Assetization

Turning Things into Assets in Technoscientific Capitalism

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4 A Crisis for Cures? Tracing Assetization and Value in Biomedical Innovation

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Introduction

New advances in biology—from the rise of genomics in the late twentieth century and more recent breakthroughs in gene editing technologies—have conjured the cultural imagination of the "cure." When Mark Zuckerberg and Priscilla Chan launched the Chan-Zuckerberg Initiative in 2016 with their bounty from Facebook, they put forward an audacious goal: "to cure all diseases within the century" (Sample 2016). In the same year, representatives from both political parties advanced and eventually passed the 21st Century Cures Act in the US Congress, with the explicit aim of accelerating more cures to patients (Hudson and Collins 2017). Part of this legislation supported the "Cancer Moonshot" led by Joseph Biden, which carries the aim of delivering long-sought after cures for the elusive scourge (Lowy and Collins 2016). If the prior century was a golden age for physics, our current century has been branded by prominent scientists as one defined by the young and maturing field of biology and its promise for human health (Venter and Cohen 2014).

This chapter locates these hopes, however, within a context of a paradox: just as these imaginations are gaining greater traction, buttressed in part by gains in the science of human disease and treatment, a future of curative therapies appears further out of reach. To unpack this contradiction, I explore recent transformations in political-economic dynamics and valuation practices in biomedicine that can belie the very existence of curative therapies. These transformations—which place what Birch and Muniesa (this volume) describe as the "asset form" at the center of scientific and technological innovation for health—combine to constitute what I call the *assetization of biomedicine*. This analysis departs from more commonly

used lenses within sociological and anthropological traditions that have focused on the processes and impacts of *commodification* on healthcare—especially the consequences of exchange relationships in capitalist markets on the objectification of illness (Sharp 2000). By contrast, to comprehend the ownership relationships and future-oriented subjectivities to human health that I argue are central to the unfolding of contemporary biomedicine, this chapter charts an alternative analytic path.

To understand the nature of the paradox, then, I draw on scholarship from science and technology studies and political economies of innovation to define two central turns in the late twentieth century that have underpinned the assetization of biomedicine (Andersson et al. 2010; Birch 2017; Dumit 2012a; Lazonick and Tulum 2011; Mazzucato 2016; Pisano 2006). The first turn has been the emergence of a "relay race" model of drug development in which ownership over intangible knowledge assets is passed along multiple actors (i.e., venture capitalists, small biotechnology companies, and the shareholders of large, publicly traded companies) from early stages to regulatory approval (Lazonick and Tulum 2011; Pisano 2006). Rather than being used to recoup research investments within integrated pharmaceutical companies, patents in this model take on a new function as monetized assets. Monetized assets in these financial markets are valued not for their current profitability but for the downstream earnings potential they bring. This first turn has been codependent with a second: an evolution in the epistemic practices and narratives of valuation within clinical medicine and health economics in which health is abstracted away from the felt illness experienced by patients toward a quantified valuation of statistical health improvements and averted future disease at the level of populations. In the process, illness is redefined as risk, and health as future-oriented risk reduction (Dumit 2012a). Taken together, the assetization of biomedicine denotes both the political-economic transformations involved in making knowledge into assets for financial valuation and business strategies, and also the associated epistemic, narrative transformations that turns health into a future-oriented "fact."

Studying assetization thus reveals the ways in which the structures and practices of valuation in finance become entangled with the valuation of health by patients, physicians, and policy makers. To examine this entanglement and its consequences, curative therapies are a particularly interesting class of "things" to consider. By ending disease processes rather

than mitigating their progression, curative therapies are culturally and biomedically valorized precisely because in producing positive health outcomes, they obviate their own necessity. Yet due to the transformations involved with assetization, curative therapies are caught within two vexing crosswinds.

In one crosswind, cures carry the possibility of eliminating the very potential for continual revenue growth on which their value as assets in financial markets rely. Cures thus present a structural business challenge for biotechnology and pharmaceutical companies (Dumit 2012b). In another crosswind, the rare curative therapies which *are* developed are valued as assets that create seemingly infinite possibilities for health improvement, which is then used as justification for increasing financial remuneration to their manufacturers (Reinhardt 2015). This remuneration, represented in the high prices of new therapies, ultimately challenges governments and health systems with finite budgets and limits patient access. Curative therapies are thus within tantalizing reach for many diseases due to advances in basic and clinical science, but what can we make of their future against the terrain of the assetization of biomedicine? After describing the transformations that define the assetization of biomedicine, I use the case of curative therapies to explore the central logics and limits of assetization and conclude by considering the competing dynamics that could shape whether this cultural imagination of curative therapies can one day mirror reality for patients.

The Context: Commodification's Blind Spots as an Analytic Frame for Biomedicine

The need to bring the "asset" form into an analysis of biomedicine, however, may not at first blush be obvious. Indeed, sociologists and anthropologists have produced a rich tradition of analyzing biomedicine, and the relationships between the "things" of biomedicine—such as drugs, genes, bodies—and their social contexts (i.e., people, markets, institutions). A central thread in this tradition has been unpacking the implications for the configuration of these "things" as commodities which, through their entry into exchange relationships in capitalist markets, become emblematic of multiple transformative social processes captured under the banner of "commodification" (Csordas 1994; Pellegrino 1999; Scheper-Hughes and Lock 1987; Taussig 2010; also see Braun, this volume).

