Taiwan.[10] In a similar cross-cultural vein, Lawrence Cohen explored the medical and cultural construction of senility and cultural anxieties in India and the United States.[11] By taking a comparative approach, these works highlight Asian cultural notions of community, sickness, and bodies that contrast with American scientific understanding. Collectively, such perspectives situate Asia within contrastive cultural contexts for modern sciences.

More recent studies about how scientific and medical knowledges are taken up in diverse regions tend to focus on exploitation and ensuing ethical dilemmas. Brandishing the notion of "biocapital," Kaushik Sunder Rajan framed India as a site that has been exploited by biomedical trials in search of readily available experimental subjects.[12] Other anthropologists have portrayed Asia as a region of coerced and illicit organ harvesting, supplying body parts for transplant procedures, as well as a site of affective labors that serves a burgeoning medical tourism industry.[13] The implications are that besides the "bio-availability" of exploitable populations, cultural and social arrangements in parts of Asia abet in the biocapitalist pursuit of readily available bodies, labors, and "fresh" human organs from the developing world.

Meanwhile, the rapid deployment of specific biotechnologies in Asia requires a shift from contrastive cultural or political economic comparisons, to consider emerging competitive scientific milieus in their own right. The volume *Asian Biotech* casts light on the varied deployment of biotechnologies in Asian sites and on their enmeshment with situated forms of nationalism, biosovereignty, and ethics.[14] The newly influential journal *East Asian Science, Technology and Society* publishes articles that attempt to discover similarities and differences in the production of scientific knowledge in various historically situated but globally enmeshed contexts. Indeed, researchers in the anthropological and science and technology studies (STS) fields are studying emerging science contexts in Asia, which can generate potentially critical insights that richly expand the field beyond its originating Euro-American context.

Framed by the concept of "global assemblage,"[15] this book identifies an emerging context of what may be called Euro-American cosmopolitan science, crystallized in Singapore. First, assemblage concept departs from simplistic cross-cultural and North–South contrasts; it also challenges the STS theory of a universal science that floats beyond local mediations. The emergence of a science milieu in Asia, I argue, is the particular outcome of complex mediations between global technologies and situated forces. Second, if we understand Euro-American cosmopolitan science as regulated science, one should not assume in advance that biomedical science in other places is merely a debased form. Rather, this work will illuminate how, in order to become universal, cosmopolitan science must remediate situated elements so that it can attend to an array of "global" scientific problems. What is "global" and what is "situated" are destabilized in processes of scientific remediation across the planet. In order to be universalizable, cosmopolitan science depends on this constant effort to be particular, to remediate situated elements.

Radical uncertainties, the historian of science Steven Shapin observes, attend much of contemporary science, and "it is the quotidian management of those uncertainties"[16] that is the stuff of my investigation here. My overarching theme is productive uncertainty, in that scientific practices responding to myriad challenges are productive of new forms that in turn create uncertainty.

Different registers of uncertainty are at play in conditioning the experiment at hand: from the calculation of genetic risks for diseases, to uncertainties surrounding the science and the endeavor, to the larger "known unknowns" that science confronts in attempts to secure the immediate future.

Here I take the opportunity to state that, as an anthropologist, my task is to report and interpret scientific practices and ideas in context, without advocating on behalf of actors or experiments under investigation. My approach has consisted less in judging ethical or redemptive claims about specific research objectives than in identifying the particular biomedical assemblages within which ethical problems and conundrums crystallize, which actors seek to resolve. By offering a multifaceted ethnography of bioscience at Biopolis, I aim to illuminate how science projects are complex entanglements of reason and the passions. The branding of a new biomedical center is often surrounded by promotional publicity. As such, media stories and hype are part of the affective work of the trust-making necessary for garnering legitimacy for this kind of state-supported scientific enterprise. Discursive and nondiscursive practices surrounding Biopolis illuminate what might be called a form of scientific "exuberance"[17] as well as the affective uncertainty that perturbs the orderly landscape of science.

At Biopolis, scientific entrepreneurialism as a mode of risk-taking seeks to shape an emerging region for health markets and biosecurity. This ambitious and potentially risky project is inextricably linked to narratives that establish a spectrum of "Asian" differences—in DNA, populations, disease risks, disease forms, geography, research capacities, customized therapies, markets, and collective goals. The remarks of scientists and physicians accord value not only to themselves as experts, but also to the techniques and procedures involved in the acquisition of these truths.[18] My informants often make optimistic projections about the novel value of their discoveries and techniques for "Asian" peoples, the region, even the world. Such narratives and claims are consequential: the regime of truth accepts and makes true the critical potentials of their science.

In addition, science discourses and metrics are strategic when lab findings migrate to the public realm, and science spokesmen must perform in order to continue to draw multibillion-dollar investments from the Singaporean state and from foreign entities. Collectively, promissory claims about the science being produced animate political interest and legitimacy in what citizens may view as an uncertain economic enterprise. Such political justifications have scientists posing the need for Biopolis and the post-genomic research that occurs there in relation to the many diseases and ailments that vex and will vex Asian bodies. To gain further traction, long-standing notions of Asia, now reworked as a genomic, epidemiological, and environmental continuity, come into play. In Singapore, discourses of cultural, ethnic, and geographic differences are less about cultural jingoism than strategic claims to leverage Singapore's potentialities in global genomic science while also making the state investment in biomedical research also a reinvestment in the well-being of a vulnerable and racialized populace.

Race and Ethnicity in Medicine

The United States is a major shaper of cosmopolitan science, but it suffers from the historical convergence between structural racism, medicine, and biology that has had a devastating impact on minority populations. The history of misuse and abuse of racial data in medicine, with actual instances of eugenic and racial violence, is well attested.[19] Owing to this history of race science—one that medical anthropologists have at times participated in—racialized medicine in America is often read as an insidious and virulent science-as-racism.

As many STS scholars of the history of American racial science have argued, race was never about nature or biology in the first place. Race itself was always "interpretive," or a cultural construction, so to speak. Critics have argued that the uses of race were and are always confused about the genetics of populations, the genetics of race, and the genetic and social causes of diseases. Therefore, the reintroduction of race as a biomarker in genomic science has stirred old fears of the biologization of race, its stigmatization, and this reinforcement of social inequalities.[20] In *Backdoor to Eugenics*, Troy Duster explores the troubling social and ethical implications of genetic technologies, including the misuse of genetic theory and information, on minority groups such as African Americans.[21] Especially among those working with populations that have and continue to be drawn into a new constellation of race and medicine in the United States, rightful skepticism continues, despite the fact that the new "ethnoracial" category incorporates the interplay of nature and nurture into medical research.

Indeed, genomic medicine has propelled the transition from race to ethnicity, thus effecting a different kind of interpretation of disease vulnerability, though the race-ethnicity divide is neither finite nor entirely clear. The employment of the ethnic heuristic should perhaps not be considered as a restoration of scientific racism in genomic science, but as a new technique that is intended to be inclusionary in the mobilization of health data. The

National Institutes of Health (NIH) Revitalization Act of 1993, Margaret Lock and Vinh-Kim Nguyen note, promotes the use of race (and gender) as a scientific category in DNA sampling. They are careful to note that "population," "race," and "ancestry" (the preferred term) that variously correspond to U.S. census categories are not considered discrete dichotomous variables but are used as heuristic devices for studying the frequency of specific genetic traits. This represents a gesture on the part of the NIH at navigating the fraught historical and political terrain in which "race" in its molecularized form has often been read as a causal explanation of historical and ongoing structural social inequalities.[22] Duana Fullwilley argues that the "molecularization of race" can be viewed as intended to rectify the systematic exclusion of gendered and raced minorities in American health research.[23] The ethnic heuristic—mobilizing ethnicity in an experiment as an interpretive tool rather than as a claim to some stable and preexisting biological reality—is one way in which researchers attempt to elaborate a bioscientific enterprise that can include questions of human difference without defaulting into the pitfalls of scientific racism and racist genetic determinism.

Ambivalence remains over the use of ethnoracial genomic data because of its unintended effects on racial politics. Even Lock and Nguyen worry that DNA fingerprinting outside the lab may give rise to biomedical practices that unintentionally promote racial stereotypes, affirm ethnoracial differences, or further commoditize racial medicine.[24] At the same time, despite risks of exacerbating racial blaming and oppression, there is a growing consensus that the use of such genetic markers should be dropped.[25] After all, besides their application as a mode of biomedical inclusion, ethnoracial categories may contribute to social healing in that minority groups, through their biomedical racialization, are finally receiving the sophisticated medical attention they have long deserved. Alondra Nelson has argued that commercialized ethnic DNA can be used as building blocks for projects of reconciliation and thus may be viewed as positive elements for the future of American racial politics.[26]

As I will argue in this book, the ethnic heuristic as an inclusionary aspect of DNA fingerprinting is more unambiguously embraced overseas as an advantageous aspect of genomic science that gives texture and robustness to the DNA maps of global populations so far excluded from genomic science.

"The Difference That Makes a Difference"

We are at a moment when there is a growing international division of knowledge and labor as well as a pluralization of the life sciences. Genomic science is a novel experiment in the interplay of biology, race, and the environment, but each national setting uses different concepts of race (historical, cultural, political, and biomedical) in relation to genomic science for different but not mutually exclusive strategies of bolstering national identity, biocapitalism, and/or biosecurity for the future.

Scientists seeking to configure new knowledge systems outside Euro-American milieus generate what Gregory Bateson calls "the difference that makes a difference."[27] Different systems constantly experiment with form where the constant value is not a thing but a contingency. Drawing on ecology and biology, Niklas Luhmann argues that in society's self-referentiality and future elaboration action is communicated through the constant creation of otherness (contingency) in relation to things that already exist. As is often the case, the largest register of difference is the West versus Asia not as stable things but as relationships among shifting contingencies identified in systems making. Differences (race, ethnicity, geography) therefore are not stable but are rather contingent values that systems use to reduce complexity but end up creating more complexity.[28] Throughout this book, "the West" and "Asia" are invoked by researchers, informants, and sometimes by me in order to indicate the registering of such contingent attributes and relationships from vantage points within different systems of knowledge making (biomedical, political, anthropological, etc.).

Difference and differentiation mark novel aspects of any scientific experiment. When American genomic science is used for non-European populations, race, used as a code for groups with distinctive clusters of genetic, epigenetic, and molecular features, is useful for developing customized medicine. In pharmacogenomics, infinitesimal genetic differences can have significant implications for disease susceptibility and therapeutic responses; and racial/ethnic markers have become a useful technology for sampling populations, testing drugs, diagnosing, and customizing therapies. For instance, variability in DNA and in immunology is scientifically significant in reproductive technologies. Charis Thompson argues that "race" in contemporary biomedical research is a heuristic for identifying the intricate interplay of nature and nurture, of genetics and epigenetics.[29] Thus, attention to "racial" biomarkers of gene–environment interactions is very critical in the success of transplant technologies.

But because race outside the lab can refer to a variety of things, the racialization of genomics often takes on political and symbolic overtones, just as it grows out of fraught histories for creating and classifying human difference.

