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Neuro-Innovation: Translational Science, Ethics & the Financialization of Health

Robinson, Mark

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NEURO-INNOVATION:

TRANSLATIONAL SCIENCE, ETHICS, AND THE FINANCIALIZATION OF HEALTH

Mark D. Robinson

A DISSERTATION PRESENTED TO THE FACULTY OF

PRINCETON UNIVERSITY IN CANDIDACY FOR THE

DEGREE OF DOCTOR OF PHILOSOPY

RECOMMENDED FOR ACCEPTANCE

BY THE DEPARTMENT OF ANTHROPOLOGY

ADVISOR: João Biehl

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Abstract

This dissertation is an ethnographic exploration of the ethical, scientific, and economic values and practices underlying clinical translational research in the United States, with a particular focus on the development of brain-based technologies. The 2000s represent a key moment in this field with a large monetary investment on national levels and the creation of dozens of new translational research programs across the country dedicated to turning the nation's scientific discoveries into new treatments for patients. Investigating the various actors, institutions, funds, and discourses involved in the constitution of the burgeoning field of Translational Neuroscience (TN), I carried out twenty-four months of fieldwork in California. I conducted participant observation in a neuroscience laboratory, attended industry-sponsored events, and engaged medical researchers and patients and their families in experimental clinical settings in Ohio. I also analyzed market reports and critically reviewed the TN literature as well as social studies of this emerging field.

Throughout the dissertation, I show that the emergence and consolidation of TN in the early 2000s coincided with the corporatization of healthcare and a crisis of innovation in the pharmaceutical industry. TN also involved a systematic transfer or outsourcing of investment risk onto non-profit universities. Both adopting and challenging the analytic of "risk," I argue that TN has become a key site for industry actors "to de-risk" high-risk neurotechnology investments. Thus, rather than being principally about health, TN may be better thought of as a contemporary form of finance. Moreover, as neurotechnological products are designed and folded into care, this study uncovers the ways in which foreclosed knowledge pathways and risk infiltrate clinical practice and patient decision-making. The dissertation thus illuminates changing ideas of health and of medical ethics associated with translational science and theorizes the unintended effects and risks triggered by TN's fast-paced production pipeline. This ethnographic study contributes to the public understanding of the institutionalization of translational science and problematizes the role of finance in the design of large-scale health interventions.

Acknowledgements

I initially embarked on a project about the novel intersections of science, technology, and medicine at work in translational medicine, and translational neuroscience in particular. This focus was to represent a unique opportunity to bring together analytics from anthropology's trenchant considerations of medicine, health, and society with the abundant scholarship in science and technology studies (STS), to examine the structures and implications of the "translational turn" in academic science and medicine. Given its explicitly ethical dimensions, this project would become important to making sense of the way translational science and medicine affect health.

However, my project quickly implicated larger moral and pragmatic questions about emerging and ever-consuming visions of the future of global health. Thus, the importance of this project ties to our collective and social obligations towards patients, communities, and advocates whose lives are inextricably entangled in the scientific and medical formations about which this dissertation is concerned. I humbly dedicate this dissertation to the patients and patient communities from whom I learned, and whose life experiences have informed my theoretical and analytical work.

In some ways, this project emerged from a long-standing trajectory of interests in medical anthropology, bioethics, and neuroethics, as well as science and technology studies and science policy. Early in my undergraduate education, an instructor gave me with a copy of Emily Martin's pivotal article, "The Egg and Sperm: How Science Has Constructed a Romance Based on Stereotypical Male-Female Roles." Not only did I change my major the next day, but I also developed an enduring scholarly interest in the ways we remake our world by making claims to powerful discourses about nature, society, and the self.

I was therefore grateful to encounter a spirit of grounded intellectual inquiry at Princeton University, where I learned the value and necessity of the ethnographic lens. For this lesson I am most indebted to João Biehl. João's tireless support of my progress and his advocacy on my behalf were integral to my tenure at Princeton. I am grateful to have been exposed to João's deep and natural ethnographic impulses—an orientation that speaks to both his concern with the impact of scholarship upon communities and his moral concerns about the way that knowledge production affects people's life-worlds. This approach was very different from the STS-inflected mode with which I entered the program; my work has benefitted from his insights. From his analytical cautions about larger issues at stake in thinking about pharmaceuticalization, to his methodological cautions about ethnography, he has been a source of scholarly and personal inspiration. I am also quite grateful to have had the support of Carolyn Rouse, whose razor-sharp analysis and broad cross-disciplinary connections helped instill rigor and precision. I am quite thankful for her prescient and brilliant insight into the fictions of integration upon which translational programs depend, especially in the realm of personalized medicine. I am also grateful to the intellectual energies of Elizabeth Davis and Lochlann Jain at Stanford, whose work and coversations helped me to think about the accidental

intersections of culture, social structures, and material worlds. I also want to express appreciation to my graduate program cohort at Princeton, including Gwen Gordon, George Laufenberg, Bridget Purcell, and especially Peter Kurie. I am exceptionally grateful to Carol Zanca for her psychic energy, warmth, sensitivity, and encouragement. Carol is not only a departmental force and advocate for students, but also a source of stability, calm, and comfort in a long and potentially unwieldy journey. Lastly, I am deeply indebted to Dean Karen Weaver of the Graduate School whose advocacy, marshaling, and indefatigable support has had a measurable effect. On the verge of matriculating at Yale, I am grateful for the serendipity that led me to Princeton.

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I am most grateful to the insights of my intellectual kindred spirit, Noelle Molé, and to Annie and George, the two most important people in my life.

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Introduction / The Futures of Neuroscience

"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." Zack says this, quickly flashing 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 rush to turn neuroscience into new innovations and biotechnologies. His answer cut me off before I had fully finished the question.

Zack continued, "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, soon after he praised as brilliant the prominent Stanford neuroethicist, Hank Greely, who works on the ethics of neural enhancement. Rather, I interpreted his statement as being about the limits and intellectual investments of bioethics and neuroethics; investments that obviate analyses of the real and unfolding consequences of emerging neurotechnological modernity. He was also -- and perhaps

moreso -- 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 40s, Zack leads the Neurotechnology Industry Organizations (NIO) and NeuroInsights, a market analysis firm cofounded with his wife, Casey. 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 Partnership Summits. 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; perfect posture allows him to exploit his entire 6-foot frame. 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 originally planned to meet in February 2010 at his home office, but his wife, 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 cafe on 24th Street in San Francisco's Noe Valley neighborhood. We sat in front of the cafe 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 special mode of neuroscience research focused on accelerating the development of novel brain technologies such as psychopharmaceuticals, diagnostics, and devices. Born from a gargantuan health policy effort spearheaded by the U.S. 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 *true 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 the impact of the idea of translational neuroscience on the commercialization of scientific research in university settings. However, in order to explore this question, I needed to inhabit the worlds of the corporate life sciences and that 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 Lynch 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 book, *The Neuro Revolution: How Brain Science is Changing Our World*, a book that explores how emerging technologies in neuroscience may radically transform the world.

Zack's book is a useful introduction into the world of neurofuturism, a field of inquiry and imagination focused on expansive opportunities and transformations that may occur via increased understanding of the brain. To be clear, Zack's coauthored book is a work of technological futurism: focused on all of the social areas in which future neurotechnologies should revolutionize human life. For example, the book 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; invoked in the latter case in order to examine issues of a subject's risk for criminality and as a means of lie-detection. Organized around a notion that the "Neuro Revolution" will comprise a major economic and historic revolution, Zack places it historically alongside the industrial, information, and agricultural 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 the book as a meditation, a serious consecration of a moral future slowly unfolding: one in which human decisions are improved, where brain diseases are eradicated, and where people, now thoroughly understood and demythologized via brain science, will be able to 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 years of searches for cures and medicines, a neurosurgeon ordered Zack 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 Zack's 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 (Figure 1) received what he called, "an invaluable inkling of the future" (Zack and Laursen 2010, 2)



Figure 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.

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 why they do. Zack explained exactly what demarcates him from others: speculators, neuroscientists, investors, and investment advisors working in the neurotechnology space. He considers himself a *tracker.* Importantly, 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 a larger sociotechnical and historical configuration:

> *Specialists are very powerful at being able to tell you what's going [in their own domain] but they can't tell you about converging technologies and so being a*

> *tracker, its 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] it's 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 07 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 Industry Partnering and Investing Conferences, Zack adroitly introduced 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 interest in a new crop of neurotechnology startups focusing on devices.

Thus, tracking refers both to the wide diversity of his experiences and data-sources as well as his use of these experiences in his work. Zack told me, "I don't consider myself to have an [high] IQ, but I have this ability to deflect and immerse…" Zack 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, but his wide interests do not signal dilettantism. His positionality is firmly rooted in allegiances to both economic markets and genuine faith

in neuroscience itself. Thus, Zack's commitments and location within the world of neurotechnology means 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 important interlocutor for me as I sought to develop emic understandings 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 often offered me useful direction in terms of getting at emic meanings.

In 2003, Zack and his wife, Casey, founded the aptly-named firm, NeuroInsights, an organization uniquely positioned in the world of neuroscience, neurotechnology, and life science investment communities. While NeuroInsights provides several services, they are largely a market information, tracking, and analysis firm. Each year NeuroInsights produces the highly influential "Neurotechnology Industry Report." The 2013 The Neurotechnology Industry Report, for example, costs $5,700.00 to purchase and is 600 pages long. According to the product description, "its 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

[1] http://www.neuroinsights.com/marketreports/marketreport2013.html

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 U.S. Food and Drug administration (FDA), which must approve neurotechnologies before they can be brought to market. NIO and NeuroInsights produce annual events nationally and internationally designed to create opportunities for partnerships and networking between scientists and investors, between pharmaceutical executives and biotechnology start-ups, among others. These "Neurotechnology Investment & Partnering Summits," constitute key spaces where TN "happens." I focus on my experiences at these events in Chapter Three.

Thus, Zack is uniquely positioned -- touching spaces ranging from laboratory discovery all the way through commercialization. To an outsider, he may be a "big man" of neurotechnology. Yet, this fails to grasp the personal importance of the brain for Zack. When talking about emerging technologies, Zack 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 to light therapies that are non-invasive. There are also all the surgical procedures and so it's where it's all going…* (Interview 07 February 12, 2010)

Like the investors with whom I spoke during my fieldwork in the late 2000s, Zack invokes the future in order to contextualize (and often de-problematize) 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, Zack 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 co-evolve with sociocultural norms; you get these techno-economic 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 techno-economic waves. [Economist] Joseph Schumpeter was a big fan … he [Schumpter] came up with the term creative destruction.…and so this idea of these techno-economic 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 07 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." Zack's invocation of "techno-economic 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 theorizations about massive social transformations emerging out of technologically-enabled industrial capitalism (Polanyi 2001). However, this convergence is also exemplified in concepts such as that of the sociotechnical ensemble, which places analytical weight on the *inextricability* of both the social and the technical in explaining techno-social change (Bijker 1997). The kind of sociotechnical historiography that Zack uses to explain how "…new societies emerge when new technologies develop, and co-evolve with sociocultural norms," makes his notion of neurosociety legible within recent theorizing regarding the co-productions or mutual constitutions between evolving life-science epistemologies and capitalist-economic exchange (Rajan and Leonelli 2013). For Zack, this "techno-economic wave" that neurotechnology enables isn't simply an exercise in elucidating the vicissitudes of history: it's about a nascent utopia that will be unveiled in the commercialization of neurotechnology.

It was during our conversation of February 12, 2010 that I began to wonder whether TN might not be a useful sphere in which to map a set of economic shifts coordinated with social transformation. I take Zack's prognostications to be less technological determinism and more a kind of economic constructivism that effectively reveals the way economic transformations enabled through technology (and especially biotechnology) become a vital space of social and relational transformations. Zack is an ardent evangelist whose futurism is animated by social concerns that emerge from the inevitable inequalities increased technological efficiency is likely to create. As with many libertarian moralities, the problems of inequality are perceptual. When I ask Zack about the social and political futures that neuroscience will author, his statements become

dramatic and prophetic. For Zack, our impending neurotechnological future will be grand, utopic 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 07 February 12, 2010)

Zack's contention, although dramatic, helps one think beyond a view of TN as simply a highly commercialized mode of neuroscience research or as a simple story of science, commercialization, and neoliberalism. It is also more than the enactment of epistemic transformations animated by global economic processes. Zack's sentiments compelled me to begin to think about TN as a means of moral envisioning: a reflection of a set of designs for intervening in global health and the market. TN reflects a neoliberal materialization (literal) of a notion of the good.

This materialization is also ineluctably commercial according to Zack: innovations in the brain sciences not only offer an opportunity to enact more equitable global futures, but also help to alleviate disease burdens, and this is where the more immediate impacts of TN shall be felt. Yet, Zack's tone regarding the morality of TN retains a sense of moral imperative. "There are 2 billion people suffering from brain-related disorders!" Zack 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] (Central Nervous System) 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 HUUGE (emphasis his), 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 07 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 clinical challenges and underlying scientific complexity that plague CNS describing the ways in which 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 Zack 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 6 weeks…and so you see super high failure rates [in CNS]. The data that I use in my meetings on Capital Hill is that to get to the average clinical trial for CNS drugs costs $1.6 billion versus $800 million dollars 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 its working, whereas for Alzheimer's, it may take 3-5 years and so tracking people for that long hosts 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 07 February 12, 2010)

[2] CNS (Central Nervous System) is a metonym that refers to the entire sector of brain-disorder related research, firms, products, investments, and speculators. Similar to the categorization of cardiac defibrillators under medical devices, "CNS" is used by insiders - investors, pharmaceutical and life science companies, and biotechnology companies to refer to the entire class of research areas and products that surround the brain.

Zack's figures and industry numbers come quickly. His congressional lobbying and facility with investors means that he articulates market sizes, corporate histories, profit and loss margins with smooth acuity. All of the challenges that Zack articulated constitute what is commonly referred to in investor circles as the "Valley of Death" (see Figure 2).

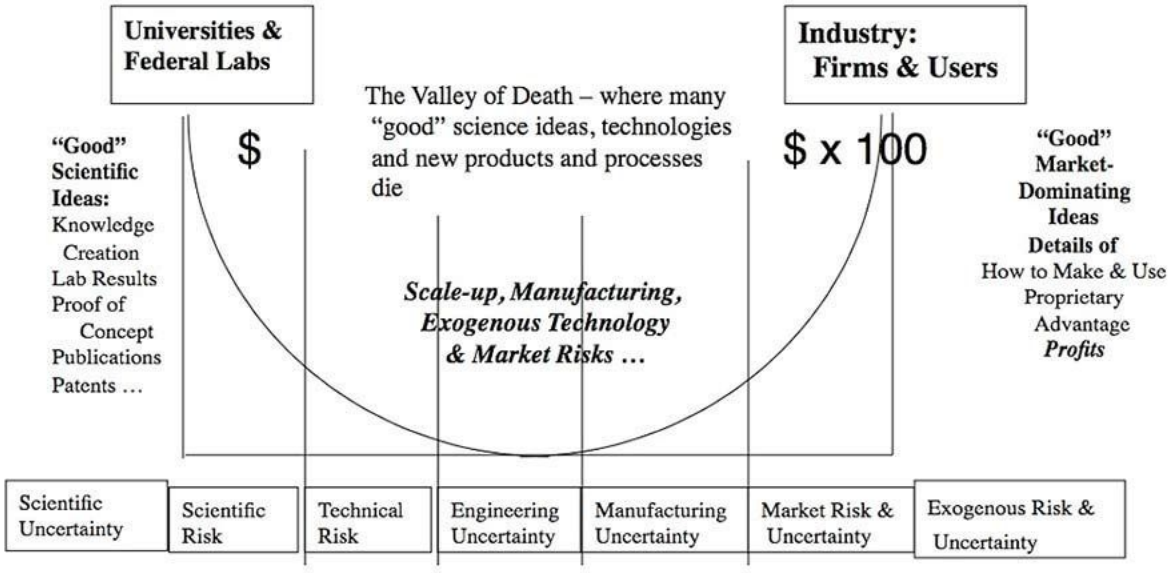

Figure 2. This graphic helps to explain the various elevations of risk and risk types, as well as the changes in funding availability that co-occur alongside research translation and commercialization. Translational research programs aim to bring more of the "good ideas" toward commercialization. Source: "Factors that Foster Industry-University Cooperation: Implications for I/UCRCs." Paper presented by M. Jelinek at the National Science Foundation - Industry/University Cooperative Research Centers Program Evaluator Meeting, Arlington, VA, June 2006. © Mariann Jelinek, Ph.D., Professor of Strategy Emerita, College of William and Mary, Williamsburg VA, 23185.

TN is 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 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." TN is thusly envisioned as a means of materialization or perhaps, a set of materializations.

Zack then explains why the specific challenges of CNS are risks that investors are willing to take. Despite its incredible barriers, clinical failures and underlying scientific complexity, CNS is, very, very profitable: "In 2008, there were 650 companies [in CNS], they generated $144 billion dollars in revenue and so its an extensive industry and about $120 billion was drugs, and $20 billion included diagnostics, brain imaging systems, in-vitro diagnostics, tests and $4.5 billion was neurodevices.[Interview 07 February 12, 2010]"

During this interview, I began to notice an important paradox: Underneath the triumphalist discourses of TN, the problems at work in CNS co-occur alongside enormous profitability. This paradox creates a question: If the failure rate for CNS is high, compared to other clinical trial areas how is it that neurotechnologies -- brain-based drugs, devices, diagnostics -- remain so profitable? What are the implications of pushing commercialization and development of biotechnologies that rely on a highly unstable science of the brain?

During our interview, 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 Ph.D., 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 academe to work for the private sector, 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* (emphasis

his)." Huge and costly clinical trial failures, Food & Drug Administrations (FDA) regulatory hurdles, the difficulty of understanding of brain diseases - all comprise some of the existing uncertainties and commercial risks attached to mental illness and its treatment. Zack was outlining matters of concern for neurotechnology investors, but it also created questions for me. What exactly is a critical uncertainty? Why might the investors in CNS and "MBAs" to which Zack referred be so focused on uncertainty or risk? Dealing with and, perhaps more importantly, managing critical uncertainty is a primary project that underlies TN. It was with these questions that I began to read Zack's optimism differently. Zack's optimism hid an enormous problem at work in commercial neuroscience: the marshaling of utopian discourses that serves to obscure the risks of neurotechnology and to compel continued investment in TN.

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 it was thought would occur in the form of new powers to read the brain or to use fMRI 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 interesting 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 that undergirded TN. However, my conversations with investors and pharmaceutical executives and the events that I attended focused on investments in the life sciences increasingly addressed risk, financial fall-outs, and the lack of any new real innovations from CNS -- a sector that received significant financial investment dollars.

I spent a total of 24 months in northern California, where I held an affiliation as a Visiting Scholar at the University of California, Berkeley's Science Technology and Society Center. 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.

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 premier region in the United States for neurotechnology investment and activity according to a report authored

by the Neurotechnology Industry Organization (Zack's firm) and NeuroInsights.[3] 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 in Neurotechnology Investor Conferences in Boston.

Insights

I talked with people in various positions- patients, clinicians, investors, neuroscientists, engineers, translational center staff, entrepreneurs, and in learning from my time in a multitude places and spaces of "translation" as well an analyses of media, I came to the 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. Thusly, 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 over-leveraging 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 to de-risk high-risk investments for further development by

[3] See http://www.businesswire.com/news/home/20091016005777/en/San-Francisco-Leading-Edge-Global-Neurotechnology-Industry.

pharmaceutical partners. Given the way that TN has compelled a wholesale mass transfer of early-stage neuroscience research to universities, I argue that university TN laboratories are literally 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 learn from my time at the Neurotechnology Industry and Partnering Summit, TN is characterized by a unique set of micropractices focused on creating solutions for the problems of biological material.

By facilitating the partnering of a patient's biological material to disease constructions, TN operates as a material-semiotic solution that helps produce order in the throws of biological, social, and technological chaos. Building on these arguments I suggest that TN relies on the creation of epistemological systems which entails the compelling of individual epistemic actions, such as those of the scientist, achieved through the design of novel environments such as the new, innovation-focused science laboratory. Lastly, I outline ethical questions about the role of the university as a risk-shelter and examine the resocialization of the risks of drug development as a public responsibility via the non-profit university.

Thus, in this dissertation I offer an alternative to recent scholarly treatments of translational science as merely the coproduction of capitalism and the life sciences or the product of an inevitable evolution of the life sciences. These theorizations hide the story of neuropsychiatric models falling apart. The importance of mapping this downfall and the resurgence it is generating in new domains lies in the problems that emerge with particular kinds of biomedical and biosocial reductions: reductions that also get embedded or engineered into neurotechnological objects themselves. Ultimately, I

propose a rehabilitation of material-semiotic approaches to mapping the dynamics embedded within TN.

Yet, as translational science is constituted as an institutional collective promise for the future health through pharmaceuticals and diagnostics, TN is also clearly becoming intertwined with health markets (M-J. Good 2007). As a major force in the production of medicines and in the conceptualization of innovations in health, this project is part of a larger move (Sharp 2013) to push theorization in medical anthropology toward considerations of biotechnology, finance, and science. The importance of this research for contemporary studies of biomedicine and health lies in its examination of what kinds of claims can be made in the name of global health and means through which institutional, political and market processes come to animate notions of innovation and progress in health.

Literature Review

Translational research and translational science is about knowledge in *transformation* - about knowledge in movement and thusly in various forms of construction and reconstruction. Sharing this interest anthropologists and other scholars have long examined the ways in which knowledge is made flexible, movable (Crick 1982; Douglas 1973; Mol 2002; Rouse 2009), transmissible (Geertz 1983; Knorr-Cetina 1981; Latour 1983, 1988, 1991; Latour and Woolgar 1986; Rajan and Leonelli 2013); and pushed into circulation under globalization (Kelty et al. 2008; Lyotard 1984; Petryna 2009; Riles 2006; Strathern 1995, 2000. Given this history translational science might be seen as the culmination of a set of discourses in which information – such as information

technology, and scientific and biomedical knowledge -- is required to be applicable, but also transmissible and connectable (Lyotard 1984). Thus, translatability becomes a demand made upon knowledge in societies where knowledge becomes a significant source and means of commercialization.

Knowledge in Translation: Laboratories and the World

Before science and technology studies turned to the laboratory as an object of intellectual interest, anthropologists tracked the variety of ways in which knowledge production is embedded in and dependent upon "the social." Anthropological concern exemplified by attention to local, indigenous rationalities (Evans-Pritchard and Gillies 1976) and to the nature and contexts of knowledge especially as inflected in the trajectory of cognitive anthropology (Bateson 2000; D'Andrade 2001; Ruesch and Bateson 1951) and sociology (Zerubavel 1999) also 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 Emile 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 brought questions of everyday laboratory practices into understanding 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, "An ethnographic approach to laboratory culture…allows one to disentangle the intricate social machinery of fact making" (Restivo 2005, 250).

While the laboratory especially early on represented a key site of epistemic and cultural work, analyses of scientific fact making could not neglect the socio-political structures that enable this work (Kuhn 1996), financed it (Rajan 2006; Shapin 2008), accorded it authority (Dumit 2004; Fleck 1981; Foucault 1972; Gilligan 1993; Habermas 1971; Haraway 1997), export it globally (Beaulieu 2001; Ecks 2005; Kamat and Nichter 1998; Knorr-Cetina 1992), transform it into capital (Healy 2004; Petryna 2009; Rabinow 1997; Rajan 2006), and use it to create medicalized identities (Biehl 2005, 2007; Canguilhem 1978; Foucault 1970 Fulwilley 2011; Jain 2006; Kessler 1998; Petryna 2006 Pollock 2008; Rapp 2011). Thus, what anthropologist David Hess calls, "the second generation" of science and technology studies, engages "a wider field site than the laboratory…including the political, institutional, and economic forces that govern the selection of research fields and programs…" (Hess 2001, 237)

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 fact-making and the larger 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 in his analysis of the pasteurization of France (1983) or via larger inferential analysis, such as that of Michel Callon's 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 has endured 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 attempt to get at the structures and structuring (Bowker and Star 1999) required to manage the technical and institutional factors, alliances, and allegiances necessary to facilitate the literal realization of science into facts and facts into truth. 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 it was to also deconstruct the sense of those facts as having emerged naturally. In other words, these approaches critiqued the narrative that facts moved seamlessly onto 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 that is explicit about aligning the "train rails" (Latour 1988, 155) necessary for the transmissibility of laboratory discoveries and their realization inside

devices, agendas, and world views. TN, I argue, actually emerges from fantasies of transmissibility as well as an acknowledgment of the fact that TN was born out of a very particular and specific set of failures. 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.

On Neuroscience

My project is a social study of neuroscience. Contemporary neuroscience is largely dominated by triumphalist narratives of reaching unbridled new horizons of knowledge about the brain (Abi-Rached 2008a) and subsequently, new possibilities for cognitive, neurological 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 upon 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 (N. Brown 2003; Tutton 2011), and that animate sustained hope in the laboratory sciences (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 Ninnerman 2012; Young 1997), sociologists (Joyce 2008; Rees and Rose 2004; Rose 2004; Zerubavel 1999), philosophers and historians (Abi-Rached 2008a; Changeux and Ricouer 2002; Harrington 1989), and ethicists (Racine 2010) about the

many ways in which neuroscience knowledge impacts society as well conceptualizations of the self.

Yet, the explosion of neuro-optimism has given risen to new scholarly concerns. The growth of an area of inquiry called critical neuroscience (Choudhury and Slaby 2012; 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 the fMRI. The application of -- and appeals to -- ambiguous neuroscience concepts and notions across all kinds of domains such as law, behavioral economics, addiction studies, and its invocation in a variety scholarly disciplines creates 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 alluded to the need for empirical data about neuroscience in translation. He suggested 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 have 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 its applications] move 'from the laboratory to the field'"(cf. Abi-Rached 2007, 4). It is in the absence of these data, that Rose is increasingly cautious about certain kinds of anti-neuroscience critiques -- especially those against neuroscience itself or against alarmist claims about neuroscience's inevitable transubstantiations and replacements. In their book, N*euro: The New Brain Sciences and the Management of the Mind*, Rose and co-author, Joelle M. Abi-Rached (2013) invoke a Haraway-ian

indeterminism (or optimism) regarding a science that is presently unfolding. Rose situates empirical data about neuroscience and society as a critique against data-less critiques.

My project here is a key move in this direction -- utilizing ethnographically informed analyses to look beyond or underneath the discourses created around TN toward its many materializations and constrictions. Tracing translation across several domains -- from microinteractions between scientists in TN laboratories to public policy discussions at neurotechnology industry conferences - this project looks 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.

TN includes discrete, concrete ways (knowledge practices, market investments, product-making) neuroscience impacts society. These acts and their implications demand ethnographic investigation and comparative critical reflection. The notion of a productive science is a central component of the translational imaginary. Among the complicated panoply of disciplines attached to the brain (Abi-Rached 2007, 2008b, 2008c; Dumit 2000) the mission of TN makes it distinct. Complementing other anthropological studies looking at scientific practices addressing the brain (Beaulieu 2001, 2002; Roepstorff 2001) and other examinations of translational research (Davies 2012; Rapp 2011; Farquhar and Kelly 2013; Rajan and Leonelli 2013), I focus on knowledge construction practices in an explicitly (and not merely implicitly) commercial mode. Though there have been internalist discussions and reflections of TN among neuroscientists, there is little social science research specifically about the field. I hope my project rectifies this in some small way.

Corporatization and the University

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; J. Brown 2000, Etzkowitz et al. 2000; Geiger 2002; Readings 1997).[4] 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; Lowen 1997; Power 1999; Rajan 2012; Readings 1997 Strathern 2000).

Certainly these concerns are not new. Thursten Veblen voiced concerns regarding the encroachment of corporate interests upon 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 focused on the impacts of neoliberalism upon university research and the life sciences sought to fill a gap in scholarship -- a gap that had missed the ways in which global

[4] Yet there is also some irony in this distinction (a la Snow's Two Cultures frame) between so-called applied, scientific knowledge and humanistic knowledge, which is in the fact that much laboratory work, while ostensibly applied, is especially speculative and may often appear rather theoretical. Many of the findings of everyday lab-work (translational and basic) yield results that are theoretical in that the value or actual applicability of said findings rely on future knowledge and/or are based on animal models but yield theoretical possibilities for utility in humans and in human contexts.

economic orders impacted scientific processes (Lave, Mirowski, and Randalls, 2010). My project engages with this latter literature, especially, in order to make sense of TN's connection to the neoliberal expansions (Strathern 2000) 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 history. One of the most impactful 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 U.S. universities to privately patent 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 causative narrative. Nevertheless, the Bayh-Dole Act coalesced with a series of shifts (Krimsky 2004; Lowen 1997; Rajan and Leonelli 2013) that caused science at the university to be increasingly seen as a space of market discovery, market penetration, and a sphere where private investors can support research that can be turned into market value.

However, as I argue in Chapter 4 (where I delve deeper into the scholarship on the issue), pointing simply to the emergence of the entrepreneurial university and the privatization of higher education in the West does not completely 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 needed specificity to understand the turn toward translation at modern research universities.

Capitalism and Science

My argument also engages with research on the growing import of capitalism and finance in the life sciences. Yet, in contrast to existing scholarship, I argue for a specific focus on the role of finance in understanding the nature and structures of translational science and medicine. For example, in the case of TN, despite the internally acknowledged problems of drug-efficacy, safety, and reliability that plague CNS, neurotechnologies revenues in 2009 still reached $141 billion. Given the market size and market opportunity presented by global mental health and brain disorders, I argue for considerations of finance in thinking about the contemporary contexts of medicine and health; a space in which there is opportunity for medical anthropology. In fact, I propose questions about whether and if so, how it is useful to consider translational science as a form of finance operating to solve science funding issues and delivering financial returns. The twist here is that the attraction of CNS to entities such as the National Institutes of Health is largely due to the health potentials of TN while the returns are often bereft of "health impacts" in the form of new and efficacious neurotechnologies.

Too, beyond the existing profitability of CNS lies its market *potential*: According to the NeuroInsights Neurotechnology Market 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 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 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 (Buchbinder 1993; Etzkowitz 2003; Hong and Walsh 2009) and/or scientific entrepreneurialism (Ong 2010, 5) and their connections to federal funding make the intertwining of science and business into a prime example for theorizations of power, knowledge, and governmentality (Foucault 1972) but these framing perspectives are in turn challenged by the instability of all knowledge as well as the unidirectionality of power and knowledge (Biehl and Locke 2010). 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) note about recent research on capitalism and the life sciences, much of this scholarship, is inattentive to "the transformation of economic processes in modern capitalism" (2012, 301), which provides specificity to theorizations of bioscience and the life sciences. Advancing the trend of tracing the interplay of capitalism and the life sciences, my project shows how specific financial and economic shifts are inextricable from 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 (Cooper 2008; Dumit 2012b; Fortun 2008; Ong 2010; Rabinow 1997, 2002; Sharp 2013; Stone 2010; Rajan 2006), especially

as these are implicated in university knowledge practice as part of larger promises for health.

The Public and the Private

However, TN is also borne out of visions of the emancipatory power of private markets. Yet perhaps paradoxically this entails today innovations in public-private partnerships that allow TN to offer specialized pathways to privatization while externalizing risks in the public domain. Translational science operates in ways that are facilitated by the provisions of the1980 Bayh-Dole Act enabling universities, and corporations to patent research carried out with public funds. Yet, this shift – towards 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. Thus, TN in the United States, broadly viewed, indexes relationships between science and the market; neuroscientists and investors; different kinds of collaborating scientists; federal funding entities and neuroscience lobbyists; and between a new science and various publics. In all these situations one finds a sustained rhetoric about applied neuroscience's emancipatory possibilities (to alleviate disease, to stimulate the U.S. economy, to create personal wealth, to advance science).

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 largely born by pharmaceutical companies so that they are now transferred onto 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 this latter resocialization is a known issue, the novel caution here may be the need to regulate optimism in light of neurotechnology's complicated realities.

Science, Biomedicine, and Health

Lastly, this project is principally about the future (and futures) of health and thusly, constitutes a major engagement with the area of medical anthropology especially as it intersects with science and technology studies. My work emerges out of a new promise for health: one that, according to its own rhetoric, leverages the weight of scientific research into a grand, biomedical solution for health. 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 bioscience and the market. Given the massive market potential for CNS, 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 philosophical 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 upon local health etiologies and practices and the convergence of neuropsychiatric models with local ontologies. The tracing of these processes invokes a particularly anthropological gift for revealing 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.

The social import of the growing hold of biomedicine on discourses of health and the implications of this make my project particularly important for anthropology, a discipline that has taken as its own the issues of biomedicine and globalization (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 notes, compels an analytic 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. [Biehl 2013:425]" 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.

Chapter Outline

In each chapter I explore the work of discourses around TN and their inflection in various social moments: clinical, financial, and laboratory-scientific. Accordingly, in

order to explicate the unfolding of TN, it is important to contextualize its history and emergence as a policy initiative. In Chapter 1, The State and Institutional Settings, I focus on underlying legislative and political contexts, especially in relation to the National Institutes of Health (NIH), that gave rise to translational science translational medicine, and TN in particular. In this contextualization, I locate a set of discursive patterns: taxpayer as shareholder, federal science research as an arena of "typical" government waste, science as a unearthed medicine, and importantly, knowledge as a moral and market good.

However, given the clinical export of TN, I wanted to know how patients became implicated in the promises and outputs of TN. Chapter 2, The Clinic, focuses on my time at the Cleveland Clinic in Cleveland, Ohio where I followed the experiences of two patients. I focus on Shana and her son Jawan. Jawan is a 13-year-old boy who has a form of pharmacoresistant epilepsy that has not responded to drugs. I focus on how Shana makes decisions about his illness treatment centered within a controversial, investigational therapeutic option: Deep Brain Stimulation for Epilepsy. I also met a patient named Pauline, who was a caregiver for her partner, Terry. Pauline and Terry were mired in a complex decision calculus about possible therapeutic options for Terry, whose epilepsy did not respond to pharmaceutical therapies. In the case of Pauline and Terry, their own life situation redirects the question about risk and neurotechnology.

I present my observations at an Epilepsy Symposium at the Cleveland Clinic and summarize my discussions with two neurology clinicians. Additional conversations with varied stakeholders and my analysis of dispersed sources -- media, industry reports, journalistic sources, patient accounts, discussions with clinicians at various levels --

provide me with a comprehensive understanding of the trenchant challenges and barriers at work in the everyday practices that surround clinical neurology and impact patients. One important issue I locate in patient and clinician discourses is the sense in which TN focuses on the acceleration of research, while largely ignoring increased risks from interventions created without adequate understandings of the biology of brain disorders. This became evident in 2010 when Medtronic, the manufacturer of a Deep Brain Stimulation DBS device, failed to receive FDA approval for its use with Epilepsy (Lee 2010). Yet, using the FDA's *Humanitarian Device Exemption*, the technology became a therapeutic solution for Shana's son, Jawan. Using this example, I discuss the analytical utility of thinking about incomplete scientific understanding or scientific risk as a *material property* produced as part of neuroscience's inevitably incomplete translations.

I also show how neurotechnologies literally contain (or are containers for) financial risk. In Chapter 3, "The Brain", I discuss the intensifying crisis for biopharmaceutical companies and investors around CNS and its profitable disease markets: schizophrenia, stroke, bipolar disorder, depression, anxiety, etc. Despite the number that Zack quoted to me, the "$144 billion dollars in revenue" that CNS companies earned in 2009, I show that "Big Pharma" was, in a financial crisis. I discuss my experiences at the annual Neurotechnology Investment & Partnering Summits sponsored by NeuroInsights and the Neurotechnology Industry Organization. At these events, I learned about the contexts that rendered TN a strategic corporate solution for biopharmaceutical companies. I include interviews with investors who helped me to think through the way that transformations in neuroscience reflect knowledge constraints produced under financialization.

In this chapter, I also outline how I learned about the massive knowledge problems that undergird neuropsychiatric models and also the difficulty at work in reconciling disease categories such as depression with the search for biomarkers and molecular entities. I attended annual Neurotechnology Industry Summits sponsored by the Neurotechnology Industry Organization and Zack and Casey's firm, NeuroInsights. These Summits offered unique opportunities to witness scientists and investors as they openly discuss the problems underlying therapies and scientific approaches, those both extant and in the pipeline (see Figure 3).

It was in these summits where I began to ask questions about the functions and fictions of TN. In particular, I look at the way that the neurotechnology market relies on a linking of TN to social disorders as part of the construction of health markets. In doing so, I also focus on how processes of innovation in neuroscience rely on matching disorders with biological material. This linking process became increasingly necessary because of the many ambiguities and biological problems that permeated commercial neuroscience. The massive problems in the sector meant that the entire area of commercial neuroscience was burdened with risk from 2006-2010.

In Chapter 4, The University, I turn to the milieu of issues that become public knowledge among researchers, scientists, and investors starting from 2006: Incomplete understanding of the "biology" of mental illness (Insel 2009; Leibnig 2009), poor and variable efficacy rates (Fournier et al. 2010; Ninneman 2012), the problem of and dependence upon animal models in laboratory research (Nutt and Goodwin 2011; Davies 2012), expiring patents and massive rates of clinical trial failures (Cutler and Riordan 2011), medication safety issues and regulatory hurdles (Healy 2012; Light, Lexchin, and

Darrow 2013), as well as the costs of research and development (Cutler, Neal and Riordan, 2011) -- all plague the process of advancing new efficacious and safe medicines to treat brain-disorders.

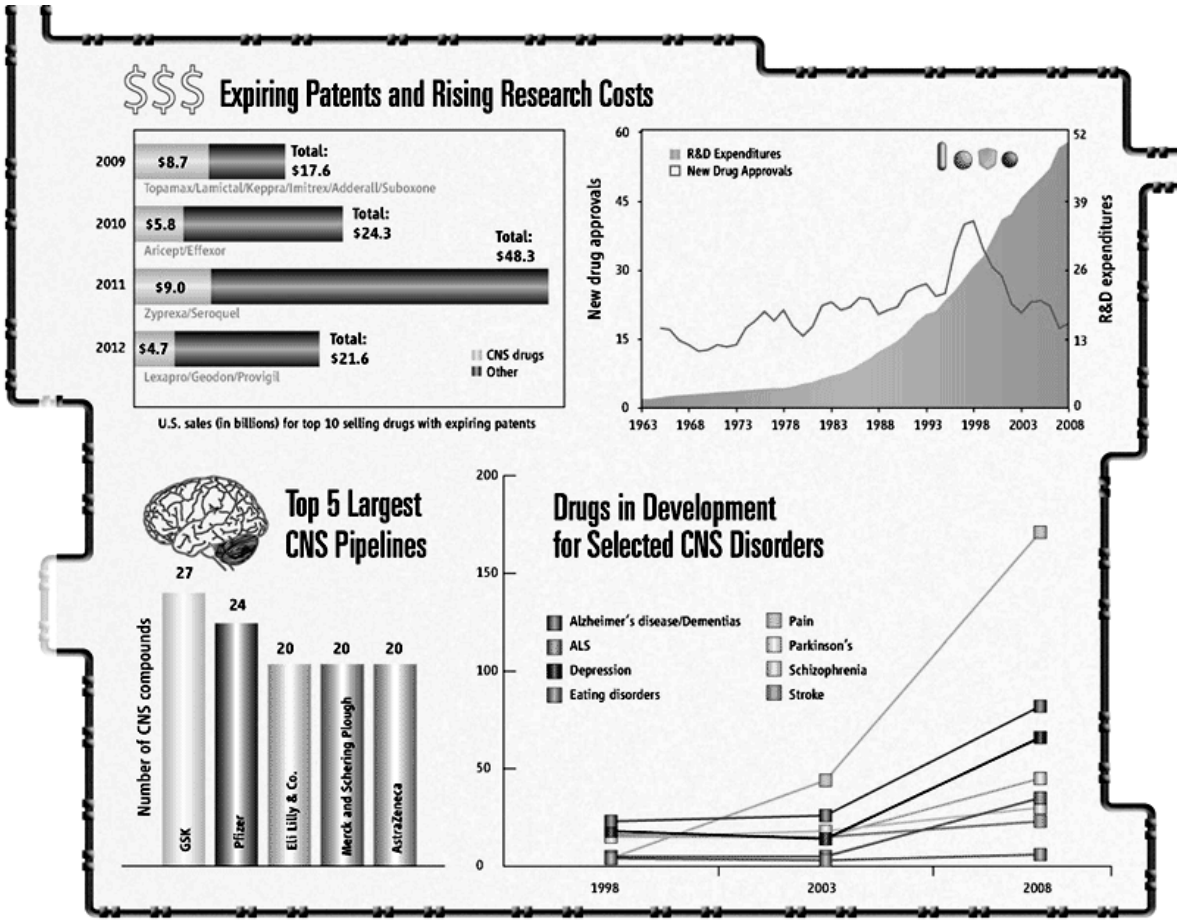

Figure 3. This infographic published in the journal *Science* provides a picture of several problems facing CNS including expiring patents, rising research costs, low clinical success rates, as well as current products in pipelines. Of the companies with the 5 largest CNS pipelines listed in the lower left bottom, only Eli Lilly has maintained its neuroscience research programs. The remaining companies have all downsized or completely eliminated their internal neuroscience research divisions: http://www.sciencemag.org/cgi/content/full/329/5991/502.

The problems were so severe that starting in 2011, major pharmaceutical players in areas of depression, Alzheimer's Disease, Parkinson's Disease, schizophrenia, pain disorders - began a massive retreat from the sector: GlaxoSmithKine, Novartis, AstraZeneca and Bristol Meyers Squibb, Pfizer, Jansen Sanofi, and Merck have all either significantly downsized or completely shut down their internal neuroscience divisions

(Skipka-Serry 2013).[5] After announcements in 2010 by GlaxoSmithKine (GSK) and AstraZeneca that they would shut down their commercial neuroscience research units, Tom Insel, then director of the National Institutes of Mental Health said during an emergency meeting at the Institute of Medicine Forum on Neuroscience organized in response to GSK and AstraZeneca's announcement:

> *The biggest problem isn't the announcements by GSK and AstraZeneca, it's when you look at the pipeline and see what companies are actually doing in psychiatric drug development. There are very few new molecular entities, very few novel ideas, and almost nothing that gives any hope for a transformation in the treatment of mental illness. [Miller 2010, 502]*

Insel's statement is useful in contextualizing TN as *more than merely a new* push toward innovation, but as the product of a deep crisis in the underlying scientific presuppositions on which psychopharmaceuticalization relies. For Insel, it is an intellectual crisis inasmuch as it is a problem of abandonment by biopharmaceutical companies. Yet, and importantly, this scientific crisis is not the same as a financial crisis. While biopharmaceutical companies shut down their internal neuroscience labs, they did not pull out altogether their investments in CNS. In fact, actual investments dollars in the CNS sector actually *increased* in 2010 (NeuroInsights 2010).

I explore in Chapter 4 the distinction between scientific risk and financial risk. The neurotechnology industry, which includes pharmaceuticals, devices, and diagnostics, reached $158.6 billion in revenues in 2011. This revenue amount represents 5.6 percent growth over $150.1 billion and 5.0 percent growth in 2010. Although this growth is significant, it is lower than the 9 percent growth that the industry experienced in 2008.

[5] See Skripka-Serry, J. (2013). The great neuro-pipeline "brain drain" (and why Big Pharma hasn't given up on CNS disorders). *Drug Discovery World*. Retrieved November 12, 2013, from http://www.ddw-online.com/p-216813.

The market size to which neurotechnology is tied is enormous and represents lucrative opportunity. To the extent that TN can help researchers commercialize opportunities, the endeavor itself becomes part and parcel of creating greater returns for those invested in the neurotechnology market.

The shift toward TN, in full bloom at universities in 2007 and 2008 occurred at the height of the economic downturn. Thus, TN emerged at precisely that moment in which partnerships with universities presented a clear risk-related opportunity for the neurotechnology industry. As biopharmaceutical companies closed or scaled down their own neuroscience research programs at pharmaceutical companies, universities began to fill a special role in early-stage neuroscience research. Thus, this is also a story about the risks of financial and intellectual investments in commercial neuroscience between 2006 and 2010. TN is thus a financial *rehabilitation* and not merely or solely a new hybrid of capitalist and life science epistemologies. In other words, I offer a rejoinder to current theorizations about the emergence and evolution of science and capitalism that excuse epistemic failures as requisite for neoliberal genesis. It is in this context that I argue TN turns the non-profit university into a de-risking mechanism, one that allows biopharmaceutical companies to outsource the riskiest parts of early-stage neuroscience innovation onto the non-profit university. Thinking with medical anthropology and its growing attention to the role of the market, I propose that we think of TN as a form of finance.

In Chapter 5 I focus on how TN births new knowledge infrastructures. As the emergence of TN rearranges university work and practices, there is a need to thoughtfully consider the kinds of epistemic invitations and architectures that financialization

produces. Chapter 5, titled "The Laboratory," therefore includes a focus on laboratory architecture and an analysis of a translation-focused website produced by the University of California, San Francisco. Thinking with notions of design, contouring, and contortion, I map the epistemologies that help to ground TN in a set of practices. Thinking with Zack's impetus to analyze moralities as they emerge in and via situations, I also point toward the analytic utility of considering the moral life of design. Yet, I also point towards the way that translation operates as a uniquely conducive space of moral envisioning- certainly in terms of market and financial envisioning, but other kinds of visions as well. Here I suggest that finance is one among many kinds of visions accorded onto translation.

I focus on the science laboratories themselves, including the architecture of TN laboratories as well as an examination of the way that the translational imperative interacts with daily practices. Modern scientists are well aware of the fact that contemporary life sciences require enrollments in market-based practices and that universities are places where market logics penetrate scientific practice. Few scientists still subscribe to idealized accounts of scientific practice (Fischer 2007; Haraway 1996; Shapin 2008). However, the transformations at work in academic scientific practice are more explicit than is being accounted for by much of the literature in science and technology studies (Lave, Mirowski, and Randalls 2010) Translational science also provides clear invitations that, I argue, compel certain epistemic contortions and accommodations. Thus, I focus on the *changing* of laboratory architecture, the *relocating* of science buildings onto corporate campuses, and the *creation* of websites charged with introducing university scientists to corporate collaborators and investors.

In the concluding section, I argue for a return to material-semiotic notions in order to make sense of the emergence of new knowledge systems engendered under the translational shift and their consequences for subjects. I discuss further the social implications offloading risks onto the public sector under the aegis of innovation. Lastly, employing the notion of substitutability, I suggest a new way of thinking through the risks engendered under financialization, especially as they pertain to the domains of medicine. This latter issue constitutes my contribution to current theorizing in medical anthropology about the intersections of finance, financialization and medicine, biotechnology and health.

Chapter 1 / The State and Institutional Settings

> *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?*
>
> - Elias A. Zerhouni, MD, "Translational and Clinical Science — Time for a New Vision" *New England Journal of Medicine* (2005)

Taxpayer as Shareholder: The Emotional and Financial Politics of Bioscience

During the 2008 U.S. presidential election, Republican vice-presidential candidate Sarah Palin appeared before a group of supporters in Pittsburgh and addressed disability research funding. Intending to show support for special education research she nevertheless veered off message and took on the topic of the waste of taxpayer dollars. With cameras rolling she created yet another campaign controversy (Figure 4). Awash in indignation, Palin informed her audience, "Sometimes these dollars, they go to projects having little or nothing to do with the public good. Things like *fruit fly* research in Paris, France" (emphasis original) then adding a folksy "I kid you not." Palin's general conversation was about children with special needs. The irony —and what Palin likely did not know— is a fact that many in the media were quick to point out: the fruit fly is at the heart of the medical research that focused on treating the medical disorders that Palin had in mind.

Palin's commentary instigated a rare public discussion of *drosophila melanogaster* (the fruit fly) and the taxpayer's stake in publicly funded scientific research.[6] In 2008 the U.S. economy was reeling from a massive recession and the threat of economic collapse loomed ominously over the country. Conservatives were anxious to articulate examples of government waste – especially endeavors for which immediate results could not be seen.

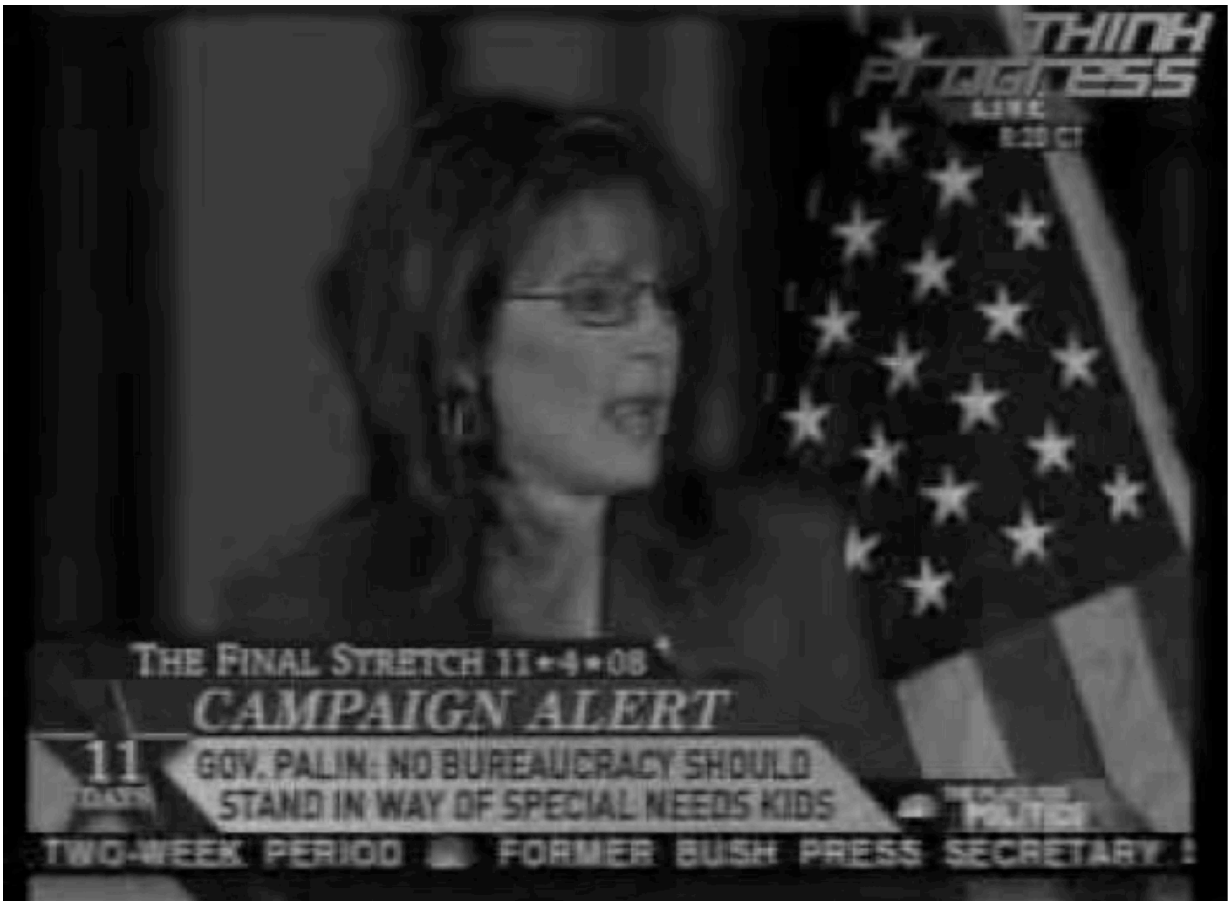

Figure 4. Vice-presidential candidate, Sarah Palin in 2008 on Fox News discussing federal science research funding and the need for new solutions to help children with special needs.

[6] To be clear, Palin referenced a research project that was focused on olive fruit flies (*tephritidae*), which are different from *drosophila melanogaster*. Nevertheless, the media conversation about Palin's purported disdain for science raged on. Much was made of this incident in blog articles and in journals such as *Scientific American*.

Scientists and commentators scoffed: they pointed out how *drosophila* research was actually *quite useful*; an important road to cures for degenerative diseases, including Down Syndrome, the disease that affected Palin's youngest son. Sentimentality about her son had always been part of her political profile. For example, she would frequently hold her son while talking about abortion and the value of life.

Palin's comment about the importance of special education and children with special needs juxtaposed this sentimentality against a rhetoric of potential scientific discoveries and medical progress. Palin's lament about the frivolity of fruit fly research and the need for "cures" was an explicitly populist indictment of ostensibly unproductive and unnecessary science research. In this view, unproductive science is knowledge for its own sake, without immediate and actionable benefits to the public (especially basic science).

Yet, Palin's larger critique also concerned the need for public money to support finding cures for diseases – all in the name of the public good.[7] Here we see a proposition about channeling federal research dollars in productive directions, rather than pursuing

[7] The complicated relationship between populist rhetoric and the democratic demands of a publicly-funded science elicits an interesting comparative history. The public value of science has been an explicit issue in Europe, as far back as the Enlightenment. Accordingly, public value has long been linked to public values. There is a European history of class structures that lies behind discourses–especially those of scientists that justify the public value of science. The discourse juxtaposes "the need for an educated citizenry" and science as the natural vocation of the intellectual and social elite and thus necessarily immune to the everyday interests of the public. Historically, instrumentalist science has had the potential for important social uses and application while general science relied upon the social value of intellectualism - without requiring a warrant predicated principally on a directly given instrumental potential. These histories reveal an aristocratic bias in historical justifications for basic science: intellectual versus instrumental (practical and applied) forms of science. Here we find an historical corollary to Palin's populist critique of science (with its anti-intellectual slant) set against a rising demand on the part of Congress and the National Institutes of Health for application-focused, market-oriented knowledge. Nonetheless, the debates about what science ought to be doing for society hinge on varying definitions of value and subsequently diverse methodologies for assessing its societal benefit. In *Public Value of Science* (Wynne, Stilgoe, and Wilsdon. 2005) the authors situate the issue of the social benefit of science within a discussion of science in the United Kingdom, an argument in which those advocating for greater federal investment in science argue for greater public appreciation of science and its enterprises. For a nuanced analysis of the boundaries between science, risk and the public – especially around policy debates, see Jasanof and Kim 2013 and Wolf 2002.

"useless" knowledge or knowledge for knowledge's sake (which can then be situated as elitist). The media treated Palin's populist outrage and ignorance about science as a story about Palin herself. However, for academics it reeked of a dangerous unreflective instrumentalism (Hofstadter 1963); an anti-intellectualism that regards non-application focused knowledge as valueless (Grace 2012), suspicious; a waste of ever precious public resources (Wynne, Stilgoe, and Wilsdon 2005).[8]

This controversy raises several issues. First, the laboratory fruit fly, much like the laboratory rat, has contributed in innumerable ways to mapping disease models in animals and has led to important innovations in medical therapies. Much of the public backlash regarding Palin's statements was focused on the potential that *drosophilae* will aid in the production of life-saving cures. Here one sees how the lab rat and the *drosophila* have come to symbolize biomedical and translational innovation (Davies 2012) and accordingly, symbolize the future of health.[9]

Second, in the context of the 2008 financial crisis Palin gave voice to complaints about two interrelated problems that impinge on federal science and medicine funding. A rise in populist sentiment among large sectors of the public questioned federal spending in general, and some members of Congress were increasingly concerned that the enormous federal investment in science has yielded little. The populist narrative expresses a social anxiety of hard-earned money being sucked into the black hole of basic

[8] There is an excellent overview of the history of the rise of instrumentalism in higher education in North America and its connection to both the Cold War and also communist-anxiety. Thus, the shift towards instrumentalism has a clear history and reflects clear political shifts on the part of state actors (Grace 2012, 225–244).

[9] For more on this, see the 2008 *Guardian* article, "Palin and the Fruit Fly: How the Vice-Presidential Candidate Became a Laughing-Stock Among Scientists." To get a sense of the tenor of public sentiment, see: http://www.guardian.co.uk/commentisfree/2008/oct/27/sarahpalin-genetics-fruit-flies. Commenters' posts often reference the promises of biomedical research as part of their castigation of Palin's sentiments.

science – the mode of scientific investigation focused on gathering fundamental knowledge and principles, positioned against translational or applied science that develops clear application-oriented scientific research. Especially in the case of health and biomedicine, translational science is seen as the precursor to global and other large-scale innovations in health.

In 2011 the National Institutes of Health poured $575 million into developing a new center, the National Center for Advancing Translational Sciences (NCATS) to "transform the translational science process so that new treatments and cures for disease can be delivered to patients faster."[10] These governmental actions engender questions about transformations in the public funding of science, but they also bring into view the perennial question of the role of the state in guaranteeing health via the strong arm of biomedical sciences. Yet, the idea of translation – for many stakeholders – is explicitly about channeling more federally funded science toward commercialization and health markets, that is, about the privatization of public resources. On the same NCATS website the relationship between translation and private sector commercialization is spelled out clearly. On the center's calendar, one sees events in which private industry, pharmaceutical companies, venture capitalists and foundations are invited to participate in a showcase of federally-funded research available for further commercial development.

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[10] National Center for Advancing Translational Sciences. Homepage: http://www.ncats.nih.gov/about/about.html, accessed November 2013. It is also important to note that these funds are not new- found funds. In fact, these funds are the result of reallocation of existing funds with the NIH. Thus, this really reflects a shifting set of priorities in terms of how health is being envisioned at least among the stakeholders at NIH. See this interview with Chris Austin, who was appointed as the director of the National Center for Advancing Translational Sciences in late 2012. http://www.raps.org/focus-online/news/news-article-view/article/3407.aspx. Accessed June 2013.

Given that, the translational tilt in federal science research is one that explicitly invites the increased commercialization of federally funded projects. This is another example of new manifestations from the global expansion of biomedical markets and their intermingling in defining health (Biehl and Petryna 2011), which, in this case, includes new commercialization efforts via translational programs. This also speaks of growing trends regarding the use of public/private partnerships and/or the import of business models in the governance and development of solutions in global health. Yet, not all translational science is created equal. TN is both one of the more promising endeavors and one of the most difficult. The complexity of the brain and the special difficulty of understanding brain disorders (especially in relation to mental health)[11] have made it quite risky in terms of continued development for pharmaceutical companies and investors (Cutler and Riordan 2011).

The birth of the explicit translational pipeline at the NIH began in 2005. However, interestingly, between 2005 and 2009, the financial crisis coalesced with new significance around risk and investment – especially in the commercial biosciences. Thus, the growth of translational science and its institutionalization at universities around the United States occurred at a particular time during which pharmaceutical companies were scaling back neuroscience investments, access to global capital was becoming more constricted, and political narratives – such as those from Palin – heightened anxieties about the future of investments in science and medicine while pressuring science toward more purposeful innovations in health.

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[11] See http://www.nature.com/neuro/journal/v7/n12/full/nn1204-1281.html, accessed June 2012.

Yet, this transformation of translational science cannot be brought up without a consideration of the slashing of federal science funding (Lave, Mirowski, and Randalls 2010). In a recent New York Times piece, William Broad (2014) chronicled the influential rise of private donors in funding of translational research at American universities. Though his focus is on scientific philanthropy by billionaires, his piece also underscores an emerging tautological narrative in which "…private gifts… will become especially important if Washington funding continues its downward spiral. [Broad 2014]" In this way, this project is as much about the multiple forces working towards the privatization of science and tracing its subsequent impacts upon the development of biomedicines.

Translational What? Describing Translational Neuroscience

In the same controversial speech that I mentioned at the start, Sarah Palin's conversation, if unintentionally, took a detour through TN. Palin said, "…Early identification of a cognitive or other disorder, especially autism, can make a life-changing difference." The early 2000s witnessed a movement among government science policymakers, university administrators, venture capitalists, and entrepreneurial academic scientists to reshape the goals and methods of biomedical science. Translational science promised to channel the breakthroughs of basic science into life-saving and life-enhancing diagnostics and cures. But what exactly is TN?

This issue of identification or diagnosis of brain illness, often called *diagnostics,* is a key focus for *TN*, a term that, according to my interlocutors, catches on culturally in the United States around 2005. The difference between TN and basic neuroscience is

complex in its implications and while institutions describe their missions somewhat differently, they do share a conceptual core: all breakdown disciplinary boundaries seeking to merge form and content – (achieved through the promotion of cross-disciplinary work and even exemplified in the building of new buildings designed to create collaboration across sectors); they engage actors from outside of the scientific community –- venture capitalists, politicians, pharmaceutical companies; they eschew knowledge for knowledge's sake in favor of propelling knowledge from the "bench to bedside." TN is therefore a field of inquiry that attempts to take the insights and knowledge of basic neuroscience and clinical research and convert them into practical applications, preferably applications that can be turned into commodities.[12]

All of these descriptions are intently focused on the processes of knowledge creation as well as on its output: medical therapeutics, diagnostics, and even knowledge that improve health outcomes. Below I include several descriptions of the enterprise of from TN centers themselves – each of which offer a different slant:

> *Duke University TN Center:*
>
> *TN applies insights gained through fundamental research on brain structure and function to develop novel pharmacological, surgical, and behavioral therapies of these diseases…Effective TN requires continuous interactions of fundamental neuroscientists and clinical neuroscientists... The Center will be housed in space adjacent to the Bryan Neurobiology Research Building. This proximity will give Center faculty easy access to the intellectual and technical resources of the Department of Neurobiology. Close interaction among clinician/scientists and basic scientists working under one roof*

[12] This follows from a surge of research of late about the commodification of university knowledge (Etzkowitz 2003, 2007; Hong and Walsh 2009; Lam 2010; Strathern 2000), of the general corporatization of the university (Bok 2003; Buchbinder 1993; Schumar 1997), of the role of capitalism in the work of life scientists (Shapin 2008; Woolgar, Coopmans, and Neyland, 2009) alongside histories of transformation at the university (Etszkowitz et al. 2000; Lowen 1997). This line of research about the university and industry is not new. Of course, Jean-Francois Lyotard's notions about the transformation of knowledge especially for late capitalist society have implications for the nature of knowledge and value (1984).

> *promises to be a potent interface for driving both discovery and development of novel therapeutic strategies.*[13]

In this description notice how translational science includes not only multidisciplinary collaboration, but also a reconfiguration of buildings and scientific locations such that proximity becomes an approximation for the free flow of ideas and exchange.