Of concern in this literature is tracing how the exchange relationship in capitalist markets renders human categories—such as the moral and phenomenological experience of health and illness—into an object of economic desire (Pellegrino 1999; Sharp 2000). The objectification in this view reduces human life to a transaction, where the value of health (represented in a drug, intervention, or surgery, for example, necessary to sustaining life) is exchanged for some counterpart value—most often indirectly, through a system of money. This process has been interrogated, often from a vantage of critique, across a wide array of settings and cases—such as with the privatization of health services due to neoliberal structural adjustment policies in developing countries, or the proliferation in technological intervention (i.e., medicalization and pharmaceuticalization) on human bodies across industrialized countries in the postwar era (Keshavjee 2014; Abraham 2010).

A related but distinct concern of commodification studies that focus on biomedicine has been the intertwining of more recent advances—such as gene-editing and reproductive technologies—with new iterations of financial capital and markets. The angle here has been to examine the impact of these technologies in creating new biological sites (i.e., genes, organs, embryos) for capitalist accumulation and thereby further fragmenting the body (Helmreich 2008; Sharp 2000). Studied with the popularized conceptual apparatus of "biocapital," scholars have been particularly adept at exploring the ways in which technological advances and financial capitalism enables biological materiality to enter into commodity relationships, as well as the critical function of promissory rhetoric in mobilizing speculative capital to convert this materiality into capitalist value and accumulation (Helmreich 2008; Rose 2007; Sunder Rajan 2006).

These literatures, while offering valuable insights into the intersection of capitalism and biomedicine, leave open at least three directions for investigation that are particularly relevant in studying the possibilities for curative therapies. First, as Birch (2017) has detailed, discourses of the future and the conversion of biological materiality via the commodity form do not sufficiently capture the genesis and management of value in these modes of accumulation. Extending our grasp of value in contemporary biomedicine requires interrogating the political-economic and valuation practices that *make* this conversion and discourse possible. By this view, cures are not inevitable, based on some biologically latent potential or promissory rhetoric, but are mediated by social dynamics that shape their prospects.

Second, while a concern with commodities has focused on exchange relationships, a consideration of the asset form allows a focus on the proliferation of *ownership relationships* in biomedicine—such as with the control of intellectual property over scientific and therapeutic knowledge (Birch 2017; Gagnon 2016). This control is, as highlighted in the introduction to this volume, also linked to market logics in financial markets that are different than those of commodities—where value is tied less to profitability but more to the potential stream of earnings that ownership of an asset may bring. This future-orientation has implications for cures which may be profitable but by definition can carry uncertainty for ongoing accumulation.

Third, this configuration of ownership, centered on future-oriented valuation, can lead to financial modes of value which colonize social spaces beyond markets—from institutions such as health delivery systems to the doctor-patient relationship, to individual perceptions of disease (Chiapello 2015; Van der Zwan 2014). Though capitalist relations can alienate and objectify through the commodity form, an analysis of the asset form may reveal the ways in which common understandings of health may also be reoriented toward an "investment" centered aspiration—where health too is an asset, and where the quantification of this value (signaled through prices) aims to legitimate and valorize. This emphasis on the future can translate to new kinds of *subjectivities* toward health among patients, scientists, public officials and business executives. The realization and affordability of curative therapies, in turn, may depend in part on the epistemic practices and narratives of value that reify these subjectivities. These relative blind spots in commodification studies regarding biomedicine present an opportunity for inquiry. My task in the remainder of this chapter is to trace the asset form and its implications for biomedicine: to do this, I look at the case of biomedical innovation—the process by which new therapies are developed—and the two transformations that have been at the heart of its assetization.

Patents for Research to Monetized Patents: Turning Drug Development into a Relay-Race of Assets

The first turn has been in the political-legal and economic dynamics underpinning biomedical innovation, where value is derived less from the revenue and sales of commodities—such as approved medicines—than from

capitalization and control over intangible assets in financial markets. In this model, therapeutic development has become akin to a relay race, in which intangible assets (i.e., knowledge property) are passed along multiple actors—from the state to venture-backed companies to large biopharmaceutical companies (Birch 2017; Pisano 2006). While this model has attracted an explosion of capital and served as the basis for significant sums of capital accumulation, it has also exposed its actors (especially the "anchor" in the relay race—large, publicly traded pharmaceutical companies) to a structure of vulnerability and crisis that has implications for the fate of curative therapies (Sunder Rajan 2012).

For much of the postwar era of biomedical innovation—which witnessed the ascendance of large industrial pharmaceutical companies—research was carried out within the confines of large firms as well as publicly supported labs (Slaughter and Rhoades 1996). To attract investments for research and development, intellectual property protections granted to these firms by the state were viewed as the critical incentive (Scherer 2004). This patent centered organization of biomedical research has been understood to facilitate scientific development, in which inventors receive monopoly ownership for a specific period of time (twenty years from the time of invention) only after which the public can gain full access (i.e., generic licensing) to the knowledge produced by the patent. As the STS scholar Biagioli (2006) has chronicled, patents have been viewed as governing a legal exchange between consumers and investors of patent protected products, with these transactions conceptualized in the law as a "bargain" or "fair exchange"—investors' right to recuperate costs of research and development in exchange for customers' access to the inventor's product.