Different national contexts of genomic science disclose various uses and meanings of race.[30] Latin American countries tend to construct "mestizo genomics" because scientists are influenced by notions of race mixture (from social, historical, and political sources) that come to shape research questions and answers.[31] In Mexico, the digital database is racialized as mestizo or mixed race, in opposition to indigeneity and in acknowledgment of interwoven histories and populations who collectively symbolize the nation. Mestizo blood samples are critical for the Mexican biomedical enterprise because they represent a form of "genomic patrimony."[32] It is interesting that genomic science in Latin America seems to be primarily concerned about constructing unified, while mixed, national races in their databases. By contrast, in Asian biomedical sites, ethnicity as "the difference that makes a difference" is deployed as an astute strategy to enhance the scope and power of genomic knowledge thus generated.

Enduring European colonial legacies in Southeast and East Asia are constructions of plural society, of coexisting races (essentialized) closely tied to language and religion. Different authoritarian political orders are based on multinationalism (China) or on multiracialism (Singapore), and the major axis of difference is between majority and minority nations/races/populations. Although there is political emphasis on protecting the group rights of minority nations/races, the majority nation/race is variously privileged and enjoys political dominance. In Singapore, electoral democracy is tempered by a communitarian ethos that extols social obligations and the importance of the common good, thus emphasizing collective over individual autonomy and rights. An official order of so-called CIMO (Chinese, Indian, Malay-Muslim, Others) multiracialism aims to balance the claims of different races in the nation. At the same time, hate-speech statutes discourage talk about race and religion, and there is a healthy public defense against disparaging the cultural practices of any "race." In this model of administrative homogenization of identities, "ascribed" race minorities are very different from "voluntary" self-inscribed minorities in liberal multiculturalism.[33]

Nevertheless, in reaction against the state's insistence on "racializing" everyone, media, academic, and "scientific" discourses increasingly use "ethnicity." Researchers in Singapore shift from the official category of race (traced through patrilineal descent) to American uses of ethnicity (based on self-identification in medical records) in their effort to model ethnic biomedical collectivities. Fortuitously, they recognize that ethnic-differentiated medical science makes their databases more performative and mobile across multiple sites. For instance, ethnic Chinese biomedical collectivities can come to represent huge numbers of people in the world who may self-identify as Chinese. Critically as well, English—the language of science and ethnicity as normalized by international social science—is utilized to strategic advantage by Singaporean health researchers. The ethnic heuristic helps to circulate their findings, claims, and applications to places where English denotes like-ethnicities are found.

Therefore, genomic science in Singapore does not reify colonial-era notions of biological race, nor does it uphold a single national race in the genomic lab. In addition, the assumed stigmatizing effects of ethnoracial medical data in the United States do not apply in Asia. People tend to have a robust sense of their (variously constructed) racial/ethnic identities viewed through the lens not of past victimization but of ancient roots and historic achievements. Genetic technology is new, and people welcome Asia-oriented research that targets their ethnoracial group for therapeutic research. Few express fear or ambivalence about ethnic specifications in biomedical sciences, which in any case are but tools to help clinicians develop the personalized genetic data one can get on a chip and soon on the iPhone. Ethnic-differentiated tools are part of being techno-savvy medical consumers.

By adopting the ethnic heuristic, Singapore can leverage an ethnic-rich genetic database and brand itself as a biomedical center for a broader Asia. Multiethnic DNA is less about investing in national unity (as in the Mexican case) than a pragmatic strategy to produce a statistical infrastructure for demographic and geographical reach. It is this convergence of the use of ethnic heuristics in cosmopolitan science and the existence and malleability of official racial classifications in Singapore and Asia through which this infrastructure emerges. Racial categories for population administration provide a convenient and salutary statistical framework for the biomedical sciences. Biopolis's American-style biomedical research is thus resolutely global in its ambition; and the ethnic heuristic, detached from specific national moorings, facilitates a transnational inclusiveness because majority populations (Chinese, Malays, and Indians) in the region who were previously excluded from "universal" biomedical research can now be brought under the molecular gaze. In recognition of this universalizable power of the ethnic heuristic, the NIH selected Singapore's "trans-ethnic" DNA project to develop statistical research on the DNA of "non-European" populations.[34] In a sense, American scientists furnished the ancestry/ethnic heuristic, as Lock and Nguyen have argued, and their Singaporean counterparts apply it to majority (not minority) populations in Asia.

This book is an experiment in what I call an anthropology of the future. How can anthropology—the study of the diverse ways of being human—be made relevant in the twenty-first century? Whereas anthropologists have long assumed that "culture" has always had a monopoly in defining the human, Stephen J. Collier and I maintain that science and technology actively mediate cultural notions, thereby proliferating novel ideas of the human, living, and life itself. The task of anthropology therefore is to investigate how contemporary science participates in and transforms preexisting cultural ideas about the anthropos in multiple registers today.[35] In an age of hopes for science and technology, ethnographies are critical for illuminating how cultural, philosophical and political differences translate and shape experimental systems and milieus.[36] Following a visit to China, Nikolas Rose has observed that the racializing trend of pharmaceuticals in Asia should not be dismissed as due to simply cultural differences. Instead of a reflexive critical suspicion, he cautions, we might seek answers in "new relations of genomics, identity, biosociality, and bioeconomics."[37]

In the chapters that follow, my study of Biopolis in Singapore, with a glance at BGI Genomics in China, goes beyond cross-cultural and cross-disciplinary translations to interrogate how science itself becomes transmuted in the process of designing anticipatory futures. This book is an ethnographic study of Biopolis, Singapore's City of Life, a global milieu that seeks not only to incubate a new life science in and of Asia, but also to mobilize new political and ethical horizons for managing uncertainties in a uniquely connected and vulnerable region. Even as therapies are becoming more and more individualized for the wealthy, as in the sequencing of Steve Jobs's genome in order to treat his pancreatic cancer, pharmaceutical innovations continue to demand the capture of huge swaths of new data. But whereas biomedical science is amazing in promising to unlock the codes of life, our diverse and shared fortune as anthropos is not so easily predictable or prepared for.

The new biology evolving in Singapore and elsewhere is an interdisciplinary field, bringing together the diverse expertise of biostatisticians and classically trained biologists, engineers, and doctors who often do not see eye-to-eye but do depend on the same sources of state or overseas funding. Different techniques are fashioned from dry labs and wet labs: that is, sites for the analysis of computer-generated data and classic bench-top experiments with biological materials. My investigation focuses on some research programs integrated with clinical and academic research communities, including genetics, oncology, stem cell research, and tropical diseases. I explore the biomedical assemblage from the inside to illuminate how the work of science is infused with intensities, optimism, and anxiety.

As part of its quest to be a global biomedical hub, Singapore shifted from a British medical tradition focused on high-quality patient care to an American style of training physician-researchers engaged in innovative evidence-based practices. In 2003, Biopolis was established by the Agency for Science, Technology and Research (A*STAR). Biopolis comprises a cluster of public research institutions and corporate labs involved in many areas of biomedical science activities. Outside the Biopolis precincts, there are many international medical programs, including the Duke-NUS Graduate Medical School and the Johns Hopkins Cancer Center as well as major teaching hospitals and global drug laboratories. Biopolis is then itself less a singular site and more a network of institutions stretched across the island and beyond. With the term, "Biopolis complex or ecosystem," I refer to this extended network of universities, hospitals, clinics, research institutions, and pharmaceutical companies in Singapore and overseas.

Singapore has gathered an international community of life experts (biostatisticians, geneticists, stem cell experts, neuroscientists, bioethicists), the so-called new specialists of the soma,[38] to meet such challenges. The bioscience research community draws from the public and private sectors, composed of more than two thousand scientists. Foreign and local-born researchers have been trained at leading world institutions such as Cambridge University, University of Edinburgh, Harvard University, MIT, Johns Hopkins, and many more in Europe and Australia, as well as Singapore's own world-class universities. Science luminaries supervise labs, unfairly dubbed "research factories," where hundreds of PhDs recruited from top-ranking universities in China, India, and Singapore work in some obscurity. Despite their busy schedules of work and travel, all scientists whom I contacted were responsive to requests for interviews. Biopolis has many corporate labs, but scientists there were unavailable for interviews because of concerns about intellectual property issues.

This book draws on research conducted between 2004 and 2013 during multiple summer visits to Singapore. In all, I interviewed a few officials and scores of researchers in fields such as population genetics, medical genetics, oncology, bioethics, infectious diseases, and stem cell research in the extended Biopolis complex. My investigation focuses on research practices rather than on therapeutic activities, and my informants tend to be scientists (principal investigators) who often are clinician-scientists. Most of my interview data were collected in the spring of 2010, when I was a research fellow at the Asia Research Institute of the National University of Singapore. Some scientists were interviewed later at UC Berkeley and the UC San Francisco Medical School in California, and BGI Genomics, China.

Besides hour-long interviews (and repeat visits in many cases) at the offices of science institutes, I attended the many international conferences and lectures at Biopolis and the Duke-NUS Graduate Medical School. I also visited major teaching hospitals and clinics throughout the island, and I generally imbibed the biomedical culture brewing in Singapore. I hung around different medical campuses and ate in cafeterias serving international cuisine. This fieldwork, driven in part by my capacity to connect with individual researchers, offers captivating ethnographic and philosophical moments that highlight the invisible work, as well as the uncertainty, going on in some of the labs.

I am grateful to all respondents, from principal investigators to lab workers, from American scientists to mainland Chinese technicians, for their desire to explain to a nonspecialist what it is they are doing. I was generally impressed by their ardent interests, strong dedication, and professed optimism for the future. The identities of informants are disguised except where otherwise indicated. Scientists with public roles and well-known reputations—such as Edison Liu, director of the Singapore Genome Institute (2003–2010), and Henry Yang Huangming, a founder of BGI Genomics, among others—retain their own names. I appreciate the time and effort they took to engage someone who is concerned about the anthropos in other guises.

Not all scientists I encountered participated in the project of ethnic-stratified medicine, and many projects at Biopolis do not mark their data or claims in ethnic terms. But as one among other Asia-born researchers, my presence may have stimulated a degree of candidness seldom encountered by other anthropologists. In Singapore, cultural discourses suggest an overlap between race and ethnicity, and that will be evident in quotes scattered through this book. At the same time, most researchers frequently invoked "Asia" and/or "Asian" to highlight some dimension or element—in genetic variants, beliefs, values, way of life, and geography—that is a necessary and significant part of their work in forming this globalized biomedical milieu.

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The practical circumstances in which I first started exploring the rise of Biopolis were generated by my visits to my mother in Singapore. Traditional Chinese acupressure, more than modern medicine, offered comfort in her final years. This work is dedicated to her memory, and that of my father.

INTRODUCTION

INVENTING A CITY OF LIFE

Others collect butterflies; we collect scientists.
—SINGAPOREAN OFFICIAL (2005)

Biopolis is a life-sciences hub in Singapore that is at once embedded in the Asian tropics and densely connected to biomedical science sites around the world. Conceived and implemented by a Singapore government body called the Agency for Science, Technology and Research (A*STAR), Biopolis is the heart of a new bioeconomy built to remake the near future. The galactic imagery of A*STAR is reiterated in the words of a Singapore leader who boasted that this port city must be like a Renaissance city-state (i.e., it must become a crucible of creativity that thrives by welcoming talented people from far and wide).[1] Biopolis, which is central to Singapore's reinvention as a knowledge economy, was introduced to the world with extravagant flourishes and fanfare.

