Introduction

Capitalisms and Biotechnologies

In January 1999, I spent a month in a lab at the National Institutes of Health (NIH), because my Ph.D. dissertation advisor Michael Fischer felt I should experience how it feels to be part of a lab as an observer. It felt pretty uncomfortable, and not just because the only place I had to sit on was an icebox in a corridor outside the lab. At such an early stage in my Ph.D, I really had no story as to why I was there, what my questions were, or what I wanted to find out or study—all of which, of course, were things that the scientists in the lab were curious about.

The lab I was "studying" itself studied signal transduction pathways within cells, and the one thing that struck me was how each researcher's bench had a computer that was constantly downloading DNA sequence information in real time, as soon as the information was released into GenBank, the public-domain DNA sequence repository. I remarked on this to the head of the lab, who said that I must go and meet Mark Boguski, a scientist at the National Center for Biotechnology Information, which runs GenBank. And so I did.

As I said, what was most uncomfortable for me about my encounters with various scientists was that I did not have a story to tell them about my presence. And yet the first words that Boguski said when he met me were: "I've read Paul Rabinow, so I know exactly what you want to do. I think someone needs to write a contemporary history of genomics, and I think you should do it."[1] Boguski was organizing the Cold Spring Harbor genome meetings that year, which was the major annual meeting of the publicly funded Human Genome Project. He waived my registration fees and got me to attend. That is how I started studying genome scientists.

In 1999 I could quite comfortably say that the subject of my research was genomics, at a historical moment when genomics meant the sequencing of the human genome and the generation of software tools to make sense of that sequence. That year was also a conjuncture marked by the "race" to sequence the human genome between the public Human Genome Project and Craig Venter's private genome company Celera Genomics. Over the next few years, genomics remained an important part of this study for reasons that I will try to explain throughout the book, but the objects of my study became inseparable from the larger epistemological and political economic terrains, themselves emergent, within which they were situated. The larger context of what I am studying is what I have called biocapital, but before I explain what I mean by that, it is worth at least setting the stage by mentioning, in the most perfunctory fashion, what was happening in genomics in 1999.

In 1998, Craig Venter was brought in to run a new company, Celera Genomics, that challenged the public Human Genome Project, which had until that point planned to sequence the genome from one end to the other, with a stringent error frequency of not more than one in every ten thousand base pairs.[2] This was ultimately resolved as a fight between "public" and "private" genomics, the key node around which contestation took place being the patentability of gene sequences. Private companies like Celera were keen to patent the sequences they generated and to realize commercial value off them, while public researchers felt that generating sequences was not particularly inventive and that granting them patents would stifle genomic research by making those sequences unavailable in the public domain.

Many things happened over the next year or so, not least the continuous running of sequencing machines in public and private laboratories around the world, so that in June 2000, when the working draft sequence of the human genome was announced both by the Human Genome Project and by Celera, everyone smiled with Bill Clinton for the cameras, and we were told that the "Book of Life" had been read, the "Code of Codes" decoded, and the "Holy Grail" attained.[3]

Such momentous happenings were not necessarily evident to everyone living in the small town of Syosset in upstate New York, the home of the famous Cold Spring Harbor Laboratories, in 1999, as exemplified by the following

story. While going to the laboratories for the 1999 meetings (held at the height of the sequencing "race"), I shared a taxi with two people, one a genome sequencer going to the meetings, the other a woman who lived in the town, going elsewhere. The two had the following conversation:

RESIDENT: Are you here doing research?

SEQUENCER: Yes, we've come for the conference.

RESIDENT: What conference is that?

SEQUENCER: Genome mapping and sequencing.

RESIDENT: Of what?

SEQUENCER: Oh, the genome.

RESIDENT: Of what?

SEQUENCER: Human.

RESIDENT: Yes, but of what? What are you mapping?

SEQUENCER: [*increasingly perplexed*] The whole thing.

RESIDENT: But that's already been done, hasn't it?

Biocapital

We live in a world of rapid changes, many of which force us to ask afresh what we mean by words that are an integral part of our lexicon, words like "life," "capital," "fact," "exchange," and "value." Genomics is one such change, but it is a change, I argue, that reflects more general changes in two broad domains. The first is in the life sciences, which, consequent to the rapid advances in genomics, are increasingly becoming *information* sciences. The second is in capitalism, which is triumphantly acknowledged today as having "defeated" alternative economic formations such as socialism or communism and is therefore considered to be the "natural" political economic formation, not just of our time but of all times.[4] The title of this book, therefore, signals its thesis that the life sciences represent a new face, and a new phase, of capitalism and, consequently, that biotechnology is a form of enterprise inextricable from contemporary capitalism. I will try to explain here what I mean by this, and specifically try to explain how I conceive of the relationship of "biocapital" as a concept to contemporary systems of capitalism and to emergent scientific and technological horizons in the life sciences. I will then provide a brief overview of the drug development marketplace and of genomics in

order to lay out the terrain on which I have conducted this study, before outlining the structure of the book.

The object of bioscience, the practice of bioscience, and the locations of bioscience have all been changing rapidly over the past thirty years, and one of the major directions this change has taken has been toward more corporate forms and contexts of research. But this drift toward corporatization has hardly been natural, inevitable, or without contestation. As demonstrated in 1999 by the angry response of public genome researchers toward the possibility that DNA sequences might be patented, the corporatization of the life sciences has simultaneously been rapid and hegemonic on the one hand, and contingent and contested on the other, setting up what I call a *frictioned* terrain on which these emergences take shape. Further, biotechnologies cannot simply be analyzed by studying them "within" laboratories. Rather, all science needs, as Emily Martin (1998) has argued, to situate changes within scientific and technological worlds in larger social and cultural contexts. This has been the practice, over the last decade and a half or so, of the also rapidly emergent field of the anthropology of science. And this contextualization of science cannot, as a number of scholars within science and technology studies (STS) have argued, simply be a unidirectional attribution of causality. In other words, it is too simple to state either that social change is a consequence of scientific and technological development or that science and technology are completely conditioned by "the social," as if "the social" were something unitary and easy to identify and thus purify. STS scholars refer to the mutual constitution of "the scientific" and "the social" as *coproduction*, and it is this coproduction of the life sciences with political economic regimes that I investigate in this book.[5]

An example of such coproduction is evident even in the extremely truncated story of genomics in 1999 that I recounted earlier. As mentioned, there was considerable anxiety among public genome researchers that private companies might patent the DNA sequences they were generating at the time. The legal status of the patentability of the sequences was (and in fact still is) quite ambiguous and rests, among other things, on whether the generation of these sequences could be regarded as an "inventive" activity.[6] In other words, the question of whether DNA sequences should be patented could not at the same

time take recourse to externally established criteria of patentability without asking the question of what those criteria meant in the context of new technological possibilities for innovation, in this case the development of automated sequencing machines that could generate DNA sequences at speeds and resolutions inconceivable before. At the same time, further use of these sequences depended in considerable measure on their legal status, either as part of the public domain or as legitimate private property. The legal status of DNA sequences depended on the technological mechanisms that produced them, while the continued production and use of these sequences absolutely depended on their legal status. Neither could a priori be settled without bringing the other into question.

The beginning of the biotechnology industry in the late 1970s and early 1980s was itself marked by a coproduction of new types of science and technology and changes in the legal, regulatory, and market structures that organized the conduct of that technoscience.[7] The "new" technoscience was recombinant DNA technology (RDT), which is a set of techniques that allows the cutting up and joining together of DNA molecules in labs. The biotechnology industry came about largely as a consequence of this technoscientific development in 1973 by Herbert Boyer and Stanley Cohen. This sort of cutting and splicing allows scientists to study the functionality of different genes and DNA sequences by expressing these sequences in organisms (usually bacterial or viral) called vectors. These vectors can be research tools that "house" the DNA to be studied, or can function as production factories for more DNA (if it gets amplified by the polymerase chain reaction, or PCR), or for the protein that might be coded by that DNA. In other words, RDT allows the life sciences to become "technological," where the product that is produced is cellular or molecular matter such as DNA or protein. Some of these proteins could, in principle, have therapeutic effects (especially for diseases that are caused by, or have as a central symptom, an abnormal amount of that protein) and be produced industrially. This, in a nutshell, represented the possibility and the rationale for the biotechnology industry.

