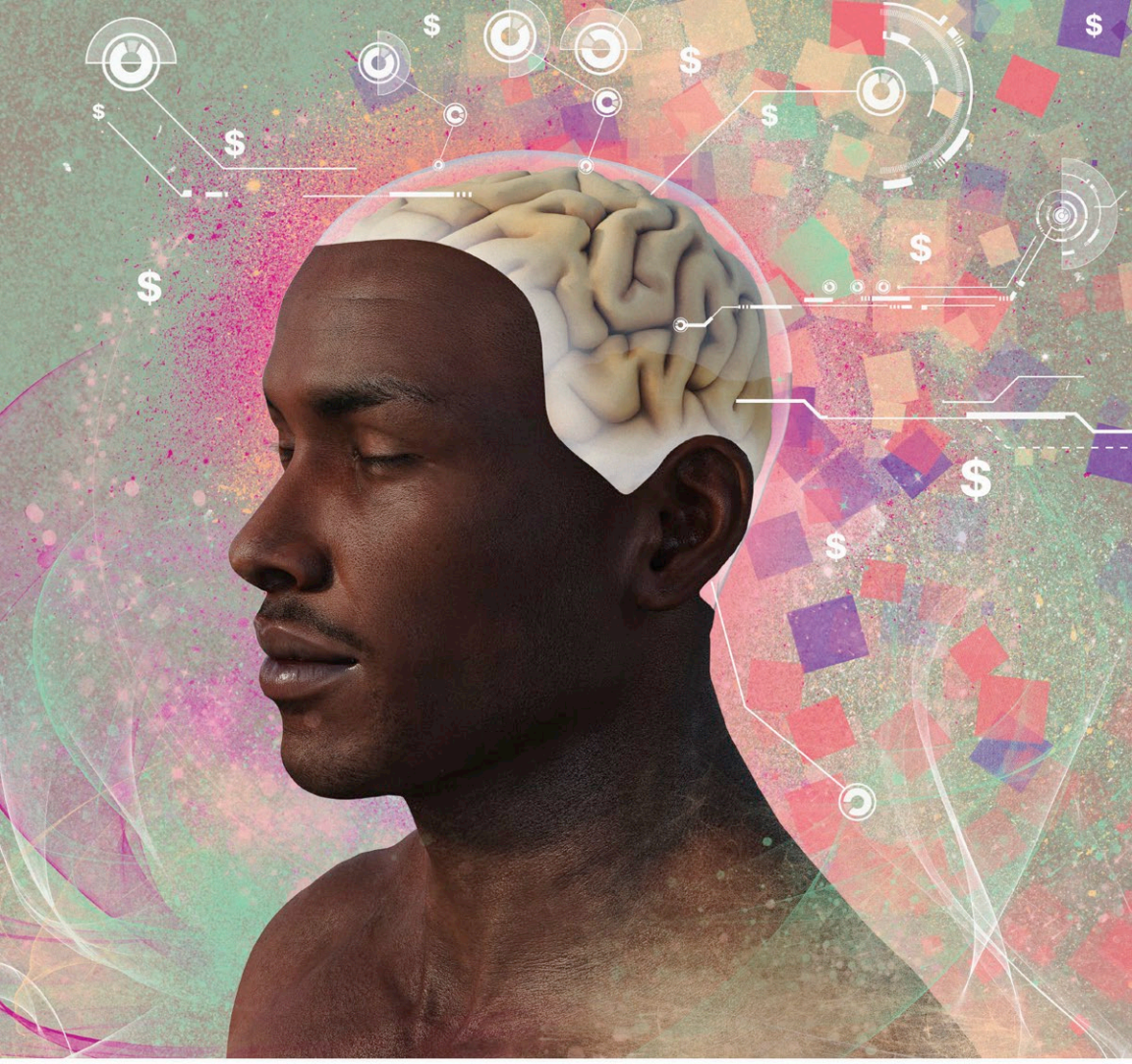

THE MARKET IN **MIND**

How Financialization Is Shaping Neuroscience, Translational Medicine, and Innovation in Biotechnology

MARK DENNIS ROBINSON

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Contents

Preface

In 2012, the US National Institutes of Health (NIH) quietly announced a new pilot program, *Discovering New Therapeutic Uses for Existing Molecules*. Managed via its National Center for Advancing Translational Sciences, the NIH did something rather curious. In 2013, it announced that it had "matched" researchers at Pfizer with professors at Yale University in the US to work on a potential therapy for Alzheimer's disease. According to the NIH, the aim of the partnership was "to test ideas for new therapeutic uses, with the ultimate goal of identifying promising new treatments for patients."

Although the NIH had always promoted the commercialization of bioscientific research, such deliberate intellectual public-private matchmaking by the NIH was unprecedented. Press releases about the new partnership garnered relatively little scholarly attention. Even fewer noticed Pfizer's near simultaneous closure of its internal neuroscience research arm. Meanwhile, the National Center for Advancing Translational Sciences (NCATS), the progenitor of the Pfizer and Yale alliance, created a flurry of similar partnerships across the US all organized under the goal of spurring something that by 2013 had become a bona fide paradigm: that of *translational science and medicine*.

This book is about the emergence of translational science and medicine in the West, part of a tectonic shift that has quietly reconfigured the landscape of biomedical research in the West. Despite the many definitions accorded to translational science and medicine (TSM), they share a core thread—that biomedical research must be dramatically reorganized to accelerate the transformation of research discovered in laboratories into medical products, including diagnostics, medicines, and technologies. Beyond mere

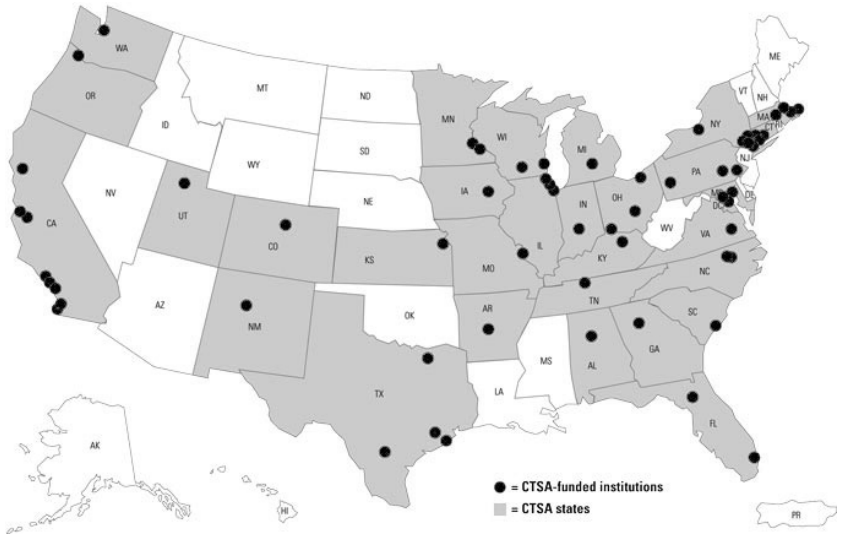

Figure 0.1
Clinical and Translational Science Awards (CTSA) site map. By 2017, the number of TSM-focused centers had grown to nearly 60 institutions. *Source*: http://ncats.nih.gov/ctsa/about/hubs.

ethos, TSM also refers to a set of realized objects—centers, professorships, funding schemes, TSM centers, and graduate programs (including nearly 60 new US programs in translational science by 2017—see figure 0.1). For its proponents, the principal goal of translational medicine was singular: to bring about a massive transformation in health. According to the NIH and others, the world's sick are both the *raison d'être* for translational medicine and its essential test.

My argument is that despite the meanings accorded to it, TSM is not principally about health. In fact, it is constitutively about something else. A crucial part of the history of translational medicine lies in the evolution of international biotechnology markets during the global economic crisis starting in 2004–2005. As universities underwent rapid transformation and increasing privatization and as biopharmaceutical companies endured a pipeline crisis, exacerbated during the global financial downturn, TSM emerged at precisely the moment of a unique market need. Thus, we must understand the translational shift in light of highly specific market actions—ones not visible through analyses of translational medicine

that treat it as a mere result of a dearth of innovation in medicine or as a spontaneous and intellectual opportunity born from an overflow of new scientific facts.