In the first two decades, the Singapore state poured billions of U.S. dollars into the biomedical center at the One North campus. Biopolis began in 2003 with an initial cluster of nine interlinked towers—there are now thirteen—dedicated to bioscience activities conducted mainly through public research institutes. The image and tone of the place were established by the international architect Zaha Hadid, who helped design a stunning parkland for scientists to work in. The key research towers are named after Greek mythological figures—Helios, Chromos, Centros, Nanos, Matrix, Genome, and

FIG I.1 A “sky bridge” hovers above a tropical garden at the Biopolis complex.

Proteus—signifying the high ambition and international symbolism of the projects.[2] These public institutes, increasingly juxtaposed with corporate labs, are engaged in cutting-edge research in genomics, stem cells, oncology, neuroscience, nanotechnology, and biologics as well as tropical diseases. The towers are linked by sky bridges, an architectural rendition of connectivity, to reflect the resolutely international and interdisciplinary orientation of the initiative (see figure I.1). Visiting British scientists, impressed by seemingly unlimited funding, top-notched equipment, and spectacular facilities at a time when funding for science has become less certain elsewhere, have dubbed Biopolis a “science nirvana.”[3]

In the early years, the hothouse atmosphere was underlined by claims that Biopolis was no butterfly-collecting expedition, but instead a project to collect scientists. Alan Coleman—the Scottish scientist who famously cloned the sheep Dolly and now leads a program in stem cell research—was the chief representation of the kind of “world-class” expert that Biopolis aimed to “collect,” who then acts as a principal investigator (PI) for different institutes and programs. The scientists oversee laboratories filled with hundreds of PhDs from China, India, and other parts of Asia who have been offered multiyear A*STAR fellowships. Recruited by headhunting programs, these lab researchers are well paid compared to those at other research centers in Asia and, once in Singapore, they are encouraged to take up citizenship. Talented Singaporean students are sent for overseas training in science and engineering, but they are expected to return to work at Biopolis. While the goal for the future is to have the biomedical hub be mostly homegrown, the community of scientists is currently international, and their work is to advance cosmopolitan science in the Asian tropics.

Biopolis is dedicated to the bright promise of developing personalized medicine in Singapore. It is part of an ambitious quest to code variations in DNA, ethnicity, disease, and location among Asian populations for the discovery of novel genomic information. Like variations in a piece of music, scientists' refrains often invoke the difference of ethnic- or Asian-stratified medical data that brands Singapore as the prime milieu in which global pharmaceutical innovations can be made in Asia and for Asian populations.

While the ethnicization of genomic data for customized medicine in the tropics remains a heuristic, utilitarian way of discovering and investing in genomic citizenship or Asian genes, at the same time, the data becomes "Asian" as does the modality of research and of life science. That is, Biopolis operates not only as the center of a new research ecology but also as a key site in the staking of a new and self-consciously Asian way of doing science. This begs the question as to why the science becomes veritably Asian while still being international and cosmopolitan in its design and practice. At stake in this biomedical assemblage is the crystallization of conditions for the cosmopolitanization of a science that now refers to Asian bodies/histories/migrations/diseases.

A City of Life

A self-description of Singapore is that it is a tiny, resource-poor island nation that is compelled to constantly self-invent. Since its independence from British colonial rule in 1959, the city-state has struggled to survive. The 1960s were a fraught decade, characterized by an ill-fated union with Malaysia that ended in 1965. The island nation also had to cope with a "*konfrontasi*" (Malay-Indonesian) policy from its giant neighbor, Indonesia, which reviled independent Singapore as a running dog of Western imperialism. Under the extraordinary leadership of the first prime minister, Lee Kuan Yew, the next few decades saw the stunning rise of Singapore as an "Asian tiger" nation, leaping from being a manufacturing center to a global port and financial hub. By the turn of the century, Singapore's GDP per capita of over US$55,000 exceeded that of the United States.[4] Orville Schell, a scholar of modern Asia, notes wryly that Singapore's experiment with modernity made "autocracy respectable" by leavening it with meritocracy.[5]

The modern history of a tiny, resource-poor island struggling in a hostile ocean has engendered an ethos of *kiasu* (Hokkien Chinese),[6] or "fear of losing out," that pervades public policy and everyday activities alike. The Singaporean version of meritocracy, which derived in part from the Confucian valorization of education and from the modernist focus on progress through expertise, has fueled a *kiasu* as an effect of fierce competitiveness in order to avoid "losing" in individual as well as government ventures. The nation's leading sociologist, Chua Beng Huat, argues that "fear" of failing to win haunts the success that has become the Singapore identity and brand.[7] Not surprisingly, an undercurrent of anxiety suffuses state entrepreneurial projects such as Biopolis. Especially since the SARS (severe acute respiratory syndrome) outbreak in much of Southeast Asia at the turn of the century, the affective effect of *kiasu* has taken on new urgency, driving new senses in the necessity of not only sound, state-led planning but also the need to be vigilant, if only to avoid anticipated disasters, including those of a biological nature. The turn to the life sciences has taken the form of Singapore being a beachhead for American cosmopolitan science, while the influx of U.S. science institutions seems to register an American anxiety about sustaining influence in the Asia-Pacific region as well.

In recent years, with an eye to the rise of China and India, the Singaporean state has shifted away from manufacturing to focus on high value-added industries. In economics, "value-added" refers to the increase in value of a product, exclusive of initial costs, at each step of its production. Knowledge and informational technologies, by enhancing manufacturing, marketing, processing, and services, are ways to add value to a product. With some of the highest student achievements in math scores in the world, Singapore has rebranded itself as an "intelligent island." The Economic Development Board began to quickly step up investment in research and development generally, especially in projects that promised to have a "high multiplying effect" in stimulating the growth of a knowledge economy.

The quest for new sources of value in the midst of anxiety over emergent viral and biological threats also prompted a refashioning of citizens as "brain workers" who are urged to reject lucrative jobs in finance for occupations that take care of "sick bodies."[8] The shift, from treating the population as an ever-productive labor force to a pool of bodies that will be the source of diseases and of novel medicines, is dramatic. With its efficient system of public health financing, and the recent computation of multiracial medical data, the Biomedical Research Council (an arm of the A*STAR galaxy) sought to reposition Singapore as a biomedical research hub and a health destination. In 2003, the SARS epidemic unleashed fears of not being prepared to deal with health epidemics looming for tropical Singapore and, as a regional transport hub, its far-flung environs. SARS threatened to derail the economies of Asian nations and grew into a pandemic that menaced the rest of the world. Because SARS was an "Asian" disease and lives lost were initially mainly in Asia, the perception of researchers and physicians as virtuous public servants is closely tied to regional and national identities. "SARS," a leading Singaporean epidemiologist confided, "helped the government to convey the message that nothing can be taken for granted." In the aftermath of SARS, a new vigilance about potential contagion threats shifted Biopolis from a center narrowly focused on shaping a bioeconomy to being on the frontlines in the fight against infectious diseases in the region.

This effort has been closely tied to new articulations of biomedical sciences, based in Singapore and, ultimately, science itself. While building a research platform for novel problematization of and intervention into "Asian" bodies, citizenship, and well-being, Biopolis has also staked its ambitions in cosmopolitan science. After all, from its beginnings, the initiative was advised by a group of well-respected experts from the United Kingdom and the United States. Among them was Dr. Sydney Brenner, a Nobel Laureate and pioneering molecular biologist who joined the Singapore National Science Council as a consultant on Biopolis.[9] As one of the pioneers of genomic science, Brenner made insightful and ethical interventions into our hubris regarding what we know with the knowledge we make in the life sciences. By having ethically minded star scientists on board, the Biopolis initiative aimed to demonstrate a dedication to science and a desire to learn and self-cultivate science as an enterprise, in the sense of to invent and create, beyond the crass materialism or bald global ambitions through which Asian sciences are often dismissed. Therefore, despite the media hoopla attending its early years, the Biopolis endeavor cannot be reduced to a purely entrepreneurial project with a still murky future. Some fitting questions posed by Biopolis may be how is scientific knowledge governed at a global scale, and what are the implications of a novel and distinctive "Asian" model of knowledge production for understandings of life?

This book illuminates a charged Sputnik moment in contemporary Asian bioscience[10] when scientists at multiple sites are experimenting with different visions of the future. Anthropologists often view biomedical innovations as contributing to the exploitative dynamics of biocapitalism,[11] or at least driving predatory practices of "bioprospecting,"[12] trends that variously intensify inequalities between rich and poor countries. At the same time, we cannot ignore how shifts in the biomedical industry beyond blockbuster drugs have opened up new opportunities for emerging countries to gain some control over their biological resources and secure the well-being of their peoples. For instance, in 2008, when Indonesia famously and controversially refused to share H5N1 viral specimens with the World Health Organization, observers considered this refusal an economic ploy to seek payments. Yet the outcome of Indonesia's negotiation with drug corporations that used the diseased samples was to provide vaccines at lower costs to donor countries, thus benefiting their citizens.[13] This is a critical example of how a big pharma–dominated notion of the "global good" is mediated by the interests of emerging nations.

The worldwide dissemination of biomedical tools and drugs has the capacity to generate a range of potential values, and only some can be construed as potentially "economic" in a strict sense. Indeed, this excess of value over the narrow constraints of classical economics is a key observation of the discipline of anthropology in general. Things being traded cannot be reduced to sheer commodities, but continue to bear the aura of social relationships and are thus animated by complex meanings and obligations.[14] Even in the era of big pharma, we may still hesitate to make a value judgment in advance and instead explore what clusters of values are in formation with the circulation of drugs and biotechnologies, what valuations are at stake, and how small countries can negotiate and constrain the power of global corporations. This more situated approach allows the anthropologist to evaluate the worth of what post-genomics science can enact, what vital investments it can make, and what hopes and dangers it can instigate for the collective good in emerging regions of the world.

It is also clear from earlier sales pitches that Biopolis positions itself as a strategic hub leveraging Asia as the world's next big drug market. Nevertheless, the creation of novel knowledge in a biomedical frontier begs the question of how the interrelation of biotechnologies, capitalism, and politics can also be generative of alternate goals. That is, if capitalism, geopolitical inequalities, and knowledge co-constitute the space in which Asian biotech aspirations operate, do they also open possibilities for other hopes and goals not overdetermined in advance? Biopolis, as I will illuminate, is not just an ecology to generate a particularly active form of scientific life,[15] but also a research milieu oriented to its tropical setting, peoples and other living forms, and closely tied to strategies for repositioning and remaking Singapore, and the Asia it represents, into a major scientific and medical player globally. Rather than invoking a new epoch in the rapacious and auto-elaborative agency of capital, I explore Biopolis as a contingent juncture of various processes and elements, of which capital is one, by attending to how practices of calculating and managing uncertainties produce enigmatic analogs of life in and of "Asia."