While RDT could be said to have "led" to the development of the biotech industry, the emergence of a new technology could hardly in itself be considered sufficient cause for the development of an entire industry. The shift of the

technoscience of RDT to industrial locales was evidenced by the emergence of a slew of biotechnology companies in the early 1980s, a development that in turn led to further research and innovation in the life sciences and biotechnology. One can only understand this coproduction in terms of a conjuncture of several events and factors.

One was the willingness of venture capitalists to invest in a technology that had little credibility at the time as a successful business model. A second was the enormous amount of money spent by the U.S. federal government on basic biomedical research through funding of the National Institutes of Health (NIH) consequent to the declaration of a war on cancer in the early 1970s.[8] A third was the 1980 Bayh-Dole Act, which was legislation that facilitated the transfer of technology between academe and industry and thereby enabled rapid commercialization of basic research problems. A fourth was a supportive legal climate that allowed the protection of biotech intellectual property, marked, for instance, by the landmark 1980 U.S. Supreme Court ruling in *Diamond v. Chakrabarty*, which allowed patent rights on a genetically engineered microorganism that could break down crude-oil spills.

While I argue that the life sciences and capitalism are coproduced, I do, however, further argue that the life sciences are *overdetermined* by the capitalist political economic structures within which they emerge. "Overdetermination" is a term used by Louis Althusser to suggest a *contextual* relationship, but not a *causal* one (Althusser 1969 [1965]). In other words, even if a particular set of political economic formations do not in any direct and simplistic way lead to particular epistemic emergences, they could still disproportionately set the stage within which the latter take shape in particular ways. And so, even if capitalism represents particular types of political economic formations, in this current moment in world history, as Slavoj Žižek argues, it "overdetermines all alternative formations, as well as non-economic strata of social life" (Žižek 2004). Therefore, even while emphasizing the historicity and the far from natural emergence of capitalism as a set of political economic forms and structures, it is important to acknowledge the importance of capital as being what Žižek calls the "'concrete universal' of our historical epoch" (ibid.).

This book, then, is simultaneously an analysis and a theorization of the life sciences, especially as they pertain to biomedicine, with an analysis and theori-

zation of capitalist frameworks within which such technoscience increasingly operates. This is the rationale for the term "biocapital." A fundamental assumption of this book is that capitalism, even as it overdetermines the emergence of new technoscience, is a political economic system whose own contours are not unitary or rigid. In other words, capitalism cannot be *assumed* in studies of biomedicine, because capitalism is in itself dynamic, changing, and at stake.

I do not make the argument here that biocapital is a distinct temporal or figural form of, or from, "capitalism" as some unitary entity. Rather, I wish to make the argument, made most powerfully by scholars such as Žižek and Susan Buck-Morss, that what is at stake is the very conception of capitalism as something unitary, eternal, and without history (see, for example, Žižek 1994; Buck-Morss 2002). Rather, capitalism is mutable and multiple; it is always *capitalisms*.[9] Biocapital is one vantage point from which to view the complexities of capitalism(s), and like all situated perspectives, it contains within it both its specificities as well as its diagnoses of more general structural features of capitalism.[10] Therefore, rather than define what I mean by "biocapital" at the outset, I wish to explain next, with a digression through the political economic analysis of Karl Marx as a basis, how I see this relationship of biocapital to systems of contemporary global capitalism writ large.

A major theoretical argument that I make in this book is for a return, not to Marx*ism* in any dogmatic sense, but to reading Marx as a methodologist from whom one can learn to analyze rapidly emergent political economic *and* epistemic structures. Indeed, I believe that Marx himself is often read too simply as heralding inevitable communist revolution. While this was certainly the polemical tone of *The Communist Manifesto* (Marx and Engels 1986 [1848]), one can see that by the time Marx wrote *The Eighteenth Brumaire of Louis Napoleon* in 1852 (Marx 1977 [1852]), he was offering a much more nuanced understanding of capitalist processes that emphasized their *tendential* nature.

The Eighteenth Brumaire is a historical treatise concerning the events between 1848 and 1851 in France, during the presidency of Napoleon's nephew Louis Bonaparte. This was a period during which France's National Assembly was dominated by the reactionary Party of Order. The period saw constant tension between the Assembly and Bonaparte, leading finally to a coup by Bonaparte in 1851. Bonaparte ended up being hailed as a revolutionary, as a

single individual who took on and overthrew the reactionary forces of Order. Marx disputes this by closely following the political happenings in these years to show how Bonaparte was, in fact, resolutely counterrevolutionary. Further, Marx points out that Bonaparte was not just hailed as a great revolutionary by the bourgeoisie but was very much the undisputed leader of the small peasantry, which was among the most economically depressed sectors of the French populace at the time. Marx's concern in *The Eighteenth Brumaire* is to show how even those sectors of society whose structural relations of production within society would have suggested that they embrace revolutionary communism might put their faith in a counterrevolutionary personage. Moreover, the desire for political stability that was expressed in the faith in a counterrevolutionary dictatorship like Bonaparte's was completely conditioned by the need for *economic* stability in a capitalist society, an economic stability that the peasants and the bourgeoisie alike saw to be in their interests. In other words, *The Eighteenth Brumaire* itself traces a co-constitution of a political regime with an economic one, in which each conditions the other, but in ways whose outcomes are not dictated as they logically ought to have been as a consequence of the structural relations of production prevailing at the time.

Marx, however, also realized that the economic structure of capitalism was multiple. Therefore, in outlining the labor theory of value over successive volumes of *Capital*, Marx begins by outlining a hypothetical system of the production and circulation of capital but proceeds to situate that hypothetical system in the context of "real" systems of capitalism that were emergent (and hardly stable) at the time. By *Capital, Volume 3* (Marx 1974 [1894]), Marx is already analyzing two distinct forms of capital, what he calls industrial capital (which was the primary subject of analysis in the first two volumes) and trading or merchant's capital. This latter form of capitalism is its emergent *commercial* (as distinct from *commodity*) form, distinct only in that its "process of circulation is . . . set apart as a special function of a special capital, . . . established by virtue of the division of labor to a special group of capitalists" (267). In other words, the function of trading capital is not just the production and exchange of commodities as a means to an end (that end being the generation of surplus value) but is commercial activity as an end in itself. This "special type" of capitalist to whom Marx refers is the speculative capitalist, a precursor to the types of capitalists, such as, for instance, venture capitalists or

investment bankers, who are central to sustaining the dynamics of contemporary capitalism. In other words, the merchant is to commercial capital what the producer is to commodity capital. And the key function of the merchant is the *advancement* of money in order to set commercial capital in motion. Commercial capital, according to Marx, does not create surplus value in and of itself but does so indirectly by constantly perpetuating the circulation of capital, and by providing it with its own self-perpetuating, self-sustaining logic that does not need to *originate* from the moment of production of commodity.

One can see a similar disjuncture in the forms of production and circulation that biotech or pharmaceutical companies are involved in today, where, on the one hand, there exists the manufacture and sale of therapeutic molecules, but, on the other, there exists an elaborate system of valuation that is essential for the existence of these companies that only indirectly depends on this actual manufacture and sale. The everyday existence of a biotech or a pharmaceutical company, then, involves the coexistence of at least these two simultaneous, distinct, yet mutually constitutive forms of capital, one directly dependent on the production of commodity, the other speculative and only indirectly so. Depending on the institutional and legal structure within which these companies operate, one or the other of these forms can predominate in the creation of value; yet neither of these forms flows seamlessly from the other. And therefore, in India, for instance, there has tended to be a more direct correlation between therapeutic molecule production, sales, profit margins, and the value of a pharmaceutical company. In the United States, where biotech companies are almost always enabled by venture capital funding, and where biotech and pharmaceutical companies almost always become publicly traded companies when the opportunity presents itself (and therefore answerable to investors on Wall Street), valuation is more directly dependent on speculative capital.[11]

Marx further outlines the relationship between merchant's and industrial capital as follows:

> Since merchant's capital is nothing but an individualized form of a portion of industrial capital engaged in the process of circulation, all questions referring to it must be solved by representing the problem primarily in a form, in which the phenomena peculiar to merchant's capital do not yet appear independently, but still in direct connection with industrial capital, as a branch of it.[12]

In other words, Marx first argues for at least two distinct forms of capital, industrial and merchant's. He then proceeds to posit the latter as, simultaneously, a continuation of, an evolution of, a subset of, and a form distinct from, the former. Both these forms of capital exist in close relationship with each other, but one cannot be reduced to the other. Further, the relationship between the two cannot be understood except at multiple registers simultaneously.

