

Future Imperfect: Science, Technology, and the Imaginations of Modernity

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Technological innovation often follows on the heels of science fiction, lagging authorial imagination by decades or longer. One hundred fifty years passed between the youthful Mary Shelley's fantastic story of a vengeful creature brought to life by Dr. Frankenstein and the production of new life forms in twentieth-century biological laboratories (Shelley 2008 [1818]). Jules Verne's *Nautilus*, piloted by Captain Nemo, took to the ocean depths well before real submarines went on such long or distant voyages (Verne 1887). At the dawn of the Progressive Era, the American socialist Edward Bellamy (1889) foresaw an economy fueled by rapid communication, credit cards, and in-home delivery of goods; a hundred years on, those imagined revolutions have become routine. Aldous Huxley (1932) fantasized about an assembly line of artificial human reproduction to serve state purposes twenty years before the unraveling of the structure of DNA, which in turn paved the way for the currently forbidden cloning of human beings. Arthur C. Clarke (1968) created the scheming, lip-reading computer Hal thirty years before IBM programmers developed Deep Blue to beat chess master Gary Kasparov at his own game. And interplanetary travel was in the minds of such writers as H.G. Wells, Fred Wilcox, and Fred Hoyle appreciably before Neil Armstrong stepped onto the moon with his "giant leap for mankind."

Belying the label "science fiction," however, works in this genre are also fabulations of social worlds, both utopic and dystopic. Shelley's lab-generated monster turns murderous because he is excluded from society by his abnormal birth and hence is denied the blessings of companionship and social life enjoyed by his creator. Jules Verne's Nemo, a dispossessed Indian prince driven by hatred of the British colonialists who exploited his land and destroyed his family, seeks freedom and scientific enlightenment in the ocean depths. Biopower runs amok in Aldous Huxley's imagined

world, overwhelming human dignity and autonomy in the name of collective needs under authoritarian rule. Equally concerned with the interplay of social and material innovation, but reversing the emotional gears, Edward Bellamy's look backward from an imagined 2000 offers, first, an optimistic account of a new social order and only secondarily a foray into technological unknowns. And as a dystopic counterpoint, George Orwell's (1949) *Nineteen Eighty-Four* presents a world of totalitarian thought control overseen by a technologically advanced, all-seeing, all-knowing, 24/7 surveillance state—whose real-life counterpart Edward Snowden, the whistle-blowing, twenty-first-century American contractor, famously revealed in the US National Security Agency.

Oddly, though, many nonfictional accounts of how technology develops still treat the material apart from the social, as if the design of tools and machines, cars and computers, pharmaceutical drugs and nuclear weapons were not in constant interplay with the social arrangements that inspire and sustain their production. In popular discourse the word “technology” tends to be equated with machine or invention, something solid, engineered, black boxed, and these days most likely an instrument of electronic communication. Yet cars as we know them would never have taken to the roads without the myriad social roles, institutions, and practices spawned by modernity: scientists, engineers, and designers; patents and trademarks; auto-workers and big corporations; regulators; dealers and distributors; advertising companies; and users, from commuters to racers, who ultimately gave cars their utility, appeal, and meaning. Similar observations can be made about contraceptives, computers, cell phones, and countless other artifacts that serve our needs while, to varying degrees, arousing our desires. Technological objects, in other words, are thoroughly enmeshed in society, as integral components of social order; one does not need fictive or futuristic stories to recognize this truth.

Bringing social thickness and complexity back into the appreciation of technological systems has been a central aim of the field of science and technology studies (STS). Historians and social analysts of technology have worked in tandem to remind us that there can be no machines without humans to make them and powerful institutions to decide which technologies are worth our investment (Winner 1986). This literature resists the temptation to construe technology as deterministic. STS scholars tend to bristle at the evolutionary economist's language of strict path dependence (David 1985; Arthur 1994). STS accounts recognize that history matters, as indeed it must, but reject the notion of rigid lock-ins in favor of a more open sense of agency and contingency in society's charting of technological pos-

sibilities. Many aspects of the presenting face of technological systems are socially constructed (Bijker et al. 1987). The stamp of conscious or unconscious human choice and user preference marks the design of objects, their weighting of risks and benefits, and the behaviors they encourage, exclude, or seek to regulate (Callon 1987; Jasanoff 2006).

Less frequently encountered in the STS literature, however, are conceptual frameworks that situate technologies within the integrated material, moral, and social landscapes that science fiction offers up in such abundance. To be sure, the normative dimensions of science and technology do not fall wholly outside the scope of STS analysis. STS scholarship acknowledges that science and technology do not unidirectionally shape our values and norms. Rather, and symmetrically, our sense of how we ought to organize and govern ourselves profoundly influences what we make of nature, society, and the “real world.” The idiom of coproduction explicitly foregrounds this two-way dynamic:

Briefly stated, co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiments are at once products of social work and constitutive of forms of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports. Scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments, and institutions—in short, in all the building blocks of what we term the social. The same can be said even more forcefully of technology. (Jasanoff 2004a, 2–3)

For all its analytic potential, however, the notion of coproduction does more to advance the Weberian project of *Verstehen* (understanding subjectively how things fit together) than the scientific goal of *Erklären* (explaining objectively how things come to be as they are). It lacks the specificity that might allow us to elucidate certain persistent problems and difficulties of the modern technoscientific world. Left unaccounted for by the bare idiom of coproduction are some of the biggest “why” questions of history—why upheavals sometimes seem to come from nowhere and why attempts to remake the world sometimes fail despite much concerted effort and expenditure of resources. Puzzles also include cross-national and cross-cultural divergences in technological development that lack obvious grounding in natural, economic, or social disparities. It is important to understand in a

time of globalization why different moral valences attach to new scientific ideas and technological inventions throughout the world and why differences persist in what we might call the constitutional position of science and technology in the political order (Jasanoff 2012b; Dennis; Miller, this volume).

The idea of sociotechnical imaginaries confronts some of these challenges head on. Our starting point is the definition Sang-Hyun Kim and I offered in an earlier study of US and South Korean responses to nuclear power: national sociotechnical imaginaries are “collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects” (Jasanoff and Kim 2009, 120). This definition, as we show in this volume, needs to be refined and extended in order to do justice to the myriad ways in which scientific and technological visions enter into the assemblages of materiality, meaning, and morality that constitute robust forms of social life. Sociotechnical imaginaries, as elaborated in the following chapters, are not limited to nation-states as implied in our original formulation but can be articulated and propagated by other organized groups, such as corporations, social movements, and professional societies. Though collectively held, sociotechnical imaginaries can originate in the visions of single individuals or small collectives, gaining traction through blatant exercises of power or sustained acts of coalition building. Only when the originator’s “vanguard vision” (Hilgartner 2015) comes to be communally adopted, however, does it rise to the status of an imaginary. Multiple imaginaries can coexist within a society in tension or in a productive dialectical relationship. It often falls to legislatures, courts, the media, or other institutions of power to elevate some imagined futures above others, according them a dominant position for policy purposes. Imaginaries, moreover, encode not only visions of what is attainable through science and technology but also of how life ought, or ought not, to be lived; in this respect they express a society’s shared understandings of good and evil.

Taking these complexities into account, we redefine sociotechnical imaginaries in this book as collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology. This definition privileges the word “desirable” because efforts to build new sociotechnical futures are typically grounded in positive visions of social progress. It goes without saying that imaginations of desirable and desired futures correlate, tacitly or

explicitly, with the obverse—shared fears of harms that might be incurred through invention and innovation, or of course the failure to innovate. The interplay between positive and negative imaginings—between utopia and dystopia—is a connecting theme throughout this volume.