The importance of this argument to the pharmaceutical industry—in which monopoly pricing is justified on the basis of research and development costs—is illustrated by a series of studies by the industry-funded Tufts Center for Drug Development. Since the 1980s, economists there have published estimates of the escalating costs of research and development (upwards of $2.7 billion per drug as of 2014) as an illustration of the need to maintain intellectual property protections and the significant pricing power these protections grant (DiMasi et al. 1991; DiMasi et al. 2016). In this conception, the prices that companies later charge for approved, patented medicines is, in turn, ostensibly tied to the investments made within the walls of corporate laboratories. Though the DiMasi figures have been

disputed (with alternative studies showing much lower costs for research and development), this justification for patents and prices has continued to dominate folk understandings of biomedical innovation (Light and Warburton 2011; Nik-Khah 2014). Yet even as this ongoing debate over patents and the costs of research and development has persisted, a series of changes around 1980 led to a transformation in the actual function of patents in biomedical innovation.

With a flagging economy and facing new global competition from Europe and Japan, US policy-makers viewed government funded research in the 1970s as a previously untapped source of growth (Rai and Eisenberg 2003; Slaughter and Rhoades 1996; Vallas et al. 2011; Berman 2012). To pursue this direction, the US Congress passed the Bayh-Dole Act in 1980s, which allowed for the private patenting of government-funded research for the purposes of commercialization (Rai and Eisenberg 2003). In the decade that followed, universities across the country developed technology transfer offices, designed to support researchers to convert their publicly funded projects into commercial ventures (Kenney and Patton 2009; Mowery and Sampat 2004). With the opportunity to gain equity in start-up enterprises (and with corporate bureaucracies more risk-averse in developing and adopting new technologies), professors could view their research as holders of business potential (Block and Keller 2009; Berman 2012). Some universities could, in turn, make handsome gains through royalty agreements with these new enterprises (Mowery and Sampat 2004).

The financing of these new firms would come from a nascent source emerging during the 1970s and 1980s: venture capital. Borne in part from changes in pension regulation in the 1970s that enabled pension funds to direct more of their capital to riskier ventures as well as new technological opportunities (e.g., computing) that brought down the start-up costs associated with new companies, venture capitalists pursued investments in start-up enterprises as a vehicle for financial returns as well as industrial transformation (Gompers 1994; Gompers and Lerner 2004). The early model from that period remains today: venture capitalists typically provide rounds of capital in the early stages of a company's development in exchange for an ownership stake in the company (Robbins-Roth 2001). Viewing themselves as "active investors," venture capitalists join the boards of the company, attempting to use their networks and financing to convert uncertain enterprises into high value investments (Hopkins et al. 2013). In

this model of investment, the exit is of pivotal importance, as venture capitalists typically stick around for three to five years, with initial public offerings on equity markets (e.g., NASDAQ) or acquisitions by larger companies as the pathways for generating returns (Robbins-Roth 2001). Advances in molecular biology in the 1970s along with the Bayh-Dole Act attracted venture capitalists to the emerging sector of biotechnology during the 1980s and 1990s (Pisano 2006). The early success of companies like Genentech stoked the hopes that new enterprises could convert these new advances in science and push the frontiers of a so-called biotech revolution (Nightingale and Martin 2004).

These new venture-backed biotech businesses exemplified a shift in business strategy. As documented by management scholar Gary Pisano (2006), these businesses and their venture backers aimed to monetize intellectual property—a stark departure from integrated, incumbent firms that sought to bring drugs from laboratory testing all the way to patients. These biotechnology companies rarely bring drugs to market and are not valued for revenues on sales; rather, their intangible assets are valued based on the earnings stream they might one day bring. This has led to the phenomenon of what Lazonick and Tulum (2011) have called "product-less IPOs"—with most biotechnology companies having no approved drugs at the time of their public offering. The existence of financial markets, however, provides investors and traders opportunities to gain a return by entering and exiting their stake in these enterprises, either through a sale, public offering, or fluctuations in share price. In this conception, patents are not bargains between investors and the public for recouping the costs of research and development, but rather tied to the expectations of future value materialized in financial markets.[1]

While biotechnology companies entered onto the scene during the 1980s and 1990s, large, incumbent pharmaceutical companies were undergoing a transformation of their own. This period witnessed the rise of shareholder value-maximization (SVM) as a corporate governance strategy with profound implications across the US economy—including the pharmaceutical sector. In this latest iteration in a long-running debate over who should control the firm, shareholders, not managers, were viewed as efficient allocators of capital in the economy. Scholars from law, economics, and finance advanced the notion that shareholders could use share prices in financial markets to direct capital toward higher growth companies and sectors, whereas managers might instead allocate capital toward increasing

the size of their businesses or risky projects that might be wasteful (Fama and Jensen 1983; Jensen and Meckling 1976). Additionally, shareholders were viewed as the only economic actors in corporations who make productive contributions without a guaranteed return—as opposed to creditors, workers, suppliers, and distributors, who are compensated through a market-determined price for goods and services (Fama and Jensen 1983). This claim has been used to justify shareholders as the recipients (through dividends and share buybacks) of any "residual" profit left over after a company has paid all their other stakeholders (Lazonick 2015). Taken together, SVM has meant directing accumulation to shareholders—both because of their role in the broader economy (as "efficient allocators") as well as their roles within corporations (as "residual claimants"). To discipline executives to follow this shareholder mandate, corporate boards and shareholders have made executives into major shareholders by offering generous stock-based rewards that tie their compensation to share price performance (Lazonick 2015).

In this context of SVM, large pharmaceutical companies are evaluated not on their current profitability, but on their potential to deliver future earnings growth for shareholders. For the incumbent companies with existing streams of revenue, shareholders expect 8 percent to 10 percent returns on an annual basis. This figure mirrors the cost of capital, which roughly represents the returns on capital that investors can expect to receive in financial markets from ownership in other assets (such as mutual funds and bonds) (Damodaran 2017; Nitzan and Bichler 2009). This shareholder-driven growth, however, exposes these larger, publicly traded companies to what Sunder Rajan (2012) has described as a two-sided structural crisis.