The book's primary argument is the following: TSM serves as a means to *de-risk* early-stage, high-risk biotechnology investments for later investment by pharmaceutical partners, investors, and state interests. Through an analysis of corporate externalization programs, I show that TSM, at the social level, enables biopharmaceutical companies to outsource the very riskiest parts of early-stage neuroscience innovation to the nonprofit university—a crucial part of a broader financial strategy. In this paradigm, university research teams become small biotechnology startups and external industry partners such as Pfizer become, in essence, early-stage investment firms. Several questions emerge from this paradigm. What does it mean for research universities to become risk shelters? What happens when universities absorb unknown levels of risk previously belonging to large biopharmaceutical companies? Additionally, beyond the economic issues at work lie implications for the production of scientific knowledge. How do entanglements such as the Yale-Pfizer collaboration contour the resulting science? As translational research directs biomedical research toward specific, predetermined research areas, what is at stake for what becomes knowable and what does not? Which research questions get pursued and which are discarded?

Yet beyond questions about science innovation lies a larger one. TSM has required a panoply of restructurings and unprecedented levels of federal funding. The NIH has spent over $5 billion since 2005 on grants through its translational science awards program alone. For its proponents, we ought to mortgage the pains of translational medicine on glittering promises of a truly transformed global health. In policy edicts and NIH guidance documents, one finds sustained references to the capacity of translational medicine to radically improve patient health—defined as the alleviation of suffering, measurable improvement in wellbeing, and the reduction and elimination of medical diseases. In all of these invocations, one sees a thorough intermingling of the moral and medical, of health and hope. Moreover, as TSM comes to be categorized as medical innovation even before these enterprises have yielded tangible benefits for patients, we are compelled to reflect on the category of health itself as symbolic and moral collateral in a broader global investment strategy. Ultimately, I argue that

TSM reflects the "financialization of health." Thus, rather than considering the Pfizer-Yale collaboration in terms of a more extensive economic and financial encroachment on and in health, one must think of how health can actually function as a means and form of finance.

This book's findings emerge from long-term research, analysis of clinical and scientific research, a study of architectural and material infrastructures designed to spur translational activity, and interviews and laboratory ethnography surrounding brain-based translational medicine. Drawing on literature on pharmaceuticalization (Biehl 2007), biomedicalization (Clarke et al. 2003), and especially the political economy of science (Robinson 2017; Tyfield et al. 2017; Mirowski 2011) and considerations of science in translation (Latour 1983; Callon 1986), this book maps the complex economic and moral nexus that lies underneath translational medicine's visions of innovation and tracks a global transformation in science, technology and medicine. Most importantly, the book's intervention is in bringing finance-specific considerations to recent theorizing about innovation in biomedicine and technoscience—areas that have greatly misunderstood and underestimated the importance of political economy in their analyses. In a context in which research and development, or "innovation," is increasingly synonymous with "mergers and acquisitions," it is imperative to understand how science and technology development is shaped by seemingly unrelated shifts in specific corporate sectors. This shift has vast implications for a whole host of scholars, ranging from those in science and technology studies to those working on research and innovation.

While the book engages with work in the fields of political economy of research and innovation, science and technology studies, and especially, medical anthropology, medical sociology, and perhaps principally, bioethics, there are additional and profound considerations for science and technology policy, health policy and public health, economic anthropology, as well as scholarship focused on biotechnology, research management and innovation studies. A final point is that while this case study asks questions of the larger enterprise of TSM, I am not suggesting that TSM is *nothing more than* the product of a set of political economic configurations. Some may criticize my analysis for being too focused on economic drivers of science and medicine and too (historiographically) inattentive to patients and patient activism. There is indeed a challenge related to capturing the role of patients within the translational paradigm. Part of the marginalization

of patients emerges from the fact that under TSM patients are marginalized and, as I argue in the book, reduced to their body parts—which both informs and reflects an "epistemology of parts" that characterizes translational thinking.

To be clear, patients matter. Indeed, patient activism has been integral to new biomedical research areas, including application-oriented ones such as translational medicine. As scholars such as Alondra Nelson and Steven Epstein have noted, local patient activism is a critical space of scientific work and innovation. However, I am suggesting that a clear set of global economic shifts were vital, inextricable drivers in the sudden rise of TSM between 2003 and 2012. This book explores this emergence at various registers—from that of patients, found in the latter part of the book, to those of investors, scientists, and entrepreneurs. By taking an in-depth look at translational innovation (on the ground), one finds a reality that betrays many of the sparkling narratives regarding patients, innovation, and science on which TSM is ushered. At the same time, this analysis also reveals a set of swelling, emerging implications brought about by the global rise of TSM and the power of ethnographic, bioethical, and political economic lenses to uniquely highlight these dimensions.

Acknowledgments

My initial project sought to understand local transformations of contemporary neuroscience laboratories after the "decade of the brain." My focus quickly transformed when I encountered modes of scientific and clinical reasoning increasingly shaped by a "translational turn." This focus offered a unique opportunity to bring together analytics from anthropology's considerations of medicine, health, and society with the abundant scholarship in science and technology studies, science and technology policy, and the political economy of research and innovation to examine the implications of this "translational turn." Given its explicitly bioethical and technological dimensions, this project would become vital to making sense of the way translational science and medicine affect health and the implications of the increasing entanglement of innovation in technoscience and global finance. Thus, this project quickly became one about emerging models of innovation in biotechnology and their implications.

However, my inquiry quickly implicated larger bioethical questions about emerging and ever-consuming visions of the future of global health. Soon, I understood this project in ethical terms: as part of our ties to collective and social obligations toward patients, communities, and advocates who live in the medical and economic entanglements about which this book is concerned. Accordingly, I humbly dedicate this book to the patients and patient communities from whom I learned, and whose life experiences have informed my theoretical and analytical work.

Drawn out of research at Princeton University, I am most thankful to João Biehl, whose ethnographic sensibility made an indelible lifelong impression and also Carolyn Rouse, whose leadership and insights helped shape the project. I am also appreciative of comments by Lochlann Jain

at Stanford, whose work and conversations helped me think about the accidental intersections of culture, social structures, and material worlds. This project also reflects the intellectual imprint of thinking on the political economy of research and innovation. Accordingly, I am indebted to Kean Birch, Rebecca Lave, Samantha Vanderslott, Pierre Delvenne, and David Tyfield. I also thank Steve Woolgar, Bennett Holman, Joseph Gabriel, Lucas Marelli, and Sheila Jasanoff for thoughtful observations about my argument. I am especially grateful for the efforts, thinking, and insights of Phil Mirowski.

I am also appreciative of the Wenner-Gren Foundation for Anthropological Research, Princeton University's Center for Health and Wellbeing, the Center for Neuroscience and Society at the University of Pennsylvania, Princeton's Institute for International and Regional Studies, the Institute for the Recruitment of Teachers, the Wicklander Fellowship for Ethics at DePaul University, the Council on Anthropology and Education, the Gianinno Bassetti and Brocher Foundations, and conference support from Professor Ken Oye at MIT. The support from Katie Helke and the editorial staff at MIT Press has been invaluable.

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Lastly, I am most grateful to my shimmering stars, Annie, Dennis, George, Lillian, and Digit.

1 Introduction: An Ethnographic Analysis of Translational Neuroscience

1.1 The Nascent Utopia of Neurotechnology

"The problem with ethics … is that it's easy to be a critic and it's extraordinarily difficult to try to create value, to create new ways of helping people. The personal, emotional capital that translational innovation requires is awe inspiring." As Zack Lynch said this, he quickly flashed his smile, though smiling in the way one does when saying something profound. He expressed this to me after I asked the entrepreneur and investor a question about the ethics of translational neuroscience: the field created to quickly transform neuroscience into new innovations and biotechnologies.

His answer cut me off before I had fully finished the question: "Neuroethicists out there … the problem is that they are so deep [in narrowly defined areas] that they lose some of the real-world contextualization of the actual—how things develop in a broad way." With hints of incredulity, he continued: "Silly bioethical issues … that's why I'm not an academician. God love them."

Despite his words, I did not construe Zack's statement as a mindless, wholesale dismissal of ethics. In fact, he quickly praised the brilliance of prominent Stanford neuroethicist Hank Greely, who works on the ethics of neuroenhancement. Instead, I interpreted his statement as being about the limits and intellectual investments of classical ethical modes, investments that obviate analyses of the real and unfolding consequences of emerging neurotechnological modernity and the real-world contexts to which they are tethered. He was also—and perhaps more so—problematizing quick and too-easy critiques made about scientists and big pharmaceutical companies.

In one view, Zack's point was about the need for an ethics rooted in context and particularity.

