

Thinking longer term about technology: is there value in science fiction-inspired approaches to constructing futures?

Clark A Miller and Ira Bennett

‘Science fact, not science fiction’ is an oft-heard refrain in the world of technology assessment and forecasting. Yet, as a literary form, science fiction offers a unique approach to thinking longer term about technology: one grounded in narratives that are people-centric, future-oriented, and focused on non-linear dynamics across the interaction of multiple technologies, value-laden images of future societies, questions of meaning and identity, and enduring symbols and problem framings. Building on this approach, we suggest in this paper that new socio-literary techniques, inspired by science fiction, could offer significant contributions to the governance of new and emerging technologies by improving the capacity to reflexively assess the social dynamics of socio-technical systems.

IN 2006, CHRISTINE PETERSON, Vice President for Public Policy at the Foresight Institute, delivered a lecture titled ‘Thinking Longer Term about Technology’ at Arizona State University’s Biodesign Institute — one of the world’s leading centers for research in the field of synthetic biology and a place that is busy inventing the future. In her lecture, Peterson laid out the process by which the Foresight Institute makes long-term predictions (by their definition, 20+ years) about technological change. Those processes, she opined, frequently made use of ‘hard science fiction’ — science fiction that stresses faithfulness to the laws of nature — as one source of prediction. Her suggestion, however: ‘Don’t think of it as literature.’ Skim the parts about people; only pay attention to the details of the predicted technologies. And be careful. Many science

fiction writers ‘selectively violate a physical law on occasion to make a human story’. The fundamentals of technology prognostication, she insisted, involved strict adherence to ‘physical law’ (Peterson, 2006).

Peterson’s lecture prompted us to write this article. While we understand why an organization like the Foresight Institute might be committed to a logic of technical rationality — science fact, not science fiction — we argue here that most ‘thinking longer term about technology’ ought not limit itself in these narrow technical terms. Indeed, in contrast, we argue that efforts to grapple with the long-term societal implications of technological change must pursue a more balanced approach that stresses the social at least as much as the technical. New and emerging technologies take their place, their form, and their influence in society from a dynamic interplay of human forces: emotions, ambitions, values, neuroses, conflicts, passions, and politics (Teich, 2006). Technology does not drive history; rather, humans create new ways of living with, in, and through technologies via a wide range of interpretations, applications, and rejections of technological systems (Smith and Marx, 1994; Bijker *et al*, 1987; Winner, 1986). Hence, if society is going to become more reflexive in assessing and anticipating technological change and its implications for society (see e.g. Guston and Sarewitz, 2002), it seems to us crucial to

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identify novel strategies for thinking longer term about technology that can incorporate questions of meaning and social dynamics — no less than physical laws — as foundational elements of analysis.

Our suggestion in this paper is that strategies inspired by science fiction — albeit with the narrative left in! — offer potentially significant value for technology assessment exercises seeking to grapple with the mutually constitutive relations of social and technological change. We stress that these strategies are inspired by science fiction: that is, they depart significantly from the traditional social and economic practices of science fiction short stories, fanzines, and novels. Much has been written from the perspective of literary theory and science studies about science fiction as literature and about the role of traditional forms of science fiction literature, the imagination of scientists and the public, and the emergence of novel technologies (e.g. Berne, 2006, Lopez, 2004, Turney, 1998). What we offer is different, however, in that we are interested in a more systematic use of strategies inspired by science fiction as part of the process of technology assessment.

What we offer in this article is far from a fully worked out analysis of what we term the use of *socio-literary techniques* inspired by science fiction. Instead, what follows is meant merely to be suggestive. We discuss some of the diverse ways that we think such techniques might be of value, and we offer some brief descriptions of a few preliminary exercises that we have run. There can be little question that science fiction as a literary form has both entertained millions of readers with fanciful stories of the future and also contributed some of the most powerful narratives of future technological societies found in contemporary culture (Sterling, 1999). We are interested, therefore, in whether efforts to create

narrative fictions of the future can also contribute more systematically to a broad range of societal efforts to analyze the meaning of long-term technological change for society: from technological assessments to citizen consensus conferences and other forms of public engagement in science and technology (see e.g. Haraway, 1991; Brin, 1999; Joy, 2000; Thurs, 2007, forthcoming). We believe that science fiction offers a potential model for balancing social and technical credibility in such efforts through its insistence on a heavy dose of social acuity and responsiveness to the wide varieties of human experience. At its most powerful, we argue, science fiction has the potential to be not just storytelling but an inquiry into the human dimensions of technological futures.