In this chapter, I lay out the theoretical precursors that inform our work on sociotechnical imaginaries and outline the major methodological approaches by which we make the term analytically tractable. Imaginaries are securely established in interpretive social theory as a term of art referring to collective beliefs about how society functions. Yet, as I show below, little has been done to link that notion to modernity's grand aspirations and adventures with science and technology. This absence is all the more perplexing because the performative dimensions of a society's self-reproduction—the enactment and reenactment of its imaginaries—so heavily depend on experiment and demonstration, practices that are intimately linked to science and technology (Ezrahi 1990; Hilgartner 2000; Jasanoff 2012b). In contrast to social theory in general, STS theorizing affirms the centrality of science and technology in the making and stabilizing of collectives, although STS has paid relatively less attention to the aspirational and normative dimensions of social order captured by the notion of imaginaries.

Sociotechnical imaginaries as illustrated by the contributors to this collection occupy the blank space between two important literatures, the construction of imaginaries in political and cultural theory and of sociotechnical systems in STS (e.g., Bijker 1997; Bijker et al. 1987). The concept helps explain a number of otherwise troublesome problems: why do technological trajectories diverge across polities and periods; what makes some sociotechnical arrangements more durable than others; how do facts and technologies transcend and reconstruct time and space; and what roles do science and technology play in connecting the individual's subjective self-understanding to a shared social or moral order? The chapter then addresses the practical questions that arise in working with this theoretical concept: when does it make sense to invoke sociotechnical imaginaries and what methods and sources are most appropriate for identifying these constructs and their constitutive elements? Lastly, the chapter lays out a map of the major thematic connections among the empirical case studies that follow.

Imagination as a Social Practice

Modern societies prize imagination as an attribute of the creative individual. It is the faculty that allows the extraordinary person to see beyond the limits

of constraining reality and to make or do things that are out of the ordinary. We rightly celebrate the seer, the visionary, the transformative political thinker. But imagination also operates at an intersubjective level, uniting members of a social community in shared perceptions of futures that should or should not be realized. Prior efforts to theorize the collective imagination constitute a fundamentally important strand in the genealogy of sociotechnical imaginaries.

More than a century after the seminal writings of Durkheim and Weber, we take for granted that vibrant societies share common narratives of who they are, where they have come from, and where they are headed. These stories are reflected in rituals of giving and receiving, producing and consuming, birth, marriage, and death. Uncovering these tacit ordering rules even in foreign and distant cultures was the project of anthropology from its colonial origins. Thus, the great structural-functionalist Evans-Pritchard (1937), who helped import Durkheim into anthropology (Kuklick 1992), attributed allegations of witchcraft among the Zande of Central Africa to a logic of averting the chaos of ignorance. Witchcraft on Evans-Pritchard's reading supported order by assigning otherwise inexplicable events to discernible social causes. His student Mary Douglas adopted a similar analytic stance in disentangling beliefs about pollution in premodern societies, eventually extending her ideas to relations between social structures and contemporary perceptions of risk in her work on cultural theory (Douglas 1966; Douglas and Wildavsky 1980). These studies blurred the lines between real and imagined realities, showing how observed facts of nature are refracted through collective desires for logic and order, producing authoritative representations of how the world works—as well as how it should work. In the language of STS, all these works can be seen as broadly illustrative of the phenomenon of coproduction (Jasanoff 2004a).

Early ethnographers did not fail to see that political systems make up a particular kind of imagined reality whose rules are amenable to anthropological investigation. Evans-Pritchard and Meyer Fortes, for example, edited a collection of essays on political systems in sub-Saharan Africa for the International African Institute (Fortes and Evans-Pritchard 1940). Notably, however, this kind of analysis was rarely directed toward modern societies; instead, realist accounts of states predominated in political theory, and little analytic room was left for such nebulous, hard to quantify factors as social imaginations. In his classic work *Imagined Communities*, Benedict Anderson sliced through the divide between ethnography and political science with his now famous definition of a nation as “an imagined political community—

and imagined as both inherently limited and sovereign" (Anderson 1991 [1983], 6). Nationalism, on his reading, is a construct of minds that may never encounter each other in reality but nevertheless are tied together through shared practices of narrating, recollecting, and forgetting. Not only did Anderson's move provide a powerful explanation for what unifies something so heterogeneous and spatially dispersed as a nation, it also validated the cultural, historical, and comparative investigation of the psychosocial attributes of political collectives.

Following Anderson's lead, Charles Taylor (2004) expanded the analysis of collective imaginations to address grand patterns of historical and political thought. How, Taylor asks in the opening pages of *Modern Social Imaginaries*, did modernity come about, with its distinctive complex of new practices and institutions, new ways of living, and new forms of malaise? His explanation can be summed up in two words: imaginaries changed. But how does Taylor define an imaginary, let alone one that looks distinctively modern and social? Here is his answer: "By social imaginary, I mean something much broader and deeper than the intellectual schemes people may entertain when they think about reality in a disengaged mode. I am thinking, rather, of the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations" (Taylor 2004, 23).

We recognize here, as in Anderson's invocation of the imagination, an anthropological vision that rejects the idea of politics as consisting simply of purposive, rational action. Taylor looks instead to a society's moral practices, those tacit rules for "how things go on between them and their fellows" that make up the foundations of social order. An imaginary in Taylor's scheme of things involves not only common understandings and practices based on a sense of what is real but also "a widely shared sense of legitimacy" about how to order lives in relation to those realities. In STS terms again, this is an incipiently coproductionist perspective that bridges, without explicitly saying so, the epistemic and the normative, the objective and the subjective. But Taylor's imaginaries do not have a space for the material aspects of order.

Social imaginaries in Anderson's and Taylor's analyses can hold very big things together, such as nationhood or modernity. But imaginaries can also operate at substantially smaller scales. Indeed, Arjun Appadurai, whose much admired 1990 essay on globalization and diasporas influenced thought far outside his field, uses the concept of imaginaries to dissolve the notion of a universal, homogeneous modernity. For Appadurai, globaliza-

tion consists of disjointed flows or “scapes”—of people, technology, money, electronic communications, and ideas—each constituted by the overlapping but not necessarily coherent practices of the people engaging in them:

No longer mere fantasy (opium for the masses whose real work is elsewhere), no longer simple escape (from a world defined principally by more concrete purposes and structures), no longer elite pastime (thus not relevant to the lives of ordinary people), and no longer mere contemplation (irrelevant for new forms of desire and subjectivity), the imagination has become an organized field of social practices, a form of work (both in the sense of labor and of culturally organized practice) and a form of negotiation between sites of agency (“individuals”) and globally defined fields of possibility. (Appadurai 2002, 50)

It is the turn from a purely mentalist notion of the imagination as fantasy to imagination as organized work and practices that puts Appadurai on a continuum with Anderson and Taylor. As we see below, and indeed throughout this volume, this way of thinking about the imagination is also consistent with current trends in science and technology studies, although STS scholars are likely to find troubling Appadurai’s implication that “scapes” flow independently of one another in their complex global circulation.

A startling, almost inexplicable omission from all of these classic accounts of social imaginaries is a detailed investigation of modernity’s two most salient forces: science and technology. Anderson’s imagined communities were bound together by the medium of newsprint, but technologies of communication as such play little or no role in his storytelling, except perhaps via the inclusion of museums and maps (along with the census) in the book’s expanded second edition. In three passing mentions, almost as afterthoughts, Taylor in *Modern Social Imaginaries* subsumes science and technology into the aggregated institutional changes that mark the emergence of modernity. But he pays little attention to their instrumental or transformative role, even in relation to the “multiple modernities”—“different ways of erecting and animating the institutional forms that are becoming inescapable” (Taylor 2004, 195)—which he takes to be emblematic of the contemporary condition. Appadurai sees flows of technology as part of the disjointed and multiple nature of current realities, but he too fails to engage with the seminal role of knowledge and its materializations in generating and anchoring imaginaries of social order. These are not accidental gaps but, as the leading STS scholar Bruno Latour has insistently argued, a systematic obscuration in the imagination of the social sciences themselves.