On one side of this structural crisis, companies face "patent cliffs"—the expiration of intellectual property protections on their existing assets that bring streams of revenue. With expirations, incumbent firms lose these streams to generic manufacturers, which can charge much lower prices—a margin on top of manufacturing costs—for their unbranded products. Take the example of Pfizer, which lost protections for its cholesterol-lowering drug Lipitor in 2011—and thus an earnings stream of more than $10 billion, accounting for over 20 percent of the company's total revenue (Harrison 2011). Between 2010 and 2014, the industry experienced an erosion of an estimated $78 billion in sales due to patent cliffs (Harrison 2011). Replacing these streams of revenue—*and* generating growth—can require

bringing major new therapies to market almost every year. But this requirement collides with the realities of biomedical innovation, where product development often takes over a decade and is riven with failures, due to the risky nature of human clinical trials which other sectors (such as information technology) generally do not face (Pisano 2006).

This time horizon for investment takes us to the other side of the structural crisis: dry pipelines of potential drugs within large, incumbent pharmaceutical companies. Faced with meeting near-term growth expectations, executives of large companies are more risk-averse to the longer-term, patient investments needed to stock pipelines through early-stage science and preclinical testing. Upon the expiration of Lipitor, for example, Pfizer had no drugs in development that could replace the lost revenue (Harrison 2011). This lack of investment does not signal a lack of resources but rather the influence of SVM as a corporate strategy. After shutting down its anti-infective research unit less than two years before, for example, Pfizer spent the first three quarters of 2015 directing $11.4 billion in share buybacks and dividends to its shareholders (Roy and King 2016). Dry pipelines are one outcome of this aversion to relative long-term investment, itself a product of shareholder control in financial markets.

To meet the shareholder expectations of growth while facing patent cliffs and dry pipelines, large companies have become almost structurally positioned in the innovation process as acquisition and late-stage clinical trial specialists, betting on therapeutic assets that may be potent near-term vehicles for earnings growth. Pharmaceutical and life sciences companies spent $228 billion on mergers and acquisitions in just the year 2015, illustrating the reliance on such transactions to generate growth. Gilead's former CEO John Martin, sharing a financial market friendly view held among many pharmaceutical executives, reassured investment analysts on a 2015 earnings call by saying, "we typically like things where we can have an impact on phase III," indicating the later-stages in drug development where companies tend to prefer acquisitions to generate near-term growth (Roy and King 2016). In making these acquisitions, larger companies like Gilead use "capitalization" as a calculative device through which to forecast this potential accumulation. As part of this quantification, companies anticipate the prices they can charge health systems—a topic to which we turn in the next section—and use debt and stockpiles of capital from previous sales to make what are often sizable bets on new streams of earnings.

This organization of innovation carries dramatic implications of the kinds of drugs that are developed. Larger companies—possessing the comparative advantages of global regulatory, manufacturing, and distribution expertise that smaller companies lack—become gatekeepers for the kinds of drugs that make it to patients. In this calculus of growth, the smaller companies (either venture-backed or publicly traded after an IPO) described earlier have become developers and suppliers of assets that larger, incumbent companies will value (Andersson et al. 2010). Acquisitions and late-stage clinical trials by these larger, incumbent companies in turn have become almost entirely oriented around meeting the continual requirement of accumulation and growth, which has quite apparent consequences for curative therapies.

This asset-centric, relay-race model of drug development represents the political-economic transformations that underpin the assetization of biomedicine. Intangible assets serve as the basis for valuation along this relay race and are configured not as patents for recouping research investment, but as monetized property that become vehicles for accumulation for multiple economic actors (from venture capitalists to equity traders) in financial markets. The future-oriented ontology of assets here shapes the trajectory of biomedical innovation, where profitability and revenue from sales of existing products is less the focus: at stake is betting and trading on quantified expectations of the future. This ontology of assets not only privileges certain kinds of assets—those that can generate continual accumulation—but it is also intertwined with changes in our understanding of health and illness.

From Felt Illness to Assetized Health: The Epistemic Practices of a Future-Oriented Health

Generating continual accumulation in financial markets has required a second critical turn defining the assetization of biomedicine: a changing locus of value in health, in which health itself is configured and valued as an asset. Health here is not viewed as healthiness, which requires no therapeutic intervention but rather as a state of preventing potential disease through ongoing and growing therapeutic consumption. Arriving at this understanding of health and the role of treatments has required the development of two sets of epistemic practices—one within clinical medicine and

epidemiology and another in health economics—which has in turn buttressed a narrative transformation of health. In this newer narrative, health through treatments is valued by individuals and patients for reducing risk and valorized by drug developers for their potential in creating population health improvements. Before unpacking the implications of this version of health for the materialization of curative therapies, I elaborate these shifts in epistemic practices and narratives.

The first set of epistemic practices has been described by Joseph Dumit (2012a), where the rise of prospective clinical studies and clinical trials in the postwar era enabled a redefinition of health from a binary of healthy/sick toward a continuum of risk. Much of the early history of modern biomedicine in the nineteenth and twentieth centuries had centered on a "felt illness" model of disease, which had in turn framed the need for new treatments: put simply, treatments allow people who feel sick to get better. In this prevailing scenario, physicians would attempt to provide the antidote for a patient seeking care for an episode of illness.