Situated Cosmopolitan Science

Scholars of science have noted that specific modes of scientific cultures and objects are shaped within various political and research environments. Lily E. Kay analyzes the interactive elements that gave birth to molecular biology in the United States,[16] while Sheila Jasanoff compares the varying impact of democratic citizenship, public culture, and nation-building endeavors in differently shaping science policies in North Atlantic nations. She notes that variable political cultures condition distinct research apparatuses, which might be understood as part of "projects of reimagining nationhood at a critical juncture in world history."[17] In a more ambiguous formulation, Hans-Jörg Rheinberger observes that the history of methods, objects, and key sites of experimentation in genetic and molecular science suggests multiple ways in which such experiments are crystallized. He maintains that "assemblages—historical conjunctures—set the conditions for the emergence of epistemic novelty."[18] This exploration of the biomedical scientific enterprise in Singapore provides a significantly different picture than studies of bioscience cultures in Euro-American environments.[19]

How to bring together—in a particular configuration of cosmopolitan science—the epistemic novelty of post-genomic science on the one hand and the situated political conditions on the other hand? How do situated political and ethical re-imaginings work to impact the *novelty* of epistemic novelty, or shape these novelties, as it were? Stephen J. Collier and I have offered the idea of the "global assemblage" as a useful lens for identifying the complex interactions of global knowledge and technologies on the one hand and situated contexts of politics and ethics on the other. Specific articulations of global and particular forms, we maintain, crystallize situated circumstances for generating novel concepts, objects, and tools for solving problems of life and living. As an alternate to conventional units of analysis such as the nation-state, empirical assemblages of technologies, institutions, and practices give a frame to emerging situations of problem solving.[20]

The Biopolis complex is formed at the nexus of cosmopolitan science and Singaporean authoritarian politics and collectivist ethos, raising questions about how global and situated elements interact with one another and what effects their adjacency elicits by defining what counts or matters in this form of cosmopolitanism, or what makes it such. The interplay of cosmopolitan life sciences and political entrepreneurialism in Singapore engenders situated problematics of risk in this emerging Asian bioscience. There is the epistemic novelty of a semiotic landscape of biopolitical governance that insists on "Asian" differences for understandings of life. At the same time, there is the development of global scientific capacities to deal with the risk of disease emergence in Southeast Asia that threatens the world. I will set out how these disparate but interlinked strategies for managing health risks complicate the meaning and challenge of science entrepreneurship in Singapore.

Scientific Entrepreneurialism in Asia

> Research scientists are artists who push the boundaries of convention. . . . They are risk-takers seeking to develop biosecurity in a world of information flows and fungibility.
> —EDISON LIU, director, Genome Institute of Singapore (2003–2010)

A model of a long spiral of DNA stands in the lobby of a gleaming Biopolis building, seeming to reach for the heavens. The double helix is both the glistening substance of and symbol for a genomic future. Biopolis's imposing architecture consists of a group of state-of-the-art research institutes housed within interconnected towers. They nestle in gardens designed to suggest a mix of tropical jungle and high-tech nursery, the image of a science designed to intervene in tropical life, scientific sociality, and innovations. Situated on a knoll, Biopolis is part of a larger digital information complex called One North (indicating its latitude north of the equator), Asia's latest venture into the brave new world of life sciences.

Biopolis was shaped during its first decade (2003–2010) by an energetic Chinese American oncologist, Dr. Edison Liu. Liu was the first director of the Genome Institute of Singapore as well as Singapore's chief science spokesman. During his tenure at Biopolis, Liu became the first Asia-based leader of the Human Genome Organization (HUGO).[21] From the start, Liu was a key thinker who envisioned and directed genomic research in Singapore and many sites in Asia. In the quote above, Liu signaled his view of scientific entrepreneurialism, emphasizing the role of scientists as risk-takers who must "push the limits of conventions" in a world of competitive information and value flows.

Genomic information, he argued, must be made fungible across spheres of knowledge, market, and security. Much more was at stake than just calculating bioprofits; governing apparatuses become fine-tuned as problems of biosecurity accumulate in diverse zones. The larger implication in a world of competitive flows is that scientists in the Biopolis ecosystem must create a distinctive space of intervention: one that is differentiated from and can tactically differentiate other contexts of biomedical science. The entrepreneurial goal of Biopolis, as expressed by Liu, is to shape a field of science research in Southeast Asia and beyond that can be the basis of defense against biopiracy so that DNA from Asia is not reduced to a "cash cow" for big pharma.

In the 1980s, a new form of scientific entrepreneurship emerged in the United States when American industries became alarmed by the perceived economic and technological competition represented by Japan and Asian "tiger" economies. The U.S. response was to encourage collaborations between research universities and major industries, and public and private institutions were encouraged to shape the growth of high-tech and biotech regions, starting in California.[22] Steven Shapin argues that entrepreneurial science cannot be disassociated from the charismatic authority of the figure of the lead scientist best exemplified by J. Craig Venter, a maverick scientist who was a key player in sequencing the human genome. Venter went on to found a private company initially called Celera Genomics that has since spun off a number of entities under various names. But as bioscience research went global, scientific entrepreneurialism has come to mean something different in a biomedical frontier such as Biopolis, and the charismatic leader has to be a very different personality type than Venter.

If Liu can be taken at his word, what is the moral lesson for scientists in Singapore that requires them to be risk-taking beyond the lab? The research model is not to be Venter-esque but to constrain the ways biomedicine has become corporatized. Asian researchers are operating in a region where big pharmaceutical companies may seek to colonize bioresources and abstract commercial values to make profits. As state employees, scientists in Singapore wish to take the lead in corralling scientific objects and findings about a variety of life forms in the region before they fall into the hands of drug companies. As we shall see, India and China are very concerned as well about protecting their natural resources and controlling the uses of data and values derived therein.[23]

In emerging nations where science has always been viewed as a tool of emancipation and thus bound up with the fortunes of the nation and citizens, the Weberian notion of virtue in science as a calling needs qualification and contextualization.[24] In Singapore, most of the scientists employed within the Biopolis ecosystem are public servants. While quite a few may love science, all are answerable to taxpayers, and virtue in science is expressed as a public service that cannot be labeled a simple vocation or as its opposite, sheer careerism. Rather, biomedical entrepreneurialism in this context is a developmental necessity to manage the collective interests of peoples in a region on the verge of being invaded by big pharma. The synergy between fear of failure and collective fate is expressed in contrary affects of anxiety and hope. The science experiment becomes inseparable from the performance of civic virtue and its investment in biological futures of the emerging world.

The interplay of hazards and hope, as well as uncertainty of outcomes, fuels "promissory" claims[25] about such an expensive biomedical initiative. It becomes the moral role of science leaders to stir up public enthusiasm and legitimacy for a state-funded, science investment in the collective good. Thus, bioscience entrepreneurship in Singapore is not best understood as a corporate strategy to shape speculative drug markets in Europe and the United States by opening the Asian arena. In Liu's discourse, the affective resonance is about being entrepreneurial with "Asian" differences—from DNA to ethnicity to disease to location—that promise to make a difference in personalized medicine and that resonate with citizens as cultural subjects, taxpayers, and patients. The Biopolis project must be shown to be bullish about Asian needs, not just be a commercial outpost of American biosciences. Singapore's scientific entrepreneurialism is in a larger sense about claiming ownership of a novel science of peoples in Asia, but it does not mean thereby that it lacks substance. A decade on, the biomedical science initiative is thriving.[26]

After SARS, Biopolis was recast as a center for biodefense, and "scientific entrepreneurialism" came to include this public responsibility to prepare for impending catastrophic events. The Duke-NUS Graduate Medical School was established to help train researchers to develop expertise on the endemic infectious diseases plaguing Southeast Asia. Biopolis and these other institutions together play a dual role as biocapitalist and biosentinel, ever alert to managing uncertainties in the market and in nature that threaten the nation and surrounding region. Southeast Asia and its surroundings are an emerging region of the world, as well as a biologically rich ground zero for the rise of deadly infectious diseases. Biomedical "Asia" is variously problematized as a multitude of risks to be managed through the discovery and oversight of findings about DNA, human and nonhuman life forms, and diseases and biothreats that are considered specific to the region.

Physician-researchers in Biopolis, then, need to demonstrate interest in the public good even as they become entangled with private interests of corporations and professional self-interest. Certainly, given their international training, scientists whom I interviewed in Asia were not immune to the American model of the entrepreneurial scientist who celebrates individual ingenuity. Nevertheless, the talk about risk-taking in Asian bioscience is a reminder that there are larger stakes in "scientific entrepreneurialism" than the quest for professional fame or corporate profits.

Scientific entrepreneurialism translated to Singapore does not describe the kind of bold risk-taking innovations by Venter that rock the new genomics. Rather, clinician-researchers in Singapore, and at BGI Genomics in China, claim that they focus on "practical things and wish to avoid controversial projects" such as creating artificial life. As is the case in many postcolonial countries, modern science is considered part of nation-building efforts, and the state tends to be the organizer of science training and research activities, and scientists tend to be public servants. Science expertise tends to be found in universities, teaching hospitals, and research institutes, the core institutions that institutionalize civic virtue among practitioners. At Biopolis, entrepreneurialism includes the moral expectation of Asian scientists, as leading public servants, to protect citizens' interests at a time when prowling drug companies are both a threat and an opportunity. Whereas Shapin argues that the uncertainties of much contemporary science in the United States have made "personal virtues" *more* central to its practice than ever before,[27] for emerging nations, public virtue remains salient in state-driven forms of scientific entrepreneurialism even in the midst of tempting opportunities offered by pharmaceutical companies. Virtue in the sense of serving collective interests would include responsibilities to produce knowledge on and take charge of national bioresources and patrimonies. As Nancy Chen and I have argued, scientists in emerging Asia are expected to defend their nation's biosovereignty in the face of challenges posed by global drug companies.[28] The public-private partnerships in scientific life are found everywhere, but perhaps in some Asian nations, public interests are necessary to generate affects such as trust and legitimacy.

Pluripotency and Fungibility

Uncertainty, Michel Foucault notes, is itself a form of power, a biopolitics that uncovers the enigma of life and materializes it into a manageable kind of present-future.[29] In Jane Guyer's words, "the near future," therefore, is that space that falls within the horizon of calculability.[30] By falling between the immediacy of the present and the loftiness of distant utopian futures, this temporal scale remains provisionally actionable and within the realm of pragmatic calculation. Genomic science, I argue, participates in this shaping of the present-future, by governing as it were through uncertainty, by calculating health normalities and risks as well as anticipating biothreats that may disrupt the near future.[31]

Furthermore, when we take a situated approach to scientific configurations, we discover glimmers of bioscience reasoning that go beyond what Nikolas Rose calls technologies of optimization focused on managing the arts of a healthy lifestyle. Given the stakes of the life sciences in Asia, "the politics of life itself" is premised on so much more than "what it is to be biological."[32] Biological sciences in emerging sites are perforce oriented less toward self-optimization than technologies for managing uncertainties that threaten in ways large and small the collective interests of life and living in the region. In Singapore, this broader concern with biosecurity may be said to be framed within an emerging form of biopolitical governance and its understanding by the government and civil servants as an ethic of collective care. In the overlapping geopolitical and sociopolitical interests that ride on bioscience in Asia, I argue, researchers are driven by larger goals in an experiment of "making more of life" that goes beyond enhancing the vital future of individual consumers.