> *University of California, San Diego, TN Institute:*
>
> *A new TN Institute (TNI) at UC San Diego will combine disciplines to bring advances in basic neuroscience from early discovery to human clinical trials. We will be able to identify and develop new therapies as this approach illuminates our knowledge of disease mechanisms...UCSD and the other neuroscience programs in La Jolla represent what may be the world's most advanced concentration of scientific and clinical knowledge for TN. We plan to leverage this community's successful track record in translation of drug, cell and gene therapies.* ***Preclinical Discovery****: Discovery of disease mechanism[s]. Investigate cell-specific disease mechanism[s]; Proteomics – identify protein mechanisms of disease and targets; Develop specific neuroscience expertise in proteomics in collaboration with other campus proteomics programs; Lipidomics-- characterize the lipid state of the cell and potential new disease targets; Bioinformatics-- Tie it all together Develop specific neuroscience expertise in bioinformatics Prioritize targets from extensive data sets.* ***Pre-clinical Development*** *Develop novel therapeutics; Develop in vitro assays and high throughput. Utilize high throughput screening capabilities, including NIH Blueprint for Neuroscience Research Parallel effort; ...Develop novel therapeutic technologies: Gene therapy, cell therapy, bioengineering."*[14]

In this description notice how TN is situated as a particular approach to the doing of what is essentially "normal" neuroscience. In this sense, one could imagine TN as defined by an ethos. The Preclinical Discovery description here comes close to many of the tasks that would be done in "basic science." Yet, here it is done with a particular outcome (and market application) in mind as denoted by the Pre-clinical Development stage. It is in this context that I began to think about the translational paradigm as something that is largely epistemological in terms of the day-to-day shift within scientific

[13] http://neurobiology.duhs.duke.edu/CTN/main/index.shtml, accessed January 2013.
[14] http://neurosciences.ucsd.edu/research/Pages/translational-neuroscience.aspx, accessed January 2013.

laboratories. In other words, might the everyday manifestations of TN be found not in terms of mundane scientific practices, but in transformations in how one comes to understand scientific practices, its purposes and its outcomes? With this frame, notice the description from the University of Nebraska Medical Center:

> *University of Nebraska Medical Center for Integrative and TN:*
>
> *The Center for Integrative and TN is the link between basic sciences discoveries and translational implementation in the clinic. It will take the fruits of neurodegenerative research from the bench to the bedside. The center brings together basic research faculty with clinicians in neurology, psychiatry, pediatrics, radiology, medicine and surgery. This joint effort will move new discoveries rapidly out of the lab and into the clinic. Neuroscience is now at the stage where we can move laboratory findings up through molecular, cell culture and animal models to people to alleviate the burden of neurodegenerative illnesses as soon as possible…Advances in technology allow us to diagnose diseases of the brain earlier and more exactly. It is at these early stages that treatments would likely be more effective.*[15]

Notice how the description above brings diagnosis earlier into the conceptual process for neuroscience. This description clearly designates TN as *interested* or instrumentalist science. Undoubtedly, however, this approach toward thinking *with diagnostics* creates questions about the implications of TN for scientific thinking and for TN as an intervention in health. Here I began to think about the impact of what I have called *pharmacological thinking* on the part of scientists, especially neurobiologists, research university administrators, and attendant stakeholders as an explicit output of the translational paradigm. Pharmacological thinking is both outcome or product of experimental research and the presumption upon which research agendas are constructed. Questions posed and around which data are culled are oriented from the outset towards presumptions of a pharmaceutical endpoint.

[15] http://www.unmc.edu/pharmacology/integrative_translational_neuroscience.htm, accessed January 2013.

Two prominent ideas shared across various stakeholder definitions of TN include the notion of *discovery* and the concept summed up in the oft-used colloquialism, *bench to bedside*. Translation is thus about turning science into medicine – and includes at least rhetorically a revamping of processes and systems to help improve or accelerate this process. Although given the enormity of what is covered between "bench and bedside," translational science and medicine are quite amorphous and as such prone to definitional diffusion even among insiders, the essential commonality among definitions is a productive end-value: a new drug or diagnostic or even new therapeutic models as made explicit in the imperative from University of California, San Diego's TN Institute: "Develop novel therapeutic technologies." In this sense, this is about the attempt turn science into biomedicine.

Yet TN is also very much about the brain. Advances in knowledge of how the brain works is one of the intellectual cores that animates the field (FitzGerald 2005; Gomez 2006; Rose 2004). The explosion of brain science discoveries since the 1990s (Abi-Rached 2008a; Garcia-Rill 2012; Vrecko 2010) and the wide use of functional magnetic resonance imaging (fMRI) (Dumit 2000; Joyce 2008; Rapp 2011) generated a moment, which the Library of Congress and the National Institute of Mental Health (n.d.) dubbed the Decade of the Brain signaling not simply the growth of neuroscience, but importantly the possibilities for what that knowledge could create. Accordingly, translation offers the opportunity to "downstream" (Rajan and Leonelli 2013) the wealth of neuroscience knowledge while it also upstreams pharmacological and biotechnological envisioning on the part of neuroscientists conducting research. According to the more optimistic (disinterested) narrative, the sheer accumulation of basic research created

conditions for the takeoff of TN and the proliferation of new medications, devices, and diagnostics.

However, TN may also become a means by which individual disorder is connected with brain science. Take for example the fact that the clinical practice of mental health has been completely transformed via neuroscience. It is now the case as scholars have noted that, "…diagnosis is now thought to be most accurate when it can link symptoms to anomalies..." (Rose 2004, 408). In this sense, it's possible to view TN as a mechanism that produces patients-in-waiting (Dumit and Greenslit 2005) by matching disorders with biological material.[16] Here I use "biological material" to refer to the panoply of biological "objects" and their subsequent meanings that become essential part of biological explanations and understandings. In other words, biological material is the material accouterment such as genes, cells, blood and facts that lend reality and mobility to scientific and medical discourses.

To be clear, this sentiment of matching disorders with biological material is about how TN, in its appropriation and relocation of biological facts, subsequently enables said facts to be enveloped within larger narratives of disease. In other words, in the constructivist view of how diseases attain social reality, TN is perfectly positioned to produce facts and research that surround particular diseases and even when those facts fail to translate neatly into patients experiences or symptoms, the very possibility of scientific facts can be marshaled to provide reality to disorders.

[16] This is especially the case for something called Mechanism of Action. Mechanism of Action refers to the biochemical means through which a pharmacologic effect is achieved (Pritchard, Justine, Bruno, Gilbert, Capron, Lauffenburger, and Hemann. 2013). This is all important in the larger biomarker search that is part of understanding complex brain-based disorders (Lock 2007), a primary means of pharmacological meaning-making around both the biological conceptualization of a disease and the rendering of a disease as an object around which to construct biotechnologies and narratives about the biotechnologies (especially for regulatory purposes).

Another way to think of this is to think with Margaret Lock and Vinh-Kim Nguyen's ideas regarding the technological "construction" of disease via biomedicine. This larger biological and molecular construction of diseases enables their social realization via the availability of biological facts associated with or imputed to a disease.

Nonetheless, the impending avalanche of new knowledge about the brain that was to radically transform medicine has yet to occur. Research about the automatic nature of the brain's functioning and the role of neurochemistry in brain behavior are the aspects of neuroscience that attract most attention for the way that neuroscience knowledge might change the brain and behavior. Beyond areas of neuroscientific imagination (hope around neuroscience's future potentials), it is in the areas of *diagnostics*, *therapies, and devices* and their commercialization that neuroscience's impact can is most explicitly felt. While there are efforts to create[17] guidelines regarding the use of evidence from imaging technologies in legal cases - reflecting fears of a neurotechnological *future* for medicine-based neurotechnologies, drugs, devices, and diagnostics used to alter the brain (such as the cochlear implant or the anti-depressant drug) are already here. Thus TN offers a next step in the mapping and analysis of neuroscience and its objects.

There is, therefore, a need for ethnographic data about neuroscience research as it is being translated into other scientific forms, into medical technologies, and into various forms of value. There is hope on the part of investors. Scientists hope about new discoveries. There is political hope for the financial returns of large federal investment and hope on the part of people looking for alleviation from illness. But there is little data

[17] Another example is the effort to develop effective yet constitutionally acceptable forms of "neurosecurity" (guidelines towards the use of neural scanning devices at, say, airport checkpoints) or to use brain images in legal settings such as court rooms.

on the process and its realistic potentials. Nonetheless, TN itself presupposes that its knowledge arena has evolved sufficiently to make practical applications of neuroscience realizable and also *reconcilable* with other knowledge forms. In this way, TN is as much a theory about communication -- between objects, agendas, disciplines, and methodologies -- as it is a fantasy about translatability. And all three components: theory, basic knowledge and practical applications when in concert actively expose gulfs in knowledge about the brain, about the brain and behavior, about the biological mechanisms that are thought to undergird mental illness (Lock 2007).

TN as an Opportunity via Scientific Excess

Emic definitions of TN often focus on the therapeutic opportunities enabled precisely because of the mountain of new knowledge emerging from neuroscience. The cognitive revolution led to a bevy of scientific research and findings about the brain (Gardner 1985). According to the director of the University of Nebraska's Center for Integrative and TN, Howard S. Fox: "Neuroscience is now at the stage where we can move laboratory findings up through molecular, cell culture and animal models to people[18] …" Official definitions (on websites, on brochures, federal funding Requests for Proposals (RFPs), as well as market analyses focused on the neurotechnology sector) describe TN in triumphalist terms – opportunities engendered through neuroscience's excess. In other words, it's the perception of an abundance of new knowledge about the brain or neuroscience's rapacious growth that informs the view of neuroscience as an opportunity.

[18] http://www.unmc.edu/pharmacology/integrative_translational_neuroscience.htm.

Here neuroscience is constituted as a treasure trove. I often found this narrative in the literature from investment groups and market speculators such as those attached to the local neurotechnology community in northern California. The investment literature represented the brain as a market frontier. It was not much of a stretch of imagination for a pharmaceutical executive at a Neurotech Investing and Partnering Summit - an event pairing scientists and investors to hype TN as "mining for gold." In this sense, translational science is both a goldmine and a "mine." It is both an opportunity and a difficult endeavor.

TN as a Solution Born from Failures: A Scientific Crisis

The colloquialism, from "bench to bedside," or bridging the gap between laboratory discoveries (the lab bench) and the patient's bedside appears in expert and official definitions of translational science. Translation is represented as a means of fixing barriers that prevent the transfer of knowledge to practical results. The National Institutes of Health uses the language of overcoming barriers, an issue I explore later at the end of this chapter. Yet the view from the ground is at odds with these official views.

For many – government legislators, weary investors, frustrated academic scientists – translational science largely emerges from productive failure: particularly the failure to produce new drugs or safe effective therapies despite a mountain of federal research (with the NIH spending 30 billion annually in medical research[19] and an estimated $5.5 billion in neuroscience across all departments). A primary factor in this

[19] www.nih.gov/about/budget.htm, Accessed January 2013.

failure is what my interlocutors at pharmaceutical companies called the "pipeline problem."[20]

In a 2005 opinion piece in the journal *Nature Reviews,* Garrett Fitzgerald, then a leading scientist at the Institute for Translational Medicine and Therapeutics at the University of Pennsylvania, proposed the institutionalization of "translational medicine and therapeutics" as a field. In his opinion piece he makes an argument for the financial opportunity here and why this new discipline would do better than previous failed attempts to create application-focused solutions. His remarks reveal some of the problems that translational science seeks to remedy:

> *Perhaps it is time to found a new discipline of translational medicine and therapeutics…Why establish a new discipline? First a new "brand" creates excitement and enhances visibility… Second, previous labels for effort in this area have not caught on. Divisions of Molecular and Experimental Medicine have been tried, but have not flourished in AMCs [Academic Medical Centers]. Moreover, the few examples have tended to favor basic rather than translational research and have lacked an emphasis on therapeutics… However, it offers a much broader fiscal opportunity to AMCs- namely, the increasingly efficient commercialization of their intellectual property.* (FitzGerald 2005, 817; emphasis mine)

Following this in the article Fitzgerald offers his own characterization of translational medicine and therapeutics: "The term "translational" medicine and therapeutics captures the momentum of the current focus on the translational process,

[20] It is important to note that although there was a pipeline problem (a slowing of new effective drugs), for pharmaceutical companies, revenues have not dried up. In fact, pharmaceutical companies have enjoyed continued profits even with a dearth of new drugs. FitzGerald notes, "A high profit margin in the United states has shielded drug development from the usual economic pressures that would ordinarily drive reform" (2005, 815). For FitzGerald, pharmaceutical companies have been using pricing innovations to sustain profitability despite a lack of new, innovative products. Thus, my definition of TN necessarily includes systems that allow neuroscience knowledge and data to be turned into financial value, even in the absence of concrete products such as drugs and devices. My analysis shows that while existing definitions of TN are necessarily object-focused (the creation of new pills, diagnostic tests) much of the product of translational science is social, reputational, and financial.

implies the projection of basic science into the domain of clinical medicine and emphasizes the object: the discovery of new and safer therapeutic entities (FitzGerald 2005, 817)." There is another place where translational science's object-oriented emphasis (its potential productivity) appears. Scientific research articles typically conclude with a claim about clinical applications. Yet, the failure for this research to turn into application had long been a conjecture. In 2003, several researchers traced the frequency with which research findings were actually translated into clinical applications.

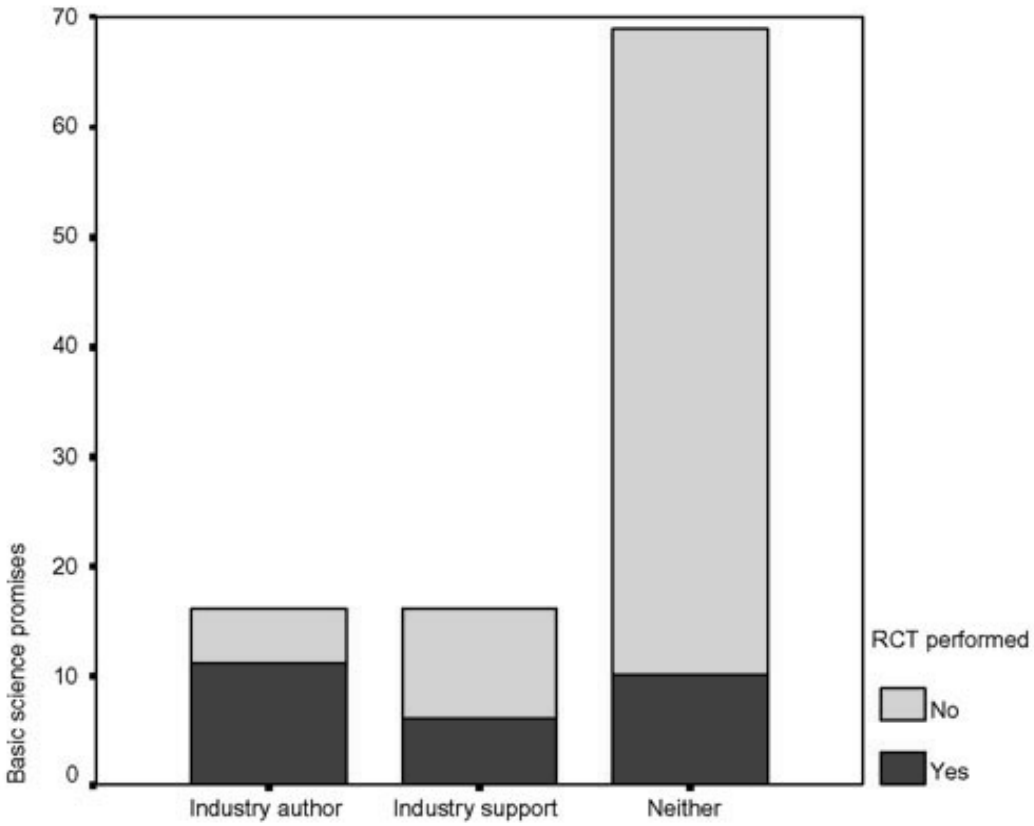

Figure 5. This table reflects a meta analysis of research publications compared against the number of actual "applications" as constituted by the creation of a randomized controlled trial (Ioannidis 2004).

The researchers screened research reports from 1979-1983 in six prestigious basic science journals and found that despite the ritualistic promise of application or the possibility thereof, few findings (Figure 5) actually turned into clinical applications

despite inspiring randomized control trials, and only one, according to the authors, materialized into a solution with major medical impact (Contopoulos-Ioannidis et al. 2003; Ioannidis 2004).

Therefore, it is the *failure* of translating research in the life sciences into safe and effective pharmaceuticals that constitutes the primary problem that translational science seeks to solve. In fact, the growth of translational science as a field and a discipline emerges out of a collective sigh of exasperation, one shared by federal agencies that fund U.S. scientific and medical research and pharmaceutical companies struggling to turn their formidable libraries of compounds into novel drugs. Accordingly, translational science must be understood as a collective promise of health applications (mostly through pharmaceuticals and diagnostics) enabled through a radical re-envisioning of science and clinical medicine. Thus, TN is also clearly becoming intertwined with health markets.

Translational medicine and translational science both index anxieties about extracting value from scientific labor and knowledge. There is also, more specifically, anxiety about the complicated specificity of the brain itself – and the subsequent anxiety that little may be actually translatable given the brain's complexity. These anxieties are similar to the anxieties that informed concerns on the part of speculators about all kinds of financial investments in 2006, when the translational shift was at the height of its institutionalization: Are federal scientific expenditures yielding an adequate return in the form of solutions to health? What about in financial returns? In the examples above one detects a polyphonous message: the anxieties that absence of new drugs provoke, especially in light of dramatic levels of investment; opportunities for commercializing IP; and the new therapeutic and financial possibilities that neuroscience envisions.

While official definitions of translational science tend to underscore opportunities and innovations in science, I found that private conversations yielded more anxiety-influenced definitions. For example, and as I referenced in the Introduction, when I asked Zack about TN, his definition focused on the "Valley of Death" (Vanderheiden and Tobias 2000) as well as its necessarily pharmacological end and starting points. For Zack translational science must "get a compound out of an academic lab, acquire initial funding, put together a small business team because you are a professor focused on translating neuroscience, getting that object out of the marketplace of ideas. That's the valley of death." For Zack it is about rehabilitating a pipeline of under leveraged assets or remedying the barriers to commercialization and thus, Zack's definition is one that is marked by anxiety and obstruction.

I also found this definitional tendency in interviews with neurotechnology industry organization members and I located it in the language used by Silicon Valley venture capitalists looking for early stage investment opportunities. Those definitions begin with a lack of new, effective drugs as the primary problem that translational science and medicine are to solve. Here they focus on the lack of new compounds for mental health compared against the enormous investment in both sciences (both federal and private).[21] The notion of shareholder value, - this sense that public investments in science ought to be thought of in financial ways - can be located in the anxiety to which translational science connects.

[21] As I have tracked representations of translational science and translational medicine, I have noted an observable rise in the number of university-based translation center websites that advertise the specific drugs they have developed – as if to indicate the *productivity* of the translational center. I take this hyper focus on the lab's discoveries as intimately linked to a set of anxieties that the translational imperative has been designed to fix.

Of course, the real problem may actually be the presumption of translatability that gets attached to much of scientific work. As discovered by many anthropologists, sociologists, and especially historians of science, laboratory work is a highly defined and prescribed context for model making (Knorr-Cetina 1992; Latour and Woolgar 1986; Traweek 1988) rendered powerful through discourses of translatability and made legible only by bringing the laboratory to the world (Latour 1983).

Presumptions of translatability have thus produced a distinct scientific problem. An essay published in 2012 in the *Journal of Clinical Studies* articulates this stance for neuroscience: "Unfortunately, the large amount of information gleaned from recent basic science innovations has had very little clinical relevance and, despite newly acquired knowledge gained on an almost daily basis, the past few years of CNS drug development have been characterized by relative stagnation. [Cutler and Riordan 2011, 15]" Yet, the growth of funding in university neuroscience research continues. Here a question emerged: Under what set of conditions does neuroscience, plagued with problems of translation from animal models as well as challenges of producing problematic data, still attract such large investments?

TN: An Ethos for Research and Application

As universities embark upon on their own pharmaceutical and biotechnological development, and as they begin to openly acknowledge "drug discovery" as part of their academic mission the "bridge" represented by TN produces questions about university workers. During fieldwork, I wondered whether the priorities of funders and the financial opportunities TN entails affect not only the priorities of research but also the ways in

which those who carry it out understand their particular research culturally and ethically. TN exemplifies the growing entanglement between academic research and market-oriented approaches toward knowledge production (Haraway 1997; Power 1999; Strathern 2000) – something discussed in much of the knowledge and privatization literature as well as literature focused on the effects of neoliberalism on scientific production. Clearly, much of modern biological research is becoming "translational" in this sense. Neuroscience, as one of the newest fields in the life sciences and despite its outcome failures, is ahead of the curve in its self-consciousness about its translational imperative.[22] TN can be a model for the translational shift – both because of the mystery surrounding the brain and because of the work pharmaceutical companies are doing to craft markets into which neuroscience innovations can be brought.

Getting to Health: The NIH and the History of Translational Science

There is a direct relationship between translation-focused funding and the growth of questions related to publicly funded science. According to Garcia-Rill, the slowdown in new patents and the rising health care costs, reflect dwindling congressional patience: "Congressional leaders, policy-makers, and the public at large are increasingly concerned that the scientific discoveries of the past are failing to be translated into tangible benefits to public health. The response has been a series of initiatives making translational research a priority." (Garcia-Rill 2012)

One challenge in tracing the rise of translational science and medicine is demarcating its conceptual emergence as a *zeitgeist*, an ethos that has gained traction at a

[22] This is partly the reason I focused on TN rather than other translational disciplines, such as translational biology.

particular moment and in a particular context, and mapping the institutionalization of translational science via discrete practices, policies, and actions. To contextualize the sociopolitical environment that surrounds the translational turn in science and medicine I provide brief historical context.

In October 2005, Elias A. Zerhouni, M.D., then director of the National Institutes of Health, provided an interview and published a now seminal article, "Translational and Clinical Science — Time for a New Vision" in the *New England Journal of Medicine*. According to Zerhouni, the NIH started in 2002-2003 to create a series of collaborative discussions with scientists, clinicians, university administrators, entrepreneurs, patients, and other stakeholders. Out of this series of dialogues, the NIH gave birth to the NIH Roadmap for Medical Research. From this roadmap, the NIH launched a new program in 2005 to fund Clinical and Translational Science Awards (CTSAs) to U.S. universities. CTSA was the funding program that gave institutional birth to university translational science and translational medicine on a large scale. In fiscal year 2013, the NIH allocated $110 million to fund up to 18 awards (see Figure 6).



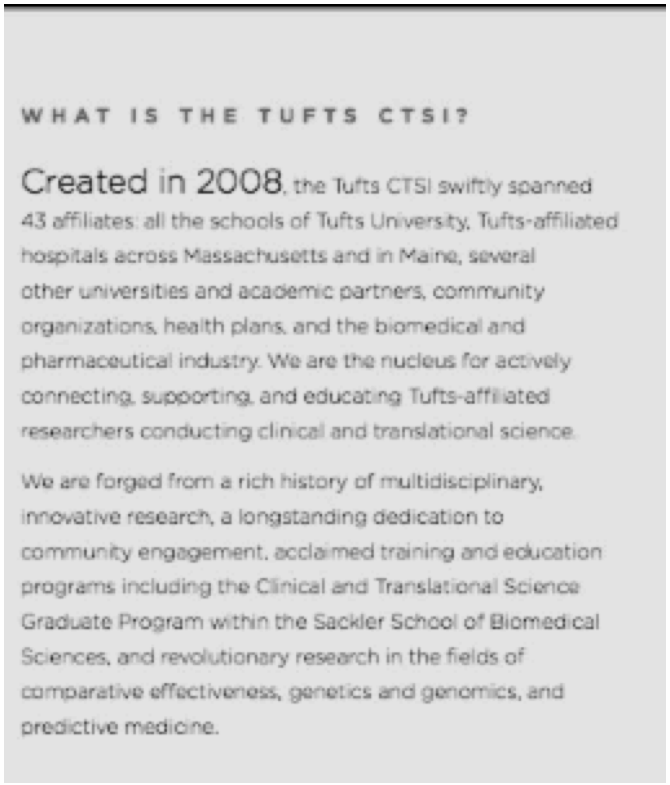

Figure 6. A Brochure from the Translational Center at Tufts University taking on much of the language from the NIH initiative.

According to Zerhouni, "We now aim to stimulate the development of a brighter vision for translational and clinical research, to ensure that these disciplines remain powerful engines of creativity. We offer the opportunity for change to those who share a vision and commitment to innovation and experimentation" (2005, 1621-1623).

Suddenly, starting from 2006-2007, universities across the country begin to erect new centers with the term "translational" therein. One finds a sudden sprouting not only of translational centers on university campuses, but doctoral training programs, new buildings, new research projects and, more important, new collaborations – all stemming from this specific program.[23]

For example, The University of Alabama formed the UAB Center for Clinical and Translational Science. UCLA created the UCLA Clinical and Translational Science Institute. These awards also facilitated the creation of multi-institution centers such as the Georgetown-Howard Universities Center for Clinical and Translational Science in Washington D.C. or The Atlanta Clinical and Translational Science Institute (Atlanta-CTSI) which is a network connecting Emory University, Morehouse School of Medicine, Georgia Institute of Technology as well as Children's Healthcare of Atlanta. These new centers produced new constituent translational programs – of which TN is an example.

These programs have created entirely novel configurations at universities: new departments, new Ph.D., programs and funding schemes, new buildings, and even the renaming of buildings. NIH's persuasive power can be seen at Tufts University in Massachusetts where funding from the NIH meant rearranging entire departments and centers to fit new funding schemes attached to translational science.

[23] http://www.ncats.nih.gov/research/cts/ctsa/funding/apply/tr-12-006.html, accessed January 2013.

This NIH program created significant change in the landscape of U.S. university research: In 2005 alone, 60 medical research institutions across 30 states and Washington D.C. were created with one fell funding swoop. . The impact of this translational shift is made even clearer because the National Institutes of Health is the largest governmental funding body of health research in the world (Ioannidis 2004). Thus, this shift represents a massive sea change regarding how the NIH institutionalizes visions for health.

Even the NIH's funding of individual translational science centers was not enough. In 2012, the NIH established its own Translational Science Center, the National Center for Advancing Translational Sciences (NCATS). According to its mission, "The Center strives to develop innovations to reduce, remove or bypass costly and time-consuming bottlenecks in the translational research pipeline in an effort to speed the delivery of new drugs, diagnostics and medical devices to patients." In essence, and with an enormous effort, the NIH created its own national research effort parallel to what it was funding other institutions to do. A priority of the NIH director, the NIH's FY 2013 budget request for NCATS totaled $639 million (out of a total of a total request of $31 billion).[24]

The creation of NCATS was momentous not only because it was the creation of an entirely new national center, but it also represented a U.S. intervention in the market via the direct licensing of its discoveries to private companies. Essentially, the NIH created its own entity to accelerate the instrumentalization of scientific knowledge. In fact, on the home page of the NCATS website the program advertises "NCATS Inventions Available for Licensing." There, an entire list of inventions from NIH

[24] http://officeofbudget.od.nih.gov/, accessed January 2013.

laboratories is available for licensing. Through NCATS, the federal government can directly partner with firms interested in investing in developing the intellectual property (IP) as well as ensure that NIH investments in science and medicine result in therapeutics. According to NCATS, "Inventions made by NCATS employees are owned by the federal government. Patenting and licensing are used to help ensure the technology is fully developed, commercialized and advancing public health."[25]

Here we see an important suturing of narratives of translational imperatives to benefits in the form of public health.[26] Importantly, it also means that the U.S government is in the business of creating assets in the form of intellectual property. Note, it is unusual to have a government agency helping broker relationships between knowledge and industry beyond mere policy such as the ever-important 1980 Bayh-Dole Act and the more recent America Invents Act. The creation of the NCATS indicates the sheer fervor at the national level to turn federally funded science into value.

Certainly, the translational shift serves a clear market need: of readying a supply chain of intellectual property around which to mobilize financial investment. However, it also addresses a central anxiety about how to ensure that the massive funding and energy expended on federal science are productive; for society, for the market, for potential patients, and for the public. Not only does NCATS compete directly with the universities that it also funds, it also represents a remedy on the part of the state designed to ensure the translation of federally funded research into commercial, medical and patient value.

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[25] http://www.ncats.nih.gov/research/tools/preclinical/patents/tech-licensing.html, accessed January 2013.
[26] The licensing occurs through The Strategic Alliances branch within the Office of Policy, Communications and Strategic Alliances. According to its self-description, it "aims to make it easy for industry and academia to interact and partner with NCATS laboratories and scientists. The branch provides a complete array of services to support NCATS technology development and partnership activities." See http://www.ncats.nih.gov/research/tech-transfer/alliances.html.

Chapter 2 / The Clinic

"We had always been focused on complementing our investments of capital into our portfolio companies with expertise, connections, and other support services to ease commercialization of the IP," Michael Hall, a partner at a prominent venture capital firm in Silicon Valley, told me in 2010. His firm has always been involved in translation, he argued. Michael shrugged his shoulders and peered out his office's large picture windows at the Presidio. The Presidio is a massive and beautiful green Park area in San Francisco that was opened up for private development and now houses a stock of residences and offices.

"It was interesting to see that the government was now pushing this too," referencing the creation of the push by the NIH toward translational research at universities. Michael further commented that the government was focused on placing commercial demands on their research portfolio in ways that he had never seen in his "many years in venture capital." He continued, "We'd always had guys who came to us looking for money and they had an idea, and they had started a small biotech thing on the side, but now I see really interesting things happening in this space [the biotech investing space] that's bringing even old investors out of the woodwork. (Interview 10, December 12, 2010)"

Michael was referring to the reluctance of some investors, especially in the San Francisco Bay Area, where there are lots of capricious investors – to continue investing in biotechnology startups. This statement from Michael also compelled me to think about the way that investors understood biotechnology in this moment of 2010. Of all of the

worlds that intersect with emerging biotechnologies, getting a handle on investor perspectives is ethnographically rare. Michael then said something illustrative about biopharmaceutical strategies: "You know, Pharma doesn't care. They are going to make their money. They have already counted cash by selling shitty new copycats or some effective marketing platform, but the little guys, we really care about the science. We can't gimmick ourselves out of the problem." Michael worked at a large pharmaceutical company before jumping to the world of venture capital. A former Vice President for Business Development, Michael was brought on staff at his current firm precisely because of his connections to startups and because of his understanding of industry trends. For venture capital firms (colloquially called, VCs) that focus on biotechnology investments, there is a revolving door with Big Pharma. Hall's statement, however, underscores what could be thought of as different investment strategies and thus, differing conceptualizations of risk. This was an important insight that I gained from my conversation. Big Pharma has the resources to leverage marketing (Applbaum 2009c) and other creative strategies to withstand psychopharmaceuticals' poor efficacy or the lack of new compounds. For Michael, who considered his multimillion-dollar VC to be one of the "little guys," the lack of innovation from neurotechnology startups was a huge problem and no amount of marketing or business strategizing could solve it. Thus, for him, good science should be the way out of the investment rut.

This conversation with Michael provides a glimpse into the industry-related terrain on which TN is fought. For pharmaceutical companies, efficacy continues to be a problem (Healy 2012; Ninneman 2012). However, because biopharmaceutical companies have created new markets (Greenslit 2002 and new profit strategies (Applbaum 2009c;

Dumit 2012a; Healy 2004; Matheson 2008; Moncrieff 2006), they achieve a critical insulation from the realities of products and patients. Michael's suggestion is that venture capital is less insulated by such marketing and must rely on "efficacious" drugs. For this reason, if for no other TN is a good thing.

One could argue that Michael's sentiments about venture capital (VS) firms were rather benevolent since small VC-backed biotechnology companies also find means of "insulation" – which is to say that they often benefit and profit from hyping and other strategies of value-creation that extend beyond mere scientific innovation (N. Brown 2003; Cooper 2008) just as pharmaceutical companies use marketing strategies to drive up revenue despite a lack of new compounds (Applbaum 2009c; FitzGerald 2005). However, Michael's statement elucidates several important issues - including how TN, if it does indeed improve science, should, therefore, also spell out improved outcomes for patients. Though seemingly obvious, the connection of good science to improvements in health is key in terms of keeping track of TN's promises.

Thus, in the translational paradigm, patients are positioned as the ultimate benefactors of this massive intellectual and organizational restart. After all, according to the NIH, the entire translational paradigm shift is about ushering in game-changing transformations in human health. In a 2005 interview then director Elias Zerhouni outlined this new direction, saying that this move towards translational science and medicine was launched as a response to a single question: "What novel approaches can be developed that have the potential to be truly transforming for human health?" (Zerhouni 2005, 1621)

The Stakes: Grand Promises for Patients and Health

I met Shana during a patient education session at the Cleveland Institute, an eminent academic hospital and research center in Cleveland, Ohio. Shana came to the session to learn more about epilepsy since her son has a particularly difficult strain. Shana attended a support group for families of children who have a clinically challenging form of epilepsy also at the Cleveland Institute. Epilepsy is a brain disorder characterized by constant seizures (convulsions) over time. In the United States, 467,711 children have epilepsy[27] the severity of which can range from mild to extreme. For those with extreme symptoms who are pharmacoresistant, clinicians may recommend surgery and other invasive therapies (Theodore and Fisher 2004).

"Jawan had been on medication for years," Shana told me. But, the drugs just didn't work. We went on this medication and that one. I was so scared, and so then they transferred us here." Once, she confided in me that she was afraid to keep hoping – a cumulative exhaustion from the constant worrying, and the constant search for answers. Shana is an African American woman in her 40s. She used to work as a home health aide until around 2006 when she lost her job at a local Ohio health worker agency.

Perpetually shy and quiet, with a young face, Jawan appeared to be much younger than his actual age. My questions to Jawan would usually go unanswered beyond a mere shrug, rarely compelling him to emerge from hiding behind his mother. Despite his age, he never uttered more than a few words to me in all of our time together. Jawan, had his

[27] National Survey of Children's Health. NSCH 2007. Data query from the Child and Adolescent Health Measurement Initiative, Data Resource Center for Child and Adolescent Health website. Retrieved 2/12/2013 from www.childhealthdata.org.

hands wrapped around her on every occasion that I saw her. He would clutch himself to her, holding his hands around her waist or around her arm.

The Cleveland Clinic has been a primary source of jobs and healthcare in the city of Cleveland – an especially salient fact given that the institution is located in a blighted and transitioning neighborhood. In fact, Cleveland Clinic sits directly on a sociopolitical boundary line. On one side is middle-class housing inhabited primarily by professionals, who often work at Cleveland clinic and on the other side are poor, blighted neighborhoods. One experiences the difference just walking from one part of the center's building clusters to the other.

The Cleveland Clinic is not only one of the largest employers in Cleveland; it is also a beacon of excellence in terms of health care, research, and education. Its federally funded research and nationally renowned clinical programs attract money into the region. Often compared to the Mayo Clinic in Minnesota, the Cleveland Clinic occupies an important political, economic role in a city that as been ravaged by the lack of high-paying jobs and political turmoil[28]. According to the 2010 American Community Survey,[29] Cleveland was the second poorest city in the United States behind Detroit.

Shana worked on and off for all 13 years of her son's life. However, the severity of his epilepsy meant that she had to be, in her words, "always on and always ready." The toll that epilepsy took on her and her family turned her into a constant advocate and a perennial participant in the research trials in neurology at the Cleveland Clinic. Jawan had not experienced a seizure in several months, but they were unpredictable. Our

[28] For more information on the disparity between the Cleveland Clinic's wealth and that of the city see Herper (2012).
[29] http://quickfacts.census.gov/qfd/states/39/3916000.html, Accessed on January 2014.

conversation, which we sometimes had at a nearby McDonalds, often centered on how desperate she was to find a solution.

In 2010, Shana and Jawan were referred to the Cleveland Clinic's well-known neurology department and active epilepsy research arm. The clinicians provided an option beyond the typical solution of antiepileptic drugs. Typically, individuals not responsive to antiepileptic drugs are considered for brain surgery. At first, Shana was excited about the possibility of it. She began to do research about brain surgery: "I really thought that this was possibly gonna' fix it and that this was going to be different. I mean it's his *brain* (emphasis hers)."

Neurosurgery for epilepsy works on the premise that performing surgery on the part of the brain producing seizures can reduce or even eliminate them. However, even surgery is not a guarantee. Some patients do not improve with surgery, and since they are often pharmacoresistant – they are at a loss in terms of options. It was at the Cleveland Clinic that Shana learned about DBS. Deep Brain Stimulation (DBS) is a special kind of brain technology in which a pacemaker like device delivers electrical stimulation through implanted electrodes attached to the brain itself. DBS is an option for patients whose condition is pharmacoresistant. Research in 2010 suggested that DBS offered a potential solution in the fight to reduce seizures.[30] The installation of the device is dramatic Surgeons create small holes in the skull to implant the electrodes and perform chest surgery to install the battery. DBS is currently used for Parkinson's disease. However, increasingly and controversially, its being pushed for use in psychiatric cases including

[30] "Deep brain stimulation reduces epileptic seizures in patients with refractory partial and secondarily generalized seizures," *ScienceDaily* March 18, 2010. Retrieved September 1, 2013, from http://www.sciencedaily.com/releases/2010/03/100318082016.htm and also "More Good News for Deep Brain Stimulation in Epilepsy," *Medscape* Dec 03, 2012.

depression and obsessive-compulsive disorders such as obesity (Fins et al. 2011; Throsby 2009). Medtronic, the device's manufacturer, has worked aggressively to expand potential markets for DBS.

DBS is often positioned as a model case for TN (Kringelbach, et al 2007), a model example of how TN might be able to affect positive health gains. And yet the technology embodies significant risks as well. DBS represents a clear two-way relationship between observations about brain functioning and the possibility of turning that knowledge into immediate therapeutic impact. It is both therapy and (when used alongside magnetic resonance imaging) a means of research. In other words, it is an avenue by which one can both manipulate neural networks in the brain in novel ways (Kringelbach et al. 2007) and, ostensibly, view the fundamental mechanisms that underlie human brain function. In this regard DBS can be used to learn about the relationship between disease and brain states.[31]

Jawan's physicians presumed that he would be a good candidate for DBS, but Shana, who had researched the possibilities independently, had concerns. She said, "Even the testing required to know if Jawan would be a good candidate [for DBS] sounded scary. They called it invasive testing and they'd open his brain up. The doctor says that there's research and that the testing is worth it if we ended up using DBS."

Then, Shana leaned in to share something with me. During this discussion, Shana and I were sitting in the foyer of one the newest buildings on the Cleveland Clinic's campus. A minimalist seating area with white floors, white walls adorned with light

[31] In fact, the History of DBS, as a method emerges from an accident whereby stimulation in animals was seen to have an unexpected clinical use possibility. Early enthusiasm for this capacity led it to be used in the 1950's for the treatment of neuropsychiatric disorders," a method often known as Shock Treatment. (Kringelbach et al. 2007).

colored art, and modern indirect fluorescent lighting. The result was a space that was both calming and sterile, somewhere between an art museum gallery and a laboratory. At every corner, there were hallways that led to various parts of the hospital but the space was acoustically muted.

While close to me, Shana revealed that she didn't feel the clinicians were certain about whether DBS would fix things. She said that the neurologist confided that although DBS could be beneficial, the testing, which requires invasive probing using depth electrodes on the brain, creates its own risks; a process too risky if not offset by benefits of DBS. In other words, the testing itself can compromise one's health status.[32] Thus, even the *information* needed to determine the suitability of DBS (and its risks) was risk-laden.

I learned more about this during a symposium at the Cleveland Clinic that I attended on October 3, 2010. During one session, Imad Najm, leader of the Cleveland Clinic's Epilepsy Clinic said, " I try to balance the benefits with the negative" when thinking about the consequences of invasive brain testing. During his presentation to the audience, he posed the following question: "Are these things worth the risks that we're taking?" Of course, the question of risks produces new questions: about risks for whom, about the temporal contingency of risks, about risks and patient experience.

[32] The rhetoric attached to TN includes an even more acute set of promises and potentials than the already promise-laden imaginaries attached to the biomedicines and biotechnology (M-J. Good 2007). Thus, while TN includes a revamped set of promises, the reality of the enterprise includes increased risks (particularly because patients are brought into the discovery pipeline earlier). In fact, the translational narrative enables the combining of therapy and research – creating further risks for patients\subjects and potentially minimizing negative side effects under the aegis of research. Scholars have made note of this increasing conflation and it ethical consequences (See Fischman 2011). Interestingly, the subsequent potential for increased risk is not part of the narratives of TN.

Several presentations at the symposium – attended by neurologists, neurosurgeons, and nurses, underscored an unspoken lack of information on potential risks for patients and for physicians. The risks include electrical toxicity from the electrodes and lesions on the brain at the site of implantation. In fact, this procedure created risk for brain damage. As a new therapeutic option, DBS for epilepsy represented a clear example of how increased knowledge of the brain, especially in terms of diagnosis, translated into potential health gains but also into significant risk (Kringelbach et al. 2007).

While considerations of how much to share with patients was mentioned, the symposium was focused largely on how much was simply *not known* – about DBS, about invasive testing, and about the brain itself. Mark Bernstein, a neurosurgeon and oncologist, articulated the dilemma this way: "We do so many things and make so many decisions without class 1 evidence and in neurosurgery, its [something like] under 10 percent of decisions [are] made with class 1 evidence for stuff that we do and its an ethical blight on neurosurgery." This ethical blight includes the "deception" that occurs in hiding the *actual* information-ambiguity undergirding clinical decision-making from patients and from the public via narratives of evidence-based medicine or in the medical promises of big data. Beyond sheer deception, the ethical blight encompasses countless risks neurosurgeons take amidst a dearth of empirical knowledge. During the same symposium, Steven Schiff, a neurosurgeon and professor at the Cleveland Clinic stated, "We don't think about the biology of placing soft material onto the brain." Schiff ended with the suggestion that risk benefit analyses should "incorporate greater knowledge of biology."

Thus, the risks of invasive testing for DBS and the many questions that exist around this technology emerged as a primary theme. Toward the end of the first session, one audience member posed a question to everyone in the room, "What happened to the most severe patients who chose not to do the surgery or who were not approved?" A second person posed another question: How do we know what works in the absence of data from alternative therapies? How does a lack of biological knowledge create specific new risks? Given the vast unknowns about what DBS actually does in the brain or about how the brain truly and precisely functions under stimulation, DBS is *an uninformed performance*. It was in this space that I began to think about feedback between knowledge and biotechnologies. In other words, I am concerned both with the knowledge that created this technology and also with how this technology creates knowledge.

DBS, first marketed in 1997 is an early example of a successful neurotechnology and it was produced and commercialized by the large biotechnology firm, Medtronic. Medtronic is a major player in biotechnology device research and design and a major player in the area of drug-delivery devices. Despite being approved in 2009 for the treatment of Parkinson's, Medtronic pushed DBS toward additional markets, including epilepsy. Problems regarding DBS for epilepsy appeared early: In 2010, the Food and Drug Administration (FDA) raised concerns about the safety of the DBS device and a clinical study failed to prove that patients using the device experienced fewer seizures than those in the control group (Lee 2010). As a result, the FDA voted against approval in 2010 as a treatment for epilepsy. Its use in the United States became investigational, while it was approved for wider use in Europe, Australia, and Canada (Walsh 2013a).

Risk and Exemption

In May of 2013, the FDA cited a Medtronic device (Cortez 2013) for flaws related to their installation and issued its highest priority class recall.[33] My interlocutors – both biotechnology investors and people recently employed at Medtronic's Silicon Valley location -- didn't seem to bat an eye during phone calls about it. John Chen, someone with whom I developed a relationship years of attending the industry conferences told me that there had been rumblings for a while about "the wires in those devices."

So, if DBS failed to get approval in the United States in 2010, how could it have been offered as an option to Shana and Jawan later that same year? The reason is that Medtronic applied for and received a strangely named exemption from the U.S. Food and Drug Administration (FDA) called the *Humanitarian Device Exemption*. Under the so-called Humanitarian Device Exemption (HDE), companies like Medtronic bypass the normal FDA requirements for clinical trials using standard measures and size in order to benefit smaller patient populations. The HDE program is the device-focused counterpart to the Orphan Drug Designation program (OOPD). Both OOPD and HDE are administered under The FDA Office of Orphan Products Development. Since its inception, the FDA's Humanitarian Use Device Program has enabled first step approval for more than 50 technologies (Food and Drug Administration n.d.).

To understand the exemptions and context of HDE, I provide an excerpt from the Food and Drug Administration program description that outlines the mission of the FDA Office of Orphan Products Development (OOPD):

[33] Also, it is important to note that all clinicians may not share the sense of urgency that the FDA applied to the recall. There were clinicians who disagreed with the alacrity of the FDA recall. For more, see Walsh (2013b).

> *The FDA Office of Orphan Products Development (OOPD) mission is to advance the evaluation and development of products (drugs, biologics, devices, or medical foods) that demonstrate promise for the diagnosis and/or treatment of rare diseases or conditions. In fulfilling that task, OOPD evaluates scientific and clinical data submissions from sponsors to identify and designate products as promising for rare diseases and to further advance scientific development of such promising medical products. The office also works on rare disease issues with the medical and research communities, professional organizations, academia, governmental agencies, industry, and rare disease patient groups. OOPD provides incentives for sponsors to develop products for rare diseases. The program has successfully enabled the development and marketing of more than 400 drugs and biologic products for rare diseases since 1983. In contrast, fewer than 10 such products supported by industry came to market between 1973 and 1983. The [more targeted] Orphan Grants Program [within OOPD] has been used to bring more than 45 products to marketing approval.*[34]

The primary goal of OOPD is to advance development of products through the creation of incentives. In the description below, taken from a symposium report on HDE (Kaplan et al. 2005), note the efficacy-related exemptions and importantly the role of HDE (sometimes referred to as Humanitarian Use Devices or HUD) in the creation of a pathway toward an otherwise complicated market access:

> *The HUD/HDE pathway was created by Congress to facilitate the availability of medical devices for "orphan" indications, i.e., those affecting <4000 individuals within the United States each year. The HUD/HDE pathway streamlines the approval process and permits less well-characterized devices to enter the market. HDE approval focuses primarily on issues of safety and scientific soundness and does not require demonstration of efficacy. In the 7 years since the first device was approved in 1997, a total of 35 HDEs have been granted (23 devices, 6 diagnostic tests). As the costs to gain regulatory approval for commonly used devices increase, companies often seek alternative ways to gain market access, including the HUD/HDE pathway.* (Kaplan et al. 2005, 502)

The FDA created the HDE to incentivize companies to bring biotechnologies to market for populations too small to make such investments financially worthwhile for

[34] http://www.fda.gov/AboutFDA/CentersOffices/OfficeofMedicalProductsandTobacco/OfficeofScienceandHealthCoordination/ucm2018190.htm.

pharmaceutical and biotechnology companies. This mode of *sidestepping* or *fastracking* constitutes a utilitarian version of ethical variability (Petryna 2005), which, in the case of the DBS device for refractory epilepsy, exploits the "problem" or crisis of a small market size as a justification to allow device developers and manufacturers to bypass risks of clinical trials. This illustrates the framing of medical issues as market problems that inhibit biotechnological innovation. It is only within such a frame that recognition of small market populations makes sense.

The very naming of this regulatory pathway, The *Humanitarian* Device Exemption (HDE), and perhaps, even the naming of the Office of *Orphan* Products Development invites questions about whether this pathway reflects what French anthropologist Didier Fassin calls humanitarian reason (Fassin 2012). Fassin uses this concept to make sense of political substitutions achieved through the mechanics of compassion created by and authored in the name of humanitarianism. In Fassin's case study he discusses the special status accorded to *children* with AIDS in South Africa. Similarly exceptional subjects are reified and invoked in the case of HDE as individuals suffering from "rare diseases." In both cases compassion can be operationalized within the given cultural context in order to enable access to special kinds of exemptions. Following Fassin, I ask whether these appeals to compassion supersede appeals to morality, justice, and other rights.

In an analysis of the moral machinery of HDE the notion of "humanitarian reason" is most useful because of the way it traces the mythopoeia that surrounds intervention. Humanitarianism enables important social and political obfuscations: In Fassin's case study, he shows that the sentimentalization of children with AIDS caused a

reification of those subjects in ways that expunges sociopolitical contextualization of the very circumstances deserving of intervention. Thus, humanitarianism allows one to aestheticize compassion "at the same time as implementing policies that increase social inequality" (Fassin 2012, 2).

The relevance of this element of humanitarianism's functionality for HDE is multifold. As scholars have chronicled (Biehl 2007; S. Epstein 2009; Martin 2007), NGOs, patient/activists, communities, detractors have fought for resources that are reflected in present-day interventions and programming such as those created at the National Institutes of Health and the Food and Drug Administration. The activities of such groups were especially important in achieving federal recognition for AIDS in the United States and in securing AIDS research funding.

Yet, that HDE is positioned as a solution to the problem of orphan diseases conceals larger system issues. Rather than thinking with the FDA terms, *orphan drugs* or *vulnerable patient populations*, policy makers and clinicians also think with the term, *market segments*.[35] [36] As HDE is an intervention built upon the need to create incentives for private companies to invest in the development of biotechnologies for smaller market segments, HDE reveals the way that market logics become the means by which biomedical interventions are justified, structured, and organized. The very nature of healthcare corporatization produces the conditions that render this form of regulatory exception to be enunciable in the language of humanitarianism.

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[35] Not only is the regulation controversial, it's also subject to misuse by biopharmaceutical companies. Critics (Fins et al. 2011)[35] point to the fact that data gathered through this use can still be used for the marketing of the intervention, during a second appeal to the FDA for approval, or for marketing of the product in different countries.

[36] This linguistic slight of hand is similar to the linguistic shift between "immigrant" and "foreigner" that Fassin locates in his analyses the discourses of public medical officers in the département of Seine-Saint-Denis in Paris' Île-de-France. For Fassin

The case of orphan drugs illustrates how moral sentiments emerge from the needs of market logics (Biehl and Petryna 2011) to create neoliberal states of exception: bypassing patient protections in order to incentivize risk-laden research. The issue of transferring risks onto patients and even, in the context of the FDA, onto the "public" in the name of health brings up questions about the public-private in governance/regulation/protection.

Shana ultimately declined the DBS option (and thus, the testing) for Jawan. She offered many reasons, however, principal among these was the lack of long-term research about the safety of DBS. The speed of biotechnology innovation and its implications for Jawan's safety were a source of anxiety. While I focus more closely on risk as produced in relation to the financialization of health and its connection to TN in Chapter 3 and 4, this example lays out here the relationship between risk, uncertainty, the complexity of brain disorders, and treatment decisions.

As evidenced in Medtronic's own clinical trial data (Lee 2010), DBS for epilepsy presents a risk of harm not only from the testing and from the device itself but also from a series of profound lacks - including an admitted lack of knowledge about how DBS works in the brain (Montgomery and Gale 2008), questions about the unknown impacts of neurosurgical interventions for epilepsy, and relatedly, a massive gap in knowledge about brain function. Beyond a simple issue of knowledge and non-knowledge, interventional neuroscience runs into the problem of the *unknown* unknowns, what is sometimes called, ontological unknowns or risk[37]: For example, what issues about the

[37] This production of epistemic risk a my principal argument about TN, TN may produce ontological and epistemic risk, precisely by virtue of the fact that it closes down knowledge avenues. In the way that TN acts specifically upon knowledge pathways, its produces a specific kind of risk This issue of the risks

interaction between DBS and devices *should* be known? What questions exist that clinicians don't even know to ask?

Here a potentiality emerges: Is the danger of DBS *enmeshed* with the potential prematurity of DBS as a brain-based biotechnology? Indeed, clinicians are always charged with balancing risks against potential benefits of a given therapy. However, what about the risks engineered into the very therapeutics that becomes part of clinical practice? Can a technology be seen as actually *containing* these gaps in knowledge about brain function, about epilepsy and its neuroanatomical signatures or an incomplete understanding of the disease? This case of Jawan and Shana created questions for me about whether TN, because of its focus on accelerating basic science research toward biotechnologies, injects neurotechnologies with these sorts of gaps. One might interpret the push toward brain-based biotechnologies despite the given knowledge problems as important evidence of risk in the context of translational science and medicine and even in the context of biomedicalization.

In their work, *Risk and Culture* (1983) Mary Douglas and Aaron Wildavsky highlight how risk is not merely the natural response of individuals and collectives to a lack (or overabundance) of information and that there is more to the process of risk selection and perception than presence or absence of information regarding harm. Importantly, they outline the way in which risk perception invariably involves social processes and values, thus de-naturalizing risk as somehow inevitable, uncontrollable, and natural. Existing risks often entail a complex of prior decisions, preparations, or the

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engendered into knowledge forms and the impacts upon health has been a focus of scholars thinking about the role of data and specific kinds of evidences in global health (Adams 2013; Biehl and Petryna 2013; Fischer 2013).

lack thereof. A constructivist view of risk enables one to see how risks emerge from decisions about knowledge and non-knowledge.

While DBS has had a measurably positive impact for some patients with more intractable forms of Parkinson's disease, for example, the same cannot be said for the use of DBS with epilepsy. Taking the known knowledge problems together - including incomplete knowledge of how DBS works neurologically, the outcomes of Medtronic's own problematic clinical trial of DBS, and problems that clinicians elucidated during the 2010 Cleveland Clinic symposium about the general dearth of basic neurobiological understanding, this should not be surprising.

In thinking about all of the problems made evident about DBS for epilepsy, the development and of DBS for epilepsy *despite its problems* and especially its *advancement* in the form of its clinical and patient circulation suggests that DBS for epilepsy must be thought of as a material enactment (especially on the part of Medtronic) of *non*-knowledge or *incomplete* knowledge. Thus, the rapid development of DBS for epilepsy imports the risks of incomplete knowledge into biotechnological forms.

Given that DBS is touted as a model form of TN (Kringelbach, et al 2007), similar questions must also animate thinking about the structures that underlie translational science and medicine. How might this material paradox - of unstable/ problematic/"early" knowledge and its accelerated objectification in the form of biotechnologies - and TN's orientation toward this paradox - impact patient risk? Thinking with constructivism, one can begin to trace the dynamic and epistemic materialities at work in TN's outputs. In other words, the case of DBS engenders a need to examine about the particular ways and means through which translational research is

especially *conducive* to epistemic forms of risk, meaning risk that is intertwined in the production of knowledge.

Further complicating the issue of risk is the indeterminacy introduced by the inherently communicative nature of translational science (Davies 2012) -- composed of scientific, social, technological and material processes in interactions that create a field of potential fissures and mistranslations. In his essay, "Lively Biotech and Translational Research" anthropologist, Michael M.J. Fischer identifies the many meta translations embedded "…across science fields and technological scales: from bench to clinic, … from green fingers to stable techniques and scalable production; and from experimental therapy to standards of care…" (Fischer 2012, 388) At every point of biological, material, and social translation, the opportunities for risks are born; inevitably part of the emerging worlds (Fischer 2003) at work in contemporary knowledge societies.

One useful example of the way that translational science is a particularly conducive space for the production of epistemic risks is pharmacology's reliance upon the research mouse. Similar to *drosophila*, the research mouse is an essential experimental "stand-in" for the human. Of course, this cross-species translation is highly fraught -- a known problem among scientists and policymakers. In his research on the epistemic and spatial roles of the humanized mouse in translational research, Gail Davies (2012) recounts a useful contemporary example of the risks inherent in presumptions of corporeal and environmental equivalence:

> *Periodically, an event dramatically reveals the gap between experimental model and human corporeality. The most recent was the catastrophic failure of pre-clinical safety trials at Northwick Park, in north London, in 2006 …The trial was testing a drug, itself a humanized monoclonal antibody, being developed to treat leukaemia and rheumatoid arthritis. The drug had been tested on mice, with no adverse consequences. Yet the first introduction of a small dose of this compound*

> *into humans produced sudden and systemic organ failure in all six trial participants not taking the placebo. Monoclonal antibodies are biotherapeutics that bind to specific cells in the patient's body. They are not the therapeutic agent themselves, but stimulate the patient's own immune system to attack the targeted cells. In this trial, the participants' immune systems overreacted, attacking the body indiscriminately in a so-called cytokine storm. The drug was removed from development, the failure of the trials investigated, and the six men warned to expect a lifetime of health problems.* (2012, 132-133)

The importance here is that TN's impact upon laboratory practices can also exemplify the presumptions of equivalence that can constitute precise examples of a breakdown in the translational continuum. Yet, TN can also exemplify how knowledge enfolds epistemic risks and how interventions such as DBS for epilepsy rationalized on the basis of incomplete knowledge contain these risks:[38]

> *The mice used for safety testing, kept in sterile laboratories, had not had the same immune challenges as the human trial subjects. Their inexperienced immune systems did not react. In humans, the memory of past infections contributed to the detrimental response. The species, but also the spaces, were not representative.* (Davies 2012, 133)

A social constructivist/denaturalized view of risk provides a useful way to view not only increased risks from potentially premature biotechnological development, but also risks that emerge from the kinds of exceptions provided to experimental biotechnologies via Humanitarian Device Exemptions. It suggests that creating

[38] For a more specific example, Medtronic, the biotechnology company that developed DBS devices, had aggressively tried to rebrand DBS devices as an option for epilepsy (MacDonald 2011) and increasingly, for psychiatric disorders - a move that recently garnered controversy. However, while pushing "off-label" use of existing compounds and drugs is a common revenue strategy for Big Pharma (Kesselheim, Mello, and Studdert, 2011), the promotion of off-label use also represents a context in which large gaps in knowledge (such as the effects of how one drug used for a disorder for which it was not tested) are folded into new biotechnological solutions and which produce enormous kinds of new patient risks (Dresser and Frader 2009). A social constructivist (Boholm 2003) and/or denaturalized view of risk provides a useful way to view not only increased risks from potentially premature biotechnological development, but also risks that emerge from the kinds of exceptions provided to experimental biotechnologies via Humanitarian Device Exemptions. It suggests that creating biotechnologies based on problematic knowledge *is already* a social decision about risk. Here we can think of this social tableaux as one that is composed of bioengineers, investors, patients, clinicians, and regulators - all implicated in an ethos in which biotechnologies get understood as the most important means of intervening in health.

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Lastly, the example of the Humanitarian Device Exemption shows how innovation in biotechnology often relies in practice on systems of *transferring* risk. In the case of DBS for epilepsy, the Humanitarian Device Exemption (HDE) enables risks to be passed onto patients via the exemption for a clinical trial; risk is transferred from the biotechnology company onto the patient and therefore the public. While the ethics of HDE are attracting scholarly attention (Alpert 2011; Fins et al. 2011; Peña et al. 2007), there is little conversation about how TN engenders all kinds of new risks – including those for patients. Here questions emerge about how TN might uniquely structure and restructure risk as part of the rush toward commercialization and how the ethos of translation may resignify these risks. As biotechnology companies are able to use HDE exemptions as part of a business strategy (Fins et al. 2012) this brings into question how transferring risk (to patients in the case of DBS for epilepsy) can be the bedrock upon which a new mode of biotechnological innovation, a global turn to pharmaceuticalization, and increasing corporatization of health rely.

Risk and Translational Thinking

Lastly, there is something instructive in the "technological drama" (Pfaffenberger 1992) surrounding DBS and epilepsy in terms for *thinking* about risk and biomedicine. Shana's own thinking - which was not immediately about technological and medical

possibility or the biomedical promises that haunt preoccupations of biomedical futurity, but rather, about her concerns about Jawan and his safety led me to several questions.

The first is about the conceptual worlds enfolded within the practices of TN. Is risk essential to the experimental system upon which commercial neuroscience innovations rely? Rather than a mere product or byproduct (in the optimistic view), is there a more deliberate configuration not necessarily willful, but inherent in the interstitial actions, inactions, and microactions that are part of planning and designing?

A second issue is about how TN operates as a "vision" that does not begin with experiences of patients. It brings into view the thinking that informs TN and which impacts its output. Figure 7 represents what could be considered a conceptual archive created by the University of California, San Francisco's Clinical and Translational Science Institute. The graphic instantiates one institutional vision regarding the translational continuum and its constituent parts. It shares with other institutional visions its molecular starting point. Therapeutic targets refer to the biological targets that are or can be manipulated toward a therapeutic effect. Even in this model, one sees the articulation of therapeutic or pharmacological thinking. Pharmacological or device-based endpoints are the pretext from which research designs are initiated. The productivity of investments in research programs get measured in terms of the "efficacy" embedded in translational progressions such as this one. Legal preparations for commercial collaboration are framed in these terms and experimental questions are developed within the same frameworks. The challenge here is that these endpoints are not self-evidently the same as better health, that is, unless that which is currently understood as health is evolving.

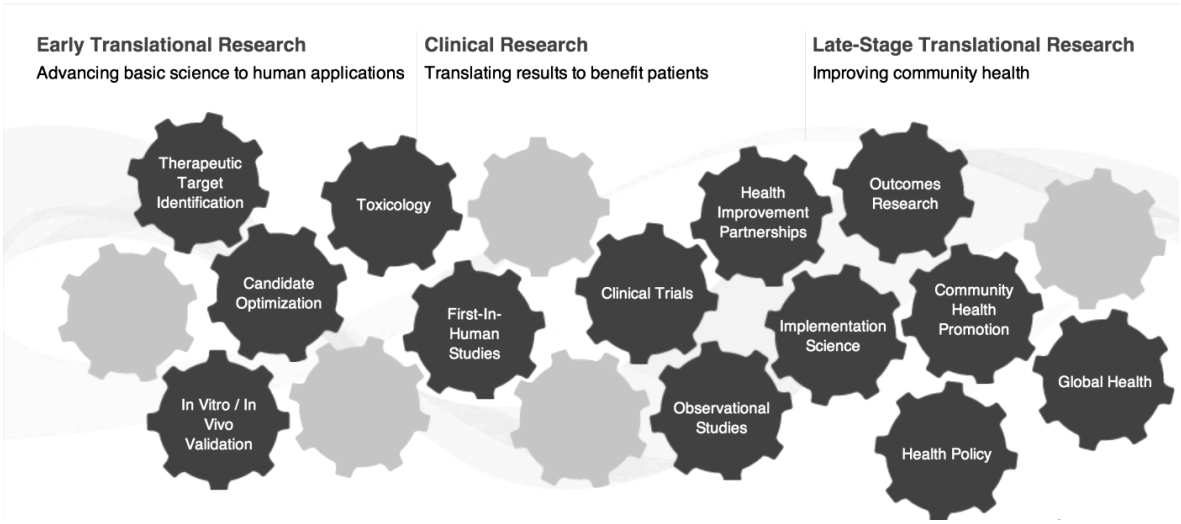

Figure 7. UCSF's Clinical and Translational Science Institute's interactive Graphic. This image, a screenshot from UCSF's Clinical and Translational Science Institute outlines the relationship between all of the disciplines and stakeholders that are part of the translational research continuum. This also represents an elucidation of the various stages in research, product development, and applications. See http://ctsi.ucsf.edu/our-work. Accessed January 5, 2013.

Nevertheless, this pharmacological or therapeutic pretext not only constructs the very objects of investigation, it also constructs its subjects. In Figure 7 one sees a literal configuring of inputs and outputs. Although part of the stakeholders, one notices a dearth of community and patient-input at the early stages within this model of the translational continuum. Translational research as depicted here begins with *hypothetical people* or, as I suggest later, partial subjects, whether via transgenic imaginations at work in the use of humanized mice models or in the elision of patients/people at the outset of the translational continuum.

In some ways, translational research works through a set of critical constrictions -- a winnowing down of research questions and agendas (Jogalekar 2012); a closing of non-application focused federal funding (Reed et al. 2012); a narrowing emphasis on the therapeutic wing rather than the entire research and development process, including basic science (Minogue and Wolinsky 2010) and implementation science (M. Solomon 2010);

a focus on fewer questions; and importantly, an acceleration of the discovery processes toward clinical trials (Garcia-Rill 2012). Such constrictions and their subsequent knowledge pathways are part of the sorts of mistranslations that occurred in Davies's example about the failure of pre-clinical safety trials in north London in 2006; knowledge constrictions or constructions[39] that, in the latter example, informed assumptions about the translatability of human immune systems and that of humanized mouse models.

I invoke this not in order to simply or naively critique the known problems at work in the reliance on animal models in biological research. Rather, I invoke this example in order to pose the question: what other kinds and forms of stand-ins are at work? What logics and omissions are enclosed within the translational imaginary? How do such knowledge enclosures become embedded and mythologized in translational science's products? In a context in which molecular "therapeutic targets" are its primordial starting place, translational science can be understood as producing moral worlds - of placement and displacement, reification and sidelining, of temporal expansions and compressions.