Yet contemporary biomedicine has been demarcated by a major change: alongside "felt illness" models of disease a statistical, population-level model of disease has emerged in which health is realized by the extent to which the risk for potential downstream disease is reduced. In Dumit's tracing of this empirical phenomenon, a central route to achieving this risk reduction is ongoing diagnosis and treatment, which, from the vantage of business, has become a primary vehicle for accumulation. To pharmaceutical companies, patients become valuable only when they can consume more treatments. Dumit (2012a, 17) calls this phenomenon "surplus health," which he defines as "the *capacity* to add medications to our life through lowering the level of risk required to be 'at risk.'" This capacity has been shaped by the rise of two developments in clinical medicine and epidemiology: prospective clinical studies and clinical trials.

By tracking individuals over long periods of time and examining the links between biological markers (such as cholesterol or blood pressure) to downstream events (like heart attacks and mortality), prospective clinical studies rendered visible a phenomenon previously shrouded: the risk of disease progression. The Framingham Heart Study, begun in 1950, is the most prominent early example of such a study, tracking over 5,000 members of a small town over multiple generations to uncover the risk factors of heart disease (Dumit 2012a). Through measuring statistical links

between risk factors and disease, such prospective clinical studies enabled what doctor-epidemiologist Geoffrey Rose (2008, 42) described as "a type of disease not hitherto recognized in medicine in which the *defect is quantitative not qualitative* (emphasis added)." Unbeknownst to the patient, even small imbalances (such as high blood pressure or low thyroid levels) could indicate the early onset of disease. The downstream impact of these small imbalances, in turn, is detectable only by measuring large populations over long time horizons. From diabetes to heart disease, from psychiatric illness to Alzheimer's disease, such clinical studies have served to reframe our conception of disease from binaries (healthy/sick) to a continuum of risk.[2]

To intervene on this continuum of risk required another development in the postwar era: randomized clinical trials. By comparing treatment arms versus control arms (that received the prior standard of care or placebo) in samples deemed to be representative of populations, randomized clinical trials aggregated evidence about the effects of treating individuals on the health of populations. Such evidence has produced what Dumit calls an array of "public health facts" (e.g., taking X medication for five years reduces the chance of heart attack by 20 percent), where once a patient crosses a risk threshold (as indicated by clinical studies and trials), treatment becomes the primary way of reducing the probability of future disease. Detecting these population-level effects required repeat treatment over long periods of time in large numbers (often hundreds or thousands) of individuals. Through this process, large-scale trials redefined disease from episodic states of abnormality in need of acute treatment to chronic events demanding long-term management and prophylactic interventions to be deployed even before the onset of disease (Sunder Rajan 2012).

For drug developers and pharmaceutical companies, this redefinition of health with clinical studies and trials became fundamental to the business strategies of continual capital accumulation required by financial markets. In the view of drug developers, new market potential was unlocked in two related ways. First, every person—even those not experiencing any felt illness—could now become subjects for intervention by crossing certain quantitative thresholds (treatment eligible). Companies could find, as one executive put it, "more hidden patients among the apparently healthy" (Dumit 2012a, 114). This meant larger market size. Second, viewing health on a continuum also grew the duration of treatment that patients might require, with disease mitigation requiring years or even lifelong treatment.

The development of statins and anti-diabetic drugs along with the aggressive pursuit of anti-Alzheimer drugs are examples of such regimens. As Dumit (2012a, 115) puts it, "Diseases previously regarded as incurable downward progressions came to be seen as long-term chronic conditions requiring prediction, surveillance, and chronic treatment." Mitigating disease through chronic treatment, then, could become a powerful accumulation strategy for companies in pursuit of continual growth.

But this mode of accumulation has been dependent not only on manufacturers seeing this "surplus health" as a locus of value, their customers—health systems around the world—have also needed to behold this value and be willing to pay for it. Translating risk reductions through treatments into a durable mode of accumulation has thus required another pivot: the economic quantification of this future-oriented value, in which the price and costs of therapeutic interventions are deemed commensurate with the value of health improvements for health systems and the populations for which they are accountable. Alongside developments in clinical medicine and epidemiology, the emergence of health economics thus contains the second set of epistemic practices of importance to the assetization of biomedicine.

With the prices of new medicines typically multiples above the median wages of individuals, assessing their value has fallen to the ultimate customers across the world: public health systems and private insurers, depending on the given country (Reinhardt 2015). With limited budgets, these buyers make pivotal determinations over how to generate the most health improvement for their populations with the money they have. To align their business strategies to the preferences of their buyers, companies which typically had defended their prices on the costs of innovation have turned to a different strategy called "value-based pricing" (Claxton et al. 2008; Gregson et al. 2005; Maldonado Castañeda 2016).

In this strategy, manufacturers set prices based on the "value" that they anticipate health systems will attribute to a given therapy. Manufacturers make their estimates based on their knowledge of the health economics methodologies that health systems use in assessing this value. Through "cost effectiveness" research, for example, health systems weigh the future benefits versus costs of a given treatment strategy (Claxton et al. 2008; Weinstein et al. 2009). New treatments, in this research, are tested for whether they create more health in the future—measured through a unit of health known as "quality adjusted life years"—than comparative interventions.