Given their location, scientists in the Biopolis ecosystem seek to discover a range of life values from the biodiversity that surrounds them. I invoke the term "pluripotency" to describe the movement from the actual to the virtual, from singularity to multiplicity. In the new induced pluripotent stem (iPS) cell technology, the perturbation of adult cells causes them to revert to earlier embryo-like stem cells that are capable of growing into multiple types. Likewise, I track how scientific practices at Biopolis shift from the undifferentiated to multiple differentiated realizations that can be understood as a deterritorialization of the life sciences through which radical possibilities are unleashed.

I argue that in Singapore a pluripotent reasoning reinvests the collective "Asian body" as a distinctive kind of medical object—not the "universal" raceless body of white or unraced medicine, but as variations of situated, ethnic, and sick bodies. By coding and valorizing genomic and ethnic variability, Biopolis scientists are better able to be competitive in the international arena of bioscience research and pharmaceutical investments while also continually re-emphasizing a reinvestment in the diverse "races" that compose Singapore and Asia at large.

It is the historically contingent composition and racialization of Singapore's citizenry, created through population flows in the British colonial adventure in Malaya (and Dutch incursions into the East Indies) and enumerated through administrative schemes that know the population as a mosaic of official races, that has become a demographic and data infrastructure for building relations with both the medical establishments of other Asian countries and consistency with ethnoracial categories in cosmopolitan science.

Building regionally and ethically varied databases provides opportunities for Singaporean scientists to collaborate across the politically fragmented landscape of Southeast and East Asia. Cross-border science alliances can yield more ethnic-differentiated data and samples, thus creating a foundation for a potential Asian DNA databank. Furthermore, trans-Asian cooperation in science training promotes the beginnings of regional preparations for dealing with epidemics and other anticipated biothreats. The life sciences, in Singapore and China, produce the beginnings of regional collaborations that may come to define the orientation of cosmopolitan science, shaping what Brian Buchanan calls an emerging form of "geo-biosociality."[33]

The coding and alignment of variations are practices that make genomic science pluripotent and fungible. Pluripotency and fungibility in Singaporean genomics operate through the reassembling of existing forms of racialization and racial accounting in the nation's official classification of its citizenry. It builds on the ongoing use of ethnic heuristics inherited from British colonial racial typologies. But while these categories come out of a history specific to British colonialism, they have been increasingly leveraged to position Singapore as a demographic kaleidoscope of the populations of East, Southeast, and South Asia at large. In other words, without recourse to postcolonial theory, or claims about the continuity and sameness of political processes of racialization, these inherited categories become entangled and repurposed in new global logics of governance. They crystallize in new ways, becoming ambiguous, flexible icons that circulate through wider circuits of contemporary science power.

The pluripotency of the population is in that its singularity can be offered as a generality, and its fungibility is in how these categories can be made to travel over space, encompassing larger and larger swaths of a racialized humanity. For instance, A*STAR states that the major "strategic research thrust" at Biopolis is its development of "stratified medicine." The official claim is that "Singapore's multi-ethnic population of Chinese, Malays, and Indians is largely representative of the population in Asia, which makes up more than half of the world's population. Many pharmaceutical companies are increasingly viewing Asia as a major growth area, especially since there are a variety of diseases common in Asia . . . such as gastric and liver cancer, and various infectious diseases."[34] My research tracks the construction of the epistemological infrastructure and the reasoning and methods that underpin the creation of stratified medicine, which capitalizes on pluripotency by generating novel values out of linked data points on DNA and "Asian" elements that can be converted into patents as well as therapies. In the process, I illuminate that "races" are not immutable facts of the nature of the human species, but rather the ongoing achievement of complex biological, political, and epistemic processes. This book might be read as a way of telling a history of the present and the near future in which older forms of racialization interact and refunction within scientific endeavors, emerging markets, and the governing of security.

A Genomic Origami

In 2010, Liu summed up the goal of all the busy, mysterious work going on in the humming, dust-filtered, blindingly bright labs. "The Biopolis," he said to me, "is about making DNA fungible." He said that the information generated from DNA sequencing is fungible, providing an entry point to the bioeconomy because everything can be reduced to a sequence basis. The original usage of fungibility has both economic and legal components, in the linked notions of interchangeability and substitution, and of transferability as well. In economics, fungible assets would be commodities, options, and securities that are interchangeable and identical in value. By analogy, making DNA fungible suggests transposing (in data and abstract forms) qualities into equitable values. In other words, it is not the fixing of biodata, but the shifting around of data points that makes them innovative.

This way of using DNA data to generate transferable value is in contrast to "biovalue," which is an important concept that recognizes inclusion of biologically engineered vital qualities in the production of capital value.[35] More recently, Catherine Waldby and Robert Mitchell recognize that biovalue can be situated within a gift economy as well as a commercial one.[36] The notion of biovalue has been treated as a stable entity than can be activated in diverse domains (market, commons, and ethics). Instead of biovalue being a chameleon entity—now commodity, now commons, now affects—we might think of it as all these things in an interlocking information system that capitalizes on the aggregation of transferable science, cultural, and economic values. In novel research milieus like Biopolis, biovalue is a heterogeneous scientific object, its meaning always unstable and ambiguous when materialized as a signifying power that gathers up diverse local components bound up with health and wealth.

Perhaps "making DNA fungible" may be said to be inspired by a pluripotent reasoning that potentialities can come out of strategic recombination. Fungibility is engendered by using metrics of biological and social differentiation—DNA, mutations, biomarkers, ethnicities, and ethics—that render them equitable qualities in a single "Asian" system of biosocial values and valuation. In other words, here is a logico-semantic maneuver whereby all these disparate bits of information are aggregated in an ecology of information. The diverse data points must be transposed into a homogeneous language so that they can be reordered and translated from various models and algorithms and data sets to information libraries. Digitally interlinked, identifiable, equivalent assets are made to perform as both market and social/ethical values, and their transposable capacities enact a specific system of calculation and valuation that productively expands the present as a resource for socio-calculative action in the future.[37] With the digital means for capturing and relating materials, a new environment is created for making things fungible through their interconnections and fluidity across virtual and material worlds and virtual and material entities populating them. Singapore's research milieu is thereby branded as the site to shape and handle a new infrastructure of pharma diversity for bodies in Asia.

In the early twentieth century, the anthropologist Gregory Bateson proposed a new epistemology, which emerged from ecology and cybernetics theory. Information can be viewed as flexible ecology (homeostasis) or a system that regulates and corrects itself as it integrates information, basing their operational modus on distinctions/differences. Information, "a difference that makes a difference," comes "out of a context into a context," thereby generating a new difference or information. Recursively, any change within the ecology leads to further changes or reactions, thus generating a new system. Therefore, to think beyond the economic, the Batesonian approach would situate bioinformatics in a so-called informational ecology, or the ecology of an autopoetic or self-affecting/regulating system.[38] As it is made to absorb information (even techniques) not native to the system, bioinformatics have nonetheless brought the context of Asianness (bodies, health, and region) to the global knowledge economy. It should not be surprising therefore that in making a new system of biomedical information in the global context of Euro-American medical knowledge, researchers in Asia generate "Asian" distinctions that make a difference in the ecology of biosciences.

Drawing on the Deleuzian notion of "the fold,"[39] I invoke origami to refer to the folding of disparate systems of code—ethnicity, disease, geography, and market—into a fluid tissue of interconnected data points. For instance, there is the identification of "Asian" biomarkers for "Asian" types of cancers, co-related with spaces of infection, specialized cures, and intervention. Origami-like relations help to connect "fluid objects" (pathogens, animals, and people) to the "fluid spaces" of research, markets, contamination, and containment. As a novel intervention into the biopolitics of uncertainty, multiethnic medicine has sociopolitical implications for what it is to be biologically "Asian" and for what "Asia" is as a space of vulnerability and intervention in the world of life sciences.

"Datadiversity," Geoffrey Bowker notes, also layers in shared meanings of identity, body, and place, thus marking where affective resonance can be invoked.[40] The knitting together of disparate but identifiable assets in Asian genomics also animates productive affects of Asian identities. The invoking, provoking, and production of ethnically ordered science induce social conditions of being imperiled as ethnic and national collectivities, but are also being targeted for customized intervention. Diffuse affects of common endangerment and hope in turn support the building of this knowledge, stirring identification with a science brand that for the first time gives value to the specific afflictions associated with Asian peoples and their health needs as defined through this calculation and valuation of stratified medicine. In short, race/ethnicity is recast as both the mechanism of pluripotency and probability, the representational soul of the machine. As Michel Callon has argued, when the performativity of the market includes the overflow of affect and action, the simultaneous processes of commoditization and decommoditization are in play.[41] This genomic origami thus transmits various affects—genetic pride, public support—that Singaporean researchers hope to leverage for market competitiveness and science solidarity in the Asian region.

The Biopolis style of genomic science deploys race and ethnicity as *active,* not *reactive,* affects to induce potential values of solidarity and sociality. Such a scientific endeavor demands an attention to the generative, affective possibilities of scientific research, even when, and indeed *because,* it relies on long-standing categories of ethnicity. Because biomedical science in Asia—Singapore, Japan, South Korea, and China—is predominantly a state-funded and organized project, though with uneven degrees of regulation and marketization, racial and ethnic differences are absorbed as active variables and affective potentials: especially in the mapping and analysis of genetic variants, divergent molecular pathways, and expressions of diseases that vary across populations. Life-science practices thus draw upon and integrate ideas of racial and ethnic differences into their calculations, objects, and goals for populations already framed as a diversity of racial and ethnic groups. Furthermore, because scientific research is almost exclusively conducted in state-funded institutions, and often as a supplement to a deracinated (white) Euro-American human biology, scientists as public servants are socially bounded to serve "their" people and the use of ethnicity or nationality as active affects demands an alternate and even patriotic reproblematization. Communities of state-supported scientists are the instigators of social responsibility organized from the top down, fostering a contrastive model of biological citizenship than those that spring forth from grass-roots organizations.[42]

I am therefore not making a claim to an Asian science based in deep cultural features of the wide and diverse region known as Asia, but rather that new biosciences draw on and generate multiple ways of thinking and practicing Asia, which has always existed in relation with the world beyond. Two models of enigmatic DNA machines—one built by Biopolis in Singapore, the other by BGI Genomics in China—draw less from Asian medical traditions than from cosmopolitan science to realize variegated types of potentiality from a mixture of ethnic, economic, and scientific dreams. Nevertheless, as we shall see, the dazzling machinery of genomics and cutting-edge discourse is not devoid of the occasional glimmer of ancient beliefs about origins, bodies, and differences. My major focus is on Biopolis as a venture to extract pluripotent values by making genomics fungible and in the process calculating but also confronting a variety of risks that both enable and challenge the Biopolis initiative. A final chapter brings in BGI Genomics as an alternative use of ethnic data for genomic research.