The Clinical Side of Translational Neuroscience

Though it is rarely touted, one important element of the translational imaginary is the "bedside-to-bench" translation. As one NIH departmental director Francesco Marincola wrote, "Translational research should be regarded as a two-way road: Bench to Bedside and Bedside to Bench" (Marincola 2003, 1479). In the founding editorial of the

[39] In a case of digital irony, my word-processing autocorrects constrictions and turns it to constructions.

new *Journal of Translational Medicine*, Marincola wrote the following about the role of clinical medicine in the translational process:

> *The purpose of translational research is to test, in humans, novel therapeutic strategies developed through experimentation. This concept is so popular that Bench to Bedside Awards were developed within the NIH to encourage collaboration between clinicians and basic scientists across institutes. But a more realistic approach would be to encourage opportunities to pursue Bedside to Bench research since our understanding of human disease is still limited and pre-clinical models have shown a discouraging propensity to fail when applied to humans. Translational research should be regarded as a two-way road: Bench to Bedside and Bedside to Bench… Bedside to Bench efforts have regrettably been relegated to a Cinderella role because the scientific aspects are poorly understood by full time clinicians and the difficulty of dealing with humans poorly appreciated by basic scientists.* (Marincola 2003, 1479)

Marincola's acknowledgment about the actual difficulties of bedside-to-bench influence inspired several questions for me about the experience of clinicians working at the intersections of patient medicine and biomedical research. Anthropologist, Michael M.J. Fischer chronicles the insights of Harvard medical scientist, Judah Folkman, whose research on angiogenesis enabled the creation of several tumor therapies. In a piece on translational science, Fischer recounts Folkman's sentiments about the ever-changing context that surrounds the physician-scientist subject:

> *…today the increasing difficulties of maintaining the dual career of physician-scientists, and the disjunctures caused by new discoveries …[come] increasingly from basic scientists without much clinical experience and unaware of many important clinical clues. It is no accident that angiogenesis research [the discovery for which Folkman is most noted] began in a surgical laboratory (his), not in a molecular library. In a molecular laboratory, like that of his good friend Robert Weinberg, he joked, one thinks of the life of cells that are flat, while surgeons like himself think that cells are crowded like they are in cancer tumors.* (Fischer 2010, 339)

Thinking with this excerpt, one is brought to the epistemological and pedagogical proposal being made about environments. Certainly, one's location in relation to patient

subjects informs one's conceptualizations and practices. As Lesley Sharp chronicles in her ethnographic work about bioengineered prosthetics (2011) and devices (2013), the sheer distances between bioengineers and the worlds of patients creates a critical and defining distancing. Discussing the work of prosthetics bioengineers, Sharp suggests, "[u]nlike the transplant surgeons who will, in the end, employ their devices, bioengineers rarely enter cardiac wards peopled with bedridden patients" (2011, 4).

For Sharp, this isolation translates into a practice: "…social isolation from patients enables bioengineers to think abstractly about organ design and privilege 'hardware' over 'software' – that is, to foreground device concerns over implantees' lived experiences" (2011, 4). Sharp's analysis mirrors the ethnographic impulse about the pedagogies that uniquely emerge from ethnographic locations as well as the influential cautions of feminist epistemologies such as standpoint epistemology (Harding 1993), regarding the situated nature (Haraway 1990; Keller 1995; Longino 1990) of all knowledges. Not only are presumptions a part of the design of innovations, but absences and omissions are also similarly embedded. Because TN does not start from patient experiences, there is a similarity in the way that these *distances* inform the designing of TN as an intervention.

Because of this question about the relationship between an "innovation" and the peoples most impacted thereby, the need arises to understand the clinical register. I wanted to learn about the ways that clinicians working within the sphere of brain-related illness make sense of the increased push toward the translation of neuroscience research into value for patients. I wanted to learn about the spaces where these therapies are rendered useful or usable. As clinicians are at the site of patients, this experiential

knowledge was supposed to become a recursive flow of clinical data that would, according to the model, inform the development of therapies. Thus, I also wanted to learn about the clinical spaces attached to TN because, under translational medicine's bidirectionality, the clinic is to be turned into a laboratory.

Given their implication in this translational context and in thinking about the importance of social location and practices, I wanted to learn more about the experiences of neurologists and neurosurgeons. However, every neurosurgeon I approached flatly refused. I approached surgeons at several sites - all working with DBS. Given the high levels of anxiety around DBS for epilepsy, their anxiety makes some sense. However, using several personal networks, I was able to interview two neurologists.

Conversations with a Neurologist

One prominent young neurologist, recently promoted to the head of neurology at a major American hospital on the East Coast offered to share her experiences about the clinical realities of trying to integrate a shifting environment upon everyday clinical practice. For Dr. Jones,[40] helping people was a major part of her decision to become a doctor. Working as physician-scientist as an academic hospital at a prominent university hospital, she was ambitious, sharp, and busy. I asked her a question about the translation of neuroscience from scientific laboratory to clinical spaces:

> *There are two problems: one is with animal research and the brain -- thinking about the brain as a complex organism. So therapeutics that are targeted at those models may not necessarily work the same in a human brain and sometimes it doesn't work in the mouse brain. The other is translating an effect in the laboratory to an effect clinically. I can think of drugs that have been proven*

[40] A highly visible and well-known neurologist, "Dr. Jones" requested that a pseudonym be used.

> *clinically to have a minor effect on the way that dementia progresses but in reality it's not very significant.* (Interview 08, May 29, 2010)

This problem of animal-human translation was a narrative that several stakeholders repeated -- from physicians to bench scientists as well as executives at biotechnology firms. Yet, the physician-researcher subject is also a role that is fraught and complex. Jones explained to me the complexity of working as both a physician and researcher. During our conversation, she explains how the translational imperative impacts her research work:

> *I think that maybe in the past we were driven by one's own curiosity and you didn't have to come up with products for a paper or have a goal in mind for research and now a lot of it is financial; you have to be thinking about how am I gonna' translate this for something that I can do for patients -- and that's a difference, because of the lack of funding and resources, people are having to come up with something for their research. [Before] there was more intellectual freedom but discovery wasn't necessarily the goal.* (Interview 08, May 29, 2010)

I asked her about whether her research had impacted her own practice thus far. Had she found a relationship between her own personal translation focused research activities and the way that she practices neurology. She said that she had not felt an impact. I was thinking about the bedside-to-bench translation that was to be a solution to the problem of the clinician-scientist gap. Then, while thinking, she modified her answer. She explained to me that scientific discourses did in fact impact the clinical experiences of patients. For Jones, science was useful as a means of garnering trust via the authentications of expertise. She explained this further by elucidating the way that neuroscience has been able to be a source of clinical explanation and a means through which to compel adherence on the part of patients:

> *I think without knowing the why of a disease, you can't … it's very hard to have a viable field and viable practice and patients' trust, with not really knowing the why of a disease. In talking to patients they are a lot more impressed and more likely to follow recommendations if they [the physicians] say, "this is what you have" and "this is what's causing it." In the past we didn't know why and so now you are able to deconstruct a lot more. Its really, really critical for the field of neurology to continue to advance and without neuroscience it wouldn't be able to advance in the way that it has.* (Interview 08, May 29, 2010)

As she framed a sort of pre-neuroscience neurology, I was interested in her use of the term, *deconstruct*. I took this to mean a discursive deconstruction. The expertise-comfort that Jones refers to here mirrors the way that scholars have mapped the affective function of biomedical discourses. The soteriological element at work in Western biomedicine, which scholars such as Byron Good have chronicled in his thinking about medicine and rationality in Western medicine, arrest both the category of health and the roles of biomedicine's practitioners (B. Good 1994, 86) in ways that tie patients to desires for understanding and faith in the larger biomedical enterprise.

Yet, as Jones continues to expound, she begins to articulate the ways that the value that she had just articulated, values predominantly about information and explanation, are not the same as improved therapeutics and better outcomes. The complicated role of information in the biomedical encounter is made clear in the complicated morass of diagnostics. Verging toward a more discursive frame, she continued to think through and deconstruct the impacts of an increasing emphasis upon diagnostics for her practice:

> *The cost of certain technologies is a problem and even though now we're able to make a different diagnosis, it doesn't change what we will do, we spend a ridiculous amount of money diagnosing something and the outcome for the patient isn't any different and that is a biggest [sic] issue. There's more emphasis on diagnosis and not more [emphasis] on treatment. We're able to have an exact diagnosis, but a lot of healthcare dollars are going where it isn't changing the outcomes.* (Interview 08 May 29, 2010)

Here we are brought to think about the effects of the corporatization of healthcare as it meets the utilization of the life sciences in clinical practices. After thinking a bit, Jones then delved into greater detail about the kinds of diagnostics that are part of her everyday clinical practice: "We do different kinds of neuroimaging as well as different kinds of antibodies for different diseases and we didn't have the antibody test before. These are the two biggest and we spend a lot of money on the diagnostics MRIs, fMRI, and we send blood tests to all kinds of places because those things are now available."

Taking her statement about availability literally, I realized that diagnostic testing increases simply because of its mundane availability. I also came to realize how a technical orientation toward therapeutics increases the usage of technologies, even when the outcomes may not be necessarily and demonstrably improved -- an issue that several scholars working on neurotechnologies have highlighted (Joyce 2008; Kesselheim, Mello, and Studdert 2011; Leibing 2009). Increased diagnostic testing and diagnoses bereft of tangible benefits in terms of patient outcomes may connect with what Joseph Dumit calls, Surplus Health, which he defines as a means by which biopharmaceutical companies profit from prescription maximization without a necessarily ensuring benefit for patients (2012a, 155).

Indeed this trend reflects the accumulative nature of pharmaceuticalization and thus, it is unsurprising to have massive new knowledge infrastructures alongside, as Jones reported, little shift in terms of outcomes. In Dumit's suggestion, science infrastructures are turning toward the production of research that supports and pushes increases: increased prescription, increased diagnostics; promises for lifelong pharmaceutical

entanglement. Yet, Jones, who astutely explained the nuances and pressures that affect modern day clinicians, is also aware of the trend of consumer empowerment through their own research and self-advocacy. Yet, how do we account for the bioscience work that physician-researchers undertake to create new knowledge about epilepsy? For Jones, who often expresses her commitment to her patients and her research, information is in itself a good thing. She explains the way that the diagnostic test is easily available, though not always easily usable:

> *I've heard discussion of the past weeks, neuromuscular neurologists-- with their frustration with the different laboratories and how easy it is to order a test when it's difficult to interpret - when things are very specialized, you need to know how to interpret the test. Some things are easy- if they are positive or negative, and then some things are more complex.* (Interview 08, May 29, 2010)

It was from this point that I began to think about TN in terms of its capacity to *attach disorders to biological material*. Thinking with Jones, I began to conceptualize the way that the diagnostic test indexes the meeting of the scientific laboratory (or laboratories) and the clinical encounter: a relationship that is difficult to map. To the extent that neuroscience enables greater biological meaning-making around brain disorders, translational medicine may enable the production of patients-in-waiting (Dumit and Greenslit 2005), but it's also about a kind of emergent materiality: the production of material-discursive worlds -- that can be leveraged as a technology of trust for desperate patients and also monetized by a Big Pharma.

Pauline and Terry

Pauline was difficult to talk to; Terry, less so. Our socially conscripted roles permeated our exchanges. We may have been an odd pairing in this particular part of Cleveland: I, a young, tall African American male anthropologist from somewhere far away and Pauline and Terry, third-generation Clevelanders who, at first glance, embodied the White working-class section of Cleveland where they had lived their entire lives. Pauline said that she had been looking for work since 2001; "there aren't a lot of good jobs here nowadays," she told me. Terry's disability benefits meant that he received a check every month from the U.S. Government. I explained to them who I was and my research. In our first meeting, Terry asked me where I was attending school.

> *Princeton. Is that in Boston? Terry asked.*
> *No, it's in New Jersey. You might be thinking of Harvard, I responded.*
> *Oh! He said, nodding, politely.*

The McDonalds where we often met was chaotic and convenient. Next door to the Cleveland Clinic, it was so frequently full of patients, clinicians, and staff, that it was an extension of the Cleveland Clinic facilities. One thing that I had learned was that my discussions with interlocutors took on a different feel and timbre at McDonalds compared with discussions inside the Cleveland Clinic. Terry, Pauline, and I would meet there for lunch on Tuesdays after a special patient support-group that Pauline attended had concluded. Pauline often played with her cell phone during our lunches. Terry would always get the same thing: a Quarter Pounder Value Meal without onions and a large Sprite. Despite our initial meeting, I was always "that Harvard guy" who had lunch with them on Tuesdays. I did not try to disabuse them.

For his 44 years, Terry was a well-built and strong man. He was 6 foot 6 and over 350 pounds. He had a tussle of strawberry blonde hair. His partner of 25 years, Pauline, was his primary caregiver. "My mom and sisters are all over the country," he told me one day. Terry often wore a baseball cap sporting the name and logo of the Cleveland Indians, the local sports team. Boisterous and dynamic, his hat sometimes became dislodged during moments of jubilance. His family was strewn across various parts of the country, without financial resources to lend a helping hand, according to Pauline.

While Terry tolerated my strange ethnographic interest in his visits to the Cleveland Clinic's Epilepsy center, Pauline was understandably skeptical and cold. In the larger context of their search for answers and solutions for Terry's epilepsy, my mundane questions felt small and, perhaps, inopportune -- at least, in the context of an everyday that was rendered apocalyptic by Terry's violent seizures. The seizures dominated daily life for Terry and Pauline until, after one particularly horrific attack, they found an unconventional solution:

"So, you know those commercials with that old lady who says, 'I've fallen… And I can't get up?!'" Terry's imitation of the actors in the commercial was perfect. For a moment Pauline smiled, on the verge of a giggle. I did remember it. That commercial had often become a source of humor across the United States for the overly dramatic theatrics of the acting and for the singsongy quality of the commercial's main tagline. I recall many instances during middle school when classmates and I would imitate the dramatic haranguing tagline during recess. Terry explained its relevance:

> *Well, that thing is called a LifeAlert. It seems like its only for old people, for the elderly and such, but it works for epileptics, too! We ordered one after I had a seizure back in 2008 in April. I had been at home 'cause I can't work and I was taking a shower and all of the sudden, I was having a seizure. I don't remember*

> *everything but I had been in the bathroom and I had apparently fallen down and cracked my teeth on the side of the bathtub. Pauly came in and she had to call EMS. I had knocked everything down; the towels, the shower curtain. I was bleeding. I totally could've died. So, then we got LifeAlert and so I have been able to use that, especially when I'm alone.* (Interview 18, September 2, 2010)

LifeAlert® is a personally wearable device that enables the wearer to press a button to alert paramedics of a need for rescue or emergency attention. Used widely by the elderly in the United States, its operative benefit is, perhaps ironically, the way it stands in for momentary lapses in social support. When Pauline was out running errands or on job interviews, LifeAlert provided a means of immediate and proximal care.

"I couldn't do anything. I mean I couldn't do *shit* (emphasis hers). I mean I loved him - of course I love him, but it was so hard." She paused, searching for words. Her body communicated years of angst, guilt, commitment, and confinement. "It impacted everything we did. Like, I needed something that could give us some sort of *life*. I just couldn't be there every second of every day. You know? (Interview 18, September 2, 2010)."

Of the primary concerns for Pauline and Terry that emerged during our interactions, few were focused explicitly on emerging brain-technologies. I also did not find them to be mired in an endless web of neuroscientific facts. In fact, knowledge itself constituted a hindrance - or more explicitly, merely a secondary source of exhaustion. Pauline's affect and mode of being spoke of perpetual exhaustion; it was difficult to delineate her own disposition and personality from the years of weathering the epilepsy and its emergency-modes. While my experiences with Jawan and Shana revealed the imprint of Shana's technological and clinical literacies, Terry and Pauline seemed permanently fixed on the everyday. In Pauline's descriptions about post-Life Alert life,

one sees that it constituted a technology of and for the everyday. Few of my other ethnographic questions mattered to Pauline; she seemed disinterested in discussions about long-range or short-range futures.

One day, Terry and I talked alone about the toll that epilepsy had conferred and his sadness not simply at his own condition, but for the way it affected Pauline. "She's really a beautiful person," he said, perhaps sensing, rightly, that I couldn't know her well enough to have any sense of who she was from our interactions. "She's really been there for me and this whole situation [of epilepsy] just made her into a zombie. She couldn't sleep. She would cry and cry every time that I had an attack. I mean, you know, it would really scare her. And I really had no one left. Its not like I had this huge family. I was by myself. There were good times, too," he said, his tone changed slightly. He continued:

> *I really don't understand epilepsy all that well or any of the medical stuff either. I was just like okay, "here are some pills"...okay, "now, here are some new pills," and Pauly, she's really good with that stuff. She'd keep all the pills together for me and stuff. I don't know what I would have done without her. She's definitely my saving grace…like, a guardian angel. But, she can also be kinda … kinda bitter and grumpy. But, it got better after I got this LifeAlert thing.* (Interview 18, September 2, 2010)

Terry caressed the imprint of his device, which was attached to a necklace that he wears under his shirt. "She can go and do stuff now and I say to her, 'go out and have a good time,' you know. Like, go get some cigarettes or something simple like that. It's been such a good thing. But, we're still scared. I still gotta' be careful." Terry said that he had only had a single seizure that year so far and about three seizures the year prior.

My experiences with Terry and Pauline were instructive in unsettling several types of deterministic presumptions. I was struck by the way that their commitment to living a good "everyday life" related to the ways that epilepsy had impacted their

"everyday." For them, LifeAlert's utility was in its restoration of time, its marginalization of a kind of apocalyptic contingency that dominates life when living in a constant state of potential emergency. Their situations became the data for their own sense of immediate therapeutic value.

The reams of biomedical data, or the clinical confusions did not arrest them as I had expected. Their lives had been much more haphazard and importantly, much slower than could be predicted. In some ways, for Terry and Pauline, they were working in a temporal register about the here and now and the immediate tomorrow -- a marked difference from the tempo of translational research and medicine. The switch in registers was visceral for me. My experiences with them made the *acceleration* at the heart of translational science's expedited logics of research and discovery feel even faster.

Risk and the Pharmaceuticalization of Global Health

Scholars have duly noted that an amalgam of promises is inherent to biomedicalization and pharmaceuticalization. In his research on the role of hype in a massive genome project in Iceland, Mike Fortun (2008) traced the ways in which a biotechnology company and the Icelandic government dangled promises of privileged access to cutting edge pharmaceuticals and a communal share in the company's profits in exchange for the commercialization of the entire Icelandic gene registry. As promissory capital turned into financial capital and genetic capital (in the form of giving genes to the company), the company raised significant funds. Despite all of the resources and capitalization, the company's stock plummeted and the entire enterprise was generally considered to be a failure.

Yet, as a case study in the construction and translation of hype, the Icelandic DeCode project is also a case study in the consequences produced through biotechnology's hype. Here the consequences included lost personal and national financial resources, investments of personal genetic material, national policy accommodations, as well as the reallocation and eventual loss of resources that could have been allocated in other critical areas.

One can certainly locate such consequences in my interview with Jones, the young neurologist I interviewed. In that interview, again, one sees how a plethora of new diagnostics and diagnostic testing in neurology has emerged, that had yet to correspond to a dramatic shift in terms of outcomes. One can also point out the effects that emerged from this promissory leveraging; increased healthcare costs, lost opportunity costs in terms of scientific investment and investment in other potential solutions, as well as the impacts upon patients. Thus, one is brought to consider the *risks* to patients, governments, communities and larger publics that emerge from biotechnology's hype.

In his article, "Hope Against Hype – Accountability in Biopasts, Presents and Futures," Nik Brown's (2003) sociological analysis of hype and biotechnology offers an articulation of costs. For unrealized promises, there are the social costs of fallout, ensuing costs in scapegoating, and internal systemic costs for future biotechnology companies including increasing skepticism regarding hype claims, subsequent difficulty attracting investment and enrolling collaborators, and rising costs of maintaining expectations. Taking the example of genomics and xenotransplantation, Brown articulates the underlying logic of using hype to underwrite massive public and private risk:

> *In the contexts of governance and policy making, the need to produce attention-grabbing imagery for the genomics future comes at considerable costs in terms of*

> *revenue allocation and also in terms of appropriate safeguards against risk. Most regulatory frameworks operate, either explicitly or implicitly, in reference to some measure of cost-benefit analysis. That is, risks taken today are warranted by some perceived notion of potential benefit in the future. In the context of xenotransplantation, for example, hugely optimistic expectations of future benefits have been used to justify proportionately costly animal trial studies.* (2003, 8-9)

Here biotechnology hype also produces an important set of moral risks; prominent among these is the way that promissory futures can be used to justify massive (re)allocations and funneling of resources and energy. Engaging a controversial ethics of the good, utopic futures can be used to rearrange social structures, institutions, finances, and moral energies. The consequences of resources lost under failed promises – such as lost public trust, large-scale social and economic fixes, lost opportunity – turn grand promissory futures into moral experiments. Yet, there is a contextual specificity at work in the promise of translational science which is distinct from Western biomedicine's nearly permanent promises (Gordon 1988; Wright and Treacher 1982) that scholars have thoroughly mapped (Adams and Kaufman 2011; Clarke et al. 2003; Ecks 2005; M-J. Good 2007; Keating and Cambrosio 2003 Greenslit 2002; Nichter and Vuckovic 1994; Petryna, Lakoff, and Kleinman 2006) and which is increasingly important in the speculative economics of contemporary biotechnology enterprises (Cooper 2008; Fortun 2008; Krimsky 2004; Ong 2010; Petryna 2009; Rabinow 1997; Rajan 2006; Rose 2007).

My proposal here is that while Brown's analysis usefully explores the dynamics of promise and expectation in biotechnology, the associated variables of hype and expectation leave out questions of the sheer *accumulation* of risks; the complex phenomenologies of pervasion. What about the analytic problem of polyphony? Brown usefully highlights the way that biotechnological promises can risk governmental and

public fatigue. However, how does one understand fatigue within a particular social context and in light of people's momentary particularities?

My experience with Pauline and Terry was not one in which they reflected endlessly upon emerging neurotechnological futures. Terry and Pauline had competing visions about potential futures but each focused on local and contextual specificities. Too, given the historically particular moment within which translational sciences emerges, a question of the historical particularity of risk; its meanings and infiltration into the public sphere arise. Risk simply is not the same in all places and in all moments in time and potential futures are always multiple. In this way, notions such as pharmaceuticalization (Biehl 2013) more effectively model the wholly unfinished relationship between patient subjects and attendant biotechnological solutions.

Shana had not recognized the term, *TN* when I brought it up to her. She said that she never recalled seeing the term or reading about it in the explanation sheets that she received as part of hospital information sessions or brochures given to her during her appointments with clinicians. Jawan had actually been part of research projects funded by NIH through translational initiatives, but Shana and others I talked with at the Cleveland Clinic reported the same "normal" entanglements with neurologists, brain research studies, and therapies that they had always experienced during the many years of what Shana often referred to as the "drama" of Jawan's epilepsy.

According to Shana, she didn't really experience risk *any more.* As Shana told me, "Every thing they give Jawan has risks." For Shana, she was often focused on risks when she first started to learn about epilepsy and treatments. "After a while, I couldn't keep up with all the side effects, all of the other options, all of the data. It was too much. I

also became numb to the information about side-effects. I just felt like it was everywhere and in everything… In every option that Jawan was given."

A risk that is "everywhere" and in "everything" creates questions about the social and political ubiquity, especially in speculative economic regimes. Thinking with Hannah Arendt's invocation of banality, one is invited to think of the historically contingent phenomenology of risk thus highlighting the importance of understanding the affective and phenomenological particularity of a given social and historical context in terms of risk perception. What does risk mean for an African American single mother in Cleveland between 2006 and 2010? Is it possible to *not* experience risk in a context replete with risks? Might risk be better understood as undulating, rather than static?

A similar challenge to Brown's rather static representation of hype arises in thinking about how the global financial crisis rearranges how one must think of risk in terms of the public. While the research on genomic hype is itself not new, recent scholarship has adeptly illustrated the way in which state complicity is a key tool (Fortun 2008; Fullwiley 2011) in the deployment of large-scale genetics-based global health interventions including projects such as DeCode. Yet, as Fortun's research on the DeCode project showed, the public ingested much of the fallout from the investment in that project.

Under the specificities of neoliberalism, there are new questions about how risk gets ingested by the public via the state -- through the machinations of public-private partnerships and via the privatization of public resources (Lave, Mirowski, and Randalls 2010). The increasing resocialization of risks onto the public that increasingly comes with privatization (Starr 1988) as well as the increasing interdependence of international

economies under financialization (G. Epstein 2005; Poon 2008) thusly require an examination into an increasingly *public* ingestion of risk and/or the production of new forms of digestibility and new banalities via the inurements of neoliberalism. Here we are reminded of the humanitarian device exemption (HDE) and the way that exemption pushes risks onto the public based on justifications informed by the logics of a private healthcare market. In thinking about financial risks -- especially those engendered from the global financial crisis between 2006-2009, the question of governmental intervention in the context of private risk-taking comes to the fore.

Of course, in the case of the actual products of translational science, risk is also at work. Patients incur specialized risks in the context of translational projects because in addition to the risks to patients of the therapies themselves -- risks such as safety issues, TN also brings patients into the research infrastructure earlier. At the 2010 Cleveland Clinic Symposium, much of the discussion on the part of the physicians was about the risks of DBS. Even an analysis of symposium titles and abstracts showed how the balancing the risks of DBS against patient benefits was a dominating theme.

The relevance here is that while the relationship between translational science and its commercialization in the form of biotechnologies may seem to be a more straightforward relationship, the blurring between research and therapy represented by translational science may reveal the work of pharmaceuticalization itself. In other words, the translational turn not only pulls patients into the process of creating biomedical solutions, it may also enable potential patients-in-waiting through honing of potential therapeutic markets (Biehl and Petryna 2011). The ever-expanding umbrella of what is considered a psychiatric, neurological, and cognitive disorder (Abi-Rached 2008a;

Applbaum 2009a; Dumit 2012a; Healy 2004) reveals how TN may function as a particular form or manifestation of pharmaceuticalization. Later, I focus more closely on the question of the ways in which TN may help produce patients-in- waiting (Dumit and Greenslit 2005) by providing biological material to partner with disorders. The importance of this material and materiality comes to light in Jones's statement that neuroscience has led to greater diagnoses and more information that bolster neurological explanations to patients.

TN creates a recursive process by which patient data and patient experiences were supposed to be fed upstream into the research and development process (Gomez 2006; Fischman 2011; Garcia-Rill 2012). This certainly was the case with Jawan, who had been part of a research project focused on data collection anticipating the creation of new therapies for epilepsy. However, the narrative of TN positions patients as the primary beneficiaries of the translational shift, despite the reality that they also became individual "trial studies" for products and therapies. They were not only patients-in-waiting, they were also clinical-research-subjects-in-waiting. It is in this sort of reshaping of biomedicine from the inside - at the level of even the research subject herself - that is a central component in theorizations of biomedicalization (Clarke et al. 2003). Yet, patients are also important to the translation process because they happen to have the brain that is, in effect (or at least rhetorically) being translated. This is the flip side of TN the narrative of which usually focuses on the translation of basic science into health improvements. One of the many promises of TN is the promise to understand the patient brain in ways that science had not been able to in the past. Thus, translation is not only a narrative

about converting ideas to products but also a narrative about and a pretension regarding the brains of patients and the associated potential for personalized medicine.

The expansion of psychiatric disorders and of related health markets creates new impetus for investments into brain science that will widen and embolden the neurotechnology market – the market for pharmaceuticals, devices, therapies, and diagnostics. Yet, this also, creates questions about medicine and health and the new subjectivities (Good, Subandi, and Good 2007; Jenkins 2011; Keating and Cambrosio 2000; Lovell 2007; Young 2007) born from the articulation of various constructions of both the brain and -- given the way that science is increasingly conceived as the key to the future of innovations in medicine -- of health itself (Davis 2010; Dumit 2003, 2004; Martin 2007).

Lastly, one important that ethnographic fieldwork provided during this study, and which brings together these multiple sections about patient subjects -- was about the particularity of patient concerns relative to the larger foci of TN. A primary problem I constantly encountered was in the difficulty of reconciling different constitutions of value – pharmacological, biotechnological, and molecular, global, community, public or individual measures of health. Thus, I wanted to track the discourses articulating grand transformations in health in which a molecular emphasis stands in for health itself. In translational research schemes such as that depicted in the graph in Figure 7 patient experience and community participation are not at the beginning of the process. Rather, one sees molecular targets – here meaning the pathological or cellular pathways thought to be involved in the biology of disease -- constitute the point of research origination. As

Sharp's work shows, one's intellectual starting point has consequences in terms of the designing of medical solutions.

For clinicians and investors with whom I spoke, there were a variety of primary issues of concern that made TN into a valuable endeavor. Yet, Shana's primary concerns were about efficacious treatments with fewer side effects rather than *mere advancements* in biomedicine. Shana decided not to go through with (DBS) to help treat Jawan's epilepsy because of a lack of longer-term research about DBS for epilepsy – a concern shared by her neurologists. Shana shared that she cared most about treatments that would not harm Jawan. For Shana, *new* and *unknown* harm occupied an important place in thinking about risk and benefits of new biotechnological interventions. In this sense, the notions of benefit and harm were informed by Shana's experience with experimental technologies such as DBS rather than an abstract possibility of emerging technologies in some abstract, future pipeline. This distinction is not only temporal; it's also epistemological.

The importance of this for TN is that it exposes the distances between the goals and objectives of translational science, its primary areas of concerns and intellectual starting points and the knowledges and experiences of patients. For example, patient concerns about "the everyday" are removed from the often long-range focus of R&D. A primary concern about patient safety on the part of patient advocates differs from the normalized tolerability of such risks for the State (in the case of the humanitarian device exemption) and for pharmaceutical companies for which efficacy may only be a secondary or tertiary concern over concerns about patents, legislation and profits (Healy 2012).

Additionally, there is a noticeably different temporal register: TN's speed and long-range envisioning buts up against Pauline and Terry's focus on the everyday and "local tomorrows." Here TN seems bounded to particular epistemologies - ones that may marginalize patient experience as a source of data and guidance. How might this marginalization inject risk into the pipeline of TN's outputs?

Aside from the neuroethical issue regarding varied and disparate visions of translational good (Racine 2010), these disparities that I note also gestures towards the bifurcations of TN's products and local etiologies regarding health or wellbeing as articulated by Jawan, Pauline and Terry. Here I began to think about whether these formations such as TN can be thought of as something other than health. How might we think of TN as composed of, connected to and a systematization of other forces, interests and histories? It was in this distance from local articulations regarding needs/desires regarding health where I began to think about the ontology of TN and its capacity to deliver upon promises of and in health.

Yet, there are other examples of disparate translational visions: For example, the pressure for biotechnology investors to find strategies to monetize intellectual property corresponds to (Gomez 2006) – but is also sometimes at odds with — the notions of value on the part of academic scientists, who are increasingly aware of the risks of too-quick pharmaceutical solutions (Fitzgerald 2005). The struggle between financially valuable patents (assets) and efficacy indexes the tension between often-lengthy periods required for thorough basic research and the pressures toward quicker in-patient biotechnologies via TN and by in-patient biotechnology investors and venture capital

firms (Fitzgerald 2005). What would these interventions look like if borne primordially from patient experience?

As translational medicine is envisioned as the future of health this implies dramatic shifts in conceptualization of health itself. Here science gets coded as *innovation in health* while care may become marginalized as hyperlocal, unsystematic, and unscientific in global pharmaceuticalization and translational research (Fabrega 1990; Gordon 1988).

The Stakes: Institutions and Academic Livelihoods

Despite the revenue it receives for providing clinical services, federal funding has been a key part of the Cleveland Clinic's longstanding tradition of research and is vital to its reputation. In fact, even during the financial crisis, which impacted Cleveland quite viciously, federal research funds helped create new buildings, initiatives, trials, departments, and positions.

For example, several new programs were initiated and their staff hired as part of ELSI funding (Ethical, Legal Social Implications [of science]) from the National Science Foundation. Not only was this funding central to the creation of these hires and the programs, the symposium that I attended on the risks, benefits, and implications of new brain technologies were funded by the NSF at about the same time. As a part of an ostensibly more reflexive institutional ethical regime now attached to emerging bioscience research (Langlitz 2010; Rabinow and Bennett 2012) and translational research (Chen and Carter 2010; Eyal and Sofaer 2010), federal funding dispersed for

science research also often includes funds to study the ethical and social implications thereof.[41]

During my time at the Cleveland Clinic, I began to think about the stakes of translational science for academics for whom research and competition is part of academic livelihoods (Lamont 2009). The competition for research dollars has become part and parcel of academic work as these monies are tied to university rankings, departmental productivity as well as the cultural capital accorded to researchers who bring in research dollars.[42] Yet, translational science has also become important for the academic medical enterprises in terms of revenue. Dr. Jones, my neurologist interlocutor, explained this further:

> *I think academic [medical] centers, and this is just me thinking about it, but some of the money to keep an institution going comes also from developing not only pharmaceutical, but also devices that can be used for patients, and that can be used to fund more research. They're encouraging us to try to, when we can, create a product that can be marketed. Research isn't just for one's curiosity anymore.* (Interview 12, September 22, 2010)

Thus, the stakes for academic institutions are large. These developments span an array of academic livelihoods and shape the kind of work that researchers conduct. Ultimately the new trends may reshape the missions of university programs. This is important for this project because part of the birth of TN requires its institutionalization at the academy manifesting increased bureaucratization and rationalization of the university. Translational science includes the proposition of greater research efficiency. Yet, the

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[41] This dissertation was not funded directly by these funds. Also, it is important to note that scholars have often noted how bioethics is impacted by its institutionalization within medical schools and by the sources from which it received funding. However, all federal research possesses this complication.

[42] Research grants are still important for universities' reputations and productivity despite evidence that the costs of research are increasingly falling to the university itself. (See Ronald G. Ehrenberg, Michael J, Rizzo, and Scott S.Condie, "Start Up Costs in American Research Universities," Cornell Higher Education Research Institute Working Paper 33 [March 2003]).

stakes also include the status of the university itself in the West – which, as result of social and political contexts, is presently in a moment of transition toward a more market-oriented and economically rational site (Erskowitz et al. 2000), Steck 2003, Strathern 2000). This context has been important for TN – both as a symbol of the stakes that exist for universities and its constituents and as potential preview into the future of academic labor and the constitution of academic value. Thus, the crisis that is facing many universities reflects the stakes at work for those in knowledge economies in general. In other words, translation reflects a larger global mandate regarding academic labor and value (Apple 2005; Olsen and Peters 2005; Orr 1997; Stewart 1997; Strathern 2000) and renders both in market and moral terms through the risks of failing to be productive.

The Stakes: Investors and Capital

A primary goal of TN is to push neuroscience along to the point at which it can be *worthy of financial investment* (Garcia-Rill 2012). It is only at this stage that there can be subsequent opportunity for investors to help develop novel intellectual property (findings) into diagnostics and medicines. In this view, one can see TN in its infancy as being about the identification of a stage.

The translational continuum necessarily includes commercialization and this brings in a host of stakeholders: physician-researchers, investors, venture capital organizations, industry organizations, scientist-entrepreneurs and university technology transfer offices which facilitate the commercialization of university-produced IP. Interestingly, several universities have created websites alongside their translational science and research centers focused on connecting scientists with investors who can

invest and develop technologies. The door between university and industry is a sliding one and even the role of the university researcher is increasingly implicated in this shift: a reality reflected in Jones' reflections about being asked to work on "product development" as a part of her research capacities at her university-affiliated academic medical center.

Even the former head of the NIH, Elias Zerhouni, became head of research and development for a prominent pharmaceutical company, Sanofi, after his tenure at the NIH. That the entire translational enterprise is deeply focused on commercialization means that TN is also about the readying of neuroscience findings for the market and all the *readying processes* that are entailed. While, TN requires a rethinking of neuroscience, its market considerations are the most important in our analysis. Thus, it's also important to look at the context at work during 2006-2010 for brain-based biotechnology investments. While biotechnology investment is a generally risky kind of investment, brain-based biotechnology is especially risky.

In the chapter that follows I move from the space of the clinic closer to the space of commercialization. How do brain-based investments impact the neurotechnologies that inevitably enter the clinic? How is commercial neuroscience dealing with the risks from the neurotechnology sector?

Chapter 3 / The Brain

The Neurotech Investing & Partnering Conference is a semi-annual event in which university researchers, biotechnology startups, large pharmaceutical and device companies, and investors gather to make deals and set agendas regarding the future of brain-based medicine and technology. While there are several similar events nationally, the Neurotech Investing & Partnering Conference, sponsored by the Neurotechnology Industry Association (NIO) and NeuroInsights is the premier event for the sector. I attended this and other NIO and NeuroInsights-sponsored events from 2010 through 2011.

While a growing body of researchers has begun to explore the conference as an important site for scientific knowledge production (Lakoff 2005 Lock 2013; Sharp 2013), I found it to be a critical site in my case. These events were essential spaces where I learned the ways in which scientific tasks, projects, products, and agendas acquire meaning in a market context. Without these events, I would not have learned the sorts of industry discourses and market logics that render new partnerships, new technologies, or new research "valuable." Yet, perhaps most importantly, I also learned how the event itself functions as a key site of "translation."

The meaning of the term *neurotechnology* is as wide and unwieldy as that of the term *brain science* (Abi-Rached 2007). While neurotechnology is conceptually comparable to biotechnology, the latter refers to a large group of objects, disciplines, and fields loosely connected to biology (widely constituted), whereas neurotechnology is conceptually tied to the brain. So while neurotechnology retains specificity in terms of

neuroscience, it encompasses a wide array of methods, diagnostics, and technologies. Too, the term is also wide because the umbrella of the brain includes everything from blood-based diagnostic tools for Alzheimer's disease to digital games focused on helping U.S. soldiers contend with post-traumatic stress. The ever expanding set of phenomena to which brain science is increasingly tied means that many products and tools can be considered neurotechnologies. From weight loss drinks to internet-based educational games, the neurotechnology umbrella (Figure 8) is intentionally large.

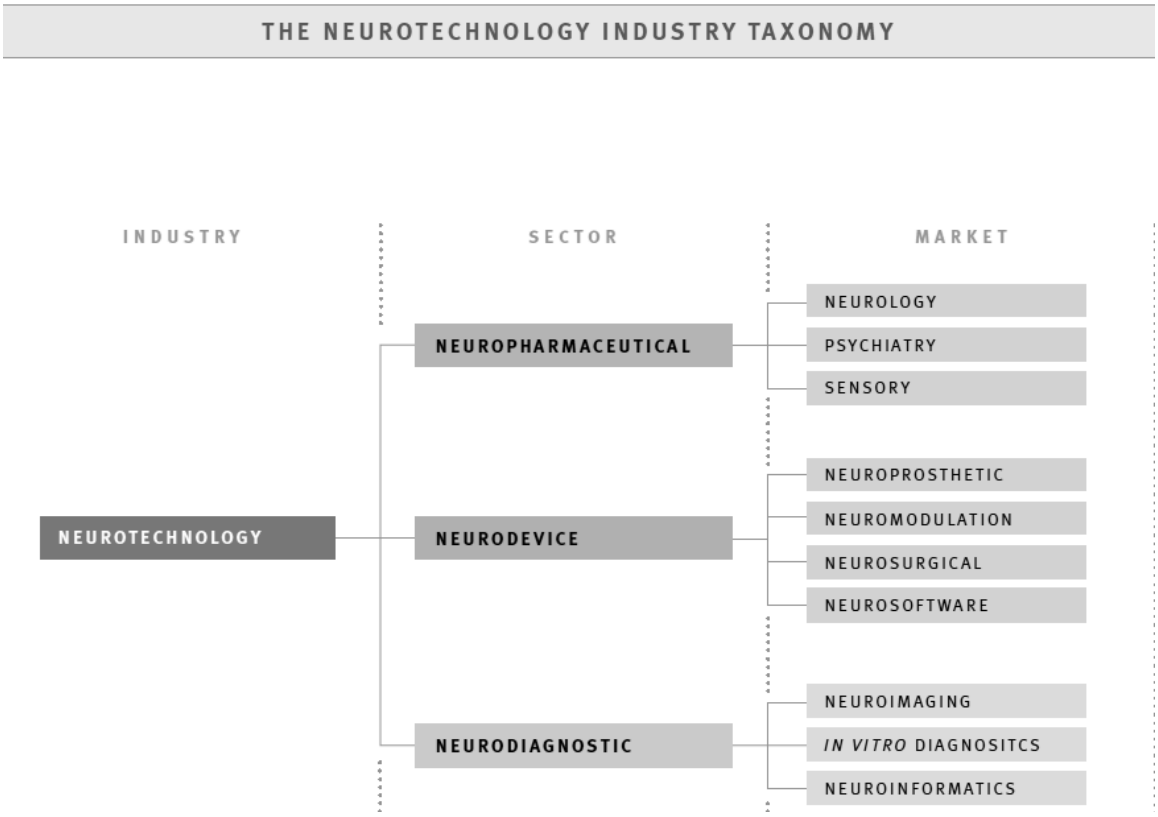

Figure 8. The Neurotechnology Industry Taxonomy. Courtesy of NeuroInsights.

This *Neurotech Investing & Partnering Conference* was also important because it helped me make sense of the larger financial and market contexts within which TN operates and to which it connects. While science and technology studies (STS) scholars

have taken laboratory studies to contexts *outside* of the laboratory - which anthropologist David Hess calls "the second generation" of STS (Hess 2001), TN is oriented toward the interplay of the inside and the outside. In other words, for TN the "outside" – the issues of getting venture capital for biotech startups, navigating regulatory concerns, connecting universities to for-profit partners -- is very much a part of its intervention inasmuch as it is concerned with the Petri dishes and modified animal models of the neuroscience laboratory.

Yet, in taking serious the mechanism of symbolic language (Black 1973), one could argue that the analogy of *the outside vs. the inside* of the laboratory does not work at all in terms of translational science - at least not in the way that this distinction has been used throughout STS scholarship. In fact, I found that much of the science of TN actually happened inside the Neurotech Investing and Partnering Conference (Figure 9); a place where the brain and its parts accrued particular meaning, where scientific and financial practices were aligned, and where both experimental and regulatory problems alike - were met with collective attempts at solutions.



Figure 9. The Neurotechnology Industry Investing & Partnering Conference is an annual event sponsored by NeuroInsights and the Neurotechnology Industry Organization - both managed by Zack and Casey Lynch.

It also became a context in which I learned about presuppositions and logics that would necessarily encumber and inform the work of brick-and-mortar science

laboratories. In many ways, the Neurotech Investing & Partnering Conference seemed to function as TN's primary laboratory and site of key emergences. During our first meeting, I asked Zack if he would allow me to attend these events. He obliged and sent me a personal invitation. According to the email invitation, the attendees would include "CEOs, CSOs, CFOs, business development executives, non-profit leaders, corporate investors, venture capitalists, private equity investors, institutional investors, technology transfer experts, licensing executives."

Of course, the importance of this list is who is left out. An important demographic that attends these events is the scientist/professor/entrepreneur looking to take his or her small biotechnology company to the next level and who is eager to create relationships with investors, licensing partners, pharmaceutical companies etc. The events organizers had designed this invitation to entice this entrepreneurial contingent. Below the list of speakers appears the following key sentence: "Don't miss this excellent networking opportunity to discover partnering opportunities from across commercial neuroscience."

Two kinds of partnering happened at the Neurotech Industry Investing & Partnering Conference. Firstly, it facilitated social partnering of entrepreneurs and their small biotechnology companies and potential investors. The conference provided opportunities for investors to meet companies on the verge of a major discovery. In a 2013 interview in the "Life Sciences Report," an influential commercial Life Sciences publication, Zack Lynch, my early interlocutor, director of NIO and co-founder of NeuroInsights offered an explanation for why events such as these are important for

entrepreneurs of early stage neurotechnology companies - many of whom are university scientists:

> *It is very important for entrepreneurs to know, in real time, who they might be able to partner with and how they might be able to get funding to bring products to market. Last year, VCs put more than $1.2B to work into the neurotech space, in more than 160 deals. Many of these companies have been speakers at our conferences over the years. We feel like we're playing a very important role in bringing the community together on an annual and global basis, to help galvanize innovation in the sector.* (Mack 2013)

There was a second kind of partnering that happened at the conference as well. In this chapter I suggest that these events became spaces for a material and semiotic partnering[43]. By this I refer to the ways in which attendees reflected and created strategies (financial, market, regulatory) to deal with the messiness of biological material and to attach biological material to discourses and to medical disorders.

These events were also ethnographically important because they were *closed*. By closed I mean that they were "insider spaces" where certain kinds of product and knowledge anxieties were be made explicit and performed out in the open. In my media investigations, for example, one finds only narratives crafted by pharmaceutical and biotechnology companies themselves. Even in some of my one-on-one discussions with pharmaceutical executives, I could detect a particular ideology -- one that occurs, ironically, in the process of translating internal meanings to an outsider. Yet, in these conferences, conversations occurred via a different set of filters. Here one could see explicit and often-contentious discussions about market demands and market insights,

[43] There is also an opportunity to think about materiality via financialization. In other words, how might financial relevance become the means through which things "matter" – objects that are produced or that emerge via becoming – or by virtue of being connected to -- a financial "matter."

something often obscured within the "official" discourses of pharmaceutical companies especially in relation to the rhetoric of health innovations.

Lastly and importantly, these conferences were a key space in which I saw the articulation of scientific, informational, and market value *as it was being ironed out* by and within a unique community of investors, scientists, pharmaceutical executives and stakeholders. By the end of 2011, I came to understand that these spaces functioned not only as a key means of several kinds of problem solving, but also as critical spaces of scientific and material arrangement. It is in this latter sense where I began to think of this event as one of TN's primordial laboratories.

My first experience at the Neurotech Investing & Partnering Conference was in the summer of 2010 in Boston. This particular event included a day focused on TN, called the Translational Neurotech Summit. The Neurotech Investing & Partnering Conference is always held at high-end hotels, in San Francisco or Boston. There are occasional fringe events in international locations or adjacent professional society meetings such as the Society for Neuroscience's annual meeting.

The May meeting was held at the Westin Boston Waterfront hotel. The standard registration cost was around $1,200 dollars for most attendees, with slight discounts for non-profit attendees. The Westin Boston is a beautiful hotel. In the lobby a tall cascading wall of dark wood makes the space feel dark. The hotel's gently curved ceiling meets a tall, slanted expanse of windows that look out to the Boston Harbor. Near the entrance, a procession of hotel attendants greeted fleets of black Town cars. Attendees quickly exited

the cars and immediately went to the registration desk. The event included a mix of people, but a large contingent of these was investors, biotechnology company executives, and pharmaceutical executives.

The main meeting events all occurred in the main banquet hall on the Mezzanine floor. Inside the banquet hall, there were rows of tables and chairs all facing the raised stage area. This area included a central podium, flanked on both sides by tables for panelists. As I sat down I noticed a very small shiny silver pin. Placed at every table in front of every seat was a metal pin molded in the shape of a brain. The pin was attached to a card that contained a single phrase, "*Give the brain a voice.*" Only later would I realize how prescient and appropriate this mantra would be.

Having arrived early, I chose to sit in the back both in order to gain a perspective of all of the activity and perhaps as a way to recede into the background. I certainly stood out: In the years that I had attended, I had only noticed only one other attendee who appeared to be African American. Composed of about 75 percent men and 25 percent women, the attendees where overwhelmingly white with a small contingent of South Asians.

The culture of neurotechnology and biotechnology investors was highly distinct from that of Silicon Valley's Internet startup investors. Unlike the youthful technology-oriented events in California where everyone had Apple computers and dressed in t-shirts and jeans, attendees had black IBM laptops and Blackberry mobile devices and everyone dressed conservatively. Rather than traditional academic attire, I wore a blue Sport coat and tan slacks, likely a result of my interpretation (and probable conflation) of a wardrobe befitting Wall Street and/or a Princeton eating club.

Despite my clothing, I was still an anomaly. Frequent, surreptitious glances were not uncommon. However, the subsequent scan of my Princeton nametag seemed to swiftly dissolve any externally discernable lingering interest. Among a sea of university researchers and entrepreneurs, perhaps it offered a quick narrative that explained my presence. Alas, this event was one in which nametags mattered. Affiliations were in a larger font than one's name. Presenter biographies were lengthy and sparkling: There was little variation among investors' very similar elite pedigrees. About 90 percent of all of the investor panelists and speakers at the 2011 event, whose written bios presented their education credentials, listed degrees from an elite and/or Ivy League school. Several of the attendees who had degrees from non-elite schools mentioned their degree and did not mention the institution. Presenting scientists, most of whom were also entrepreneurs and were attending to share information about their startups, displayed a greater educational variety including a smattering of scientists from nearby Harvard and MIT.

On the first day of the Boston conference I happened to sit next to the investor that I mentioned earlier, Michael Hall, with whom I met in his San Francisco office overlooking the Presidio. In this, our first meeting, he looked at me and glanced at my nametag - and I his. His well-regarded venture capital firm was one of a small circle of firms that regularly had a presence at these events. I introduced myself. I explained to him what I was doing; that I was an anthropologist and that I was working on learning more about neurotechnologies and TN in general.

"Hmm, that's interesting…Sounds cool," he said. I asked him about his interest in this event. Michael was a relatively young partner at his Silicon Valley venture capital firm that specializes in biotechnologies. "But they let me keep an office in San

Francisco," he said. His firm, a darling in Silicon Valley's tight biotechnology community, was involved early on in several medications that, in his words, "had amazing exits." In the world of venture capital, the primary concern for every firm that invests in a startup company is the issue of a successful *exit* -- which means that the company receiving investment is eventually acquired for a large amount of money. Potential acquirers include pharmaceutical companies, a private equity company or a large holding company. In the best scenario, the startup company will grow and eventually go public via an Initial Public Offering (IPO).

In both cases, a firm's initial investment can yield a colossal profit. For example, Michael's firm was an early investor in a Boston-based oncology startup. After several years a large pharmaceutical company purchased it for over $500 million dollars the year Michael was hired. As a result, that firm's investment fund yielded a large profit that quarter, which in turn, attracted additional investment. According to Michael, the firm's principals made seven-figure incomes that year from management fees. The profit from that one exit was enough to make up for the failures of other startups that were part of the firm's investment portfolio. "We are always looking for that *one* company," he said holding up one finger. A glint in his eye, I could sense his passion and anxiety.

I asked Michael additional questions about his experience at these events. "I've attended this event annual for several years now," he said. Michael then expounded on the role of social connection in these events and in the larger world of venture capital and investment circles:

> *I come to these events for a couple of reasons. One thing is that its important for me to be well-connected and to nurture my connections because a lot of times, when I'm investing with people, I may co-invest with other investors and other VCs [venture capital firms]. So, the relationships that I've built, I need to*

> *maintain. And I've built a lot of 'em. But, I also go to these events to find out what's going on in the field, what new stuff is coming out, what people are thinking in terms of Neurotech and Pharma. I also like to see how scientists are framing certain problems. I also like to see what other investors are doing. Sometimes it's difficult to get to have one-on-one conversations with other investors. These conferences give me a glimpse of where other investors are. And of course, you know I also am looking for deals.* (Interview 14 May 20, 2010)

He explained that he attended these events "just to hang out" and perhaps most importantly, to see if he "can get deal flow." I asked him to talk more about "deal flow." While it was clear that these events were important for small biotech companies as they sought investors, capital, advice, or key relationships, I began to see that these relationships are part of the *product* of the event. Yet, I was also interested in investor perspectives in order to understand the underlying market logics that animate investments in neurotechnology companies. Michael explained what he was looking for in terms of possible investments:

> *So, deal flow is basically a phrase that we VCs use to talk about the possible companies with good ideas. They [biotech startups] are all looking for money. But finding novel ideas, new models, new things to invest in his not easy. I see probably about 40 different ideas a quarter and I may fund two or three of them. The problem, though, is that we are always trying to get a piece of the hot new thing and to not miss it. And I know a lot of startups think that we don't really care about the startup exhibits [presentations to investors], but we really do. I'm always looking for the next big thing. Right now devices are really hot. So, I'm always looking device verticals. I'm also always checking up on the Big Pharma panels. I used to be part of that world and have lots of friends who still are. I'm always looking to see where Pharma is going and if that can help our current portfolio of investments. We always need for our portfolio companies to have good and successful exits. So, that also means understanding where the science is right now, what the consensus [is] about certain disorders. Here I learn both about the industry and the science all in one. This is a major part of my education around CNS each year in terms of progress, evolutions, challenges*. (Interview 14 May 20, 2010)

Michael's explanations were quite useful. To begin to understand the various goals of these diverse stakeholders — investors, biotechnology startup executives/scientists, licensing executives — I constructed a cursory map, a network of relationality between bioscience, investment, the market, and biotechnology that I would develop in more detail.

Investing in Risky Neurotechnology

The first panel of the morning focused on the current state of investment/investing in neurotechnology. Panelists consisted of five investors from venture capital firms. Of all of the events, this panel was the best attended. Each panelist, a key decision-maker in his respective firm, outlined what firms were generally looking for when investing. Some hinted at the interests/niches of their own specific firms: "We're looking for good opportunities; good *teams,*" said one investor. Another investor offered a useful indication of his firms shift toward investing in less risky propositions:

> *The majority of investments in new ventures nowadays happen at or after phase two. Were looking for good science and if there is inefficiency in market valuation after market data. We try to mitigate our risk and prefer to invest after some of the clinical risk has passed, until there is better efficiency in the market and the company is better valued.*

For this investor, his firm moved away from considering companies in the earliest stage of research and development. Thusly, his would be considered a *late-stage* investment firm. At the end of the panel, there was a question and answer session. An audience member asked what qualities each investor's firm looked for specifically when evaluating startups: "Venture capitalists get a lot of inquiries," Justin Long said. Long then listed things that he and his firm are not interested in: "I wouldn't look at epilepsy,"

he said, making a quick decapitation gesture. One investor said, smugly, "The best proxy for a venture capitalist is to look at what companies they have." Another investor added, "Uh, I would look at neurodegeneration, where there is high unmet need and a known mechanism [of action]. I'd look at schizophrenia."

Although each investor articulated widely different product and vertical interests and aversions, I detected a tone of caution that permeated the panel and the conversation. While the panel's title, "Investing in Neurotech" seemed innocuous; the conversation quickly displayed a deep crisis in the industry. This crisis was about the lack of new drugs coming in the pipeline, drug patent expirations, and a failure to create safe and effective psychopharmaceuticals. Few were explicit about the crisis during my conversations outside of this event. However, inside this event it informed the panels, the conversations, the audience questions, and even the conference written material. In the description of an afternoon panel on new business models in neurotechnology, one sees clearly articulated the way that risk and time tolerance are implicated in investor's shifts:

> *With venture capital steering away from long term and risky investments, neurosoftware, neurofeedback, neuromarketing and other new business models represent far lower risk and faster times to market. What winning strategies are emerging in brain fitness, disease management, neuroplasticity, advertising and even sports performance?*

Several of the panelists spoke about the problems in translating brain science and the subsequent risks. According to one panelist, "translational risks make it difficult for big biotech companies to invest, but people are trying to use TN to forge new understandings." One panelist insisted that even though the latest neuroscience research is only providing *information* at this point, this information is still valuable: "this is still important," he implored the audience. In carefully crafted language, panelists

acknowledged the shift away from neuroscience by Big Pharma because of a multitude of risks, including clinical trial risk, problems with pharmacological efficacy, and a lack of neurobiological understanding. This retreat by Big Pharma necessarily impacts investor decision-making.

"Everyone is scared, now" Michael later said to me. Always witty and curt, he added, "Things change quickly." In light of this move by pharmaceutical companies and venture capital firms, the question that remains is how these changes might also impact the interests and areas of interest for the academic neuroscientist.

Yet some panelists exhorted others to try to maintain a view of neuroscience's importance: especially in terms of the dire need for increased neuroscientific understanding. For some of the panelists, their pleas for sustained faith revealed hues of dignified desperation. Eventually, the panel moderator brought up the issue of risk tolerance among neurotechnology's investors: "There *is* big fear that the big companies are getting out of neuroscience, especially in psych [psychiatric drugs]. This sentiment reflects the evolution away from psychiatric drugs, once a boon of the pharmaceutical industry" (emphasis his).

One the panelists quickly responded: "Big Pharma is evolving toward the things that they do better - which is big [phase] three trials, and the things where you need additional soldiers and this leaves more opportunities for us." The "us" to whom the panelist referred is the cadre of venture capital firms as well as individual investors (some of these firm executives also invest their own wealth in deals as private individuals). It also means that these investors believe that new opportunities emerge in the retreat of large pharmaceutical companies from psychopharmaceuticals and away from the

discovery process in general. Lastly, it provided a glimpse into the evolution of pharmaceutical industry's strategies — toward those in which their "soldiers" can prove advantageous. In other words, it signaled the possibility of dissolution of the research and development pipeline and a movement toward the outsourcing of various parts of that process.

Another panelist, Dr. Simon, a Yale M.D./MBA and his firm's managing partner, made the risk issue more explicit. According to Simon, "the risk is *huge* in neuro" (emphasis his). He continued, gesturing concertedly, "You don't have the models." While several high impact research articles were published in 2006 and 2012 discussing the hidden, unspoken problem pharmaceutical efficacy (Fournier et al. 2010; Light and Lexchin 2012), I had never seen such an admission by an investor in neurotechnologies.

Simon went on to say that while big companies are certainly interested in these products, they don't want to be involved at the beginning stage. Simon recounted some of the many problems specific to neuroscience -- including the growth of quick generics, the high failure rate in phase three trials, and the daunting costs of neuroscience research: "There is significant need in psych, in neurology, as well, but Pharma has a big interest, in neurotechnology." According to Simon, "psych is very last year."

After Simon's statement about psych, I began to think about health. Up until this point, I hadn't been explicitly thinking about health. It was only because of the dissonance that I experienced in hearing Simon's statement about psychiatry being "last year" that I began to think about health in this context. I experienced dissonance when compelled to think about mental disorders such as psychiatric disorders in terms of trendiness, especially in the context of semi-public discussions about health.



Figure 10. A Europe-focused Neurotechnology Industry Investing and Partnering Conference in Helsinki.

Of course, arguably, this conversation and the larger conference were not principally *about* health. In fact, one could argue that these conferences, which take place annually in major centers all over the world (Figure 10), are about something else entirely. However, it reminded me that this conversation should include patients as a key stakeholder. In recounting a recent risk his firm took, Simon recounted in a moment of humor, "We've bravely …or foolishly …created a new company in psychiatry…" The audience laughed at his turn of phrase.

The investors' clear admission about the lack of models, pharmaceutical companies' abandonment of psychiatric product areas, and the move toward new investment trends - showed the impact of market logics upon the strategies of corporative biotechnology innovation. This conversation also illuminated several possible neuropsychiatric futures: What are the implications of this massive de-investment upon the practice of psychiatry? How might this shift impact those living in the webs of psychiatric diagnosis? For those already diagnosed, what do we make of Simon's refrain,

"You don't have the models"? What does a potential investor abandonment of the sector mean for the future of psychiatry? What about the lives being lived inside those models right now?

The panel compelled me to think about the importance and opportunities that emerge around risk for post-collapse, post-boon investors. In thinking about the risks attached to "the early stages" of neuroscience research - the stage where, ostensibly, messy foundational and underlying questions and models are supposed to be ironed out, we see a key intertwining of epistemic and financial risk. We also see the terrains on which the outside – here the admissions about the problems with "models" in neuropsychiatry and the risk attached to the general sector – begin to produce contexts that condition the inside, including the questions that may get assigned to TN laboratories, and a clear set of meaning that is being attached to recent neuroscience research. For Simon to proclaim, "you don't have the models" is an interesting instance of public "reading" of scientific work by a powerful stakeholder. Here the "insides" and "the outsides" of TN came into clear view.

Mechanisms of Action

During the same panel, an impromptu conversation between audience members and panelists turned to the problem of scientific evidence -- an issue that I increasingly learned was especially salient for investors and VCs. The conversation focused on a discussion about biology in the form of the Mechanism of Action. For Simon, Mechanism of Action was an essential component in his firm's decision-making regarding investments in new startups: "We don't invest if there isn't knowledge about

what the mechanism of action is. And there are many tempting things that we find in which we want to invest. So, novelty also has to be part of something that has to be demonstrated."

During my time in the field, few phrases emerged as frequently as that of Mechanism of Action. Mechanism of Action, sometimes referred to as mechanism of Drug Action, is essentially the particular biochemical interaction created through a pharmacologic drug substance (Spratto and Woods 2013). It constitutes a sort of biochemical roadmap that *explains* its effect in the body. It requires an understanding of a set of molecular targets on which a pharmacologic drug substance works.

Thus, given its pharmacological focus, the translational process usually is organized around identification of a specific molecular target (Garcia-Rill 2013). Out of a molecular target, an entire research agenda is designed with the hope that it can be translated into a biomedical solution. The importance of the Mechanism of Action for biomedicine reveals the underlying pharmacoepistemology at work in the way that we understand not only the structuring of research agendas, but also the therapeutic logic of pharmaceuticals.

Importantly, this epistemology also, consequently, animates the social -- and specifically epistemological -- construction of disease. As medical anthropologists have noted, the notion of "Mechanism of Action" has also helped to engineer the foundation of Western biomedical research since the 1950's: "…strictly controlled research to demonstrate pharmaceutical efficacy and mechanism had greatly influenced the way biomedicine conducts research today—that is, by privileging the placebo-controlled RCT as the 'goal standard' for demonstrating efficacy" (Thompson, Ritenbaugh, and Nichter

2009, 115). Mechanism of Action constitutes a biochemical bridge that connects human biology to pharmacology and pharmacology to disease claims.

Despite its definition, it is compelling even in its phraseology, which confers an aura of surety and authority. Yet, for investors and for laboratory scientists, Mechanism of Action – the term and the question about its importance -- indexes the anxieties and possibilities that surround the research process in the search for novel scientific facts that can be turned into medicines and products. I quickly learned that Mechanism of Action was a key unit of scientific and market value.

During this panel I began to see how Mechanism of Action (MoA) constituted a sphere of corporate, social, biological, pharmacologic and investor trust. MoA suggests that there is a clear factual and biological basis not only for understanding drug interactions, but also for understanding the underlying mechanisms involved in the disease state itself, or its symptoms. Given its importance in randomized control trials and for notions of pharmaceutical efficacy, MoA constitutes a kind of epistemic gold. In other words, in a context of great scientific uncertainty, MoA ushers in the sense that what one has found is scientifically real.

Yet, it is not only a proxy for investor confidence, here consecrated in Simon's confident claims about its necessity in terms of investments. It is also a proxy for scientific anxiety over the terms of biological and pharmacological truth, despite the fact that finding the MoA is still is no guarantee of a safe and effective therapy. To have a conversation about MoA is to have a conversation about the problematic nature of much of the science that underlies psychopharmacology and psychopharmaceuticals.

Visibly interested in the mechanism of action question, the moderator asked, if mechanism of action is also important for investing in devices. To be clear, by devices, the moderator is talking about technologies like the Deep Brain Stimulation device, the technology that Shana had considered for Jawan. Here I begin to reflect upon the meeting between on-the-ground situations and their representation in the quick exchanges between investors who knew as much or possibly more about the material and intellectual history of devices than the neurologists that prescribe them.