In his early forties, Zack leads the Neurotechnology Industry Organization (NIO) and NeuroInsights, a market analysis firm cofounded with his wife, Casey. (The firm has since closed.) Through NeuroInsights and NIO, Zack touches nearly every aspect of commercial neuroscience from lobbying the federal government to connecting investors and entrepreneurs through NeuroInsights' annual Neurotechnology Investing and Partnering Conferences. Because of his wide reach and deep social networks, he is among the most important social connectors in the Silicon Valley neurotechnology community. Yet, his ever-present self-deprecation and quick wit render him engaging and disarming. In fact, his personal warmth obscures his significant influence. He also has an inimitable physical presence. With coiffed hair, a fresh shave, and an eager smile, his persona reveals optimism and aspiration, a far cry from the cold, East Coast pessimism found among Silicon Valley's Ivy League–educated investors and venture capitalists. His stance and smile reflect a nearly permanent confidence; one is convinced by his statements even before he finishes them.

Zack was the first person I reached out to after relocating to San Francisco in 2009. We had initially planned to meet in February 2010 at his home office, but Casey, who was pregnant, went into labor on the scheduled day. We rescheduled and met on a crisp Friday afternoon at La Boulange, a French café on 24th Street in San Francisco's Noe Valley neighborhood. We sat in front of the café with the sun streaming in. He allowed me to tape our conversation. In meeting Zack, my primary goal was to see what else I could learn about this thing called *translational neuroscience*. I was interested in the logics and contexts that animated this new mode of neuroscience.

What exactly is translational neuroscience? In short, *translational neuroscience* refers to a particular mode of neuroscience research focused on accelerating the development of novel brain technologies such as psychopharmaceuticals, diagnostics, and devices. Born, in part, from a considerable health policy effort spearheaded by the US National Institutes of Health (NIH) in 2005, it was to be more than a plan for the commercialization of university neuroscience research. In a catalyzing article published in the *New England Journal of Medicine*, "Translational and Clinical Science: Time for a New Vision," Elias Zerhouni, then director of the NIH, articulated

how translational research would lead to *real transformation* in human health:

> It is the responsibility of those of us involved in today's biomedical research enterprise to translate the remarkable scientific innovations we are witnessing into health gains for the nation. In order to address this imperative, we at the National Institutes of Health (NIH) asked ourselves: What novel approaches can be developed that have the potential to be truly transforming for human health? (Zerhouni 2005, 1622)

Starting in 2006, the NIH led a national transformation of university-based neuroscience centers, creating a network of academic clinical translational science centers focused on optimizing research programs and environments in order to push neuroscience research toward commercialization. Commercialization here means the creation of market-ready products that use this science and includes the entire process involved in bringing these products to market and subsequently producing profits. Thus, while the translational imperative indexes visions about the future of health, translational neuroscience also paves the road for explicit commercial opportunities for universities and encourages a shift regarding the mission of university neuroscience research programs. Importantly, it provides a pathway for investors, as well as pharmaceutical and biotechnology companies, to create partnerships with universities and university laboratories. Thus, my principal question regarding translational neuroscience was about its impact on the commercialization of scientific research in university settings. However, to explore this question, I needed to inhabit the worlds of the corporate life sciences and of biotechnology investors. I had hoped that Zack might help me with this, and indeed he did.

I was introduced over email to Zack by Joe Powers, executive director of the University of Pennsylvania's Center for Neuroscience and Society, where I had participated in a neuroscience training program in the summer of 2009. Joe explained that Zack was someone I had to meet given my interests in translational neuroscience (hereafter TN). I had already heard of Zack well before Joe's suggestion. Zack's name emerged in conversations with other academics and during early conversations with pharmaceutical executives. I had even seen him on television discussing his coauthored book, *The Neuro Revolution: How Brain Science Is Changing Our World*, which explores how emerging technologies in neuroscience may radically transform the world.

This book introduces the world of neurofuturism, a field of inquiry and imagination focused on expansive opportunities and transformations that may occur via an increased understanding of the brain. To be clear, the book is also a work of technological futurism, focused on all of the social areas in which future neurotechnologies should revolutionize human life. For example, it discusses how new brain technologies, including software, will be used to hone financial traders' decision making or how neurotechnologies will be used by dating services and in judicial contexts (in the latter case to examine a subject's risk of criminality and as a means of lie detection). Organized around the notion that the "Neuro Revolution" will comprise a significant economic and historic revolution, Zack places it alongside the agricultural, industrial, and information revolutions—all of which produced dramatic social, cultural, and economic effects. For some reviewers, the book was too hyperbolic, nothing more than unstructured futuristic prognostication. Yet one can also read it as a meditation, a consecration of a moral future slowly unfolding: one where we can improve human decision making, where we can eradicate brain diseases, and where people, now thoroughly understood and demythologized via brain science, can be romantically matched to others who are neurologically, psychologically, and emotionally optimal mates.

Zack begins the book by recounting a telling experience in which he was, in a word, *saved* by biotechnology. While on an international vacation, he had a skiing accident that produced a painful and debilitating back injury. After he'd spent years searching for cures, a neurosurgeon ordered him to undergo a full-body MRI scan in 1996. Zack describes the experience of being fully immersed within the scanner: its cacophony of sounds, the visual claustrophobia. In his narrative, it was the magic of the MRI scanner that enabled the doctor to find the diagnosis that led to his recovery. In my reading, this moment constituted a kind of biotechnological conversion narrative: a thoroughly technological soteriology. There, as he emerged from the scanner, Zack (see figure 1.1) received what he called "an invaluable inkling of the future" (Lynch and Laursen 2010, 2).

While Zack is many things—investor, principal of his firm, entrepreneur—he often discusses his background as an economic geographer studying how and why industries emerge, how they develop, and the reasons they do. He explained precisely what demarcates him from others: speculators, neuroscientists, investors, and investment advisors working in the

Figure 1.1
Zack Lynch in his home office, in the basement of his house in San Francisco's Noe Valley neighborhood. He and his wife, Casey Lynch, are the owners and directors of NeuroInsights. Image, *San Francisco Chronicle*. Copyright © 2014 SF Gate.

neurotechnology space. He considers himself a *tracker.* He also articulates the importance of understanding how various stakeholders in the translational system may be so domain-focused that they are not able to clearly see how they are part of broader sociotechnical and historical configurations:

> Specialists are very powerful at being able to tell you what's going on [in their own domain] but they can't tell you about converging technologies and so being a tracker, it's very difficult to get people to—other than venture capitalists and even they have an issue with it—to sit down and talk about drugs, devices, and diagnostics [at large] and you're either a biotech person in your silo or you're a medical device person or you're diagnostics, personalized medicine … but to me [these larger trends are] the essence … and you have to take into consideration converging technologies. … You've got to really embed yourself in as much random stuff as possible … so you're not missing texture. … I'm like a massive data collector. (Interview 7, February 12, 2010)

Zack's use of the term *tracker* coalesces with the positionality of the ethnographer, simultaneously on the inside and the outside. And in many cases, this describes the radical heterogeneity of his daily routine. During the annual Neurotechnology Investing and Partnering Conference, Zack

adroitly introduces investors to startups, deploying enough neuroscience knowledge to know why one particular startup might be of interest to a given investor. On another day he is in Washington, D.C., lobbying Congress or writing op-ed pieces. In each case, he strategically uses his on-the-ground knowledge to structure arguments about trends, challenges, and larger logics at work within commercial neuroscience or to convince, for example, investors to take an interest in a new crop of neurotechnology startups focusing on devices.

Thus, tracking refers to the vast diversity of Zack's experiences and data sources as well as his use of these experiences in his work. He said to me that "I don't consider myself to have a [high] IQ, but I have this ability to deflect and immerse." So while he runs in many related and interconnected circles—biotechnology startups, private equity executives, pharmaceutical company leaders, Silicon Valley entrepreneurs, neurofuturists and neurogamers, popular neuroscience writers, Bay Area neuroscientists, and "normal" professors—his broad interests do not signal dilettantism. His positionality is firmly rooted in allegiances to economic markets and genuine faith in neuroscience itself. Thus, his commitments and location within the world of neurotechnology mean that his tracking enables him to be an effective and diversified broker of the brain. Given Zack's location in various microworlds, he was a particularly useful guide for me as I sought to develop what for anthropology is an emic understanding (i.e., adopting the meaning perspectives of insiders and using internal logics) of large-scale shifts at work within commercial neuroscience and neurotechnology investments. His perspectives were so contoured by his faith in neurotechnology that his insights and work often offered me useful directions in terms of getting at emic meanings.