What is important in our approach is not prediction, in contrast to the approach offered by the Foresight Institute. Rather, tools built on science fiction might serve as means for building a reflexive capacity into the governance of technology: for helping individuals and communities to meaningfully deliberate technologies and to democratically construct technological futures (Jasanoff, 2005). Nearly every student in the United States reads George Orwell's *1984* or Aldous Huxley's *Brave New World* in class. More people in the United States take *Science Fiction 101* in college each year than will ever read most government reports or even participate in public dialogues about technology. Even in its current literary forms, science fiction is, *de facto*, technology assessment for the rest of us. Indeed, science fiction authors have pursued technological criticism for well over a century. Rather than rejecting that success, societal efforts to understand and assess new technologies might embrace it. Effectively integrating science fiction into such efforts may take considerable effort, but if it can help create the capacity in society to meaningfully evaluate new and emerging technologies and to democratically govern the design and construction of future technological worlds, then it will be well worth it.

To accomplish this objective would require the design of new approaches to engagement and assessment that integrate elements from science fiction. While we do not, in this paper, deliver a complete design for the use of science fiction in societal long-term thinking about technology, we have over the past year performed several exercises using novel socio-literary techniques that deploy science fiction in cultural settings that might be adapted for larger-scale public engagement or technology assessment activities. These exercises have different goals, methods, and social organization than the typical SF productions that appear in books, fanzines, and films. Their ambition is not merely to entertain but to engage citizens in thinking longer term about technologies in ways that avoid the overly narrow strictures of technical rationality while, at the same time, opening up dialogue to a wider range of publics.¹

A central problem in contemporary democratic societies is to engage the public in questions about the technological future. Narratives of socio-technical futures are already central in the technological imaginaries of contemporary societies, of course

We begin this essay with a brief discussion of what we see as the broad possibility for using science fiction in societal longer-term thinking about technology, followed by a more systematic exploration of the specific elements of science fiction approaches we see as valuable. We then discuss two of our socio-literary exercises in greater detail, concluding with an analysis of how such exercise might be expanded to larger scales of activity.

Science fiction and public engagement

A central problem in contemporary democratic societies is to engage the public in questions about the technological future. Narratives of socio-technical futures are already central in the technological imaginaries of contemporary societies, of course (Van Lente and Rip, 1998; Brown *et al.*, 2000), as well as in the literature of science fiction. By and large, however, these narratives and the imaginaries of which they form a crucial element are rarely subjected to systematic public analysis and deliberation in democratic societies (Jasanoff, 2005). Despite the foundational — one might even argue constitutional — importance of technological infrastructures in shaping the social and political arrangements of modern societies, these aspects of technology are often largely ignored in conventional forms of technology assessment, let alone broader societal dialogue and deliberation about technology.

Thus, Langdon Winner, in his classic book, *The Whale and the Reactor*, for example, argues that modern societies are engaged in a form of technological somnambulism — sleepwalking through rapid changes in the technological constitution of society (Winner, 1986: 5–10). Likewise, Sheila Jasanoff argues in *Designs on Nature* for renewed attention to strengthening the pathways by which democratic societies collectively know and imagine their futures — pathways she terms civic epistemologies (Jasanoff, 2005: 247–271). These critiques, which have begun to be taken seriously especially in the European Union, have led to a

growing array of efforts to engage democratic polities more broadly in the process of technology assessment (Felt *et al.*, 2007).

Engaging the public in such questions is not easy, however. Government reports addressing such questions languish unread by all but a small elite, for example, prompting in recent decades wide-ranging calls for the democratization of technological decision-making (e.g. Sclove, 1995; Petersen, 1984; Nelkin, 1977). Responding to this call for greater public engagement in technological choices, the US government has built public comment periods and public hearings into regulatory decision-making processes, while European governments and universities have pioneered novel forms of public engagement such as consensus conferences and *cafés scientifiques*. These are important and novel venues for public input into decision-making.