For example, in the famous 1971 debate between Noam Chomsky and Michel Foucault on Dutch television, neither giant of twentieth-century social thought, both deeply attuned to the history and politics of science, paid much attention to material inventiveness, or the “*grille*” of technology, in their accounts of human nature, power, and justice.¹ Bridging this gap in the analysis, indeed in the apprehension, of modernity is a central purpose of this introductory essay and this entire collection.

Curiously, too, performance as a social practice gets short shrift in much of the theorizing on imaginaries, even though theatricality has been part of the machinery of statecraft and rulership from the earliest times. Machiavelli, writing in exile in 1513 and addressing his work to Lorenzo di Piero de Medici, grandson of Lorenzo “the Magnificent,” called attention to the importance of spectacle to a ruler’s reputation: “Nothing gives a prince more prestige than undertaking great enterprises and setting a splendid example” (Machiavelli 1977 [1513], 65). He noted too the delicate balance that politics must strike between displays of greatness and of familiarity, both essential to the prince’s public standing: “He should also at fitting times of the year, entertain his people with festivals and spectacles. And because every city is divided into professional guilds and family groupings, he should be inward with these people, and attend their gatherings from time to time, giving evidence of his humanity and munificence, yet avoiding any compromise to his dignity, for that must be preserved at all costs” (Machiavelli 1977 [1513], 65–66).

Localized in time and place, Machiavelli’s prescriptions nonetheless resonated far beyond his immediate circumstances. The cult status of successful European monarchs from Louis XIV of France to Elizabeth I of England, dubbed *Gloriana* by her subjects, bears witness (Strong 1984, 1987). In Britain, the union of state building with monarchical pomp and pageantry persisted down the ages, through Queen Victoria’s acclaimed Diamond Jubilee celebration in 1897, at the high-water mark of the British Empire (Morris 2003), down to the rain-drenched but feel-good Thames flotilla, fittingly led by a royal barge named *Gloriana*, that provided visual distraction for an economically depressed British nation at Queen Elizabeth II’s Diamond Jubilee in the summer of 2012.

That same summer’s Olympic Games in London, however, provided spectacles relying less on royal history and more on Britain’s artistic and cultural heritage, liberally spiced with high-tech fantasy. Epitomizing that postmodern synthesis was a hugely popular video of Queen Elizabeth herself making a mock parachute landing in the Olympic stadium accompanied by Daniel Craig, the latest incarnation of James Bond in Ian Fleming’s

perennially popular franchise. The Bond stories showcase not only Britain's mechanical inventiveness but Britishness writ large²: the shots of the helicopter daringly skimming under the Thames bridges and the parachute descent itself conjured up Britain's heroic World War II history, when mastery of the air proved essential for the nation's defense. The video—which soon attracted more than a million viewers on YouTube—blended together memory, technology, the monarchy, and popular culture in a performance designed to play to every register in Britain's happiest imaginations of itself. It reinforced nationhood on many levels at once, and it did so in part by appealing to what we call sociotechnical imaginaries.

Performance, Visibility, and Instrumentalism

Bringing performance back into the landscape of political theory helps reposition science and technology as key sites for the constitution of modern social imaginaries. Performances of statehood in modernity are increasingly tied to demonstrations and to public proofs employing scientific and technological instruments; equally, however, acts of popular resistance, from terrorist attacks to Wikileaks, draw on the same repertoires of technoscientific imagination and instrumental action. That histories of science and technology are interwoven with political histories is not in itself a novel claim; in particular, it will not raise eyebrows among social scientists familiar with STS. Yet the mechanics of the interconnections between technoscientific and political practice have not been articulated in detail or systematically. A few landmark works serve as milestones for explorers, but the map of the highways and byways that link science, technology, and state-making lacks its Mercator or even its Ptolemy. Particularly empty of theoretical guidelines is the domain that connects creativity and innovation in science, and even more technology, with the production of power, social order, and a communal sense of justice.

A promising starting point is the notion of “technoscientific imaginaries” developed by George Marcus (1995) and his colleagues in the anthropology of science and technology. At first blush, this term seems to perform the very same bridging that we, too, seek to accomplish in this volume. Yet, while Marcus notes in his editorial introduction that technoscientific imaginaries might have encompassed the “reflective, visionary thoughts of scientists,” this is not the direction his essay collection pursues. Instead, in a move more consistent with disciplinary anthropology than STS, Marcus and his colleagues “were much more interested in the imaginaries of scientists tied more closely to their current positionings, practices, and ambiguous

locations in which the varied kinds of science they do are possible at all" (Marcus 1995, 4). As in all work on imaginaries, the focus in the resulting, highly individual accounts is on futures and future possibilities, but the context of the imagination is the scientific workplace, and imagination's aims and achievements are tied to forms of scientific production. Our ambition in this book is spatially and temporally larger and more symmetrical. It is to investigate how, through the imaginative work of varied social actors, science and technology become enmeshed in performing and producing diverse visions of the collective good, at expanding scales of governance from communities to nation-states to the planet. This is why we choose the term "sociotechnical" (not technoscientific) to characterize our elaboration of imaginaries.

For this purpose, a more congenial point of departure is *Leviathan and the Air Pump*, the classic account by Steven Shapin and Simon Schaffer (1985) of the conflicts between Robert Boyle and Thomas Hobbes in Restoration England. The book does not use the term "imaginaries," but it is at its heart a story of competing, coproduced imaginations of natural and social orders. Boyle and Hobbes, Shapin and Schaffer argue, were fighting for the same dyad of causes: how to establish truth and how to achieve authority in a time of immense epistemic as well as political upheaval. Their study of the controversy suggests that what was at stake in that revolutionary moment was not simply the legitimacy of scientific experiment, although Boyle the scientist and Hobbes the political philosopher³ conflicted in their views of whether seeing an experiment could be a valid basis for believing its findings. Implicated as well in these two men's quarrels was the emergence of a democratic public sphere in which authority would depend on experimentally verifiable truths, observable in principle by everyone, rather than on declarations from an inaccessible central authority such as the monarch. In short, the rise of the experimental method—which depends on transparency, a common language for speaking about matters of fact, and the assent of witnesses who are not necessarily in the room with the experimentalist—simultaneously laid the foundations for the political movement toward modern democracy.⁴ Experiments, in this telling, were important performative occasions, requiring carefully orchestrated meetings of minds and eyes to build consensus around what was being shown and seen.

The political scientist Yaron Ezrahi carried forward these suggestive connections between epistemic and political performance in his *Descent of Icarus* (Ezrahi 1990). According to Ezrahi, the shift of viewpoints introduced by experimental science eventually permeated political culture, allowing subjects who had previously functioned as mere consumers of the state's

displays of authority to become skeptical witnesses of its claims. Democratization entailed in effect the conversion of the “celebratory” eye of the passive subject into the “attestive” gaze of the modern citizen, able to question and evaluate the factual assertions of those in power. We are reminded here of Immanuel Kant’s famous description of *Mündigkeit* as “the human being’s emergence from his self-incurred minority” (Kant 1996, 11). This is the state of maturity attained by enlightened humans when they learn to think for themselves without leaning on others for guidance. Importantly, however, Kantian enlightenment is tied to an inward capacity to reason on one’s own, similar to attaining adulthood or independence, whereas the transformation that Ezrahi posits, following Shapin and Schaffer, relates more to the capacity to apprehend natural facts for what they are, in short, to trust the empirical evidence of one’s senses.

Ezrahi’s democratic theory reopens a space for political performance, a space in which technology, in addition to science, finds an explicit role. In his political universe, the democratic state is sensitive to a continual need to prove itself to witnessing citizens. This ongoing demand for accountability can most easily be met through public demonstrations of power and efficacy, leading to increasingly instrumental uses of technology. In an evocative passage, Ezrahi calls attention to the ritual that goes on at the Kennedy Space Center when American citizens from all parts of the country are given a tour of the premises, to observe how their state’s contributions helped create the marvels on display: “Perhaps the most important artifact is the body of a Saturn 5, a gigantic space leviathan whose carcass lies wide open in a didactic gesture toward curious taxpayers always eager to be informed” (Ezrahi 1990, 42). From an author of Ezrahi’s erudition, the use of “leviathan” here is no accident: Saturn 5 is a material manifestation of the American federation, and the tour guide’s enthusiastic efforts to tie the machine’s components back to the visitors’ home states is nothing less than a performance of nationalism to train, and retain, the loyalty of citizens.

