Introduction

"Templates broken, membranes burst"

Bioscience research and the biotech industry are increasingly organized on a global level, bringing together novel, hybrid artifacts (such as genome databases and DNA chips), with new means of distribution and exchange (most notably, the use of the Internet in exchanging biological data).[1] Indeed, a glance at contemporary biotech-related events reveals novel artifacts and practices that are in their very constitution networked and global: international genome sequencing efforts such as the International Human Genome Sequencing Consortium (IHGSC), the proliferation of genomic databases (GenBank in the United States, the European Molecular Biology Laboratory in Europe, the DNA Data Bank of Japan in Japan), continued developments in national and international property laws (World Intellectual Property policies [WIPs]), the "borderless" business of biotech start-ups, spin-offs, and subsidiaries, and the various efforts to integrate health care and medicine with the concerns of national security (the World Health Organization [WHO] Global Outbreak and Response Network, the U.S. government's Project BioShield). Biotechnology, it seems, takes place on a global level, be it in terms of exchanging biological information, controlling epidemics, deterring biological attacks, or standardizing intellectual property laws.

Yet, in another sense, none of this is new, for modern biotechnologies have always been global, whether they involve the development of worldwide markets for pharmaceuticals or the collection of biological materials from

various cultures around the globe. In a sense, the degree to which the biotech industry is globalized is proportional to the degree to which the business of health care is seen as financially independent of particular governmental regulations. Although the division between the private and public sectors in bioscience research and health care is today more complex that it has ever been, there is also a sense in which the very notion of a semiautonomous, biotech "industry" implies the active development of new alliances between government regulation, federally funded research, biotech start-ups, information technology companies, and "Big Pharma."

What is new, however, is the extent to which information technologies—and an informatic worldview—are increasingly becoming part and parcel of our understanding of biological "life itself." Certainly, the discursive intersections between genetics and cybernetics, biology and information theory, are in themselves not new. Yet in an era in which it is commonplace to move from DNA in a test tube to DNA in an online database—and back again—the metaphorical relationship between biology and information is raised to a new level. The various efforts to map the genomes of a range of organisms, from the roundworm to human beings, is only the most recent sign of this intersection of biology and informatics, of genetic "codes" and computer "codes." The combination of biology and informatics is arguably affecting nearly every field within the biotech and health care industries, from the quotidian use of bioinformatics software, to the ongoing transition to "infomedicine."

Yet this integration of biology and informatics brings with it a host of difficult questions, questions that are at once philosophical, economic, and political. If the emphasis on informatics is indeed a constituent part of biotech today, how does this ease of mobility between the material and the immaterial, the "wet" and the "dry," affect the biological and medical understanding of the body (and should biotech become "moist")? If biology is really just pattern, code, or sequence, then how does this fact change the conventional property relations surrounding biological materiality? How has our understanding of the relationship between organism and environment changed in light of recent network forms of organization (e.g., disease surveillance networks, bioinformatics and genomics databases)? How might the economic, political, and cultural dimensions of globalization affect the current informatic paradigm of molecular biology?

Thus, not only do we see biology being networked and distributed across the globe, but we are also seeing a hegemonic understanding of biological

"life itself" that ceases to make a hard distinction between the natural and the artificial, the biological and the informatic. This is the twofold aspect of biotechnology that this book intends to explore. On the one hand, we witness a range of current events that readily display features of a globalizing industry. On the other hand, we also witness an ongoing integration of biology and informatics, genetics and computers, DNA chips and gene-finding software. The aim of *The Global Genome* is, then, to comprehend these two developments: to situate changes in the biotech industry within the larger context of globalization and political economy, and, conversely, to understand globalization as a core part of the practices and concepts of the biotech industry.