These benefits are then weighed against the costs of different treatment strategies, with health systems using a value threshold—the upward limits of what they are willing to pay for a unit of health—to determine whether they will approve funding for a new treatment.[3]

To further quantify the value of their therapies, manufacturers also attempt to calculate the prevention value of their medicines: the amount of money saved and economic value created by preventing downstream disease (Maldonado Castañeda 2016). Such a view can be found in the marketing materials produced by the industry. In a fact sheet produced by the US pharmaceutical lobbying group PhRMA they argue that "every additional dollar spent on medicines or adherent patients with congestive heart failure, high blood pressure, diabetes and high cholesterol generated $3 to $10 in savings on emergency room visits and in-patient hospitalizations" and that "a 10 percent decrease in the cancer death rate is worth roughly $4.4 trillion in economic value to current and future generations" (Zirkelbach 2015). Dollars spent today on medicines, goes the story, creates future economic value. These cost-effectiveness value and prevention value methodologies thus aggregate the benefit across populations, quantify the economic value of this future benefit, and then compare this against competing or prior standards of care.

While clinical studies and trials have rendered visible the health benefits for early and ongoing treatment, these economic methodologies have quantified future benefits and provided a rationale for their valuation and pricing. These epistemic practices from medicine and health economics are part of a larger narrative shift, in which different actors carry new subjectivities toward health. From the vantage of governments, for example, health through therapeutic intervention is recast from an expenditure to an investment (Bach and Pearson 2015; Van Nuys et al. 2015). High prices, in many cases exceeding $100,000 for a course of treatment, are represented as signifiers for the potentiality of health improvements for its citizens. Across many therapeutic areas, each price sets the floor for the next product's price, as better health outcomes are to be valued with greater remuneration (Bach 2015; Vernaz et al. 2016). To sustain population health improvements, then, the state must be willing to continue to pay higher prices for more valuable therapies.

Patients are also brought into this mode of value, where the realization of future health is in part dependent on an individual's willingness to

consume therapies now (Dumit 2012a). Such therapeutic consumption is far more than is necessary to maintain current health; this kind of future-oriented health through therapeutic intervention, not a healthiness that obviates treatments, has become central to the accumulation strategies of pharmaceutical companies. Treatment now, and into the future, is an asset, with health redefined into an asset—one that can be measured through statistical probabilities and then translated into economic value through cost-effectiveness research and prevention modeling. Along with shifts in the political economy of biomedical innovation, in which patents become monetized assets for accumulation, this assetized health carries stark implications for the possibility of curative futures.

Illusory Cures? The Limits of Assetization

In this context of valuing health in terms of the future, curative therapies would appear to lack any rivals. Medicines which end the progression of disease, not simply mitigate it, can radically alter the outlook for a patient and for populations—a future, as one recent conference considered, "free from disease" (Research America 2017). Of course, such a utopian forecast is far from our grasp, and the notion of curative therapies is not a monolithic one, given that the impact of a cure depends on the nature of the disease being targeted. In the case of an infectious disease like hepatitis C, for example, curative therapies are eliminating the pathogen from the blood stream, and over time may eliminate the disease from the population altogether. In the case of diseases that arise less from external pathogens but from genetic (e.g., cystic fibrosis) or gene-environment (e.g., many cancers) etiologies, a curative therapy may halt disease in an individual patient, but the disease would recur in the population with new incidences. The point of considering cures here, however, is not to capture all the complexities of different pathologies and their curative "matches," but to better understand the dynamics and limits of assetization for materializing the kinds of therapies so often imagined in our conversations about the future of biomedicine.

In thinking about assetization alongside cures, two potential crises feature centrally: first, the generation of continual growth in accumulation through therapeutic consumption and second, the naturalization of surplus health (and the justification of increasing prices) against the finitude of public budgets. To these, I also add a third potential crisis: the tendency

of logics and practices of assetization to appropriate—and in many cases, elide—the public interest and the role of public investments in the breakthroughs behind curative therapies.

First is the problem of continual growth in accumulation in a stock-market, shareholder-driven political economy of therapeutic development. As I described earlier, throughout the life of an intangible asset, from the laboratories of a venture capital-backed company to control by a publicly traded pharmaceutical business, its value is determined by the future earnings *growth* that ownership and control of an asset might derive. Yet curative therapies are assets that eliminate the very possibility of growth on which its value as an asset relies. In this financial context, therapies for chronic diseases that require patients to take medicines over a long duration are—in contrast to cures—the optimal vehicle for accumulation. As Dumit (2012b, 81) puts it, "In too much drug research, cures get in the way of repeat revenue." Better than cures, from the vantage of a publicly traded company, are treatments for chronic pathologies such as high cholesterol and Alzheimer's, which show no sign of abating in terms of prevalence and incidence. With mitigator treatments, companies can accrue the kind of recurring revenue and growing accumulation structurally mandated by shareholders.

The logic can be used to understand why vaccine development is eschewed by companies in favor of mitigator treatments. In a study of different revenue models, Kremer and Synder (2003) put this view forward plainly: "Vaccines are more likely to interfere with the spread of the disease than are drug treatments, thus reducing demand for the product." A parallel to this situation can be found with the case of hepatitis C, a rare instance in which a cure has been developed. Gilead, the manufacturer that brought the curative drug *sofosbuvir* to market in 2013, made over $45 billion in revenue in the first three years of sales—a major key in tripling the company's annual revenue in that time-period (Roy and King 2016). Yet after its share price reached a peak near $120 in 2015, Gilead's market value dropped by almost half by early 2017 (Nisen 2017). The reason: by curing hepatitis C and reducing the potential patient population, Gilead was diminishing its opportunity for future growth. In a 2017 research report for industry leaders, financial analysts at Goldman Sachs posed Gilead's predicament with hepatitis C as a cautionary tale for the future of genomic therapies. In asking "Is curing patients a sustainable business model?" Goldman Sachs suggested that the central proposition of genomic advances—producing

cures—represented a threat to the search for sustained cash flow that companies sorely needed (Kim 2018). Cures, in other words, do not work as financially valuable assets.