Performance becomes yet more centrally the lens through which Ezrahi looks at politics in a later book, *Imagined Democracies* (Ezrahi 2012). Here his focus is on the “necessary fictions” that societies adopt when they perform democracy. Those fictions make democracy work, despite all the hidden backstage machinery that also makes democracy as we experience it a matter of artifice, illusion, and pretense. Technologies seen in this light operate as performative scripts that combine values and interests, materializing and making tangible the invisible components of social imaginaries. Such performances in turn embed technological systems into the “masonry of political world-making” (Ezrahi, personal communication).

Almost inevitably, Ezrahi's historical and imaginative sweep comes at the expense of specificity. *Descent of Icarus* tends to merge all of European culture into a single monolithic formation marked by ambivalence toward technology, as opposed to the instrumental enthusiasm that Ezrahi attributes to the United States. Yet the evolution of engineering and of technological systems, as well as the status and power of engineering in society, followed distinctive paths in Britain, France, and Germany. These national trajectories included institutionalized differences in educational systems for science and engineering, in the role of these fields in elite formation, and in political culture, via what I have called civic epistemologies (Jasanoff 2005). Twentieth-century history might have looked quite different if all of Europe had held uniformly skeptical views toward technology. Science and technology continue to play diverse legitimating functions in the world's newer democracies, corresponding to differences in the nature and status of expertise and in cultural expectations about evidence and proof in the public sphere. Simplifying these subtle variations into binaries, such as esthetic Europe versus utilitarian United States, misses the finer threads that help define the place of science in the distinctive political and constitutional cultures—and imaginaries—of sovereign nations and their polities.

Michel Foucault's assessment of the power of inspection in his elaboration of Jeremy Bentham's idea of the panopticon (Foucault 1979, 195–228) contrasts markedly with the emancipatory role that Ezrahi ascribes to the transparency of science's experimental regime. Ezrahi takes his cues from Jefferson, Paine, and Priestly, all men of the Enlightenment, and perhaps more Kantian than Foucauldian in their commitment to reason. He observes, "once it is the government itself which becomes an object of increasing observation, inspection as a technique of control is transformed into a democratic instrument for holding authority publicly accountable" (Ezrahi 1990, 116). This, however, fails to take on board the constructedness of seeing in all its complexity. The viewer after all construes what she sees; in turn, the viewer's capacity for observation is socially trained in ways that delimit what she can perceive. The state, too, commands innumerable devices that occlude vision and limit transparency, such as large databases, weapons programs, and laws of official secrecy. Sight, to borrow a term from Foucault's repertoire, operates within the *grille* of historical conditioning (Chomsky and Foucault 2006), with "its choices and exclusions" determining what can be seen and what passes unnoticed (consider, for example, the critique of courtroom witnessing in Jasanoff 1998).⁵

Appropriately, in an era dominated by the mass media, the filmmaker Akira Kurosawa provided a memorable challenge to the very possibility of

being all seeing. *Rashomon*, Kurosawa's midcentury masterpiece, dramatized how the same "reality" is perceived in radically different ways depending on the position, perspective, and indeed imagination of the observer (Kurosawa 1950). Yet, perversely, vision still remains the great naturalizer. What we "see" in familiar surroundings looks right, epistemically as well as normatively. So the socially conditioned eye can take for granted that all-male orchestras or all-black passengers on the backseats of buses, or even scenes of filth and abject poverty simply represent the rightful order of things. And, as Foucault preeminently observed, when bodies are well disciplined to live inside those orders, what looks natural from on high may not be so different from what looks natural from below. The same collective imaginary may condition and constrain the sense of justice that binds a community.⁶ Other ways of seeing and reasoning—ways that would make injustice palpable—may not enter anyone's imagination, even in democratic societies, and hence may never give rise to organized criticism or opposition, let alone to revolutions that could hold power accountable, or at the extreme overthrow it.

To understand order and, its obverse, disorder in contemporary societies, we need an encompassing theoretical framework that draws together our scientifically and culturally conditioned perceptions of reality, our capacity to create new collectives through technological as well as social means, and the changes in expectation that arise when science and technology interact with individual self-awareness and the sense of being well ruled. The idiom of coproduction offers such a framework: it is symmetrically concerned with mutual emergences in how one thinks the world is and what one determines it ought to be (Jasanoff 2004a). Work in the coproductionist vein sensitizes us to the ways in which elements of human subjectivity and agency get bound up with technoscientific advances through adjustments in identities, institutions, and discourses that accompany new representations of things. It offers an entry point into the means by which *is* and *ought* remain fitted together while our awareness of the world and what to make of it both move. Less explicitly, the idiom of coproduction also allows us to consider how time and space are involved in the formation, or reformation, of conceptual, material, and social orders, thereby helping to explicate such pervasive shifts in consciousness as the Reformation, the Enlightenment, decolonization, globalization, racial and sexual emancipation, and modernity itself (Jasanoff 2010; Jasanoff and Martello 2004). More needs to be done, however, as this volume shows, to clarify why, at significant forks in the road, societies opt for particular directions of choice and change over others and why those choices gain stability or, at times, fail to do so.

The Flatness of Networks

One influential way of accounting for both stability and instability is actor network theory (ANT), an STS framework developed by French sociologists Michel Callon and Bruno Latour at the Ecole des Mines in Paris in the 1980s. ANT offers a systematic mode of inquiry into the connections between humans and the animate and inanimate features of the environments they make and inhabit. In other words, it offers a conceptual foundation for examining the nature of the “sociotechnical.” In this respect, ANT is a significant strand in the genealogy that sociotechnical imaginaries draw upon, but the two concepts also decisively part company in their treatment of power and normativity.

ANT grew out of a felt need to bring human relations with nonhumans, and with materiality more generally, back into sociology. ANT thus seeks to avoid preconceived analytic boundaries between the components that hold social systems together. All are seen as hybrids composed of heterogeneous elements: people, objects, nonhuman entities, organizations, and texts are taken as interactive participants in the networks that make up the structures of modernity. To correct for the humanistic bias of classical sociology (see Latour 1988, 35–40), Callon and Latour put forward the notion of *actants*, nonhuman agents that mediate among humans and help mold their collectives. This allowed the authors to pursue what they termed a symmetrical approach to society and nature. Callon (1986) famously insisted on using the same terminology to account for modes of resistance and engagement that occur among scientists, fishermen, and scallops when a form of scallop cultivation was imported from Japan to France’s St. Brieuc Bay. Latour’s provocative history of pasteurization represented microbes as powerful agents, not only channeling Louis Pasteur’s efforts to come to grips with them in the laboratory but eventually extending their force outward to transform farming, medicine, markets, and society. In his signature polemical style Latour pronounced, “There are not only ‘social’ relations. Relations between man and man. Society is not made up just of men, for everywhere microbes intervene” (Latour 1988, 35). Not only microbes but hosts of inanimate objects, such as maps, legal reports, speed bumps, and door locks share space with humans in Latour’s ordering of social relations, forming a kind of dark matter of society. To this array, Callon (1998) and his followers have added the instruments that make modern economies function, such as the infamous credit derivatives that were blamed for the worldwide economic collapse in 2008.