I wish to clarify the relationship of biocapital to capital (and to capitalisms) in precisely these terms. Biocapital does not signify a distinct epochal phase of capitalism that leaves behind or radically ruptures capitalism as we have known it. At the same time, there are significant particularities to biocapital that have to do both with the institutional structure within which drug development takes place, and with the technoscientific changes in the life sciences and biotechnologies over the last thirty years, that make it too simplistic simply to say that biocapital is a "case study" of capitalism having to do with the life sciences. Rather, the relationship between "capitalism" (itself not a unitary category) and what I call biocapital is one where the latter is, simultaneously, a continuation of, an evolution of, a subset of, and a form distinct from, the former. Further, biocapital itself takes shape in incongruent fashion across the multiple sites of its global emergence.

Indeed, the relationship of emergent and constantly mutating forms of capitalism to "capitalism" as a theoretical concept describing a political economic system has continued to vex social theorists since Marx, and the agent often implicated in this mutation of capitalism is technological change. An outline of the relationship of a form of a system under analysis to the concept underlying that systemic understanding that I take inspiration from is Jean-François Lyotard's. In *The Postmodern Condition* (Lyotard 1984), a "report on knowledge" written for the Canadian government in the late 1970s, Lyotard is also confronted with theorizing a moment in capitalist modernity that is marked by rapid technological change, much of which had to do with what might be called the information revolution. These technological changes, on the one hand, saw the persistence and reproduction of some "fundamental" aspects of capitalism as diagnosed by Marxism (such as, for instance, structural inequities in relations of production, especially when extended and considered

globally) and yet occurred in the context of a different set of political conjunctures, most notably the dissipation, to the extent that it existed, of a strong notion of proletarian class consciousness that was central to Marx's analyses of industrial capitalism. Lyotard's definition of the "postmodern," then, is not a system that marks a radical rupture with modernity but rather one that is a subsumed, incongruent, evolving component of it. In other words, for Lyotard, postmodernism is a *symptom* of modernity, just as I attempt to show biocapital as, among other things, being *symptomatic* of capitalism (with "symptom," of course, itself being a biomedical term), rather than a new phenomenon that is radically distinct from, and rupturing with, the old.[13]

While my relationship of biocapital to capital is similar in form to Lyotard's relationship of the postmodern to modernity, it is also not dissimilar in content. Fredric Jameson, for instance, posits Lyotard's analysis of the postmodern squarely in the frame of contemporary capitalism when he says that "postmodernism is not the cultural dominant of a wholly new social order . . . but only the reflex and the concomitant of yet another systemic modification of capitalism itself" (Jameson 2003 [1991], xii).

And yet what is crucial here is not just an understanding of capitalisms (however multiple) as *structures* that form the grounds for the emergence of a certain sort of technoscientific enterprise but also an understanding of political economy as an *epistemology*. I read Marx as himself only able to achieve a critique of capital by means of critiquing political economy as the emergent foundational epistemology of the time that had consequences for structuring social formations.[14]

Many of the life sciences involve production and circulations of many sorts, not all of them geared toward the generation of surplus value. Indeed, Robert Merton (1942) propounded communism as one of the four fundamental norms of science. By this, he meant not a particular system of scientific governance or regulation but a self-imposed scientific ethos that valued the sharing of scientific information and materials. Such an ethos is very much a part of the everyday functioning of much academic life science today: it is, for instance, extremely common for one lab to send another information, or materials such as a DNA clone or a cell line they may have created, without any charge and even if no formal collaboration exists between the labs. At the same time, of

course, there is the increased protection of these same forms of information and material as private property, not just among corporate biologists, but even among academic scientists. This protectionism could arise because these academic scientists are themselves, actually or potentially, also corporate entrepreneurs on the side (an increasingly common phenomenon in the United States thanks to the incentive structures of the Bayh-Dole Act that reward the transfer of technology from academe to industry); because the university that employs these scientists seeks to aggressively protect its intellectual property much as a corporation would; or defensively, to protect information or material *from* private protection by industry. Further, the biological "stuff" that circulates, whether information or material, could circulate as objects that have different connotations attached to them. For instance, information could be "raw data" (useful but not worked into anything "theoretical" or "factual"); it could be in the form of an algorithm or some form of software code that might itself be a potential or actual commodity protected by intellectual property rights; or it could be "scientific facts." Therefore, understanding the systems of production, circulation, and consumption of various "biologicals,"[15] including the ways in which these circulations insert into more "general" processes of capitalist circulation, is one side of the analytic challenge of studying biocapital as a system of exchange.

But the other side to its study springs from Marx's analysis of political economy as epistemology, and that is the study of the *epistemic* reconfigurations of the life sciences. In this case, as I have mentioned, these epistemic reconfigurations are co-constituted by *technical* reconfigurations as well. "Biocapital" is a study of the systems of exchange and circulation involved in the contemporary workings of the life sciences, but is also a study of those life sciences as they become increasingly foundational epistemologies for our time. In the former register, it is indeed a subset or "case study" of contemporary capitalism; in the latter, it points to the specifically *biopolitical* dimensions of contemporary capitalism.

Biopolitics is a notion put forward by Michel Foucault to show how modernity put *life* at the explicit center of political calculation (see, for instance, Foucault 1990 [1978]). Through his work, Foucault traced the constitution of modernity, which he felt was marked by a qualitatively different operation

of power, leading to the construction of a different type of subject, from the power that operated between a regal sovereign and his subjects in medieval times. Therefore, tracing the processes by which power operates, and looking consequently at ways in which different types of selfhood (such as, for instance, that of the madman, the leper, or the criminal) emerge, was in a sense the purpose of Foucault's analyses.[16] Once again, however, I am interested in the methodologies that Foucault employs to attain such an end.

What Foucault focuses on specifically is the fact that power (which, consequent to having life firmly in its calculus, is a form of what he calls *biopower*) operates through *institutional*, *epistemic*, and *discursive* mechanisms. In other words, Foucault puts together what he calls his archaeology of modernity by looking at the institutions and the disciplines that constitute it. And therefore his corpus of work traces the emergence of institutions such as the prison, the clinic, the school, and the asylum, or disciplines such as demography and psychology.

Of particular interest in terms of the methodological influences on this book is Foucault's "archaeology of the human sciences," *The Order of Things* (Foucault 1973), where he argues, first, that a constellation of disciplines collectively concerning the knowledge of humanity becomes fundamental to the operation of modern rationality, and, second, that three such disciplines of particular importance are biology, political economy, and philology, corresponding respectively to understandings of life, labor, and language.

In a very different register, then, from Marx, and with a very different set of analytic operations, one sees an articulation of "the life sciences" and "political economy" as a central operation of an emergent modernity—an operation that I argue is still very much in process and whose understanding is still very much at stake. What Foucault does explicitly is what I have argued Marx does implicitly, which is consider political economy as consequential not (just) because it is a political and economic *system* of exchange but because it is a foundational *epistemology* that allows us the very possibility of thinking about such a system *as* a system of valuation. The biopolitical, then, does not just refer to the ways in which politics impact everyday life, or in which debates over life (such as, to take an evident example, over new reproductive technologies) impact politics, but rather points to the ways in which our very ability to

comprehend "life" and "economy" in their modernist guises is shaped by particular epistemologies that are simultaneously enabled by, and in turn enable, particular forms of institutional structures.