Zack and Casey founded NeuroInsights in 2003. NeuroInsights is an organization uniquely positioned in the world of neuroscience, neurotechnology, and life science investment communities; while it provides several services, it is mostly a market information, tracking, and analysis firm. Each year NeuroInsights produces the highly influential *Neurotechnology Industry Report*. The 2015–2016 version of this report, for example, costs $5,700 to purchase and is 650 pages long. According to the product description, "It's the only publication to provide a comprehensive pipeline and market analysis to help investors, companies, and entrepreneurs easily identify opportunities, understand the competitive landscape, determine risks, and

understand the dynamics of rapidly changing CNS [central nervous system] markets."[1] The report links networks of entrepreneurs, investors, and biopharmaceutical, device, and biosoftware companies otherwise difficult to access. NeuroInsights also works at the interface of neuroscience and translation in that the firm provides strategic business and advisory services to small neurotechnology companies looking for investments, while also providing advisory services and investment leads for those seeking to invest in neurotechnology companies.

Zack also founded the Neurotechnology Industry Organization (NIO), a trade organization composed of neuroscience-related companies, organizations, university research centers, as well as pharmaceutical and medical device companies. This organization focuses on lobbying efforts around federal research funding as well as advocacy for a host of industry interests in everything ranging from taxation of investment gains to regulatory issues of the US Food and Drug administration (FDA), which must approve neurotechnologies before one can bring them to market. NIO and NeuroInsights produce annual events nationally and internationally designed to create opportunities for partnerships and networking between scientists and investors, and between pharmaceutical executives and biotechnology startups, among others. These Neurotechnology Investment and Partnering Conference constitute crucial spaces where TN "happens."

Thus, Zack is uniquely positioned to lay out the landscape of neurotechnology—touching spaces ranging from laboratory discovery all the way through commercialization. To an outsider, he may be a key figure in neurotechnology. Yet this fails to capture the personal importance of the brain for Zack. When talking about emerging technologies, he speaks quickly and excitedly:

> So let's go into cochlear implants, brain stimulators for Parkinson's, and there's a whole frontier of emerging neurodevices to treat a whole series of things and not only psychiatric [diseases]. One company developed a portable TMS [Transcranial Magnetic Stimulation machine] for migraines that goes beyond magnetism and that goes [in]to light therapies that are noninvasive. There are also all the surgical procedures and so it's where it's all going. (Interview 7, February 12, 2010)

Like the investors with whom I spoke, Zack invokes the future in order to contextualize (and often deproblematize) the present. He says, "The crudeness of 2005–2020 when people look back from 2040 will be like the

invention of propeller planes … it's like, 'can you imagine that we couldn't fly to Hawaii?!'"

I asked Zack about the concept that he'd created called *neurosociety*. After a moment, he provided an explanation:

> Humanity has gone through an agricultural society. Currently we're in an information society where information technologies drive fundamental political economic and social change, and so if you look at history you realize that new societies emerge when new technologies develop and coevolve with sociocultural norms; you get these technoeconomic waves and they give rise to new forms of human society that are different from predecessor societies. My background is as an economic geographer—[studying] how and why industries emerge and how they develop and why they do and the reasons why they do. I coined the term *neurosociety* and what this represents is a society where neurotechnologies begin to transform political and economic relations, sociocultural relations, business methods, personal patterns of interconnectivity, ways of being, ways of seeing, ways of existing, and norms of our lives—[and] … in many ways [are themselves] radically influenced by this society. That's what the neurosociety means. …
>
> I mean you have these grand revolutions—agricultural, industrial revolution, then information revolution and then the neurorevolution, within those, you can pick out and tease out even more finely grained patterns of technological development that are tied to the capitalist mode of production … and so Nikolai Kondratieff, who's a Russian economist—came up with classic analyses of these technoeconomic waves. [Economist] Joseph Schumpeter was a big fan … he [Schumpeter] came up with the term *creative destruction*. … and so this idea of these technoeconomic waves, they emerge and then go through a process where low-cost products engender entirely new ways of doing business, they impact industries that already exist, they require new industries which create new modes of work and which create new modes of living. (Interview 7, February 12, 2010)

For Zack, there is a crucial relationship between emerging innovations in neuroscience and economic transformations "tied to the capitalist mode of production." His invocation of "technoeconomic waves" may get at the inextricability of "the social" and "the technical" that early economic historians such as Schumpeter and Karl Polanyi prefigured in their theorizing about massive social transformations emerging out of technologically enabled industrial capitalism (Polanyi 2001). Concepts such as that of the sociotechnical ensemble, which places analytical weight on the *inextricability* of the social and the technical in explaining technosocial change, exemplify this convergence (Bijker 1997). The kind of sociotechnical historiography that Zack uses to explain how "new societies emerge when new

technologies develop and coevolve with sociocultural norms" makes his notion of neurosociety legible—in some ways—within recent theorizing regarding the coproductions or mutual constitutions between evolving life science epistemologies and capitalist-economic exchange (Rajan and Leonelli 2013). For Zack, this "technoeconomic wave" that neurotechnology enables isn't merely an exercise in elucidating the vicissitudes of history: it's about a nascent utopia that the commercialization of neuroscience will unveil.

1.2 Translational Neuroscience as a Moral Imperative

It was during our conversation in early 2010 that I began to wonder whether TN might not be a useful sphere in which to map a broader set of economic shifts. Little did I know that the domain of translation is tethered to a variety of moral and political concerns. For Zack, an ardent technological evangelist, we should be concerned with what will emerge from the inevitable inequalities increased technological efficiency is likely to create. As with many futurists, Zack's fantasies exist alongside concerns about plebeian publics and global underclasses left behind as a result of technological, genetic, and robotic innovation. As with many libertarian moralities, the problems of inequality are thought to be in the domain of perception. When I ask Zack about the social and political futures that neuroscience will author, his statements become dramatic and prophetic. For him, our impending neurotechnological future will be grand, utopian, and moral. I lean in. He continues:

> I'm gravely concerned about humanity's future. I have been ever since I was a young child. My mother took me on a trip to India when I was like 13, and we meditated for six weeks and on my way back we stopped at Dubai airport … and I saw this radical difference in the disparity of wealth and [came to the conclusion that] when everyone else figures out what everyone else has there will be a cultural war. The most powerful way that we'll be able to influence humanity on a broad scale … are these new neurotechnologies—whether they are used for warfare or sophisticated neuromarketing and neuropersuasion or rapid education or training in empathy, to me, this is where humanity must go. (Interview 7, February 12, 2010)

Zack's contention, although dramatic, helps one think beyond a view of TN as merely a highly commercialized mode of neuroscience research

or as a simple story of science and commercialization. His sentiments compelled me to think about TN as a means of moral envisioning. A masterful storyteller, he had teased out the moral, emotional imaginaries through which significant investments in biomedical research are made: untold scientific progress, groundbreaking technologies, and a universe of medical cures. And yet, at the same time, this sentimentality masked the on-the-ground reality of TN. Behind its glittering promises lay a complex backstory. According to Zack, while innovations in the brain sciences certainly offer an opportunity to enact more equitable global futures, it's the alleviation of disease burdens where society will experience the more immediate impacts of TN.