From this configuration arises a second problem with assetization and the possibility of curative futures: even if such therapies are developed, the valuation practices involved in a future-oriented view of health (e.g., value-based pricing) aim to naturalize increasing prices, thereby creating challenges for access to care for patients and health systems. When breakthroughs do occur, as in the case of hepatitis C, they often lead to significant potential improvements for patient and population health. In attempting to commensurate this potential improvement with price, health economics practices such as cost-effectiveness and prevention value legitimate rising prices with each progression in therapeutic advance.

These practices, however, place patients and public health systems in a challenging situation. Governments want to allow for innovation while also assuring access to new treatments. By making the value assessments I described earlier, health systems signal to drug developers that they are willing to pay more for better therapies while also setting a relatively high ceiling on the extent to which companies can push their monopoly pricing power. Such valuation practices present both budgetary and moral challenges for health systems. Public officials here are encouraged to "think like investors," as Birch and Muniesa (this volume) put it, to account for how paying for a given therapy at a certain price *now* may optimize a return on investment in terms of savings and quality adjusted life years *later.* Such stewardship of resources is thought to be well within the remit of public servants and policy-makers, and in the case of value-based pricing, is cloaked in the positive, aspirational view that *health is indeed an asset*—one requiring our generous remuneration as a society.

Yet health systems typically budget with a near-term time horizon (one to three years), while this future-oriented asset value of health is quantified over ten to fifty years. Locating this "value" within the health system—in the form of savings and health improvements—is a thorny and perhaps almost impossible accounting task. As people live longer and require more medical care for other causes, the valuation practices of "surplus health" can actually be used to argue for an ever-increasing consumption of treatments over a duration of one's life—which negates the very notion of future savings, as more treatments amount to growing spending (Dumit

2012a; 2012b). Ultimately, health systems with finite budgets often end up rationing treatment as a way of controlling expenditures and limiting opportunity costs in other areas of health and social spending, thereby making fraught ethical decisions about who should get access to treatment (Kesselheim, Avorn, and Sarpatwari 2016). Returning to the case of hepatitis C, health systems across Europe and the US initially limited access to only those patients in the latest stage of disease due to the price of the curative medicines, thereby diminishing the much touted prevention value of early treatment (Canary et al. 2015; Gornall et al. 2016; Iyengar et al. 2016).

Finally, the third crisis is the manner in which assetization tends to appropriate or elide considerations of public interest and the multiple roles played by the state in biomedical innovation. Assets, via the ownership and control protections granted by the state, allow for a measure of value by a singular metric: the accumulation that may be accrued in the future by its owners. In attempting to justify this accumulation through value-based pricing, biopharmaceutical companies have adopted the discourse used by many governments of value-based health delivery for patients and populations (Reinhardt 2015, 2016). This quantification and narrative strategy not only runs into the challenges noted in the prior point above, but this conception of value renders invisible the fundamentally social character of *value creation* in innovation, in which multiple actors contribute to the knowledge production process—with the state often a pivotal actor at the riskiest, uncertain stages.

In the US, for example, the National Institutes of Health (NIH) provided over $804 billion toward fundamental and applied scientific research from 1938 until 2012, with a significant bulk since the doubling of its budget in the 1990s (Lazonick and Mazzucato 2013). This funding has been behind major advances in biomedicine, such as the advent of molecular biology that served as the basis for the biotechnology sector (Vallas et al. 2011). Through this financing, the state, far from crowding out private actors as is often argued, has *created markets* for investors (Mazzucato 2016). The NIH, via the US government's small business innovation and research program, also provides direct investment to many of the early-stage companies that attract venture capital (Keller and Block 2013). By supporting innovation across multiple stages of the process, the state has played a pivotal role in some of the most important therapeutic leaps.

But in a "winner takes all" game of innovation, the company owning the right asset at the latest stages can accumulate the most. By contrast, the

state—often the first investor—rarely receives any direct reward for their risk-taking (except for a small number of cases in which they retain a license or royalty agreement). Though the taxes paid on this revenue are considered an indirect return to the public, even these returns are diminished. In a world where intangible assets like capital are internationally mobile, multinational pharmaceutical companies move their control over assets across borders to tax havens, thereby reducing their tax rate in their home country (Lazonick and Mazzucato 2013). One study estimated that by domiciling assets (e.g., patents on approved medicines) in the favored tax haven of Ireland, US pharmaceutical companies have paid a tax rate of only 6 percent on over $100 billion in profits over the previous decade (Houlder et al. 2014). Such tax avoidance, however, threatens the very revenues used to fund the public investments in science that underpin the possibility for curative therapies and pay for the health systems that will deliver them.

On the one hand, assetization, as both political-economic and narrative transformations, has been used to attract vast sums of capital for innovation and make visible the potential for future health improvements at the level of populations. Yet on the other hand, some of the core logics of assetization—continual accumulation, the commensuration of value with rising prices, and an appropriation and elision of public interest—each presents distinct problems for a future of cures.

Concluding Thought Experiment: Competing Pathways for Confronting Curative Prospects

Despite the forbidding picture I have just sketched, what if the *longue durée* investments in scientific and technological advance mean that therapeutic breakthroughs in the form of cures cannot be avoided? Though such a techno-utopia may never appear before us as a possibility, a brief contemplation of such a thought experiment allows me to offer a few final possibilities for the transformations that have come to define the assetization of biomedicine.