The third peg of Foucault's triad, however, is equally important, and that points to the way in which the *grammar* of life is itself at stake. Layered within my arguments about the articulations between the life sciences and capitalisms in this book are central arguments about the discursive forms that both take, at a moment in the life sciences that might be called "postgenomic," and at a moment when our global political economic systems might unequivocally be called "capitalist."[17] Therefore I argue (most directly in chapter 4) that the sorts of knowledge genomics provides allows us to *grammatically* conceive of life in certain ways, *not* in terms of an Aristotelian poesis, but rather as that whose futures we can calculate in terms of probabilities of certain disease events happening—and this shifting grammar of life, toward a future tense, is consequential not just to our understanding of what "life" now means, but contains within it a deep ethical valence, what Nikolas Rose and Carlos Novas (2005) refer to as a "political economy of hope." Similarly, the current moment in American capitalism, which was grotesquely magnified during the dot.com heyday of 1999–2001, sees speculative capitalism as apparently disproportionately setting the terrain of valuation—a triumph of Marx's "commercial" capitalism over his "commodity" capitalism. Speculative capitalism, as I show most directly in chapter 3, contains its own future-oriented grammar, which is also consequential for value in both senses of the word and pertains to what might, in parallel to Rose and Novas, be called a political economy of hype. In other words, the articulations of life, labor, and language are themselves in formation (and information) that constitute biocapital and postgenomic life, and it is an analysis of these articulations that is a central attempt of this book.

Therefore this book is an explicit attempt to bring together Foucault's theorizations of the biopolitical with a Marxian attention to political economy, labor, value, commodity forms, and processes of exchange as they get constituted alongside the epistemic and technical emergences of the life sciences and biotechnologies.[18] It is, further, an attempt to do so with an explicit attention to the *globalizing* dimensions of capital and, increasingly, of technoscience. To that end, this book is a comparative investigation of postgenomic

drug development marketplaces in the United States and India. I elaborate on my reasons for choosing these two sites at a later stage of this introduction, after further explaining the theoretical groundings of this work.

Materiality and Abstraction

So far, I have outlined the relationship as I see it between biocapital and the life sciences and contemporary capitalism. Central to my analytic method throughout the book is to show how both the life sciences and capital are constituted by relationships at multiple levels between different forms and registers of materiality and abstraction. In this section, I attempt to explain what I mean by this. I show how five distinct domains of analysis in this book—exchange, commodities, valuation, science, and globalization—are all animated by this dialectic. For that, it is important to again digress into Marx's methodology and explain historical and dialectic materialism.

Marx borrows the dialectic from Hegel. The logic is that the dialectic whole inherently consists of two antithetical parts and is an inherently contradictory structure. However, both parts are essential for the constitution of the whole. By showing both objects and systems to be thus contradictorily constituted, Marx both shows the object or system under analysis in its entirety and points to its instability.

Marx, however, inverts the Hegelian dialectic by basing it not in the mind or the idea or consciousness but in materiality. Human activity for him is a consequence of the historical material conditions of human existence. Marx designates consciousness as being "from the very beginning a social product, [remaining] so long as men exist at all."[19] The attempt, according to Marx, should be not to see how consciousness creates social existence but to see how the conditions of existence shape consciousness. Therefore, a simple interpretation would suggest that Marx shows material relations of production as underlying the evolution of the social phenomenon that capitalism was.

This straightforward reading of the Marxian method is expectedly too simplistic to withstand rigorous analysis, if only because it reduces all politics to the politics of class. But there is something to be grasped from a materialist analysis as it might be applied to biocapital that I shall do before attempting to read Marx's own formulation of materialism in more complex terms.

For instance, as mentioned earlier, one of the things said to be unique about

genomics is the way in which it allows us to conceive of life in informational terms. And yet the idea that life is information has been very much a part of the central dogma of molecular biology, which signifies the mechanics of life as being a series of coding operations, where DNA gets *transcribed* into RNA, which gets *translated* into protein—an algorithmic conception of life that has been prominent within molecular biology since at least the 1950s.[20] The difference now is that genomics allows the *metaphor* of life-as-information to become *material* reality that can be commodified. In other words, one does not just have to *conceive* of life as information: one can now *represent* life in informational terms that can be packaged, turned into a commodity, and sold as a database; and this change itself is enabled not so much by conceptual advances as by the development of the technological hardware that enables the generation and processing of information at speeds and resolutions inconceivable before. And indeed, the evidence of genomics as an assemblage of technologies that generates material information that can be commodified was made explicit by the fact of the "race" to sequence the human genome. What was at stake in regulating the commodity status of DNA sequence information was not just Merton's norm of communism but also the fact that whoever owned this *object* that DNA sequence information had now, consequent to genomic technologies, become was consequential to the modes of conduct of subsequent research.

And yet Marx's materialist analysis is rife with moments that defy materialist explanations. Marx's own schema to account for this was outlined in terms of his conception of *base* and *superstructure*. According to Marx, the material relations of production constitute the basic driving force of social activity, and forms of consciousness are "superstructures" that need to be understood in terms of this base. Therefore, for instance, in *The German Ideology* (Marx and Engels 1963 [1845]), he is able to dismiss religion as "false consciousness," as not something grounded in the material relations of production.

By the time Marx outlines the labor theory of value, however, this simple relationship of base as material and superstructure as abstract is considerably muddied.[21] This is evident in Marx's analysis of surplus value, which in many ways grounds his structural analysis of capitalist exploitation. To understand how surplus value leads to exploitation, Marx poses the question of the funda-

mental contradiction of capitalist political economy that he is trying to resolve, which is how an exchange of equivalents can lead to the generation of surplus.

To answer this question, Marx locates the generation of surplus value not in the labor that the worker exchanges for wages from the capitalist but in the *potential* of the worker to perform work *in excess* of that wage. It is this potential that Marx terms "labor power." As creative potential, labor power is not predetermined value. Therefore the apparent act of equivalent exchange (worker's labor for capitalist's wages) has hidden within it an element of nonequivalence, because wages are fixed remuneration, but the labor, which is actually labor power, is the potential for creation of value *over and above* the money expended in wages.

The key here is that labor power is an entirely abstract concept, and yet it is in this abstract concept that the fundamental dynamics of the labor theory of value, as an explanation of political economy distinct from the bourgeois understanding of it, rest. Historical materialism depends entirely, then, on this fundamental abstraction, but it is an abstraction, in turn, that stems entirely from the structural, material relations of production, because it is an abstraction that can only be enabled by the fact that the capitalist controls the material means of production. Therefore, at the very heart of Marx's analysis of capital is the dialectic relationship between forms of materiality and forms of abstraction.

This sort of relationship between materiality and abstraction runs throughout Marx's work and is a central methodological lesson from Marx that I incorporate into this analysis. For instance, the very act of exchange is animated by this dialectic. This could be the case whether the act of exchange in question is between capitalist and worker, or whether the exchange in question involves the circulation of money and commodities, the contours of which Marx describes at the start of *Grundrisse* and *Capital*. Biocapital, like any other form of circulation of capital, involves the circulation and exchange of money and commodities, whose analysis needs to remain central and at the forefront of analysis. But in addition, the circulations of new and particular forms of currency, such as biological material and information, emerge. One of the things that genomics fundamentally enables is a particular type of materialization of information, and its decoupling from its material biological source (such as tissue or cell line).

And yet, as Marx teaches us, one cannot be satisfied by simply tracing the circuits traveled by various forms of commodity, currency, or capital. Because again, at the heart of Marx's analysis of the circulation of money and commodities is the *mystical* and *magical* nature of the commodity, the fact that it is, in his words, "full of metaphysical subtleties and theological niceties" (Marx 1976 [1867], 163). In other words, at the heart of the interaction between either worker and capitalist or money and commodity is an uncanny kernel of abstraction that eludes capture in purely materialist terms.[22] It is this uncanny kernel that enables the commodity, which as an object is a rather banal thing, to become the mediator of social bonds. Indeed, that Marx alludes to it doing so in a "theological" manner is particularly striking. If, twenty-two years previously (in *The German Ideology*), he dismissed religion as ideological and therefore superstructure, a form of false consciousness, then by the time he writes *Capital*, the "theological" character of the commodity becomes a central symptom of its fetish.[23] It is not surprising, then, that a moment of exchange is also referred to as a moment of conversion, conversion being a process whereby one type of object (money, for instance) gets converted for its holder into another (such as commodity), but *also* being, explicitly, a theological category.[24]

Just as the act of exchange is animated by the dialectic of materiality to abstraction, so too is the act of valuation. Indeed, valuation is an integral part of the exchange process, but with the differentiation of capitalism into its industrial and speculative forms, valuation too starts operating at multiple levels or registers. Therefore, on the one hand, we have registers of valuation that depend on tangible material production—the amount of product manufactured, distributed, or sold by a company, for instance, or its profit margins and revenue flows. On the other hand, and certainly in many ways more central in the dot.com heyday of 1999–2001 that much of this book traces, we have forms of valuation having not to do with tangible material indicators of successful productivity, but with intangible abstractions, such as the felt possibility of *future* productivity or profit. Vision, hype, and promise, as I show in detail in chapter 3, are fundamental drivers of this kind of valuation and are central animating factors in drug development, whether it involves the valuation of start-ups by private investors such as venture capitalists, or the valuation of public companies on the stock markets of Wall Street. As the stock

market scandals over the last couple of years indicate, this different level of abstraction is not merely discursive but has led to different, tangible material practices such as creatively articulated accounting mechanisms. Layered on these different registers of valuation is the fact that "value" itself, like conversion, is a double-jointed word that not only implies material valuation by the market but also suggests a concern with meanings and practices of ethics. This is particularly salient for industries such as biotech and pharmaceuticals, which generate significant symbolic capital from being, as they are never averse to pointing out, in the business of saving lives. Just as commodity objects and exchange processes are animated by a certain theological mystique, so too are systems of valuation.