These moves are enormously appealing because they dissolve binaries that seem intolerably rigid in complex modern societies: nature-culture, science-society, subject-object, human-nonhuman. More important for the social sciences, ANT's vision of networked societies encourages greater attentiveness to forms of distributed agency and action—and hence of dispersed causality—that disciplinary training tends to simplify or dismiss. The political theorist Timothy Mitchell, who embraced the ANT approach in writing about Egypt's political modernization, placed on a par the military invasion of the country by British forces from the north and the biological invasion by the malarial mosquito from the south. Normal history, Mitchell suggested, errs in giving voice only to humans when narrating such periods of nation building. In reality, things happen in mixed-up ways. It takes power, as Foucault and other historians of the human sciences have long seen, to create demarcations and simplifications in a world of hybridity: “indeed producing the effect of neatly separate realms of reason and the real world, ideas and their objects, the human and the nonhuman, was how power was coming to work in Egypt, and in the twentieth century in general” (Mitchell 2002, 52). It follows for Mitchell that the traditional social sciences uncritically replicate modernity's established forms of power by paying homage to the very intellectual binaries and categorical separations that are the characteristic outputs of modernity (see in this connection Latour 1993).

Truthfulness in the social sciences today, most would agree, demands simultaneous attention to more forms of agency, more pathways of change, and more narratives of causation than single disciplines are wont to provide. In this respect, ANT and the new investigations of materiality (a trend some call “speculative realism”) in STS perform a valuable function. They urge us not to take any aspect of the world for granted as natural or given, and hence foreclosed to investigation, even those that seem to hold still and do nothing; but instead to look around at all the compass points from which forces originate to make up reality as we see it. Such analysis in the round should be mindful of all the devices—not only law or policy or culture or armed might—with which power seeks to achieve its ends. Yet this hugely appealing celebration of mixtures, hybrids, and complexity suffers from its own fecundity. It is too distributive, too promiscuous in attributing cause and agency. As even friendly critics have observed (e.g., Mitchell 2002, 52–3; Farias and Bender 2010, 305), it risks a kind of moral nihilism, making all actions and agents seem equally empowered, or disempowered, and therefore equally responsible, or irresponsible, for the networks within which

they function. Network-based accounts seem in this respect to play into and reinforce what Ulrich Beck (1998) has called modernity's "organized irresponsibility."

The preoccupation with hybridity also risks establishing a troubling normative equivalence between nonhuman and human agents. Gifted writers can make anything speak, in the sense that their stories give voice to that thing and captivates readers with the subversive pleasure of hearing from entities usually held to be mute. Animals talked and even frogs demanded a ruler in Aesop's popular fables, and life forms seamlessly transmuted into one another in Ovid's fantastic narratives. In our day, when science has liberated nature from such enchantments, giving voice and agency to things can be seen as a form of rebellion, an enterprise of reenchanting. One need only look at the explosion of interest in cyborgs and interspecies ethnography (Haraway 1991, 2003) or the transhuman and the posthuman (Hayles 1999). Yet, it is still humans and their collectives who can imagine a world—or a continent as Helen Tilley (2011) argues in her work on Africa and William Storey's essay on Cecil Rhodes explores in this volume—that is governable by science and technology and emptied of mosquitoes. Only humans can devise the strategies of disciplining and targeted eradication that may accomplish such wonders. Maybe the mosquito can speak, or be ventriloquized by an exceptional storyteller. But can the mosquito imagine? In this book, we argue that imagination, a crucial reservoir of power and action, lodges in the hearts and minds of human agents and institutions, although imagination's skilled implementation requires putting in play the intricate networks whose construction has been the stuff of so much STS analysis.

If networks diffuse responsibility, they can also depoliticize power by making its actions opaque or invisible. Here again, a cardinal virtue of network analysis, namely, its utility in explaining how big formations cohere, calls for a confrontation with critical political theory. Illustrative for these purposes is Bruno Latour's influential essay "Drawing Things Together," in which he argued that the diffusion of scientific ideas can be attributed to two linked phenomena: the production of inscriptions that simplify and "flatten" the world, making "immutable mobiles"; and their subsequent distribution by "centers of calculation" that enable these representations to draw together actors and actions far outside the initial loci of production (Latour 1990).

Latour's most vivid example of the mobility of inscriptions is remarkable for its elision of power:

La Pérouse travels through the Pacific for Louis XVI with the explicit mission of bringing *back* a better map. One day, landing on what he calls Sakhalin, he meets with Chinese and tries to learn from them whether Sakhalin is an island or a peninsula. To his great surprise the Chinese understand geography quite well. An older man stands up and draws a map of his island on the sand with the scale and the details needed by La Pérouse. Another, who is younger, sees that the rising tide will soon erase the map and picks up one of La Pérouse's notebooks to draw the map again with a pencil . . .

What are the differences between the savage geography and the civilized one? (Latour 1990, 24)

A cartographic mission is undertaken at the behest of a king, with explicit aims of advancing science, expanding trade, and establishing French outposts in the Pacific. It is hard to miss the colonizing undertones, albeit in this case both monarch and minion came to violent, untimely ends: La Pérouse's entire expedition mysteriously disappeared in 1788, a year before the revolution that consumed his royal patron's life. Latour's language, however, preserves the hierarchy of center and periphery, contrasting the "savage geography" of the older Chinese man's sand drawing with the "civilized" geography of La Pérouse's scientific team.⁷ Latour himself is far too knowing to buy into such easy binaries as "savage" and "civilized": "There is no need to bring a prescientific mind into the picture," he goes on to say. Nevertheless, the relationships he describes appear natural, part of the order of things, and well in line with France's famed *mission civilisatrice*. There is no acknowledgment here of the turbulent histories through which centers of calculation obtain the resources to draw things together or the force and violence often required to make representations circulate. Raw power has little overt place in actor-network narratives, which tend not to disrupt science's own self-presentation as gentlemanly, civilized, and civilizing (by contrast, see Visvanathan 1997; Scott 1998; Jasanoff 2004a, 26–27). Disrupting this flatness, revealing the topographies of power, is one aim of work on socio-technical imaginaries.

For a sharply contrasting vision of science's mobility, we can turn to Donna Haraway's spirited deconstruction and reconstruction of a site of scientific representation, the African Hall of New York's American Museum of Natural History—a place in which time, space, and power intertwine altogether less innocently (Haraway 1989). Haraway's pathbreaking essay on the dioramas produced by the hunter, photographer, scientific taxidermist, and naturalist Carl Akeley offers a riposte against the formal symmetries between human and nonhuman that form the backbone of ANT. For Har-

away (1989, 55), "Sciences are woven of social relations throughout their tissues. The concept of social relations must include the entire complex of interactions among people; objects, including books, buildings, and rocks; and animals." Seen in this light, the dioramas she interprets are first and foremost "meaning machines." Like all machines they freeze social relations, reinforcing an impression of predestination that analysts should seek to dissolve. This Haraway does with gusto, bringing to life the extravagant male egos of Akeley and his friend President Theodore Roosevelt, their intrusive, omnipresent, violent cameras, the dead but immortalized animals, and the silenced voices and bodies of Africans and women, including Akeley's irreverent first wife Delia, who were altogether alive and active during the adventures that secured the trophies for the museum. No longer mute representations of truth to nature, the dioramas become in Haraway's telling raced and gendered objects created to give that era's anxious white American males the illusion that nature is still there to be fought and conquered in trials of male vitality. If Haraway's African exhibit functions as a center of calculation in Latour's terms, then we see that its very construction is a project of politics—it is a site (in my terms) of coproduction. The exhibit reflects and reinforces a specific, historically situated, American sociotechnical imaginary in which nature and manliness are simultaneously defended against threats from urbanization. The science of natural history thus ends up speaking truths subservient to the power of a specific cultural imagination.

Sociotechnical Imaginaries

Sociotechnical imaginaries occupy the theoretically undeveloped space between the idealistic collective imaginations identified by social and political theorists and the hybrid but politically neutered networks or assemblages with which STS scholars often describe reality. Our definition pulls together the normativity of the imagination with the materiality of networks: sociotechnical imaginaries thus are "collectively held and performed visions of desirable futures" (or of resistance against the undesirable), and they are also "animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." Unlike mere ideas and fashions, sociotechnical imaginaries are collective, durable, capable of being performed; yet they are also temporally situated and culturally particular. Moreover, as captured by the adjective "sociotechnical," these imaginaries are at once products of and instruments of the coproduction of science, technology, and society in modernity.