"Globalization" is a phenomenon that has been widely discussed in a number of contexts: economic (e.g., international organizations such as the World Trade Organization [WTO], the International Monetary Fund [IMF], and the World Bank), political (e.g., the so-called withering of the nation-state and the limits of geopolitical borders), and cultural (e.g., the hegemony of American culture or what some call "cultural imperialism"). But little attention has been given to the consideration of globalization as a biological phenomenon—that is, globalization in the context of biotechnology. The emergence of a biotech "industry" in the 1970s and the continued expansion of the pharmaceutical industry have arguably been global endeavors from the beginning. In this sense, biotechnology is coextensive with globalization. Similarly, "big science" projects such as the mapping of the human genome and events such as the emergence of new infectious diseases (the 2003 Severe Acute Respiratory Syndrome [SARS] outbreak) take place on a global level that includes networks of all kinds. Biological networks of infection (a novel virus strain) are contextualized by networks of transportation (the air-travel industry), which are then affected by governmental modes of regulation (travel restrictions, quarantine), which are countered by medical response efforts (disease surveillance networks), which are linked to medical-economic interventions (new vaccines, "fast-track" U.S. Food and Drug Administration [FDA] drug approval), all of which have a palpable effect in terms of the mass media and a larger cultural impact (science fiction films or television programs featuring bioterrorist attacks or dirty bombs).

Thus, the primary aim of this book is to understand how the processes of globalization form a core component of biological knowledge and practice, without, however, simply determining it. In our contemporary context, biotechnology and globalization will be seen as indissociable, while not simply

being identical. Indeed, it can even be stated that biotechnology and, by extension, a biotech "industry" are unthinkable without a globalizing context. The intersection of biology and informatics in this case is instructive. A large-scale scientific endeavor such as the mapping of the human genome integrates genetic and computer codes at many different levels, from the agglomeration of information in databases, to the use of diagnostic technologies, to the development of novel genetic pharmaceuticals. In this increasing globalization of biotechnology, we witness the exchange of not only information, but, specifically, many types of genetic information. The "global genome" is the result of what happens when biotechnology is globalized, when economic exchanges, political exchanges, and semiotic exchanges are coupled with biological exchanges.

But the biological exchanges that characterize the global genome are not simply just another type of information. Modern biological thought always makes two demands of "life itself": that it be essentially information (or pattern) and that it also be essentially matter (or presence). The tensions in this dual demand often lead to apparently contradictory positions within the biotech industry. For example, in the ongoing debates over the patenting of biological life (genes, cell lines, plants, animals), biotech and pharmaceutical corporations have often put forth an awkward position. They make the claim that a given gene or genetically modified organism (GMO) is fully artificial and not something already found in nature. This claim is the foundation for fulfilling the patentability criteria in the United States and the European Union: that patents be "new, useful, and nonobvious." Those against genetic patents argue that by definition "life itself" cannot be subject to patent laws because "life itself" is synonymous with "nature," or something that already preexists human intervention. The claim that a genetic sequence or GMO is artificial underscores the "tech" part of the biotech: it is in some minimal way the result of human intervention, industry, and technology.

But we also see another, contradictory claim from many of the very same companies that are ostensibly in the business of patenting and licensing. This claim is the exact opposite of the first: that these new, useful, and nonobvious inventions are "natural" and thus safe for the environment, for the human body, for agriculture, and for medical application. In other words, when discussing a GMO or genetically modified (GM) foods or a new drug, the claim often made is that the GMO, GM food, or drug does nothing that "nature

itself" does not already do. This argument has especially been put forth in debates over the safety of GM foods, but the same rhetoric is in the research, advertising, and promotion of new pharmaceuticals. The logic here is that biotechnology is not the opposite of nature, but rather that which compliments how the environment, nutrition or human health normally operates. In fact, much biotechnology research takes its cue from nature or from the normal functioning of the body. This is the basic approach of fields such as regenerative medicine or gene-based therapies. The "technology" in these practices is seen as nothing more than biology itself, or "life itself."