So too, indeed, is science, which operates with its own authority by virtue of its ability to generate scientific "fact." This fact production is itself, as mentioned earlier, never driven by conceptual advances alone but often requires enabling technological advances. Indeed, genomics would have been a nonstarter had it not been for what are called tool companies, the companies that manufacture kits, reagents, and technological machinery that in many ways fundamentally enable genomic research to happen. The development of subjects (as in technoscientific disciplines such as genomics) is, however, always already entwined with the configuration of subjects (as in disciplined agents). In the case of genomics, these latter subjects could, for instance, be patients, or consumers, or experimental subjects, as I trace in chapter 2 and, especially, in chapter 4. This is particularly so when the disciplines in question are those that concern the very meanings of life, as the biological sciences in general and genomics in particular claim to do. In many ways, the particularities of *bio*capital stem from a combination of the specific market terrains of drug development (elaborated hereafter) and the specific epistemologies and subject formations of new life sciences.

So far in this introduction, I have talked about biocapital in delocalized (and implicitly in American) terms. This book, however, is a comparison of biocapital in the interlinked contexts of the United States and India and is specifically attentive to capitalisms as *global* regimes and practices. And indeed, globalization too is animated by a dialectical relationship between materiality and abstraction.

One of the methodological challenges of a project such as this is that symmetrical comparison between American and Indian techno-capitalism is in fact impossible, because there is an evident and wide asymmetry in the resources available to the two countries to do science or to influence the global marketplace. Therefore there are significant, material differences in structural relations of production that are absolutely vital. At the same time, I argue that the actions of Indian actors in this account cannot be explained simply by recourse to structural inequalities, because they are animated by a range of individual and collective *desires*, specifically the desire to be a global free market player. However, this desire, for these actors, always already implies acting *as if American*: there is a marked imitation of an American free market imaginary. In spite of these imitative desires, however, actual emergences of techno-capitalist systems on the ground in India tend often to diverge in incongruent ways from their American models. And these divergences are themselves conditioned both by different structural histories (such as India's colonial past, and five decades of postcolonial state socialism) and by the fact that Indian free market imaginaries are themselves not seamlessly articulated but rather frictioned and in tension with various forms of nationalist indignation at the unequal relations between India and the West. Similarly, the normative attribution of a particularly American mode of globalizing free market imaginary as somehow being the unmarked form of free market capitalism is itself, I show, animated by underlying abstractions such as nationalism, which get articulated differently in the United States than they do in India.[25]

In other words, an account of a system of global capitalism, if one learns from Marx's methodology, cannot simply be a network analysis that traces the various types of technoscientific or capital flows that occur in order to produce and sustain this system.[26] Such an account also needs to understand how these flows are constantly animated by multiple, layered, and complex interactions between material objects and structural relations of production, on the one hand, and abstractions, whether they are forms of discourse, ideology, fetishism, ethics, or salvationary or nationalist belief systems and desires, on the other. These abstractions may be hard to pin down and map in the same diagrammatic fashion as networks and flows, but it is essential to acknowledge them if we are to make sense of what Donna Haraway might describe as the biocapitalist "onion."[27]

The Upstream-Downstream Terrain of Drug Development

I have argued so far that the complex relationships between materiality and abstraction constitute the nature of the tendential emergences of biocapital, as sets of systems and practices that are simultaneously globalizing and particular in their manifestations. However, these relationships are themselves constituted on certain terrains that have evolved historically. At their simplest, these terrains are overdetermined by logics of capital in our present historical conjuncture. But capitalist terrains are themselves multiple, and different market segments have different market terrains. One of the particularities of biocapital is the particular terrain of drug development that is constituted both by the nature of the drug development enterprise and by the histories of market evolution of the biotech and pharmaceutical industries, which, as I show hereafter, are two distinct arms of the drug development enterprise. In this section, I describe this particular American terrain, referred to as "upstream-downstream," and provide a brief overview of the drug development process, before briefly situating the Indian pharmaceutical industry in relation to this terrain.

The stages of drug development start with the identification of potential lead compounds (what is known as *drug discovery*), through a process of clinical trials (which is the subset of the entire process actually referred to as drug development), to finally the manufacture of a therapeutic molecule that gets marketed. The earlier stages of this process are referred to as *upstream* stages, the later ones as *downstream*.

Biotech and pharmaceutical companies represent two quite distinct arms of the drug development enterprise. They have evolved at different historical moments, have engaged for the most part in quite distinct science, and tend to occupy different locations in the drug development market terrain. The development of therapeutic molecules by the pharmaceutical industry has largely occurred by organic chemical synthesis, where derivatives of often serendipitously found biological substances were created in order to obtain therapeutics with better safety and efficacy profiles than the natural substance from which it was derived. The major driver of new molecule development over the last seventy-five years has indeed been synthetic chemistry. These traditional methods still form the bedrock of the pharmaceutical industry, in spite of considerable investment to make the initial identification of lead compounds less serendipitous and more rational and predictive.

The beginnings of the biotech industry, on the other hand, depend on recombinant DNA technology (RDT), as mentioned earlier.[28] If the logic of pharmaceutical organic chemical synthesis is the production of small chemical molecules that interact with and modify cellular and molecular components, then that of biopharmaceutical development is to engineer molecules that are normally components of the cellular and molecular machinery.

The story of the pharmaceutical industry has arguably been one of the most dramatic stories of industrial growth in the twentieth century. The pharmaceutical industry was actually incubated in, and grew out of, the dye industry, just as the biotechnology industry in the 1970s was initially supported by, and grew out of, the petrochemical industry. The "boom" in the pharmaceutical industry occurred in the 1930s with the discovery of the sulfa drugs, followed by the industrial-scale manufacture of penicillin as part of the World War II effort, which highlighted the importance of the links between defense and security needs during war and pharmaceutical innovation.[29] At the end of the nineteenth century, the two companies that could be called pharmaceutical companies were Bayer and Hoechst. They were joined in the 1930s and 1940s by would-be pharmaceutical giants such as Ciba Geigy, Eli Lilly, Wellcome, Glaxo, and Roche. The burst in natural-product chemistry occurred in the 1940s and 1950s, starting with the successful development of streptomycin for the treatment of tuberculosis. Not surprisingly, the development of biopharmaceuticals has a more modest history, both because the history of the biotech industry is much shorter and because in many ways the synthesis of biopharmaceuticals, which are chemically much more complex than small organic molecules, is often a much trickier process than traditional pharmaceutical development.[30]

If biotech has an origin story, then it is probably to be located in that of Genentech, even though Cetus Corporation, formed five years before Genentech in 1971, is considered the first biotech company. It was Genentech's initial public offering (IPO) on October 14, 1980, however, that really announced to the world the reality of biotech companies on Wall Street and further pointed to the market possibilities of companies that could by definition operate only on promise for years, until tangible therapeutic products could emerge from their R & D efforts.[31]

The innovative capabilities of biotech companies—which tend to be much smaller than pharmaceutical companies—are not simply the consequence of their doing "newer" science but are also a manifestation of a smaller, more adaptable, and managerially supple organizational structure. Nonetheless, there is no questioning the starkly differential positions of power and bargaining that biotech and pharmaceutical companies occupy when they actually do business with one another, and a fundamental aspect of the upstream-downstream terrain of drug development is that, with a few exceptions, biotech companies tend to focus on upstream drug discovery, but do not always have the capital to take molecules through downstream clinical trials processes. Instead they often license a promising therapeutic molecule out to a pharmaceutical company that does have the resources to do so.