We have located sociotechnical imaginaries in genealogies that refer spe-

cifically to theories of national and social identity in political theory and to hybrid collectives in STS. The performative dimension of sociotechnical imaginaries, however, also relates this term to concepts more closely linked to instrumental political action—in other words, to policy as well as politics. Differences between theoretical concepts are notoriously hard to pin down by definition alone, and refining them in practice entails considerable elaboration and boundary work by communities of scholars over time. Nevertheless, it is worth making a few quick observations about the relationship between sociotechnical imaginaries and related ideas in studies of public policy. Possibly closest in spirit is the concept of a *master narrative*. Like an imaginary, a master narrative—such as “American exceptionalism”—offers a rationale for a society’s long evolutionary course while also committing that society to keep performing the imagined lines of the story. But a master narrative implies a more monolithic and unchangeable vision, closely bound to a singular retelling of national and cultural history, and not necessarily welcoming of invention or prescriptive of new goals to be achieved.

Discourse shares with imaginaries the properties of being collective and systemic (e.g., Hajer 1995), but it usually focuses on language and is less directly associated with action and performance or with materialization through technology. Political ideologies are perhaps more obviously tied to power and social structure than are sociotechnical imaginaries, but ideology is generally seen as entrenched and immovable. Ideology also lacks the imagination’s properties of reaching and striving toward possible futures, and ideology has not typically been analyzed as being encoded in material technologies. Policy itself refers to formal or tacit programs of action, not to the underlying rationale or justification that may be provided by sociotechnical imaginaries. Similarly, a plan conveys the intentionality of sociotechnical imaginaries, but it usually refers to near-term futures with specific, designated goals (e.g., a plan to build a weapon or a highway) and is usually a product of formal institutional authority rather than a shared cultural property. In the same vein, a project usually involves a single, targeted, technological endpoint, such as the Apollo moon landing, the “cure for cancer,” the sequencing of the human genome, or the mapping of the brain; such projects may themselves reflect animating sociotechnical imaginaries. Finally, unlike sociotechnical imaginaries, which can be articulated and advocated for from below the seats of power, public reason tends to be shaped by institutionalized relations between citizens and the political authorities who govern them (Jasanoff 2012b).

These contrasts carry us forward to some degree, but a more user-friendly way to operationalize sociotechnical imaginaries is to ask what explanatory

work the concept enables. Here we lay out four ways in which sociotechnical imaginaries help overcome some limitations of earlier work in both STS and political theory. The first problem for which the concept provides answers is that of difference, in particular the unexpected divergence of sociotechnical outcomes across political regimes, even among liberal democracies that share fundamental aspirations and commitments. If, as political scientists have traditionally argued, exogenous events drive political agendas (Kingdon 2010), then after momentous happenings convergence rather than divergence ought to be the rule. One might expect, for example, that nuclear disasters like Chernobyl and Fukushima would generate equivalent fear and revulsion around the globe; the hacking of climate scientists' e-mails at the University of East Anglia in 2009 would provoke similar skepticism and distrust toward climate science everywhere; and policy framings for new bio- or nanotechnologies would converge over time from Washington to Brussels and New Delhi to Tokyo. Similarly, revolutionary discoveries such as the decoding of DNA should drive social values toward similar patterns of rejection or acceptance of engineered forms of life. Yet the reverse is often true (Jasanoff 2005, 2011a; Jasanoff and Kim 2009, 2013). Discrepancies persist in responses to new and emerging technologies and technological disasters, suggesting that even earth-shattering events are absorbed and integrated into preexisting imaginaries in ways that forestall globally homogeneous meaning making and policy formulation.

A second problem is time and its companion, change. Past and future connect in a complex dialectic that is widely acknowledged. The past is prologue, but it is also a site of memory excavated and reinterpreted in the light of a society's understanding of the present and its hopes for what lies ahead. As Alberto Melucci (1996, 12) put it, while "the future is born of the past, it is equally true that the past is also continuously shaped by the future." But why do people's expectations of how things fit together (in Charles Taylor's formulation), and how they ought to fit, remain stable for long durations, so that we can speak of extended eras such as modernity? And when sweeping change happens—the Arab Spring, for example, or decolonization, or the fall of the Iron Curtain—where does the impetus come from and how in turn does it take hold? Clearly some account of relative embedding, or rootedness, is needed for us to understand both durability and change; I return to this point in the final chapter. The popular though disconcertingly flat metaphor of networks, whose durability depends on the thickness of horizontal linkages and the density of nodal connectivities, does scant justice either to the historical *longue durée* or to moments when things catastrophically fall apart.

The materiality of technoscience, as this collection demonstrates, is surely implicated in the stability and instability of social arrangements, but just as important are the belief systems out of which those materialities emerge and which give them value and meaning. A better balance needs to be struck between the theoretical poles of abstract idealism and deterministic materialism. By turning to sociotechnical imaginaries, we can engage directly with the ways in which people's hopes and desires for the future—their sense of self and their passion for how things ought to be—get bound up with the hard stuff of past achievements, whether the material infrastructures of roads, power plants, and the security state or the normative infrastructures of constitutional principles, juridical practices, and public reason (Jasanoff 2012b). Technological systems serve on this view a doubly deictic function, pointing back at past cultural achievements and ahead to promising and attainable futures, or to futures to be shunned and avoided.

A third problem, especially familiar to critical geographers, is space. Space and social order are coproduced in part through the spread of ideas and practices—and indeed ideologies—across times and territories. Views and practices originating with individuals or small groups acquire governing force across much wider domains, both physical and temporal. In the concluding chapter I refer to this phenomenon as extension. For STS scholars, it is tempting to put science and technology at the heart of such stories because science is modernity's ultimate traveler, its findings accepted everywhere as universal. Latour (1988), as noted earlier, used actor network theory to great effect in his account of the spread of pasteurization, a case of one man and one scientific idea that—with the help of microbes—took over a country and eventually the world. But are scientists and engineers, and the materialities they harness, really prime movers in building the grand architectures of states and markets, or of empires, let alone the myriad lesser constellations of meaningful spaces nested within those encompassing structures? And does the world really come as unconfigured and available to be reorganized, with only nodal frictions and struggles for power, as some STS accounts of the spread of scientific and technological networks suggest? ANT stories, as we have already observed, risk flattening—even sanitizing—the circulation of knowledge in a world of persistent inequality and dominance.

Sociotechnical imaginaries tackle head-on, and more symmetrically, the complex topographies of power and morality as they intersect with the forces of science and technology. As the term itself suggests, the concept allows for spatial imaginations to preexist and channel the spread of science and technology, instead of only vice versa, as when a Cecil Rhodes, with his dreams of conquest, bestrides Africa like a colossus (Storey, this volume); or when

President Lyndon B. Johnson's press secretary, George Reedy, is persuaded of the "poetry" of the space program on a deserted hilltop outside Austin, Texas (Jasanoff 2004b, 40); or when an institution such as the World Health Organization mobilizes expert technical resources around common fears of a global pandemic (Lakoff; Miller, this volume). Then, too, by allowing for competition among different visions of futures, the framework of sociotechnical imaginaries restores some of the indeterminacy of history and avoids the determinism built into grand narratives of scientific progress, such as pasteurization. From an imaginaries perspective, moreover, space and scale are linked in a normative coupling that cannot as easily be captured by the metaphor of networks. For imaginaries not only help to reconfigure actors' sense of the possible spaces of action but also their sense of the rightness of action, at scales ranging from locality to nation (Barker; Chen; Kim; Moon, this volume) to continent (Smith; Storey, this volume) and to the planet itself (Lakoff; Miller, this volume).