In our discussion, his tone regarding TN retains a sense of moral imperative. "There are two billion people suffering from brain-related disorders!" He quickly recites all of the diseases and conditions considered brain-related disorders—everything ranging from Alzheimer's to depression and epilepsy. He explains how the sheer market size attached to CNS[2] causes investors to articulate the brain sciences as a space of both market need and incredible difficulty, especially compared with other kinds of diseases:

> So these are *huge* [his emphasis], massive healthcare market opportunities that are profit driven, and they [investors and companies] are looking for new market opportunities, and this is an especially complex area in which to do science and R&D. It's the last frontier primarily driven by the fact that there is a brain-blood barrier scientifically and it's a complex organ. (Interview 7, February 12, 2010)

He also tells me about the trends in diagnosis: "Psychiatry is a much larger market … depression continues to grow versus Alzheimer's (neurology), [which] is smaller," Zack says. However, he provides a glimpse into the kinds of clinical challenges and underlying scientific complexity that plague CNS, describing the ways brain disorders diverge from models used for other kinds of diseases. As an analyst of neurotechnology markets, Zack explains the risks at work for investments in CNS. It was the first time in our conversation that he used the word *failure*:

> You can't tease out causation [in CNS]. In [prospective therapies for the treatment of] cancer you can see if it's in remission in six weeks … and so you see super high failure rates [in CNS]. The data that I use in my meetings on Capitol Hill is that to get to the average clinical trial for CNS drugs costs $1.6 billion versus $800 million for an average pharmaceutical trial. To send it through clinical trials from

> figuring out a compound, … [what about] the lost profit of those programs that didn't make it?! [CNS] also takes longer. [A] pain med can be seen if it's effective within 30 minutes to know if it's working, whereas for Alzheimer's, it may take 3–5 years, and so tracking people for that long costs hundreds of millions of dollars … and so it costs more for many areas in CNS [as compared to other sectors]. Another issue is that because we're dealing with the brain we have side effects that influence our behaviors, such as suicidality, and safety agencies have woken up too … and it's another cost for Pharma development. (Interview 7, February 12, 2010)

Zack's figures and industry numbers come quickly. His congressional lobbying and facility with investors mean that he articulates market sizes, corporate histories, and profit-and-loss margins with both clarity and acuity. All of the challenges he articulated constitute what is commonly referred to in investor circles as the "valley of death" (see figure 1.2). Translational science and medicine (of which TN is part) are created to remedy the "valley of death." As Zack describes it, TN is an attempt to "get a compound out of an academic lab, acquire initial funding, put together a small business team

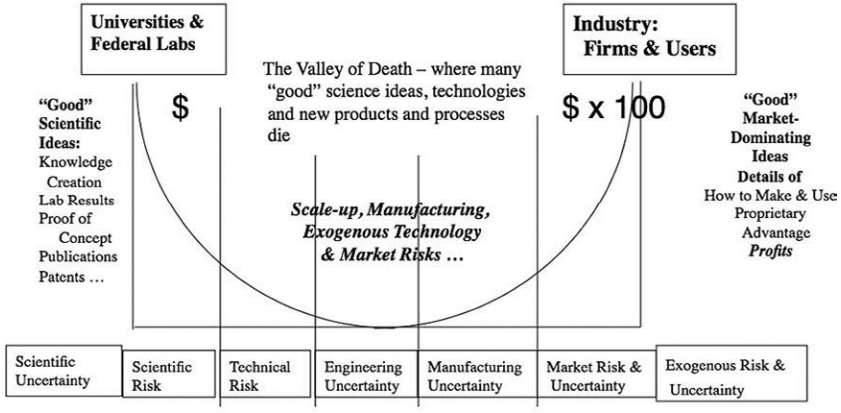

Figure 1.2
This graphic helps to explain the various elevations of risk and risk types, as well as the changes in funding availability that co-occur alongside research translation and commercialization. Translational research programs aim to bring more of the "good ideas" toward commercialization. *Source*: "Factors That Foster Industry-University Cooperation: Implications for I/UCRCs." Paper presented by M. Jelinek at the National Science Foundation Industry-University Cooperative Research Center Evaluators' Meeting, Arlington, VA, June 2006. © Mariann Jelinek, PhD, Professor of Strategy Emerita, College of William and Mary, Williamsburg, VA 23185.

because you are a professor focused on translating neuroscience, getting that object out of the marketplace of *ideas* (emphasis mine) into a company. That's the valley of death." As evidenced in his elucidation of the path between research and application, TN is thus envisioned here as a means of materialization, or perhaps a set of materializations.

During this interview, we find an interesting paradox: underneath the triumphalist discourses of TN, the problems at work in CNS co-occur alongside enormous potential profitability and massive risk. The separation between the underlying science of CNS and its (perhaps paradoxical) financial profitability compelled me to think in economic terms about CNS. Zack took the conversation in this direction. He explained how his interests in large-scale socioeconomic shifts spanned his academic and professional interests: "I was doing a PhD in economic geography, and I was trying to understand spatial dynamics. I had to do large-scale economic forecasting and then I was hired by a private firm to do large-scale economic geography." He then mentions that in leaving academia to work for the private sector, he found that his own optimistic neurofuturism was often incompatible with the very focused interests of investors. Zack continued, "I was telling them [the MBAs at the private firm], 'you have to think about *potential forces*' and I got pushback from MBAs who wanted to figure out critical *uncertainties"* (his emphasis). Vast and costly clinical-trial failures, Food and Drug Administration (FDA) regulatory hurdles, the difficulty understanding brain diseases, all comprise some of the existing uncertainties and commercial risks attached to mental illness and its treatment.

Concerns about uncertainties in CNS were justified: in 2010, the year I first interviewed Zack, as in prior years, CNS was still very profitable. According to him, "In 2008, there were 650 companies [in CNS]; they generated $144 billion in revenue, and so it's an extensive industry. About $120 billion was drugs; $20 billion included diagnostics, brain imaging systems, in vitro diagnostics, tests; and $4.5 billion was neurodevices" (Interview 7, February 12, 2010). By 2015, the revenues grew to $172 billion according to the Neurotechnology Industry Organization.

While Zack was outlining matters of concern for neurotechnology investors and market analysts (whom he called "MBAs"), he also underscored the importance of dealing with and managing critical uncertainty (in other words, risk) for companies that worked in CNS. Thus, alongside his

optimism, an enormous tension existed in commercial neuroscience: the marshaling of utopian discourses that obscure the riskiness of TN. What I later learned is that there is a complicated and relatively hidden history that helps to explain the sudden explosion and global expansion of translational science and medicine in the 2000s and that continues to shape these areas into the present—a history tied to pharmaceutical divestment, diminishing appetite for shareholder risk, and the emergence of increasingly entrepreneurial universities.

1.3 Spaces of Investigation

My research began in a local California TN community in late 2009, almost 10 years after the "decade of the brain." In the 1990s it was predicted that the growing portfolio of discoveries in the brain sciences would allow for unprecedented new knowledge and capacities in the realms of neuroscience, medicine, and society. The gradual unfolding of this promise was to occur in the form of new powers to read the brain or to use fMRI technology to instantly understand psychiatric function and dysfunction.

Yet 2009 was also a moment of economic uncertainty because of the global economic downturn. Thus, it was an exciting time in which to talk with those in the neurotechnology community. I had no idea just how important the issues of economic uncertainty would be for my understanding of the dynamics that undergirded TN. However, my conversations with investors and pharmaceutical executives and the events I attended that focused on investments in the life sciences increasingly addressed risk, financial fallouts, and the lack of any real innovations from CNS—a sector that received significant financial investment dollars.

I spent a total of 24 months in Northern California, where I was a visiting scholar at the Center for Science, Technology, Medicine & Society at UC Berkeley. Following anthropologists who study science outside of the laboratory (Hess 2001; Martin 1991), I explored specific sites of TN: university-based research centers/laboratories, as well as external industry conferences and neurotechnology/neuroscience industry spaces. I also conducted interviews with investors, scientists, clinicians, entrepreneurs, and university administrators, and I spent time in a neuroscience laboratory at a university in Northern California and studied the design of the laboratories, new science campuses, and translation-focused software.

While this project includes several sites of investigation, my research focuses on discourses that transcend particular sites, taking seriously the work of talk around TN in terms of what it accomplishes and what it obscures. Ethnographic perspectives help dislodge some of the more deterministic assumptions about the implications of TN—assumptions that may compel one to think of TN as being primarily about neuroscience and translation or that center ethical issues on access to new neurotechnologies or simple corporate intrusions into science.

I focus on Northern California because of its importance as a premier region in the United States for neurotechnology investment and activity. Eventually, via my relationship with Zack, I was able to inhabit a tight community of companies and biotechnology startups and investors. I also spent time in other spaces outside of Northern California, including time at the Cleveland Clinic in Ohio and at Neurotechnology-focused Conferences. Though the conversations recounted here are verbatim, many of the names associated with them are pseudonyms.

1.4 Insights

I spoke with people in various positions—patients, clinicians, investors, neuroscientists, engineers, translational center staff, entrepreneurs—and in learning from my time in a multitude of places and spaces of "translation" as well analyses of media, I came to a key conclusion: TN, and by extension, translational medicine, is not principally about health. This is not to say that TN does not create gains in health. Rather, I demonstrate that TN is better understood as a system of systems enabling the working out of particular problems produced in the corporatization of healthcare. Thus, I argue that in the fallout from the global financial crisis, the emergence of TN intersects with and becomes a solution for the financial costs and risks associated with early-stage neuroscience innovation, risks that actually emerge because of an overleveraging of problematic models in neuropsychiatry. Because of TN's particular financial functionality, I ask the question: Can translational science and medicine increasingly be considered a form of finance?