To summarize, then, the market terrain of drug development in the United States today is constituted by small biotech companies that tend for the most part to work on upstream drug discovery projects before licensing potential therapeutic molecules out to pharmaceutical companies, and by big pharmaceutical companies that, in spite of some moves toward biopharmaceutical development, still tend to rely for the most part on the development of small therapeutic molecules through organic chemical synthesis. In addition, much of their strategic functioning involves in-licensing molecules from biotech companies or occasionally acquiring biotech companies with promising molecules in their pipeline. This terrain fundamentally structures the dynamics of drug development and provides it with some of its particularity.

Genomics very much occupies an upstream market niche in the drug development process, though the dream of most genome companies, like that of any biotech company, would be to increase capital reserves and revenue flows so as to be in a position to increasingly move their therapeutic lead molecules further and further downstream. From the point of view of the empirical content of this book, which is about postgenomic drug development marketplaces, pharmaceutical companies are a fundamental animating specter rather than a site of analysis themselves. Different pharmaceutical companies are interested to different degrees in genomics as sources of potential value to them, and some do invest resources in genomic-related research and development. But for the most part, pharmaceutical companies act as the eight-hundred-

pound gorilla in the drug development process, the one institutional entity with the capital reserves and the proven history of being able to take molecules to market. As mentioned earlier, the way they often do that with biopharmaceuticals is by in-licensing molecules from biotech companies and then taking them through downstream stages of drug development. In many ways, pharmaceutical companies, in addition to making molecules, could be said to be the regulators of capital and commodity flow in the drug development value chain, often deciding which upstream technologies and molecules are worth investing in, either through a licensing agreement or by buying the upstream company. In this manner, pharmaceutical companies almost act like the investment banks of the drug development enterprise.

The other crucial aspect worth noting here is that there are two economies at stake that are themselves not seamless with respect to each other and that correspond to Marx's "industrial" versus "commercial" capitalisms that I discussed while talking about the relationship of biocapital to systems of capitalism writ large. On the one hand, there is the R & D, manufacturing, and marketing of drugs, the component of the drug development economy that has to do with the production, distribution, and sale of commodities (similar to Marx's "industrial capitalism"). On the other, there is the speculative market, which for pharmaceutical companies (almost all of which in the United States are publicly traded) translates into market valuation on Wall Street (similar to Marx's "commercial capitalism").

Ironically, the larger and more powerful a company is, the harder it is, in some ways, to satisfy Wall Street. This is because while one metric for measuring the value of an investment is its stability and reliability (on which score pharmaceutical companies are extremely sound investments), another, whose importance was particularly magnified during the dot.com boom of 1999–2001, is the ability of a stock to appreciate in value. This is known as earnings per share (EPS), which is the annual percentage increase for an investor in the value of the shares he or she holds in a company. Investors like to see between 12 and 15 percent EPS in any stock they hold; typically, pharmaceutical company EPS has been in the range of 8 to 10 percent. This has largely to do with the time, capital intensiveness, and high risk of drug development. It also has to do with the fact that large, successful, and extremely profitable industries

have to do correspondingly more in absolute terms to register an equivalent increase in relative value of a share than a much smaller company. Thus a small biotech company with one therapeutic molecule in its pipeline will generate huge stock market excitement when a second therapeutic molecule enters clinical trials, whereas for a large pharmaceutical company that has, say, twenty patented molecules on the market, seven of them blockbusters, and eight others in various stages of clinical trials, the addition of a ninth into the pipeline, which requires the same amount of development resources and research efforts as it would for the small biotech company, would likely not generate the same amount of investor excitement, because it would not be as defining an event for the larger company relative to its own market history. This is why one can simultaneously have an activist discourse that points to the huge profitability of the pharmaceutical industry as an argument against high drug prices, and an industry discourse that points to the need for high drug prices in order for the industry to survive, as apparently completely antithetical discourses that both make market sense: the former discourse points to the commodity marketplace and the generation of revenues, the latter to the speculative marketplace and the need to satisfy investors.

I have so far talked about the upstream-downstream terrain as descriptive of drug development in the United States.[32] But pharmaceutical companies exist, and have existed for decades, as robust industries in many countries other than the United States. The Indian pharmaceutical industry, for instance, is one of the most interesting national pharmaceutical industries in the world today, in large measure because its character has been so significantly shaped by patent regimes. The 1970 Indian Patent Act granted process as opposed to product patents on drug manufacture. This meant that Indian pharmaceutical companies, unlike their American counterparts, could manufacture drugs that already existed on patent in the market, as long as they came up with their own method for doing so.[33] This helped shape the industry into one that was capable of cheap reverse-engineered bulk drug manufacture, which has in turn enabled Indian drug prices to be among the lowest in the world. In 1995, however, India became a signatory to World Trade Organization–imposed patent regimes, which required the industry there to be completely WTO compliant by 2005. The change in patent regimes toward a WTO-imposed one has

therefore necessitated a paradigm shift in the Indian industry, as after 2005 Indian pharmaceutical companies will not be able to take a molecule already on the market, remake it through an indigenous process, and then sell it. Indian companies will now have to focus on novel drug discovery and development in a manner much more closely reflective of the American drug development marketplace.

The major question facing the Indian pharmaceutical industry today is what effect becoming WTO compliant will have on it, a question of what exactly the consequences will be of a paradigm shift toward a property regime that will not allow reverse-engineered bulk drug manufacture. The Indian pharmaceutical industry was not a sick or dying industry in need of market rejuvenation but was, throughout the 1980s, a quite profitable industry. Therefore, changing over to a WTO regime, for this industry, does not just mean adopting new and unfamiliar methods of drug discovery, which necessitates the setting up of R & D facilities; it also means abandoning a revenue-based business model in favor of the potentially lucrative but far riskier growth-based model, in which Indian companies would be evaluated not just by the amount of product that they are able to sell but also by the potential value that investors speculate they can provide, while pitted in direct competition against more powerful Western companies.

There are, however, an increasing number of Indian companies that have been in the process of retooling themselves to become companies that can discover new chemical entities. The stakes are not just profits but global expansion. The niche that Indian companies starting to invest in R & D occupy becomes similar to the one a Western biotech company occupies with respect to a big pharmaceutical company. Dr. Reddy's Foundation (DRF), for instance, is the R & D division of Dr. Reddy's Laboratories, which is one of the Indian pharmaceutical companies best positioned to retool itself away from reverse engineering of generics and toward novel drug discovery and development. But it employs just 250 people (the size of a very small U.S. biotech company); its R & D efforts involve drug discovery rather than development; and its new business model has involved out-licensing the molecules it discovers to big pharmaceutical companies that can take a molecule through clinical trials. From the revenue garnered from such licensing, companies like

Reddy's hope to move further up the value chain by holding on to the molecule longer before out-licensing it. While it is nearly impossible to actually get breakdowns of milestone payments at different stages of drug development when the drug has been licensed from a discovery company to a development company, it is well understood that a molecule's value increases exponentially the further up the clinical trials process it gets before being out-licensed. In other words, the story of drug development in India, from the perspective of its pharmaceutical companies, is one that sees a shift from the reverse engineering of generic molecules for primarily domestic markets, a profitable business model in terms of revenues, to one that much more closely approximates the role and market position of a U.S. biotech company, involved in early-stage novel drug discovery (though still primarily using traditional organic chemistry), that it hopes will allow it to eventually take its molecules further downstream.[34]

While the Indian pharmaceutical industry is well established, India does not have much of a biotech industry. As indicated earlier, this is partly because of the absence of a traditional scientific strength in the life sciences to match that in the chemical sciences, coupled to the risk aversion of pharmaceutical companies that do not want to abandon research in areas of their core strength. However, as I note at many instances throughout the book, Indian state actors are particularly keen to change this situation, and view genomics as the answer to India's developing an emergent biotech industry. As with the Western pharmaceutical industry, the Indian pharmaceutical industry too is not an explicit site of analysis for much of the rest of the book. Rather, I focus on India's biotech and genome ventures, many of which are enabled in considerable measure by the state and strategically constrained and influenced by the global influence and strength of Western pharmaceutical companies. I continue to set the stage for this further analysis by briefly explaining the changing meanings of genomics, both as science and, in the United States, as business model, over the past few years.