A fourth and final problem that the concept of sociotechnical imaginaries helps tease apart is the relationship between collective formations and individual identity. From Foucault's observations about the capillary effects of power on human bodies to Anderson's characterization of nationhood as a product of communal imaginations to Pierre Bourdieu's (1990) sociological analysis of the individual's habitus as a historically conditioned subjective state—as well as in volumes of work on feminism, critical race theory, and subaltern studies—the relationship between the ideas of rulers and the self-understanding of subjects has long been the stuff of social theory. Accounts of subject formation, with their focus on humans as psychosocial beings, bring to light features of making collectives that tend to get backgrounded in impersonal studies of institutions, as well as in the behaviorist-leaning microsociologies of technoscientific practices favored by many STS scholars. Yet joining a collective does matter to the actors who join it; and those who form and manage collectives are often intensely (if unconsciously) aware of the need to control the emotive registers of adherence and belonging. I am reminded of my own "naturalization" as an American citizen in Ithaca, New York, in 1987, when the presiding judge told us to think of that day, October 22, as our "personal Independence Day"⁸; or of the tug at the heartstrings when newly minted Harvard PhDs are welcomed each year into "the ancient and universal company of scholars." By stressing the roles of memory, language, and performance—in short, by keeping the focus on human actors and their collectively enacted hopes and expectations—the essays in this volume seek to remedy some of the shortcomings of accounts that reduce human agents to mere cogs in machines (see especially Barker;

Dennis; Hurlbut; Moon; Storey, this volume) or represent them as agents defined chiefly through their struggles with the material elements of the heterogeneous sociotechnical networks they happen to be caught in.

Reflections on Method

A theoretical term is worth little unless it fits into the circumstances of the world, casting light on corners that need illumination. Such terms need to be operationalized, and for that purpose method is indispensable. How can we recognize when something as abstract yet durable as an imaginary is in play and what are its constitutive components? How can we confidently identify a sociotechnical imaginary and be sure that it is not mere rhetorical flourish, institutional ideology, or fleeting policy preference? These questions receive detailed treatment in the following chapters and in the conclusion, but some broad outlines can be sketched here.⁹

As an analytic concept, “sociotechnical imaginary” cuts through the binary of structure and agency: it combines some of the subjective and psychological dimensions of agency with the structured hardness of technological systems, policy styles, organizational behaviors, and political cultures. The methods best suited to studying sociotechnical imaginaries therefore are the methods of interpretive research and analysis that probe the nature of structure-agency relationships through inquiries into meaning making. Although few of these methods are specific to the analysis of sociotechnical imaginaries, they can be applied in ways that are especially attuned to this concept: by attending to the means by which imaginaries frame and represent alternative futures, link past and future times, enable or restrict actions in space, and naturalize ways of thinking about possible worlds.

Perhaps the most indispensable method for studying sociotechnical imaginaries is comparison. Comparing across social and political structures not only helps to identify the content and contours of sociotechnical imaginaries but also avoids the intellectual trap of taking as universal epistemic and ethical assumptions that turn out, on investigation, to be situated and particular. Cross-national comparisons have proved especially useful in revealing the ingrained normative commitments that distinguish political communities, such as their ways of knowing and reasoning (Burri, this volume). These are rarely discernible from inside the safe havens of nation-states, where so much of political culture is accepted as part of the natural order of things; only by adopting the comparatist’s estranging gaze does one perceive the artifices of one’s own reasoning (Jasanoff 2005, 2011b, 2012b). But comparison need not be limited in kind or scale to nation-states alone.

Comparisons can be conducted across policy sectors or over time to illuminate the distributed character of the practices that hold imaginaries in place (see especially Felt; Hurlbut; Kim, this volume). Then, too, actors in these stories themselves compare, shaping their personal visions in accordance with imagined elsewheres and elsewhens, and those comparisons in turn get woven into social meaning making (Barker; Bowman; Dennis; Storey, this volume). The challenge for analysts is to conduct their own comparisons with epistemic charity and due respect for difference: not to apply universal yardsticks for measuring advances toward, or deviance from, allegedly transcendental ideals but instead to reveal, and destabilize if we are so inclined, the naturalized logics of functioning, self-contained, and self-replicating social and political systems.

Imaginaries by definition are group achievements—for example, of nations (Hecht 1998), ethnic or linguistic communities, social movements (Epstein 1996), or biosocial formations such as carriers of genetic traits for disease (Rabinow 1992; Parthasarathy 2007). Biographies of individuals are therefore not the most obvious route into uncovering the origins of imaginaries, although as several of the following chapters illustrate (Barker; Bowman; Moon; Storey, this volume), individual dreams and aspirations take hold and acquire collective force only when key actors mobilize the resources for making their visions durable. The literature on social movements has engaged with this interplay of subjective identity and action with the possibilities for intersubjectivity created by social norms. Melucci (1996, 33), for example, notes that identity is “both our ability to recognize ourselves and the possibility of being recognized by others.” In tracing how individual visions sometimes rise to the status of collectively held objectives, the imaginaries framework urges us to note not only the material instruments that reformers are able to accumulate but also their uses of symbolic and cultural resources, such as images, texts, memories, metaphors, and language itself.

The languages of power, especially the official discourses of the state, have provided fertile ground for social theorists, but once again the coalescence of the collective imagination with scientific and technological production offers particular stream beds along which to direct the flow of such analysis. Some are exemplified in this volume (Burri; Felt; Miller, for example); others can be found in work not explicitly invoking the concept of sociotechnical imaginaries. Policy discourses and processes of issue framing and agenda setting offer one commonly recognized starting point (Gusfield 1981; Schon and Rein 1994; Hajer 1995). Adding to that corpus, we can ask how actors with authority to shape the public imagination construct stories of progress

in their programmatic statements and how they blend into these their expectations of science and technology (Barker; Bowman; Dennis; Moon, this volume). Those questions, in turn, can be turned toward specific types of technopolitical order. One may ask, for instance, how narratives define the public good with respect to biotechnology (e.g., Chen; Hurlbut; Kim; Smith, this volume) or how they delimit, control, or contain risk in projects aimed at furthering goods such as energy provision (Jasanoff and Kim 2009, 2013). And, recognizing the potential of imaginaries to configure shared understandings of space and time, one can trace in policy discourse the creation of new geopolitical boundaries (Jasanoff and Martello 2004; Lakoff; Miller, this volume) or references to past achievements in promises (or fears) of future developments (Dennis; Felt; Hurlbut, this volume).

Practices matter in the analysis of sociotechnical imaginaries as they do in all attempts to make sense of the nature of collective life. An imaginary is neither cause nor effect in a conventional sense but rather a continually rearticulated awareness of order in social life (Jasanoff 2012b) and a resulting commitment to that order's coherence and continuity. A sure guide to finding such regularity is to look at how social actors and institutions respond when confronted by events that might disrupt order. Law then emerges as an especially fruitful site in which to examine imaginaries in practice. Legal disputes are in their very nature moments of contestation between disparate understandings of the good; and in the modern world these attach with great regularity to questions about science and technology. Should trees have standing (Stone 1974), should a regulatory agency be entitled to treat nuclear wastes as posing no risk (Jasanoff and Kim 2009), should living organisms be treated as property (Jasanoff 2012a; see also Sunder Rajan 2006)—these and countless other questions of equal or lesser significance have perplexed American legal thought in the past half century, requiring judges to issue rulings that often reproduce dominant sociotechnical imaginaries.

Legal decision making enjoys a special status in American political culture, because US courts are so heavily implicated in solving public problems. But legal practices are equally important to the construction of sociotechnical imaginaries in countries where power is differently allocated among the major branches of government. The practices of the Indian Supreme Court, for example, present striking similarities and differences in comparison with its American counterpart. The Indian high court has been as intimately involved in resolving disputes of a deeply political character on a range of issues involving science and technology, such as environmental protection, rights to life and health, and intellectual property. Yet, because Indian citizens may bring a so-called writ petition asking for direct adjudication of

claims of fundamental rights, the Indian Supreme Court has arguably been more open to the imaginations of the poor, or those normally seen as outcasts and outsiders of society, than the US Supreme Court, which is empowered to hear only well-formed cases and controversies. Even among Western industrial nations, comparisons of legal practices may prove extremely productive as a method of identifying and characterizing sociotechnical imaginaries (Jasanoff 2011b).