The very concept of a biotechnology is thus fraught with internal tensions. On the one hand, the products and techniques of biotech are more "tech" than "bio"; biology is harnessed from its "natural" state and utilized in a range of industrial and medical applications. On the other hand, there is no "tech", only "bio"; the unique character of the technology is that it is fully biological, composed of the workings of genes, proteins, cells, and tissues. On the one hand, biotechnology appears not to be a technology at all, but only "life itself" rearranged or recontextualized, but nevertheless performing the same functions it always has. On the other hand, biotechnology appears to be the new nature, the promise of a healthy and optimized body without cyborglike accoutrements of artificial organs, pacemakers, prosthetics, or invasive surgery. The advantage claimed for biotechnology is that it is more natural, a direct working with "life itself." In its ideal guise, biotechnology promises to bypass technology altogether, a biology working upon itself.

On the surface, it appears that the tensions inherent in the concept of biotechnology have to do with the relation between biology and technology, between nature and artifice, and so on. But I suggest something further: the core tension in the concept of biotechnology is not that between biology and technology or that between the natural and the artificial, but rather a tension between biology and political economy. The aim of this book is to present a set of concepts for understanding this twofold tendency within biotechnology—its globalizing tendency and its tendency to integrate biology and informatics. Another aim is to develop a better understanding of the contradictory logic of the biotech industry, its claims to be at once natural and artificial, biological and technological. With regard to the global genome, the central issues are those of biological exchanges, genetic and computer "codes," and the network effects of health and medicine.

A Brief Overview of the Chapters

Again, a point repeated frequently throughout the book: the mere existence of economic models in relation to biotechnology research and application is not necessarily problematic in itself. However, when different value systems conflict—conflicts between medical and economic value—the ethical quandaries and scientific controversies emerge. *The Global Genome* can be considered an attempt to trace and outline some of these points of tension. As previously stated, one of the general goals of the book is to comprehend the twofold tendency that currently characterizes the biotech industry: its globalization and its integration of biology and informatics. Thus, each chapter can be seen as a more focused exploration of some of the ontological, political, and economic facets of biotechnology. In fact, a better, more methodological description of this book might be a "political economy of molecular biology." Today, the term *political economy* has largely been replaced by the more familiar term *economics*, but this change in a way provides the occasion to revitalize the philosophical and political dimensions of the former term.

A glance at the table of contents reveals a larger organizing principle of this book as well. The three sections—encoding, recoding, and decoding—are meant to cover the three primary activities of biotechnology today: the encoding of biological materials into digital form, the recoding of that digital form in various ways, and the decoding of that digital form (back) into biological materiality. Together, these three activities form an incomplete circle—or, rather, a spiral. The biology produced is not necessarily the biology with which one begins. Whereas in more straightforward techniques such as DNA synthesis, the input and output do tend to be identical, in other instances, such as the lab-based regeneration of skin or the engineering of a patient's stem cells, the result may not be entirely identical, though it may be identical enough to ensure biocompatibility. In still other instances, such as genetic drugs or gene therapies, the output can radically diverge from the input, and compounds taken in can often have drastic side effects. Thus, the overall tripartite organization of encoding, recoding, and decoding is meant to underscore the different ways in which biotechnology mediates between the biological and the informatic.

This same tripartite division is also a political-economic one as well. In a sense, *encoding* is synonymous with *production*, for it is in the process of encoding the biological that the biotech industry is able to accrue profits (as intel-

lectual property, as a proprietary database or software). *Recoding* is then synonymous with *distribution* (and its related term *circulation*), for the practices of bioinformatics, database management, and computer networking are predicated on the ability of biological information to be widely distributed and circulated. Finally, *decoding* is synonymous with *consumption* in that, in a medical sense at least, it is in the final output or rematerialization of biology that biological information is used, consumed, or incorporated into the body.

However, this separation of production, distribution, and consumption is only heuristic. As Marx notes in the *Grundrisse*, "production, then, is also immediately consumption, consumption is also immediately production," and furthermore, "distribution is not structured and determined by production, but rather the opposite, production by distribution."[2] There are many ways in which production is consumption (in the use of raw materials), in which consumption is production (in the creation of need), and in which distribution conditions both production and consumption (exchange dictates what is made and used). This confusion of categories is further illustrated in the way in which the practices of biotechnology incorporate information technologies at the same time that they insist on the referent of biological materiality.