Given TN's financial operability, I show that university-based TN actually functions as a mechanism at the social level to de-risk high-risk investments for further development by pharmaceutical partners. Given the way

that TN enables a transfer of early-stage neuroscience research to universities and Pharma models that seek to externalize innovation sources, I argue that university TN laboratories are becoming research arms of biopharmaceutical companies. In all of these elements, I see the work of what I call the financialization of health taking form. Additionally, as I learned from my time at the Neurotechnology Investing and Partnering Conference, TN is characterized by a unique set of micropractices focused on creating solutions for the problems of biological material.

By facilitating the meeting of a patient's biological material with disease constructions (such as TN's focus on developing diagnostic tools which seek to locate brain disorders), TN seeks to intervene in a science where there are huge knowledge gaps, diseases that are not always well understood, and biotechnologies that don't always work. Thus, at the social level, TN could be thought of as operating on a material-semiotic level, helping produce order in the throes of biological, social, and biotechnological chaos. Building on these arguments, I suggest that TN relies on the creation of epistemological systems that entail the compelling of individual knowledge-actions such as those of the scientist, achieved through the design of novel environments such as the new, innovation-focused science laboratory and software programs designed to compel certain actions around knowledge and information. Lastly, I outline ethical questions and implications associated with translational science and medicine writ large, including questions about the role of the university as a risk shelter, and examine the consequences of "offshoring" the risks of drug development onto the public via the use of federally funded research and partnerships with nonprofit universities

Thus, I offer an alternative to (though not necessarily a refutation of) scholarly treatments of translational science that see it as the coproduction of capitalism and the life sciences or the product of an inevitable evolution of the life sciences. Though elegant, these theorizations obscure or neglect the story of biomedical models falling apart, the crisis in R&D during and after the global economic crisis, the very particular transformations in the biopharmaceutical sector, and especially the impacts of specific transformations in global finance—all of which are necessary (Farquhar and Kelly 2013) to thoroughly map and explain the translational shift. By tracing these specific contextual elements in the rise of TN, I will suggest that a very specific set of documentable histories help explain crucial elements in the rise of TN and translational medicine in general. This history is

important. By mapping the crises of commercial neuroscience R&D and drug development, one finds the now bulging outgrowth from biomedicine's many scientific reductions, a fact uncovered by medical anthropologists, sociologists, historians, and others who have mapped how biomedical models reduce important complexities associated with illnesses into "languages" that make them scientifically, technologically, and economically digestible. These "reductions" get embedded or engineered into neurotechnological objects themselves. Shareholder risk during the financial crisis meant a mass exodus from neuroscience R&D and a search for a solution to problems of R&D risk, cost, and shareholder value. That a field such as TN emerged precisely in the aftermath of these failures must be understood as a validation of the numerous critiques of biomedicine in science studies, the critical social sciences, as well as research and innovation scholarship.

Lastly, there may be a question about whether my conclusions about TN are generalizable across other translational fields. TN is one among many translational fields, such as translational oncology, which seeks to turn research into cancer therapies and diagnostics, and translational genomics, which seeks to inject explicit application-oriented aims into genomic research. Like these other fields, TN is part of the larger infrastructure that comprises translational science and medicine. Yet there are many aspects of TN that are specific, given the particularity and challenges of neuroscience research and neuropsychiatric models. Thus, the in-depth analyses in this book are as much a historiography of contemporary neuroscience as they are a picture of science in transformation under financial imperatives. At the same time, these latter imperatives—which are a significant focus of the book—animate the entirety of translational science and medicine as well as contemporary science models writ large. As this project traces both of these poles—the macro and the micro—the book also goes back and forth between this general analytical mode and closer, in-depth considerations.

1.5 Knowledge in Translation: Laboratories and the World

The ethical importance of this research for contemporary studies of biomedicine and health lies in its examination of the kinds of claims that can be made in the name of global health as well as the means through which institutional, political, and market processes come to animate notions of

innovation and progress in science and medicine. Thus, an exploration of the translational shift must also delve into the very notion of translation—the idea of pulling facts from laboratories into the external world.

Before science and technology studies turned to the laboratory as an object of intellectual interest, scholars tracked the variety of ways knowledge production is embedded in and dependent on "the social." Anthropological research focusing on local, indigenous rationalities (Evans-Pritchard and Gillies 1976) and on the nature and contexts of knowledge, especially in cognitive anthropology (Bateson 2000; D'Andrade 2001; Ruesch and Bateson 1951) and sociology (Zerubavel 1999), provides a rich history of theorizing about the many cultural particularities (Shweder 1991) and inextricable interplays (Bloch 2012) between culture, contexts, and thinking. Mary Douglas, critiquing Émile Durkheim and Marcel Mauss for their differentiation between primitive and modern scientific knowledge-production practices, made the following observation:

> Even in the laboratory, the researcher has options open to him. There are options for following this line of inquiry rather than that, of referring to these other works or omitting them. … The categories of valuable and useful areas of work are identified, ranked and bounded, elements assigned to classes and sub-classes, rules made to hold the framework of knowledge steady. The alleged gap between what we know about the construction of everyday knowledge and the construction of scientific knowledge is not so big as is supposed. (Douglas 1973, 12)

The sense that all knowledge is equally constituted via thoroughly social means made knowledge of every variety conducive to anthropological inquiry. The ethnographic turn in science and technology studies that focused on everyday laboratory practices and that led to an understanding of how scientific knowledge is collaboratively created follows from a discrete but rich tradition of first-generation laboratory ethnographies (Knorr-Cetina 1999; Latour and Woolgar 1986; Martin 1991; Merz and Knorr-Cetina 1997; Traweek 1988). According to Sal Restivo (2005, 250), "An ethnographic approach to laboratory culture … allows one to disentangle the intricate social machinery of fact making."

While the laboratory especially early on represented a critical site of epistemic and cultural work, analyses of scientific fact making could not neglect the sociopolitical structures that enabled this work (Kuhn 1996), financed it (Rajan 2017; Robinson 2018; Shapin 2008), accorded it authority (Dumit 2004; Fleck 1981; Foucault 1972; Gilligan 1993; Habermas 1971;

Haraway 1997; Holman, et al 2018), exported it globally (Beaulieu 2001; Ecks 2005; Kamat and Nichter 1998; Knorr-Cetina 1992), transformed it into capital (Rajan 2017; Petryna 2009; Rabinow 1997), and used it to create medicalized identities (Biehl 2005, 2007; Canguilhem 1978; Foucault 1970; Fullwiley 2011; Jain 2006; Kessler 1998; Petryna 2006; Pollock 2008; Rapp 2011). Thus, what anthropologist David Hess (2001, 237) calls the "second generation" of science and technology studies engaged "a wider field site than the laboratory … including the political, institutional, and economic forces that govern the selection of research fields and programs."

Early ethnographic (Haraway 1989; Knorr-Cetina 1999; Traweek 1988) and ethnographically inflected scholarship (Latour and Woolgar 1986) that focused on the inside of scientific laboratories mapped the two-way translation between laboratory facts and the broader social, contextual milieu. Yet one could only map how facts move from the laboratory into the world through theoretical positing or analyses of a historical example such as that of Bruno Latour (1983) in his analysis of the pasteurization of France, or via larger inferential analyses, such as that of Michel Callon in "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay" (1986).

Indeed, science and technology studies (STS), exemplified in the work of Latour and Callon, have had a sustained interest in the stuff of translation: the notions of boundary object (Fujimura 1992; Star and Griesemer 1999), boundary organization, trading zones (Galison 1997), and the actor network theory/approach (ANT) (Latour 2005) all attempted to get at the structures and structuring (Bowker and Star 1999) required to manage the technical and institutional factors, alliances, and allegiances necessary to transform science into facts and facts into truth. Contemporary STS work amended these early findings to consider the interrelationship between science and knowledge in relation to gender, race, sexual orientation, and disability (Benjamin 2014; S. Epstein 2005; Haraway 1990; Keller 1995; Nelson 2016; Sharp 2013; Wailoo et al. 2010; Wailoo 2017). In this research and the critical perspectives emerging with it, the theoretical intervention was not only to expose the social and political negotiations that went into the social construction of facts, but also to deconstruct the sense of those facts as having emerged naturally. In other words, these approaches critiqued the narrative that facts moved seamlessly into the world because they reflected unmediated truth.