In brief, the fungibility of DNA is created not by fixing biological coordinates but by aligning relations among bits of information in order to discover fungible aspects of variation. By holding their ethnic forms but shifting their relations, researchers at Biopolis hope to generate a spectrum of values that yield insights for customized medicine, to manipulate market risks, and to enhance affects of identity for scientific collaboration across the region. In its quest to map and enact a generalizable database for all of Asia, the Singaporean case of genomic origami illuminates how cosmopolitan bioscience is rife with topological possibilities.

Configuring an Ecosystem

Therefore, we need to situate the bioscience enterprise, and its operations and practices that enact and produce space-time configurations. John Law and Annemarie Mol argue that the double location of science and technology in labs and institutional networks implies that technoscience is "caught up in and enacts" the topological forms of "region" and "network." Science and technology also "exist in and help to enact" additional spatial forms that are fluid and constant objects.[43] Therefore, making DNA fungibility through strategic mapping, mobilization, and folding of diverse points and sites is productive of value-producing systems.

Throughout the book, I often refer to the "Biopolis ecosystem" or "Biopolis complex" in order to indicate that while Biopolis has its own campus one degree north of the equator, it is the center of a network of institutions, public and private, state and foreign, on a Singaporean island (see figure I.2). In other words, publicly funded projects at Biopolis are often connected in some way with these other institutions that may supply supplementary expertise, data, tissues, and critical funds. In addition, PIs from Biopolis may hold positions as professors in the national universities and hospitals, and corporations may become interested in their particular lines of investigation. Therefore, by the Biopolis ecosystem, I mean this network of collaborations and resource sharing that links four nodes of bioscience activities scattered across the island. The linked sites include Biopolis at One North; the main campus (major universities); "Hospital Hill," where public hospitals, clinics, and the Duke-NUS Graduate Medical School are located; and, to the west, a cluster of corporate manufacturing facilities near Changi International Airport.

Biopolis is a functioning knowledge ecosystem, with specialized niches and the circulation of actors, practices, and objects among them. Public research institutes, public universities, and hospitals are located near the downtown area, while global drug companies are at the periphery near the airport. Figure I.2 shows this interwoven public-corporate bioscience world, with dozens of corporate labs inhabiting Biopolis, American research programs embedded in national universities or hospitals, and the Duke-NUS Graduate Medical School on Hospital Hill. To put things too simply, state venture capital, public scientists, research material, and data are found in Biopolis, the

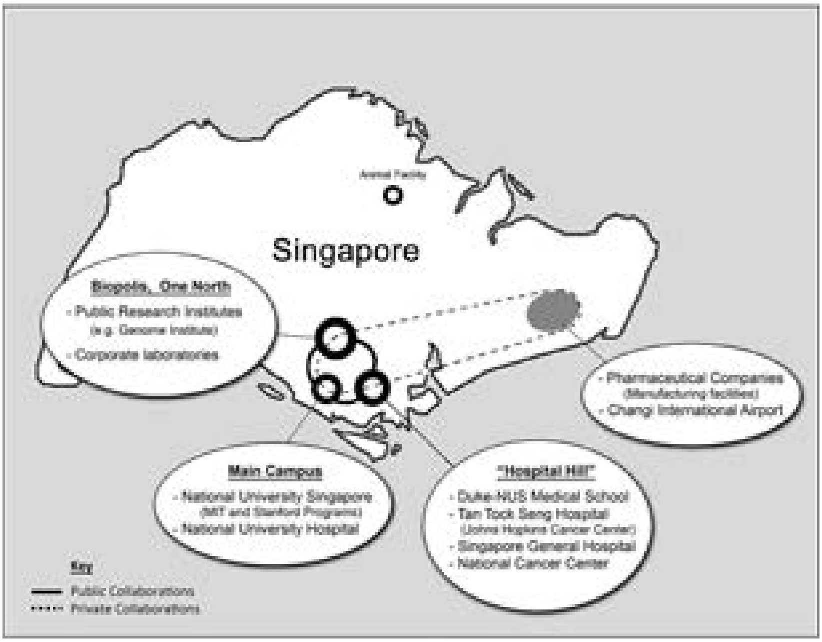

FIG. I.2 The Biopolis ecosystem, Singapore. Diagram by Robert R. Ng.

main campus, and Hospital Hill. As a quite cohesive, state-dominated half of the ecosystem, they attract drug manufacturing companies looking for promising investment opportunities. In their quest to be "global," universities as well as corporations have been pulled to well-regulated Singapore in search of Asian bodies, diseases, and data for making novel medicine.

This book is interested in how situated cosmopolitan technoscience, by combining materialist and symbolic powers, exists in and enacts fungible spaces and objects that help shape a regional security. In taking this materialist-posthumanist stance, my goal is to illuminate as well how experiments are forged in conditions of uncertainty. This maelstrom of Asian bioscience is traced from the molecular to the cellular to the corporeal, and from the institutional to the communal, national, regional, and global scales.

Cascades of Uncertainty: An Outline

Contingency is modern society's defining attribute, and the very techniques to temper uncertainties engender more risks for which we are often unprepared. For Niklas Luhmann, experts increasingly operate in an "ecology of ignorance," a space of the unknown future where we deal with only probabilities or improbabilities.[44] Anthropological literature on governing future contingencies offers some insights on security threats as problems of technological governing. Andrew Lakoff and Stephen J. Collier have argued that twentieth-century modernity has required the development of "preparation technologies" that plan for potential "events whose probability is not calculable but whose consequences could be potentially catastrophic."[45] In this study, I consider a spectrum of modern techniques at multiple scales designed to shape a more secure future, but I concede that there are uncertainties—sprung upon us by the contingencies of politics and nature—that may be beyond technological control.

I recognize three figures of uncertainty that confront the Biopolis initiative, along a continuum of more or less calculability, amenability to preparation technologies, and anticipated but radical contingency.

Part I investigates how researchers in the Biopolis complex calculate an array of risks—genetic, disease, and ethnic—in building the knowledge infrastructure that underpins Biopolis's claim as the biomedical hub of Asia. We live in a "risk society," Ulrich Beck observes, in which scientists (and policy makers, hopefully) reflexively respond to uncertainty by devising risk calculations to counter a range of random threats.[46] Indeed, modern power has relied to a large extent on mathematical techniques as the basis of rational decisions for mastering uncertainty. For instance, the health sciences have moved from moralizing claims about good or bad, to mathematical calculations of normalities for managing life.[47] Some uncertainties are productive in that they are reducible to rational calculations and risk assessments. In *Security, Territory, Population,* Foucault traces the modern calculation of biological events—morbidity, mortality, and risk—as vital to governance, or the biopolitics of security.[48] Power over life is continually reorganized, and the interplay of diverse statistical normalities—the "law of large numbers" and the "stable" object to be measured[49]—permits the prediction and projection of collective risks.

Statistical devices have now become an important foundation of post-genomic science. Algorithmic formulations now extend the calculation of normalities and probabilities of risk to the molecular level. Risk genomics is in part driven by data diversity that is both foundational and performative of research, affective, and market values. For instance, by aligning variations in ethnic (Chinese, Indian, and Malay), genetic, and disease information, Biopolis hopes to make DNA fungible, thereby positioning itself as the site for research on majority populations in Asia. Of course, computations themselves tend to generate other kinds of risk, from the misfolding of data to perturbations that build into multiplier effects. The first three chapters explore how the ethnic heuristic is variously deployed: in biostatistical databases and in disease science, cancer research, and other programs that help the Biopolis ecosystem serve a broad "Asian" market in pharmacogenomics.

Chapter 1, "Where the Wild Genes Are," explores how the deployment of ethnic variables and heuristics operates, both as the artifact of a confluence of historical and epistemological conditions for cosmopolitan medical science and as a site through which new conceptions of Singaporean populations are articulated. I illuminate how the National Institutes of Health (NIH) policy of racialization-as-inclusion in research informs the building of Asian DNA databases at Biopolis. Singaporean biostatisticians maintain that genetic traits among populations in Asia that are relatively new to medical genomics gain value from being calculated and databased. Singapore's ethnic-specified DNA databases, scientists claim, are more "competitive" than those from Europe that lack such ethnic diacritics. I argue that ethnicity is rendered an immutable mobile that circulates databases beyond tiny Singapore, permitting tiny Singapore to represent an entire continent by shaping a topological space of biomedical "Asia."

Chapter 2, "An Atlas of Asian Diseases," gives an account of how Singapore drew on its biomedical resources in order to launch Biopolis as a site for clinical testing and medical tourism. Public-private joint ventures and the establishment of a bioethics committee quickly made Singapore a site for stem cell research and organ transplantation. The assembling of an atlas of Asian-type diseases became the foundation for biomedical research, as well as the mapping of "Chinese cancers." By thus differentiating from a "universal first world body," Biopolis assembles the data, information, experiments, and meanings of "Asian diseases," configuring a potential cancer research market as well as an economy of reciprocal research.

"Smoldering Fire," chapter 3, discusses the identification of genetic risks for forms of cancer prevalent among ethnic Chinese and other Asian groups. I explore in particular how cancer research at Biopolis, especially those projects that mine large amounts of racialized genomic information, creates the conditions for new ways of understanding and living in susceptible bodies. By identifying genetic and ethnic risks, cancer research engenders contrary affects of vulnerability and optimism. I discuss how researchers in Hong Kong and Singapore create novel objects such as the "Asian female nonsmoker" as biomarkers for certain cancers. The self-performance of the clinician-scientist illuminates how, as a boundary subject, he is poised between seemingly objective scientific work and the ethical promise of customized therapy. The search for cancer biomarkers engenders a state of attachment to a disease that comes to be imbued with both dread and hope.

Part II, "Uncertainties," covers those contingencies that cannot depend on quantitative risk calculations, but rather come to rely on preparation technologies and infrastructures that anticipate a range of economic and scientific challenges. Entrepreneurial uncertainties that Biopolis must contend with include shifting global conditions that impinge directly on the success or failure of the state-funded biomedical enterprise as well as the competitiveness of the infrastructural and experimental aspects of the project. International standards of bioethical experiments, including the establishment of internal review boards, are part of the arrangement necessary for the conduct of reputable science. Chapters in this section explore a variety of challenges confronting the Biopolis science initiative: the role of bioethics in the success of a biomedical enterprise; the uncertain meaning of scientific virtue in a milieu of expatriate scientists; uncertainty in funding levels; and promising outcomes for high-stakes experiments.

Capitalism deterritorializes all previous existing codes in order to become the universal coded form as capital.[50] In other words, volatility in market and knowledge flows can be mitigated by establishing codes that standardize biotechnological rules and practices that facilitate market flows. In the pharmaceutical industry, Andrew Lakoff observes, diagnostics technology must be in place to ensure "liquidity," or the capacity of information to acquire value through circulation.[51] In addition, the transition from medicine to biomedicine involves the recasting of medical architecture and infrastructure. Global competitiveness requires the building of the "biomedical platform," defined by Peter Keating and Albert Cambrosio as a specific configuration of instruments, individuals, and programs, an institutionalized space that generates routines, entities, and activities held together by standard reagents and protocols.[52]

In Singapore, the preexistence of legal and business regulations helps boost the capacity of its biomedical project to engage global business. The country's reputation—consistently ranked highly as one of the least corrupt places to do business—as a corporate and financial center helps to reduce some of the uncertainty of roiling global markets. The strategic mix of "best practices" in global business and cosmopolitan science has created as "risk-free" a zone for investing in science research as anywhere in Asia. Critically as well, widespread fluency in English and Mandarin Chinese, and multicultural experience in bridging Asia and the West, allows the city-state to be a matchmaker between scientists, data, samples, companies, and cultures from diverse sites. But such systems of value creation, we should not forget, are vulnerable to the vagaries of situated politics.