Genomics

One set of background contexts necessary to understanding the assemblages of actors, practices, stories, and events that I narrate in this book concerns the

terrain of drug development.[35] However, I also argue that genomics represents an epistemic and technological shift of some significance to biocapital in its particularity. In this section, I provide a quick tutorial on genomics. "Genomics" itself, I wish to show, is not a stable referent, and its own meaning has evolved over the last few years, from the days of the initial conception to map and sequence the human genome at the start of the Human Genome Project (HGP) in the late 1980s to today's postgenomics era subsequent to the completion of the working draft sequence of the human genome. Further, this evolution in what genomics means has not just been consequent to technological innovation or epistemic advances but has also been conditioned, in significant measure, by what is deemed a potentially successful business model at the time.

Genomics itself, then, is multiple things, but it is first and foremost an articulation of experimental with informational science. To this extent, it involves an articulation of different scientific perspectives on biological systems, of mathematics and computational biology on the one hand with molecular genetics and cell biology on the other.

Genomics has to a significant extent been technologically enabled, and analysis has also tended to be driven by automated technology rather than by hypotheses. It represents the rapid, high-volume analysis of information, what is known as *high-throughput* science. The initial attempts of genome scientists focused on mapping and sequencing human (and other) genomes, which has been followed now by more complicated genomic analysis. Therefore the first "phase" of genomics was very much about the generation of databases, and this was very much the prime activity of many of the public labs and private companies from 1999 to 2001, the period that I trace most directly in this book.

An important informational tool in genomic analysis is knowledge of genetic *variability* between individuals and populations, and the potential correlation of that variability to phenotypic variability (i.e., variability in visible traits). Major informational artifacts that enable such analysis are called single nucleotide polymorphisms, or SNPs (pronounced "snips"). SNPs are single base variations in the genetic code that occur about once every one thousand bases along the three-billion-base human genome. Knowing the locations of

these closely spaced DNA landmarks both eases the sequencing of the human genome and aids in the discovery of genes variably linked to different traits. A map of all the SNPs in the human species would provide the basic database to perform association studies, which compare the prevalence of particular genetic markers among individuals who possess a certain trait (which may be a disease trait or a predisposition to a disease or to side effects to certain drugs) and those who do not. Association studies can provide insights in unearthing obscure disease-related genes or in helping preventive diagnosis. SNPs, therefore, have a potential value as tools leading to therapy, in a more pinpointed and versatile way than a random DNA sequence. Indeed, the "human" genome sequences generated by the public HGP and by Celera represent a rather small sampling of human DNA sources.[36]

As mentioned toward the beginning of this introduction, the HGP started as a public initiative to sequence the genome. This was officially undertaken by a five-nation consortium, though not surprisingly much of the policy impetus came from the United States. Therefore, at the outset, genomics was hardly overdetermined as corporate. In fact, the initial interest in the project came from the U.S. Department of Energy. Many biologists were skeptical because what was being proposed was not hypothesis-driven science. Indeed, in its guise as a state-sponsored project of big, industrialized science, whose planning proceeded throughout by means of the generation of five-year plans, the HGP could almost be said to have resembled Soviet science in its conception rather than American.[37]

The approach of the genome project was to start by developing genetic and physical maps, and then to sequence regions of interest. All of this could be done only through the concomitant development of technological hardware, and by the parallel sequencing of model organisms.[38] This was followed by the development of database tools to annotate the sequence and the beginnings of the development of functional genomics capability, with a special focus on DNA sequence variations.[39]

All these plans were accelerated by the formation of Celera Genomics, and by Craig Venter's challenge to the HGP mentioned at the start of this introduction. This also marked the upstaging of big state science by entrepreneurial corporate science and was enabled in large part by new automated sequencing

machines developed by Applied Biosystems (ABI), whose parent company, Perkin-Elmer, was the company that also seeded Celera. Therefore, while biotechnology's corporate contours had already taken shape in the early 1980s with events such as the Bayh-Dole Act, *Diamond v. Chakrabarty*, and the Genentech IPO, genomics itself only started looking increasingly corporate because of the enabling role played by Perkin-Elmer, a company that until that time had been a completely unglamorous instrumentation company, a nuts-and-bolts company far removed from the sort of cutting-edge research and development associated with biotech.

I have, so far, myself tried to provide some nuts-and-bolts background at the start of this introduction, by outlining what I see as some of the central theoretical terrain that I am trying to cover through an attempt to explain the notion of biocapital, and by explaining all too briefly the market terrain of drug development and a brief overview of genomics. Both these latter contexts are essential to understanding the arguments of especially the first four chapters of this book. I now move on to outline the structure of this book and to describe some of the sites of my analysis.

This is a book that studies a global political economic system and uses ethnographic methods to do so. This is already an incongruent attempt, which effectively sets out resources well equipped to study *locality* and *particularity* in order to map a set of *global* systems, structures, and terrains. In many ways, it is this incongruence that captures the spirit of what George Marcus and Michael Fischer diagnosed for social and cultural anthropology in the 1980s, the constitutive element of what they called an "experimental moment in the human sciences" (Marcus and Fischer 1986), and that indeed typifies the fundamental contradiction of ethnographic practice.[40]

This necessitates reconfigurations of the spatial boundaries of ethnographic practice to map onto the spatial reconfigurations of the relationships between "local" and "global" brought about by global capitalism. Traditional, "single-sited" ethnography, as Marcus and Fischer point out, tends not to be sufficient to capture the complexities and multiple causalities that constitute contemporary social systems and structures. They therefore proposed multisited eth-

nography as a methodological solution to the problems confronting "experimental" social and cultural anthropology. By multisited ethnography, they do not simply mean a multiplication of the number of field sites that an anthropologist travels to, a quantitative "adding on" to single-sited ethnography. Rather, they have argued that multisited ethnography is a *conceptual topology*, a different way of thinking about field sites in relation to analytic and theoretical questions about the world we live in. This might require different methodological strategies (for instance, involving new types of collaborations, formal and informal, between anthropologist colleagues, or between anthropologists and their informants), access to a different range of sources (for instance, Web sites and other sources of mediated information in addition to participant observation and formal interviews), and different narrative strategies (more dialogic and polyphonic).[41]

The ambition of this book, in a similar vein, is to make social theoretical interventions in science studies and political economy by using empirical ethnographic material. Therefore, on the one hand, this book is about "biocapital"; on the other hand, it is also a multisited ethnography of postgenomic drug development marketplaces in the United States and India. Such a limited demarcation of sites necessarily leads to partial and fragmentary insights into a political economic system. I argue that it is nevertheless in the particularities that constitute global systems that the functioning of those systems can truly be elucidated and understood. Further, as I have argued earlier, if capitalisms are always already multiple and mutable, then the challenge is less one of creating a grand unified theory of capitalism than one of contributing to a proliferation of thick, multiple, locally grounded analyses of technoscientific market regimes and practices. India and the United States are central and in many ways unique sites that contribute to such an analysis, but they by no means capture "biocapital" in any sort of entirety. Rather, they provide windows into global capitalisms, together generating a systemic perspective.[42]

The other challenge of this book is to confront the fluidity of the systems that I am writing about. If capitalism is multiple and mutable, any analysis of capitalism needs to relentlessly emphasize it as *process*. Similarly, biotechnology is a constantly emerging and changing field: to repeat, even genomics fails to be a constant referent over the last five years that could be said to constitute the

period of ethnographic investigation for this book.[43] The changes in genomics as an epistemology have paralleled changes in genomic business models, as business plans that in 1999 or 2000 were deemed to be the future of the life sciences (such as, for instance, those based in the creation of bioinformatic databases) now often seem to have been naively optimistic. Indeed, many genome companies that generated their initial investment on the basis of bioinformatic business models are in the process of reinventing themselves as drug discovery biotechnology companies. Perhaps the most notable example of such a company is Celera Genomics, which played such a major role in generating the working draft sequence of the human genome. Meanwhile, changes in Indian technoscience and capitalism have been particularly rapid over the past decade and a half, as the recent dramatic investment in high technology has been matched by drastic changes in an economic and legal environment that has been retooled, both intentionally and as a consequence of global structural constraints, toward an aggressive embrace of the free market.