Thus, the emergence of translational science offers a novel opportunity to explore a form of knowledge production *that begins with* the gaps between the laboratory and the world, a scientific mode explicit about aligning the "train rails" (Latour 1988, 155) necessary for the transmissibility of laboratory discoveries and their realization inside devices, agendas, and worldviews. This becomes abundantly clear in the rapid design and creation of infrastructures intended to connect research and researchers, align potential collaborators, connect capital with projects, and help integrate data across various scientific fields. TN, I argue, actually emerges from fantasies of transmissibility—fantasies made bare against the backdrop of great scientific failure. These failures included poor understanding of the neurobiology of mental illness, mushrooming evidence about the general inefficacy of newer generations of antidepressants, as well as expensive and frequent clinical-trial failures for psychopharmaceuticals. As my fieldwork shows, the response to these failures has also included the creation of novel infrastructures and architectures—buildings designed to foster collaboration, software technologies designed to durably impact research activities and collaborations, as well as semipermanent legal and commercial structures that enable translation.

1.6 On Neuroscience and Neuroethics

My project is a social study of neuroscience. Contemporary neuroscience is dominated by triumphalist narratives about new horizons of knowledge about the brain (Abi-Rached 2008a) and subsequently, new possibilities for cognitive, neurological, and neuropsychiatric intervention. Scholars are concerned (and rightly so) about how neuroscience might reshape social relations and society writ large via novel neurocentric notions (Dumit 2000; Martin 2007; Rose 2004). Given that these promises of neurotechnological futures rely on investments in future-oriented "returns," TN relies on speculation in ways that are similar to the speculative performances that undergird grand promises in genomics (Fortun 2008; Rajan 2006) and biotechnology (Brown 2003; Tutton 2011), and that animate sustained hope in the laboratory sciences above and beyond their actual productivity (Ioannidis 2004). There is also an interest on the part of anthropologists (Beaulieu 2001, 2003; Dumit 2004; Kirmayer and Raikhel 2009; Lakoff 2005; Lock 2002; Martin 2007; Schlosser and Ninnemann 2012; Young

1997), sociologists (Fitzgerald 2017; Joyce 2008; Rees and Rose 2004; Rose 2004; Zerubavel 1999), philosophers and historians (Abi-Rached 2008a; Changeux and Ricoeur 2002; Harrington 1989), and ethicists (Racine 2010) in the many ways neuroscience knowledge impacts society as well as conceptualizations of the self.

Yet the explosion of neuro-optimism has given rise to new scholarly concerns. A new area of inquiry called critical neuroscience (Choudhury and Slaby 2018; Kirmayer 2012) focuses on tracing and analyzing the explosive growth of the use of brain concepts in all aspects of social life, especially after the advent of fMRI. The application of, and appeals to, ambiguous neuroscience concepts and notions across all kinds of domains and scholarly disciplines such as law, behavioral economics, and addiction studies, create questions about the growth of neuroscience as a particularly prolific space of mythogenesis. Critical neuroscience approaches enable a critique of the ever-present deployment of neuro concepts bereft of critical reflection, empirical data, and/or appropriate contextualization.

Nikolas Rose has alluded to the need for empirical data about neuroscience in translation. Contrasted against the often-theoretical foci of neuroethics, he suggests that "there [have] been many debates over the implications of what could be referred to, at least over the past decade, as 'the new brain sciences' [but none] of them ha[s] been grounded 'in a sound empirical knowledge' of what is actually happening in those fields and what are the actual implications when they [the brain sciences and their applications] move 'from the laboratory to the field'" (cf. Abi-Rached 2007, 4). The absence of these data leads to Rose's caution regarding certain kinds of antineuroscience critiques—especially those against neuroscience itself or against alarmist claims about neuroscience's inevitable "harms." In their book *Neuro: The New Brain Sciences and the Management of the Mind*, Rose and coauthor Joelle M. Abi-Rached (2013) invoke a Haraway-ian indeterminism (or optimism) regarding a science that is presently unfolding. Rose and Abi-Rached call for empirical data about neuroscience and society as an obvious antidote to dataless critiques.

My project is a move in this direction—utilizing ethnographically informed analyses to look beyond or underneath the discourses created around TN toward its many materializations and constrictions. Following emerging social science research on the impacts of translational policies

(Mittra 2015), this project traces translation across several domains—from microinteractions between scientists in TN laboratories to public policy discussions at Neurotechnology Investing and Partnering Conferences—to look at how brain science is continually broken down, disseminated, reconstructed, and exported. Thus, I offer a rare possibility to map brain facts in the in-between, rather than a study of knowledge after it has left the laboratory.

1.7 Policies for Science and Health Innovation: Commercialization and the University

The move to use policy initiatives to inspire innovation in science and medicine and to compel economic development is at the heart of the global translational shift (Robinson 2017). Because translational science emphasizes commercialization of university research, translational science and medicine necessarily create explicit and complicated entanglements between the university and corporate stakeholders. As TN privileges commercialization-oriented neuroscience work over basic science research, this translational imperative appeals to concerns about the changing nature of the university—including its increasing bureaucratization and privatization (Apple 2005; Brown 2000; Etzkowitz et al. 2000; Geiger 2002; Readings 1997). TN exemplifies the growing entanglement between academic research and the market (Buchbinder 1993; Kahn 2012; Krimsky 2004; Shore and Wright 1999), and my research highlights the institutional influence of market-oriented approaches on knowledge production, a trend that many have mapped (Etzkowitz 2003; Haraway 1997; Krimsky 2004; Power 1999; Readings 1997; Strathern 2000).

Indeed, these concerns are not new. Thorstein Veblen voiced concerns regarding the encroachment of corporate interests on academic work at Harvard in 1918 (Veblen 1918), prefiguring the commercial transformation of universities such as MIT and Stanford after the Cold War (Etzkowitz 2007; Lowen 1997). Yet a new strain of research emerged that analyzed neoliberalism impacts on university research and the life sciences (Berman 2012; Lave, Mirowski, and Randalls 2010). My project engages with this latter literature, especially, to make sense of TN's connection to the neoliberal expansions (Strathern 2000), shaping (Hackett 2014), and contractions (Apple 2005) at the modern university.

While the university has long been at the center of political and financial shifts in the United States, these shifts also have a clear policy history. US policies such as the 2011 America Invents Act and the 2016 21st Century Cures Act (as well as European programs such as Horizon 2020) have sought to reshape biomedical research and regulatory approval processes. One of the most influential factors in the commercialization of the modern university has been the passage of the Bayh-Dole Act of 1980. Sponsored by Senators Birch Bayh and Bob Dole, this legislation allowed US universities to create intellectual property (IP) from research financed by public funds, essentially crafting a route for the privatization and commercialization of public resources. While some scholars attribute the growth of university licensing and patenting to this legislation, others (Mowery et al. 2004) complicate this narrative. Nevertheless, the Bayh-Dole Act, alongside other legislation, coalesced with a series of shifts (Krimsky 2004; Lowen 1997; Rajan and Leonelli 2013) that caused science at the university to be increasingly conceivable as a space of market discovery and penetration and a sphere where, as many scholars have noted across various contexts (Langley 2018), private investors can support research conducive to transformation into market value.

However, pointing only to the emergence of the entrepreneurial university and the privatization of higher education in the West does not sufficiently contextualize the emergence of TN. My research provides the contexts and contingencies—such as the crisis in the pharmaceutical sector and the related reality of the global economic crisis—that lend the specificity necessary to understand the turn toward translation at modern research universities.

1.8 Neoliberalism and the Financialization of Science and Medicine

My argument also engages with research on the growing import of capitalism and finance in the life sciences. Yet, in contrast to other authors, I argue for the importance of focusing on the role of finance in order to understand the nature and structures of translational science and medicine. As with the biotechnology industry, the distinctive "science-business" quality of TN creates particular challenges (Pisano 2006). For example, in the case of TN, despite the internally acknowledged problems of drug efficacy, safety, and

reliability that plague the CNS sector, neurotechnology revenues in 2009 still reached $143.1 billion, according to one estimate.

In addition, beyond the existing profitability of CNS research lies its market potential: according to the NeuroInsights *Neurotechnology Industry Report*, brain-related illness and mental health issues impact "two billion people" globally and more than 100 million people in North America. Thus, the market size for CNS (market size being a key indicator used to make arguments for the profitability of an investment) is estimated to be $1.3 trillion (NeuroInsights 2009). With aging populations, an ever-growing categorical and diagnostic umbrella, the market size for products and services for brain-related illness is swelling. It is in the context of the massive profitability of TN that questions about the relationship between TN and health arise. In this way even the mere promise of health ushered in via TN can create access to capital.