In response to the device-related diagnostics question, one investor, a M.D., responded: "In many cases we haven't understood the mechanism of action in these [clinical] trials as we should have." He continued, "In devices, the bigger challenge is the reimbursement area. I think it's important in devices since there is a large upfront cost compared to biopharma, you really have to show an improvement in disease outcome, but also a reduction in system cost to see rapid reimbursement potential." Here the risk for devices is treated differently than that accorded to biopharmaceuticals. One audience member, a woman with glasses, stood up and made a comment:

> *We should be a little less obsessed with mechanisms of action. In terms of devices, we don't have a clue about how deep brain stimulation works.. not a clue.. but it works now…(emphases hers). Yes, mechanism is nice. But, let's not throw out the idea where we don't know the mechanism. Biologically, we know a little bit about the receptor in the drugs and [yet] there are lots of impacts in the brain.*

Simon responded that his firm "had some successes" with an approach focused on investing in companies where there is a proven mechanism of action; " and so that's why there is such an important check box for us," he ended. The audience member's admission— which came across as more of a collective acknowledgement than merely a statement of personal knowledge—elucidated a VC perspective on biological ambiguities

embedded in devices such as DBS. Unlike the discussion among the clinicians during the Cleveland Clinic's Epilepsy Symposium, the concerns regarding patient perspectives and realities did not color this exchange.

But this discussion was also about an ambiguity over biological material. It was in the moment of this back and forth over the necessity of MoA that I began to think about the exchange itself as a means of problem-solving. This was not only a unique problem for investors and the researchers in the audience. MoA is also a regulatory problem in this view – a problem made evident in the battles that companies wage with the FDA. Given the power of the placebo effect, MoA is also a way to demarcate actual pharmacological effects from the effects of a placebo response. One panelist went straight to that point saying, "In neuro, the placebo effect is quite large. We now know that X drug works and so now have to figure out the regulatory and the market strategy." This meta-conversation about the importance of the MoA, at least in thinking with the audience member's retort, is much more about a larger, *working ambiguity* involved in biological sciences.

In a different panel, the back-and-forth over MoA delved more clearly into the question of the molecular basis for biomedical intervention. At one point, the panel discussant, a director at a life sciences advisory firm, commented on the new emphasis on this kind of molecular biology-focused scientific knowledge. According to him, "This new approach is interesting especially in placing a premium on molecular biology knowledge." This also signaled to me a shift - even if only within a single advisory firm - about pushing for more molecular biology knowledge or approaches. As an advisory firm that provides strategic consulting to companies and investors alike about how to profit/grow, this ethos could translate into consultations with biotechnology companies. I

was witnessing the emergence of distinct scientific direction and at the very least, scientific possibilities - in much the way that one would observe such emergences and possibilities in a traditional, brick-and mortar laboratory.

Then, Chris Marshall, a Princeton Ph.D and Chief Science Advisor at a Canadian pharmaceutical company, offered a caution about having too much knowledge. According to Marshall, "knowing everything that happens —having the mechanism of action actually makes things complicated. The FDA doesn't have a requirement that you present the mechanism of action." Another panelist offered a useful distinction -- one that set off an exchange about how neuroscience had changed and about how neuroscience is unlike investigations of other disease categories: "I don't think it's a big deal. I think it's [the MoA] nice to have. It's certainly not necessary. If there is good evidence that it's safe and effective, that's it. The productivity of neuroscience has declined in terms of specificity. It may work for cancer but not for neuroscience." This admission about specificity was telling.

Mary Holburn, Vice President for a prominent U.S. pharmaceutical company, responded, "Were agnostic to mechanism." She continued, "Some of our most interesting things are where we don't know it." Holborn's sentiments matter because she directs her company's acquisition of companies and licensing of intellectual property. Given that this pharmaceutical company is involved with bringing emerging technologies to market, this scientific position is meaningful in order to answer the question about how technologies and their material ambiguities — models, assumptions, foreclosures — are brought to the patient bedside. After more back-and forth, Chris Marshall, the Chief Science Officer of the Canadian pharmaceutical company offered an important admission that crescendoed

throughout the ballroom. Uttered in a tone somewhere amidst incredulity, gratitude, and joy, Marshall disagreed with the necessity of deeper knowledge: According to Marshall, "Not knowing our molecular target is what got us to where we are *today*! That was a pretty productive way to do drug discovery!" (emphasis original).

For these two representatives of major pharmaceutical companies, scientific ambiguity, especially around molecular targets and their mechanisms, was not necessarily a problem in bringing products to market. This apathy over ambiguity marked a clear difference from the stance articulated by the investors, who very much want a mechanism knowledge and who inevitably absorb a large amount of risk in early-stage biotechnology investment (N. Brown 2003). Observing this bifurcation as it occurred in this space was useful because it enabled me to see the various positionalities in terms of risk. I was also curious about this difference. Why might pharmaceutical companies be more amenable to dispensing with this knowledge? In the life cycle of a neuroscience discovery, where and when do its constituent facts matter and for whom? One astute audience member asked a question about the public. She asked about how new innovations are being thought of in terms of potential to help patients. Marshall's subsequent response seemed accidentally unambiguous, if slightly dysphonic and robotic: "Health economics plays a big role in our [business] development teams at [her pharmaceutical company]. And the FDA and payer environment wants to see clinically meaningful benefit."

The setup of these events (Figure 11) meant that the discussions among panelists and this back-and-forth between panelists and audience members took on a dramaturgical dimension. Perched at the front of the room and flanked by large screens on both sides, the panelists were more or less literally on the spot.



Figure 11. The 2011 Neurotechnology Industry Investing & Partnering Conference in San Francisco at the St. Regis Hotel. A group of panelists is sitting at the panel atop the makeshift stage.

Of course, Marshall's automaticity rendered his response as strange. Would not the pharmaceutical company itself also be interested in "clinically meaningful benefit"? Was this so obvious that Marshall assumed that we assumed that his company was obviously interested in clinical benefit as well? Juxtaposed against the first sentence about health economics, Marshall's statement aesthetically relegated clinically meaningful benefit as a necessary hurdle among many for business development teams.

One audience member quickly approached the microphone. The woman's speech was slow and weighty. It was of a noticeably different tempo than the swift rhythms that marked the event up until this point. The woman said, "Remember; we're all patients *too*" (emphasis original). The woman then sat down. With a sheepish smile, the panelists nodded their head as if to suggest obvious agreement, but the exchange ended there.

This comment was compelling. Firstly, Marshall never actually mentioned patients. Marshall's discussion did not explicitly focus on patients at all. It was also

interesting because, in its concision, the statement presumed that everyone in the audience and the panelists would necessarily understand the relevance of his statement. I think he assumed the audience members were all thinking what he was thinking. I suspect that the audience response may have been a way of saying that clinically meaningful benefit actually matters; that it is not merely a perfunctory checkbox during business development processes. It was, perhaps, a way of saying that we, too — as both professionals in this industry and as human beings — have a vested interest in pharmaceuticals that *actually work*.

The audience member's retort, "Remember, we're all patients *too*." was the first time I "saw" or experienced a patient during the event. After some time, I had begun to assume that patients were simply missing within these discourses. I learned that I was wrong. Patients were very much part of the picture, though not in the ways that I had anticipated. I certainly did look for more signs of patients and patient subjects. Some presenter presentations had generic pictures of faces that were ostensibly those of patients. Occasional discursive gestures to health and patients were fleeting and cursory. One audience member, who worked for an advocacy organization brought up the issue of patients, but the panelist responses to her questions incited responses about management and FDA regulation. The only spaces where I saw or "felt" patients were in the pieces and slivers of images of cells, fMRI brain images and data scans that filled presenter presentations and event brochures. The subject that I saw was a pixilated one – a subject that was both missing and yet, inextricably implicated.

The Socialities of Translation

Nevertheless, these events went beyond mere theatres of discourse and scientific negotiation. These spaces were also key means through which new relationships were born, forged, renewed, and emboldened. Built into the very design of these events lay promises of opportunities, connections, and partnering. Consequently, I learned that the events and discussions in the main hall were not the only conversations that mattered. Many significant conversations and connections occurred in spaces hidden from view.

The 2011 Neurotechnology Investing & Partnering Conference was different from its predecessor in Boston. Held at San Francisco's St. Regis Hotel, this event space felt noticeably more intimate and exclusive. The St. Regis, unlike the Westin Boston Waterfront hotel, is a noticeably more designed hotel. Every one of the investing and partnering conferences in San Francisco has been held at this venue. The Boston event has since switched to the Boston Ritz Carlton.

The San Francisco St. Regis (Figure12) is both a hotel and luxury condominium building. A towering, modern, glassy structure, the ground floor is flanked on one side by the relatively new Museum of the African Diaspora, known as MoAD — a modern and sparse space more reminiscent of a gallery than an actual museum. On the other side of the building, a Porte-cochère gently indents the side of building to accommodate the hotels' private driveway.



Figure 12. The San Francisco's St. Regis hotel's lobby looks out onto the hotel's private driveway, which connects to the adjacent city streets. Surrounded by glass, the lobby provides a view out to downtown.

In the middle of one of the most frenetic and congested parts of downtown San Francisco, the hotel feels recessed from both the street and the city at large. Surrounded by glass on two sides, the ground floor lobby offers a clear view to the cavalcade of town cars that drop off passengers. On the ground floor, there was a prominently placed bar, a lounge-like space with light colored, modern, lush furniture. The elements of the space stood out to me. The lounge space is chic, severe, and luxurious. Adjacent to the bar area, the lounge also includes about nine to ten seating arrangements. As I arrived, I recognized several faces from the Boston event. Already with cocktails in hands, a group of men whom I recognized as panelists in the 2010 event were sitting in a dyad in the corner of the lounge area on the ground floor. The space was so suitable for sociability that I began to take note of the ambience of the lounge and its design, to watch how sumptuous club chairs and dim lighting seemed to coalesce with sudden intimacies and social lubrication. The registration table was a few floors up. I grabbed my name tag and

immediately explored the space. On the same floor as the registration section lay a large, brightly lit hallway area (Figure 13). Surrounded by glass on two sides, the area served as the entrance to the main hall where the sessions occurred. I thought that I had understood the event in its social terms.



Figure 13. The St. Regis Mezzanine. The hallway served dual purposes. It was both an entry to the main event space on the right and also functioned as an immediate, external social space away from the main events. During social hours, the hotel staff brought out standing cocktail tables and the space became dedicated to mingling.

By this, I mean that it was clear to me that one significant function of this event was to facilitate the social relationships and networks at the heart of TN. The movement of a finding from a scientists' laboratory bench to its actualization within a biotech firm requires a host of social formations and connections. My discussions with Michael Hall provided me with a sense of the varied ways that social interactions work in the "translation" from the laboratory to a market-ready product. Here I remembered what he said in our initial meeting in Boston:

> *...It's important for me to be well-connected and to nurture my connections because a lot of times, when I'm investing with people, I may co-invest with other investors and other VCs [Venture Capital firms]. So, the relationships that I've built, I need to maintain. And I've built a lot of em'. But, I also go to these events to find out what's going on in the field, what new stuff is coming out, what people*

> *are thinking in terms of neurotech and pharma. I also like to see how scientists are framing certain problems. I also like to see what other investors are doing. Sometimes it's difficult to get to have one-on-one conversations with other investors. These conferences give me a glimpse of where other investors are. And of course, you know I also am looking for deals.* (Interview 14 May 20, 2010)

From this I learned to think about the functions of sociality for biotechnology/ life science investors and advisors in terms of co-investment and in terms of the inherently social structures through which in-group knowledge accretes. Yet, Michael's description also gets at informal learning; finding out "what people are thinking in terms of neurotech and pharma." I began to wonder about how sociality functions for everyone else: How do new entrepreneurs navigate these social spaces? What about pharmaceutical company executives? Beyond already existing relationships, how do individuals form new relationships? What do social relations mean and do in the worlds of TN? I wanted to know more about the conversations that happened right outside of the main event space and in adjacent meeting areas.

On the first day of the San Francisco event, the importance of social connection became suddenly clear during the presentation of an unusually loud and colorful presenter, Leonard Elliot, a rotund man, with big, expressive blue eyes. Quick to offer a joke and a grin, his smile is distinguished by unusual intensity. As a vice president of business development and research at a major medical device company, he is charged with helping the company create alliances with partners -- smaller firms, biotechnology companies, universities, or even large pharmaceutical companies -- where alliances may help his company acquire, access, or develop new products and markets. These alliances can come in the form of licensing agreements and can even take the form of an acquisition of a firm or its intellectual property. For many venture capital investors and

startup entrepreneurs, an acquisition is a good "exit" and thus makes Leonard a key person to know.

In fact, as Leonard outlined his company's partnering strategy in his presentation, he began with a remark about the importance of sociality, what he called altruism. He began his presentation with a long pause. Surveying the audience, he starts his speech with a drama that is uncommon at these events:

> *...Be altruistic…"What?!" you're thinking, "You're not supposed to be altruistic!" But this meeting shows how important altruism is! More than half of you (gestures toward the audience and smiles) are my friends and more will hopefully become [so]. Be altruistic or you will not find the relationships that are necessary to create alliances.*

Leonard's presentation created more questions: What does he mean by the admonishment, "be altruistic"? What is he implying when he says in a sort of collective acknowledgement, "you're not supposed to be altruistic"? Is he referring to some shared ethos of profit over all else? Is his a statement about a culture of greed? I also assumed his statement about half of the audience being his friends to be mere hyperbole. The audience members in the room numbered 400 people or so at any one time. A stream of people entered and left the main event space. Attendees also arrived and departed from the event altogether. Nonetheless, it was unclear to me whether he was serious in his statement that half or more of the audience was his friends.

During the break between sessions, I went out into the hallway right outside the venue. In a bit of luck, I spotted Michael Hall, the investor that I first met in Boston as we he was thumbing around on his Smartphone in the seating area adjacent to the main event space. It had been awhile since we had seen each other. We exchanged small talk. As we chatted, Michael would catch various other attendees' eyes and other participants would

gently touch his shoulder as they passed. A flurry of micro conversations permeated our conversation. I asked Michael about Leonard's statement about being friends with half or more of the audience. Michael had not actually seen Leonard's presentation, but agreed that Leonard was likely to know much of the audience.

"Oh, he's *super* connected," Michael said. "He's definitely someone you want to know. I tried to get him to be an advisor for one of my portfolio companies." A ball of energy, Michael stroked the side of his hair every so often. Michael continued, "He's so busy, but he is just the most connected person in devices. But, you know, [Leonard's company] has been on a rampage lately. Its probably true that he knows half the people in that room or more." Michael explained that Leonard has been at the helm of several high profile acquisitions, and so small startup companies were always trying to talk to him. According to Michael, companies do best if they first get an introduction through Zack.

I asked Michael about Leonard's comments about altruism. Seated in his chair, Michael shifted his body and straightened his clothes. Softly clearing his throat he turned to me. "Well, one thing you need to know is that everybody's hungry," he said, as his eyes eventually met mine. He continued:

> *For startups, for one thing, they are at the bottom of the totem pole in one sense 'cuz they don't have anything. I mean they only have a few compounds or some other thing that they think that they've found. But, they are at a disadvantage and yet, pharma is big trouble right now. I mean, it might not look like it, but investors are up in arms, pharma is closing their neuroscience arms left and right, and so far they have been just skirting along, you know. Leonard works in devices, which is the hot thing right now. Delivering drugs through devices is a unique angle, especially because you can wrap services around it. I say all this to say that while startups are the little guys, the buys still need them. Pharma especially. The medical device companies have been eating up small biotech firms like crazy. That's why my firm really tries to find device people. But small device companies are hard to start. It takes lots of money. So, a lot of time a professor might come up to me just with an idea. You know ideas aren't as easy to claim as devices. So, then the risk is that if you tell the wrong person your idea,* [Leonard's company]

> *may very well just take that shit. I mean just take it. So, a lot of times Leonard wants to have conversations, but some of the little guys are scared to talk to him. In these spaces, info is key. But, at the same time, every startup founder thinks he's some Einstein or something.* (Interview 20 May 21, 2010)

"Everybody thinks they're Genentech" he said, referencing the billion dollar biotechnology company that began out of a scientist's laboratory at the University of California San Francisco (Hughes 2011). Michael's impromptu proverb, "everybody's hungry" adeptly sums up the tensions and risks at work in sharing information; a process both necessary and simultaneously, risky. Moreover, how much to share and with whom is not obvious. For entrepreneurs, for example, the task of finding the right people with whom to share is not easy. A person's placement on the "totem pole" impacts their vulnerability.

From this conversation, several things became clearer: It is likely that Leonard's use of the term, altruism, was not accidental. In order to remain competitive, to learn about new business opportunities, to assess new ideas and movements in the field of medical devices, social connections were key. Yet, for as much as social connection was important, it was information that was the currency of exchange. Leonard, Michael, investors, pharma executives, Zack, and the entrepreneurs - all needed people *to share* with them. This provided me with more context in which to understand the importance and breadth of Leonard's relationships.

While the sociality at work in this event was clear, sustained observation also caused me to reimagine these spaces as vital *financial* communities. I eventually learned that a large number of the attendees knew each other and also had strategic financial ties and relationships to each other. Startup entrepreneurs, for example, needed financial investors, life science investors need to find that one business that will create enormous

financial returns. Zack leveraged his network to be able to find clients for his advisory services and market research products and pharmaceutical companies needed these relationships to find potential acquisitions and/or to learn new strategies that will lead them to increased profits or minimized losses. The concentric circles of financial dependence and relevance shed a different light on the webs of social connection at work. Interested in the specific social connections among the group, I asked Michael to do a quick search on his LinkedIn profile. He confirmed that he and Leonard, with whom he was connected, shared a larger concentric circle of contacts – people who were also at this event. LinkedIn revealed that this world was a small one built upon a rich network of connections.

Be that as it may, the risk that a company or investor could effectively steal a small startup's idea presents a challenge for entrepreneurs. I imagined that secrecy could, at times, also benefit investors like Michael, who could be incentivized to take a novel idea and give it to one of their his firm's portfolio companies. I asked him about that possibility. With perfect confidence and lightening-quick speed, he responded, smiling, "Naw, I'm a good guy." Then he winked. Tepidly, I smiled back, not knowing if Michael was joking or not.

Michael said that pharmaceutical companies have partnership interests too and that these interests are similar to those of the large device companies, such as Leonard's, for which internal innovations have come to a standstill lately. During a break between sessions, Michael introduced me to one of his contacts, a Harvard scientist, Simon Chiang, who was also an entrepreneur working in the depression area. The two had met at the Boston event in 2010. Michael and Simon quickly caught up before the

conversation delved into the crisis at biopharmaceutical companies, especially in the area of CNS disorders, and the subsequent need for these companies to create partnerships:

> ***Simon****: Yea, I had a couple of meetings with [a large U.S. pharmaceutical company], and they were really interested in what I was doing. Their VP was telling me how the only way that they've been able to get new ideas has been by partnering, and that's a real focus this year. I see them all the time around our part of campus. I feel like they should just open up an office inside Harvard (he chuckles).*
>
> ***Michael****: Yep! That would be funny. You know, we've been doing well because they [pharmaceutical companies] are so thirsty for ideas. It's crazy because they are still raking in billions every year.*
>
> ***Simon****: I know. I'm always thinking, how is pharma so poor, and yet, still pulling in billions? You know my sister is in a Science Office at a biotech firm in Cambridge, right? And she says that part of the whole [concern] deal is from investors.*
>
> ***Michael****: (Interrupting), yea, it's really about future returns. Investors are obsessed with seeing down the line. It doesn't matter though. Pharma always gets its money.*

Simon and Michael's exchange brought up the paradox of how pharmaceutical companies, with a drying up pipeline of new products and a tough regulatory environment, still remain profitable. It also brought up the possibility of investor response as a factor in Pharma's strategy towards partnering. The conversation suggested that perhaps the concern for pharmaceutical company shareholders was about risk that was only now unfolding. Perhaps the concern was about the fact that pharmaceutical companies could only employ so many creative business strategies in lieu of real innovation – a point that several scholars have made (Applbaum 2009b; FitzGerald 2005). During his presentation, Leonard outlined his partnering strategies:

> *We will partner our internal talent with academics and I think that this has been successful but I think that what we felt we needed to do is to build a small biotech*

> *company within [company and specific division] and so we had to bring in people who could really understand biotech. Not to just understand new therapeutic concepts…We used to have lots of alliances, and they were at very arms length. I wanted to change this and I feel strongly that we don't just sell a device, we sell a therapy and we want a 50\50 sense with our deals.*

I had heard of this trend of building a small biotech company within biotechnology and pharmaceutical companies before as a strategy for inspiring entrepreneurial innovation within each company's own research and development divisions. But, I was intrigued with Leonard's statement about the limits of therapeutic understanding for building successful products. In Leonard's formulations, a necessarily collaborative approach brings together the expertise of scientists and those with expertise in the business of the life sciences. In this way, I began to see these social spaces as contexts for a kind of hybridity; not merely bringing scientists into mere partnerships with existing company infrastructures. Rather, it was about fusing expertise together folding them into new corporate formations[44].

Significant venues for connecting were the cocktail hours and the catered lunch. At the St. Regis, lunch was held outside on an enormous terrace on a middle floor that afforded only brief views of the city on account of the large cream-colored tent that into which about 20 tables were clustered. A working lunch, a keynote speaker approached the podium and began discussing the "true cost of risk" for companies working in the neuroscience sector. The speaker took up about a 30-minute portion of the lunch hour. A sunny San Francisco day, a warm, muted glow from the sun lit the tent and produced a lush light.

[44] One also finds this fusing together in the growth of professional master's programs that are now being created to produce business-minded scientists as well as science-versant business executives.

The speaker, CEO of a company that creates products to help improve the quality of clinical trials, spoke in a strangely grave way about the impossible difficulties that pharmaceutical companies face in an overly burdensome regulatory environment. Despite his company's self-ascribed focus on increasing quality in clinical trials, his speech almost exclusively addressed all of the creative ways and strategies that can be used to massage clinical trial data and outcomes. The end of his presentation convinced me that his real goal was to attract new clients among the pharmaceutical, biotechnology, and medical device industry representatives in the audience. As he ended his short speech, he began to excoriate the risks and true costs of being innovative ending with dramatic stories about his experiences with large, expensive clinical trials, the role of awful government regulation in those costs. The speech became a harangue about regulation and the way that the larger "system" punished innovative pharmaceutical companies. An older, white-haired man to the left of me nodded aggressively in agreement with the speaker. He then went on to bombard his rather disinterested neighbor with a prolegomenon about taxes.

As the keynote speaker started his conclusion, an orderly battalion of serving staff marched in unison into the room. The warm glow from the sun caused the metal serving platters to sparkle as they entered the room and were deposited in front of each attendee. As Zack had designed, the end of the keynote left about an hour for lunch and mingling. Squinting at my nametag, the white-haired man to the left of me, hunched down in order to get a better look, his chin almost approached the height of the table. "So, Princeton, eh? What do you do there?" he said, still squinting. "Well, I'm a researcher. I'm interested in understanding more about TN," I replied. He nodded slowly as if to signal

understanding and, clearly disinterested, returned to his filet mignon. Nothing tangible emerged in our interaction. Later, he revived his harangue about taxes with his now inured neighbor.

To the right of me was a woman named Suzanne White. A young attorney, she gave me her card as a matter of custom. She explained to me that she works on issues of intellectual property, especially for life science and biotechnology companies. Based in Silicon Valley, her office was part of larger international law firm that does a lot of work for "clients in this space." I asked her about her experiences working with entrepreneurs. She said, "although I'm relatively new, I have had some experiences with university-based scientists looking to establish intellectual property protections." She continued:

> *One problem that they now encounter is an aggressive intellectual property agreement on the part of universities, which lay claim to not only IP developed at the university, but also, to the extent to which they can, they try to also lay claim to IP that they believe resulted from discrete research, learning or educational activities that happened at the university." Universities are really wising up to the revenue potential attached to their intellectual property and their resources.* (Interview 11 May 21, 2010)

Following from my conversation with Michael, I was interested in whether she worked with entrepreneurs as they formed relationships with companies. White replied that at her firm, those concerns were handled by a different practice. However, she did articulate a caution. Leaning in slightly, she said, "I know a lot of stuff about many of the companies in this room. *Honestly*, some of these guys will choke their own family for a good deal (Emphasis hers)." Then, as she sat back in her chair she whispered with a chuckle, "sharks." I asked her what she meant. Eating her salad, she began gesturing with the other hand, “Well, you know, information is sometimes as valuable as IP, I've found. Remember, IP is only as valuable as the market.”

At that moment, people began slowly exiting the tent, turning back into the building. As staff came out to collect the plates and trays, White and I went down to the main hall. However, around the corner from the registration table, there was a maze of hallways and informal areas. Up a half flight of stairs, there was an additional maze of nooks and informal seating spaces. We found a quiet spot in a nook that looked out over the city. Peering out, she said, with a tone verging on shock, "It's a beautiful day!" As she laid her jacket over the side of the club chair, she continued.

> *I mean that even IP is really only valuable in a context. I can't tell you how many times I hear about companies that purchase a small firm, but which write into the contracts these super long engagement or consulting times from the entrepreneur, sometimes for years just because of the all of the contextual and domain information that he has and to which the IP is often irretrievably tied. In that way, these super bold IP agreements that universities are now requiring of faculty makes sense. You really can argue that the university helped create the context where certain knowledge took place. Some entrepreneurs are now wising up and once they come up with an idea, suddenly [they] quit the university and wait a length of time before filing for a patent. Another example, [of the importance of context for IP], one that I'm thinking about that happened recently, was with a client who decided to sue an advisory firm that was helping him and his small biotech company. He had eventually fired that firm. He was an academic - a little on the crazy side. But, he decided to sue them claiming that his IP was valuable and only valuable because of a key relationship that the advisory firm had that was now lost because the advisory firm will no longer make the connections. He's saying that his IP is rendered value-less. This was something that I really learned in my time learning the ropes in this practice -- that there is more to IP than what you might think.*(Interview 11 May 21, 2010)

White's positionality made her explication especially useful. Her insight into the legal risks and entanglements for university-based entrepreneurs provided a novel angle into the relationship between scientist-entrepreneurs and their location in a complex social web of interdependence. Her own theorizing about the way that legal structures around IP impact collaboration and the inherently contextual nature of IP corresponded with my own hunch about the fact that TN's output is *rendered important* in and via

given contexts-- an issue that has also been missing in modern analysis of science-technology distinctions and the problem of knowledge (Faulkner 1994) White eventually got up to return to the event. I stayed in the vicinity to look for a place to jot down thoughts.

As I peered down the half flight of stairs that led back down to the main area, I saw Zack enthusiastically greet someone in the main area and quickly whisk them up the half-flight of stairs past me to introduce that person to another. Zack was a key connector in this space; introducing advisory firms to potential biotechnology clients, or connecting IP lawyers to startup entrepreneurs. TN could only occur via such social connections. White's story came back to me. In her example about the man who sued the advisory firm that could no longer connect him and subsequently rendered his IP without value, it is clear that social networks constitute productive capacities[45].

The social is a crucial vehicle enabling what Kaushik Sunder Rajan and Sabina Leonelli outlined as the "trans" in translational science and research (2013). In fact, thinking of White's example of the client whose IP could only "move" with the help of his relationships and witnessing Zack's constant introductions, I believe that the sociality I was witnessing at the Neurotech Investing & Partnering event constituted the very "mobility" that Rajan and Leonelli outline as integral to the concept of translational research: According to Rajan and Leonelli, "Mobility is therefore central to the idea (and ideal) of knowledge that animates translational research. In order to act toward the

[45] This is especially the case among venture capital communities. There is interesting work and recent (Sharp 2013) scholarship about the role of social networks and social capital in the machinations of investment and information gathering processes, an issue that has been well documented (Cohen and Fields 2000; Dierkes and Hoffman 1992; Kenney and Florida 2000; Saxenian 1996; Welz 2003)

aspiration of "improving human health," biomedical claims, objects, and practices have necessarily to move across boundaries (2013, 466)."

Still in the upper area, I sat down at a bench to write down my observations. I began to re-evaluate my initial propositions about the functions of these events for academic scientists. Indeed, for university-based researchers who have made a discovery in their lab that they believe could be later translated into a useful therapeutic or diagnostic, finding ways to capital and resources is important. On the path between discovery and invention lie expertise, pitfalls, and questions that the researcher must successfully navigate. These events function as a space where a university scientist can introduce a laboratory discovery and render it -- quite literally -- meaningful and/or *valuable* in all of the diverse, subjective and complex ways that translational value gets codified (Rajan and Leonelli 2013, 465). Here we see how finance helps to "matter" scientific findings.

The sequestered space in the upper area where I sat to write was quite beautiful; with dark, muted rouge carpets that complemented the slightly glossy, salmon-colored, grass cloth wallpaper. Momentarily absent of people, the space acquired a Zen quality. Throughout all of the hotel spaces, one consistently found art. There was a beautiful and intricate wire sculpture suspended from the ceiling over the stairs that connected the two spaces. In expected and unexpected spaces one found art installations. However, near the area where I sat and wrote, I noticed a cluster of framed images neatly arranged on the wall (Figure 14).

It drew my attention and went over to get a closer look. As I looked closer, I discovered that the cluster of pictures were dark, stylized images of inkblots, reminiscent

of Rorschach tests, the tests that psychologists used most widely during the 1960s in United States. I took a picture of it. For me, the prominence of the Rorschach Test was a result of its cultural appropriation in U.S. Television shows where it was used during scenes that depicted interactions between a psychotherapist or psychoanalyst and his or her patient subject. Yet, the Rorschach test was much more than this. Its inventor, Hermann Rorschach, a Swiss Freudian psychiatrist, had intended for it to be a tool that could be used for the diagnosis of schizophrenia (Rorschach 1921,2008). Based on an experiment using 300 institutionalized patients alongside 100 control subjects, Rorschach created an inkblot-based diagnostic tool that used "Psychodiagnostic Plates" as a key element within a larger diagnostic method outlined in his 1921 book, *Psychodiagnostik.*

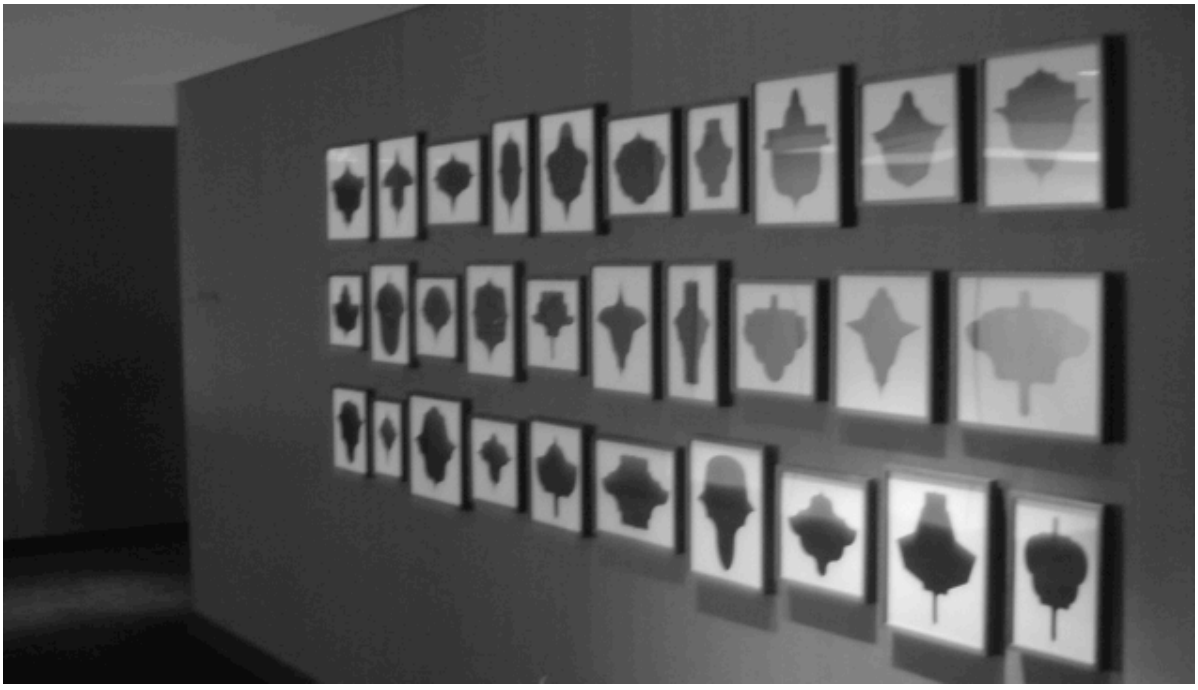

Figure 14. The Rorschach-Inspired art installation at the St. Regis Hotel. The upper area adjacent to the event space with the Rorschach test-inspired art installation.

The serendipity is multiple: Firstly, it is interesting that this early relic of psychiatric diagnosis had really become relegated to an aesthetic; a psychiatric and

technoscientific anachronism -- a cultural artifact now used within pop culture to gesture towards historicity and also, in this case, via its modern reinterpretation by an artist. Yet, a second serendipity exists: This art installation is staged no less than 50 feet away from an event focused on -- and in many ways, charged with collectively producing and predicting -- the future of psychiatric diagnosis. In some ways, it felt like a sort of museumification of tropes and modes of early psychiatric thinking and doing: an aesthetic mummification of a sociotechnical presumption. It represented the impermanence of psychiatric understanding as well as the history of tools used in capturing and understanding human madness.

One now-vital space for the research and design of new neurotechnologies and diagnostics is through emerging collaboration models that partner larger pharmaceutical and biotechnology companies with innovation centers such as universities. By the time that this conference happened in 2011, this model was widespread among a variety of innovation-focused corporations across many sectors.[1] Thus, the dialogue between Michael and Simon, the Harvard scientist, about the firms staking out Harvard's bioscience faculty -- only served to further confirm this shift. In a panel titled, *Translational Partnering and Investing Opportunities*, the written description of the panel included the following summation articulating the relationship between academia and spaces of "opportunity":

> *This session will feature selected cutting edge, research projects from academia, research institutes, and government labs ready for collaboration or hand-off to industry. Don't miss this showcase of the next generation of drugs, devices, and diagnostics selected from the top TN projects. Supported in part by a grant from NINDS, NIA, and NIMH.*

After incorporating and filing patents lies the process of scaling: researchers must find investors to take their small, newly formed biotechnology firm to the next level. Often, they'll get an introduction to Zack. Michael Hall, my investor friend who would become a major interlocutor, explained to me during intermission that Zack's introduction means a lot. According to Michael, "to have an idea vetted by someone who understands the industry and the space and the climate is really important. Certain introductions mean more than others."



Figure 15. At the Neurotechnology Industry Investing & Partnering Conferences much of the program is devoted to providing scheduled time for networking. Additionally, the venues selected often include a panoply of rooms, lounges, and adjacent spaces where participants have discussions, entrepreneurs discuss their companies, and ostensibly, deal are made.

While the importance of a social connection in the world of biotechnology is known among scholars who have explored the impacts of venture capital upon the practices and the viability of biotechnology startups (Rabinow 1997; Rajan 2006; Shapin

2008; Sharp 2013), the reputational of structures at work in investor introductions speaks of an altogether different vector of meaning -- an area where there is a need for additional research. Michael explained to me the delicate currencies accorded through key social introductions: "So, I definitely go and talk to scientists in their labs, but I definitely pay attention when Zack says to me, 'hey, I've got something here.'" For both the 2011 and 2010 Neurotech conferences, an important scheduled part of the events included social hours where Zack continued to broker conversations, introductions and, importantly, where conversations went from official to unofficial.

As time went on, these social spaces became havens of trust. At the St. Regis, conversations would move from the area surrounding the main space down to the lounge areas. The intimacy of these conversations made them difficult to join, especially for a marked outsider. Nonetheless, the shift from official to unofficial discussions was noticeable. I observed gradual shifts in body language, sudden intimacies between two speakers. Several young academics pulled out computers to show to their interlocutors. All the while, I also watched Zack. I noticed that he was not only arranging interactions and sharing among people; he was also consuming. He always asked soft, pointed questions while bringing attendees to meet others. He was constantly learning. It was because of this -- his knowledge repository of interests, projects, and goals that Zack was a consummate neuroscience broker. I initially thought of the Neurotech Investing & Partnering Conference as a sort of marketplace. Indeed, the need for deal making -- for investors, entrepreneurs, investment firms, advisory firms, lawyers -- enabled it to be conceived in this way. However, as is clear by now this event is more than space for trading commodities.

Clifford Geertz, prompted in part by the theoretical poverty of rationalist models of economic behavior which reduce all kinds of markets and marketplaces to the logics of competition and thusly, rational choice theory, — wrote about the role of information and knowledge in systems of exchange. Reflecting on his own research in the Moroccan bazaar in the town of Sefrou, Geertz elucidates the ineluctable functions and paradoxes at work around information in the bazaar economy. Writing about the ubiquity of ignorance inherent to the bazaar, Geertz attributes the importance of information precisely to its tyranny:

> *The search for information one lacks and the protection of information one has is the name of the game. Capital, skill, and industriousness play, along with luck and privilege, as important a role in the bazaar as they do in any economic system. They do so less by increasing efficiency or improving products than by securing for their possessor an advantaged place in an enormously complicated, poorly articulated, and extremely noisy communication network.* (1978, 29)

Thinking of the Neurotechnology Industry Investing & Partnering conference as a bazaar helps to make sense of its complicated sociality and the way various stakeholders -- investors, entrepreneur, scientists, scientist-entrepreneurs as well as biotechnology and pharmaceutical company executives -- employ practices for modulating access and information. This contextualizes the edict of Leonard, the boisterous medical device company executive who warned attendees to "be altruistic." This admonition, and perhaps desperation, reflected both his "privileged" position within the bazaar and his vulnerabilities from the poor articulations and extreme complications of the bazaar's "communication network."

The concept of the bazaar as an information economy also helps make sense of the information anxieties worked through during panel presentations. I notice how the panel titles simultaneously inspired information anxiety and also promised information

advantages: “New Investment Strategies for an Increasingly Unstable Neurotechnology Industry,” “Emerging Treatments in Epilepsy and Pain,” “Next Generation Psychiatry.”

In Geertz’s formulation, he distills micro-meanings that make information worthwhile. According to Geertz, “Information search thus, is the really advanced art in the bazaar, a matter upon which everything turns. The main energies of the bazaar are directed toward combing the bazaar for usable signs, clues as to how particular matters at the immediate moment specifically stand” (1978, 30). The notion of usable signs is quite apt here in that it specifies the process of reading indicators of potential, for example, recognizing a new startup working at the edge of the latest innovations in bioscience. Michael, for example, is not simply in search of information. Rather, his constant conversations and his relatively small number of actual investments speak to this notion of combing - of looking for, thinking with Geertz, something like investable signs. One sees this ethos throughout the event. Notice how the description for the 2010 panel event, “Investing in Neurotech” uses “usable signs” as a means to entice the attendee to participate in the event in order to gain a competitive advantage:

> *Investing in Neurotech Panel*
>
> *A diverse panel of private, public and strategic investors will discuss their investment strategies. What does it take to get a neurotech company funded? What are the benefits and risks of business models in devices, pharmaceuticals, diagnostics and information technology? What are today's deal terms and valuations? What are the best exit strategies and how is neurotech comparing to other industries? (2011 Neurotechnology Panel Listing)*

The notion of signaling usefully gets at the practices of the investors, in particular, who are looking not only for good information and strategic advantages, but who must also *discover* opportunities. It points to the performative practices of those hoping to

convey the right signs. Thus, Leonard's exhortation about altruism was also designed to create opportunities for discovery. This paradox -- the need for an excess of information and exposure to an abundance of possibilities in tension with the search for rare, usable signals — produces a challenge. One needs a robust network and exceptional winnowing skills to find the needles in the haystacks. The "…primary problem facing its participants is not balancing options but finding what they are" (Geertz 1978, 30).

Yet, among the noise of the "bazaar," the polyphony of varied and situated voices, lay an internal structure of strategic intimacies. These intimacies are signaling processes between potential collaborators: Michael's leaning-in to impart information about the fact that "everyone's hungry" or Zack's strategic sequestration of potential collaborators away from the main event space. The abundance of intimate spaces and areas are designed to induce and stabilize momentary intimacies, what Geertz calls, "personal confrontation between intimate antagonists" is an essential element of the event's design (1978, 32). These moments can be thought of in terms of something like pollination. However, in the larger lifecycle of TN, one could ask the question about the ways in which the entire process of translation depends upon — and is perhaps, sustained through — these arranged intimacies.

Lastly, I want to point to the applicability of Geertz's notion of *clientalization*, a tendency for those involved in the bazaar to "…establish continuing relationships with particular purveyors…" Against any notion of pure dependency, Geertz's notion of clientship is adversarial, competitive, and egalitarian. Moreover, it is a means for the hazards and costs of information search to be reduced and systematized:

> *...clientship is a reciprocal matter, and the butcher or wool seller is tied to his regular customer in the same terms as he to them. By partitioning the bazaar*

> *crowd into those who are genuine candidates for his attention and those who are merely theoretically such, clientelization reduces search to manageable proportions and transforms a diffuse mob into a stable collection of familiar antagonists. The use of repetitive exchange between acquainted partners to limit the costs of search is a practical consequence of the overall institutional structure of the bazaar and an element within that structure. First, there is a high degree of spatial localization and "ethnic" specialization of trade in the bazaar which simplifies the process of finding clients considerably and stabilizes its achievements. If one wants a kaftan or a mule pack made, one knows where, how, and for what sort of person to look. And, since individuals do not move easily from one line of work or one place to another, once you have found a particular bazaari in whom you have faith and who has faith in you, he is going to be there for awhile. One is not constantly faced with the necessity to seek out new clients. Search is made accumulative.* (1979, 30-31)

In this view, clientalization produces a sort of stabilization, a means to conceptually manage labor divisions, and enables what could be called a kind of market analysis: a holding in place of knowledge, meta-knowledge, and signs in order to ease processes of information and exchange. Consequently and concurrently, clientalization, for Geertz makes possible a necessary and systematized means of filling-in for an inevitably impoverished system:

> *Clientalization represents an actor-level attempt to counteract, and profit from, the system-level deficiencies of the bazaar as a communication network--its structural intricacy and irregularity, the absence of certain sorts of signaling systems and the undeveloped state of others, and the imprecision, scattering, and uneven distribution of knowledge concerning economic matters of fact--by improving the richness and reliability of information carried over elementary links within it.* (1979, 31)

Now, it is the case that in the world of biotechnology and the corporate life sciences, there is significant turnover unlike the Sefrou bazaaris in Geertz's example. However, given the increasing role of technologically mediated networks such as the professional social network website, LinkedIn, we see the ways that technology is positioned as a mediator in creating and sustaining intimacies, Given these technologies' capacities to organize information about divisions and competencies, digital mediation

has become a significant tool of clientalization complementing the on-the-ground social process. I think about the way that Michael Hall quickly brought up LinkedIn to answer my question to him about the social connections of those attending the conference. White, the Silicon Valley IP lawyer whom I met at lunch still needed to attend these events in person in order to create the sorts of intimacies, which while later codified via LinkedIn or initially opened up through LinkedIn, still required that she sit around a lunch table in the middle of sunny day in May handing out business cards to prospective clients.

Geertz's articulation of the relationship between structure and knowledge in the bazaar functions as a complement for -- if not an antecedent to the material --semiotic analysis of material and social worlds conceptualized in theorizations such as those within actor network approaches (Law 2009) and that of the trading zone in Peter Galison's work on the many cultures of microphysics (Galison 1999).

The social problems of knowledge and information for which processes such as clientalization constitute a solution are conceptually useful for thinking about the thoroughly social means through which the "gaps" at work in TN are traversed. If the continuum between a scientific laboratory and its commercialization includes a meeting of materials and epistemologies — animal models and fertilization tools, glial cells and psychopharmacology — social arrangements can be seen as levers and bridges that fill in the gaps over which translation must occur. In this way, the very architecture of the St. Regis hotel seemed to work in concert with the event's necessary social flows and designated meeting areas. I began to think of the social networks and LinkedIn connections alongside the lounge space and mezzanine levels as constituting an important

ecosystem. These socially enabled cross-pollinations enable the essential bridging activities of translation. My point is to suggest that it is via these social and material bridging systems that one can locate not only the categories of knowledge mobilities engendered and required under the regimes of translational research (Rajan and Leonelli 2013), but also knowledge in transit moving in particular and specific *directions*.

The Subjects and Objects of Neurotechnology Markets

The sociality of TN is also useful in tracing the avenues through which pharmaceutical presumptions may impact upstream practices in university-based science laboratories. For a university scientist attending the Neurotechnology Industry & Partnering Event, experiences with investors and articulations of investor value can impact decision-making to select one scientific question over another. One might ask what are the impacts of the endless panels of scientists and entrepreneurs (funded and unfunded) in discussion about fruitful and non-fruitful trends in life-science research upon the micropractices of university scientists?

While scholars such as economic historian Phillip Mirowski have traced the shifts in university practices under neoliberalism (2011), these structural and institutional evolutions are not the same as the ethos, the long-harangued scientific sensibility thought to animate and undergird science under classic, triumphalist accounts of the scientist and "his" vocation (Haraway 1997). Efforts of scholars to trace trends toward commercialization in the university itself have been significant and yet the imprint of market forces upon the work of scientists in terms of ethos is less clear (Gieryn 2008; Hong and Walsh 2009; Kleinman 2003; Krimsky 2004).

However, to measure the impact of market forces upon the practices of individual scientists, their decision-making, epistemologies, and subjectivities would be a nearly Sisyphean task. In the absence of data about a scientific consciousness, Mirowski, in the middle of his historiography, inserts a fictional scientist, Viridiana Jones whose subjectivity becomes a space in which he theorizes relationships between the encroaching commercialization of research and basic science in individual scientific practice and thinking (2011).

For historian Steven Shapin, market forces have not entirely displaced trust and virtue as the every-day currency of scientific collaboration and work even in the contexts and soft erosions of late modernity's "entrepreneurial science" (2008, 251-252). Yet, if, as scholars have ardently suggested, there is an indubitable shift toward increasingly market-oriented (Berman 2012), patentable (Mowery et al. 2004 and commercializable (Bok 2003; Lowen 1997; Shapin 2008) academic bioscience research, it is legitimate to ask whether the need for venture capital and the language of translatability necessarily prefigures research agendas at the modern research university. Does an assumption of a psychopharmaceutical endpoint necessarily produce psychopharmaceutical thinking? Are there risks from this mode of thinking as it relates to other kinds of marginalized data, questions, and possibilities? During one panel focused on collaborations between large life-science companies and universities, a partner at a New York-based venture capital firm said to the audience of university scientists, investors, and others, "The goal is to think about how Big Pharma and Medtech are thinking about neuroscience."

A first reading of this statement concerns the aligning of smaller firms' strategic thinking about neuroscience research with that of larger pharmaceutical and

biotechnology companies. However, there is a potential second reading of his statement, which would be about scientific thinking as it impacts on-the-ground laboratory practices. In other words, if "…the goal is to think about how Big Pharma and Medtech are thinking about neuroscience", then this suggests that universities that hope to one day partner with pharmaceutical and device companies (or to create knowledge considered to be valuable in that realm) may begin the process through modulating their on-the-ground laboratory practices and research agendas in order to complement "how Big Pharma and Medtech are thinking about neuroscience." Here, "thinking" becomes the first step towards legibilities.

Beyond the increasing commercialization of academic bioscience lies the question of the implications for biological meaning. How does one distinguish between biological observation and a finding or distinguish a finding from an invention, even if that invention is merely a new means or method for revealing biological material? Underneath concerns about permuted scientific practice emanate questions about the changing semiotics of biological material under neoliberalism.

"The Secret of Weight Loss is the Scale"

Scholars have shown just how lucrative psychiatric disorders and global biopsychiatry in general have been for pharmaceutical companies *despite known problems* (Applbaum 2009b; Ecks 2010; FitzGerald 2005; Gagnon and Lexchin 2008; Healy 2012). According to the "Neurotechnology Industry Report," in 2008, neurotechnology companies generated revenues of $144.5 billion, representing 9.0 percent growth.

Within this paradox that I began to think about TN not only in terms of its epistemic and financial risk, but its capacity to mitigate risks that had ballooned based on a history of problematic practices by pharmaceutical companies. Here I thought about the pharmaceutical executives at the Nurotech Industry and Partnering events who display a relative agnosticism regarding the absolute necessity of deep neuroscientific knowledge. This way of thinking compelled me to reflect upon Simon's earlier reference to an emerging industry preference for neurotechnologies (by which he really means devices and diagnostics, rather than psychopharmaceuticals, though these technically are also neurotechnologies) over pharmaceuticals because of their lower risk profile. In other words, neurotech has a risk mitigation function for TN.

I want to point to another instance where risk is prominent: At one point a panel moderator said, "Boston Scientific is selling its neurostimulation division. Does this reflect waning interest?" Boston Scientific was one of several companies that either sold or shut down their neuroscience research groups in 2010. One investor, who directs his own eponymous venture capital firm, said, "We like …diagnostics" He said that his firm sees it as a huge opportunity and is actively trying to figure it out. Of course, what is intriguing is that his statement, "We like diagnostics" was said in a way that conveyed the sense that diagnostics are *something* or at least *one thing* that his firmed embraced. In response to this, Simon interjected: "One of the challenges is diagnostics -- at least the way that we use them now is that there is an interplay between diagnostic and therapy. Some simply molecular diagnostic or some prognostic market is a huge market going forward." Here again I thought back to my conversation with Dr. Jones, the neurologist

and her reference regarding the increased availability of diagnostics and the challenge of actually interpreting them.

Simon's articulation is key. But it is also important to note that how the move towards diagnostics reduce risk. Diagnostics themselves are less risky than therapeutics. And Simon rightly acknowledges that a problem for diagnostics can emerge when tied to an existing therapeutic solution. However, diagnostic tools that are untethered as a "solution" effectively commercializes a patient's own biology. For example, molecular therapeutics that rely on genomic science simply offer predictions about tolerances. They are less tethered to actual therapeutics. In fact, molecular therapeutics make *biological information* its primary product (Fortun 2008; Lippman 1992; Savard 2013). In other words, a molecular diagnostic product monetizes sheer biological material alongside an attached clinical interpretation of its meaning. The logic of this strategy became clear during a morning panel at the 2011 event titled, "Frontiers in Neurotechnology."

Laura was the CEO of a startup, SkyBridge Diagnostics. SkyBridge Diagnostics is an early stage company focused on the development of blood-based tests for neuropsychiatric disorders. "In vitro diagnostics" she called it. Laura began her presentation with unrequited scientific confidence. "We take the *biological approach,*" she said, quickly scanning the audience. Laura then delved into an explanation about her company's current project and its partnership with a well-known hospital in New England: "Were in a network with [a prestigious New England hospital] to develop a blood test for bipolar disorder. Why do you need this? When you examine the challenges experienced at the clinic, it's hard to argue against additional biological tools or some additional diagnostic tools…"

Laura revealed several important interplays at work in terms of clinical decision-making. As was the case with Dr. Jones, the neurologist I spoke with, we see this aphorism that *more* science simply can't hurt. In this view, additional tools contain a value in and of themselves. Here again we see the prospect of a neurotechnology such as a blood-based neuropsychiatric diagnostic that produces mere information in a context in which mere information can be considered clinically valuable or, at minimum, bereft of any real harm. Of course, soon thereafter, Jones added a quick, soft refrain about ballooning healthcare costs. However, Laura's aside that "…its hard to argue against additional biological tools or some additional diagnostic tools" in the contexts of the clinic corresponds with the information hegemonies that Dumit articulates in his discussion in *Drugs for Life* of the complications that build up around the problems of screening, especially as it is distinguished from the thresholds of diagnosis. Recounting internalist articulations from the researchers and designers, Dumit recounts several questions that emerged about the purpose of screening tests for depression:

> *Was it to indicate referral to a psychiatrist? Did the screen itself constitute diagnosis of depression? Was there any evidence that screening improved patient outcomes?…Choosing to screen and setting a threshold thus involved a careful assessment of the entire healthcare system and the effect that the screen would have on each part of it. In the language of science studies, screening was understood to be part of a large-scale sociotechnical system…Screening also raised the socio-medical problem of confusing the screen with the diagnosis and with proof of illness. Would a screen given to primary doctors to pass along possible depressives to psychiatrists to be properly evaluated come to be taken by the primary care doctor and patient as a diagnosis of depression and indication for treatment? These problems were… being raised by the same researchers who were conducting the surveys, studies, and clinical trials, and designing new and better screening tools.* (2012a, 146)

Laura's confirmation of the accretive nature of diagnosis and treatment at work in the clinical encounter rendered the information itself as beneficial for patients.

However, as the concerns in Dumit's recounting enunciate, the problem is one of ontological conflations and confusion: Is a screening the same as a diagnosis? Is a diagnosis the same as proof of an illness? How might various diagnostic test results actualize or eliminate the reality or unreality of a disease? In this sense, the screen becomes a space in which to see various forms of material and semiotic actualizations; actualization that also produce confusions and ambiguities that are acknowledged as such, but which are still understood as not constituting patient harm. Hence, Laura's easy, nearly axiomatic apothegm, "…its hard to argue against…"

The question of whether the *diagnostic* that Laura discusses in her scenario would transform into a *screen* garnered greater importance as she continued talking:

> *…and so there is a diagnostic continuum that exists, half of the reason, maybe, that contributes to the failure rate of the initial use of drugs. So the efficacy of the drugs is compared against high levels of clinical accuracy and so the blood test -- were talking about a blood test -- that approaches that level [a clinical research level] of high diagnostic accuracy and taking it to the clinic. So, with that we hope to get able to see that these patients have better control of their disorders. Patients are seeking blood tests. We believe and the psych. community and the primary care docs agree that it helps for the patient to see their disorder. It helps patients to understand -- for patients to understand that it's that it's biologically based.*

Laura's scenario includes primary care physicians, a convenient obligatory passage (Callon 1986) within the sociotechnical system of the blood test, rather than placing these tests exclusively within psychiatry. However, I was also drawn to Laura's suggestion that the higher level of diagnostic accuracy to be provided by her blood-based diagnostic tool might offer a solution to problems of psychopharmaceutical efficacy.

While it ushers in the promises of personalized medicine, biological material here becomes a resource for problems of already existing therapeutics. I noticed similar repurposing of patient biology during a panel on neuromodulation devices. One presenter

advocated for a new way of thinking of brain devices, as a means by which implantable biotechnologies might become a source for more perfect medical treatment. According to that presenter: "Don't think of the little implant as a little implant. Think of it as a computer. There will be genomic and feedback info based on this. We need to make sure that healthcare is a zero sum game. We have to make sure that medical practice changes so that we get perfect treatment."

In this mode, one sees implanted devices, such as deep brain stimulation as a meeting between, in his words, "informational, pharmaceutical and device-specific approaches." However, these approaches all work in tandem with a patient's own biology -- as the source of genomic feedback, for example. One's biology becomes a part of the therapy just as it also becomes the laboratory where data, modulation and reporting all come together.

Accordingly, thinking back to Laura's explanation about the *utility* of blood testing, it is clear how a blood-based test offers not only a means of making an informational commodity out of blood, but it becomes a means for deeper entanglements with pharmaceuticalization and the clinic. While the promises of personalized medicine are drawn on the possibilities of more tailored and more efficacious medicines, the logic enables a *systematic undoing* of the barriers to pharmaceuticalization thereby creating a need for greater access to patient data and more sharing. After her statement, Laura then indicated that the *real* benefit is in the fact that tools like the blood test create "conversations between patients and their doctors."

According to Laura, "If just 10 percent of overall conversations could lead to a blood test, it leads us to a huge market potential." In this way, one sees that sheer

information is in no way neutral. Rather, it becomes pregnant with implications for ontologies, confusions, risks, therapeutic and economic possibilities. We also see in Laura's numerical and market reasoning ("just 10 percent") the kinds of power accorded to numbers and market sizes in the clinical encounter, a phenomenon that Lochlann Jain (2013) chronicles in her research on cancer and the effects of numerically-driven diagnostic and clinical cultures. Yet, the most evocative image during Laura's statement lay in her remark about the importance of helping patients "see" his or her disorder. This conflates biological material —blood and all that it's contained within in — with patient "disorders." Laura's statement inspires both visions and questions: What does it mean for a patient to "see their disorder"? How might TN's leveraging of sheer biological material work in relation to the construction of psychopharmaceutical subjectivity or what Janis Jenkins has unearthed as the shaping of "the pharmaceutical self" (2011, 66)?

Yet, the claim also conflates a diagnostic and its disorder. This produces questions about the mechanics of diagnostic realization. Through which practices does a diagnostic test transform into visions of one's medical disorder? Might this moment of emergent social and material practice at work between the clinician and the patient represent something like psychopharmaceutical intersubjectivity? This question suggests the discursive production around biological material, which is in itself an ineluctable part of the "product" of diagnostics. In other words, the diagnostic test is inextricably fused to the discursive authentications and scientific explanations of the clinician. However, an additional and critically important part of the therapeutic role of the diagnostics was elegantly summed up in Laura's statement about biology, " It helps patients to understand - for patients to understand that it's biologically based."

I found Laura's statements be telling. Her initial statement, "its helps patients to understand" and her mid-sentence clarification, "it helps for patients to understand" both align with the objective and subjective utility of biological meaning-making in the realm of the clinical encounter. In the former, the diagnostic helps patients to see and understand their own disorders. In the latter, Laura affirms the benefit to larger structures — the clinical encounter, patient education paradigms, pharmaceutical practices — of having patients achieve psychopharmaceutical realization. In this sense, the critically important part of the therapeutic role of diagnostics is the capacity for a patient's biological material to effectively conjure up epiphany and recognition. Perhaps, this is the material phenomenology and associated technological accompaniments that enable something like an Althusserian interpellation, by which I mean the material means through which according to Althusser, "ideology 'acts' or 'functions' in such a way that it 'recruits' subjects among the individuals (it recruits them all) or 'transforms the individuals into subjects'…" (Althusser 1971, 174). In other words, interpellation becomes not only the material means through which an ideology is effectively activated within and transferred to given subject, but also a means of realization that works through subject's "recognition" of the self.

The importance of this productivity around biological material becomes clearer as the conference goes on. The movement of the industry towards genetics enables and constitutes a solution for the problem of the messiness of psychopharmacological presuppositions and the fact that psychopharmacological models simply don't adhere to the same kinds of science and efficacy requirements as other drugs (Applbaum 2006, 107). By this I mean to suggest that that these diagnostic-based strategies enable a

repurposing of biological material -- in this case, via genetics -- as a solution for the problems of existing scientific models and patient care. In other words, in a context in which "you have no models", here invoking the damning words of the investor that I referred to earlier, this idea that one's own body can become the means and the evidence for intervention is powerful. The productivity of using one's own biology as a product in concert with diagnostics was elegantly summed up in a terse adage stated by a young CEO of a company that sold at-home Sleep Apnea diagnostic tools. He said, "People can use their own data and to try to become more healthy. Remember, the secret of weight loss is the scale."

Discourses for Biological Material

Linda, a neuroscientist from Colorado is a tenured professor and neuroscientist. However, like many other scientists at the Neurotech Investing & Partnering Conference, she is also an entrepreneur, looking for both funding and important social connections in order to move her small biotechnology company to the next level. At her turn, she approached the podium. Middle-aged, she wore navy slacks and peers through enormous glasses. As her PowerPoint slides are loaded onto a large screen, she begins her presentation, which varies minimally in structure from that of all of the other startups at this event and most others that I attended over several years. These talks — the startup investor pitch — further validate these spaces as neuroscience pageants, or perhaps more precisely, bazaars for epistemologies. With vivid PowerPoint images of bright brain scans and boisterous visions of biotechnology futures, the event is both a scientific carnival and an elegant marketplace for disease.



Figure 16. This image of a presentation at the 2011 Neurotech Investing & Partnering Conference held at the St. Regis Hotel in San Francisco. This presenter at the podium is an entrepreneur/scientist presenting his company and its novel findings to the audience.

Like clockwork, Linda introduces herself and her findings: "Hello. My name is Linda Roberts. We have identified a novel mechanism of action and a new class of therapy in a large market place where existing mechanism knowledge has led to unmet need." Linda continues through her presentation, making sure to provide data about the large market that her product could serve. In a strange moral-linguistic ornamentation, large markets are often spoken of with the phrase, *unmet need*. A large "unmet need" or potential market is an imperative for investors and thus, the phrase permeates startup presentations, written material, and private conversations. In these spaces, well-done science without a market is almost meaningless. Her statement, "where existing mechanism knowledge has led to unmet need" is a euphemistic way of saying that the current product is clinically ineffective. In the end, as is obligatory, she concludes with what is colloquially termed, "the ask." With somewhat timid aplomb she announced, "We need 7 million dollars." The audience barely blinked. Flurries of startups ask for an assortment of million-dollar amounts. Some in the audience simply write down notes during the pitches. Occasionally, the startup entrepreneur is approached at the end of the

pitch only to be taken to the hallway or a nearby lounge area, purposefully designed to encourage informal interaction.

Yet, for Linda's startup there is interest. Linda's company produces a gene-based therapeutic to treat neuropathic pain that works by stimulating the body's anti-inflammatory cytokine. Given the molecular basis of her company's product, her work is timely in the context of commercial neuroscience's move towards molecular biology and gene-based research. In response to a question by an audience member, she outlined several challenges that she experienced in her initial search for the right compound to constitute a safe therapeutic:

> *How do you identify the numerous compounds that are effective, and which are reasonable candidates to try to take to clinical trials? There are excellent research compounds…but maybe that compound's mechanism of action is that it's a metabolic poison, so there are a lot of examples from the research end of it, but in reality it [a compound that acts as a metabolic poison] couldn't possibly go to humans... Targeting: how do you get a compound to work on the glial receptor? Targeting is a problem in getting it to the site that you want…Glial cells are immune-like and so changes to glial cells will have that consequence, as well.*

Though Linda's statement here usefully explicates challenges involved in the molecular search for productive compounds, this statement, and the ensuing dialogue are also acts of biological *problem solving*. Here, the problem includes the vicissitudes of biological inadherence, made clear in her example about the immunological "behavior" of glial cells, and about biological (in)compatibility and between human parts and that of animal models. This was not simply an articulation of her own research journey. Linda's presentation indexes an event-wide dialogue about making sense of complicated and unruly biological material. How does one deal with mechanisms of pharmacological action? Is knowledge of such mechanisms a necessary component of the research and

design process? How does one deal with the unruly biologies of engineered mouse models? Linda's statement about the immunological character of glial cells also maps onto another, trenchant biological problem of adherence and efficacy between therapies and patient's individual biologies. Thus, the turn to genomics is not only about the failures of premature therapy, or the riskiness in the too-complicated biology of mental illness, its also a means to use biology to understand pharmacogenomics in ways that can lead to personalized medicines (Ninneman 2012). In this way, pharmacogenomics becomes a means to deal with problems of biological variability optimistically assumed to be at the heart of poor psychopharmaceutical efficacy.

Thus, discussing the methodological problem of glial cells functioned as a sort of collective walking-through with the audience of the various cellular and compound possibilities and their respective limitations. One locates in her extrapolation an epistemological journey around compound possibilities and routes, known cellular facts and unknown ones, productive questions versus non-productive ones -- as well as a kind of collective reflection about potential paths and pitfalls.