Nonetheless, public involvement in these activities remains small. The largest public engagement exercise ever held, for example, the UK Government's GM Nation, directly engaged roughly one out of every 1,000 UK citizens. The resulting deliberation involved over 600 local, regional, and national town meetings and debates, as well as 24,000 individuals visiting the GM Nation website. That said, however, this kind of experiment may very well never be repeated, and the vast majority of European public engagement exercises are substantially smaller, with most directly engaging fewer than 100 individuals.

One of the aspects of science fiction that makes it potentially interesting, in contrast, is the scale of its readership. More than 250 science fiction novels were published in 2003, as well as over 300 issues of magazines devoted to science fiction, testifying to broad public engagement.² Sales volumes for science fiction books are not easy to find; however, as we write this, Scott Sigler's *Ancestor* is the No. 7 bestseller on Amazon.com, indicating a sales total probably in excess of one million. Eighty years after its initial publication, Huxley's *Brave New World* rates among the top 2,500 books on Amazon.com in terms of annual sales. An NSF survey from 2001 notes that 30% of Americans read science fiction, including 31% of men and 28% of women. The question is whether novel forms of technology assessment, inspired by science fiction, can take advantage of the popularity of science fiction to engage publics more broadly in deliberations about technology.

Nor is science fiction simply a one-way exercise in the dissemination of ideas from authors to publics. One survey of websites estimated over 1 million fan fiction stories³ had been posted on a single website <fanfiction.net> by 2003. While not all of these are science fiction, over 1,000 fan-authored books are included in the genre of hard science fiction (by comparison, over 24,000 books have been posted by fans of the world of *The Lord of the Rings*). <Sf-fandom.com>, one of several fan websites built

for discussions of science fiction, has over 7,000 members. Nor do these numbers count viewers of mega-hits, such as the *Star Trek* TV series and films.

In his foreword to the 1984 edition of George Orwell's *1984*, Walter Cronkite highlights the symbolic influence of science fiction in shaping the public understanding of its technological future:

Seldom has a book provided a greater wealth of symbols for its age and for the generations to follow, and seldom have literary symbols been invested with such power. How is that? Because they were so useful, and because the features of the world he drew, outlandish as they were, also were familiar.

While *1984* is exceptional, it is hardly the only science fiction novel or film to shape the technological imagination of modern societies. Shelley's *Frankenstein*, Huxley's *Brave New World*, Clarke's *2001*, *Star Trek* — all have cast indelible shadows over the meaning and imagination of science and technology in modern societies. So, too, have blockbuster films, from *Technopolis* in the 1920s to *Minority Report* in 2004, while others, such as *Gattaca*, have become cult hits (typically one third to one half of co-author Miller's freshmen classes in any given year have seen *Gattaca*). Through their powerful messages these stories have shaped fundamental aspects of the moral texture of modern life.

Forms of truth-telling

The potential power of science fiction (and, arguably, fiction more generally) to shape the public imagination of science and technology derives fundamentally from its form of narrative story-telling. This form of story-telling departs markedly from the forms of technical rationality common to more classic approaches to thinking longer term about technology. 'Why speculate about technological possibilities that cannot exist?' these approaches seem to suggest.

And yet, why not? In 1932, when Huxley wrote *Brave New World*, he imagined his story as taking place 600 years in the future. By 1946, when he wrote the preface to the paperback edition, he imagined it perhaps 100 years in the future. In 1932, by the standards of technical realism espoused in technological assessments today, *Brave New World* would have been branded the most outlandish of fiction. Watson and Crick wouldn't identify the structure of DNA for another quarter century, while Dolly the sheep's birth 60 years later would still take the world by surprise. Surely few in 1932 could have imagined the technical possibility of sequencing a human genome or the existence of a vast pharmaceutical industry devoted to the production of new drugs like Prozac. (Recall, the first blockbuster drug, penicillin, is a product of World War II).

What then did Huxley offer to his readers, besides speculation? In our view, the best science fiction accords careful attention to what it means to be human and to live in human societies. Science fiction stories are just stories, myths, narratives, nothing more. And yet, writers like Orson Scott Card offer them as true⁵ — true in the sense of careful, thoughtful representations of what it might be like to live in the kind of world we might get in the future; true in the deeper sense of reflecting enduring realities of human existence, meaning, and identity; true in the sense of illustrating fundamental moral dilemmas faced by individuals and communities when confronted by new and emerging technologies, and the struggles to grapple meaningfully with those dilemmas in the only ways humans know how. So what does this alternative truth offer us?