Through its focus on biotechnology, the present project engages with the body of work that theorizes emerging scientific practice as intertwined with—and at times indistinct from—market practices. Yet much of this literature has yet to deal with neuroscience as it has with genomics and bioengineering. The "science-business" model (Pfotenhauer and Jasanoff 2017; Etzkowitz 2003; Hong and Walsh 2009; Pisano 2006) and/or scientific entrepreneurialism (Ong 2010, 5) and their connections to federal funding make the intertwining of science and business a prime example for theorizations of power, knowledge, and governmentality.

While many have theorized the interrelationship between capitalism and the life sciences, the most significant implications of changing models occur in the regime of health. And yet, as Kean Birch and David Tyfield (2013, 301) note about ongoing research on capitalism and the life sciences, much of this scholarship is inattentive to "the transformation of economic processes in modern capitalism," which provides specificity to theorizations of bioscience and the life sciences. Advancing the conversation about the interplay of capitalism and the life sciences, my project inserts critical specificity regarding financial and economic shifts that get lost in analyses of the contemporary life sciences. This project therefore contributes to scholarship focused on the emerging stakes, risks, and potentials of biotechnology as intertwined with neoliberalism (Barben 1998; Birch 2006; Cooper 2008; Dumit 2012b; Fortun 2008; Mirowski 2012; Ong 2010; Rabinow

1997, 2002; Rajan 2006; Sharp 2013; Stone 2010; Styhre 2015), especially as these interconnections implicate university knowledge practices.

Indeed, this book offers a case study about neoliberal policies as manifested in one particular set of transformations in research and innovation. In the case of TN, neoliberalism is perhaps most implicated in TN's particular stance on the role of marketability in determining what ought to be considered valuable scientific and biomedical endeavors. While I go into greater detail about this in later sections, one finds consistent suggestions by its proponents that a true realization of the translational shift requires a new way of understanding and assessing scientific work (Addison 2017; Robinson 2018). This substitution—whereby patents are better measures of scientific success and "truth" than a high-ranking journal publication—shows the way that under translational research, the market becomes understood as the ultimate arbiter of value in science and knowledge production, a defining aspect of neoliberalism's (long-standing) ideological apprehension (Lave et al. 2010; Mirowski 2012; Wailoo et al. 2010) of knowledge practices.

This study reveals that even where no transformation in patient health or new pipeline of innovations has occurred, the global biopharmaceutical R&D sector has still achieved a significant strategic goal, which is the divestment of risk, a lowering of costs, and at least ostensibly, the broadening and development of a global pipeline of potential innovation sources. Thus, I emphasize that TN's transfer of risk and its absorption of R&D cost from the private sector constitute its own *fully complete* financial outcome, even before questions of new medicines for patients or a wellspring of novel innovations arise. Even as few new medicines or innovations materialize from the economic assumptions regarding innovation that power TN's promises, it is essential to see the financial functionality of what Kean Birch (2017b) calls technoeconomic assumptions.

However, while neoliberal policy is at the heart of the case that this book outlines, my aim is not to add to the many theorizations of neoliberalism. Instead, I analyze specific, often-overlooked processes of commercialization and corporatization that are necessary to understand the complex empirical realities of TN and by extension, translational science and medicine. Here I borrow from the insights of contemporary economic anthropologists (Langley 2018; Ofstehage 2018; Pitluck et al. 2018) who seek to

move beyond purely functionalist accounts to explain the expansion of financialization.

Analyzed as a political economic configuration and not merely a product of patient activism or epistemic opportunity, one sees more clearly the role of financialization (Tyfield 2011) in the emergence of TN. I combine this attention to political economy with an ethnographic sensibility necessary for understanding the many on-the-ground realities that get missed in accounts too inattentive to the unintended local and on-the-ground implications of global, national, and institutional goals, regimes, and programs aimed at fostering global innovation.

1.9 The Public and the Private

TN, and, I argue, translational science and medicine in general, are also born out of visions of the emancipatory power of private markets. Yet perhaps paradoxically this entails innovations in public-private partnerships that allow translational science and medicine, including TN, to offer specialized pathways to privatization while externalizing risks in the public domain. Academic translational science operates in ways that are facilitated by the provisions of the 1980 Bayh-Dole Act (as well as other policies, including the Federal Technology Transfer Act) enabling the commercialization of research carried out with public funds. For its proponents, the Bayh-Dole Act includes specific provisions that incentivize and mandate the public use or dissemination of federally funded research, to ensure a public benefit from federal science funding. Yet this shift—toward greater accommodation of private interests on the part of the state—also reflects increasing privatization, which, as many scholars have pointed out (Jameson and Miyoshi 1998), co-occurs with, and is further spurred by, downturns in markets, which was the global situation in 2006.

However, the public domain also constitutes a "hiding space" for the risks that emerge from privatization. In fact, I propose that TN rearranges risks that had been borne mainly by pharmaceutical companies so that they are now transferred to the nonprofit university. That TN invokes federal agencies, federal research dollars, and risk-laden public-private partnerships means that TN is also a case study in the public ingestion of corporate risk-taking. While risk resocialization is a known issue (Atkinson-Grosjean

2006; Avorn and Kesselheim 2011), the novel caution here may be the need to regulate optimism in light of neurotechnology's complicated realities and the financial aims of such partnerships. It is also critical to understand how the emergence of TN reflects a much larger set of private-sector transformations and financial strategies, which when uncovered, illuminate the broader logic behind the translational turn.

1.10 Science, Biomedicine, and Health

Lastly, this project is about the future (and futures) of medicine. The promise of translational research and medicine, according to its own rhetoric, leverages the weight of scientific research into grand, biomedical solutions to the world's pressing health challenges. Yet, to the extent that this promise entails a mode of research explicitly focused on creating biotechnologies and new potential therapeutic markets (Biehl and Petryna 2011), and promotes continuing investment opportunities despite a lack of new health outcomes (Dumit 2012a), TN lies at the intersection of R&D risk and sizable market potential. Given the massive market potential for CNS interventions, the ability to generate enormous wealth bereft of clear impacts on health, and the utility of TN to engineer solutions regarding corporate financial risks, I argue that TN should be considered primarily a form of finance.

Beyond neuroethics concerns about the potentials of TN in areas such as cognitive enhancement, there has been scholarly interest in the practical impacts of the brain sciences on local health etiologies and practices and the convergence of neuropsychiatric models with local ontologies. The tracing of these processes invokes the power of ethnographic sensibilities in tracing scientific and biomedical transformation in various registers: institutional, national (Biehl 2007; Lakoff 2005; Lock 2002; Lock and Nichter 2002), personal (Biehl 2005; Löwy 2000), and local (Biehl 2005; Das and Das 2006; Petryna 2006; Petryna, Lakoff, and Kleinman 2006). More than merely promises for the alleviation of suffering in mental health, neuroscience was supposed to usher in an era of scientific modernity positioned to impact all kinds of sciences that rely on knowledge about the brain.

Given the impact of biomedicalization on discourses around health, emerging models of health innovation have become an essential site of analysis for medical anthropologists (Biehl 2007; Ong and Collier 2005;

Petryna 2005). While I am attentive to recent work on biomedicine and biomedicalization, this project is particularly indebted to the notion of pharmaceuticalization, which as João Biehl (2013, 425) notes, compels an analytical mode that moves "beyond the unidirectional construction of patient subjectivity by medical diagnostics and treatments to account for the entanglement of multiple social forces and markets, the chemical concreteness and circulation of pharmaceuticals and illnesses, and the role of patients' agency and desires." I hope to map this "entanglement" both analytically and ethnographically in my tracing of institutions, organizations, systems, diagnoses, patients, and subjectivities as they are implicated in translation's logics and rearrangements.

Yet patients remain central in this entanglement. In what I observed during large investment conferences, which I detail in this book, I learned that patients are imagined in those spaces in very partial ways, constituting what I call an *epistemology of parts*. I ask if such ways of conceiving patients are related to the privileging of biological therapeutic solutions over other ways of imagining solutions. Might such a focus on parts also enable the tendency within translational fields to focus on distinct disease categories over more holistic or systemwide conceptualizations of patients and their afflictions? How are patients—figured as the beneficiaries of the translational shift—implicated in the shift that is translational science and medicine? In a field that sees people primarily in relation to their biological parts, what consequences emerge from a science that produces "partial subjects"?

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