I want to point to an additional instance of problem-solving focused on biological material during the conference. During a panel on next generation psychiatry, Luis Manuel, a scientist-in-residence at a life-sciences venture capital firm, simply presented a list of failed or discontinued compounds that comprise existing knowledge in the search for novel new drugs and devices in psychiatry. His PowerPoint presentation consisted of compounds and what he called, approaches:

Compounds:

1. Beta- 3 agonis

2. NK@
3. Etc

New and Upcoming Approaches:

1. Neurogenesis
2. Combos
3. Circadian genes
4. miRNA
5. Epigenetics
6. Optogenetics
7. Ultrasound
8. Biomarkers (years away)
9. FDiagnostic devices
10. BBB penetration
11. iPS cells

Manuel only minimally accompanied his presentation of compounds and approaches with dialogue. For example, when he got to circadian genes, he mentioned more "focus there in research for psychiatric disorders" and ended there. When talking about miRNA, he explained how its real value is in its use for blood-based diagnostics. For biomarkers, Luis simply said, "We are years away." There was no additional discussion, as if the objects on the presentation spoke for themselves. The ensuing silences during his presentation did not cause audience confusion or unrest. Attendees on both sides of me continued noting, writing, and checking their Blackberry devices. These absences of explanation and discussion showed the importance of these biological materials — and compounds in particular, as objects around which to find solutions, begin investigations, and produce narratives.

It was in this context that I began to think of the space of the Neurotechnology & Industry Partnering Conference, as well as TN in general, as means for creating not only solutions from the problems of biological material, but also potential market solutions for

existing or potential biological *disorders* - in all of their social and technical complexity. In this partnering of biology and disease categories one sees how TN produces what scholars have called *patients in waiting* (Dumit and Greenslit 2005) linked to futures and markets. In a panel at the San Francisco event focused on developing partnerships, Harry Thiel, M.D, Ph.D., head of neuroscience for a major pharmaceutical company offered an overview of the role of *connection* in the various stages between "candidate selection" and "proof of concept." He begins his presentation explaining that his department had moved to the biotech model in their research firms and their new approach when evaluating potential startup companies in which to invest:

> *We begin by looking at proof of mechanism. Investment decisions are approached. Most clinical trials fail because [the underlying facts] don't work [because the science is bad]. This is in contrast to the me-too companies in which try to get your data to work [through data manipulation or other strategies]. We know the way that functional neuroanatomy works because we know where we should be - which is to say that we know the science well enough that we know if your little experiment is based in fact or not. Linking disease to understanding and clinical outcomes is the first step and then we try to link it to the right patients; the right drugs to the right patients.*

Thiel's biography charts his background at two biotechnology companies and at many of the largest global pharmaceutical companies where he held leadership roles. Among all of the speakers at that event, he was perhaps the most experienced and most senior neuroscience-focused pharmaceutical executive who had an impact on the direction of neuroscience within Big Pharma. Also, according to his background, he may have been the person closest to the "realities" at work in commercial neuroscience. I tried to follow up with Thiel but was never able to reach him even via email. At the end of Thiel's presentation, he thanked the audience: "Thank you for sticking with

neuroscience and as business models change," he said. He quickly got into the back of a town car and was whisked away.

Nevertheless, Thiel's jagged refrain, "your little experiment," suggests that his larger statement was directed at the small firms and university academics with whom his company may potentially partner. Thiel's tone was not one of collaboration; it reeked of unrequited hierarchy. Unlike the pharmaceutical company executives at the Boston event who displayed relative agnosticism about MoA, neuroanatomical facts mattered according to Thiel. This would suggest that he does not treat brain science as a pool from which to simply cull narratives and explanations. For Thiel, the brain's materiality consists of a sort of functional grammar of the sort one finds in foundational psycholinguistics. His aside, "we know the [neuroanatomical] science well enough that we know if your little experiment is based in fact or not" is a statement about materiality presuming that experiments that draw upon or interact with the *right kinds of brain areas* -- those known to correspond with disease states -- get coded as more likely to be based in "fact." In this sense, there is a literal matching process between the biological material of the brain and "disease" at least in Thiel's scientific estimations.

I want to hone in on the statement, "Linking disease to understanding and clinical outcomes is the first step." For Thiel, the word *link* may reference a process of proving the relationship between a disease etiology and known scientific facts about the brain and then using that knowledge to understand a potential, therapeutic clinical effect. In addition, he invoked the word *linking* to discuss the matching of interventions to the right patients. This latter point and his statement about retrospective analysis both refer to the

pharmacological importance of understanding individual biologies, diagnoses, and, importantly, tolerability.

However, in a more constructivist sense, Thiel's use of the notion of linking renders explicit forms of biological and epistemic practice that allow neuroscience facts to be *connected* and *partnered* to particular brain areas, and that for very *connection*, to authenticate the status or likelihood of "fact." Similarly, Thiel's statement about "linking disease to [scientific/ biological] understanding" underscores the discursive mechanics involved in suturing biological understanding to diseases. Yet, for Thiel, good translational work is not merely translational, it is, in his words, *transitive*. Rather than a process that relies on a kind of *biological duress*, Thiel advocates for a sort of biological "listening," which allows for something like an auto-biological translation. During the panel he said, "Transitive, not only translational medicine. It tells us what the next set of studies should be. So, again, our approach right now is complex but we're really trying to match the right patient for the right outcomes, as a clinical development tool. Let the biology dictate what we do rather than force biology to fit a particular need."

Here, we see additional evidence of the way the conference operates as a means for collective biological problem solving. Thiel's admonition about allowing biology to "dictate" scientific investigation, rather than the inverse speaks to an epistemological proposition. It also, perhaps inadvertently, implies that *forcing science* through creative means such as clinical trial and data contouring practices, or hiding internal clinical trial data marked the history of Pharma's practices regarding pharmaceutical research and development.

Yet, what did he mean by *transitive*? The notion that translational medicine merely provides *markers* toward further research suggests, in fact, basic research. Transitivity may be a discursive means of allowing a dearth of new therapeutic results from TN to still be understood as a *product*. In my view, merely creating narratives and affixing them to biological facts become part and product of the translational enterprise even where there is no immediate, actualizable intervention. In his discussion of the many mobilizations that molecularization enables under what he terms, molecular biopolitics, sociologist Nikolas Rose wrote of molecular biology's transitivity and especially, its capacity for "disembedding" (2007, 38):

> *Molecularization strips tissues, proteins, molecules, and drugs of their specific affinities— to a disease, to an organ, to an individual, to a species — and enables them to be regarded, in many respects, as manipulable and transferable elements or units, which can be delocalized — moved from place to place, from organisms to organism, from disease to disease, from person to person… "molecular biopolitics" now concerns all the ways in which such molecular elements of life may be mobilized, controlled, and accorded properties and combined into processes that previously did not exist.* (2007, 15)

Scholars such as Sarah Franklin (2003) and Margaret Lock (2003) and Rose (2007) have created a body of scholarship focused on how to make sense of contemporary biosciences, its emergent subjectivities and capacities and in particular, the ways that emerging bioscientific capacities bring into question long-held narratives about life (Cooper 2008 Rajan 2006) and death. Much of this work (Helmreich 2008) takes biopolitics as a key axis through which to investigate contemporary concerns.

However, for all of the mobilities that molecularization and translational research both enable and compel, a question still emerges about how directions for research are determined. The industry's channeling of goals for TN, the determination of directions for knowledge in transition, and the application of directives (literally) for scholarly

agendas toward some *particularities* rather than others – shows directionality. Beyond indeterminateness for biological material, a study of the contemporary capacities of bioscience and its subsequent transitivity invites scholarly work mapping not only these *directions*, but also the obfuscations and partialities that linger from foreclosed histories.

Thus, a concept such as molecularization is useful because it produces an analytics through which to make sense of the capacity for biological materials to be rearranged. However, there is a need to understand how these rearrangements engender certain outcomes over others. There is a need to understand phenomena such as molecularization as an exercise in the ontologies of partiality. The very capacity to separate and rearrange glial cells for the purpose of experimentation indicates not only mobility, but, to the extent to which the glial cell is still semantically tied to the human, to a mouse model, or both, it constitutes the production of part of a *subject*. Against simplified narratives of reductionism or flattening, an ontology of partiality looks more like pixelation. Thinking with the parts of a subject emphasizes the question of bioscience's connections to the individual. In this sense, the slogan attached to the small silver brain pin I received at the beginning of the conference, "*give the brain a voice*" felt strangely literal. It was also a directive: one that animated this hermeneutic community of practice. Biological material ties my experience here at the neurotech event with the observations of Jones, the neurologist for whom TN functioned as an effective means of clinical and patient meaning-making, through which patients could see that their disease was based in biology.

Indeed the Neurotechnology Investing & Partnering event, partnering was a birthplace for all kinds of coupling; between a disorder and explanation, between patient

explanations and biological knowledge, between biological knowledge and emerging diagnostics, between university laboratories and corporate laboratories, between pharmaceutical companies and biotechnology startups and perhaps, as a space for connecting biological materials with other biological materials. In this way, this event functions as an essential laboratory for TN.

Subjects Partially Constituted or Ethics for a Partial Subject

I want to return to the issue of what I'm calling the partial subject. Near the end of the first panel, focused on the current state of investments in neurotechnology, the moderator asked panel members about the areas of their excitement. The panelists offered an array of current interests:

> *"Neurodegeneration, pain and epilepsy."*
> *"I'd echo that and we like the neurogenesis area," another investor concurred.*
> *"Pain, neurodegeneration, schizophrenia," another offered.*
> *"Severe disorders;… things that are generating some 'exclusivity' to make it more of a challenge to genericize," yet another investor said.*

"It's not the most ethical, but we'll take a drug out there and increase the price, even if its an orphan medication," someone indicated referencing the pharmaceuticals and biotechnologies developed for rare diseases that I discussed earlier. What the investor likely means by "not the most ethical" is the fact that patients who have no other therapeutic options are forced to pay higher prices for these drugs which, in effect, provides a pricing protection against pharmacological risk that is somewhat similar to that of patent. The moderator enthusiastically agreed: "there is a lot of money to be made there." The sense of the *severity* of a disorder constituting a kind of market, an opportunity, invokes a complicated moral juxtaposition: it forces a convoluted thinking

exercise: how does one monetize the drama of Jawan's epilepsy? Can one excavate an opportunity hidden within Shana's piercing desperation?

There is something else that ties all of these investor preferences together. The investor willingness to exploit "rarity" in the form of rare diseases and to go after "exclusivity" toward barriers to genericization could be seen as operating along a similar kind of market functionality opened up via the exception. That both forms of exception (rarity and exclusivity) can be useful profit strategies creates questions about ways that state-sanctioned exceptions can function as variegated entry-points for the expansion of capitalist markets.

And yet, patients still exist in these formulations. Visualizations about severity and rarity, the investors' quick listing of trendy, interesting disease/biological states such as "neurodegeneration" — all implicate subjects. I began to rethink my assumptions that patients were essentially missing during these discussions. Patients were indeed "in the room" on that grey May day in Boston. However, I began to understand these subjects as only *partially constituted* or perhaps more precisely, constituted in and via (their) *parts*.

For example, much of the May 2010 conference focused on finding new pathways to new markets and new verticals. Vertical markets here reference the attempt to use existing products for novel potential customers, the use of existing technologies towards new products, and expansion of opportunities in the form of global markets. During the part of the event focused on providing a spotlight to new startups, Roger, founder of a neurosoftware startup pitched his company to the audience of investors and researchers. According to Roger, he had created software that would provide "real-time FMRI-based therapeutics and diagnosis. His software would obviate the problems of patients. He used

the example of an everyday encounter between a patient and a doctor and the problem of getting to a patient diagnosis: "It's upsetting that [if] you want to get a diagnosis, you have to ask them how they *feel* (emphasis his). This is a shame and with this technology you will see mechanistically based, quantitatively based information. You will be able to diagnose real-time."

Several things stand out in this particular diagnostic vision. Certainly in one view, the marginalization of experience enabled within Roger's clinical scenario — both that of the patient as well as the intersubjectivity between the patient and the clinician — constitutes a kind of erasure or reduction. Nevertheless, I also want to suggest a different view. Perhaps it can also be seen as being about the subject constituted in his or her neurological *parts*, as partially constituted; a partiality made manifest through the marginalization of the patient's own phenomenological representations.

Another example of the sort of diagnostic vision that Roger articulated came during the presentation by Harry Thiel, prominent head of neuroscience at a major pharmaceutical company, to whom I refer earlier. During a preview of his division's current projects, he explained how his company was working on a diagnostic tool in cooperation with General Electric's research support that would enable an earlier detection of dementia using voice-based diagnosis:

> *...Physicians will be interested in diagnosing this early, and we don't want to wait until dementia [appears] but people aren't tracking themselves. So, we're looking hard with GE to cull all of the databases together to develop non-invasive tests that could be much more widely used. Here is something we're really interested in; voice-based diagnoses. Patients as they progress or as physicians identify more and more risk, we move them into more invasive [tests]. Let's say a spinal tap."*

Here we see a similar kind of confusion between diagnosis and screening as well as a desire to create "non-invasive tests that could be much more widely used." Voice-based dementia diagnosis had been an idea in circulation in the neurotechnology community for a few years. The possibility of such a tool is based on research that suggests that dementia and Alzheimer's disease indicators can often include a discernible change in speech patterns (Baldas et al. 2011).

Nonetheless, as was the case with Roger's scenario, the diagnostic formulations presented here render patient subjectivity as problematic, a hindrance. The notion that "people aren't tracking themselves" becomes a means to look for dementia as it is manifested within the *parts* of patient subjects — which, in a rather grand irony, is that of the *voice* of the patient. A voice-based diagnostic test would work by using a natural language processing tool that captures a patient's voice and compares it against itself at an earlier time to measure any changes. The splicing of the patient's voice from the actual patient as a means of diagnosis also creates questions about the relegation of the "embodied" voice in these diagnostic regimes.

In one view, this diagnostic future, in its various technical, bodily, and digital mimicries was reminiscent of the repetitions at work in the many images in the Ink Blot exhibition, although, the resonances extend beyond mere aesthetics. For while the Rorschach sought to find truth using image-based prompts and the voice-based diagnostic seeks to employ language-based prompts, in both cases, mental disorder is assumed to be locatable in the inevitable betrayals of a diseased person's speech.

Nevertheless, in the diagnostic visions – both that of the voice-based diagnostic for dementia and Roger's real-time neurosoftware solution –technological traces are

codified as representing brain truths, which comes to represent the brain *speaking*. In the diagnostic vision for the voice-based dementia diagnostic, the voice of the subject becomes the voice of and for the brain; the translational vision involved relies on an epistemology of parts.

I want to also bring up another example of what I'm calling an epistemology of parts. While I pointed to the voice-based diagnostic technology to demonstrate how subjects can be constituted via their parts, one also sees this constitution of neurotechnology's subjects even in the question of interchangeability between animal models and humans. Parts become the key to an intellectual exercise in which animal parts could operate as models for that of the human. The question of the human emerges necessarily through his or her parts, and this is what I mean by the constitution of subjects *in* or via their parts.

Linda's articulation early on about the fact that many useful compounds correspond to solutions that could "not possibly work in humans" reflects the challenges that exist for an enterprise reliant upon animal models that constitute a stand-in for the human. After one panelists' s discussion about mouse models in research on new approaches towards understanding schizophrenia, an audience member asked, "Can mice be schizophrenic?" The question compelled the audience to laugh, though it was unclear whether it was posed in jest.

However, the very possibility of *schizophrenia* research — using the cognitive system of a mouse model -- relies on the possibility of translation between the respective cognitive systems of the human and that of the animal model. Even when acknowledged by a scientist as merely a *model* or an *animal model,* an animal model's reference to the

human is enabled through an epistemology of parts. The ability to establish a semantic tie between the experiment using a mouse model and the fictive schizophrenic human patient relies on the *isolation* of the mouse cognitive system as the means through which the human is tethered to the experiment and through which the human subject is *conjured up* at all. Here again, I suggest a constitution of subjects via their parts.[46] Without such isolation, the remaining parts of the animal body become an analogical hindrance. By positing some sort of commonality between the cognitive system of an engineered lab mouse and that of the human – even under experimental pressures, – we see parts as a necessary and entirely indispensable conduit for such a substitution.

However, while Gail Davies in his work on the role of animal models in the larger translational imaginary adeptly discusses the humanization of the laboratory mouse in the form of the engineered laboratory mouse, the interchangeability that he notes also reveals a reconstitution of the human as well. The translational capacity of the humanized mouse to stand in for the human in biological research models *can only work* in a context in which humans could be modeled or conceptualized in and via their parts (a parts-based rendering). For example, the very operability of the notion of translatability between mouse immune systems for that of humans or the very possibility of trying to reproduce cognitive stress using a humanized mouse in a laboratory setting - relies upon a partial constitution under experimental pressures of the human subject. One must sideline all of the other aspects of the human body and experience and the conditions of a disorder in

[46] There is resonance in thinking about parts with discussions of the fragmentation that Leslie Sharp, Margaret Lock and Judith Farquhar articulate in terms of materiality and the body. Yet, there is also an opportunity to connect it to the way it produces partial subjects and ontology that is an interesting way to think about embodiments.

order to make the animal model make sense. Thus, by the constitution of people via their parts, I'm referring to the act of producing a *partial subject.*

In much of the recent work looking at the transformation of the life sciences, the ways in which biological life has become an experimental domain, the biosciences have treated biological material (the human, the cell, the genome, or the molecule) as the primary unit of analysis. Thus, the panelists that I witnessed discussed new approaches to psychiatric illness simply in terms of compounds, approaches, data, and models. Yet, it is also the case that in their most detailed description of biologies, we see something that has the elements of a subject. My earlier use of the metaphor of pixilation gets at the way that knowledge regimes such as molecularization may still actually help produce subjects. It is just that these subjects are only partial (figure 17).

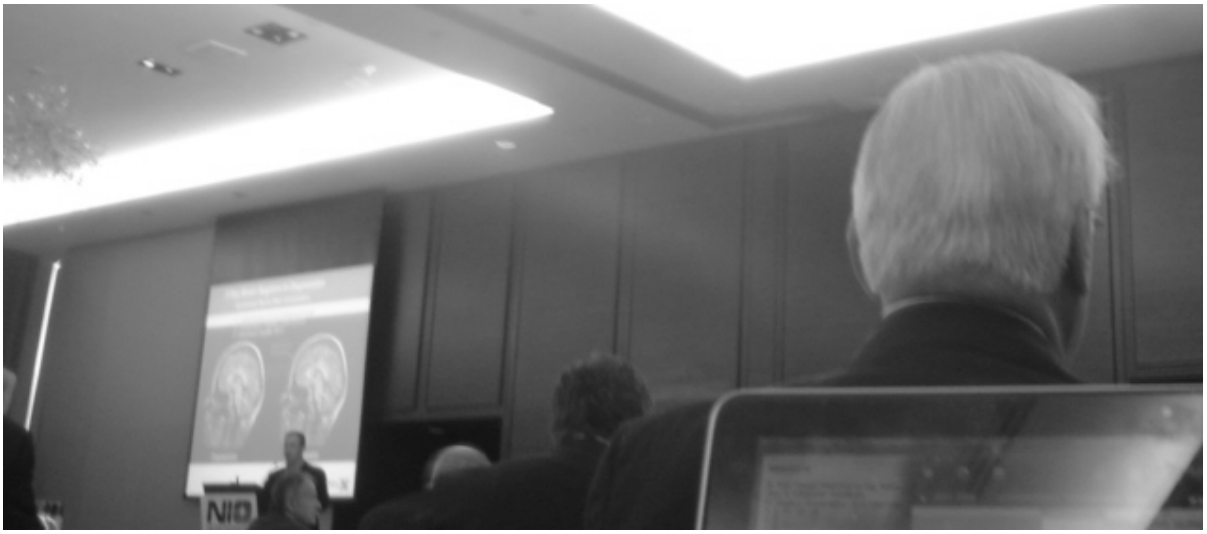

Figure 17. The 2011 Neurotechnology Industry Investing and Partnering Conference in San Francisco at the St. Regis Hotel. The conference also included visual panoply of fMRI images, microscopic images of cells, pathways, proteins, graphs representing clinical data, as well as pictures of brains.

An ontology of partiality enables a re-envisioning the demarcations of cells and systems, of redesigned genes and blood together as composing a sort of partially embodied form. It is the difference between viewing an image as a collection of dots or

as just as unassembled dots, versus reading it as a partial rendition of a larger image. Thus, there is a difference between analytics that posit the complete erasure of a subject versus one that reveals the ghost of a subject: a subject left in parts, an assemblage of remnants. In this sense, a simple critique founded on biomedical, pharmacological, and technological reductionism or erasure may miss specific kinds of ontological constitutions that are at work in TN. Anne Marie Mol's useful invocation of ontologies in her work on the way that atherosclerosis is constituted multiply via spheres of practice offering a rethinking of the ways in which clinical encounters, and their attendant worlds of practice inevitably produce multiple diseases. One could propose a similarly diverse set of practices that contribute to alternate versions of biological disorders.

Yet, what happens to the subjects who become attached to those disease ontologies? How does one act toward a partial subject? While ontological considerations raise the question of multiple ontologies, the systems that render things into matter (Barad 2007), questions remain: How does one make sense of the ways in which things, objects, subjects are only partially produced? How should scholars, scientists or venture capitalists understand the ontology of the unfinished? Of course, how one thinks of subjects produces ethical implications: what social obligations do members of the industry or the public have towards subjects who are only partially constituted?

Dealing with partial subjects or subjects only in their parts also brings us back to the difficulty of the subject for TN. Indeed, the brain is a mess; unruly cells, turgid activity, ever-changing complexity produce a storm of complexity. However, translating "the brain" also requires coming to terms with the unabashed messiness of people – of complicated and tethered patient subjects. TN is faced with the problem of brains that

will not translate themselves; of coming to terms with complications of patient subjectivities and the inevitable mythogenesis of human experience. In this way, TN again is about risk; scientific risk, patient risk, investor risk, and market risk. As a discourse TN is a means for creating realities out of biological, sociological, and technological chaos.

Chapter 4 / The University

> *We have seen a tendency to separate risks into rigid silos— operational risk, market risk, credit risk and so on. But what we have found is that major shocks and problems do not come that way. For instance, in the financial world, you would see trading desks staffed with people who were experts in market risk, but they were trading instruments that were laden with credit risk. The skills you need to think about each of those kinds of risk are very distinctive, and unless you have an integrated view of risk, you could encounter major problems.*
>
> --University of Pennsylvania Professor, Richard J. Herring
> *(Knowledge@Wharton 2009)*

> *A RISK is a potential for a LOSS.*
> *The LOSS is the realization of that negative potential.*
> *A RISK is running across a busy street blindfolded.*
> *A LOSS is getting hit by a car while doing that.*
>
> *Riskviews*

On the last day of the 2010 conference in Boston, there was a morning panel that was sparsely attended. This panel was devoted to "Partnering and Licensing in Neurotech." Yet, the panel's focus belied a sense of crisis. In the panel description, licensing and partnering were clearly elucidated as avenues through which to remedy pipeline problems. In the description, one finds a useful set of questions:

> *Big Pharma, biotech, and Medtech are increasingly looking to smaller firms to provide innovative product candidates to fill pipelines. What are current trends in strategic alliances and partnering? Is there a new model for partnerships emerging? Is Big Pharma looking to earlier stage product candidates for partnering and in-licensing? Can major medical device companies continue with their high rate of acquisitions?*

Given the massive profits that pharmaceutical companies made from 2006-2011 despite a lack of novel compounds, coupled with efficacy problems and patient safety concerns, I had assumed that large biopharmaceutical companies did not experience risk in the same as, say, investors. However, I learned that risk is a major complication that TN, by design, was created to fix. I also learned that underneath the calm demeanors of event participants, commercial neuroscience was on the brink of collapse. I explore this in chapter 4 as I address the partnering for TN between universities and private industry.

Jeffrey Nye was a tall, youngish man with rimless glasses and a Blackberry that seemed never to leave his hands. Even during the Neurotechnology Investment and Partnering Conference panel in which he participated, he checked it constantly. He sat upright and accompanied every handshake with a quick and confident smile. A PhD, MD, and Harvard graduate, Nye exuded a masculine confidence—one that even spilled into his informal interactions with the other panelists. Nye attended the event as the Vice President and head of External Innovation for Neuroscience at Johnson & Johnson, a large multinational medical device, pharmaceutical, and consumer-goods company. On a panel dedicated to internal and external research and development, Nye explained how public and private partnerships allowed Johnson & Johnson to lower the cost of bringing a drug to market. He used the example of the risk of psychiatry and brain-based medicines made evident in the "abandonment" (Stowall 2011) of the CNS sector by a large number of companies as part of what, in his narrative, was a strategic corporate opportunity. Importantly, he also made explicit what had been obscured: the pharmaceutical industry's abandonment of the commercial neuroscience sector. Nye continued:

> *We're still looking for partners! …We're partnering largely with academic —recognizing that [other] Pharma companies have abandoned this space [including psychiatry, antidepressants, Alzheimer's] and this offers us an opportunity to get involved with innovation at its earliest stage and not start the race when publications start appearing and start the race with everyone else. We have created partnerships with Johns Hopkins and our attempt is to capture this innovation at its earliest stage. …So we have external discovery engines to afford us the opportunity to offload the overflow from our academic collaborations. In the past, we signed a deal with Vanderbilt and…we looked at external development partnerships and we're looking to capture the innovation of academics and we're looking to increase our partnerships. One of our objectives is to increase early stage partnering [so that] we can get the biotech companies to do the experiments that we want. We're able to come in at a lower cost.*

There are several telling parts in Nye's statement. Firstly, Nye praised the opportunities that early-stage investing offered, yet he also situated this new opportunity as part of a new Johnson & Johnson strategy--one focused on *early-stage innovation*, the stage at which pharmaceutical companies partner with scientists in university laboratories, rather than a standard partnership in which pharmaceutical companies would license a late-stage intervention or piece of intellectual property from a university's licensing department. This distinction demarcates how corporate partnerships may affect early-stage or upstream knowledge practices at the university--even in the realm of the hallowed scientific laboratory. However, a second important point and the focus of this chapter, is how this early stage partnership strategy constitutes an *investment* strategy. In other words, university-industry partnerships around translational science and translational medicine are not merely about science or mere innovation in health, but are quite fundamentally about finance. In fact, this project proposes that TN may be better thought of as a means of finance rather than some purely accelerated form of application-oriented neuroscience or a means of health innovation.

Johnson & Johnson

While pharmaceutical companies have historically invested heavily in their own commercial laboratories for discovery-based research, these companies have now closed most of their internal labs. Similarly, many multinational corporations outside of the pharmaceutical sector have increasingly closed their internal research laboratories. U.S. companies that had developed reputations for research and discovery, such as AT&T and Bell Labs, shut down their research and development centers that had focused on early-stage science and technology research (Mirowski 2011).

Nye's statement underscores the sense of opportunity presented when companies partner with university-based laboratories at the research stage, that is, prior to "publication." Nye's statement about getting involved before "the race when publications start appearing" clearly implicates laboratory research, or even the moments of scientific ideation that precede it, as a prime stage for instigating commercial involvement. An important characteristic of corporate partnerships with university researchers at this stage is the untangling of epistemological knots. The relegation of early-stage university research to the realm of corporate commercial discovery produced a specific epistemological question about TN laboratories: How might this focus on early-stage interventions reframe laboratory research and affect laboratory practices? Given the discovery-oriented ethos at work in the institutionalization of TN, TN laboratories enable

optimal legibility between university-based laboratory discoveries and the "discovery engines" created by corporate partners.[47]

In 2011, Johns Hopkins's Center for Biomedical Engineering Innovation and Design announced a partnership with Johnson & Johnson (n.d.) for the creation of a Technology Accelerator Fund. The Johnson & Johnson funds would be used to "support innovative translational research and development activities, with a focus on medical device development" (Johns Hopkins University n.d.). Johns Hopkins even matched Johnson & Johnson's $250,000 investment. According to a press release, the funds would focus on "translating early innovative designs into high-quality prototype solutions." In this way, Johnson & Johnson not only created access to a pipeline of (and competitive advantage regarding) potential innovations; they also externalized the intellectual labor involved therein to the students at Johns Hopkins.

Nye's statement and the example from Johns Hopkins show how externalization enabled lower opportunity costs associated with the discovery process, created less intense competition for licensing university-based innovations (or exclusive access to said research), and formed an entire externalization system for the firm's internal discovery process, which according to Nye (2007), also included "biotech companies to do the experiments" once promising knowledge comes to light. In this way, Johnson & Johnson effectively externalize a large element of the scientific discovery process from the intellectual labor of the university scientist all the way through to the clinical trial managed by a clinical research organization.

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[47] The very velocity of the university's corporatization and privatization (Geiger 2002) may necessarily obviate questions about corporate pressures external to the nonprofit university. In other words, the distinction between the nonprofit university and for-profit corporate partners may be an increasingly difficult demarcation.

However, the Johns Hopkins example also shows how an early-stage intervention allows greater capacity to influence construction of the very science that may inform the venture resulting from the biomedical finding. The Technology Accelerator Fund, brought to Johns Hopkins's biomedical engineering students as an educational opportunity, also brought translational modes into everyday learning practices and made those objectives a *starting place*. Nascent educational objectives take shape in a similar manner. Research methods, priorities, and educational outcomes for university-based science work now prefigure later development activities such as product development or intellectual property licensing. In this sense, entrepreneurial thinking becomes a precursor to other kinds of thinking for biomedical engineering students participating in the program. Here I began to think about translational thinking as constituting a set of investigational and epistemological practices born from a set of key presumptions.

To think of laboratory work as part of corporate strategy is also to consider how the aegis of "innovation" enables stakeholders to fold all kinds of agendas into local scientific practices. For example, Nye was part of the Johnson & Johnson subdivision, *Johnson & Johnson Innovation Centers*, which, even in its own self-description, fastened together innovations in finance (such as creative deal structures) as part of its work of supporting innovations in the "healthcare innovation ecosystem":

> *With the current pressures on the healthcare innovation ecosystem, it's more critical than ever to find new ways to accelerate scientific breakthroughs to benefit patients worldwide. By working together with scientists and entrepreneurs at universities, academic institutes and start-up biotech companies, and by employing collaborative and flexible deal structures, we seek to identify and invest in a wide variety of prior to*

> *clinical proof of concept innovations. We will be a part of the innovation community and share a diverse range of expertise and resources.*[48]

Here, financing innovations such as "flexible deal structures" and diverse partnerships "with scientists and entrepreneurs at universities, academic institutes and start-up biotech" were narrated as *strategies*. This view of externalization as a corporate strategy is important in order to think through the university's role under new global innovation regimes. Yet, a second part of the Johnson & Johnson Innovation Center's statement is worth noting. Creating financial innovations such as "flexible deal structures" to "identify and invest in a wide variety of prior to clinical proof of concept innovations" brings these partnerships into view as part of an early-stage *investment* strategy. In this way, externalization brings into view the way that TN, in its operationalization at universities, constitutes a form of finance and produces additional questions: How and in what ways might these new partnership modes reflect financial and investment considerations, rather than merely interests in inspiring health innovations? What do these partnerships reveal about the entanglements between science, health, and finance? To the extent that the opportunity presented in university-based translational science and medicine may help enable biopharmaceutical companies to "outsource" early-stage neuroscience innovation, what exactly is TN and medicine and its connections to systems of financial problem solving?

During the Neurotech Industry Investing and Partnering events, the language of sharing and partnering was everywhere. Each constituent group at that event seemed to define *partnership* differently. Concepts such as "sharing" and "collaboration" created

[48] "Johnson & Johnson Innovation Centers" http://www.jnj.com/partners/innovation-centers. Johnson & Johnson, n.d. Accessed 2 April 2014.

particular strategic meanings for biopharmaceutical companies. Although innovation narratives tended to underscore notions of democratic progress, unfettered openness, and sharing, especially to provide access to the Global South (Tsing 2005, this ostensibly open, sharing-focused innovation model uses external partners such as a university as an innovation *source* for ideas and products to be commercially exploited, licensed, and patented. This is not to say that the university does not benefit in partnership models with private industry. Rather, it recasts the university work as an extension of larger commercial and sociopolitical trends.

However, the surging focus on innovation in neoliberal economies--part of what Kaushik Sunder Rajan (2006, 133) called the "ideology of innovation"-- has increased the need to think critically about how networks created to share and collaborate "openly" (Kelty et al. 2008) may also obfuscate the ways they articulate existing power networks, produce new information privatization and control systems, or (as suggested in the ensuing sections) enable sharing and outsourcing risk. In fact, the insider term *externalization* may be a much more appropriate descriptor for the articulations and restructurings that occur under the aegis of "innovation."

Externalization at the University as a Risk Strategy

What is *externalization*? In 2011, Booz & Company, a leading global consulting firm, published a white paper, *Building an External Innovation Capability*. In the section "Harnessing the World's Innovators," the authors offered the following description of the benefits of an external innovation system:

> *Many companies can now point to external innovations that have dramatically increased their competitive advantage. Apple and Google leverage the power of tens of thousands of independent software developers to build portfolios of hundreds of thousands of applications for their products to showcase and their users to buy. Life sciences leaders such as Amgen and Pfizer are collaborating with external scientists around the world to push forward the boundaries of biopharmaceutical progress. For these companies and others, the benefits are already clear: an enormous universe of innovators working on technologies, products, and services of relevance to the company; reduced costs associated with moving a larger portfolio of innovations down the pipeline; reduced risk as others put their human capital to work on risky propositions; and accelerated time-to-market as innovation is freed from the shackles of the cumbersome large-company financial, planning, and pipeline process.* (Le Merle and Campbell 2011, 3)

The externalization of innovation in this context included the appropriation of diverse and dispersed labor and human capital (e.g., Google developers and Pfizer external scientists) as well as the expansion of the commodification networks through which innovations can be brought into the realm of a company's discovery engine. In that sense, it also constitutes a growing trend toward life-science outsourcing--a solution that biopharmaceutical companies have already enacted for clinical trials via contract research organizations (CRO) (Petryna 2009). Yet, externalization also intersects with and likely benefits from global labor rearrangements such as the growth of independent contractors, use of temporary labor forces, and global outsourcing—dislocations that produce highly precarious workers under neoliberalism (Molé 2012).

The Booz & Company (LeMerle and Campbell 2011) document also reveals the enactment (even if rhetorical) of an anti-corporate narrative in which innovation is "freed from the shackles" of big business bureaucracy. Such narratives often blatantly negate the inevitable commercialization and privatization that happen once corporate partners copyright and patent outsourced innovation work. Thus, embers of a libertarian DNA

may undergird many innovation policies and rhetoric (Barbrook and Cameron 1996; Zlolniski 2006) organic innovation "hindered by regulation" could now emerge "naturally" and meritocratically through the ostensibly open and free exchange of ideas.

Juxtaposed against this conflation of externalization and innovation also lies an explicit playbook of sorts for how and why this mode of innovation externalizes the risks and costs inherent to corporate product development. In the same Booz & Company (2011) publication, the authors outline how externalization enables "reduced costs associated with moving a larger portfolio of innovation down the pipeline." In this sense, externalization allows firms to partner with universities at various points along the research and development process without having to take on the labor and costs of the entire process. Yet, they outline the most pertinent component of externalization by stating that externalization enables "reduced risk as others put their human capital to work on risky propositions" (2011, 2).

In addition to an overview of externalization's benefits, the white paper provides an external innovation toolkit that executive leaders can use to create or embolden an "external innovation capability." The toolkit (Appendix A) outlines fifteen tools, including strategies such as leveraging innovation networks and later-stage tools such as acquisition programs. Several tools involve university-industry partnerships, including grants and scholarships, innovation networks, joint research and development agreements, corporate venture funds, and in-licensing programs. The two tool descriptions below show how the university is implicated:

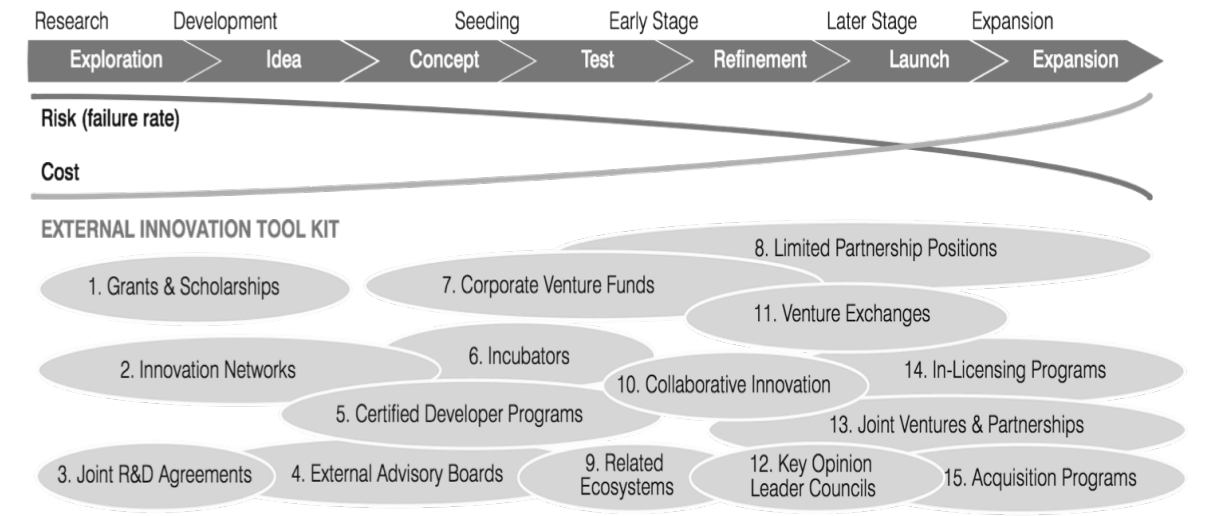
> *Grants and Scholarships: Providing research grants to education or government institutions can leverage outside expertise with smaller investments. Funding innovative organizations can also provide a*

> *company with new technology and ideas from the diverse set of companies and stakeholders often brought in by these external bodies.* (Le Merle and Campbell 2011, 4)

> *Joint R&D Agreements: These agreements, typically made with academic institutions or government agencies, are designed to support the mission of each partner. Such agreements are typically structured as long-term partnerships focused on areas of mutual interest to both parties. Potential benefits include breakthrough university research or government insight into industry challenges.* (Le Merle and Campbell 2011, 4)

As one can see in Figure 18, the model provided by Booz & Company, the highest level of risk in the product development lifecycle lies exactly at the point where the tools employed involve partnerships with universities. In Figure 18, one sees how early-stage externalization models enable private firms to "outsource" some of the *riskiest parts* of the research and development process to universities. Thus, a primary contention of this project is that, in a context in which "externalization" is an explicit corporate strategy, one sees how firstly, TN is a thinly veiled externalization program and secondly, that these externalization-focused industry-university partnerships in fact function as a system by which high-risk investments are de-risked prior to later commercial investment.

Exhibit 1
External Innovation Capability Tools Also Mine the Risk–Cost Trade-Off



Booz & Company analysis

Figure 18. Booz & Company's external innovation tools analysis. The upper left shows how the riskiest part of the product development process corresponds to "tools" closely associated with university partnerships. Although the profile refers to the risk of failure, multiple risks make early-stage innovation even more challenging (Le Merle and Campbell 2011, 7).

I argue that TN's systemic function is as an investment de-risking tool. As TN turns the research university into an innovation engine and a de-risking system, it is clear that TN serves a particular financial function for risk-burdened biopharmaceutical companies. The research and development risk involved in translating neuroscience has rendered it such a huge investment risk that abandonment of the sector by many companies has been essential, This process started in 2006. Simultaneously (2006-2010), biopharmaceutical companies exited commercial neuroscience sectors and TN centers emerged at universities. Thus, the institutionalization of TN at the university bears examination against an emerging context of risk that is historically situated and inextricable from a set of specific healthcare corporatization events between 2006-2010.

The following sections highlight the context in which major pharmaceutical companies abandoned CNS and the function of externalization programs in relation to this shift, and then ties this history to a discussion of larger knowledge problems specific to psychopharmaceuticals that became known between 2006 and 2010. Using an ethnographic example of the role of TN in how solutions are envisioned in psychiatry, I explore the unexpected relationship between knowledge risk and financial risk in the CNS sector. This section ends with a more detailed discussion about how TN has subsequently turned the translational university into a risk shelter.

The University of AstraZeneca (NYSE:AZN)

Few people are aware that something as seemingly ubiquitous as the everyday antidepressant is on the verge of collapse. A dramatic transformation in the way that psychiatric and neurological therapeutics have been envisioned is unfolding. Given the growth and evolution of psychobiological theories on mental illness stemming from the cognitive revolution of the 1950s (Gardner 1985; Reusch and Bateson 1951), the global expansion of psychopharmaceutical models throughout the twentieth century (Lakoff 2005; Petryna and Kleinman 2006) and their authentication within biomedical narratives about mental illness (Gordon 1988; Rose 2004), the antidepressant had expanded to become a primordial solution for depression within global biopsychiatry by the end of the late-twentieth century. By 2011, however, the landscape had changed dramatically.

During Jeffrey Nye's presentation at the 2011 Neurotech Investing and Partnering conference, he compared Johnson & Johnson's decision to stay with neuroscience with the act of "running into a fire." He said, "First I want you to feel *good* about yourselves.

…I feel that this audience and the [conference] organizers are running into the fire to rescue people with neurological diseases when people [pharmaceutical companies] are abandoning them."

By 2011, this abandonment was all too apparent. Six months after the 2011 conference, the Swiss pharmaceutical company Novartis announced it was closing down its neuroscience facility and planning to create a small group in Cambridge, Massachusetts focused on neurogenetics (Abbott 2011). By December 2011, several big pharmaceutical companies--AstraZeneca, Merck, and GlaxoSmithKline--significantly downsized or entirely closed their neuroscience research divisions (Cressey 2011; Smith 2011). When AstraZeneca and GlaxoSmithKline closed its internal neuroscience research infrastructures, they also retreated from their psychiatry research--shuttering any new research programs and products for depression and schizophrenia and constituting a "mass exit by many pharmaceutical industries from the sector of the central nervous system disorder (CNS) drug development" (Van Gerven and Cohen 2011, 72). The exit from CNS was also a retreat from multiple neuroscience-related areas of research in psychiatry, neurology, Alzheimer's, and anxiety disorders.

To be clear, this massive shift also had a global dimension: In concert with global psychopharmaceuticalization, there had been subsequent globalization of these psychiatric models that dovetailed with the creation of psychiatric markets. Given that these markets were shaped so strongly by pharmaceutical companies (Applbaum 2009b; Biehl 2007; Healy 2004; Petryna 2009; Petryna and Kleiman 2006) and that many of these companies were in the United States (Nutt and Goodwin 2011), questions remained about the implications for global health in the afterglow of Pharma's abandonment: What

would be left of the psychiatric models exported globally and then abandoned by their progenitors? What would be the consequences for patients, whose identities and social worlds would now be thoroughly implicated in existing psychiatric discourses?

Well before Novartis's 2011 announcement that it was dropping CNS, the French pharmaceutical company Sanofi-Aventi also dramatically scaled back its neuroscience division, ending the development and research programs for more than a dozen pharmaceuticals in 2009. Ironically, in 2009 Sanofi hired Elias Zerhouni, the former director of the National Institutes of Health (NIH) who largely spearheaded the push toward TN at U.S. universities. Not long after, Sanofi partnered with a university to do the work of its now-shuttered internal laboratory.

Are university TN arms morphing into externalized R&D arms for pharmaceutical companies*?* Soon after AstraZeneca announced in 2012 that it was shuttering a large part of its own internal neuroscience research and development arm, it also announced the creation of a new strategy: Rather than a wholesale retreat from neuroscience, AstraZeneca was, in its words, transforming its approach to innovation. What was the company's solution? AstraZeneca announced the creation of a new research unit called Neuroscience iMed. Organized around small virtual teams around the world, AstraZeneca researchers would work directly and primarily with academics, rather than researching in-house as was their old model. According to Frank D. Yocca, Ph.D., Vice President for Strategy and Externalization for AstraZeneca, this infrastructure virtualization was a partnership model:

> *As a general rule, projects were always prosecuted internally. True collaborative efforts with academics and biotechs were the exception. In the new Neuroscience iMed, all projects will be engaged through collaborative efforts with academics, biotechs or CROs. ...From a*

> *Neuroscience iMed perspective, we are operating in a new model where almost all our activities are conducted through CROs and partners.*
> (Vinluan 2012)

Scholars of science, technology, and society have an attendant need to think critically about the evolving structure of the research laboratory. The virtualization of AstraZeneca's innovation arm meant that the entire world became a potential collaborating laboratory. This has implications for understanding the future of global innovation and the export of highly specific research agendas across the world. Yet, it is also intertwined with transformations in global labor practices: Akin to the "thousands of independent software developers" that Apple and Google "leveraged" according to the Booz & Allen report (Le Merle and Campbell 2011, 3), outsourcing innovation and growing labor casualization under neoliberalism means this virtual innovation center is both expanding and globalizing while it is exercising the neoliberal management models of downsizing, outsourcing, and constricting. AstraZeneca, like many of the large Pharma companies that closed their internal research programs, fired many of its full-time employees while creating this new virtual model. AstraZeneca's move was a new strategy among biopharmaceutical companies; the company's model *entirely* externalized its neuroscience research structure.

Even more surprising, in 2012 the National Center for Advancing Translational Science (NCATS), the NIH agency responsible for the institutional birth of translational research and science in the United States, announced its new pilot program *Discovering New Therapeutic Uses for Existing Molecules.* In this program, the NIH spent $12.7 million to match academics with pharmaceutical companies. As part of the program, the pharmaceutical companies would lend their unused compounds to university researchers

trying to create new therapies. Especially interesting is that the list of pharmaceutical companies involved in the pilot included the very companies that had shut down or reduced their own internal neuroscience research and development arms: AstraZeneca, Bristol-Myers Squibb, Eli Lilly, GlaxoSmithKline, Janssen Research & Development LLC, Pfizer, and Sanofi (National Center for Advancing Translation Science 2013).

As evidenced both by the shuttering of internal neuroscience research and development programs and the subsequent partnering and outsourcing of formally internal commercial activities to the nonprofit university--partnerships facilitated by the NCATS program--university TN programs quite literally appear to have *become* the biopharmaceutical companies' research and development arms. Thus, an analysis of externalization and the emergence of university TN programs must attend to several important commercial transformations at work within the modern pharmaceutical company. Such a historically situated analysis is a distinct departure from reigning analyses of the corporatization and capitalization in the life sciences. This massive shift onto universities takes on new meaning in the specific context of pharmaceuticalization. First, however, I want to explain what caused the massive deinvestment in commercial neuroscience, including the histories and issues that precipitated the pharmaceutical industry's exit from the antidepressant.

There are No Biomarkers: Understanding the Retreat from Psychopharmaceuticals

One primary concern for commercial neuroscience begins with a simple, intractable problem: the brain. The problems attached to brain-based research, especially on brain disorders, have been profuse: Brain-based clinical research has a high rate of

failure across the discovery spectrum and failures have been unusually expensive (Nutt and Goodwin 2011; Cutler and Riordan 2011). Finding molecular targets' mechanisms of action can be exceptionally difficult especially for psychiatric disorders (Insel 2009; Miller 2010). Compared to other pharmaceutical and biomedical therapies like cardiovascular interventions, the failure rate for therapies targeting CNS disorders is particularly high (Cutler and Riordan 2011). In a report from the 2011 European College of Neuropsychopharmacology meeting, the report's authors cataloged problems that plagued research and development pipelines:

> *With an average of 13 years, the time to develop a medicine for a psychiatric indication is longer than that for other disease areas. …The failure rate of medicines in psychiatry and neurology is higher than that for other disease areas and many medicines fail late in the development process–at Phase 3 or even at registration–leading to particularly high financial loss.* (Nutt and Goodwin 2011, 496)

Beyond the difficulty of research and development lies the challenge of trying to create models for psychiatric and neurological diseases. In other words, problems arise in trying to understand the underlying neurobiology of disease states and turning neurobiological knowledge into safe, effective therapeutics. Although clinical neuroscience research tends to narrate this difficulty using the language of biological complexity, the unique and multimodal nature of *mental illness* also renders problematic the very categories and methods used in bioscience research. According to the report, challenges in understanding the biology of psychiatric disorders has hindered additional research using existing biological conceptualizations and methods:

> *Predictive and prognostic biomarkers for psychiatric disorders are largely nonexistent, and the poor predictability of the pre-clinical models for both psychiatry and neurological diseases is only now being addressed by the development of experimental human models. Most psychiatric medicines*

> *have been discovered by guided or "well-educated" serendipity.* (Nutt and Goodwin 2011, 496)

Accordingly, it is the combination of early stage roadblocks (Cutler and Riordan 2011), especially concerning poor or insufficient scientific understanding (Cressey 2011; Nutt and Goodwin 2011) alongside challenges in development, clinical trial problems, and regulatory hurdles — many of which themselves are considered consequences of ambiguous science – that comprise the many problems that make CNS research do difficult (Garcia-Rill 2012). Because "only around 8% of CNS drugs that make it to clinical trials end up being approved," (Miller 2011, 503) the 92% failure rate for the larger enterprise shows just how costly CNS is. From an investor's perspective, the enterprise of CNS research is overloaded with risks--particularly knowledge risks.

Although there has been broad consensus among neuroscientists, investors, translational researchers, academic medical center executives, pharmaceutical executives, and patients about the many complications along the pipeline between the laboratory bench and the patient bedside, pointing to the existing problems and challenges with CNS research fails to resolve the inefficacy of many of the psychopharmaceuticals marketed in the last decades. In a provocative article, Director of the National Institutes of Mental Health (NIMH), Thomas Insel (2009), compiled research showing that new antipsychotic psychopharmaceuticals are no more effective than older ones. In the case of antidepressants, there is little evidence that existing first- or second-generation pharmaceuticals are effective at all compared to placebos:

> *Studies have begun to examine the value of newer, expensive medications relative to older, less expensive, and less commonly used compounds. For the antipsychotics, there are now four large-scale studies demonstrating the lack of superiority of the second-generation compounds over first-generation compounds ...For the antidepressants, with either first-*

> *generation or second-generation medications, the rate of response continues to be slow and low. In the largest effectiveness study to date, with more than 4,000 patients with major depressive disorder in primary care and community settings, only 31% were in remission after 14 weeks of optimal treatment with the second-generation medication Citalopram, a selective serotonin reuptake inhibitor (53). In most double-blind trials of antidepressants, the placebo response rate hovers around 30%. (*Insel 2009, 702)

Insel's analysis suggests two things. First, the new class of medications that Big Pharma brought to the market perform no better than off-patent pharmaceuticals indicating a failure of pharmaceutical or pharmacological innovation. In other words, new drugs marketed in the late twentieth century did not provide significant clinical improvements. Second, and perhaps most damning, is the research and larger contention regarding the poor efficacy of *all* antidepressants. In a massive and even more controversial meta analysis published in the *Journal of the American Medical Association*, Fournier and colleagues (2010) suggest that for the mainstream population of users antidepressants statistically just do not work.

However, pharmaceutical innovation problems are often chalked up to problems in biological understanding of mental disorders and attendant psychopharmacology challenges. According to Insel (2010), "There are very few molecular entities, very few novel ideas, and almost nothing that gives any hope for a transformation in the treatment of mental illness" (2010, 503). Insel's statement historicizes several important points. First, an important dualism: the *realization*[49] of the failure of the antidepressant is the articulation of the massive scientific ambiguities upon which new psychopharmaceutical solutions were based. Second, this realization produced a question about the

49. "Realization" refers to its cultural articulation as a scientific reality rather than some sort of cognitive understanding. The ambiguity of the science behind antidepressants, for example, has existed for a long time.

disconnection between the psychopharmaceuticals and their promises. That the underlying scientific ambiguity did not slow the growth of psychopharmaceutical markets or advancement of existing pharmacological models and neurobiological presuppositions during the late twentieth century has created its own question: What is inside antidepressants--what do they contain?

November 2010: Opportunity via Scientific Uncertainty

In November 2010, I attended a seminar given by Tom Insel, MD entitled "Ensuring Public Trust: Conflicts of Interest in Psychiatry." This neuroethics-focused event (See Figures 19 and 20) was part of a panel on global mental health that took place in San Diego, adjacent to the 2010 Society for Neuroscience Conference. I attended this event to learn more about whether, and if so, how pharmaceutical practices were being approached and understood within neuroethics. The primary topics encompassed classic and philosophical concerns such as issues of enhancement, consent, autonomy, and free will. However, there was little discussion of the transformations at work in the pharmaceuticalization of mental health or deployment of problematic neurobiological models, and surprisingly little research or discussion about the politics of pharmaceutical practice.

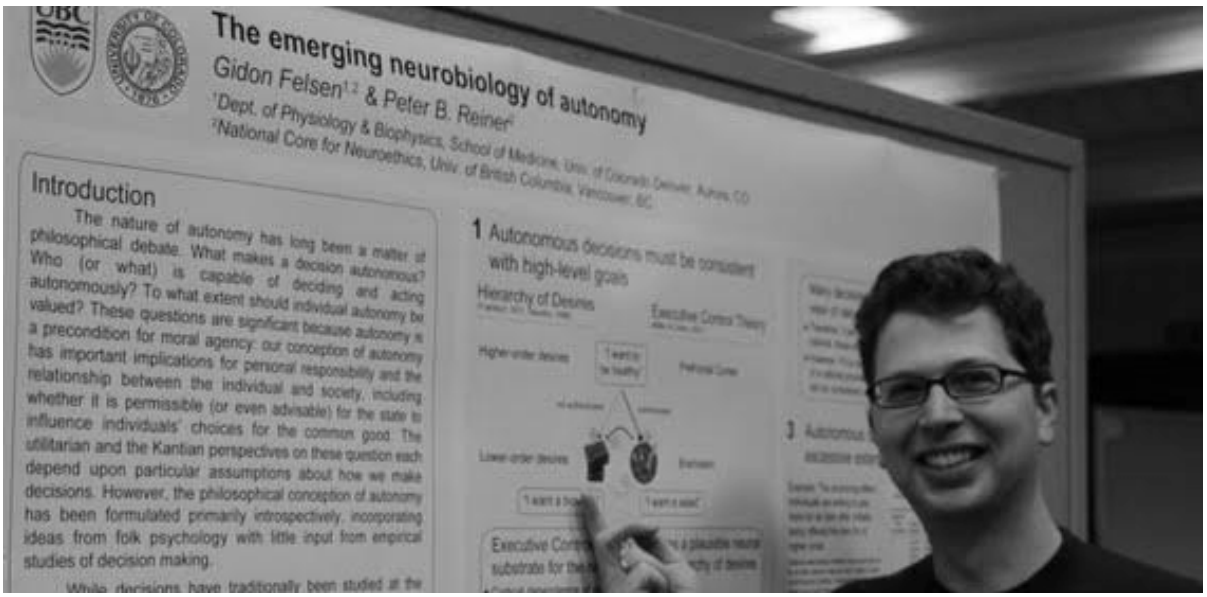


Figure 19. A presenter at the neuroethics-focused event in San Diego, California in November 2010.

I was especially interested in this event because Tom Insel, then head of the National Institutes of Mental Health, had the year prior published an article I cite earlier in which he is critical of the trajectory of TN (Insel 2009). Although much of his writing focuses on practical changes needed within neuroscience, Insel rarely explicitly articulates the political and ethical issues attached to the modern landscape of neuropsychiatry, pharmaceuticalization, and global health.

Insel spoke about the specific neuroethical issue of conflicts of interest in the relationships between pharmaceutical companies and university-based physician-researchers and about the practices of pharmaceutical companies generally. "I wanted to give a topic that hasn't been brought up," Insel said during the keynote address. He added that even though classic conflict of interest issues had not been dealt with in neuroethics literature, "there was a research opportunity here." He went on to describe explicitly what he saw as a conflict of interest in prescribing psychiatric drugs:

> *There is a correlation between those [psychiatrists] who receive the funds with the level of prescribing. A fact that's not well-known to the public is this: the number one class of prescribed drugs is antipsychotics. Not cancer drugs, not heart or blood pressure medications, but antipsychotics. Atypical antipsychotics are at numbers 5 and 6, with antidepressants a bit further down.[Informal comment at "Ensuring Public Trust: Conflicts of Interest in Psychiatry," San Diego, November 2010]*

The ethical issues according to Insel were locatable in pharmaceutical companies' widespread practice of creating "me-too drugs," referring to the practice by pharmaceutical companies of creating similar or minimally different new pharmaceuticals for the purpose of profiting from patents accorded to that "new" drug. As this practice causes high healthcare costs and is seen as a strategy motivated by profit seeking over actual improvement in patient health, this corporate practice, which continues today, raises an ethical issue. Insel also referenced research that showed a drug's patent-status rather than efficacy or patient benefits is most highly predictive of prescribing practices. According to Insel, "Prescribing practices are the primary reason for high health care costs in this country and for Medicare and Medicaid—this is part of the problem." Several panelists at the table looked down during Insel's speech. One panelist seemed to stare intently at the intricately patterned rug that adorned the floor in the exhibition space. "There is a tendency to demonize Big Pharma or psychiatry, and that is not my goal…," Insel offered. He continued, "There are no biomarkers for psychiatric disorders, which creates opportunities for bad behaviors such as the creation of new diagnoses."

Insel's contention about the social construction of disorders was a rare instance in which scientific ambiguity (here exemplified in the absence of biomarkers for all psychiatric disorders) was explicitly tied to exploitative pharmaceutical practices. Yet,

while I sat in the audience I began to think about the materialities of these drugs: If they do not directly implement precise knowledge about biomarkers, what presumptions and models might they contain? Might this history also reflect the literal enrollment or embedding of scientific ambiguity into the materiality of emerging neurotechnologies? One can begin to think of the risks of scientific imprecision as a material property of these new drugs.

In his optimism about the presumptions of the problem-free nature of biomarkers, Insel still situated *good science* as a recourse—a protection mechanism against exploitative pharmaceutical practices. This explanatory trend was something that I often noticed among the few neuroscientists and physicians who waded into neuroethics. Informed by a high-minded scientific determinism, they often proposed designs for ethics in which the truth of science was the source and the solution for neuroethical problems. Nevertheless, Insel then went on to provide an interesting insider history of the role of psychiatry as a professional discipline in prescription practices and how academic medicine was implicated. According to Insel:

> *Psychiatrists have long been at the low-end of the economic ladder. There isn't much that a psychiatrist can make money from. Big Pharma was having a problem of a failure of new ideas and had to find a way to market "me-too" compounds. "That was a great business strategy, but it means Big Pharma gets focused on remarketing compounds and the creation of new intellectual property. Pharma has found that appealing to academic prestige and currency leads academics to become marketing agents for pharmaceutical companies, who then have a real impact on physicians. But NIMH [National Institute for Mental Health] also cares about what clinicians do. We're not funded to help academics write papers. Scientific messages become counteracted and so the Pharma strategy is good business practice and their incentive is to keep a patent alive. Most new drugs are "not so new." This happens to be correlated to the rash of new stories about new and old technologies and the problems of efficacy and cost.*

Insel then posed the following question: “So, [with a market share of] 25% of the entire pharmaceutical market, antipsychotics are huge sellers for the pharmaceutical companies. Is this a problem?" Insel then paused and vocalized a search for a euphemism. He continued, "Might it [at the very least] enable destigmatization?"[50]



Figure 20. Presentations at the San Diego neuroethics event in 2010.

The problem, according to Insel, was that off-patent products were equally effective as the new (patent-worthy) ones; so the costs were unnecessary: “The cost of healthcare in this country means that this is an ethical issue.” Of course, this particular problem of efficacy for *new pharmaceuticals* is separate from the problem of general

50. Destigmatization is often pointed to as both a desire for the field as well as good byproduct of biomedicalization of psychiatric disease. However, destigmatization becomes a glib justification for pharmaceuticalization–it is a common solution that clinicians and pharmaceutical company representatives harp upon, out of what I believe is moral anxiety.

efficacy for all psychopharmaceuticals--an issue that Insel outlined controversially in his 2009 article. Interestingly, healthcare costs--rather than development and marketing biotechnologies such as pharmaceuticals based on scientific ambiguity--became the means for Insel to envision this as an ethical issue, leaving aside the question of the general efficacy of psychopharmaceuticals for general populations.

Insel addressed the question written in bold letters across his PowerPoint slide: "Does Promotion *Effect* Prescribing?" According to Insel, the answer is yes. Yet, doctors "simply can't see it." Free samples are about creating a relationship, but physicians are not aware of labeled drug indications. Solution? "Pharma has really stepped up" and disclosed payments to doctors, said Insel, but he suggested that this was not entirely voluntary. Pharma was leaving CNS and trial data to work in other areas. For Insel, this retreat from CNS was anything but amicable. Instead, he saw academics as part of the problem because medical schools had yet to go beyond disclosure in talking about physician -- researcher embeddedness in pharmaceutical practice.

According to Insel, "This is about something more complex, which is, how do you take the need we have for the next generation of therapeutics [and develop it such] that it doesn't become a marketing exercise in which all of this gets perverted for the gain of a few academics that get involved and ultimately to the violation of public trust, which we're most afraid of losing." To explain the way that pharmaceutical practices affect clinical outcomes, Insel brought up the example of psychiatrists who expressed interest in cognitive behavioral therapy despite the rising prominence and dominance of psychopharmaceutical treatment modalities, and who, because of their interest, became a source of pharmaceutical disinterest. The problem with this pharmaceutical distancing is

that cognitive behavioral therapy was still shown to be *highly effective*, Insel stated emphatically.

Insel's caution renewed my ongoing interest in the ways that pharmaceutical interests produce narrow psychopharmaceutical presumptions, which in turn affect the way innovation is conceptualized in TN research focused on psychiatry within the academic laboratory. His caution also pointed to the work of *psychopharmaceutical presumptions* upon psychiatry, made evident in the denigration of cognitive behavioral therapy. Most importantly, such a presumption likely also shaped the research programs and research interests advanced by the National Institutes of Mental Health. Insel's caution also underscored the issue of foreclosing of other potential solutions when thinking about TN's epistemological contours (toward pharmaceuticalization).



Figure 21. The question and answer session at the San Diego neuroethics event in 2010.

In the context in which novelty, intellectual property, and patents are primary goals in neurotechnology innovation, TN may lead to the marginalization of effective, non-technological, and even effective, extant solutions. During the question and answer session, one slightly disheveled man asked a rambling question in which he stated,

somewhat antagonistically, that he *did not believe* that NIMH was an advocate for cognitive behavioral therapy--in contrast to Insel's exhortation--and that there had indeed been a cultural aspect to this shift. Somewhat haggard with a mop of grey hair, the audience member said that he was a physician. But one could sense the audience's discomfort with this man whose appearance suggested he was an outsider to these conversations. According to the man, the NIMH itself had created a culture in which prescribed drugs were viewed as the primary way to treat psychiatric disorders. In response, Insel offered a critical insight:

> *When we've talked about these issues, we see that the culture of drugs-as-treatment was created by us, and secondly, when there have been alternatives, it's hard to make a living arguing that CBT [cognitive behavioral therapy] does impact the brain. This model makes academe the primary force and companies as a capitalizing figure and there is something interesting about this chicken-egg formulation.*[51]

Here Insel offered a rather direct admission about the commercial considerations at work. The idea that it is "hard to make a living arguing that CBT does impact the brain" references both the clinical encounter for lowly paid psychiatrists as well as the difficulties of garnering federal funding to answer certain kinds of research questions about the brain and mental illness. In this sense, Insel was already referencing the institutionalization of a set of epistemologies that have a life beyond concern for patient outcomes alone. Here TN has become a kind of pathway that tethers visions of health innovations to particular kinds of approaches and models. To admit that certain arguments might make it "hard to make a living" acknowledges how certain

[51] It is not clear to whom Insel meant by "us". It is possible that here he refers to the NIMH, in its early funding of neurobiology research and subsequent dissemination of neuropsychiatric models, especially via diagnostic categories (Lee, Ng, Lee 2008).

psychopharmaceutical modes have apprehended psychiatric, institutional, and scientific thinking. However, the pharmacological presumption is also *technological*. The norm of "drug-as-treatment" thoroughly apprehends how one envisions solutions. It is here that one sees the ethical axis involved in technological determinism. In something like a psychopharmaceutical determinism, the ethics lie not only in the export of pharmaceutical and corporate pressures; the moral issue emerges in defining and articulating available and optimal solutions, and in the means of recognition (via diagnosis) accorded to patients.