Will "small, smart, and nimble" Singapore indefinitely provide generous public support for the doing of cosmopolitan science? Singapore's engineers and economists control state funding, and they tend to be impatient, results-oriented leaders. How long will state managers waiting for findings "from bench-to-bedside" continue to support Biopolis as a biomedical hub in Asia? During his directorship of the Genomic Institute, Edison Liu's job was as a fervent rainmaker. In order to please his paymasters, he needed to justify spending on research by projecting long-term and short-term metrics of bioscience output. In his more informal moments, he envisioned at minimum four decades of state investment, amounting to some US$40 billion. After all, post-genomic science research needs a long period to make discoveries that can be proven valuable; state-supported science is especially critical when big pharma routinely avoids research that has no immediate market application. Uncertainty in funding is a constant for all scientific experiments.

Chapter 4, "The Productive Uncertainty of Bioethics," explores the theme of how bioethics and other regulatory regimes can reduce uncertainty surrounding the viability of a biomedical initiative. The chapter follows Asian researchers in their own working through of the limits and contradictions in a universalized ethical framework as it plays out in their various fields and sites. In contrast to a focus on bioethical violations in the emerging world, scientists in Southeast Asia view global bioethical regulations as inadequate in at least two ways. Bioethical guidelines such as "informed consent," they argue, are not able to address the substantive needs of indigenous donors. Second, the application of bioethics alone does not guarantee normative conditions that regulate any reputable biomedical science endeavor. Biopolis illuminates how bioethical procedures need to be embedded in a biomedical platform and facilitated by cross-cultural skills to deal effectively with international science actors and institutions.

Chapter 5, "Virtue and Expatriate Scientists," examines the unstable meaning of virtue in science as it goes global. It argues for a notion of "situated virtue" by exploring how a variety of researchers "collected" in Singapore negotiate the unstable meaning of virtue attached to the science enterprise. Superstar Western scientists are in Singapore to seek great working conditions, access novel data, and sometimes have a chance to do good in Asia. Foreign lab assistants, many from China and India, tend to view science as a lucrative job that gets them overseas. By contrast, for locally born scientists, scientific virtue and civic duty are entangled in the emergence of Singapore as a regional biomedical hub. The effect of *kiasu* is an additional pressure on native scientists to recruit, train, and inspire younger Asian scientists to eventually take over the enterprise and shoulder regional responsibilities.

Chapter 6, "Perturbing Life," explores the world of stem cell research, a high-stakes field of rapidly changing innovations that pose difficult technical and ethical challenges for developing immunology. The ethical debates over stem cell research in the United States, combined with historical strengths in livestock breeding in Asia, created an opportunity for the development of stem cell research as a distinctly Asian field. As researchers attempt to use stem cells for modeling diseases, they continue to be haunted by the question of whether and when iPS cells will ever be viable and useful for developing medications for autoimmune conditions. Experiments with iPS cell technologies also have larger implications for our changing notions of the cell, the Asian body, and the body politic. Finally, the prominence of researchers of Asian ancestries in cellular research worldwide has led to the view that it is an arena of "Asian" specialty and intra-"Asian" rivalry, thus adding yet another uncertain element to this highly competitive field.

Part III, "Known Unknowns," considers the challenges of meeting radical uncertainties that combine potentially disastrous events with a sheer variety of possible outcomes. In February 2002, Donald Rumsfeld, the former U.S. secretary of state, under questioning by the press, invoked "known unknowns": "that is to say we know there are some things we do not know."[53] I use "known unknowns" to consider how experts must be ready to take responsibility for any contingent outcomes. Because potentially disastrous events such as pandemics and climate change distort our temporal and physical coordinates, they are semilegible and defy conventional methods.[54] Therefore, security initiatives depend on "imaginative enactment" or scenario-building exercises, which are key ways in which possible future crises can be generated—and therefore prepared for—in the present.[55]

Cosmopolitan science confronts a dizzying array of interconnected possibilities engendered by shifting knowledge, contexts, and contingencies. Beyond the focus on "preparation" in the form of anticipatory enactment, the Biopolis and BGI Genomics cases include not only the management and mining of flows of populations, data, tissues, and other objects, but also the shaping of strategic international relationships and the reimagination of belonging and of Asia. Therefore, the scale of potential intervention is not always as clearly given as in a U.S.-focused understanding of biosecurity in a terrorism framework. Biothreats, or pandemics, in Southeast and East Asia are borderless and are perhaps more about an existential problem of living in a region with neighbors who may or may not cooperate. In post-SARS Asia, preparation technologies—public health interventions, genomic infrastructure, and disease surveillance systems—are being put into place, but political uncertainty remains as to whether different countries can come together as an epidemiological region in combating disease emergence. Uncertainty of cross-border coordination is ramified by the uncertainty of nature, in the form of newly emerging infectious diseases and potential disasters triggered by climate change. But as we shall see, Chinese scientists seem to view the future as a shifting mosaic of elevations and temperatures that will spatialize human habitation in ways that demand new arrangements of biogenetic capabilities. A known unknown is the kind of uncertainty surrounding the misalignment of the epidemiological and the political Asias. Related political and natural unknowns also haunt the future of cosmopolitan science itself. The final chapters consider the gap between the known and the unknown in anticipating high-stakes events. Policy makers and scientists are confounded by unknowns surrounding transborder science collaborations, capacities to deal with the next pandemic, and the health effects of climate change.

Chapter 7, "A Single Wave," discusses how Asian scientists interpret population genetic data in order to create a story about the conceptual unity of diverse peoples on the continent. Against the backdrop of historical and continuing political tensions, scientists at Biopolis have led the effort to form a first-ever trans-Asian genetic network. The assembled genetic data have permitted researchers to claim that a single human wave out of Africa populated the Asian continent, thus challenging an earlier anthropological model of a two-prong entry. By stirring affects of genetic pride, storytelling participates in a scientific renewal of "pan-Asianism" by getting disparate colleagues together in a single biomedical commons. Despite a new imaginary of a unified Asian past-present and a potentially collective present-future in science, it remains unpredictable whether deep trans-Asian factionalism can be overcome to confront future epidemiological threats in the region.

Chapter 8, "'Viruses Don't Carry Passports,'" discusses the rise of Singapore as a potential CDC-like center for a tropical region teeming with deadly viruses. In the aftermath of the SARS pandemic, the Duke-NUS Graduate

Medical School established a program to deal with epidemiological dangers that are still unknown, that is, the "newly emerging infectious diseases" that threaten the region and beyond. The chapter frames the battle against tropical diseases as an emerging biosecurity assemblage that shapes cascading scales of intervention. It identifies problems presented by the flows of "mutable mobiles"—deadly viruses, their animal and human carriers—as well as spatializing techniques from the molecular to the zoonotic to the national and global scales. In addition, international health, corporate, and U.S. military agencies are ready to be part of the assemblage in times of emergency.

The final chapter, "The 'Athlete Gene' in China's Future," shifts to South China, where BGI Genomics provides an important contrast to Biopolis in its mix of a commercial global thrust and the use of ethnicity in a national framing of genomic science. BGI has become "a global DNA assembly factory" for having sequenced most of the world's life forms. Domestically, BGI deploys official *minzu* categories that reinforce the national model of a Han majority versus non-Han minorities. A Tibetan-Han DNA study is focused on finding the "athlete gene" that may provide insights for developing therapies for Han people, who lack the physiological adaptation for living in oxygen-thin highlands. This preemptive focus on a biological capacitation of populations suggests that China's scheme of official ethnicities is conceptualized as a diversified pool of genetic resources for the fortification of China's genomes against the pressures of an environment to come. I illuminate how scientists at BGI are attuned to scenarios of catastrophic events associated with China's huge, aging population and the survival challenges of climate change.

The epilogue returns to the ethical quandaries of a technology that, by seeking a pluripotent fate, may indeed open us up to a multitude of "unknown unknowns." I compare Biopolis as a transborder biomedical zone that acts as a "DNA bridge" to American cosmopolitan science, to BGI Genomics as an octopus-like global biotech enterprise that also has a domestic agenda anticipating China's national health challenges. These contrasting modalities of Asian biomedical entrepreneurialism both particularize and universalize the life sciences as we know it. The pursuit of fortune, fungibility, and hope in bioscience, I conclude, must confront fear and the finitude of life itself.

PART I

RISKS

NOTES

Prologue

1 23andMe solicitation letter signed by A. Wojcicki, September 30, 2013. Copy on file with author.

2 When the semester began, some professors objected to the experiment on grounds of its violation of student privacy and for lacking an educational briefing on personalized medicine. The data thus gathered from incoming freshmen was subsequently anonymized (for research?) and posted on a website forum. One finding (not new) is that many students (e.g., Asian Americans) have a genetic tendency to be lactose intolerant.

3 The Genetic Information Nondiscrimination Act was passed in 2008, but personal DNA information is commercially available.

4 By 2015, 23andMe decided to strengthen its health component by teaming up with drug company Genentech to use the database for finding therapeutic targets for Parkinson's disease.

5 In actuality, the National Institute of Health (NIH) has created a new American model of socially robust medicine that links academic research in drug discovery and state investments in public infrastructure and commercial companies. A new 2015 "precision medicine initiative" will provide funds for collecting the genetic data from one million American patients.

6 See Guyer, "Prophesy and the Near Future," and Fischer, *Anthropological Futures.*

7 "Enigma" was the name of the coding machine used by Germans during the Second World War for enciphering and deciphering secret messages.

8 Traweek, *Beamtimes and Lifetimes*.

9 Lock, *Encounters with Aging*, and *Twice Dead*.

10 Kleinman, *Patients and Healers in the Context of Culture*.

11 Cohen, *No Aging in India*.

12 Sunder Rajan, *Biocapital*.

13 Cohen, "Operability, Bioavailability, and Exception"; Scheper-Hughes, "The Last Commodity"; Wilson, "Medical Tourism in Thailand"; and Vora, *Life Support*.