Policy documents, no less than judicial opinions, can be mined for insights into the framing of desirable futures (or, as Dennis argues, for the “monsters” that policy seeks to keep at bay) as well as for specific verbal tropes and analogies that help identify the elements of the imaginary (e.g., Burri; Bowman; Chen; Felt; Hurlbut; Kim; Miller this volume). Imaginaries, moreover, are not exclusively the property of state actors. National socio-technical imaginaries may permeate into popular culture, finding expression in the mass media and in nonofficial genres such as advertising (e.g., Felt, this volume) or the popular writings of prominent individuals (Barker; Moon; Storey, this volume). Multinational corporations increasingly act upon imagined understandings of how the world is and ought to be, playing upon the perceived hopes and fears of their customers and clients and thereby propagating notions of technological progress and benefit that cut across geopolitical boundaries (Smith, this volume). Coalitions between corporate interests and the media, through advertising and outright control, are increasingly likely to play a pivotal role in making and unmaking global sociotechnical imaginaries.

Conclusion

The essays in this book deal with questions that are central to any examination of political and social order. What makes a given social system—a nation or polity or movement or community—not only cohere (Benedict Anderson’s primary problem) but also be capable of absorbing and coming to terms with its own internal tensions and contradictions? How do the practices of collective imagination resolve conflict and produce consensus? Do powerful imaginaries mainly constrain and exclude action from below, or—like Foucault’s *grilles* which train perception and channel action but are themselves open to reshaping—can imaginaries be transformative, as vehicles for reenvisioning and recalibrating human futures? In the latter case, how do new mind-sets break free from older, culturally stereotyped ways of knowing that keep dominant hierarchies in place and alternative imaginations from flowering? How more particularly do the omnipresent agents,

instruments, and processes of science and technology—woefully neglected in so much social analysis—help mediate among competing expectations; and to what extent are institutions of power equipped to detect and correct for their own unexamined presuppositions when pursuing or implementing grand visions of progress?

In this chapter and those that follow, we provide methodological pointers for how to begin addressing such questions. We take comparison, in all its forms, to be a foundational technique, recognizing that comparison can operate across all kinds of organizational variables: political across nations and actors; historical through time; geographic in relation to space; economic across sectors; and cultural between groups and societies. Historical research in our view is essential to the exploration of imaginaries: it is only by following ideas through time that one gains a feel for what is fixed and what is changeable in social self-understandings as well as the reasons why. We have indicated, too, how many of the classical methods for studying social meaning making can be adapted and put to use in the framework of sociotechnical imaginaries. For example, the languages, metaphors, and symbols of official political talk can be mined for framings of risk and benefit, attitudes toward regulation and the market, and visions of technologically mediated progress or failure and backsliding.

The organization of the volume as a whole traces the basic dynamics of sociotechnical imaginaries: how they stop being personal or actor-centric “vanguard visions” (Hilgartner 2015) and how they instead become collectively held reference points and anchors for future projects. Scales matter on this account, as when the power to imagine moves from single “inspired” individuals or small collectives to communities and their leaders to nation-states and supranational global agencies. But the following essays should be seen more as braided together through overlapping themes than as divided into discrete blocks of sectoral or scalar analysis. Thus, historical origins matter centrally in chapters 2–6, modes of imperialism in chapters 2–4, Asian sociotechnical imaginaries in chapters 7–10, new technologies in chapters 9–12, and globalization in chapters 11–14. Paired juxtapositions explore more specific themes, such as memory making in the chapters by Felt and Hurlbut, Indonesian imaginaries of resistance in the chapters by Moon and Barker, and global imaginaries of risk and security in the chapters by Miller and Lakoff.

The book’s conclusion offers a more structured and sequential review of the chapters. Here we build on the content of the individual contributions to show how reforming visions are translated into imaginaries through interlinked phases of origination, embedding, resistance, and extension. In

recapitulating the stories told in each chapter, the conclusion reinforces the work done throughout the volume to dissolve hard-and-fast binaries: between descriptive and normative, structure and agency, material and mental, local and translocal. Imaginaries operate as both glue and solvent, able—when widely disseminated and effectively performed—to preserve continuity across the sharpest ruptures of innovation or, in reverse, to upend firm worlds and make them anew.

Regardless of the methods by which, and the sites in which, they are studied, sociotechnical imaginaries allow us to explore more thoroughly and understand more completely some of the most basic elements of human welfare. These include, most centrally, questions about the stability, durability, and coherence of social arrangements, all the more pressing in the postmodern condition, which has sensitized us to the contingency (Hacking 1999), fluidity, and chaos that often lap at the margins of achieved order. Squarely located in the space of science and technology studies, sociotechnical imaginaries at the same time break disciplinary boundaries, borrowing or building on theories and methods from anthropology, history, sociology, critical legal studies, and political and cultural theory. In this way, the framework avoids the analytic blinders that Latour, Mitchell, and others have rightly cautioned against. Most exhilarating, though, as this volume attests, is the fertile hybridity of the term itself. It offers unfettered entry into the coproduced realities of the known, the made, the remembered, and the desired worlds in which we live and which we have power to refashion through our creative, collective imaginings.

Notes

1. Creativity as a feature of human nature figured prominently in the debate, with Chomsky asserting that he means the everyday linguistic creativity of the child and Foucault insisting that individual creativity is enmeshed in prior, collectively formed regimes of truth within which minds unfold themselves. The word “grille” was used by Foucault in a meaning quite similar to Taylor’s social imaginary. A full transcript of the debate can be found online at <http://www.chomsky.info/debates/1971xxxx.htm>.
2. In 2012, the Bond film series enjoyed its own Golden Jubilee as “the longest running and (adjusting for inflation) most lucrative franchise in cinema.” See “From Britain with Love.”
3. These designations, as Shapin and Schaffer show, are themselves anachronistic. Hobbes was also a natural philosopher in his day, and his views on the nature of truth were deeply entangled with his political thought. Boyle for his part engaged with Hobbes on matters of political authority. Both men were concerned with the question of ultimate authority to resolve disputes over factual claims.
4. *Leviathan and the Air Pump* has canonical status in STS with respect to its claims about the origins of English experimental science. There is, of course, a large literature on

Thomas Hobbes in political philosophy, but it has not generally engaged with STS on a deeper level. A fairly recent book by Stephen Finn (2006), a political philosopher by training, affords an interesting glimpse into the noncommensurability of disciplines. Finn, following another political philosopher, William Lynch, rejects what Lynch refers to as the “holistic sociology of knowledge thesis” advocated by the authors of *Leviathan and the Air Pump* (Finn 2006, 17). Only Finn repeatedly, and erroneously, refers to the book’s second author as “Simon Shapiro.”

5. Ezrahi (2012, 288) makes a partial bow to these aspects of what he terms “perceptual indeterminism” and the subjectivity of visual experience in his later work on the imaginaries of democracy.
6. This was a major point of disagreement between Chomsky and Foucault in their 1971 debate. Chomsky, while disavowing any commitment to an idealized notion of justice, argued for the possibility of a gradual evolution toward greater justice (“we must act as sensitive and responsible human beings in that position to imagine and move towards the creation of a better society and also a better system of justice”). Foucault denied any such pragmatic evolution toward betterment without falling victim to the entrenched practices of power within which any notion of justice is embedded. See Chomsky-Foucault debate, *supra*, note 1.
7. Given where La Pérouse sailed, the elderly Chinese was more likely to have been one of the Ainu, the indigenous inhabitants of Japan.
8. We were each handed a red rose and a little rolled-up American flag, a potent symbol of nationhood, in addition to our naturalization certificates.
9. As an accompaniment to this book, the Program on Science, Technology and Society at the Harvard Kennedy School has also created a web-based research platform, which provides additional information on which kinds of primary sources provide researchable insights into sociotechnical imaginaries. See <http://sts.hks.harvard.edu/research/platforms/imaginaries/>.

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