After the event, I caught up with the man who had posed the question. A quixotic individual, Dr. Stein lived in Santa Cruz, a small left-leaning city in the central coast of California about an hour away from Silicon Valley. I asked him about his comments during the event. In particular, I wanted to know what he meant about the culture that NIMH had created. We sat down in an area at the rear of the hall where the session was held. A flurry of attendees was still milling around; a soft murmur surrounded the ten or twelve neuroethics posters set up at the back of the room. Stein explained his experience as a psychiatrist:

> *I've been in psychiatry for a long time. I used to think that I wanted to be a pediatric psychiatrist only, but then I realized that I wanted to help everyone. My mother had bipolar disorder. Back then, when I was in medical school, they called her a Manic Depressive. I've seen things change and go up and down since the early 80s when I first started out as a psychiatrist. In particular, the part that has changed the most is the tendency to create a diagnosis around everything and, especially working with patients, you quickly learn that the issues that people present can't be neatly fixed with some magic bullet. I really did not like -- and a lot of my colleagues at the time resisted -- this rush towards the single bullet solution. I mean, for me, I thought, "I really know these people." I know that the issue that they are dealing with is a lot more complex. Now, for the really severe patients, the medications have gotten better and better.*

> *For schizophrenia, medication can mean the difference between a life and no life at all. But for the rest? They just don't get a huge benefit from every new drug that comes out and it's been this way for a long time.* (Interview 21, November 12, 2010)

"You know, therapy *still* works. I'm one of the few psychiatrists that still talks to my damn patients!" he said with a chuckle. Stein had lines in his face. Close up, he looked somewhat frail with frazzled hair, tanned skin, and tattered pants. His speech was informal and easy-going, yet also cerebral. He continued:

> *It's only from talking to my patients that I started to question this whole drive towards some magic molecular bullet. I mean these people have never talked to a person. I can tell you that you wipe away / explain complex behavior, pain, and abuse with a simple label and a pill. And look, I'm no scientific denialist, I believe in science and I believe in the brain. I believe that children's brains are impacted if they aren't interacted with as children. I believe in development. I believe in facts. However, I know from years and years of doing this that some simple molecular bullet notion is just…just the wrong direction. I've had patients that were addicted to all kinds of stuff. Putting them on psych meds just did, well nothing. Nothing! This sale exec came marching into my office some years ago trying to push antidepressants for overweight children. I don't even prescribe it anymore to treat addiction. I think we're missing a whole lot of other options out there because we're so obsessed with this stuff. Sometimes I wonder what we could have come up with. So, nowadays, since I have less clients now, I go and I try to attend these events and I try to get people to think about this stuff. I wanna' try to change the conversation.* (Interview 21, November 12, 2010)

During an earlier discussion, the neurologist Dr. Jones had made a statement about the relative standing of psychiatry compared to neurology. For her, neurology was entirely more scientific, and thus more rigorous. I wondered if Stein's contention that he was no "denialist" was about this ongoing assumption/stigma attached to psychiatry as being less scientifically rigorous. Nevertheless, the current antidepressant prescribing practices and its reflection of the role of pharmaceutical companies in clinical practice is

quite relevant to questions framed in the laboratory. In this way, Stein's question about potential alternatives is compelling. Insel's statement about the university also creates questions about the status of university knowledge in relation to questions of mental illness and academic psychiatry. What histories and paths animate the now-problematized antidepressant?

A History of Nothing: The Science of Psychopharmaceuticals

In order to invoke thinking about the pharmaceutical as object, I begin with the question: What do psychopharmaceuticals contain? There is an opportunity to re-envision the symbolic life of biotechnologies, given that they reflect an amalgamation of scientific practices such as complex theorizations about the brain and *known* knowledge ambiguities, as well as (from a different view) financial practices—including the interplay of trends in global finance and the movement away from high-risk investments during the 2006-2009 financial crisis (Appadurai 1988; Baudrillard 2005). To think of these pills as containing these histories opens up research possibilities.

Beyond mere functional analyses of therapeutics or considerations of whether they work or do not work, there is an important consideration for how psychopharmaceuticals have become objects that represent particular forms of modern rationalization; objects that, via Baudrillard, "synthesize gestures of the human in their technical evolution" (2005, 53). In particular, there is real relevance in Baudrillard's notion of *functionability*—a concept that does not refer to an object's ability to function per se, but to an object's *manipulability*--its capacity to incorporate other social and material forms. In thinking about the swath of scientific ambiguity that surrounded the

use of DBS for epilepsy or Insel's admission that the absence of a biomarker for psychiatric illnesses made psychiatry conducive to problematic behaviors on the part of pharmaceutical companies, we can begin to see how psychopharmaceuticals are particularly porous, functionable objects.

I argue here that modern psychopharmaceuticals actually comprise multiple kinds of risk. Given the relationship between psychopharmaceuticals and the problematic knowledge upon which they rested, they have become sites of epistemic risk and are highly amenable to the ambiguities at work in clinical neuroscience and psychiatry. However, psychopharmaceuticals are also products of knowledge-related risk taking. Nevertheless, in *A Dry Pipeline for Psychiatric Drugs*, the author--a Cornell University psychiatry professor--suggests that the reason for the lack of new pharmaceutical solutions is not simply a dearth of scientific knowledge, but also connects to the complications of a particularly complex object:

> *The simple answer is that we don't yet understand the fundamental cause of most psychiatric disorders, in part because the brain is uniquely difficult to study; you can't just biopsy the brain and analyze it. That is why scientists have had great trouble identifying new targets for psychiatric drugs. Also, knowing how a drug works in the brain doesn't necessarily reveal the cause of the illness. For example, just because an S.S.R.I. antidepressant increases serotonin in the brain and improves mood, that does not mean that serotonin deficiency is the cause of the disease; many depressed patients get better with medications that have no effect on serotonin.* (Friedman 2013)

Certainly, narratives focused on scientific explanations about the complexity of mental illness refer to its esoteric and biological complexity. Nevertheless, the complexity of mental disorders--and its undoing of various biomedical and cultural framings--often escapes the same sort of scientific attention. The cultural etiology of mental illness renders it a complex object that maps onto complex subjectivities.

In addition to the slowing pipeline of new therapies, which is often thought of as a problem of scientific innovation (Insel 2009), industry insiders point to regulatory roadblocks and expiring patents (Miller 2010). This, alongside the large number of failed trials; the highly subjective nature of the scales used in diagnostics and assessment; the vicissitudinal nature of brain disorders (Ninnemann 2012); and the impenetrable problem of environments, socio-political contexts, local categorizations upon brain illness categorizations, which scholars have long mapped (Biehl, Good, and Kleinman 2007; Lakoff 2005; Moerman 2002; Van der Geest, Whyte and Hardon 2003), lend a devastating complexity to neuroscience-based discoveries–a complexity that was to be ameliorated through the translational shift.

However, for scientific explanations that point to the sheer complexity of the brain as the reason for the scientific problems, these deterministic narratives usually call for increased neuroscience knowledge in order to find therapeutic targets. Thus, TN, positioned as a solution to the problematic nature of commercial, for-profit neuroscience, promotes further engagement with psychopharmacological models of mental health. In this sense, the problems with old neuroscience are solvable with more neuroscience.

For scientific problem-narratives (Fujimura 1996) founded on the complexity of the brain, the problem is the exceptional difficulty of finding *mechanisms of action* in the brain and biomarkers around which to develop therapeutics and approaches. While TN seeks to remedy this by supplying clinical scientists with increased, basic knowledge on neuroscience and pathophysiology (FitzGerald 2005), issues such as depression and overeating do not neatly correspond to biomarkers in ways that are easily addressed

solely through *pharmaceuticalization.* The problem of the social and the individual remains an unaddressed issue in the translational paradigm.

Quite a few scholars have made the point that psychopharmaceutical solutions do not easily map onto given individual experience (Biehl 2005 Dumit 2003; Greenslit 2002; Jenkins 2011; Lock and Nguyen 2010; Ninnemann 2012; Schlosser and Ninnemann 2012; Whyte et al. 2002); local meanings and contexts (Das and Das 2006; Lovell 2007; Petryna and Kleinman 2006); biological difference and complexity (Lock and Nguyen 2010; Ninneman 2012; Petryna 2006; Shlosser and Ninneman 2012); or national and cultural narratives (Applbaum 2006; Ecks 2005; Good et al. 2007 Kirmayer and Raikhel 2009; Lock and Gordon 1988; Schlosser and Ninnemann 2012; Young 2007).

In fact, the complexities at work in mental illness tend to point to the importance of understanding it as a product of co-constitutions and its articulation as a multimodal phenomena (Barad 2007) or *technophenomena* (Lock and Ngyuyen 2010). Lock and Ngyuyen's notion of technophenomena addresses the way biomedicine's regimes necessarily construct illnesses as *technological problems*. Their unique reading of technological determinism illustrated the way technological framing can lend a very particular reality to the problem for which the technology was constructed as a solution; this is made especially evident in the approaches towards diagnostics and clinical measurement of complex phenomena such as depression.

According to scholars, the problems of measuring depression are part of a larger lack of understanding that imperiled science behind antidepressants. "People have not paid enough attention to how to measure depression, how to measure psychosis" (Van Gerven and Cohen 2011). The construction of mental illness as a brain disorder thus

informs the conceptualization of a wide array of interventions, including the design of diagnostics. The large movement toward envisioning mental illness via the lens of genetics (Insel 2009) and the move by pharmaceutical companies to invest in genetic research programs in lieu of neuroscience foci (Abbott 2011; Bell 2013) may have given birth to a new kind of biotechnological conceptualization: *geneticization*[52] of brain-based medical disorders- something that I believe is an emerging trends within TN and translational science in general.

Scholars such as Joseph Dumit have shown how the move toward defining disorders technologically--especially diagnostics and screening--dovetails pharmaceutical companies' corporate strategies focused on commoditizing prevention, thereby pushing pharmaceuticalization of individuals who had merely the *risk* for a given disease. According to Dumit's (2012a) analysis, this trend reflects an emerging birth-to-death prescription model. By treating genetic predisposition, pharmaceutical companies move toward gene articulation (more specifically, genetic possibility) as a point of biomedical intervention, itself a veritable ground-zero for twenty-first century global health response and a source of local, individual (Rouse 2009), and clinical (Keating and Cambrosio 2003; Fullwiley 2011) truth-making.

However, in the case of clinical neuroscience, the move toward genetics as a new strategy may reflect, as suggested earlier, a failure of existing theories in neuroscience (Insel 2009), including existing models at work in research programs focused on depression, autism, and Alzheimer's disease. A clear example of this sort of

52. This refers to the notion of geneticization that epidemiologist Abby Lippman (1992) offered to make sense of the ways in which genetics became a driving force in medical meaning-making. For Lippman, geneticization was a form of reduction/simplification.

psychogeneticization of brain-based illnesses is reflected in Margaret Locke's (2013) work on Alzheimer's, in which she chronicles how a profound dearth of effective, new solutions based on existing Alzheimer's research models led to a turn toward both prevention and gene-based approaches. Yet, as Lock suggests, the growing genetic reconceptualization of Alzheimer's has not entirely supplanted older hypotheses. She states, "The model is currently being questioned by an increasing number of key researchers, but has by no means been overturned, and continues to be a driving force, even as the entire Alzheimer enterprise moves to include prevention as a major goal" (2013, 52).

Given similar diagnostic and ontological problems of depression, biomedical logics that enable a view of depression as something conducive to measurement and standardization illustrate the multivalent expansion of epistemologies regarding mental health and suffering; epistemologies that may still be highly contested, but inform diagnostic categories such as those enshrined in the Diagnostic and Statistical Manual DSM. Additionally, the scientific crisis of the antidepressant represents a literal problem of *translation*: translation being the imaginary bridge connecting facts and realities within the laboratory with the world (Latour 1983). Science studies (à la Latour 1983, 1988; and Knorr-Cetina 1981) commonly observe that laboratories exist in and create "alternate worlds" but these alternative realities may not have been operationalized in the pragmatic shaping of translation-focused laboratories in university campuses.

However, no matter what the laboratory setting, translating findings from a basic laboratory into the world includes a milieu of issues: epistemic, departmental, scientific, political, regulatory, and so forth. Translational science, which in the ideal model informs

translational medicine, includes laboratory research focused on drug discovery. In the case of pharmaceuticals, it requires translation between brain sciences and pharmacological and human-drug interaction; in the case of brain devices, an understanding of the bioengineering of devices attached to human bodies. Translational science ultimately aims to translate genomic and physiological data to systems of personalized medicine (Garcia-Rill 2012). Thus, translation gets at the way that biomedicine suffers from an ever-evolving set of *multiple* mistranslations between, for example, pharmacological and individual bodies; between laboratory rats and clinical-test subjects. Between genetic facts and their neurological expression, translations can be multiple.

The ideology of TN and translation more broadly is, therefore, that it would be a remedy for the very real panoply of breakdowns that ultimately occur between the laboratory bench and the patient bedside--a process that necessarily sutures together wide-ranging fields, methods, interests, individual and personalized data, and institutional and social stakeholders--incorporating this heterogeneity to operate as a bridge.[53] In this sense, translation is as much a fantasy about integration as it is an anxiety about *falling apart*. Risks--especially scientific risks--are imbued with the very philosophy of TN: replete with the underlying anxieties for which translation had been envisioned as a solution, brought to the fore, and displayed in narratives of scientific and clinical complexity in the aftermath of controversies over psychopharmaceutical efficacy and

53. The constant use of the term *bridge* in translational programs, research articles, reports, and communication shows both its conceptual tie to "connection," as well as the gulfs that exist in the translational imaginary created for neuroscience.

questionable gains in health. But, for pharmaceutical companies there is more; scientific risk is not the same as financial risk.

Scientific Risk vs. Financial Risk: Knowledge Problems are not always Financial Problems

The massive financial risks of CNS development eventually proved to be too much for many biopharmaceutical companies (Cutler and Riordan 2011). The financial risk in CNS included the exceptionally long development process, investor preference for short turn-around time (FitzGerald 2005), high failure rates of clinical trials, high risks and costs of regulatory hurdles, expiration of patents, and the growth of cheap generics. However, CNS had always been risky for investors as well as for biopharmaceutical companies. The knowledge problems that undergirded psychopharmaceuticals had been recognized throughout twentieth-century research priorities (Insel 2009) derived from a consistent pattern of failed clinical trials, speculation about efficacy, and complaints about research and development pipeline problems.

Only recently have CNS investments been considered to be financial risky. This reality produces the inevitable question about why investments in commercial neuroscience continued into the twenty-first century. How does a sector so prone to scientific uncertainty still attract massive private investment?

For the present project, I wanted to better understand the relationship between scientific and financial risks in CNS development. In May 2011, as a fellow at UC Berkeley's Center for the Study of Science, Technology, and Society, I was introduced to David Grosof, a neuroscientist who had worked as an academic at UC Berkeley. Like

many scientists in the neurotechnology community, he had dual degrees: a Ph.D. from UC Berkeley and an MBA from Massachusetts Institute of Technology. Grosof later returned to UC Berkeley to work in computational neuroscience, developing mathematical models from neurology to apply to commercial endeavors, eventually leaving to pursue an ophthalmological startup at Washington University in St. Louis, Missouri. His oscillation between academe and industry was typical among academics involved with the neurotechnology industry, creating new startups, and serving as experts for university-industry institutes.

However, Grosof was not a typical ethnographic interlocutor; he was a self-described admirer of Durkheim and, as is often the case with bohemian, modern scientists (Rajan 2006), he was familiar with anthropologists who studied scientists. In our first encounter, I was reminded of the reflexive nature of modern scientists who are deeply aware of their social worlds (Luhmann 1993). During our first conversation, he boasted of conversations with Paul Rabinow[54] and told me, "Chances are I've got more of an appetite for the hypotheses and emphases you're bringing to bear than most life scientists." Grosof, having experienced both academic and entrepreneurial contexts, offered insight into the industry-academic partnerships in TN: one that is attentive to the problems of expectations engendered through translational fantasies accorded to neuroscience:

> *Alzheimer's research is quite protean like cancer research in the 1970s…yet the economic and political demand for a better treatment is huge as the aging U.S., European, and Japanese populations are creating a crisis in human and fiscal cost. Quite risky clinical trials of lousy drugs (which all failed so far) have been done because the existing drugs are so*

54. Ironically, Kaushik Sunder Rajan's (2006, 1) ethnography also included an interlocutor who had read Paul Rabinow and who was familiar with anthropologists working among scientists.

> *poor that any quarter-assed [the result of only the most minimal of effort] treatment that's any better will get sales of a billion-dollars-a-year.*
> (Interview 22, March 23, Berkeley, California)

Investment risk inherent in certain neuroscience projects could be offset by the large market opportunity that neurotechnologies offer–-a principal consideration in the evaluation of investments. Thus, the possibility of even incremental improvements in treatment would justify the high risks of CNS research and development.[55] Thus, market size is a principal element in biopharmaceutical companies' sustained interest in the sector, made evident by many companies' innovation *externalization*, rather than complete abandonment. According to NIMH, one in four adults suffered from a diagnosable mental disorder in any given year[56] The gargantuan market for CNS made neuroscience a persistent investment target. Because mental health presented a massive opportunity, CNS--despite the knowledge problems upon which it depended--offered the possibility of incomparable financial returns.

This lucrative investment opportunity has also been reflected in investing activity: enormous amounts of capital were invested in brain-based biotechnology companies between 2006-2009. In 2008, venture investment in neuropharmaceutical companies totaled $977 billion (68% of total neurotechnology investment for that year) and in brain-based device companies $390 million (27% of the total neurotechnology investment). Yet, investments in neuropharmaceutical and neurodiagnostics dove 25% compared to 2007 (NeuroInsights 2010), representing disinvestment from CNS. The high investment

55. This also sets the therapeutic bar very low: A "quarter-assed" (Grosof) effect would yield a positive financial outcome.

56. See http://www.nimh.nih.gov/health/publications/the-numbers-count-mental-disorders-in-america/index.shtml

rates prior to 2008 occurred because CNS and its objects--antidepressants, diagnostics, peripheral technologies, and procedures--proved highly profitable (Figure 22).

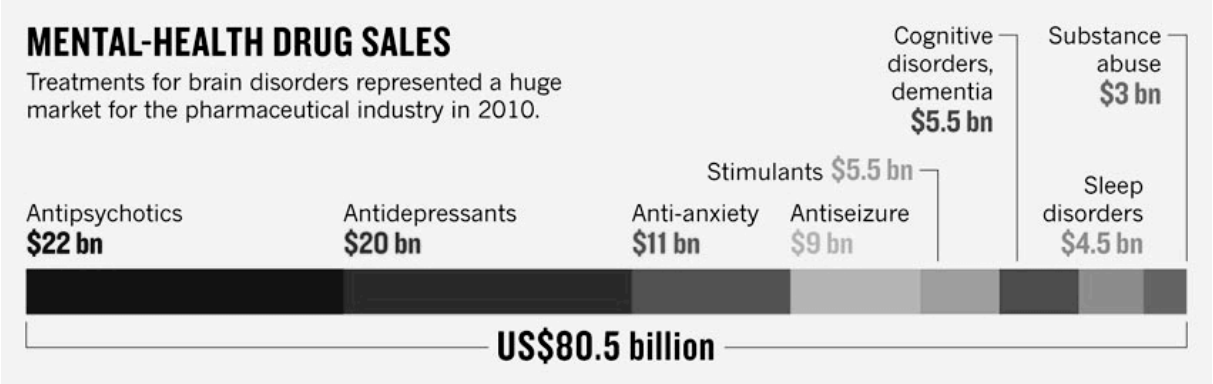


Figure 22. Sales from CNS in 2010 according to BCC Research (Abbott 2011).

The $80.5 billion sales in 2010 showed CNS profitability despite skepticism regarding the science of psychopharmaceuticals and growing research about efficacy problems (Fournier et al. 2010; Healy 2012; Insel 2009). Considering all neurotechnologies--diagnostics, surgical methods, devices, and services, 2009 revenues were $141 billion, according to the Neurotechnology Industry 2009 Report (figure 23). The enormous profitability of CNS products was also expected only to grow as psych diagnoses continued to rise alongside an ever-widening umbrella of what would be considered a psychiatric or neurological disorder.

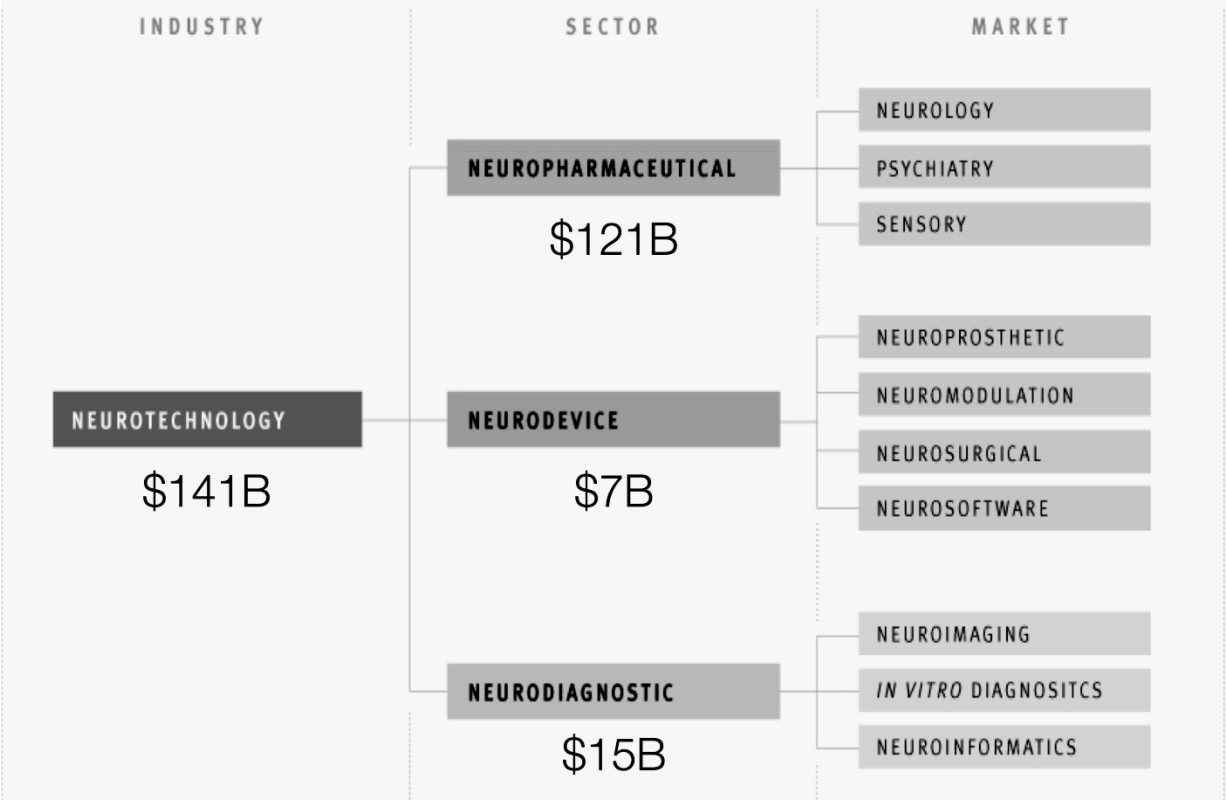


Figure 23. Neurotechnology industry taxonomy of each area's revenues. (Neurotechnology Industry 2009, courtesy of NeuroInsights, Zack Lynch)

All this emerged in spite of the accumulation of evidence that there are massive scientific problems at work in the theories that undergird psychopharmaceuticals and internal awareness of knowledge problems attached to pharmaceuticals (Healy 2012). "Knowledge problems" refers to the crises over efficacy (Fournier et al. 2010; Insel 2009; Ninneman 2012). According to NIMH Director Insel's observation, "Remarkably, despite the heavy use of these medications, we have no evidence that the morbidity or mortality of mental disorders has dropped substantially in the past decades" (2009, 704). It also refers to the problematic pharmaceutical practice of pushing a given drug's off-label use and promotion among doctors (Kesselheim, Mello, and Studdert 2011), problems of ghostwriting and scientific authorship (Applbaum 2009b; Healy 2012), concerns about massaged clinical trials (Petryna 2005), pharmaceutical truth

constructions (Dumit 2012a; Joyce 2005, 2008; Matheson 2008), and problematic biological conflations (Ninneman 2012). Also included in the category of "knowledge problems" is research about psychopharmaceutical safety and attempts to manage such research (Healy 2012). The question emerges: How can a pharmaceutical company maintain high profit margins with a lack of novel new products and products that contain knowledge problems?

In the essay, “Is Marketing the Enemy of Pharmaceutical Innovation,” Kalman Applbaum (2009c) suggested that *pharmaceutical value* had increasingly become a marketing proposition, bringing much of research and development into the marketing process. For Applbaum, “In the integration of marketing and R&D across contemporary medicine, we find fewer and fewer expressions of scientific value” (2009c, 15). In this view, the push for profits means a reliance on marketing, rather than scientific, innovations. Similarly, the pharmaceutical strategy to treat risk factors for diseases in anticipation of the possibility of their expression (Dumit 2012) illustrates a strategic focus on prescription maximization beyond sheer symptomology.

While Applbaum’s (2009c) analysis relies on scientific optimism about cures culled from “honestly pursued scientific outcomes,” pharmaceutical companies' practice of growing profits from marketing practices (Moncrieff 2006) rather than from therapeutic benefit has been especially well documented (Applbaum 2009c; Dumit 2012; FitzGerald 2005; Greenslit 2002 Healy 2012). However, this also brings into view that while psychopharmaceuticals are laden with scientific or epistemic risks, there are still opportunities for positive financial returns. In other words, just because CNS relied on knowledge problems did not mean that their pursuits were not profitable.

The 2010 Neurotechnology Partnering and Investing Conference made this especially clear. Manuel Lopez-Figueroa, a vice president at Bay City Capital (a venture capital firm) discussed the status of psychiatry. He said, "I want to begin with the status of the psychiatry market. As you all know, in the last couple of years, the number of drugs that will expire is significant, and it's about $95 billion dollars--$95 billion will be expiring in cumulative numbers." He then put up a slide that showed CNS had the lowest clinical success. Another slide showed that CNS mergers and acquisitions had the second highest level of transactions among all CNS areas. Why is that significant? The juxtaposition of high levels of mergers and acquisitions alongside low levels of clinical success suggests speculation.

The accumulation of too much financial risk by biopharmaceutical companies and the subsequent need to expel that risk is why I invoke the metaphor of *overleveraging*. Externalization is one mechanism by which biopharmaceutical companies have dealt with the overleveraging and overcommodification of risky products in a move toward the university as a space of externalization as a solution to this larger risk crisis.

Only in the coming to light of the massive scientific ambiguity folded into pharmacological solutions and the acceleration of commercialization despite this ambiguity can we understand pharmaceuticals as both epistemic and financial risk objects--just as the risks attached to the use of Deep Brain Stimulation (DBS) in epilepsy patients (which came to light in the admission of the absence of knowledge about its impacts upon the brain) could not be understood as some *inevitable consequence* of technological modernity, a narrative that conveniently treated risk merely as a cost of innovation.

Thinking critically about the hidden ontology of objects (Schüll 2010) and the social and technical construction (Pinch and Bijke 1984) of biotechnologies, I suggest that neurotechnologies "contain" those risks. Consumers of psychopharmaceuticals *ingest risk*. Risk tolerance is not some kind of neutral, natural category. As discussed in Chapter 2, the very digestibility of risk is also a key product of neoliberalism's impact—an issue made clear in the case of the global financial crisis and public ingestion of the risks from collaterized debt products.

Returning to the question of what psychopharmaceuticals are made of, I propose that they consist of a panoply of scientific, knowledge and health risks of psychopharmaceuticals (Light, Lexchin, and Darrow 2013); the concretization of strategies to promote prescriptions based on unclear evidence about their efficacy; and swelling investor and financial risks. I argue that these immaterialities that are buried inside psychopharmaceutical products are as significant as the pharmacologic agents they also contain and their external packaging. The similarity between the roles of the risk-laden collaterized debt product at the heart of the financial crisis and the risk-laden psychopharmaceutical is uncanny, especially so because both rely on monetization of products containing known knowledge problems, and for particular stakeholders both risk objects are financially lucrative. This similarity is useful. As suggested at end of this chapter, this may offer an opportunity to think critically about risk and knowledge in the context of *knowledge financialization*.

Becoming Translational: The University as a Risk Shelter

In thinking about the transfer of risk back to the public (as in the case TN), one again returns to the nonprofit university. The emergence of the university as a space of *innovation in neuroscience* cannot be taken as a mere reflection, as several scholars have suggested, of the animations of capital and capitalism. Rather, a very important context informs the sudden demand that universities become translational. To the extent to which NIH animated the translational turn made manifest predominantly at the nonprofit university, a key argument is that there was a clear movement toward transferring early-stage neuroscience innovation risk to the public via the university.

Therefore, it is important to understand how the university is envisioned as the space for this kind of innovation. Quite a few commenters support an invigorated role for the university in pharmaceutical research and development, including many academics critical of biopharmaceutical companies' knowledge practices (Applbaum 2009c; FitzGerald 2005; Gomez 2006; Insel 2009; Minogue and Wolinsky 2010). Often, these arguments position universities as a necessary reprieve from a for-profit ethos that was responsible for the CNS innovation crisis. The proposal by many of these aforementioned commenters to separate drug development into "humanitarian" research and scientific drug development areas reflected this ethos and outlined the roles for universities and pharmaceutical companies.

Stakeholders saw the university as perfectly positioned to contribute to the ecosystem of biomedical innovation because of what they considered the university's focus on *good science*--an issue that was brought up frequently in explaining the failure rate in bringing neuropharmaceuticals to market. During one executive statement about "good science," I began to wonder if this was an explicit acknowledgement that low

quality science went into the development of new psychopharmaceuticals. During a cocktail hour at the 2011 Neurotech event, one pharmaceutical executive confided to me (after several drinks) that CNS (the neuroscience sector) had to change; larger shifts in the pharmaceutical industry coincided with opportunities offered by the university partnership model. He stated,

> *We can't do it like we have been doing in the past–finding a drug and just marketing the hell out of it. We're trying to understand the diseases in a much more biologically rigorous way and we're looking for a signal, and then we'll look forward. This is why academic partners are useful. They are patient and take a lot more time than we take in the private sector.* (Interview 24, May 21, 2011)

It was in the pharmaceutical companies' interest for universities to assume responsibility for basic research into neurobiological mechanisms for Alzheimer's, since this lack of knowledge (perhaps combined with overpromising neuroscience's new insights) was a barrier for pharmaceutical companies (Belluck 2011; Graham 2006) in commercializing and developing new compounds and drugs (Minogue and Wolinksky 2010).

However, the partnership between universities and industry is not one sided: University-based translational science centers have the intellectual resources to meet the industry needs. They also benefit from join with industry, especially after enduring large funding cuts in the late twentieth and early twenty-first century (e.g., billions of dollars cut by the 1997 U.S. Balanced Budget Act); decreased clinical-service reimbursements (resulting from a rise in uninsured patients using academic hospitals), and shifting federal funding (Karlin 2013). Universities are under increased pressure to transform their mission toward developing applied learning, marketable skills, and corporate-

partnerships. The modern nonprofit university is under explicitly neoliberal pressures (Bok 2003; Olssen and Peters 2005; Strathern 2000) despite its long history of instrumentalist concerns (Brett 1945). Additionally, that universities have historically relied on a stable demarcation from for-profit corporations challenges the notion they ought to become the space to reclaim big science. The growing evolution of the university and its increasing trend toward partnerships with pharmaceutical companies--clearly evidenced through the recent NIH-mediated program matching unused compounds with academic partners--suggest the nonprofit university is emerging into a hybrid institution.

Additionally, in the sense that pharmaceutical companies "outsource" to public universities via public institutions such as the NIH, the public has *already* become a site and means for development or private industry concerns. The evolution of public -- private partnerships and assimilation of corporate models into public institution infrastructures may suggest that "the public" may enable a moral hiding space for the interests and risks of the private. Assumptive ethics about the superiority of a more democratic public science (in which research and discovery would be the domain of the university instead of pharmaceutical companies) dismiss the reality of new, complex formulations that inhabit and potentially remake the entity that is the public institution.

I therefore argue that given the acknowledged risks of early-stage TN research and the intentionality with which for-profit companies discharge the riskiest parts of their research process, this shift is turning universities into risk shelters. In a New York Times op-ed, a Cornell University psychiatry professor extolled the benefits of bringing pharmacological research to the university and the university's suitability for this kind of

research: "The pharmaceutical industry has little taste for the long-term financial risk of discovering new psychotropic drugs. …In contrast, academic researchers, who are not beholden to shareholders, are much freer to do high-risk, high-gain experiments that can fail. …These discoveries, in turn, may entice the drug makers to reinvest in psychiatric drug development" (Friedman 2013).

The author, while correct about the distaste for risk by pharmaceutical companies, is wrong on several other fronts. He offers an unrealistic, idealized view of the university--one that neglects the reality of increased rationalization and demands of bureaucratization (Shore and Wright 1999). The author also, problematically, assumes that pharmaceutical companies have cut all ties to the development pipeline and this is not the case. Pharmaceutical companies are very much involved in retaining licensing options and in the emergence of industry-university partnership programs such as Pfizer's CTSI or AstraZeneca's iMed that illustrate this emerging reality. In fact, the translational shift at the university may very well bring "shareholders" into the fold of academic science. The university would no longer be nonprofit exactly this way. But in the sense Friedman articulated, the university could sustain risky investments and failures in science and experiments in ways that a for-profit company could not. However, the notions that universities can fold risky pharmacological research into their larger mission, and that university research without a yield is *merely education* under the university's educational mission (rather than a *loss* for the pharmaceutical company) reflects an important amalgamation: The educational mission of the university and thus its nonprofit status justifies the import of for-profit research modes from newly risk-weary biopharmaceutical companies. Here conflations occur: The articulation of the university

as both risk immune (i.e., nonprofit) while possessing indefatigable risk capacity, and the university as both outside of the market and yet also perfectly conducive to market processes. The assumption about risk presumes that the risks taken on by universities simply disappear therein rather than recognizing the complex financial costs incumbent with the new partnering.

A larger issue about the way that risks emerge in the translational paradigm exists. As universities take on the risk-laden wing of translational research and development and corporations commercialize university products, the university's role transforms in relation to private investments in risky bioscience. Thus, a primary contention of this dissertation is that in this risk exchange at work in TN's public-private partnerships, the university becomes a *de-risking mechanism* for high-risk neurotechnology investments. That is, the university ostensibly improves or cleans high-risk, often early-stage investments (investments made after the scientists or biotechnology company ostensibly have proven and de-risked pharmaceutical potentials for development through strong empirical research). Thus, even if accomplished within the nonprofit university, the process essentially cleanses a pipeline of discoveries for financial investment. In this sense, federally funded TN and the restructuring of academic science becomes part of a growing *financial mechanism* in which high-risk investments are de-risked via the public sphere.

This is not to suggest that universities are exploited. Indeed, universities potentially benefit from licensing "effective" discoveries to pharmaceutical companies (FitzGerald 2005). For example, Northwestern University made a total of $1.48 billion revenue from licensing agreements between 2002 and 2011 (Wang 2012). A large

amount of the revenue was due to the success of the drug Lyrica, a blockbuster anti-seizure pharmaceutical developed from the work of a Northwestern University chemistry professor during the 1980s. A local Chicago newspaper (Wang 2012) chronicled the story:

> *Lyrica was better than a good idea. In the 1980s, Northwestern chemist Richard Silverman developed a molecule that limited epileptic attacks. The drug produced $3.7 billion in 2011 sales for New York-based pharmaceutical firm Pfizer Inc., which started marketing Lyrica in 2005. Northwestern received a onetime, $700 million payment as well as big annual fees from the drug's sales. The university's gross licensing revenue reached $191.5 million in 2011, "virtually all" of it from Lyrica, officials say.*

Despite these staggering revenue figures, the norms for licensing revenue were much less profitable, and blockbusters—for universities and pharmaceutical companies alike were rare. The same newspaper article quotes Eugene Sunshine, then Northwestern's senior vice president of business and finance, as he explained the rarity with which scientific research could be translated into large profits: "The track record is not great that it's going to happen frequently." Additionally, this particular configuration whereby universities are charged with entrepreneurial missions toward research and discovery engendered important questions: Where there is typically little revenue and low yields from research, what are the consequences for a university newly burdened with risks that were outsourced through industry collaborations? I have been especially interested in how externalization may embolden neoliberalism's fictions of disappearing risk.

In a research and development timeline replete with risk and with the incredible difficulty of mapping the brain, existing CNS failures have been categorized as mere scientific problems (Fang and Casadevall 2010); the university is envisioned as the

solution by defining CNS failures of as knowledge problems. However, imagining the university as a solution still relies upon the view that psychopharmaceuticalization failures and possibilities for improved health are principally about science. In other words, a scientific determinist view would see "real" (rather than corporate) science as the solution to unearthing the biological bases for mental disorders. In this sense, externalization to the university would be a scientific homecoming as well as a preservation of certain models of mental order and disorder. But this is not the case.

Consider the externalization process beyond assumptions of mere scientific legibility. Externalization enables a series of risk levers whereby commercial partners *offload*[57] risk in their quest for profitability and flexibility. Externalization achieved under the aegis of innovation may obfuscate such risks under notions of flexibility and openness.

The University is not Merely Entrepreneurial

After the Clinical and Translational Science Award (CTSA) Program launch in 2006, the institutional effect was sudden and dramatic. For the approximately sixty academic medical institutions across the country that launched translational science centers, it was a collective and tectonic movement. Since the CTSA program led to creating university-based centers and consortiums, the university became a key player in institutionalizing translational shift within neuroscience. This institutionalization also

57. By "offload," I do not mean to imply that all risk is transferred to universities. However, partnerships transfer risk to universities that did not have the same degree of risk previously. Corporate partners accumulate some financial risks as well in support of their university research arms and especially in competing for licensing options of successful discoveries. In the argument here I separate risk from opportunity cost and research and development risk.

necessarily included reorganizing university departments and programs, rearranging institutional missions and priorities, and injecting a translational ethos into existing departments. According to the CTSA program description: "CTSA institutions provide core resources, essential mentoring and training, and opportunities to develop innovative approaches and technologies designed to re-engineer existing translational research capabilities. By providing integrated academic homes for clinical and translational science, these awards foster change" (Clinical and Translational Science Awards n.d.).

Thus, translational science becomes not merely additive or extensional; it seeks to re-engineer and supplant existing academic organizational landscapes. This is about institutional transformation. The genesis for these new institutional forms began around 2005, when a host of stakeholders were thinking about how to institutionally re-articulate translational programs at universities. For example, in 2005 University of Pennsylvania scientist Garrett FitzGerald, a national leader in translational research, proposed institutionalizing what he named *translational medicine and therapeutics* as a formal discipline. He argued for a new research model focused on translation that would serve the need for "a new educational experience, one that integrates elements of segregated disciplines" and that would enable an "increasingly efficient commercialization of their [academic medical centers'] intellectual property" (2005, 817).

University research programs were also redesigned under the interdisciplinary aegis. The ideology of translational science proposed that disciplinarity and academic silos were primary culprits in the problems that translation sought to fix (FitzGerald 2005; Garcia-Rill 2012; Klein 1996). In nearly all definitions of science and medicine—whether articulated in the *NIH Roadmap* or by pharmaceutical companies touting their

own innovations—there was strong emphasis on creating partnerships *across* fields, disciplines, methods, and models. Perhaps, translational science was obsessed with cross-disciplinarity, but only inasmuch as this cross-disciplinarity afforded instrumentalism--solving particular problems, focusing on *particular* agendas. In other words, undoing barriers was about a methodological and conceptual pidgin to facilitate cross-disciplinary productivity, and create shared values and agendas.

One way to read this is that a shift toward the latter--a collective and shared ethos important for commercialization--became a working ethos at the university. This reading allows one to see translational science and medicine as being about designing an ethos to enable commercialization, producing operational systems to create cleaner pathways and reduced barriers to collaboration, and creating technical strategies to generate greater operational efficiencies—all toward the goal of "efficient commercialization of their intellectual property" (FitzGerald 2005, 817). Recounting this short institutional trajectory of translational science connects to thinking about the role of externalization as a means by which the university is brought into commercial partnership with biopharmaceutical companies and allows a renewed understanding of the relationship between TN, translational medicine, and health.

My contention is that the turn to the university -- i.e., the focus on the university as a key enactor of translational and translation-focused neuroscience and as the space *charged* with neuroscience innovation should not be taken simply as a move toward better neuroscience or by extension better health. Rather, this institutional emergence is notably about enunciating a new role for the research university amidst a particular

moment in healthcare corporatization and the effects of the fallout from the financial risks of overleveraging the financial and medical promises of psychopharmaceuticals.

Thus, we can think about externalization as a means by which: a) university-based TN provides financial opportunity for private firms through offloading risk during a moment of crisis for the sector, b) academic medical centers can commercialize their underleveraged assets in the form of intellectual property, c) corporate firms can access a specialized route to the privatization of public resources, and d) thus, TN becomes a solution to the biotechnology market problems—including exhausting revenues via Big Pharma marketing and the dearth of pharmaceutical innovation.

Yes, the "entrepreneurial university" is indeed at work (Clark 2005; Etzkowitz et al. 2000; Slaughter and Rhoades 2004). Scholars have analyzed and documented many ways in which universities became implicated in rationalization and bureaucracy (Apple 2005; Krimsky 2004; Shore and Wright 1999; Strathern 2000); turned toward the market (Berman 2012; Bok 2003; Buchbinder 1993; Hong and Walsh 2009; Olssen and Peters 2005; Orr 1997; Shumar 1997), underwent corporatization (Etzkowitz et al. 2000; Readings 1997 Schreker 2010) and privatization (J. Brown 2000; Lave, Mirowski, and Randalls, 2010); and bifurcated into university-industry segments of large-scale research firms (Etzkowitz 2003; Lam 2010; Lowen 1997). The trajectory that rendered the university a key player in economic development and regional and global innovation is long and complex (Apple 2005; Berman 2012; Mowery et al. 2004) and university transformational scholarship long-standing (Brett 1945; Veblen 1918). However, recent work tends to narrate the relationship between life sciences and capitalism as being

predominantly about capitalism's logics at work in both. That view is, at best, incomplete.

One cannot appropriately contextualize the rise of translational science and medicine at the university without also pointing to larger trajectories of which the university is part: the move to push university-based scientific discoveries toward commercialization has been inextricably linked to an entrepreneurial or startup culture at the university (Clark 2005; Etzkowitz 2003; Rajan 2012); the demands placed on knowledge workers in capitalist societies (Shapin 2008); and the transformation of the modern university. Accordingly, much of the scholarship focused on university transformation has brought into view the ineluctable role of neoliberalism (Cooper 2008; Lave, Mirowski, and Randalls 2010; Olssen and Peters 2005; Shore and Wright 1999; Strathern 2000). The commodification of university activity, the privatization push at the university with respect to licensing and patenting intellectual property, and the defunding of public universities all speak to the logics of neoliberalism at work.

Yet scholars have suggested that science and technology scholars have not adequately addressed or theorized "the deeper changes in scientific practice, management, and content as neoliberal concepts have been used to justify major innovations in the structure and organization of science" (Lave, Mirowski, and Randalls 2010, 644). In this sense, the translational shift in university neuroscience must be seen as evidence of a much larger change in the organization and systematization of *knowledge in general* under neoliberalism ideology.[58]

58. The particular relevance of neoliberalism in thinking about TN is in the way it fits with the rhetoric of defunding the public university, in this case seen as the reallocation of federal funding to market-oriented research and not basic science; and perhaps the general defunding trends regarding the

More recently, explicit considerations of the interplay between the life sciences and capitalism also delved into how universities have played a central role in the commercial trajectories of the life sciences (Berman 2012; Cooper 2008; Haraway 1997; Herder 2013; Kleinman 2003; Mirowski 2011). In recent work recounting the trajectory of biotechnology commercialization at Stanford, Rajan suggested that the university has been implicated in the "changing nature and locus of 'commercialization'…with the university becoming a more explicit- and institutionally-regulated stakeholder in the entire process" (2012, 4). Thus, few would argue against the contention that economic logics have animated both the life sciences and the university in a "neoliberal direction" (Cooper 2008) or that increasing university privatization toward the market has affected university practices and revised their central aims.

However, with respect to the life sciences, the neoliberal shift at the university is only part of the overall picture. Rather than a broad-based theorization of capitalism's transformation or triumphalist narratives that see TN as merely a manifestation of neuroscience's advancement, there is space for viewing translational science and TN functions in relation to specific financial realities that affected the biotechnology sector during 2006-2010. During those years, very specific financial situations occurred in the global economy--situations that presented particular consequences for pharmaceutical and life science innovation. In this sense, there is an opportunity to see the political-economic formulations that resulted from the chaos and degeneration of psychopharmaceutical promises. Beyond a "totalizing" theorization (Kingfisher and

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public university (Mirowski 2011) and federal research dollars. Neoliberalism is especially germane in its forwarding of privatization interests. Thus, as TN creates new opportunities for public-private partnerships, it is consistent with this element of neoliberal ideologies and represents a good case study for the scientific manifestation of neoliberalism's ideology. However, there is much more to TN than its neoliberal legibility.

Maskovsky 2008) of TN as merely one more manifestation of neoliberalism, it is important to retain a view of TN operating in the context of a moment of knowledge *failure as such* (Miyazaki and Riles 2005--in this case, the massive problems and crises drug development and brain-based biotechnology sectors faced.

In other words, the translational ethos was not simply neoliberalism at the university. Rather, it was a transfer of the risks of early-stage neuroscience innovation and investment from the private to the public sector, as well as the biotechnology sector's articulation of innovation strategies produced in anticipation of impending financial losses produced via speculative pharmaceutical markets.[59] Clearly, TN and translational medicine in these ways operate as a financial strategy. Together, the observations about what externalization did and how it functioned leads to the argument that rather than being a form of capitalism, an argument that is in line with current theorization, TN is, more precisely, actually a form of finance.

59. In this sense, perhaps neoliberalism at the university had been appropriated in the interests of other social and technological dramas (Pfaffenberger 1992).

Chapter 5 / The Laboratory

The last chapter suggested that the narrative of TN as an inevitable evolution in neuroscience's innovation achieved an obfuscation. Like many of neoliberalism's revisions, its historiography hides the story of a system falling apart. Yet, a large number of recent life-science theorizations tend to treat the manifestations of neoliberalism in ways that presume that they were wholly successful. Grand theorizations about the emergences and evolution of capitalism within the life sciences may inadvertently have expunged capitalism from its failures and treated it merely as a genesis. Contemporary studies of the formations and malformations of neoliberalism must also include a thanatological imperative that does not miss the limits, messes, and debunking of economic theories and their formations (Miyazaki and Riles 2005), or the inability of neoliberalism to apprehend people (Biehl and Locke 2010; Kingfischer and Maskovsky 2008).

The rehabilitative needs of financialization played a key role in the emergence of TN at universities and represented the amalgamation of a new form of neuroscience innovation created through the consequences of overleveraged psychopharmacology markets. It was not only a transfer of research portfolios and corporate research and development logics, but also a transfer of risk and subsequent obligations—now accorded to the university—of de-risking. In other words, the falling down of CNS created a particular de-risking function for this form of university neuroscience research: health care corporatization and life-sciences financialization were directly involved in systemically restructuring neuroscience at the translational university.

Because of healthcare corporatization via pharmaceuticalization and the subsequent "outsourcing" of neuroscience innovation work to universities, TN's emergence represented a major reformulation of university work and practices authored by the death of a larger economic-scientific system. What are the epistemological implications of the translational shift and how is this change achieved? Given the close relationship between the context of healthcare financialization and its role in TN's rise at the university, what are the means, avenues, and systems through which financialization affects university knowledge processes? Chapter 5 begins from the implications and reordering outlined in Chapters 3 and 4. My goal was to learn the kinds and forms of epistemological contortion enabled by translational science and medicine.

Yet, while Chapters 3 and 4 work to elucidate a primary point about the role of TN within a specific history of healthcare corporatization and in its financial functionality, I also want to show that TN is about much more than this. As I learned from my early discussions with Zack Lynch, the prominent "Big Man" of neurotechnology whom I introduced at the outset, TN and translation in general occupy a space of envisioning. For Zack, TN was the key to a gilded future and a means for improving the human condition. In fact, I hope to show that market envisioning is just one of multiple fantasies that translational enables. Thus, in the sections that follow, I aim to articulate not only the ways that epistemological goals get enacted in the scientific laboratory, but also the material and discursive life of translational imaginaries as they pertain to moral envisioning and the articulation of fantasies.

Open Questions about Epistemologies and Environments: The Importance of Design

Despite the growing relevance of this issue on the social study of science, there is a dearth of scholarship especially in science and technology studies about the specific mechanics and particularities of scientific practices and knowledge systems affected by neoliberalism and pressured towards commodification (Lave, Mirowski, and Randalls 2010; Sismondo 2009). Research in this area tends to be simply assumptive of the import of market logics into university scientific work and organization. As universities were uniquely implicated in translational science and medicine (Fang and Casadevall 2010; Garcia-Rill 2012), the particular impacts of neoliberalism upon science still represented a fruitful area for investigation--especially with the increasing relevance of and expectations for commercialization of university scientific work (Etzkowitz 2003; Krimsky 2004; Herder 2013; Lam 2010). How might this move toward translation create (or already have created) new kinds of scientist-subjects (Herder 2013) and (re)contour perspectives with respect to the university's mission? These questions go to the very heart of classical models of science, scientists, and scientific practices at the university (Haraway 1997; Mirowsky 2011).

Translational science and research as well as the increasing corporatization of universities rightly necessitate a scholarly focus on the "epistemologies and practices of the life sciences themselves" (Rajan and Leonelli 2013, 464) as they were increasingly impacted under regimes of financialization and caught in the throes of neoliberalism. Melinda Cooper's (2008) work on the complex interplay of the life sciences and

neoliberalism attempted to get at the ways that liberal economics co-evolved with life-sciences epistemologies in ways that suggest inextricable entanglement or "entrenchment" (Rajan and Leonelli 2013, 468). Often constructed upon readings of Marx, this more recent research on capitalism, neoliberalism, and the life sciences tends to follow the theoretical impetus of biopolitics (Helmreich 2008). Scholarship that follows the category of life as the object of capitalistic intervention and function thus emerged.

However, this theorizing sidelines specificities and leaves transformations without people, context, or place. Scholars missed, for example, the subterranean swelling of risk that leaked onto the people, institutions, and publics from creating the humanitarian device exemption. The multiple ways that global publics were already prefigured in large-scale, innovation-lifecycle transformations became obfuscated in theorizations that began from agnostic positing of the relationship between the life sciences and capitalism as marked by co-evolving structures. Thus, while there has been a litany of critiques about the problems produced by increasing commercialization of research, the usual proposed solution of creating more public, “nonprofit” science is not without additional complications.

The point here is that recent social theory that attempted to map the colocation of financial logics within the new epistemologies of the life sciences performed a critical simplification. AstraZeneca's decisions to create, plan, and design virtual innovation spaces structured primarily around academic partners or University of California San Francisco's decision to help design and construct a new physical neighborhood into which pharmaceutical companies could relocate their research and discovery arms were

not merely products of life sciences institutionalization, co-evolving financial and scientific structures, or sheer epistemic transformation. They spoke of something else.

Clearly, the translational shift and life sciences financialization were poised to affect epistemologies (Cooper 2008; Ecks 2008; Rajan and Leonelli 2013). Rajan's notion of biocapital necessarily included the "regime of knowledge" as it evolved into "foundational epistemologies" (2006, 21). However, there is a real need to map exactly how these new formulations created epistemologies; in particular, how these formulations actually achieved these effects in ways that were durable and yet not totalizing. In particular, there is a need to understand the way subjects became implicated, though not entirely determined, in these very formulations. Although potentially bereft of grandeur, there is an analytical opportunity that arises from mapping the emergence and formulation of TN through a view toward objects, environments, and their embedded logics (Latour 1991).

Thinking about the ways that knowledge goals could be enacted toward considerations of environmental designs not only encompasses the role of environments for social and epistemological (re)arrangements, but also raises the question of how environmental designs rendered such new arrangements *durable*. Thus, while it is clear that market concerns were fully present in scientific and academic knowledge practices (Kleinman 2003; Krimsky 2004; Slaughter and Rhoades 2004), the questions that emerged included: How do these systems function? How is durability achieved? How might design offer a useful approach to understanding the complex interplay of structure and agency at work in the performances of environments that never entirely overdetermine those within it? Which stakeholders are implicated in these designs and

how? The section below offers several arguments about the importance of material and design-focused considerations in understanding the institutionalization of TN and translational science and medicine and considers the ethical impulses at work in the task of designing.

Liquefaction: A Short History of Mission Bay

My 2010 fieldwork consisted of observing in a northern California university laboratory, as well as intense involvement with the larger neurotechnology industry community. In addition, I became part of San Francisco's biotechnology startup and entrepreneurial communities located in the newly developed neighborhood of Mission Bay (Timmerman 2010), which was home of the new the biomedical research campus of the University of California, San Francisco (UCSF). The UCSF was a highly ranked medical center and teaching hospital known for its entrepreneurial ethos, research productivity, and proximity to Silicon Valley.

A long neglected industrial neighborhood in San Francisco, Mission Bay was located in the eastern portion of the city. The area's adjacency to the San Francisco Bay meant that historically it had been an important space for industrial and commercial work. In the mid- to late-nineteenth century (Figure 24), Mission Bay was home to shipping companies that used the bay as a dumping site and slaughter-houses that would send blood and guts from slaughtered animals directly into Mission Creek to float out into the bay (Conor 2007).

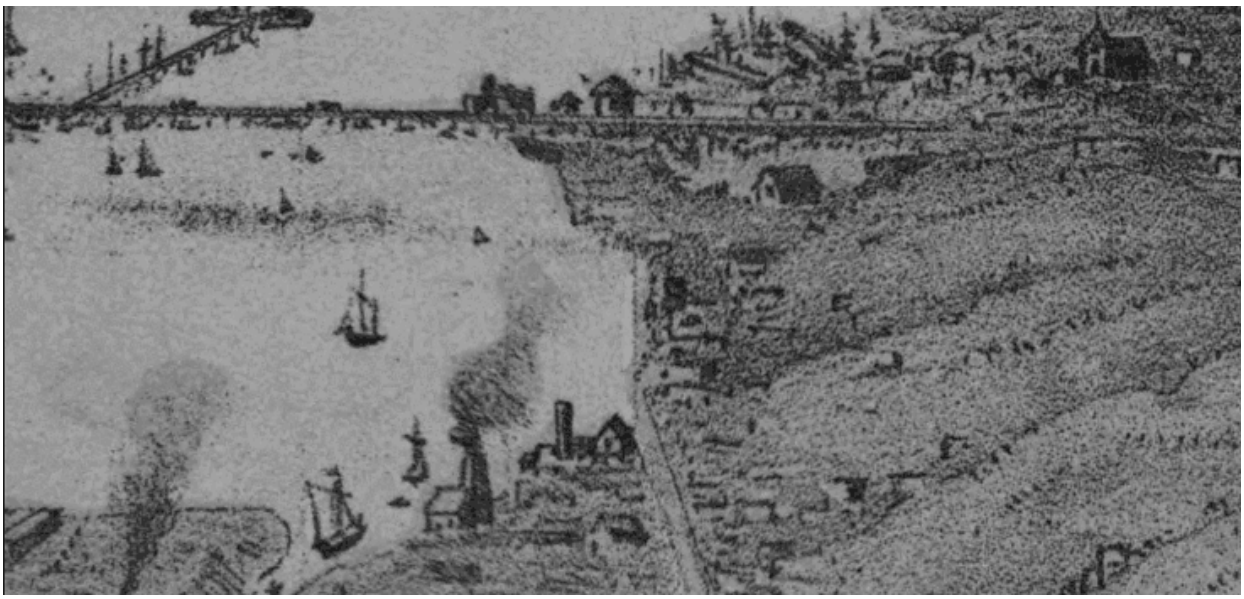

Figure 24. Rendering of Mission Bay and the former Mission Creek in the 1870s (@Library of Congress).

In 2000, the city embarked on a massive cleanup effort to remedy the area's toxic soil after years of industrial pollution. After San Francisco designated the area as a redevelopment zone in 1998, Mission Bay morphed into a new, strange geography that seemed suddenly to emerge from the ground (Allday 2013). By 2003, UCSF built a 34-acre campus in the zone. In 2004, two life-science companies moved to the area. By 2012, over fifty-four life-science companies alongside a smattering of other research institutes, companies, and venture capital firms (Ross 2013) called Mission Bay home (Figure 25). Once home to railroads, warehouses, dilapidated buildings, festering shipping yards, and small communities for those industries' workers, the Mission Bay neighborhood looks and is quite different today.



Figure 25. Mission Bay in 2009. ***Photo: Chris Carlsson*** **. Attribution-Noncommercial-Share Alike 3.0.** ***Courtesy of FoundSF.***

Mission Bay is topographically and geographically unique. Compared to San Francisco's steep hills, tall trees, and Victorian buildings, Mission Bay's eerily flat terrain and contemporary architecture seem removed and peculiar, producing the feeling of an entirely imported neighborhood. The strangeness is ubiquitous. Walking around Mission Bay, construction is everywhere. Entire landscapes and city blocks emerge quickly. Fully mature trees are brought in from elsewhere. Although different, the erected buildings feel aesthetically and textually similar: glassy, contemporary, and thematic. Even in their faux difference, or what has been called "demassified difference" (Nye 2007, 610), the architectural similarity is more prominent than any aesthetic novelty.

The UCSF was a major stakeholder in Mission Bay's massive development. Located prominently in the center of the new campus is its centerpiece Genentech Hall (Figure 26), named after the Bay Area biotechnology company started at UCSF. The sprawling new campus includes new laboratories, academic buildings, dormitories, and

plans for a new hospital in 2015. Suddenly, the neighborhood spawned new conference centers, hotels, and corporate office parks. Mission Bay also represented the verdant and shimmering youth extolled in narratives of northern California innovation. Lured by a flurry of controversial tax incentives,[60] starting in 2011 several biotechnology companies relocated to San Francisco from other states; some at the suggestion of largely California-based venture capital firms that wanted to be close to their portfolio of companies.



Figure 26. SF Gate: Genentech Hall. Photo: Michael Macor, The Chronicle.

In 2011, the German pharmaceutical and chemical company Bayer moved its research and development hub to Mission Bay, creating a 10-year agreement to produce an industry-university partnership with UCSF. Adjacent to its and UCSF's research and development facilities, Bayer created a facility program called "the CoLaborator," an aptly named shared workspace for healthcare-oriented entrepreneurial startups. One of several healthcare and pharmaceutical companies opening up collaborative innovation

60."Biotechnology Payroll Tax Exclusion" (n.d.) Accessed on April 3, 2014, http://oewd.org/Biotechnology-Payroll-Tax-Exclusion.aspx

spaces in Mission Bay (Ross 2013), Bayer's CoLaborator was part of an innovation strategy focused on exploiting partnerships. Local startups could also participate in a suite of services offered by Bayer and nearby UCSF. Indubitably, Bayer's narrative positioned these new models under the aegis of forging innovations in health:

> *At Bayer, we believe collaboration is an essential way to bring new therapies to the patient. This philosophy led us to open the CoLaborator, a unique incubator space for start-up companies next door to our U.S. Innovation Center in the Mission Bay neighborhood of San Francisco, CA. Located in the heart of the city's thriving life sciences cluster, the CoLaborator is within walking distance of UCSF, QB3, the Gladstone Institutes, several venture capital groups, and more than 60 emerging life science companies, making the Mission Bay location well-suited to support the success of a start-up company. The CoLaborator's design is a flexible, open floor plan with 6,000 square feet of shared, rented lab space designed to house startup life science companies whose technology platforms, drug targets, or drug candidates may align with Bayer's interests. The environment fosters opportunities for idea exchange by bringing researchers together in a common space. The CoLaborator includes basic equipment for life science startups to quickly begin putting their ideas to the test. Bayer support includes Environmental Health & Safety and Biosafety licenses, and access to nearby UCSF core services such as imaging, bioinformatics, and proteomics. Partnering with Bayer can also provide access to the global expertise and equipment of Bayer's research network.*[61]

Thus, Bayer's description illustrates that, as part of UCSF's development, Mission Bay became a regional and national hub for life-sciences innovation; the neighborhood is now home to a peculiar mix from academia, young startups, and venture capital. This very mix was understood to be necessary to foster innovation (Horvath 2004); in particular, innovation in health under the translational imaginary. Nevertheless, as I wandered around Mission Bay staring at a sea of glass facades, building foundations, and truck beds with fully-grown palm trees awaiting installation, I created a mental map

61. "The CoLaborator, an incubator space for start-ups" Bayer. (n.d.) Accessed on April 3, 2014, http://www.colaborator.bayer.com/en/about-the-colaborator/

of new streets and buildings. One weekend in particular, I wondered about why the neighborhood was so flat.

Late one afternoon, I noticed a man pushing a cart full of found objects and cans off 16th Street where Mission Bay meets the Potrero Hill neighborhood. I asked the man, "Why is that area over there so flat?" Behind us to the east, Potrero Hill's hilly terrain protruded into the evening sky. Gesturing east towards the flurry of new buildings, the man responded, "It's all built on sand." He smiled and shrugged his shoulders. I learned that much of the neighborhood of Mission Bay was "filled in" with sand to enable building into areas that had once been part of the bay. The part of Mission Bay where the UCSF campus was built lies directly atop of this new ground. According to one engineer, "It's like building on a bed of Jell-O" (Ginsberg 2008).

In-filled areas are not rare in the United States. However, for San Francisco the problem is earthquakes. In areas composed of landfill, earthquakes cause the land to undergo what geologists called "liquefaction." In fact, UCSF's Mission Bay campus--a throng of new high-rise residential towers--and many of the biotechnology companies' buildings are located in a designated "liquefaction hazard zone" (Zeng, Hiltunen, and Manzari 2008, 4).[62] I began to think about the irony of building this new physical environment, an impromptu global center for innovation, itself an ecosystem of sorts atop a bedrock of risk, not only financial but environmental as well.

Proximity + Intimacy = Epistemology

62. In addition to liquefaction, the history of industrial contamination at Mission Bay (now rendered nearly invisible because of the area's rapid transformation) left toxins in the soil. Built near former rail yards, toxicity levels were sufficient to spur a petition to move a UCSF day care center away from Mission Bay.