In one scenario, the political economies and epistemic practices of biomedicine in an era of assetization may not change in any drastic fashion, and the status quo would remain. The incentives for companies to produce chronic mitigator treatments over cures would remain strong. Even though curative therapies would be produced in a few instances, their valuation in

terms of high "value-based" prices might mean that a "rationing model" would persist and expand. Health systems, clinicians, and patients would be involved in perpetual struggles to gain access to new breakthroughs, as the value of curative therapies—indicated by escalating prices—would pose vexing questions of who should get such therapies first (Kesselheim et al. 2016; Kolata 2017; Reinhardt 2015, 2016). Public companies producing such therapies would need other products capable of producing sizable growth over time or risk becoming disposable businesses—ones that are acquired or go out of business once a disease is eliminated.

In contrast to the rationing model, a "public prize model" would entail severing the assetization process into two separate markets of assets—a market for the research and development of assets, and another market for the sales and distribution by the owner of the asset. Prizes for successful therapies, funded by taxpayers for disease areas of public health concern, would create sizable reward incentives as well as competition among teams of drug developers (e.g., $10 billion for a cure for HIV/AIDS) with the state then licensing this knowledge asset to generic manufacturers which could then distribute the medicines near the cost of production. Such a prize model has been raised as a possibility for drastically lowering the prices of new medicines and would pose a paradigm shift in the ways drug companies currently operate (Baker 2008; Love and Hubbard 2009). Yet even as the prize model has gained traction in discussions centered on reimagining biomedical innovation, generating the political will and momentum for such prizes across therapeutic areas remains a challenge—and may be more likely used in disease areas defined by citizen and patient-led advocacy as well as in cases of public health emergencies (e.g., antibiotic resistant pathogens, epidemic disease).

Another scenario for curative therapies involves a "Netflix model" of payment, in which patients and health systems become *subscribers* of particular companies or therapies. Rather than make per-treatment payments, members could pay a subscription fee to gain access to curative therapies (Goldman 2018). Such an arrangement would have the advantage of providing pharmaceutical companies with ongoing revenue while also enabling a payer—such as a health system—to space out their budgetary expenses and potentially guarantee greater access to medicines. This idea is being tested jn the state of Louisiana over access to hepatitis C treatments, in which the state would gain access to the therapies for five years for their poorest patients in exchange for an annual fee to pharmaceutical

companies (Sagonowky 2018). While this strategy would address certain challenges associated with curative therapies (i.e., creating upfront access for cash-strapped health systems along with recurring revenue for companies), questions over how to calculate the prices of subscriptions, length of payments, and the extent of access to a given asset would likely remain deeply contested.

In the frontiers of disease where the current model of assetization prevails, still another possibility lurks: the "mortgage model." Payment for new breakthroughs, in this case, would not be limited by a public health system's finite budgets (or even private insurers' expectations of profitability), but rather would be facilitated by access to loans akin to buying a home. Upon a down payment (by an insurance plan, government, or individual patient), patients could gain access to a medicine, with a monthly or annual installment used to pay the total cost with interest over a duration of years. Through what a group of financial engineers at MIT recently proposed as "healthcare loans," the cost of cures is spread or amortized over many years with diversified pools of such loans securitized as financial products that can attract further capital (Montazerhodjat et al. 2016). These engineers argue that like a mortgage used to buy a home rather than rent it, healthcare loans would "buy health" through cures rather than "rent health" through continual payment of chronic treatments (mitigators). This expansion of payment financing may spur drug developers to direct science toward more curative therapies, given the ability to gain continual accumulation via interest and installments for such therapies. Yet this mortgage model could represent a different form of rationing with potentially unfair consequences, with patients' access to medicines tied to their socioeconomic positioning to participate in such loan programs. Here the logics of finance—with the valuation of the future enabling capital accumulation over a duration of time—would come to colonize not just the epistemic valuation practices of payment (e.g., value-based pricing) but the very financing of those payments.

The mortgage model represents the assetization of biomedicine in its most comprehensive and quintessential arrangement, from the development of new therapies in asset-driven financial markets all the way into their payment via securitized loans. That this proposal could even be widely discussed (published in one of *Science*'s journals) illustrates the powerful place that the processes of assetization have come to take in biomedicine. Surely the scientific and biomedical mysteries will be difficult to surmount in the

development of curative therapies; yet it may be the turn to assets in the social organization and valuation of innovation that may prove most vexing.

Notes

1. These expectations are shaped by any number of events, from milestones such as the start of human clinical trials, clinical trial results, to an acquisition of a competing asset. Dramatic developments such as a clinical trial success or failure or a run of acquisitions can lead to asset bubbles, with share prices rapidly escalating, or bubbles bursting, with market value plummeting.

2. In following the history of disease since the 1970s, Dumit finds the rise of "pre-diseases" as emblematic of this conception (i.e., "pre-diabetes" and "pre-hypertension") denoting no felt symptoms by definition, but where risk factors could provide a rationale for treatment.

3. The use of this approach is common across Europe and gaining currency within the US, with the most prominent example the UK's National Health Service and its National Institutes of Clinical Excellence (NICE). In assessing new health technologies, agencies like NICE also set a "value threshold"—the upward limits of what they are willing to pay for a unit of improvement in health (measured in "quality adjusted life years"). See Claxton et al. (2008) and Bach (2015) for more on value-based assessments by health systems.

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