14 Ong and Chen, *Asian Biotech*.
15 Collier and Ong, "Global Assemblages, Anthropological Problems."
16 Shapin, *The Scientific Life*, 5.
17 "Irrational exuberance" was coined by Alan Greenspan, the former U.S. Federal Reserve chairman, to describe market speculations that led to crises.
18 See Foucault, *Knowledge/Power*, 204.
19 See, e.g., Washington, *Medical Apartheid*.
20 Besides Washington, *Medical Apartheid*, see, e.g., Montoya, *Making the Mexican Diabetic*; Wailoo, *How Cancer Crosses the Color Line*; and Pollock, *Medicating Race*.
21 Duster, *Backdoor to Eugenics*.
22 Lock and Nguyen, *The Anthropology of Biomedicine*, 353.
23 Duana Fulwilley, "The Molecularization of Race: Institutionalizing Human Differences in Pharmacogenetics Practice," *Science as Culture* 16, no. 1 (2007): 1–30.
24 Lock and Nguyen, *The Anthropology of Biomedicine*, 353–358.
25 Hacking, "Making Up People."
26 Nelson, "DNA Ethnicity as Black Social Action?"
27 Bateson, *Steps to an Ecology of Mind*, 318.
28 Luhmann, *Observations on Modernity*, 16, 48.
29 Charis Thompson, "Race Science," *Theory, Culture & Society* (special issue on problematizing global knowledge) 23 nos. 2–3 (2006): 547–549.
30 Hartigan, "Mexican Genomics and the Roots of Racial Thinking."
31 Wade, Beltran, Restrepo, and Santos, *Mestizo Genomics*.
32 Deister, "Laboratory Life of the Mexican Mestizo." For the notion of genes as national cultural patrimony, see Rabinow, *French DNA*.
33 Chua, "The Cost of Membership in Ascribed Community."
34 Yang, "The Stats behind the Medical Science," 22.
35 Collier and Ong, *Global Assemblages*.
36 See Fischer, *Anthropological Futures*; and Marcus, "The End(s) of Ethnography," 1, 12.
37 Rose, *The Politics of Life Itself*, 183, 86.
38 Rose, *The Politics of Life Itself*, 29.

Introduction

1 George Yeo, "Singapore Must Be Like an Italian Renaissance City-State," 938 LIVE radio station report, August 13, 2007.
2 In the lead is Helios/Titan, the personification of the sun, who drives the chariot each day through Oceanus (the equatorial flow) and returns to the east at night. Chromos, a brief form of chromolithograph, identifies the techniques of vision and color itself, thus denoting the saturation of hues or "value" in art. Nanos refers to microscopic scales of space and time. Matrix in zoology refers to the generative part of the animal, thus referring to origins and to the milieu of productivity in a living system. Genome identifies that which produces, and in Greek it is also the stem for "race" or "offspring." And Proteus is a sea god who can change his form at will, symbolizing mutability in biology. These Greek terms have been liberally applied to science artifacts and techniques. Thanks to Gabriel Coren for rendering the symbolisms clearer to me.

3 Quoted in G. Traufetter, "Biotech in Singapore: A Treasure Island for Elite Researchers," *Der Spiegel*, March 26, 2005, http://www.spiegel.de/international/spiegel/0,1518,349122,00.html.

4 World Bank, "GDP per Capita by Country," http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?order=wbapi_data_value_2013+wbapi_data_value+wbapi_data_value-last&sort=asc, accessed March 28, 2015.

5 Orville Schell, "Lee Kuan Yew, the Man Who Remade Asia," *Wall Street Journal*, March 27, 2015.

6 In Mandarin Chinese, *kiasu* is *pashu*.

7 Chua, "Singapore as Model."

8 Clancey, "Intelligent Island to Biopolis."

9 Sydney Brenner is a leading pioneer in genetics and molecular biology and a fellow of the Crick-Jacobs Center in the United States. Early in his career, he worked with Francis Crick at Cambridge. Brenner's work contributed to the analysis of gene sequencing, and he established the existence of messenger RNA (ribonucleic acid), which functions as a blueprint for the genetic code. In 1996, he founded the Molecular Sciences Institute in Berkeley, California. Besides receiving recognition from Singapore, Brenner has received awards from BGI Genomics in Shenzhen, China.

10 See Ong and Chen, *Asian Biotech*, 21.

11 Sunder Rajan, *Biocapital*.

12 Hayden, *When Nature Goes Public*.

13 See Ong, "Scales of Exception."

14 For originary conceptions, see Marx, *Capital*, and Benjamin, *Work of Art in the Age of Its Technological Reproducibility*. Classic anthropological works include Mauss, *The Gift*, and Malinowski, *Argonauts of the Western Pacific*. More recent explorations of the value-laden nature of economic activities include the symbolic meanings generated by the Atlantic sugar trade (Mintz, *Sweetness and Power*); the "marginal gains" of African money (Guyer, *Marginal Gains*); and the "everyday communism" that underpins traditional credit systems (Graeber, *Debt*).

15 Helmreich, *Alien Ocean*.

16 Kay, *Molecular Vision of Life.*

17 Jasanoff, *Designs on Nature*.

18 Rheinberger, *Epistemology of the Concrete*, 10.

19 See Rheinberger, *Epistemology of the Concrete*; Kay, *Molecular Vision of Life*; Jasanoff, *Designs on Nature*; Haraway, *Simians, Cyborgs, and Women*; Haraway, *Modest_Witness@Second_Millennium*; Rabinow, *French DNA*; Rose, *Politics of Life Itself*; and Clarke, Shim, Mamo, Fosket, and Fishman, "Biomedicalization."

20 Collier and Ong, "Global Assemblages, Anthropological Problems."

21 HUGO was inspired by Sydney Brenner. The international organization was founded in 1988, in Cold Spring Harbor, New York, and it has members from two dozen countries. HUGO focuses on the study of human genetic variation in relation to environment, disease, and treatment. See the Human Genome Organization website, "History," http://www.hugo-international.org/HUGO-History, accessed June 5, 2015.

22 For an account of scientific entrepreneurialism in American industry, see Shapin, *Scientific Life*, 209–267.

23 Ong and Chen, *Asian Biotech*.
24 Weber, "Science as a Vocation."
25 See Fortun, *Promising Genomics*, 11.
26 According to an A*STAR (2015) tenth-anniversary report, Biopolis has "put Singapore on the scientific world map for biomedical research." Although Biopolis began with the state as a venture capitalist, the trend has been to promote public-private collaborations. Its research strategy to develop ethnic-stratified medicine has attracted many investments in research initiatives and made Singapore a venue for clinical tests for foreign companies. A biomedical manufacturing sector comprising drug companies scattered across the island—Genentech, Merck, GlaxoSmithKline, Sandoz, and Novartis, to name a few—contributed close to $30 billion in revenue in 2012. Besides the value-added contribution of the drug and biotechnology industry, scientists in Singapore have advanced the understanding of cancer, eye disease, neuroscience, metabolic diseases, and infectious diseases. A detection kit for SARS and a vaccine for the H_1N_1 flu virus are among Biopolis's achievements. The official "success story" therefore depicts a more varied picture than narrow commercial goals from the kind of late capitalist, big pharma–funded contexts of innovative science in the United States.
27 Shapin, *Scientific Life*.
28 Ong and Chen, *Asian Biotech*, 38–39, 89–91.
29 Foucault, *Security, Territory, Population*, 11.
30 Guyer, "Prophesy and the Near Future."
31 Foucault, *Security, Territory, Population*, 70–71.
32 Rose, *Politics of Life Itself*, 17–18.
33 Buchanan, "Deleuze and Geophilosophy."
34 A*STAR Research, "Singapore's Biopolis: A Success Story."
35 Waldby, "Stem Cells, Tissue Cultures, and the Production of Biovalue," 310.
36 Waldby and Mitchell, *Tissue Economies.* See also Rose and Novas, "Biological Citizenship," 455.
37 See Moor and Lury, "Making and Measuring Value," 451–452.
38 Bateson, *Steps to an Ecology of Mind*, 318, 400. See also Luhmann, *Observations on Modernity*, who identifies the autopoetic system as operating within a larger ecological context.
39 Deleuze, *The Fold*.
40 Bowker, "Biodiversity Datadiversity," 643.
41 Callon, "What Does It Mean to Say That Economics Is Performative?"
42 See, e.g., Rose and Novas, "Biological Citizenship."
43 Law and Mol, "Situating Technoscience."
44 Luhmann, *Observations on Modernity*, 95.
45 Lakoff and Collier, *Biosecurity Interventions*; Lakoff, "Preparing for the Next Emergency," 247.
46 Beck, *Risk Society*.
47 In earlier times, the division between the "normal" and the "pathological" in the life sciences was fundamentally a moral exercise that established adaptation to a particular standard of social normativity. See Canguilheim, *Knowledge of Life*, 121–133. But

in contemporary biopolitics, the relation of the standard to the norm has shifted as political rationality and scientific rationality are increasingly entangled.

48 Foucault, *Security, Territory, Population*.

49 Desrosieres, *Politics of Large Numbers*.

50 Deleuze and Guattari, *Thousand Plateaus*.

51 Lakoff, "Diagnostic Liquidity," *Theory and Society* 34, no. 1 (2005): 67–68.

52 See Keating and Cambrosio, *Biomedical Platforms*. Besides infrastructural development, the shift from medicine to biomedicine involves redefinitions of the human body, diseases, and therapies. See also Clarke et al., "Biomedicalization."

53 Quoted in Errol Morris, "The Certainty of Donald Rumsfeld, Part III," *New York Times*, March 28, 2014, http://www.realcleardefense.com/2014/03/28/the_certainty_of_donald_rumsfeld_part_iii_260988.html, accessed December 12, 2014. Rumsfeld was responding to journalists who were seeking information about how the Pentagon established a link between Saddam Hussein's regime in Iraq and weapons of mass destruction. Journalists found that Rumsfeld's use of the term "known unknowns" for the imponderables that are part of military decision making was an evasive ploy to avoid telling the truth.

54 Morton, *Hyperobjects*. "Known unknown" risks are less improbable than the black swan events (e.g., the 9/11 terrorist attacks on the United States) identified by Nassim N. Taleb in *The Black Swan*.

55 See also Lakoff, "Preparing for the Next Emergency"; Samimian-Darash, "Governing Future Potential Biothreats."

Chapter 1. Where the Wild Genes Are

1 For a portrayal of J. Craig Venter as a pioneering entrepreneurial scientist, see Shapin, *Scientific Life*, 223–226.

2 Website of the National Institutes of Health, http://grants.nih.gov/grants/funding/women_min/guidelines_amended_10_2001.htm, accessed September 11, 2013.

3 Lock and Nguyen, *Anthropology of Biomedicine*, 353.

4 Hacking, "Making Up People."

5 Furnivall, *Netherlands India*.

6 See Nonini, *"Getting By."*

7 See Goh, Gabrielpillai, Holden, and Choo, *Race and Multiculturalism in Malaysia and Singapore*.

8 Chua, "Cost of Membership in Ascribed Community," 174.

9 Mitchell, *Rule of Experts*.

10 Heng and Devan, "State Fatherhood," 204–205; Ong, *Flexible Citizenship*, 68–72.

11 Coincidentally, in 2003, the United Kingdom finally ended its ban on homosexuality. I suspect this had an influence on relaxing Singapore's social attitudes toward modern forms of homosexual and transsexual practices.

12 As well as perhaps beyond what is denoted by "nature," "wild," "culture," "lab," "virtual," "organic," and so on, but only after anthropologists and other human and social scientists vet each of these through contemporary instance work. Also does beyond calculation imply beyond the imaginable too?