In order to map the institutionalization of translational science at the university, I needed to understand how translational science was being "done" at the university--to sit with administrators helping to realize the translational visions outlined by the NIH and trace their effects inside the laboratory itself. In my initial formulation, I thought that to quantify translation shift manifestations in the laboratory I would need to spend most of my time inside the laboratory itself. However, spending time at the university taught me just how much of the translation work was about the larger environments of which the laboratory was part. Rather than thinking of the laboratory as undergoing change, I now consider how the laboratory was brought into an emerging configuration: a larger system through which the work of translation occurred. The upcoming sections are devoted to this issue: the means through which the university was implicated in a changing system; a change discernible through attention to changing networks, systems, articulations, formations, and technologies that enabled institutionalizing university-industry partnerships and the shift in university research toward translational aims. Through this lens, I became interested in the material ways these proximities affected epistemologies.

The San Francisco Bay Area offered an opportunity to explore TN animations because the area was a major hub for neurotechnology investment (BusinessWire 2009). In September 2010, in conversation with an administrator at the UCSF Clinical and Translational Science Institute I raised an question about the center's location: I just could not figure it out. I had located the institute's website and searched several digital maps for information about its location. However, I could not find an actual building that housed the center on the UCSF campus. It was almost as if the institute were invisible—a fiction.

I learned that an office building on the far northeast side of Mission Bay, housed the center at some remove from the UCSF's other campus buildings. The sign for the institute pointed toward a modern urban office complex called China Basin. China Basin was the complex that the drug company Pfizer had initially considered as a place to house its new Center for Therapeutic Innovation focused on creating new biotechnologies, but Pfizer had backed out of the deal. Pfizer had entered into a strategic partnership with UCSF. In 2013, UCSF provided a press release about this collaboration:

> *The collaboration builds upon an October 2010 agreement between CTI [Pfizer's Center for Therapeutic Innovation] and UCSF in large-molecule–also called biologics–discovery, with both agreements aiming to accelerate the translation of biomedical research into new medications and therapies. According to the terms of this new collaboration, CTI will provide UCSF with funding and scientific expertise. ...If drug candidates achieve agreed-upon objectives, the partnership between CTI and UCSF could move from discovery into clinical trials, leading to potential milestone payments and royalties in the event a product is commercialized*. (Bole 2011)

Pfizer eventually settled on a location *closer* to the UCSF campus. Proximity was part of a larger strategy through which the university, via translational initiatives and transformations, was becoming the biopharmaceutical companies' research arm. "Proximity" does not refer only to physical proximity but maps a panoply of intimacies achieved through the creation of connections; agreements, joint ventures, technologies, as well as physical relocations. In the articulation above, one sees quite literally the means, terms, contingencies, timelines, and structures (financial and legal) that underlie and enabled this proximity.

This chapter discusses the mechanics of handing off to universities biopharmaceutical projects and research agendas, and how these transfers functioned as

part of a larger corporate strategy. Thus, it is important to understand that this relationship was not merely an extension of Pfizer's existing research infrastructure. Rather, it represented Pfizer's hand-off to university partners research portfolios that had been internal, and its implications. By 2011, Pfizer had reduced its research and development infrastructure by 35% (Jarvis 2012), laying off employees and shutting down laboratories and manufacturing centers. In 2012, Pfizer opened up what its Centers for Therapeutic Innovation (CTI), starting in San Francisco, then Boston, San Diego, and New York City (Said 2011). Pfizer's was part of a cascade of layoffs among a host of pharmaceutical companies (Reisch 2011).

One common factor for many pharmaceutical company layoffs between 2010 and 2013 was that the reductions occurred, in the words of a Novartis vice president of research and development spoken during an investor phone call, "most heavily on scientists in early discovery" (Reisch 2011). For Pfizer, university partnerships represented both an internal strategy and a means of dealing with its own risk. Thus, proximity became part of a bifurcation process whereby university translational research programs hosted initial phase research that corporations found too burdensome or risky. Partner university laboratories were suddenly populated with new and specific projects, agendas, corporate interlocutors, and funding sources.

A clearer example of biopharmaceutical companies handing off their own early-stage research to university laboratories is the NIH initiative "Discovering New Therapeutic Uses for Existing Molecules," referred to earlier. In this little-known program piloted in 2012, the NIH brokered relationships between pharmaceutical

companies and academic researchers, whereby each university took over a commercially failed research program on a single molecular compound.

It is important to note that in each case, the pharmaceutical company ceased their research and (pouring resources into an alternative) passed on the project and its imperatives, presumptions, and risks to the research university domain. It is in this transitivity and corporate rearrangement of research transfer from pharmaceutical to university laboratories that we see the morphing of university translational laboratories into de facto biopharmaceutical company laboratories.

This leads to questions of the unseen risks to the public in the transfers, transformations, and rearrangements that occurred by enacting novel public-private partnerships touted as necessary solutions in forging innovation (Horvath 2004). Handing off to the university early-stage research also creates questions about the implications and costs to the university for taking on projects that tend to have a 95% failure rate (National Center for Advancing Translation Sciences 2013). Since pharmaceutical companies such as Pfizer and Novartis were able originally to ingest these costs through reaping billions of dollars in profit, what does it mean if these costs are externalized onto universities that lack the same profit component? Lastly, what does objectivity mean in the context in which a pharmaceutical company has outlined research objectives for a partnering academic laboratory and also (as in the case of Pfizer's CTI programs) funds laboratory researchers and PhD students?

Additionally, the NIH's brokering of relationships between pharmaceutical companies and U.S. universities brings into view questions about how translational science works in geospatial rearrangements. It was in the creation of national and

international partnerships between university research and pharmaceutical scientists where one could see the importance of proximities: the creation of environments. Thus, it was no surprise that Pfizer's CTI also relied on incorporating universities and creating proximity. Since the creation of its program, Pfizer has placed each CTI very close or even adjacent to a prominent research university. This adjacency is no accident. In a journal article focused on CTIs, one sees the key ingredients of the collaboration between Pfizer scientists—brought in specifically to work in these new CTIs—and academic scientists of the adjacent university:

> *Pfizer and academic scientists appear to work side by side on a weekly, if not daily, basis, trading reagents, sharing equipment, and exchanging data and knowledge. "What's so cool is they have badge access here," Martinez says of his academic collaborators. "That proximity really fosters a quick exchange and ease of interaction." The same is true at Pfizer's other CTI sites. "The CTI guys have UCSF IDs, and the UCSF guys have Pfizer IDs," Coyle says. The access reinforces the notion "that this is a joint project team and we're doing it together."* (Bole 2011)

The symbolism of the keycard access is telling. Indeed, the imagery of openness, sharing, and togetherness are hallmarks in the oft-romantic language of innovation. However, in this snippet one sees in explicit terms the enactment of a model of an externalization strategy coupled with a risk strategy that enabled Pfizer to discharge the risks of managing its own internal innovation strategy, but did not preclude Pfizer from exercising options over exclusive rights to the commercialization of anything useful that might emerge from the research of its new partner lab.

Nevertheless, the more compelling part of these articulations of partnerships is in how they reveal ways in which a partnership might necessarily structure the kinds of questions asked and the objectives created within the UCSF laboratory. The questions themselves become the domain of the translational imperative. Thus, Pfizer's proximity

is also intellectual--here, proximity nearly becomes epistemology. Quite clearly, this extrapolation of a corporate-style research and development process at UCSF has implications for the kinds of scientific practices considered useful. The very notion of "agreed-upon objectives" on the part of UCSF and Pfizer suggests not simply imbrications, but articulation of singular objectives.

Another seemingly minor but crucial rearrangement evolved between pharmaceutical companies and their university partners: As part of its design, the NIH's Discovering New Therapeutic Uses for Existing Molecules program created a tool to speed up the legal and intellectual property process between universities and pharmaceutical companies using so-called template agreements (National Center for Advancing Translational Science 2013). According to Christopher P. Austin, MD, NCATS director, these template agreements "streamline the process by limiting the amount of negotiation required before a project can begin." This streamlining process achieved through the template agreement also points to the potential diminishment of negotiation over risk as an additional strategy within the translational shift risk transfer.[63]

The creation of template agreements (exemplified in the very notion of a ready-made template) constituted a system of reproduction through which complex legal barriers were surmounted more systematically, and in which *ways of thinking* or *not thinking* about collaboration became automated. In this sense, translational science's institutionalizations are especially epistemic. From this point I began to think about TN in relation to the creation of environments that produce specific kinds of epistemic effects.

[63]. The terms of the agreements were something that I wanted to explore further; however, no stakeholder or entity was willing to share these agreements and even talk about them.

In other words, a *template agreement* is a crucial structure or system that produces and reproduces; it eases *negotiation* and *thinking* about new partnerships. That Pfizer's placed CTIs adjacent to universities while closing its own research laboratories manifests the creation of public-private environments designed for specific knowledge purposes. Another important example of an environment that produced epistemic effects was the decision to have "agreed upon objectives." Such objectives created durable epistemic effects in the everyday interactions between Pfizer and UCSF stakeholders. Templates and objectives speak to epistemic systematicity supported by material/environmental conditions. Lastly, I point to the development of Mission Bay (Figure 27) as perhaps the clearest example of an engineered environment: a grand, impromptu micro-world, not merely a new hybrid environment in which pharmaceutical companies and university labs are placed side by side, but also a knowledge ecology that, importantly, is *rendered more stable* via its new geographic arrangements and proximities.

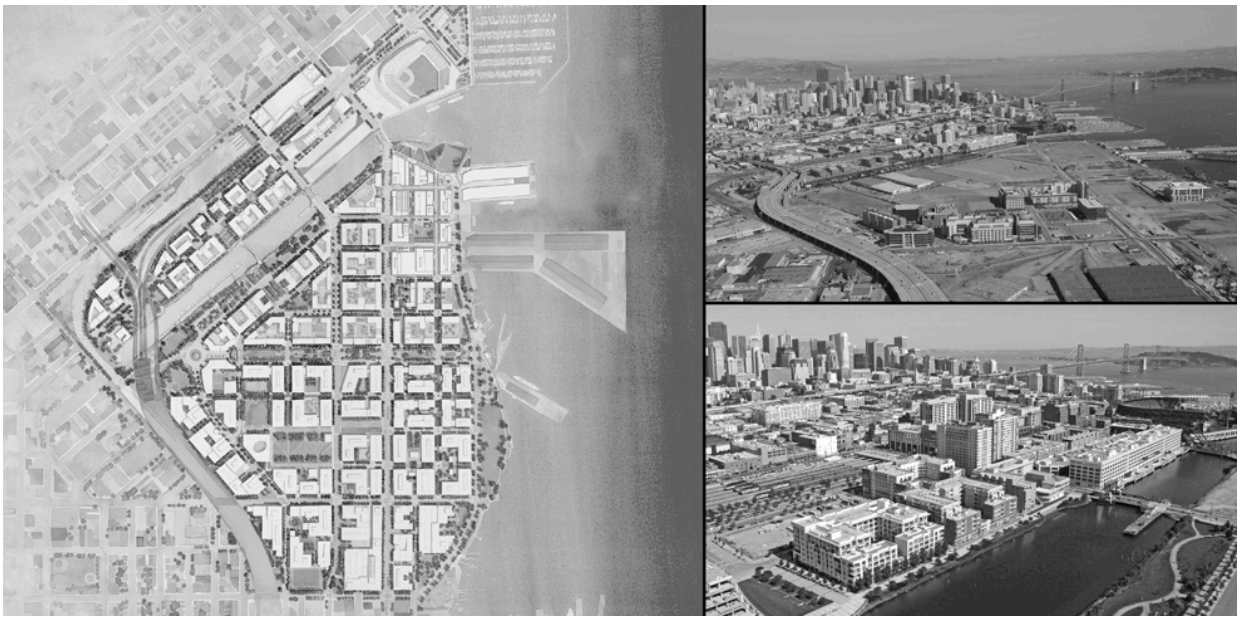

Figure 27. Left: San Francisco's new Mission Bay neighborhood. Right: Mission Bay's rapid and dramatic geographic transformation.

I suggest that the new partnership between UCSF and Pfizer's CTI was not only about creating "commercialized products," but was also about creating *conditions* in which such commercialization becomes easier, efficient, and prolific. Theorizing this process of epistemic (re)production reveals the means through which the life sciences today actually enact logics borne from financialization. However, in thinking about how translational science and research produced and relied on creating systems and environments designed for enduring epistemic effects, I also became interested in the design of these environments via translational science. How might I learn more about how these environments are being produced?

The Search for Invisible Centers: Technologies of Collaboration and Facilitation

Inside the China Basin complex, a four-story complex of offices on the bank of a small river on the northern edge of Mission Bay, I located the administrative offices of UCSF's Clinical and Translational Science Institute. Several floors up and far down a lonely hallway, the institute was surrounded by startups and other offices. Its location felt peripheral. Upon walking into the Clinical and Translational Science Institute (CTSI)[64], I noticed the space felt more like a minor waiting room than a collaboration or even a startup incubation space. There were few wide-open sites for active collaboration; instead, on one side of the office were a bank of administrative offices for the institute staff.

Placed prominently in the middle of the office was a large conference room enclosed in glass. The expensive, high-tech chairs, large monitor, and sophisticated

[64] UCSF's CTSI is not to be confused with Pfizer's CTI that I mention earlier

conferencing system visually dominated the room. The space itself created more questions about the center and its constitution. Perhaps presciently, my initial observation suggested to me that it was a meeting place for late-stage deal-making rather than the open collaboration space that I had imagined. The institute director welcomed me, shook my hand, and led me into the conference room where she provided me with her card. Interviewing UCSF Clinical and Translational Science Institute (CTSI) director Maninder (Mini) Kahlon, Ph.D., I asked about the overall structure and role of the CTSI. Kahlon's style was direct: "We're going to work with industry to find out what they need--and its connected to industry's need and Pharma has found itself in a crisis right now and the pipeline has dried [up] and they are even more eager to create partnerships."

Kahlon revealed CTSI's proactive approach toward partnership. This proactive mode was a significant contrast to narratives in which translational science centers were simply waiting for industry to approach, or merely working on discovery-oriented neuroscience research. In this sense, the quality of autonomy or pure creativity associated with the concept of discovery felt like an inept descriptor of the process Kahlon described. In other words, the language of corporate "need" betrayed narratives of unbridled innovation and vocation attached to the translational science enterprise; this symbiosis provided university laboratories a particular orientation toward corporate functionality. Too, universities actively sought out these partnerships.

Kahlon's responses are quick and terse. Given its location in northern California, "ground zero" for biotechnology startups, UCSF had a prolific history in terms of its partnering activities. Like its contemporary, Stanford University (Lowen 1997), UCSF had both a long history and an open stance that aggressively embraced the free market,

encouraged faculty entrepreneurship, and did not shy away from explicit industry-embeddedness. The new campus's physical location among a flurry of biotechnology and venture capital firms was more than a metaphor for intimacies with industry.

Yet the growth of public-private partnerships was not simply about creating discrete programmatic and external relations between institutions. As anthropologists and historians have noted, objects were also transformed through connection. In the case of the university, this meant that the reconfiguration and transformations within universities were about systems-making. In this way, there would be no need for UCSF's translation activities to be housed in some expansive physical building. If translation was not only about making facts translatable (technical), but also about mobilizing and creating *systems and environments* to facilitate translatability, then I needed to look at the systems UCSF had created to facilitate translation and translatability: How does CTSI help compel connections and create legibilities?

In searching the UCSF website to find the location of UCSF's translational science institute, I noticed that the website for the institute was central to many of the tasks of a translational center, but there was very little information about the institute itself. Still interested in this issue of CTSI's location, I asked Kahlon, "Where *exactly is* the center? Is this it?" She caught on to my question:

> *If you're thinking the brick-and-mortar, this [where we're now sitting] is it. So the Board [of directors] is here, and the central administration meets here, but then there are other programs, and they have leadership across campus--the physical site. But we emphasize the virtual site because the community is necessarily distributed. We don't want the physical location to be a barrier to facilitating translation, collaboration, and partnering."* (Interview 6, October 8, 2010)

According to Kahlon, to foster greater collaboration among different kinds of scientists, CTSI created a website which, for all intents and purposes, *is the translational center itself*. I asked Kahlon about their process for building the website. She said the website designers wanted to make sure that their site was less a brochure and more an interactive portal. In fact, the website changes in response to the needs of a user. "Especially as we increase partnerships, we need a platform to say what we do. The virtual home had to be presented in the language of the user." An ever-flexible interface that understands the needs of various stakeholders, the system enables key legibility among multiple stakeholders in the translational process. I had not previously thought about the role of digital tools in facilitating translation between a neurobiologist and for example, a CTSI consultant and the scientists who escalate the research of their joint interest.

I also wondered about how these virtual centers and strategies work in relation to the very physical relocations, rearrangements, and proximities manifest in creating the Mission Bay campus. With the shift toward physical proximity among pharmaceutical companies, what does virtualization achieve?. Given all the attention to relocating campuses, the move by pharmaceutical companies to be near UCSF, and using the web to facilitate networking, what is the role of "place?" As I continued to explore the CTSI website, I noticed that the site consisted of functions and capacities one could access and use to complete tasks including networking, finding partners and equipment, and requesting CTSI consultation. I began to think about similarities between CTSI's web-based tools and AstraZeneca's new virtual neuroscience innovation model, iMed.

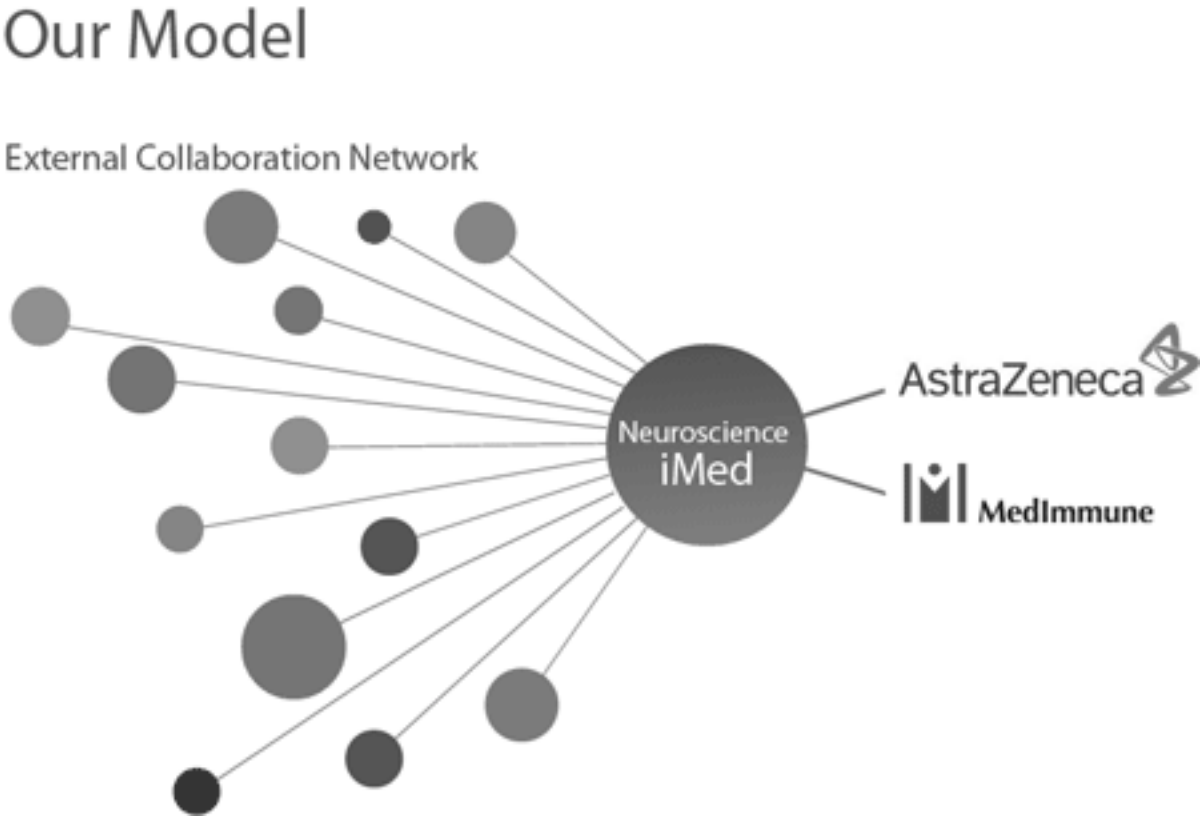

Figure 28. AstraZeneca's model depicting its new externalization-focused neuroscience innovation approach.

In 2011, AstraZeneca decided to take on an entirely external model for its neuroscience innovation program, closing all of its neuroscience-focused laboratories and laying off its own scientists and neuroscience staff. AstraZeneca then announced its entirely partner-based approach (Figure 28): partnering with university academics virtually. Its new iMed program would not only replace its brick-and-mortar laboratories, but also included tools to manage a global network of academic collaborators.

Creating a virtual center to connect global partners also created (in digital parlance) *engines* (internal and external to AstraZeneca) focused on aligning knowledge in ways that made it discoverable and integratable by AstraZeneca. Thus, I began to think of virtualization in terms of its capacity to transcend the barriers of place-based

partnerships (Figure 29). In this form, stakeholders can execute the creation or integration of common goals and objectives for knowledge work. In other words, virtual relationship management and collaboration tools enable a form of knowledge organization that helps manage immaterialities such as aligning objectives and research interests. Virtualizing the partnering, resource gathering, and consultative processes also has an epistemic function: to render knowledge, stakeholders, and resources legible and connectable.



Figure 29. At one of AstraZeneca Neuroscience's two small offices, AstraZeneca stakeholders videoconferenced with partners. (Reprinted with the permission of AstraZeneca)

Kahlon explained that much of the collaborations engineered through CTSI's website were still social and connective, but the web tool streamlined the kinds of tasks that one might do to turn research into *an enterprise*. The tool categorized not only the work and expertise within UCSF, but also of the larger UC system. Kahlon described the website's functions and its likely users:

> *We don't have the data but we imagine that those who use it most are faculty---and academic staff. Junior faculty probably really use it, and they are the ones that need to find resources: entrepreneurial assistants, trainees, residents, and fellows. You can get info without signing in, but if you want to request a consultation service, the CTSI consultation service, then you have to sign in. The consultant is paid*. (Interview 6, October 8, 2010)

Kahlon paused as if she were going to talk about something sensitive. After reaching for the right wording, she continued, "Charging [internal stakeholders] for university services is a cultural change, and they don't expect to have to pay for university services. Translation is new for all of us. They now have to budget for consulting–in case they want to be connected with the right people to do something *with* their research" (Interview 6, October 8, 2010). CTSI's internal consultancy, which charged a fee for providing consulting services to academics about how to scale, monetize, or assess their research is similar to the management consulting model commonly found in the for-profit sector. In fact, the very availability of internal management consultants who provide advisory services for creating a venture clearly speaks of an entrepreneurial strategy at work at CTSI. Yet, Kahlon's nonverbal admission that academics were not accustomed to this model showed just how much the translational shift is clearly toward a model in which academics are being asked to *become* entrepreneurial. In this way, the shift to which Kahlon referred was more than a cultural change. It was also about an evolving scientific subject--one prefigured in environments designed to compel entrepreneurial thinking.

Eager to learn more about ways the CTSI website worked to forge connections, I asked about its development, programming, and impact. Kahlon explained that a primary function of the site is also to foster collaboration within UCSF, across campuses, and also outside of the university. In particular, the goal for the technology is to foster cross-disciplinary collaboration. "You can search for research cores!" she said excitedly.

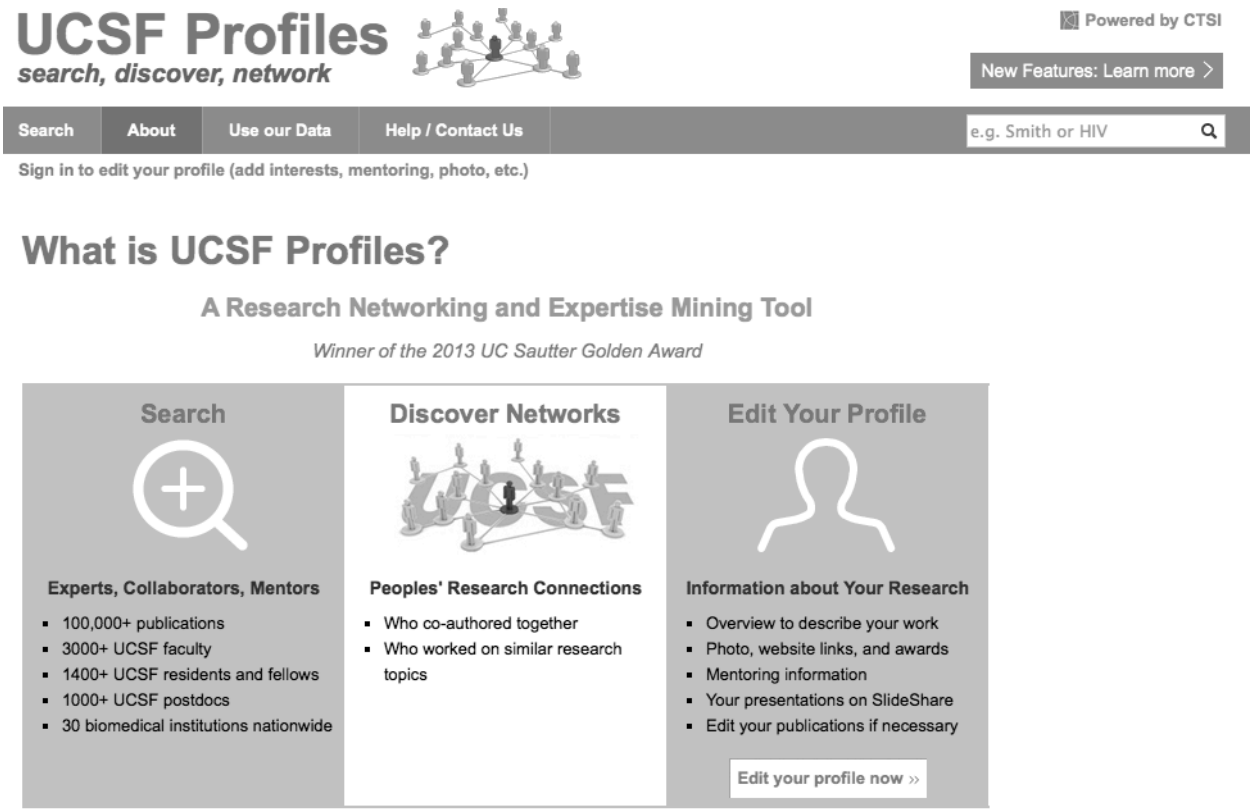

Figure 30. UCSF Profiles, an "Expertise Mining Tool" created by UCSF and funded by NIH's CTSA program. (https://profiles.ucsf.edu/about/AboutUCSFProfiles.aspx)

Research cores are on-the-ground research areas. UCSF had more than 100 cores; most laboratories and researchers were associated with multiple cores. Kahlon said, "A distinct technology that we use in the website is UCSF Profiles. It's a tool and it's the domain of research networking that is emerging." The CTSI website achieves several functions using the profile tool (Figures 30 and 31). In addition to providing personalized resources and information to each user, it also categorizes expertise areas and groups to which university researchers are tied. Thus, the profile tool categorizes scientists' academic work and provides a knowledge database that could be used internally by UCSF or externally by potential collaborators, investigators, or other stakeholders.



Figure 31. UCSF Profiles had both open and closed functions, such as requests for CTSI consultancy. The "finding" functions are open and enable external collaborators to more easily find and proposition UCSF researchers.[65] . Screenshot of CTSI website in April 2014.

The UCSF Profiles tool uses the language of "expertise mining" to explain its functionality in creating collaborations within UCSF and the larger UC system. The mining excavation metaphor, now thoroughly overused in database language, still captures the evolution of digital search. The UCSF Profiles system is also digitally and informationally linked to similar databases at research institutions nationwide. Thus, while editing one's profile enables personalization, it also feeds an even larger system of categorization, management, and organization.

[65] As I explored the system, I noticed how similar the small logo atop the UCSF Profiles site (in Figure 30 and 31, resembling a small human head connected to a host of other heads) was to the network image found at AstraZeneca Neuroscience's iMed website (a rainbow of small circles connected by sharp lines into a network anchored by an AstraZeneca logo) (figure 28).

I was particularly interested in the external functionality of the web-based search tools. A quick look at the Profiles tool reveals that certain website functions are strictly internal and require use authentication. However, many of the search functions are entirely open, inviting internal and external users to mine UCSF's expert knowledge resources. .

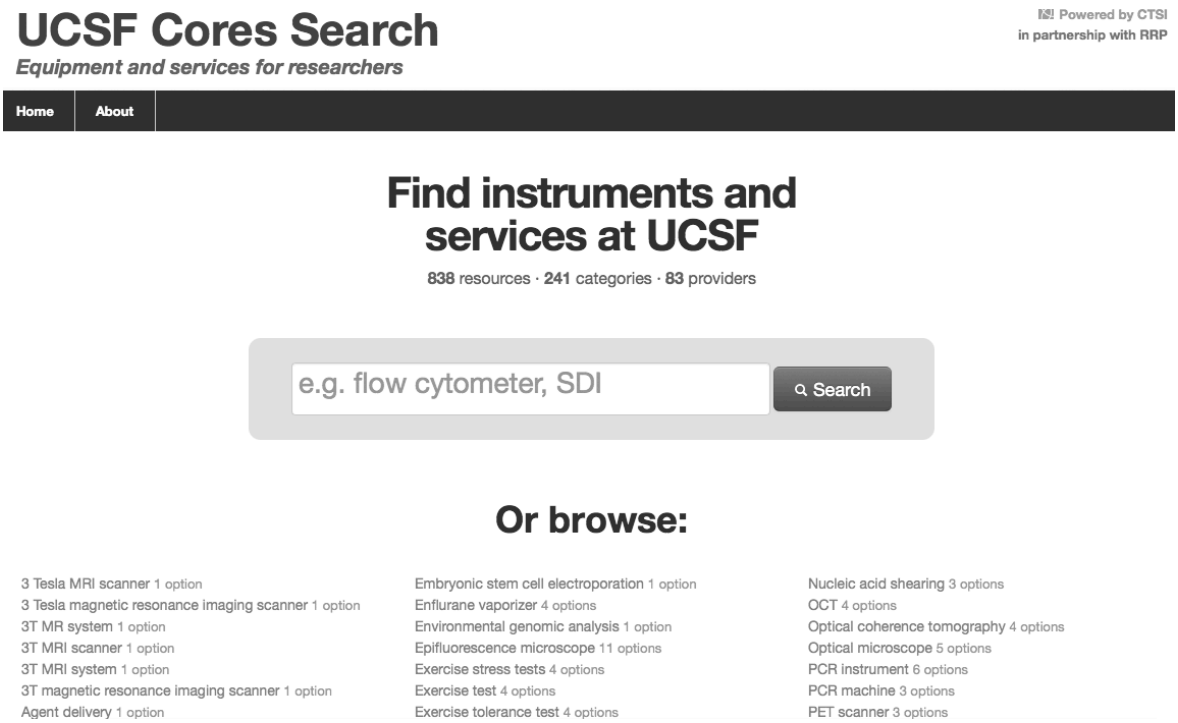

Figure 32. UCSF Cores Search. Screenshot of CTSI website in April 2014.

Kahlon's excitement about research cores was palpable. To understand it, I looked for the website's research cores section. In one area of the site with a cluster of tools presented to the viewer, I saw a small selection of search tools on the right of the screen and eventually arrived at a screen entitled "UCSF Cores Search." Enclosed within a rather simplified graphical user interface, a large entry box enabled the user to create searches. Most interestingly, the tool revealed how "research core" is understood. Listing 838 resources, 241 categories, and 83 providers, it references a marketplace of tools and

capacities, methods and know-how, instruments and experts all in one place: a perfectly streamlined, library of objectification.

Initially, I was drawn to the methodological usefulness of UCSF Cores Search in an analysis of the social construction of science. It provided, if inadvertently, an ingredients list for the objects, expertise, experts, and connections that allow the construction of experimental practices. Thinking with the accoutrement involved in actor-network approaches, this directory could provide a useful material history of scientific practices. That is, in following one user's use of the resource, one might be able to see this tool as a scientific cookbook--as the tool helped facilitate critical experimental and research steps. Beyond its implications for scientific practice, the system of categorizations achieved under CTSI's web tools also enables an opportunity to view a set of scientific morphologies.

Post-Fordist models and programs of scientific work (Gieryn 2008) achieved many deterritorializations: laboratory benches became movable and computer monitors flexible and adjustable, data was shared via "the cloud," and knowledge was mythologized as open and organizable (Barbrook and Cameron 1996). In this vein, the very objects and means of knowledge production must also adhere to the need for academic labor to be conceptualizable in terms of contemporary neoliberal flexibility. I consider the formations and formatting achieved through the CTSI webtools as an extension of this reformulation toward flexibility, extended to even include the scientific subject category. Research has come to be understood as resources and assets, capacities and tools, experts and expertise, connections and connectability.

For scientists who use and reference this library of instruments, know-how, and assets for part of their experimental process, it is a central tool for everyday thinking. Might it inject entrepreneurial considerations in the moment when scientists conceptualize their research--the very contexts where one might use this online tool? It also, therefore, could illustrate the ways that translational science produces real epistemic consequences for the practice and organization of certain kinds of everyday scientific practices – an issue that I hope to explore in future research.

Yet, another crucial epistemic effect was achieved through these web tools. From an external view, the webtool's "mining" capacities resemble a marketplace in which research interests and questions, scientific histories, publications, research domains, funding histories, and identities are indexed and categorized in service to a *particular* set of logics and users. The system is a digital cart for scientific possibility, fully connected to the kinds of infrastructure discussed at the Neurotechnology Industry and Investment Conference. Unlike LinkedIn, UCSF's Profiles allow researchers in the network to do more than connect to each other. It also engineers a key vehicle to organize assets and resources in ways actually designed for external use. Unlike other webtools, the ability to search UCSF's researchers and expertise is intentionally open to the public.

This raises the question of the mechanics of intimacy in virtual worlds. This question was a concern for the anthropologist Tom Boellstorff, whose ethnography of the virtual world *Second Life* (2008) explored digital terrains through which new forms of intimacy could be created: intimacies that were not merely reflective or mimicry of the actual world. Distinct in its materiality, Boellstorf showed how the mechanics of meaning accrete in unique ways in the decontextualizations of digital environments. Of course, the

question remains about whether network systems such as LinkedIn constitute virtual worlds. Nevertheless, UCSF Profiles is more than merely a social network. It also seeks to categorize and organize research areas, expertise, and competencies, and to assess ever-evolving industrial and technological resources. The system's sociality is but one component of its larger function.

I was interested in what kind of relationship building or knowledge gathering practices occurred through UCSF Profiles and how these practices interacted with or sought to enable intimacies. On a hunch, I called Michael Hall, my biotechnology investor interlocutor to ask if he had heard of this online tool. Over coffee in San Francisco's Mission District, he explained that he used UCSF Profiles for several purposes--some of which supplanted older methods of finding information about academic work, of getting "to know" people, and learning about their work in deep ways:

> *I've used their system and its pretty good. It's effective. I have used [it] to try to search for scientists working in the areas that I'm interested in, and I also have contacted researchers directly using the site. It's much easier than having to do all of this networking. It's also better than LinkedIn because I can see exactly what science they are working on. They [scientists using the system] also know that we [venture capitalists] are looking, and so I've seen some scientists start to work more in the directions that we're interested in so that they can be discovered. I like the system. It makes deal flow a lot easier, it also lets me avoid wasting time talking to the wrong people, and it just puts this information at my fingertips. It a breeze for--actually, I really like their tool, too, 'cause it lets me find exactly who I'm looking for even if I didn't know that I was looking for [them]. It's organized by research and by background, so it helps guide me as to who I might want to talk to*.(Interview #30, January 2013)

Two things appear here. Firstly, Hall's use of the tool to learn about potential partners and new research directions shows how CTSI's web-based system helps create and enable knowledge-gathering processes that might otherwise require or rely on

intimacy--the kinds of intimacies at work in the partnering processes that I observed during the Neurotechnology Industry and Partnering conferences. Specifically, the UCSF Profiles tool helps categorize scientists in relation to their existing projects. Such categorization may only become visible after extensive social networking but it works in tandem with the actual interactions of university and industrial partners. It not only possesses part of the self-presentation capacity enabled on professional networking sites such as LinkedIn, but is also a resource developed for partners with the goal of specific kinds of connectivity in mind.

However, Hall's contention during our conversation also confirms a second point. A large part of these mining tools is presenting knowledge projects in ways digestible for venture capitalists and therefore the language eases barriers between university research work and partnership with venture capitalists and the biopharmaceutical industry. How might such digital organization impact everyday knowledge practices in the lab? Such software tools facilitate and even guide scientists to the kinds of scientific questions that may be relevant for potential external partners like Hall. His statement about the system suggests relevant research questions or researchers of interest show that the CTSI system does more than merely provide results. Instead, Hall's searches led him to the work of researchers about whom he had been unaware, suggesting that the CTSI discovery system also enables a crucial "filling in" of scientific gaps for potential partners. In this way, the tool becomes an agent of translational thinking. This implication may also be relevant for those on the other side of the search.

Beyond that, the CTSI website constitutes a kind of *extensional formatting* attached to what one might think of as everyday scientific practices; that is, the way a

scientist might engage in a set of laboratory experiments, which historically may have had no life outside of the laboratory. A discovery engine in which all of a scientist's work is locatable and seeable enables that work to be executable, findable, and leverageable in commercial terms. This is a crucial means by which scientific work might be reborn as an asset. As I began to think about the role of connection in the translational endeavor—connecting biological material to disorders, biological material to discourses, markets to new therapeutics—I began to think of the institutionalization of translational science in relationship to its effects on scientific thinking. What might it mean to think of these web tools as vehicles to change how research and researchers are conceptualized in relation to a capacity for commercialization, connection, investment, and entrepreneurship*?* Here I began to think of translational research and science as a means of *epistemic action*.

By epistemic action, I refer to actions that "are not used to implement a plan, or implement a reaction; they are used to change the world in order to simplify the problem-solving task…actions that make mental computation easier, faster, or more reliable" (Kirsh and Maglio 1994, 513-14). My fieldwork, observations, and analyses impelled me toward the proposition that the whole of translational science and research is positioned to compel epistemic action. That the CTSI website reorganized research, expertise, and researchers to be easily managed using its database and search function thereby changing the world to enable indexability and search functionality.

Although the notion of epistemic action, especially as used within cognitive science, philosophy, and social neuroscience, can be useful in that it maps "world" transformations of thinking practices, it tends to leave out the inextricability of context, especially in relation to materiality. Given the central role of the CTSI website

architecture in facilitating these conceptual and organizational effects, it is imperative to consider the website's material coproduction of new kinds of meaning. That is, the notion of epistemic action is not attentive enough to the functionality of the *larger material world* to incite or compel epistemic action. The material world includes embodied epistemic logics beyond the scope of approaches and disciplines that tend to focus on the rationalist mechanics of the individual. In other words, the ways environments compel action is a key element in the understanding of how epistemic action becomes a material possibility. Further, epistemic action tends to emphasize cognitive action over any analytic mode that considers how and why such actions become necessary. In other words, the notion of epistemic action is less concerned with how such actions are inextricably part of larger social processes and practices. Thus, while concepts such as epistemic action could be useful to hypothesize the kinds of changed internal states or orientations produced during an epistemic process, the efficient truncations achieved via epistemic action are rendered necessary only in a *specific* context and toward *particular* kinds of social actions.

In this meeting of epistemology and material tools (such as the CTSI website) we can derive guidance from the history of cognitive anthropology and especially its reflection on the use of the material and social worlds in thinking practices. One concept that targets this interplay is the "cognitive artifact" which Roy D'Andrade, invoking the work of Edwin Hutchkins, referred to as "a physical structure that helps humans perform some cognitive operation. Cognitive artifacts range from complex machines such as computers to simple devices such [as] paper and pencil" (1995, 210). Thus, beyond philosophically inflected concepts such as epistemic action, there is a need to consider the

roles accorded to tools and artifacts in social processes. While the CTSI webtools consisted of actual tools (i.e., web search and profile and account creation tools), I also conceive of the CTSI website as *an environment*. As such, it is important to understand how the website's constituent tools produce cohesive sets of practices. The tools focused on data organization, entry, mining--all speaking to a common system with articulated goals. Thinking of CTSI as a cognitive artifact brings up a critical question of the ends to which CTSI compels thinking and practice.

Catalyzed in part by $112 million in funding from NCATS in 2011, the CTSI webtools provide an example of how translational science's institutionalization at the university creates entire systems. The UCSF portal is not only a means of connection, but also includes transformations that enable potentially all research and research capacities to be organized according to one's needs or agendas, or more importantly to the needs and agendas of others. To the extent to which the tool compels one to *think* of scientific practice in particular ways, a question emerges about how the institutional work of translational science--especially work focused on finding and aligning interests or creating epistemic legibility—is facilitated by creating systems.

Creating software programs to identify knowledge synergies and catapult researchers into the known paths of venture capitalists represents a significant moment in how universities handle innovations and treat university knowledge. In fact, this mode of technology-assisted, internal-discovery processes and internal consultancies reflect a real shift on the part of universities toward becoming rationalist, knowledge-management organizations focused on the "efficient" organization, management, and monetization of knowledge resources and assets (Shore and Wright 1999; Strathern 2000).

The importance of these website technologies (known as *information engines*) produces an interesting picture juxtaposed against the Booz & Company report that discussed means to create external innovations system. (As an aside, the facilitative nature of the website also shows the need for greater anthropological and ethnographic investigations into websites, since they are becoming the *means of things* rather than just sources of flat information.) The report similarly underscored the importance of digital tools in scientific practices--an area that has only gradually attracted scholarly attention (Beaulieu 2002).) Nevertheless, the UCSF center's website is an integral system through which exchanges of capital, expertise, networks, and access are mediated and tracked. To underestimate the power of this information technology in the system of translational science would be to overlook how the commercialization of science encourages efficient management of university assets. Here, management is the primary bureaucratic force through which systems were produced and university work and resources sustainably organized.

The implications of both the CTSI technology and the management practices around it (such as UCSF's consulting service) show the durable work of systems and the role of systems-making as a part of the translational paradigm. These point toward an analysis of the role of environments, technologies, and materialities in the creation of epistemic effects. Next, I examine this systems-making process in detail, addressing the construction of new architectural designs for TN laboratories.

Technology, Design and Contoured Actions

An additional point that became clear in the discussion with Kahlon was the importance of considering the ways technologies reflect and inform social action in relation to their embodied logics. Kahlon explained how the CTSI web system went far beyond merely enabling the user to search. Rather, the system compelled action among its users--whether scientists, university administrators, or prospective investors. She stated, “The [webtool's] everyday search and discovery functions are fine for older researchers, but these technologies are trying to put together information and get people to act upon it. There is a side to networking beyond mere discovery.” In this way, I began to think about this tool as key to the mobility of knowledge necessary under TN. Kahlon's elucidation answered the question of how scientific resources (human or otherwise) became actionable for investors, potential collaborators, or partners. Yet beyond questions about knowledge mobility lies the question of the technology itself.

How was the CTSI digital environment designed to "get people to act upon" the information on the CTSI website? In thinking about the website's actual "architecture," I began to reflect upon the coding and programming that lay underneath the design (Figure 33)--a system programmed to send users from one entry point to the next, which automatically recognized certain search terms and replaced them with others, and which transformed raw data into usable forms for the site user.



Figure 33. Coding behind UCSF's CTSI web interface.
(https://profiles.ucsf.edu/about/AboutUCSFProfiles.aspx)

To think of these webtools' back-end design would also be to conceptualize the many pathways, predetermined goals, and literal "logics" encoded in the system and designed to not only assist one's thinking (i.e., in the way that search tool helps suggest proper spelling or related interests), but also compel the user towards specific *actions.* In this sense, the picture of the programming code underlying the CTSI website began to look like a kind of ideology and the birthplace of a kind of epistemic subjectivity. These actions that the CTSI site was designed to elicit were not arbitrary. Rather, the design reflected goals elucidated within CTSI's larger mission, which itself reflected a changing and entrepreneurial landscape of academic laboratory science and which, as argued earlier, was inextricably implicated in financial shifts in the pharmaceutical sector. Hence, an ecological conceptualization (Star 1995) of the many built environments that enabled TN (such as the CTSI website) helps us to think about processes, materialities,

and designs through which TN compels and contours actions in its implication of subjects.

Environments

Part of my research in northern California included ethnographic work at a university-based TN laboratory. Zack Lynch, the primary interlocutor with whom I began, provided good language to help me get introductions to academics working in TN. Tell them its about "innovation" he suggested. I was particularly interested in gaining access to TN laboratories at a university, to explore the laboratory as it was implicated and situated within this regime of research commercialization and reorganization, and in the externalization of corporate research portfolios to universities. After months of networking, I was finally able to secure an invitation to observe a laboratory at a northern California university.

However, the interlocutors at this particular laboratory were reticent to share much of their work with me--especially as they were embarking upon work that had particular intellectual property risks. In keeping with translational science's rhetoric, my interlocutors articulated strong concerns about the risks of sharing potentially "ground-breaking discoveries." The laboratory's head was concerned about my sharing (even inadvertently) details about their actual research. I had not anticipated this barrier and yet it made complete sense in the context of rapid commercialization of university research. Their reticence compelled me to think about the ethnographic conditions at work during Paul Rabinow's (1997) early ethnography of a biotechnology company's development of the polymerase chain reaction in the 1990s. In that ethnography, one notices that his

interactions are much more open and less shielded than my interactions among those within this particular laboratory. The contemporary turn toward aggressive *valuation* of potentially patentable knowledge has created true intellectual property risks related to university discoveries. Therefore, as requested, I have anonymized the participant names, university, and specific laboratory center within which I worked.

Upon arrival, I spent some time acclimating to the campus. As I navigated the campus for the first time, I prepared mentally for the social interactions that I would likely encounter and tried to remember the laboratory hierarchy. As an anthropologist who worked at the intersections of neuroscience, translational medicine, and patient communities, my initial focus was on the social worlds within which the laboratories existed and how they were impacted by the changing landscapes of translational science and research. My ethnographic assumptions led me to think about people and their relations.

Yet, the *building* was a surprisingly important starting place for this rather complicated puzzle. The building design, boundaries, and spaces became important material artifacts. This university had recently erected a spate of imposing, glassy modern structures to house an amalgam of centers and laboratories dedicated to translational research and medicine. Clustered in one area, this new "health campus" was to be the space of "world-class innovations" according to one dean. As I explored, I began to reflect about how these structures might affect what stakeholders thought about health and how their conceptualization might affect the outcomes of subsequent work.

Listening to Architectures

When I first got to know the building that housed the laboratory, I was unexpectedly captured by its design. The building stood out against more dated buildings across campus. A plethora of angles, it was a study in glass and steel. From the outside, one could clearly see into workspaces and hallways. From the outside view, the views into the building were impressionistic. Details were not clearly discernible; people, objects, and light came into view as impressions. The external architecture caused one to imagine the inside as light and airy, clear and open. The olive and blue planes of glass that clad the building's outside dominated the view. The building was a material force itself.

Although there were several entrances, a voluminous, multistory foyer clearly marked the primary entry. Inside the foyer, my eyes were drawn to the extensive vertical space. Colors were neutral and soothing; furniture in the public spaces was modern and low-slung. The combination looked like an aesthetic of the future. I later found renderings of the interiors and exteriors of the building before its construction. Even in the digital renderings, which displayed nothing more than an architectural imagination, the foyer's waterfall of light and its dramatic ceiling, the features that first attract the public's attention, were reminiscent of a cathedral. Yet the building was decidedly modern and conveyed a sense of grand lucidity.

Another element of the design caught my attention and would become important for my thinking about the role of design in TN. Throughout the building, one found what seemed to be endless planes of glass. Inside the building, the interior walls, including hallways and the conference room walls, were glass. Some hallways were set on a curve.

The multiplicity of gentle curves around an open atrium created the feeling of being inside a translucent wave. The building seemed to be a flowing collection of laboratories and centers dedicated to advancing the larger project of health.

Initially, I began with an analysis of the particular building to show how it actually affected the behavior of those inside it. While I learned some details about this, and I expound upon this issue later in this section in my discussion about the laboratory worker, Miku, my larger point, however, was not necessarily to show a causal relationship between the specificity of the architecture of these translational spaces and imprints upon the micro-level work in a Petri dish or with laboratory rats, nor to show some sort of architectural determinism. Rather, I began with the building and the particularity of its design to show how these elements fit within a larger set of social, medical, material, and moral blueprints.[66] I am not saying that design was not doing any detailed work here. I suggest precisely the opposite. Designs are not simply dead archives of thinking and planning. In the case of the translation laboratory in which I worked, the environment's design became host to a set of agile discourses and fantasies about TN. In

66. The morality is in outlining social problems and the space of possibility in which one can make choices. This is analytically important because it obviates an overreliance on explicit theories of power to explain the work of designing. This is not to do away with power theories. However, it does destabilize the analytic tendency to renarrate institutional decision-making (such as the university's decisions regarding partnerships with private industry around biotechnology) solely in those terms. This approach also removes one from a deontological obsession with explanation and analyses of large-scale interventions. Often the greatest locus of meaning is found not in biomedicine's end-product but instead, emerge in the research process (Pfaffenberger 2001). One might connect the tendency to focus on outcomes and end-products to the growth of ethical critiques against biomedicine that hinge on consequentialism. Scholars have noted the idealized nature of the design imaginary (Kingery 2001). But I propose that design's invocation of necessarily idealized imaginaries, such as idealized renderings in digital simulations, or assumptions of pristine, "treatment-naïve bodies" of the global poor in the design of clinical trials (Petryna 2009) speak to design's role in the moral realm. As I propose later, an ineluctably affective component works alongside the historical situations out of which TN and translational medicine emerges. The kinds of fantasizing that a translational imperative requires (particularly for translational medicine) become a necessarily moral model of imagining. While, Latour (2008) points out how history often narrates design decisions in moral terms, I believe that using the analytics of design to describe the present can also expose the birthing of moral realities.

fact, I propose that design became a means to exercise those discourses and fantasies. Through viewing design as an archive of a set of decisions, histories, plans and thinking, I identified social and epistemic performances that revealed the relationship between desires embedded in discourses and central epistemic goals of TN.

The "Alzheimer's Laboratory"

I received an invitation to spend time at one of the scientific labs of the larger Alzheimer's laboratory from prominent neuroscientist and prolific researcher Tom Carlisle. Carlisle did not spend as much time in his laboratory as he did in his other office across campus. However, as the principal investigator for several grants that keep the laboratory going, his influence was constant. Very reticent to talk about the laboratory's hypothesis regarding neuronal death in relation to Alzheimer's disease--a reticence that may have connected to his desire to create a diagnostic based on the laboratory's work--Carlisle was enthusiastic in talking about the new laboratory space.

During the tour he provided of the whole building and his laboratory, Carlisle talked about trend towards open knowledge, sharing, collective work, and decreasing knowledge silos in science. He used the example of a recent move by an academic publisher to prevent open-access research. For him, being "closed" was antithetical to the spirit of science. Perhaps reflective of a northern California ethos, Carlisle's speech was peppered with frequent uses of the word "new" and the term "future." I followed up with Carlisle about his own collaboration efforts. He reported frequent collaboration with other members of campus. I then asked if he thought the laboratory arrangement had anything to do with this impetus, and he responded, "Probably not." Tangible instruments

such as funding stipulations tended to facilitate more cross-disciplinary collaboration, he said.

Relatively new, the laboratory was located on the top floor of a glassy building. According to Carlisle, the lab focused on understanding the neural mechanisms that coincided with Alzheimer's, to determine a clearer (or less fuzzy) set of clinical markers for the disease. The goal was to create a better set of diagnostic criteria for early detection and accordingly, early intervention. After my experiences with the Neurotecch Investment Partnering & Investment conference, Dr. Carlisle's concern about privacy and intellectual property immediately made sense.

He noted that the challenge with Alzheimer's, "as is the challenge with many degenerative disease categories, is demarcating it from typical shifts in memory that occur with age." Thus, the work of this laboratory was one of isolation, characterizing "normal aging" in the brain and isolating the special features that might more clearly characterize Alzheimer's. Anthropologists (Kaufman 2006; Good, Subandi, and Good 2007; Graham 2006; Hinton et al. 2006; Whitehouse, Maurer, and Ballenger 2000) and recent work by Lock (2013) have drawn attention to the various constructions of Alzheimer's and dementia by clinicians and practitioners. Even outside neuroscience, the Alzheimer's category has challenged clinicians and the problem was not lost on this group of researchers. The incredible diagnostic and pathological difficulty of Alzheimer's has impaled the field and grabbed headlines (Belluck 2011). Nevertheless, the ostensibly mundane laboratory science of working with cells and proteins, and creating experiments using animal models–when conceptually tied to the sociomedical fact of Alzheimer's–enabled a particular kind of value under the banner of translation.

The laboratory I visited is prolific in terms of deliverables: research articles, citations, and research funding dollars procured. Headed by Carlisle, a prominent neurologist and professor, it embodied the kind of work that the larger university touted. The laboratory is also symbolic of future health innovations. It constituted an important ethnographic space on its own: low-level experiments were done in the name of Alzheimer's, a disease that is pathologically complex but which also indexes larger questions about the brain, the aging body, and the nature of clinical demarcation. Alzheimer's is also an emotional disease. Sara, a Chinese lab worker, explained that this project resonated with her:

> *Back in Shanghai I have my grandmother. … She has Alzheimer's. It's been very hard to watch. I love my grandmother and seeing her decline has been very difficult. My mother and some other family take care of her. It makes me feel good to be working on Alzheimer's. It makes me feel like all of this work that I do is for something good. I don't get back to Shanghai very often but I always make a point to visit her.* (Interview 25, December 5, 2011)

The language that lab workers used to describe their research clearly reflects the connection of this laboratory work to the larger aims of health and specific disease categories, even when it was more about specific, yet otherwise typical, biological processes (degeneration being a typical biological process). I had often thought that the "translation" lab workers made of their microscale work in disease categories was created simply to accommodate me as an outsider. I thought, perhaps they were doing this to make these small micro-experiments make sense in a larger view. Those with whom I spoke, however, similarly narrated their own experience as working on a disease even after I was no longer a newcomer. Tiffany, another worker in the laboratory, often found popular news articles about Alzheimer's and would post them in public view for other lab

workers. During laboratory meetings, there would be informal conversations about the news articles or pieces of popular media about Alzheimer's disease.

Goals "in Mind"

Miku worked on the molecular mechanisms of neuronal death–a primary Alzheimer's marker. Tiffany, who once made a macabre joke that theirs was the "Death Lab," tested degeneration using rat models. According to Carlisle many therapeutic opportunities could be tied to this research. Miku seemed interested in this possibility of application whereas Tiffany rarely articulated her everyday lab work in therapeutic or otherwise grand terms. I had asked Miku about what possibilities this research could create in terms of therapeutics. She quickly offered, "Well, if you get to understand this stuff more intensely, then maybe you could try to create prevention strategies," she said tepidly and with a tone of uncertainty. I asked her what she meant by strategies. "I mean pills. I guess maybe there could be other prevention methods, but pills are the main way that this stuff works." I later asked Miku if she recalled thinking about pills as she began to setup experiments and propose new research priorities. She confirmed that she did definitely "think about the end product" as she did this kind of work.

I was also interested in the specificity of their lab work compared to a basic neuroscience laboratory research because neuronal death is a characteristic of many neurological diseases and the problem of isolating Alzheimer's meant this research was actually rather broad. When I asked Miku about the difficulty of balancing what looks like basic research with the expectations of specific applications, she quickly nodded in agreement but did not respond further. During the time that I knew Miku, she tended to

keep laboratory life within the confines of the lab. An otherwise super-jovial person, she tended to do her work, go out for lunch, finish her work, and quickly leave for home. She did not tend toward long, tortuous reflections on her work or that of the larger laboratory, at least in the context of our conversations.

However, Carlisle was able to provide a more specific, but limited response to my questions. The work of this laboratory and its connection to the translational project was about focus. For Carlisle, “We’re doing this work with a goal in mind--the discovery of novel ways to make a difference in this disease.” Carlisle's pun-like phrase, "goal in mind" coalesced with my notion that TN is marked by a particular way of thinking--a mode that may constitute the primary differentiation between TN and basic science. From both Miku's contention about "finding pills" and Carlisle's response about "goals in mind," one sees the articulation of what I call *therapeutic or pharmacological thinking*. By this, I refer to the affect of priori presumptions of a psychopharmacological, pharmaceutical, or device-based product that becomes both the pretext from which scientific designs are drawn and the measure for how scientific successes are assessed. A technological heuristic, it produces upstream effects, determining which experimental questions are asked, which data disregarded, and which solutions envisioned. Pharmacological thinking not only constructs the very objects of investigation, it also constructs its subjects.

Additionally, Carlisle's suggestion about "making a difference in this [Alzheimer's] disease” relied on an understanding of translatability between the work inside this laboratory using animal models (and disease models specific to these animal models) and "Alzheimer's disease." This distinction about *goals* as key differentiating

factors between basic and translational research corresponds with early laboratory studies (Knorr-Cetina 1981; Star 1989) about the inherent everydayness of laboratory work. The external (social) and internal (scientific) significance *accorded* to laboratory work is a key component in the production of what the work in the laboratory means. Bruno Latour's (1983) discussion about the displacing nature of translation targets the way that laboratory objects can stand in for real-world objects: "Like all translations, there is a real displacement through the various *versions*" (146). Keeping these versions together, according to Latour, is the principal means by which laboratories maintain the power to speak to macroscale problems using microscale laboratory work,[67] which is the essence of bench-to-bedside translation.

The movement of the fact from the laboratory to the world of disease categories is at the heart of translation for Latour. Heretofore, scholars have had to theorize about how facts travel, since few pathways were clear.[68] Thus, it is important to understand the role of translational science as representing a new point in the history of these investigations: a useful new configuration in which boundaries between the outside and inside are

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67. For Latour, this displacement also undergirds the mystification and black-boxing of science.

68. Translational science, the commercialization of science, and the growth of public-private partnerships in the university present a useful analytical entry point for science and technology scholars interested in following a fact through its translation. Scholars such as Bryan Wynne (1993) pioneered empirical research about how facts moved outside of the laboratory into the world, and the role various publics in science have in this process (a concern the British took up earlier than their American counterparts due to the structural particularities of British universities). In "Misunderstanding Science? The Public Reconstruction of Science and Technology," Wynne and Wynne's (1996) project of getting at public understanding necessarily required a cognitive consideration. The cognitive methods in their research of Cumbrian farmers and scientists in a post-Chernobyl context compelled a different mode of understanding the fundamental translation project. In thinking of TN as an institutionalized assimilation of new knowledge onto existing knowledge, my project could be one about thinking. More than a study of scientific production, mine is a study of knowledge representation and, to some extent, learning. Yet, part of my larger proposal is that understanding or misunderstanding is not central to TN work to the extent to which poor or problematic scientific understanding is not necessarily an impediment to translational "success." Because TN is also about commercialization, a cognitivist approach towards the study of TN would miss how TN is a much more complex phenomena. Mistranslation is a necessary and intended part of the translation process rendered less important by the engines of the market and speculative investing in biomedicine. This is why I did not take a cognitivist approach in this project.

rendered open, and this openness rendered explicit. Translational science relies on this categorization of valuable and useful work, as well as the identification, binding, and codification of relevant research options. Translational science therefore not only includes a moral orientation toward bringing knowledge out of laboratories (this is not just biological research, it is "*Alzheimer's* research") and the explicitness of interested science (i.e., instrumental[69] knowledge is moral knowledge), but also includes infrastructures, legal accommodations, private partners, state institutions, and discourses to help support the process.

In "Give Me a Laboratory and I will Raise the World," Latour (1983) attempted to show the means by which activities inside the laboratory were understood to be exportable to the larger problems in the world--the "macro" referred to within the laboratory. For Latour, "Something is happening in these [Petri] dishes that seems directly essential to the projects of these many groups expressing their concerns in the journals." Yet Latour, in a latter part of an article, uses Louis Pasteur as an example to think with and offers a useful proposal for considering innovation and its presuppositions:

> *That this metaphorical drift, which is made of a succession of displacements and changes of scale…is the source of all innovations is well known (Black 1961). For our purposes here, it is enough to say that each translation from one position to the next is seen by the captured actors to be a faithful translation and not a betrayal, a deformation or something absurd. For instance, the disease in a Petri dish, no matter how far away from the farm situation, is seen as a faithful translation, indeed*

69. If classic accounts of scientists' work sounded like objective, interest-free pursuits of truth, or "pure science," the translational model of science was instrumentalists doing science for a clear goal. Scholars such as Sandra Harding (1993), Donna Haraway (1997), and Sharon Traweek (1988) have thoroughly reflected on and intervened in these narratives, and shown their inextricability from the work of gender and in the construction of "cultures of objectivity" that marked narratives of scientific practice (Rosenberg 1997). Rather, this highly interested science wore it values on its sleeve. This was not the "disinterested science," older science subjects that were the paragons of historical accounts of scientific discovery. Historian Steven Shapin (2008) delineated this classic scientific subject as characterized by an honor among scientists tied to one's independence towards a new paradigm marked by experimentalism.

> *the interpretation of anthrax disease. ...It is useless trying to decide if these two settings are really equivalent–they are not since Paris is not a Petri dish–but they are deemed equivalent by those who insist that if Pasteur solves his microscale problems the secondary macroscale problem will be solved*. (1983, 155)

This model suggests that there is a work of faith in the rectification, in bringing together the microscale and the macroscale. This was certainly the case for my interlocutors at the Alzheimer's lab, for whom their microscale research about the workings of neurons (a very common, mundane process) was easily mapped onto the larger disease category and the possibility of discovering an intervention. Yet the very fidelity of these meanings, which bound the Petri dish in Pasteur's lab to the social category of the disease to which it was attached, could only occur through the key tool of discourse. Specifically, the discursive mechanics involved in maintaining meanings is a key process in the work of translation. Thus, in the example of the Alzheimer's lab, even before Carlisle hired these laboratory workers--before Tiffany and Miku were doing their work--this was already an "Alzheimer's lab."

This is not to say that translational science is reducible to nothing more than discourse. Rather, this points to the importance of the discursive work in translational science, to codify it as work connected to larger disease states and goals. Although displacement is especially useful in thinking about translational science, where scientific claims move from the "Petri dish" to outside, this emphasis ignores the work of discourse that ties the scientific claim to other translational efforts (medical, technical and epidemiological) and allows research to be *constituted* as health. It is, importantly, in the discursive attachments where TN is made into an exercise that is meaningful to health.

Here, I refer both to social discourses (i.e., “this health campus is the future of health”) and internalized discourses (e.g., "we're working in Alzheimer's").

In Latour's (1983) example, aside from seeing the work of displacement, it is necessary to also notice the way that a given *environment* (the lab) and its associated epistemologies engineered and reproduced important discourses about what is done within the laboratory.

> *Thanks to a chain of displacements–both of the laboratory and of the objects--the scale of what people want to talk about is modified so as to reach this best of all possible scales. ...Then everything they have to talk about is not only visible, but also readable, and can easily be pointed at by a few people who by doing this dominate.* (1983:164)

However, to focus simply on the ways in which discourse facilitates such displacements--or in a more limited sense, the “contract” of translation, obscures the importance of material environments for contouring discourses and subjectivity. It is important to look at the ways in which translation narratives give life via material processes in the laboratory and to assess the affects of these environments on scientific practices.