Given this political-economic organization, each of the chapters within these three sections takes up a particular field or set of practices within the biotech industry. Chapters 2 and 3 consider the fields of bioinformatics and genomics, respectively. In particular, chapter 2 focuses on the way that bioinformatics—as a practice and as an industry—redefines the problem of "life itself" that has been at the heart of biological thinking for some time. Georges Canguilhem's work in the history of biology is useful in this regard, for it connects the modern, genetic view of the body with a rich tradition that extends from Aristotle through molecular biology. This problem of "life itself" is also understood as inseparable from the question of economic value, and it is in chapter 3 that the notion of "intellectual property" is explored in greater depth. This topic links chapter 2 to chapter 3 by considering genomics from a political-economic perspective, but one based on "excess" as elaborated by Georges Bataille. Placing the economic critique of Marx next to Bataille allows us to see the way in which a field such as genomics manages all that "junk DNA" with databases and Gene Expression Markup Language (GEML).

The section on recoding contains three chapters, each of which takes up a field that depends on or makes use of the results of bioinformatics and genomics (chapters 2 and 3). Chapter 4 considers the recent efforts to map

the genomes of genetically isolated ethnic populations, what some have critically referred to as *biocolonialism*. Michel Foucault's work on the historical emergence of biopolitics is helpful here in talking about how biocolonialism makes the transition from "territory" to the "population." Chapter 5 considers the financial strata of the biotech and pharmaceutical industries—not from a purely economic standpoint, but rather as a layer connected to scientific and technical advance. The concept of biomaterial labor makes a reappearance here, in dialogue with the work of Marx as well as with the Italian autonomist tradition. Chapter 6 takes a look at the areas of biological warfare and bioterrorism, areas that are at once medical and nonmedical in their application. Foucault's Collège de France lectures, which position biopolitics in relation to the "war between races," and Paul Virilio's notion of the "genome bomb" (which I argue against) help to situate biowarfare within the current concerns over the weaponizing of biology. At the core of these topics is a pervasive concern over what I call "biological security."

The final section, on decoding, contains two chapters that deal with the overlapping fields of tissue engineering and regenerative medicine. Chapter 7 revisits Canguilhem's theories of normativity as a way of elaborating the philosophical and ethical challenges brought about by tissue engineering. The confusion of the boundaries between biology and technology in tissue engineering leads to a strange type of body that is at once restored and "natural," yet augmented, improved, and technically "optimized." Similarly, regenerative medicine research (including telomere research and stem cell research), discussed in chapter 8, promises a great deal, but is ultimately compromised by the question of normativity and the Aristotelian theories of morphogenesis. Here Virilio's philosophy of speed helps to highlight the aporias in the "biotechnical time" of the regenerative body, a particular kind of time that is, as Antonio Negri points out, also a value time.

Finally, the book closes with a chapter on possible models through which critical questions can be raised and sustained. A consideration of the discourse of "tactical media" and "post-media" is juxtaposed to selected groups and individuals who practice what some have called "bioart," or art projects that make use of biological techniques, knowledges, and practices. Whether such bioart practices can offer a viable, alternative venue for questioning biotechnology is left an open issue for the reader.

A closing note concerning what is not in this book. For various reasons, I have not included a number of equally important fields here, either because

they are outside the scope of this book or because they have been dealt with thoroughly elsewhere. For instance, I do not consider agricultural biotechnology or the industrial use of GMOs, largely because the focus of *The Global Genome* is exclusively biomedical and genetic research in the biotech industry. More popular topics, such as human cloning or gene patents, have been dealt with elsewhere in more detail. The relationship between biotechnology and popular culture is also a fascinating one that deserves more attention in a political context, and appendix D briefly offers some informal thoughts on this issue and several references.