Therefore, complementary to a multisited ethnographic methodology that emphasizes the spatial scale and incongruence of global systems is a necessary emphasis on *temporality* as a consequence of the fact that these systems are not rigid or eternally resolved structures but processes constantly in formation.

On the one hand, then, this book tells stories of people, places, technologies, epistemologies, business models, and market logics in two countries that are distinct yet interrelated in asymmetric fashion. On the other hand, however, many of these stories are structured by flows of various sorts—of materials, people, money, and information. While I trace the cultures *of* particular sites throughout the book, I am also interested in tracing the multiple exchange relations *between* these sites. I do not, therefore, study and describe the sites in this book as reified, static, or solitary entities, but as nodes in multiple sorts of exchange.

In my fieldwork, I have adopted a combination of different approaches: intensive, medium-length participant observation (one to six months per site); short targeted "probes" (one- to two-day site visits); ongoing monitoring of written products of the drug development marketplace; semistructured, multiple life history and career development interviewing; use of scientific conferences and trade shows as ritual spaces for seeing many of the promotional,

competitive, and status constituents enacted and renegotiated; and seminars that I gave at one of my sites (GeneEd, an e-learning start-up based in San Francisco), which emerged as an ethnographer's variant of a focus group technology. In the process, I have physically covered a number of sites in the United States (mainly around Boston and the Bay Area) and in India (mainly in New Delhi, Hyderabad, and Bombay) over a five-year period from early 1999 through mid-2004.

This book is written in two simultaneous narrative registers that implicitly ground its structure. The core theoretical argument of the book is that understanding biocapital involves analyzing the relationship between materiality and modes of abstraction that underlie the coemergences of new forms of life science with market regimes for the conduct of such science. In other words, one can understand emergent biotechnologies such as genomics only by simultaneously analyzing the market frameworks within which they emerge. In doing so, for instance, marketing discourse, the hype and hope surrounding emergent technologies, the fetish of genetic determinism, and the belief in science, nation, and religion all constitute the assemblages of postgenomic life that this book maps at the same time as it maps the technological and epistemic shifts that are both cause and consequence of genomics, biotechnology, and drug development.

The book also maps three sets of terrains: one, the upstream-downstream terrain of drug development that I have already briefly described; the second, terrains within which start-ups deal with investors and customers; and the third, the global market terrains that structure technology and capital flows between centers of innovation such as the United States and aspiring "Third World" peripheries such as India.

In chapter 1, "Exchange and Value: Contradictions in Market Logic in American and Indian Genome Enterprises," I argue that much of the genomics "revolution" is based on technological advances rather than on fundamental conceptual advances. New technological hardware and methodology allow experiments and measurements to be performed at resolutions and speeds inconceivable before. The chapter shows how market logic is as much at stake as technological change, as such innovations always emerge in the context of fluid and contested ownership and intellectual property regimes.

Further, these are exchange regimes in which the apparent binaries of "public" and "private" are in fact hard to maintain as American corporations take strategic recourse to gift regimes at the same time that the Indian state attempts to negotiate global playing fields as a market agent.

In chapter 2, "Life and Debt: Global and Local Political Ecologies of Biocapital," I explore, through fieldwork conducted in the outskirts of Hyderabad and in the center of Bombay, the local political ecologies of indebtedness that are constituted by, and constitutive of, globalization. Biocapital is referred to here in two distinct yet simultaneous analytic frames, more explicitly than at any other point in the book: on the one hand, as the circuits of land, labor, and value (in a classic Marxian sense) that are inhabited by biotechnological innovation and drug development; on the other hand, as the increasingly constitutive fact of biopolitics in processes of global capitalism. In other words, the chapter explores both what forms of alienation, expropriation, and divestiture are necessary for a "culture of biotechnology innovation" to take root, and how individual and collective subjectivities and citizenships are shaped and conscripted by these technologies that concern "life itself." I thereby argue that the playing out of First World–Third World asymmetries in globalization, as opposed to those of industrial colonial expansion, occurs through the reconfiguration of the relationship of imperial power to colony into one of vendor to client.

In chapter 3, "Vision and Hype: The Conjuration of Promissory Biocapitalist Futures," I argue that genomics, and indeed all biotechnology, is a game that is constantly played in the future in order to generate the present that enables that future. I therefore trace the conjuration of corporate promissory futures as a constitutive feature of biocapital, which changes the very grammar through which "life," which now gets transformed into a calculable market unit, is understood, and which structures the strategic terrain on which biotech and drug development companies operate.

In chapter 4, "Promise and Fetish: Genomic Facts and Personalized Medicine, or Life Is a Business Plan," I follow the modes of abstraction that genomic knowledge itself provides and is based on, leading to what I term "genomic fetishism."[44] I reflect the tensions between abstraction and materiality when considering the operation of scientific facts, which themselves are pro-

duced on terrains overdetermined by questions of ownership and the public domain on the one hand and vision and hype on the other. I argue that genomic facts centrally imbricate multiple types of risk discourse. These discourses, on the one hand, concern the probability of future disease that genomic technologies can foretell, and on the other hand, they concern the high-risk, capital-intensive process of drug development that biotechnology and pharmaceutical companies are involved in.

In chapter 5, "Salvation and Nation: Underlying Belief Structures of Biocapital," I show how the promises of biocapital are undergirded by salvationary and nationalist rhetorics and discourses. I talk about the structural manifestation of biotechnologies in the United States as promissory salvationary science; show how such salvationary stories are embedded in specific biographies of individuals; and argue that they are embodied in the ethos of specific corporate cultures, and in cultures of the biotechnology and drug development industries writ large. I contrast this to the nationalist manifestations of biocapital in India, in terms of everyday work practices, institutional structures, regulations and mechanisms, biographies of Indian scientists, and the missionary zeal of Silicon Valley–based nonresident Indian (NRI) entrepreneurs and the role they see for themselves as agents in India's development. I thereby conclude that understanding technoscientific emergence in India is not simply a case study of Third World science and technology, but rather that global market terrains are structured by tensions between dominant hegemonic imaginaries (invariably American) and countervailing nationalist imaginaries. These latter simultaneously submit to and resist American market hegemony in ways that lead to manifestations of market logic, state action, and scientific development that diverge in incongruous ways from what gets conceived in ideologies of innovation and technology transfer.

In chapter 6, "Entrepreneurs and Start-Ups: The Story of an E-learning Company," I describe fieldwork at GeneEd, a San Francisco–based start-up that sells e-learning courses in drug discovery and development to biotech and pharmaceutical companies. GeneEd is neither a biotech nor a pharmaceutical company, but it is situated in all three sets of terrains that I concern myself with throughout the book, and therefore is the one site to which I devote an entire chapter of traditional, single-sited ethnographic attention. By virtue

of being a start-up, GeneEd negotiates the investment terrain that entrepreneurial ventures have to contend with, something that much of the biotech industry has had, and continues to have, to do in a market segment where dealing with venture capitalism and venture capitalists is a central constitutive element. Both of GeneEd's founders are Indians in Silicon Valley and, although not (yet) directly involved in technology transfer to India, are to varying degrees networked into the Silicon Valley nonresident Indian entrepreneurial community, which forms one of my central links in this book between Indian and U.S. market biotech worlds. And finally, GeneEd sells its products to upstream biotech and downstream big pharmaceutical companies and therefore has a particularly invested, and well-situated, perspective on the upstream-downstream terrain of drug development (a terrain that has itself significantly shaped the emergence of GeneEd's own history as a company). This chapter therefore shows how innovation is structured in start-ups, how start-ups relate to their investors and customers, and how labor and management practices and core values are impacted within the start-up itself in the course of its evolution.

In my concluding reflections, I return to Marx to redefine what I have meant by biocapital at various points in this analysis. In the process, I try to tease out some of the continuities and some of the novel specificities that the implosion of emergent life sciences with emergent market terrains and logics present to us.