An Architecture for Fantasies

The Alzheimer's lab was part of a larger cluster of centers and institutes that had been physically relocated near one another. The university administration’s push toward a modern, biomedical health sciences center was itself reflective of a larger imagination about health. Even the visions regarding the new campus reflect a narrative about the ability to “build” an ostensibly complete health solution. In other words, biology labs were established adjacent to policy research offices; their proximity to a new research

center focused on genetics was also no accident. The idea was that this interdisciplinarity would be the means by which large kinds of problems in health could be solved. These dramatic visions about the future of health were reflected publicly. While in northern California, I visited multiple sites where buildings were being erected and programs founded. I attended one particular groundbreaking for such a project at the University of California. The center's director offered a rather biopolitical context for the new building's role in emergent health innovation:

> *We are indeed at the beginning of a new era of scientific research and innovation that promises major advances in the biological sciences that will profoundly impact human health. …Knowledge of biology and how the body works is reaching a level of sophistication that could change the paradigm of health care. By treating and preventing diseases at the molecular level, a new generation of doctors, clinicians, and researchers will redefine how disease, aging, and life itself is understood and experienced*. (Robert Tijan, faculty director of California Institute for Regenerative Medicine at ribbon-cutting and dedication of new Biomedical and Health Sciences Center [Tijan 2011])

In this narrative, one finds the kinds of displacements in the Alzheimer's lab, in which everyday laboratory work is connected to the larger category of Alzheimer's. However, one also finds the work of envisioning a highly mobile and interconnected scientific enterprise that brings together scientists and clinicians, and science and medicine, which will in the biopolitical phrase above redefine how "life itself is understood."

Thus, to illustrate the importance of looking at the designing of the Alzheimer's laboratory as a specific environment, I demonstrate that much of translational science is informed and pushed by *desires* for a seamless shift from "bench" to "bedside." Although it may seem obvious, designs that hide the many fissures and challenges in the translational pathway obscure much of the complexity of the process of "translating" a

basic discovery into a health solution. Creating translational infrastructures is powered by octane-fueled envisioning. One article about the ethics of translational science programs provides a great example of how embedded desire is in the animations around translational research and medicine:

> *The current "celebrity status" of translational research reflects the aspiration to facilitate the progression from basic discoveries to new interventions, and from their approval to their widespread use*. (Eyal and Sofaer 2010; emphasis mine)

Accordingly, the NIH went through an extensive research phase in which their stakeholders spoke with scientists, clinicians, universities and private industry to try to *rethink infrastructure*s according to a grand vision for health. However, the imagined *legibility of facts* (i.e., that a fact about cellular degeneration patterns in a lab rat could be transformed into a clinical diagnostic test), and imaginations about the ease of transferring knowledge from one domain (a department or discipline like neurobiology) to another (e.g., engineers creating testing tools) also heavily relied on vision. This led to an interesting commonality that tied together scientists, pharmaceutical companies, and institutions as part of an imaginary.

Even in the many graphs, diagrams, and flow charts that outline the pattern by which translation ought to occur, one finds digitally produced images in which areas and knowledge are perfectly separated, separable, integratable, and then connected by arrows to gesture toward translation. To be clear, I do not aim to paint a critique of translational programs in which they suffer from delusions of ease. My ethnographic experiences from the Neurotechnology Industry & Investing Partnering conference and my conversations with neurologists provided clear evidence of stakeholder concerns regarding the ineluctable difficulty of translation. Instead, I point to *the essential work of imaginaries*

in the elucidation of translational programs and translational work--imaginaries made clear through an examination of the design of the laboratory environment itself.

Glass Labs and Ghost Corridors: The Material Life of Transparency



Figure 34. An image from an architecture firm that designed the Boston-based translational laboratory, Broad Institute, that is quite similar to the one in which I worked in northern California. A prominent architectural firm that specializes in modern laboratory design also used this image to illustrate the designs for transparency. (Perkins + Will)

To the casual observer, the Alzheimer's lab seems encased in a glass box (see Figure 34). Attached to an explicitly named TN center, the laboratory's glass walls and internal walls blend. Space separation is difficult to discern because the walls separating labs and offices are all glass. The sense of transparency is immediately disorienting for a new person. At least once a month, I would make the same mistake and walk into an adjacent lab because I was disoriented.

Miku hated these glass walls. She once said to me, “I always feel on the spot.” Like most of the workers in her laboratory, much of her day was spent behind these walls working--in her case, with lab mice. Occasionally, she and I would have a lunch of Vietnamese spring rolls from a nearby Thai place. We often talked about how to induce neuronal degeneration. But when we weren’t talking about that, we frequently spoke about the glass walls. “I feel like…I feel so *exposed,*” she said. I felt similarly inside the space.



Figure 35. Laboratory "Ghost Corridor" Circulation. Copyright: Christopher Frederick Jones

At one side of the Alzheimer’s lab was a hallway. One could see through the glass hallways all the way into the building spaces beyond. I later learned that the colocation of multiple, interconnected laboratories operate through the use of what in architecture are termed *ghost corridors* (Figure 35), a provocative term for an essentially invisible hallway that spans the length of multiple laboratories. The amalgamation of laboratories and the extensive use of glass walls shaped Miku’s anxiety. I asked her about

her initial statement on feeling "exposed." In her elucidation, she talked about feeling as if she were constantly observed. I found Miku's statement intriguing: narratives of openness and transparency attached to open designs usually invoke a rhetoric of collaboration; yet glass walls and open spaces can also simultaneously become means of surveillance (Figure 36).



Figure 36. Stanford University's Clark Center open lab (Perkins + Will Website).

One day, Miku put up small curtain covering a portion of the glass wall adjacent to where she worked. It became a minor source of jovial conversation inside the lab. I later found that Miku's decision to put up curtains was not dissimilar to similar actions by other scientists working in overly transparent, glassy laboratories. In fact, there was a

similar occurrence by a scientist working in a newly redesigned, open lab at Princeton University.[70]

Yet, there is also a crystalline irony here. Miku's research on neuronal death involved studying laboratory mice that lived their entire lives inside clear Lucite boxes on lab tables. There were no illusions regarding the need for those Lucite boxes to be amenable to laboratory observation. Nevertheless, there was something provocative about this parallel between the Lucite boxes housing the lab mice and Miku's "Lucite laboratory." In one sense, the glass-bounded lab itself could be seen as part of an experiment, which like the Lucite box was designed or redesigned toward particular experimental knowledge goals.

Miku was not the first person I had met at the laboratory. Sarah and Tiffany had both been very friendly during our initial conversations. But Miku and I had developed something of an impromptu relationship: We were the same age and we could talk easily. She became my principal interlocutor in the laboratory. A relatively recent transplant to the laboratory and the region, she had come to California to conduct laboratory research as a Ph.D., student. Like many of the laboratory's mostly international lab workers, Miku was married. Unlike the other lab workers, she also had children. Miku's husband, Justin, was a postdoctoral fellow in biology also at the university. Justin worked at a laboratory not far away. Occasionally, when he and Miku would plan to have lunch, Justin would come up to Miku's floor, come up to the laboratory, and wave through the glass, inviting Miku to lunch. According to Justin, the campus had relocated several labs in order to segregate a portion of the campus devoted to science and engineering, relegating it to a

70. See Collins(1999) for research on the phenomenon of lab workers putting up obstructions to obscure glass in glass-oriented laboratory architecture.

new science and engineering cluster in a newly developed part of campus. “The move was awful,” Justin said, explaining the logistical difficulties involved. “We had movers come and several professors didn’t want the relocation, but it was part of the strategic plan.” The need for greater innovation via translational science was a part of a strategic plan in which the university’s new health-sciences and science campuses were centerpieces. I began to think of the relocations to which Justin referred and the specific design of Miku’s laboratory and building as part of a connected discourse around “innovation.”

To achieve a greater understanding about the design of the “transparent laboratory” in which Miku worked, I spoke with John Miu, the principal architect of the Center for Health and Biomedical Innovation that housed Miku’s laboratory. Miu was a distinguished, gray haired man with distinctive mauve glasses. An esteemed architect, he had designed a myriad of academic science buildings; his eponymous firm practiced what he called *architectural minimalism*. Inside his office, one felt the opposite of minimalism–a bevy of awards, furniture, and models littered his massive space, a rehabilitated warehouse in "SoMa," San Francisco’s converted (So)uth of (Ma)rket industrial area, now home to young tech companies and a burgeoning nightlife. Like many such firms, several dozen young architects and interns do much of the work of designing, planning, and managing client projects to facilitate Miu’s building projects. As I entered his office, Miu’s space was abuzz with fashionable young architectural designers, engineers, and project managers. Grateful for the opportunity to meet with Miu, however briefly, I asked him about his thoughts and intentions with respect to using

so much glass in the science building. I wanted to know how this functioned in terms of the larger rationale for the building's design.

"Glass walls inspire cross-disciplinary conversation, collaboration, and innovation," he said. Spry and energetic, Miu popped up from his Eames-style office chair to walk to the other end of his large office. I followed him around his office as he showed me pictures of interior designs for Silicon Valley technology companies, which he then used to talk about the design of the university building:

> *See the open space and attention to common spaces? That's how you create an innovative company. Closed offices and closed-off rooms are a thing of the past. Knowledge has now got to be mobile and openness breeds creativity, open thinking, and creativity. Think about this [design for the Center] as representing the breaking down of walls and barriers. Knowledge for the new economy.* (Interview 27, January 2012)

Miu's thoughts about how to compel "open thinking" brought together the materiality of the laboratory and a set of logics regarding knowledge. In this way, designing environments of knowledge became a means of executing neoliberal fantasies about innovation, information, communication, collaboration, and an emerging post-Fordist modernity. For Miu and others, glass walls inspired and compelled subjects into certain kinds of knowledge workers. Toward the end of our conversation, Miu talked about how glass walls spoke to modernism in the way that glass both erected boundaries but also removed them. After our discussion, I returned to the glass building. In the foyer, light would often move in from skylights, through the atrium, and spread throughout the interior hallways and corridors as the day passed--this only further cemented my sense of the building as a kind of cohesive, Lucite box.

The idea that designing for free-flows of knowledge might compel interdisciplinary collaboration served to imprint both social and epistemic goals via lab design. In this way, Miu's statement, "Glass walls inspire cross-disciplinary conversation, collaboration, and innovation" included a view of design as a directive or prescription in which the goals are not merely social, but also imbibed ways of thinking ultimately affecting the kind of knowledge created, a mode that presumes that mere interaction or communication will transform the kind of knowledge that emerges. Of course, open laboratory design is nothing new. Thomas Gieryn's work traces the evolution in science laboratory design and its connections to market "insistences of late capitalism" (2008, 796).

However, the rearrangements that compelled the redesign in which Miku works and the campus rearrangements of which Justin was part when his laboratory was relocated reflect the displacements justifiable under TN narratives. They also became codified as environments necessary to achieve the visions of science and medicine under translational science. Interestingly, I found traces of these same discourses about the material conditions for scientific innovation in architectural discussions about the future of laboratory design.[71] In an article on "Trends in Lab Designs" the authors stated, "Science functions best when it is supported by architecture that facilitates both structured and informal interaction, flexible use of space, and sharing of resources" (Watch 2010).

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71. It is important to note that there was a great variety in architectural opinion regarding laboratory design, as was the case with design in general. For some, openness and flexibility should be seen less as an attempt at engineering social relations and more as an environment tooled for conductivity and "accommodation," as architect Robert Venturi (1999) contented in *Thoughts on the Architecture of the Scientific Workplace: Community, Change, and Continuity*. Also see Solomon, N. (1993)."Laboratory Innovations." Architecture, 82, no. 3:123-27.

Sociality, flexibility, spatiality, and transdisciplinary collaboration were all seen as the ideal in a modern, global, and ostensibly open and transparent knowledge economy. Thinking about these desire-laden discourses attached to the narratives regarding the design of open laboratories and "social buildings," I wanted to return to the laboratory itself. Indeed, Miku's experiences of "openness" betrayed the optimistic visions of "collaboration" and "flexibility" imbibed in such discourses about the new, modern laboratory.

Nevertheless, I remained interested in the *environments being produced* under the translational imaginary. The rearrangement of university workers, the narratives attached to the design of the building's public spaces, and the glass walls all revealed the importance of material understandings of the laboratory as a productive discursive space (Galison 1997; Galison and Thompson 1999; Knorr-Cetina 1992; Latour and Woolgar 1986; Rabinow 1997) with the laboratory's materiality as a central issue.

While Miu and Carlisle articulated how openness and transparency worked as part of a material, epistemological logic related to ideas about scientific modernity, globalization, and innovation, I also connect the concept of the open laboratory to the underlying notions of translation, mobility, and translatability. Translational science at the university worked through the creation of environments that compelled *epistemic orientations* on the parts of scientists towards openness and collaboration. I point toward the creation of a design in which an orientation toward openness reflected a design decision concerned with producing epistemic effects. According to these discourses, producing such knowledge environments essentially helps to shape the way inhabitants think and engage in scientific work. This project was not actually about mapping the

effects themselves. While I discuss what I call *pharmacological thinking* in a translational context, this project is not about thinking patterns. Rather, the focus is on how epistemologies and thinking patters are *essential objects that are being designed for* in the creation of systems such as the CTSI website and in environments such as the "open" translational laboratory. In *The Design Process as a Critical Component of the Anthropology of Technology,* W. David Kingery revealed design's methodological solicitations:

> *Design, the process of conceiving and visualizing an artifact, of forming a plan, of contriving an arrangement of parts in a device, a process or system is at the core of technological change. ...Design is required not only for the artifact but also for each of the production activity processes and use activity processes associated with a system of technology*. (2001, 123)

Thus, I focus on design and planning as a means to target envisioning and institutional planning in the creation of pathways such as those engineered into the backend of the CTSI website. The question of whether all subjects within these environments were actually changed, and the question of resistances (evidenced by Miku's curtain) rightly complicate any narratives that presume necessary outcomes for designs--especially when those outcomes involve the transformation of subjects. Nevertheless, in mapping a set of designs and logics, I hope to show how these designs are part of—and essentially work through—moral visions regarding TN and the translational project in general.

The Paradoxes of Sharing

Thinking about the CTSI website, one clearly sees the sense of "open" as a hallmark in discourses about translational science. CTSI web-based tools enable sharing

of data and resources across institutions and departments, and establishing connections with other stakeholders internal and external to UCSF. Additional web-based collaborative research tools such as those at Pfizer's, and others such as early brain-mapping technologies (Beaulieu 2002), facilitate the ability to more easily analyze data across sites, collaborate, and share knowledge. Simultaneously, the move toward open labs, cross-disciplinary research, and collaboration as concretized in the redesign of university laboratories and campus areas connects with what I have called *systems of epistemological contouring*.

While I had been thinking largely in terms of the way such environments may be designed to compel translational thinking, Miku's lament caused me to think of the ways that openness operates toward different aims. Miku's visceral reaction to her open laboratory environment was marked by feelings of being closed in, rather than "open." The narrative of "the open" neglected the reality of a multilayered positionality. The translational laboratory is open from some perspectives and closed in others. After my discussions with Miku and Miu, I began to think of knowledge goals as they imbricate through designs in relation to the needs of the market--especially pertaining to the need for translatable and mobile knowledge. Thomas Gieryn's (2008) study of Stanford University's award-winning biomedical engineering and sciences building revealed a similar design approach in university science buildings:

> *Bright yellow "hotel benches" can be rolled anywhere if a scientist from outside gets teamed up temporarily with a Clark-anchored project. Nothing much is a secret at the Clark Center, since there are no doors to close off your lab space from other scientists, and even the hoi polloi can watch the action from those publicly accessible balconies.* (2008, 798)

In the new laboratory, openness and movability were central themes, along with the death of the historical world of scientific silos. In contrast to secrecy among scientists, openness makes science more accessible and coincides with a pedagogical philosophy that sees transparency as encouraging learning and innovation. For example, in May 2010, Texas-based Trinity University broke ground on a $100 million dollar Center for Sciences and Innovation. In an interview with the *San Antonio Business Journal*, university president Dennis Ahlburg explained the use of glass in the building in terms of collaboration and demystification: "The exterior-facing glass walls will let people see inside classrooms as a way to demystify science and spark curiosity." Yet, in the other corner of the building is the Innovation Center known as The Cube, the center of what Ahlburg called the "entrepreneurial engine room" (*San Antonio Business Journal* 2011). Here the sense of openness as an educational value was juxtaposed against its utility as a market value.

In contrast, "the closed" was narrated as part of a historical, anachronistic imaginary in science. I envision a closed, medieval science marked by formality, politicization, elitism, inequality, and exclusion (Galison 1999; Hannaway 1986). Open scientific structures and policies were therefore narrated against this particular depiction of a classical, prototypical science. Yet, the rapacious growth of private patenting and licensing agreements, and the emergence of university lawsuits over ownership of scientific discoveries has been not only well documented (Basken 2011; Mowery et al. 2004; Shapin 2008), but shows a more complicated picture supporting a culture of both open and closed access. This dualism and rhetorical contradiction are similar to narratives of neoliberalism in which promises of openness via globalization are undermined by

problems of global access (Biehl 2007; Collier 2005; Harvey 2005; Tsing 2004; Whyte et al. 2006).

Thus, ideas of "the open" and "the closed" intersect as a set of paradoxes. Tom Carlisle was eager to show me the brand new open space conducive to sharing and collaboration. Yet, increased demands regarding the development of intellectual property meant that he was reticent to share information about his laboratory's technical work or discoveries. Thus, the orientation of the knowledge worker has become both increasingly open and closed under translational science's environments.

From a market view, these partnership technologies were extensions of the market. To the extent that Carlisle's laboratory may find new means to make new partnerships using web-based partnering tools or consulting services such as those UCSF offers, openness may actually facilitate the meeting of ideas with capital. Transparency narratives function as self-fashioning vehicles for those involved in the translational system (ranging from investors to lab workers) and enable the laboratory to become a beacon for public-private partnerships accommodating an increasingly entrepreneurial university. An open lab also signals market openness.[72] The openness of translation, even in the symbolism of the concept of translation, invokes the evolution of the university. In the introduction to their volume, Henry Etzkowitz and Andrew Webster offer an interesting articulation of the shift from the implicit knowledge transfer from universities to corporations toward a more explicit transfer model:

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72. Why were relationships necessary? One thing I learned was that knowledge did not translate itself. Often laboratory results were so difficult to reproduce by companies that owned the patent for a given piece of research, that increasingly part of the very patent included (necessarily) consulting on the part of the scientist that created the result in the initial laboratory experiment. This has shown that the actual transfer process included arranging for a legally sanctioned series of social relations–to confer what legal scholar Peter Lee (2012) has called embodied knowledge that is necessarily part of scientific research.

> *Transfer of knowledge to industry was theoretically freely available through the literature. But in practice industry needed relationships with academic scientists to translate this knowledge into a usable form. This is one of the driving forces behind normative change in academic science.* (Etzkowitz and Webster in Etzkowitz et al. 1998, 3)

However, if the narratives of openness and sharing that animated translational science's knowledge environments (laboratories, web tools, new campus communities) were actually about an openness to the market, then TN must also include a means of *modulating* and managing such openness. I aim here to redirect attention. The question, Is modern science more open, collaborative, and transparent under translation, may be the wrong question. Transparency and flexibility have always been understood to be inextricable from the power to enable openings and closures. Consider Georg Simmel's thoughts about the functional polyphony and subsequent significance of the doorway:[73]

> *Given the fact that the door creates a sort of hinge between the space of man and all that lies outside it, it overcomes the separation between the inside and the outside. Precisely because it can also be opened, its closing produces an even stronger sensation of separation from all that is outside this space than that produced by a mere undifferentiated wall. The wall is mute. But the door speaks.* (Simmell 1909, 67)

Transparency became the articulation for market potential inasmuch as it became a means for it. The enunciation of openness works similarly in the case of the glass walls, where the discourse of openness belies realities of surveillance and control. As scholars have noted, discourses regarding transparency tend to produce epistemic effects (Collins 1999; Gieryn 1999, 2006; 2008; Kohler 2002; West and Sanders 2003) even when such designs do not necessarily lead to openness, collaboration, or innovation. Importantly,

73. In his essay, "Bridge and Door," Simmel actually discussed the nature of the window and the meaning of its transparency. However, Simmel suggested that the window, unlike the bridge, was more often used by the insider gazing out and thus conferred on it only "part of the significance of the door." In a world of glass walls and buildings with glass exteriors, I propose that Simmel's door functions as a better metaphor--especially in thinking about how the increasingly "open" laboratory functions as a kind of doorway to new scientific knowledge and practice.

discourses about epistemic practice help to contour perceptions of openness, collaboration, and innovation in representing TN. In thinking about how the design of spaces such as TN laboratories intersect with perception, I turn to social theorist Henri Lefebvre's discussion of the semiotic representation of space:

> *Conceptualized space, the space of scientists, planners, urbanists, technocrat subdividers and social engineers, as of a certain type of artist with a scientific bent--all of whom identify what is lived and what is perceived with what is conceived. …Conceptions of space tend, with certain exceptions…towards a system of verbal (and therefore intellectually worked out) signs.* (Lefebvre 1991, 38)

Such discourses are especially important for translational science because of how TN *relies* on discourse to separate it from basic science. In other words, Miku's experiments, ongoing during the time of my visits, on neuronal death using animal models within the space of the TN laboratory were likely the same as the research on neuronal death using animal models several years earlier when it was not attached to something called "TN." Yet the consecration of the TN laboratory and its design are critically enmeshed in a new conceptual frame, the construction of TN as being *about health*. In many ways, we can think of the very design of the laboratory as part of this discourse about what TN is and how it functions in a larger knowledge economy.

Making the Moral Material: Environments for Translational Thinking and Perceiving

Design does several things in the context of translational science. It targets the working out of *problems* at the level of symbol and thereby is a crucial component in the difficult process of tying the practical to the moral. An example of this may include the

perceived problem of "academic silos" and the decision to create a building design that "solves" this problem by locating labs near each other. In this way, a set of designs become a symbolic space for the acting out of desires and the solving of "problems." Thus, this is how "ghost corridors" and plans for new science campuses become constituted in the name of progress in health. In some ways, promises have merely rhetorical power, but designs have the assistance and ambiance of "the real."[74] Thinking of design as a space of symbol-making, objects such as architectural plans, engineering designs, and conceptual work enable a mapping of the relationship between discourse, fantasy, and a kind of material actualization. In the case of TN, designing environments such as UCSF's CTSI webtools and Miku's redesigned TN laboratory constitute the material life of translational fantasy. Yet, to the extent that both the laboratory and webtools are also means by which university workers engage in scientific labor, one sees a key manifestation of TN in the shaping of university knowledge workers and those who interacted with them--such as venture capitalists.

In the way that designs for health interventions, economic regimes, and clinical trials implanted moral prescriptions (Biehl 2007; Jain 2006; Lakoff 2005; Petryna 2009; Whyte et al. 2006), they became a means to follow visions for intervening in the future. Thus, designs reek of moral possibility, while also consecrating disorders befitting intervention. Similar to the characterizations of ethicists, designers change the "is" to an "ought." In this way, the designing of TN brings into view questions about how scientists, scholarly researchers, and the public ought to envision large-scale interventions

74. The reality here is in the cognitivist sense, but also reality as gestured to through design's materiality. In that sense, design constitutes a kind of prematerialization. Peter Galison's *Image and Logics: A Material Culture of Physics* (1997) addressed enabling ontological machinery. In addition, there is a phenomenological component: designs incite experiences in the register of the real in their formation processes.

in health while also providing an ethical archive of decisions about the (experimental, programmatic, conceptual) future of health.

Conclusion / In the Name of Health

"Billionaires With Big Ideas Are Privatizing American Science." This was the title of a recent (March 2014) *New York Times* piece by science journalist, William Broad. In it, Broad chronicles the rise of the wealthy private donor in the shaping of research at universities. He includes specific examples of wealthy entrepreneurs, such as Oracle founder Larry Ellison, whose research priorities reflect not only highly personalized interests, but also a specific and decidedly entrepreneurial ethos:

> They have mounted a private war on disease, with new protocols that break down walls between academia and industry to turn basic discoveries into effective treatments…The new philanthropists represent the breadth of American business, people like Michael R. Bloomberg, the former New York mayor (and founder of the media company that bears his name), James Simons (hedge funds) and David H. Koch (oil and chemicals), among hundreds of wealthy donors. Especially prominent, though, are some of the boldest-face names of the tech world, among them Bill Gates (Microsoft), Eric E. Schmidt (Google) and Lawrence J. Ellison (Oracle). This is philanthropy in the age of the new economy — financed with its outsize riches, practiced according to its individualistic, entrepreneurial creed…

The metaphor of a "private war on disease" speaks effectively to the emergence of a particular *mode of envisioning and doing* large-scale projects in science and medicine. These visions – much like the translational research programs I've written about here -- tend to be entrepreneurial in nature and to reflect the installation of market logics into the planning, structuring, funding, and assessment of these research schemes. Yet, this mode renders these large projects dependent upon individuals, single donor systems or donor streams, and single corporate partners. In all of these dependencies,

narrow interests crowd out broader interests; singular goals may overrule collective priorities.

When I read this, I immediately recognized both what Broad had obscured, the process behind this outcome that my research project illuminates, as well as what it makes vivid for an intellectual New York Times public: the comingling of private interests and federal research priorities. In a quick snippet, Broad describes the history beneath President Barak Obama's *Brain Initiative*, the $200 million dollar funding program launched in 2013 aimed to recharge brain research to improve health and which, according to Obama, would help "to grow our economy." Broad (2014) hopes to re-insert an underlying history of wealthy benefactors whose priorities and influence were obscured in Obama's announcement about the initiative:

> *Absent from his [Obama's] narrative, though, was the back story, one that underscores a profound change taking place in the way science is paid for and practiced in America. In fact, the government initiative grew out of richly financed private research: A decade before, Paul G. Allen, a co-founder of Microsoft, had set up a brain science institute in Seattle, to which he donated $500 million, and Fred Kavli, a technology and real estate billionaire, had then established brain institutes at Yale, Columbia and the University of California. Scientists from those philanthropies, in turn, had helped devise the Obama administration's plan*. (Broad 2014)

Broad ends with translational research, the darling of these programs and now a dominant research mode. In so doing, he asserts the public standing of a field of science whose rise to "darling" status drew me to my own research grounds. In this respect, one must read Broad as someone who names outcomes for a series of more complex trends that I point to in this dissertation. Firstly, as the present study has now made clear, translational science and medicine have emerged as a means and primary sphere through

which private interests spill over onto the public via re-envisioning and restructuring large-scale research enterprises in the realms of science and medicine, especially as they deliberately involve the creation of centers at the nonprofit university and as these initiatives are funded and promoted in the name of public health. Secondly, however, as evidenced by Obama's invoking of economic growth in his announcement for an initiative housed in the National Institutes of Health,[75] one sees the way that *health is leveraged* as a means through which to stage or enact market-related interests.

While Broad's analysis situates the privatization of *science* as the article's main issue, my own study has uncovered the inverse: the scientization/medicalization of finance, that is, translational science and medicine operate as a theater for the working out of privatized desires and accordingly, the articulation of financial and market logics. In other words, health has become increasingly and superbly conducive to the origination of new therapeutic markets, and a space of new critical entanglements that tether together patients, biotechnologies, governmental agencies, and the healthcare corporations. My research uncovers the infrastructure beneath the wide promises of transformations in global health articulated for translational research to find that such interventions are a simmering nexus of unseen stakeholders, historical legacy, private interests, and complex agendas.

I began this dissertation research in 2009 to map on-the-ground effects of the shift in biomedical research toward translational neuroscience (TN), which began after the National Institutes of Health (NIH) launched the Clinical and Translational Science Awards (CTSA) program in 2005. In that year alone, 60 medical research initiatives were

[75] The Brain Initiative. http://www.nih.gov/science/brain/funding.htm, accessed on April 16, 14

created with one fell funding swoop.[76] Beyond mere ethos, TN had become actualized both in terms of new institutional births -- departments, programs, faculty lines--as well as the creation of particular kinds of research questions, investigations, and priorities.

At a cost of $639 million,[77] these new federally funded TN programs, centers, and initiatives were ushered in on the promise of grand transformations in health. My initial questions were about these promises and in particular, how TN is posed to impact health for patients. Is it improving health-related outcomes? How does TN work as a mode of knowledge production? Who are TN's key stakeholders? Aside from the grand claims about TN, there was very little research about its on-the-ground effects and implications.

My project is a move in that direction. Across 24 months, I traced translation across multiple spheres – from interactions between scientists in TN laboratories and startup pitches by entrepreneurs at investment events to conversations with neurologists and clinicians. My aim was to map these translations, to follow brain facts in the in-between, and as they emerged in a host of situations, agendas, needs, and promises.

My questions became more complex as my research continued, especially as the work converged with the lives of individuals with aspirations toward better health: why is it that Jawan and Shana, who I discuss in Chapter 2, were offered Deep Brain Stimulation (DBS) as a therapeutic solution despite the fact that it failed to receive general FDA approval. How is it that this DBS technology, despite its known clinical and safety problems and failures still constituted a novel "solution" for epilepsy? Terry, another person with epilepsy, and his partner, Pauline aspired to solutions that improved their

[76] The creation of National Center for Advancing Translational Sciences (NCATS) in 2012 which, according to its mission, "… strives to develop innovations to reduce, remove or bypass costly and time-consuming bottlenecks in the translational research pipeline in an effort to speed the delivery of new drugs, diagnostics and medical devices to patients."
[77] http://officeofbudget.od.nih.gov/, accessed January 2013.

quality of life, how is it that these kinds of non-molecular, patient-centered concerns were left out of TN's primary research agendas? Where does one see the impacts of TN upon patient outcomes? Using my fieldwork in these various domains, including interviews with patients, clinicians, scientists, investors, and incorporating social science and clinical science research, I unearthed several key findings about the institutionalization of TN.

In what follows, I review some of the main findings of my ethnographic work and theorize these results. In a summary discussion of the emergence and financial character of TN as it appears in the scientific arena in the past decade or so I address compromises in health outcomes associated with the many risks of translational research. I point out the transfer of scientific and financial risk to public domains, and the special role of space and digital environments in transforming research practice and promoting "translation". I also point to the translational impact on epistemologies and research priorities. I then move to argue for the notion of substitutability as a means to understand the significance of the shift from basic to translational research, I end with a short note on ethnography as a research tool that is perhaps uniquely designed to unearth important dimensions and implications at work in new configurations in science, technology, and medicine.

Key Findings: The Paradox of Promises in Health

A primary point that became apparent during my investigation is as follows: expanding TN knowledge and practice does not on its own provide outputs that have translated into clear, improved health for patients – something research has increasingly confirmed, but which is also reiterated during my interview in Chapter 2 with Dr. Jones, a neurologist at an academic medical center for whom "the outcome for the patient isn't

any different...” The paradoxical ease and availability of TN’s many new diagnostics and the subsequent difficulty culling clinically meaningful benefit from these diagnostics shows how TN’s outputs become part of a clinical toolkit bereft of clear improvements in patient health.

Yet, I also argue that TN, at least in clinical registers, becomes a means through which medical disorders such as Alzheimer’s disease are encompassed within biological discourses – a finding that re-emerged in my later observations as well. Yet, as my discussions with a neurologist and medical researcher suggests, the benefits of increased knowledge, and new diagnostic tests have not necessarily translated into better health outcomes for that neurologists’ patients. This disjuncture coalesces with a strategy that I unearthed during the Neurotechnology Industry Investing & Partnering Conference in which creating biological discourses essentially stood in for an absence of innovative and efficacious new drugs – a strategy that came to the fore in the industry push towards the development of diagnostics (sometimes independent of any actual therapeutics tied to that diagnostic). The possibility of “innovations” in health that do not necessarily lead to better health (at least in the short term) creates questions. Why did neurotechnology and its profits continue to rise despite problems in terms of efficacy and underlying knowledge? It was here that my fieldwork among investors, pharmaceutical executives, and scientist-entrepreneurs at the Neurotechnology Industry Investment & Partnering Conferences allowed me to understand the social networks that accord value to neurotechnology investments and TN practices.

What I learned at those events and through observations at the Cleveland Clinic supports yet another finding: TN, as a knowledge enterprise, emerges from a design that

does not begin with the experiences of patients but rather emphasizes molecular starting points. In this way TN sidelines patient-focused knowledge streams. An associated discovery of my own work concerns TN's acceptance/incorporation of certain kinds of risks, which are ultimately folded into TN's production of "emerging worlds" (Fischer 2003). With its accelerated developmental timeline (Garcia-Rill 2012) and its narrowed knowledge interests (Fang and Casadevall 2010), TN generates risk as a key element in the clinical encounter between clinicians and patients both because of the nature of biotechnology development under TN (that is, the focus on molecular strategies without clear connections to patient symptoms and experiences) and the already complicated nature of the science of brain function and the concretization of this lack of understanding in the material development of the biotechnologies themselves.[78]

However, this is not to say that it is experienced uniformly. In fact, my study shows that risk must be understood as unpredictable, local, and historically contingent. It was the ubiquity of risk that allowed Shana, who had undergone years of experimental treatments for her son, to suggest that everything felt risky. Thus, what emerged was what I have called "banalization of risk" – a position that is ultimately produced by one's historical circumstances, including the inurements to risk engendered via neoliberalism. This combination produces a dangerous ambiguity located between a dearth of understanding about the brain and a disregard for this dearth on the part of brain device manufacturers. Utilizing Shana and Jawan's experience as well as an analysis of the federal Humanitarian Device Exemption (HDE), I argue that risk –social, economic,

[78] Lochlann Jain's (2006) book on injury is an excellent example where assumptions about risk and injury are embedded into product design in ways that allow for an argument about the material and semiotic structures and social decision-making that lay within objects and which affect subjects in relation to those objects.

corporeal, financial, epistemological--is intimately intertwined with TN's products and processes.[79]

I show that the disjuncture between TN's outputs (neurotechnologies) and the dearth of health improvements emerged not only because of TN's orientation toward creating market-focused outcomes, but also because of the foundational scientific problems that underlay emerging neurotechnologies and were tolerated, even encouraged as essential to the progress of TN on occasion, by the industry.[80] Thus, as I reveal in Chapter 3, federally funded TN – ultimately institutionalized at the non-profit university - is a result of the risks of financial and intellectual investments in commercial neuroscience between 2006 and 2010. TN is also a consequence of the risks that permeated privately finances commercial centers before its transfer to the university. Rather than a view of TN as merely a gradual evolution of science and capitalism or an inevitable innovation within neuroscience, university TN programs are the byproduct of a set of key failures: a dearth of novel pharmaceutical innovation, efficacy problems for a

[79] Tracing TN's long continuum through animal models through to government exemptions I show that TN becomes a site for the transfer of risk – onto the public, the state, devices themselves and, as they enter the clinical encounter, onto patients. It is in this transference I see a glimpse of TN's unique operability in relation to risk. Anthropologist, Janet Keller offered a helpful question about how TN's financial operability is unique given the promises of leveraging of biotechnology. I offer that TN's unique operability in examining TN as a form of externalization and by recognizing the way that externalization was engineered to be a corporate strategy around risk and one that goes hand-in-hand with larger political and economic changes such as globalization, labor precaritization, cultural shifts towards democracy, "open-ness" as well as an increasingly global source of education labor and talent.

[80] Via ethnographic observation at the annual Neurotechnology Industry Partnering & Investing Conferences and analysis of market data and clinical research, I show how long histories of problems in pharmaceutical development and significant gaps in neuroscience, psychopharmacology and neuropharmacology knowledge alongside the tumult of the global financial crisis converged to make commercial neuroscience too risky for pharmaceutical companies and some risk averse investors. In this way, I show how the emergence of TN, in full bloom at universities in 2007 and 2008 materialized precisely at the moment in which partnerships with universities presented a clear risk-related opportunity for the neurotechnology industry. As a spate of biopharmaceutical companies downsized or closed their internal neuroscience research arms, universities began to fill a special role in early-stage neuroscience research.

generation of new psychopharmaceuticals that were already out in the market, and the inability of neuroscience to grasp the neurobiology of mental illness.

These failures were elucidated in my reports on observations at the Neurotechnology Industry Partnering & Investing Conferences, which were marked by anxieties over scientific problems. I mapped out how such events function as means to deal with problems in brain science. Via ethnographic examples I noted how TN links the pharmacological notion, Mechanism of Action, to scientific and biomedical truths about brain disorders. From here, I realized that TN was not only tying medical disorders to its own agenda, but something more: TN was and is facilitating the alignment of biological material with medical disorders.

As TN facts do not translate themselves, I traced the massive amounts of social work needed to marshal scientific facts for brain disorders. Because of the challenges of unambiguously linking language, concepts, and biological material, I concluded that TN was and is distinguished by its material-semiotic production; including the attempt to carve order out of biological and scientific chaos – requiring innovation in a context of severe knowledge absences.[81]

In the process of this research I unearth a key observation. I show in Chapter 4 how TN, as a research enterprise, turns the non-profit university into a risk shelter. Having already established risk as a category I see as both unpredictable but also tied to unknowns or the failures and faultiness of knowledge production, TN functions to "clean" high-risk, early-stage science for financial investment. For example, I chart how

[81] I show the development of necessarily discursive products: where discourse itself becomes the technology –in the forms of market ready explanations, in the form of new diagnostics which use one's own biological material and providing narrations for it and in the use and monetization of sheer biological material. In the end I ask a questions about the status of subjects in an epistemology of biological parts.

AstraZeneca "cleans" its investment by externalizing its early-stage research capacities onto university partners. In this sense, federally funded TN and the restructuring of academic science becomes part of a growing financial system in which high-risk investments are de-risked via the public sphere. It is here where I suggest that given TN's financial functionality, translational research actually functions as a form of finance.[82]

In tracing the means and systems through which these partnerships occur and their upstream effects upon the work of the scientific laboratory, especially as specific epistemologies get folded into the material practices and systems at the university, I also show how translation is facilitated through various transformations at the university level that were material, design-based, and architectural. I consider translation-focused websites, redesigned neuroscience laboratories, and the terms of university-industry partnerships to show how translational logics are reified and create durable epistemic effects among scientists and their partners external to the university. Like the redesign of markets, banks, and online sites in the rise of neoliberal economies so to, TN had a material infrastructure that would support and sustain novel financialization practices.

Consequences of the Financialization of Health: Risk and Substitutability

I want to add an additional argument about what I've called the financialization of health in relation to TN and its impact upon how risk is theorized.[83] For some scholars, financialization is merely a symptom of neoliberalism. However, to the extent that

[82] Thinking in this way ties TN to both corporate histories of risk-taking especially between 2006-2010 in the development of problematic pharmaceuticals and the over leveraging of pharmaceutical markets.
[83] Financialization, according to scholars is the growing encroachment of financial principles and its constructions upon everyday social life (Poon 2012): the "increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies" (G. Epstein 2005 p.3). Accordingly, the logics of finance become inextricable from analyses of contemporary knowledge societies or rather, knowledge economies.

endeavors such as that of TN become codified as producing health and to the extent that biomedicine is interpreted as constituting health itself, one sees a particular intersection of finance and health. One of my chief contentions is that given the financialization of knowledge in knowledge societies, risk and knowledge under regimes of financial speculation interact in novel ways. Thus, here I suggest a revision to the way that risk is being envisioned. I suggest that under financialization, risk becomes *that which can be increasingly substitutable* for problems in knowledge.[84]

An example of substitutability in the realm of health is in the case of the FDA's Humanitarian Device Exemption provided for the Deep Brain Stimulation (DBS) device in cases of epilepsy. As I recounted, there was initially widespread and documented clinical ambiguity about the use and benefits of DBS for epilepsy.[85] [86] However, via this FDA exemption, Medtronic, the device manufacturer, bypassed the normal FDA requirements for clinical trials, justifying it's use under the promise that it would benefit smaller patient populations, thus meeting the criteria for this particular FDA exemption program. According to the FDA's own description, this exemption allows for

[84] This is not merely to say that with the commodification of knowledge and biomedical knowledge in particular, that there is a concomitant increase in risk. Certainly this is the articulation of theories about the growth of risks under industrial modernization and its social implications (Beck 1992). Yet, the notion of a risk society does not get at the material implications or consequences of risk as it becomes wrapped up in epistemologies.

[85] As recounted earlier, pointing to Medtronic's own clinical trials showing little evidence of improved outcomes, the device failed to get FDA approval for widespread use in the United States for epilepsy patients

[86] Thinking with Mary Douglas and Aaron Wildavsky's (1983) contention that knowledge on its own cannot explain social decisions regarding risk. Douglas and Wildavsky's constructivist intervention ordains a view toward analysis of the socialization and social construction of risk and risk perception. The importance here is in its denaturalization. In others words, a constructivist conception works against seeing risk as simply emerging naturally from information and knowledge or its lack. Constructivist perspectives argue against models that treat certain kinds of responses to risk as merely inevitable, rather than viewing risk as a result of prior social, technical and political decisions. Thus, the notion of substitutability emerges from a constructivist view in which knowledge problems are allowed to persist. This diverges from a view in which such risks are simply inevitable and endemic to increasingly complex financial products in the case of the global financial crisis (Ho 2009; Poon 2008), or the ineluctable social costs of biomedical innovation (N. Brown 2003). Substitutability gets at an important kind of ontological precarity.

manufacturers to bypass "effectiveness requirements" that are standard for normal pre-market device approvals. According to the FDA:

> A device manufacturer's research and development costs could exceed its market returns for diseases or conditions affecting small patient populations. The HUD [Humanitarian Use Device] provision of the regulation provides an incentive for the development of devices for use in the treatment or diagnosis of diseases affecting these populations.[87]

Here we can see that problems in knowledge about the DBS device, evidenced by the FDA's initial denial based on *evidence problems* within Medtronic's own internal clinical trials, were "deproblematized" because of market intolerances[88]. As referenced by the FDA statement above, the necessity of manufacturer "market returns" created demands that justify the creation of this kind of state exception (Agamben and Attell 2005).

I locate this suggestion of a rethinking of risk in the notion of *substitutability*. It is not merely the rise in risk and its socializations that emerge in modernity. It is also the way in *which risk is increasingly accorded the capacity to stand in for problems in knowledge* such that knowledge problems can be assimilated into the needs of markets.

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[87] http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/HowtoMarketYourDevice/PremarketSubmissions/HumanitarianDeviceExemption/

[88] There is an alternative interpretation here. One could suggest that this exemption enables the manufacturer to continue research on the product despite its known problems, offering an incentive for companies to wade into the area of therapeutics for "smaller" populations. In other words, it would be a stop gap because, as anthropologist, Janet Keller hypothesized in a conversation about this issue, it is hoped that despite the problems and efficacy issues of the device for the diseases for which it is designed, it may still produce beneficial effects. In her wording, it is less a deproblematization and more of mechanism by which manufacturers can address evidence-based issues while also possibly providing some aid to severely ill patients. In response to this interpretation, I suggest that what is important here is the specific market-based justification "market returns" that opens up this possibility in the first place. In a system in which exceptions are ordained via market-based justifications, one is compelled to examine the regime under which knowledge problems are treated in particular ways and are dealt through specific decisions. In a context in which DBS devices were denied DBS approval based on concerns about its own trials, the system through which DBS devices were suddenly made available for patients necessarily includes *decision-making* around the status of problematic knowledge.

Her I hope to get at a kind of material precarity. Thus, rather than a theory of knowledge in failure, this is a view regarding the enrollment or incorporation of problematic knowledge into larger systems (in this case market systems) that deproblematize or sideline knowledge problems in the marketing of health related products[89]

Substitutability is also therefore useful in thinking about the ontological status of objects. Thinking with the social construction of biotechnologies, I argued in Chapter 2 that psychopharmaceuticals *contained* risk. Here I meant both the kinds of epistemic risks that emerge from unstable science or perhaps even from the assumptions of stable science as well as the financial risks that are part of the market needs that push commercialization in spite of these knowledge problems. In this material sense, risk more or less literally *stands in for* (or was allowed to stand in for) knowledge problems.[90]

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[89] There is similarity between the risk-laden collaterized debt products at the heart of the U.S. financial crisis and the crisis that occurred with psychopharmaceutical drug development. This similarity appears because both relied on monetization of objects containing known knowledge problems. In both cases one saw an accumulation of risk (for investors in both cases) as well as the transfer of this risk (to the public, to the university). While scholars noted the increasing transfer or resocialization of risk onto the public, crises such as the global financial crisis also revealed important details about the status of "problematic" knowledge. Of course, the "knowledge problems" in both situations are different. Furthermore, I do not mean to create a binary separating "good knowledge" from "bad knowledge." In using the term, *problematic knowledge* I refer solely to a social designation. What connects the case of risk-laden collaterized debt projects and my own case study about the use of risk-laden DBS devices for epilepsy is, I believe, financialization. In both cases, risk was allowed to stand in for documented knowledge problems. Importantly however, regulatory accommodation such as the HDE exemption did not necessarily change the status of problematic knowledge. The lack of evidence supporting the use of DBS for epilepsy was still found to be a scientific issue. My suggestion is not therefore that the notion of substitutability necessarily remedies given knowledge problems. Thus, perhaps *deproblematization* may be a confusing word. It is intended to reference ways of dealing with problems in knowledge and it is in this process of dealing with problematic knowledge where the notion of substitutability is pertinent. Lastly, in thinking about substitutability, I find the metaphor of the jalopy to be useful. The jalopy is often composed of "replacement parts" that may or may not work- including the use of sub-optimal parts or parts that were not intended for cars at all (like the use of duct table in lieu of rear light covers). Substitutability gets not only at the precarity of the overall car, but it also necessarily includes the decisions about what parts can be replaced and which ones cannot be replaced.

[90] Additionally, I suspect an even closer relationship between life science investments and the collaterized debt mortgage products that are at the heart of the global financial crisis that started in 2007. In fact, patent portfolios, catalogues of biomedical intellectual property constitute the new speculative assets in that their logic is akin to that of collateralized debt obligations in which massive problems in knowledge juxtaposed against sustained profitability created a rising tide of risk. In the example from psychiatry, where drugs had

However, knowledge problems undergirding psychiatric medications continue to persist despite the growth of the antidepressant market. Thus, rather than deproblematizing knowledge problems in their entirety, perhaps substitutability disconnects knowledge problems from *consequential* market problems or problems of access. The Humanitarian Device Exemption meant that the scientific problems found by the FDA did not necessarily translate into problems for some instances of therapeutic availability (as in the case of Jawan).[91] Efficacy problems with psychiatry drug investments did not necessarily translate into problems for investors in 2009 who anticipate ongoing research will continue to improve the scientific knowledge base that can be translated into efficacious outcomes. In fact, risk and problematic knowledge co-occur with all of the exemptions or exceptions I note. Thus, substitutability retains, importantly, a transitive property. Humanitarian Device Exemptions produce risk for patients and substitutes access for efficacy. Overvalued assets from a new psychiatry-focused biotech startup create risks for that biotech companies' investors and for healthcare markets alike. In this sense, substitutability's deliverance of risk necessarily implicates subjects.

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low rates of clinical success, but mergers and acquisition activity were quite high, one sees the way that knowledge problems in psychiatry, here represented by the "low rates of clinical failure" according to investor Manuel Lopez-Figueroa, did not translate into value-less intellectual property in psychiatry. I suggest that these problems became substitutable for risk - in a context of deep financial investments in CNS and a track record of existing profitability. In many ways, TN enables and institutionalizes a multitude of transferences: producing transitive knowledge as well as transitive risk.

[91] Of course, one could ask about whether the initial failure by Medtronic to get FDA approval is evidence of the way that knowledge problems do translate into a commercial problem. One can also ask about the extent to which HDE enables manufacturers to create new ways to continue research and testing for the purposes of improving a given device or intervention. Interestingly, DBS for epilepsy won approval in several other counties outside of the United States, Nonetheless, here I am focused on how knowledge problems get worked out under the demands of financialization, rather than the in response to a continuum of efficacies from unknown to poor to adequate to successful for "health" products.

Since the Humanitarian Device Exemption allowed Medtronic, the manufacturer of the problematic DBS device, to bypass normal safety and efficacy requirements (which it was found not to have met under the regular FDA review), and because this specific exemption was justified according to presumptions about the necessity of such exemptions to ensure private investment and continuing research, one can understand how DBS, a *problematic* device for epilepsy patients, was still presented as a solution for Jawan. That DBS's known knowledge problems did not prevent it from being offered to him suggests that financial viability can take the place of (Jawan's) *health* concerns under a regime in which risk is increasingly acceptable as a part of the translational continuum from science to health under the pressures of financialization. This prioritizing therefore also constitutes a shifting "moral" ground for decisions made around epistemic uncertainty.[92]

This construction of moral logics around which populations deserve state-facilitated exception relies on a moral reasoning process that explicitly "prioritizes" small populations at risk while simultaneously supporting the overarching biomedical translational research and therapeutic endeavor (Fassin 2012). Certainly, the explicit narrative of moral good at work in the Humanitarian Device Exemption obfuscates the working of markets. However, the creation of this exemption (and others) was only necessary because of a larger structure in which market logics ordain state-level healthcare interventions. Substitutability (thinking again about a poor person's use of

[92] For example, the FDA's Humanitarian Device Exemption employs a moral notion of humanitarianism to justify creating exceptions for risky biotechnologies to be used for small affected populations.

various devices/objects/materials as replacement car parts in a jalopy) is accordingly a form of contingency opened up via the demands of the market. [93]

Substitutability is, I argue, one of the emerging challenges for the continuing financialization of health. That the production of new risks emerges from this process means that the market driven translational process from research to production is as much about developing a tolerance for risk-burdened subjects and institutions, as it is an enterprise for the improvement patient health. Inevitably, the question emerges about what risks are acceptable or rather, what contingencies can be displaced (and which cannot be so sidestepped) under financialization. The translational continuum obscures health, rendering secondary the well-being of individuals like Jawan.

Against Totalizing Theorizations of People: Knowledge Performativity

Here I also want to point to the value of ethnography in the study of institutional processes. In particular, my findings regarding the role of space and digital environments in creating and sustaining translational processes and in facilitating translational partnering redefined epistemologies and priorities for research. Here ethnography revealed the simultaneous forces driving new social developments. In mapping how people are implicated in new knowledge regimes – such as the push for scientists to

[93] However, substitutability is more than mere speculation. In thinking about DBS for epilepsy, the folding of problematic knowledge into agendas to push the use of DBS into new market segments, beyond the limits of diseases such as Parkinson's and toward epilepsy in the absence of clear scientific support, illustrates something beyond speculation. It is also not simply deception, because in the case of DBS for epilepsy the science was simply unclear and there was an absence of positive clinical data. Therefore, this knowledge problem was substituted for accepted risk as Medtronic pushed for this new therapeutic use. Substitutability is not simply about a process based on unsound knowledge. Rather, its also about transience and replacement. It is about decisions and indecision. From a view to the intersections of culture and morality (Ericson and Doyle 2003) this process is about a kind of surrogacy that becomes the birthplace of moral calculations.

engage in translational questions over other questions, this project theorizes science and creates a new analytic for addressing scientific objects, processes, and outcomes. I discuss herein how environments such as the laboratory can compel subjects to engage in sustained forms of what I call knowledge contortions in terms of practices.[94] In a conference panel on suspension of disbelief, along with several colleagues I applied the literary device of "suspension of belief" that allows users to perpetuate literary fictions to technoscientific and medical contexts. In so doing, we began to think about knowledge performances at work in the clinical encounter where medical knowledge or facts are ambiguous and scientists and clinicians must choose among incomplete and ambiguous alternatives. Here I began to think of something like an "epistemic genuflection" in order to better understand knowledge performances that may not *ipso facto* be evidence of a subject's own belief and knowledge. Genuflection is the kneeling; it is a temporary moment in which the subject yields to what might otherwise be viewed as fictional or incomplete, even perhaps inferior, knowledge or belief.

Genuflecting to the language of a larger system within a translational network is an intellectual *gesture*; one that does not presuppose the ontological status of a reader's beliefs or disbelief, but rather, speaks to the epistemological genuflection (a genuflection made before contingency if we think with the literary device of suspending belief) that is

[94] As a metaphor, contortion is useful to get at the way that people are wrapped up in regimes, but also not permanently encased within them. Thus, Miku whom I introduce in Chapter 5, while largely unable to "resist" having to work in an environment in which she is "on display," her statement to me about her discomfort spoke to a kind of practical contortion produced in this new knowledge environment. Another example is illustrated in my use of the search functions at the CTSI website. Upon searching research cores, the website augmented and suggested alternative search paths which compelled me to rethink and re-phrase not only the search terms that I had used, but to consider adopting the proffered language in order to be in keeping with the larger terminological framework (as well as the CTSI database terminology). These small examples get at the implications of the subject in epistemological systems. Yet, the metaphor of contortion doesn't quite get at the loose connection or separation between something like a "contortion" and its tenuous connection to the subject.

often conducted or that is necessary as part of the new research processes and that is rendered necessary during knowledge transformations. This is most clearly shown in Chapter 2 where I witnessed clinicians at a Cleveland Clinic symposium, who worked at the forefront of new brain technologies and surgical methods and who expressed both deep concerns and cautions about new translational products such as invasive brain testing while also trying to reconcile their need to adhere to standard clinical practices

Thus, the notion of genuflection is useful because it gets beyond an overwrought scholarly emphasis on theories in which subjects are thoroughly apprehended or entirely predetermined via – "hegemonic regimes of truth" or the inevitabilities of neoliberalism. Genuflection is a performative choice (including suspension as a kind of performance) that gives the subject some agency rather than encompassing the individual totally within a theoretical frame. It reflects a suspension of disbelief or uncertainty in the service of the translational enterprise. This likely gets closer than totalizing theories to the complicated reality of knowledge in transformation and perhaps even the micro-processes involved in human meaning and metaphor making. Thus, reflection upon a reader's suspension of disbelief as part of the practice of reading fiction is instrumental in understanding the realm of a kind of epistemic genuflection.[95] [96]

[95] In fact, my time in the Alzheimer's lab revealed a reality that is much more akin to a set of devices that are located in contingency - a contingency that already approximates well-known ambiguities within the laboratory: the indeterminacy of discovery-oriented scientific process: often born out of chance, complication, technological revolution and sudden discovery. The sheer legacy of failure in creating effective biotechnologies for mental illness renders the underlying biological presumptions as still unproven rather than disproven. Thus, I think of the ethnographic example that Clifford Geertz invokes of "the wink" in The Interpretation of Cultures in thinking about the kind of opportunity that knowledge performativity enables – as a way of marking knowledge in various constitutions of social contingency. Certainly, the notion of epistemic genuflection also speaks to the mechanics of materiality; for the neurologist who admitted to Shana the possibility that DBS for Epilepsy may not work for Jawan, his admission falls in line with his professional ethical obligations, which are separate from his own medical knowledge and experience. That we are all implicated within systems that compel knowledge actions is to also acknowledge how systems and contexts compel performances.

Health as a Productive Site: How Ethnography Reveals What Health Becomes

My primary intervention in this dissertation is that rather than a view of TN as merely an evolution in neuroscience innovation or, optimistically, an enterprise concerned solely with improving health, that TN emerges at a particular historical moment in the corporatization of healthcare and reflects a strategy marked by the systematic transfer or offloading of investment risk rather than simply a new solution for patients. Here, I have suggested that TN is not principally about health. Rather, TN is a system for the *working out of particular problems in finance* that allow the health fields to continue to develop. TN solves material problems including the suturing of scientific narratives to biotechnologies, effectively matching marketable disorders with biological material. Yet, this thesis does not mean that TN does not lead to improvements in health. Rather, I point to the way that a primary function of TN is to remedy problems produced in the corporatization of health via pharmaceuticalization. In the process, translational neuroscience introduces questions about the category of health itself and the place of health in translational priorities.

In the way that public private-partnerships in the realm of TN get constituted in the name of health and grand bioscientific genuflections begin to be conceptualized as *health itself* - one can see how the *category* of health becomes increasingly transformed into a conduit for other forms of social, technical and market logics. As

[96] The importance of this is here to also destabilize any conflation between arrangements designed to conjure epistemological shifts and some necessarily actualized or total effect in the form of belief. It was not clear to me that Miku did not also regard the new regimes in which she was now mired as merely bureaucratic or as passing trends. In other words, I could not infer actual belief or faith underneath her rather perfunctory statements about TN or her work. Thus, I think that any analysis of translational shifts at the university must also include thinking about performances.

health becomes a site — a locus of risk, affect, and hope, and as it increasingly becomes a vehicle and machinery of finance in the enunciation of privatized interests, health becomes a crash site in the meeting of the moral, the material, and the market. In this site, an outstanding question looms large: where does the plight of patients fit in these emerging configurations? And what is the responsibility of the public to discern and recommend, even demand, alternative pathways?

It is in this set of complex convergences and the ways that people become implicated in these new configurations where the analytic capacities of ethnographic investigations become clear. Ethnography becomes particularly well suited to investigations that may enlighten the public regarding institutional growth and development especially as the risks to subjects and institutions (such as universities) are not apparently clear. As new research and science configurations come to stand in for real reflective practices in health, it is imperative to document the many seen and unseen ramifications, especially as these configurations enfold new and swelling risks.

Yet, there is also a real benefit for these kinds of in-depth investigations for the understanding of contemporary science practices and their effects. As I show in my analysis of the UCSF webtools, one can see the working of unspoken processes – digitally mediated – which impact on-the-ground scientific process, practices and conceptualizations. In this way, ethnographic investigations can transcend the optimistic rhetoric of TN to identify underlying values at work in TN as a system.

Yet, and perhaps here ethnography enables a critical precision, my research shows how the network of neuroscientists, academic and hospitals clinicians, and

investors, occupy a complicated relationship to these regimes. The laboratory scientist, Miku both performed resistance to her new laboratory configuration by putting up a curtain, and yet also yielded and continued her work in that very laboratory. Shana both investigated TN's new products and yet ultimately rejected them. Terry and Pauline found alternative solutions to help manage Terry's epilepsy. People are inextricably implicated in TN's shifts, but not entirely determined by them. Here, patients found ways to transcend TN's ideology and interrogate its infrastructures, and also asked questions about TN's implications for them as individuals. In complex institutional regimes such as TN, the task of the ethnographer is to reveal foundational processes that subjects themselves either champion, ignore, fail to recognize, or even consciously hide.

Lastly, to the extent that TN suffers from marginalization of key knowledge streams -- especially those created from the lives of patients -- in the creation and design of new research infrastructures and the outlining of important questions and priorities, a public caution must inform and interrogate the emerging transformations in research and medical productions carried out or designed in the name of health. In this way, ethnography enables the researcher to articulate contradictions- something that I do in mapping the financial impetus that allows risky products to be provided as therapeutic options to ill patients- a situation that I could have only learned about in spending time with patients and clinicians alike.

It is in this space of positionality where I hope to leave a concluding thought. As a mode of analysis, the ethnographic advantage lay in the ability to suture together the situated evidences borne from multiple perspectives. Rather than being tethered to

a single institutional rhetoric, the ethnographer is charged with understanding a system (and its systematicity) that permits the diverse rhetorics from different stakeholders. In making sense of this diversity - clinicians, patients, scientists, investors – and in connecting it with other forms of evidence, one begins to construct a picture of the larger infrastructure in which all are embedded and upon which new designs for interventions in health will be modeled.

Appendix A

The External Innovation Tool Kit

Though by no means exhaustive, the chief innovation officer's external innovation capability tool kit draws on a variety of tools at each stage of the innovation value chain:

1. *Grants and Scholarships:* Providing research grants to education or government institutions can leverage outside expertise with smaller investments. Funding innovative organizations can also provide a company with new technology and ideas from the diverse set of companies and stakeholders often brought in by these external bodies.

2. *Innovation Networks:* An innovation network can enable a company to develop an external community of interest within a framework controlled by the company that is open to outside innovators but closed to competitors. The goal is to encourage problem solving by a systematically identified network of global thought leaders in areas of interest to the company, as Amgen has done with its "extramural research alliances."

3. *Joint R&D Agreements:* These agreements, typically made with academic institutions or government agencies, are designed to support the mission of each partner. Such agreements are typically structured as long-term partnerships focused on areas of mutual interest to both parties. Potential benefits include breakthrough university research or government insight into industry challenges.

4. *External Advisory Boards:* An external advisory board is a multi-stakeholder group made up of different businesses and industries, often with representation from government or academia as well. The external members of such boards are usually independent experts with a diverse set of specialized expertise or knowledge. It is typically easier for a company to introduce expertise through an advisory board than to hire similarly experienced resources.

5. *Certified Developer Programs:* Certified developer or user networks can create communities of loyal partners, helping to accelerate and improve development and adoption. Aggressive adopters like Apple and Google have pioneered the reliance on third-party ecosystems to develop core products far more quickly than competitors that focus on in-house development.

6. *Incubators:* Incubators typically work with early-stage startups by providing facilities, contacts, and business advice to help them prove and launch their business. Partnering with an incubator can provide valuable access to potential technology partners as the startups develop their products.

7. *Corporate Venture Funds:* Similar in operation to a traditional venture capital fund, this type of fund is run by an individual company and uses the company's capital to invest in promising technology. It allows the company to exercise more control and to participate directly in the success of the companies it invests in. Corporate funds typically invest in companies with close tie-ins to the investing company's strategic goals, rather than for purely financial reasons.

8. *Limited Partnership Positions:* Investing in a traditional VC firm as a limited partner allows a company to make focused investments in particular technologies while spreading some of the risk with the general partner and other limited partners. This technique also takes advantage of the general partner's access to deal flow and expertise in negotiating and structuring deals and crafting exit strategies.

9. *Related Ecosystems:* Related ecosystems usually come in the form of alliances or joint ventures among companies joining together to support a technology or to package products into a solution. Cisco, EMC, VMware, and Intel have recently created such an ecosystem by contributing some of their intellectual property and product expertise to launch VCE, which targets the virtual computing environment. These ecosystems allow individual companies to leverage partner companies' capabilities and potentially gain access to untapped capabilities or resources, along with new customers in adjacent markets.

10. *Collaborative Innovation:* These efforts come in many forms, ranging from collaborations with individuals to working with other leading enterprises. Companies can use external innovation to collect ideas from a variety of sources, which might include external communities of enthusiasts, such as the open competition sponsored by Netflix to discover improved algorithms for recommending movies; vast networks of internal employees like Procter & Gamble's; or other companies in related fields.

11. *Venture Exchanges:* Venture exchanges provide a structured environment in which participating venture funds can feature their portfolio companies. Typically, a group of venture funds agrees to participate on a regular basis, although some venture exchanges are ad hoc in nature. Funds showcase companies with the requisite focus to potential customers, partners, acquirers, the press, and others, depending on the venture exchange's focus.

12. *Key Opinion Leader Councils:* These councils typically resemble an external advisory board in makeup, but they differ in scope, focusing on the problems and needs of the broader industry rather than on the direction of a single company.

13. *Joint Ventures and Partnerships:* Joint ventures are formal arrangements in which two companies form a legal structure and combine a defined set of assets and capabilities to jointly address a specific market need. This arrangement is particularly useful when the companies have complementary capabilities but neither could go to market on its own. JVs are one step removed from a merger, in that the parties are still independent but have very closely allied themselves in the chosen market.

14. *In-Licensing Programs:* In many cases, companies find it more cost-effective to license intellectual property that has already been developed than to develop their own. A company typically makes such a deal to enhance the functioning of its current products, or to use its superior commercialization capability to bring new technology to market more effectively than the technology owner could.

15. *Acquisition Programs:* When a technology that rounds out a company's product portfolio or strategic position is developed by another company, one avenue is to acquire sole ownership in the technology and/or the company that has developed it. Working with corporate development teams, CIOs can put in place technology acquisition programs that will scan the external environment for promising targets and bring them in-house.

Each of these tools can be quite effective when properly matched to the user's technology and market conditions. The key is to employ the right set of tools to maximize the probability of success without spreading management resources and attention too thin.

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