People-centrism

Even the hardest science fiction, the stuff deeply concerned with getting the laws of physics right, centers on characters. People make stories come alive. Conventional efforts to analyze the long-term meanings of new technologies in society often seem to lose people, and especially individuals, even in forums of public engagement. Science fiction, on the other hand, revels in them: their strengths, their weaknesses, their greeds, their desires, their jealousies. Yet, it is wrong to see science fiction as merely about individuals; science fiction narratives are about individuals who inhabit societies, and the best science fiction allows us, through individual stories, to have societies very different from our own come alive. Science fiction thus attends to what Winner called technological forms of life (Winner, 1986). We live through, in, and with our technologies, and thus it seems sensible to seek approaches to informed deliberation that provide us with at least an imagined sense of what tomorrow's forms of life might look like. Michael Flynn's story, 'Soul of the City', offers a compelling example of this kind of human truth, as one character systematically undoes the technological acts of the other, reminding us of the deep interpretive flexibility of most technological

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systems in the face of human ingenuity, and the conflicts that often drive innovation.

Future orientation

The technical realism of many conventional forms of public engagement and technology assessment often constrains one to consider only the present, the past, and maybe the near future. Christine Peterson argued in her lecture that it was almost impossible to foresee technologies in a technically realistic way beyond a decade or so — for the Foresight Institute, 20 years is long-term speculation. And yet, when engaging democratic publics in the task of imagining technological futures, surely some kind of grip on longer timescales would have value. Most technological infrastructures, for example, have life cycles of over 30 years. Considerable housing stock in the United States has lasted now 100 years or more. David Brin acknowledged as much in his novel *Earth*, set in the mid-21st century. Brin argues that medium-term science fiction, which he defines as a half century in the future, is the most difficult to write well. It is also the most difficult to factor into decision-making. Nonetheless, it is crucial to the ability of democracies to understand and set in motion key elements of the technological worlds societies of the future will inhabit.

Non-linearity

All too often, current forms of technology assessment and public engagement in new technologies have a habit of treating technologies one-by-one. Here, an assessment of genomics; there, a discussion of personal communication and identification devices. Yet, reality is a matrix of interacting ideas and technologies more conducive to stories that are more fluid, complex, and open-ended. Likewise, rather than focus on the incremental, science fiction often grapples with the transformative. In these regards, as we mentioned above, what is important is not prediction. Science fiction likely provides little technical accuracy about how technologies and their interlocking meanings are likely to interact, especially under conditions of disruptive change. Instead, it suggests intriguing possibilities that provide needed attention to the character, dynamics, and uncertainties of non-linear interactions.

A fertile playground for the imagination

Speculation and creativity seem essential to the practice of democratic design of technological futures. In the preface to *Ringworld's Children*, Larry Niven relishes in the fans who spent years, sometimes, deconstructing the technical and social realities of the Ringworld:

All of these readers had found something worth knowing. The Ringworld is a great, gaudy,

intellectual toy, a playground with the gates wide open. Some readers just read a book and stop. Others play with the characters, or the assumptions, or the environment. They make up their own homework ... This is a playground for the mind. It's a puzzle, a maze. Question every turn or you'll get lost. When you've finished the book, remember not to lock the gate.

Good science fiction encourages not only speculation and creativity on the part of authors but also readers, who, captured by imaginary peoples and worlds, remain fully engaged. Could this creativity be captured in the design of future technological societies by democratic publics? Is not this kind of creativity and engagement precisely the aim of deliberations about the future of society? Can this creativity and speculation open up technology assessment to possibilities not yet imagined and industrialized?

Clear visions of desirable — and not so desirable — futures

Architects draw plans and build models in order to stimulate people's ideas of what they want — or don't want — in their future home or office. Outside of science fiction, no such models exist for the technological futures of societies. It is hard not to watch *Gattaca*, for example, without arriving at some sort of moral judgment, good or bad, about a world in which each individual's life is structured by statistical likelihoods expressed in their genome. Even if the answer is not to give up genomic medicine — which is hardly likely given today's trends — such imageries provide guidance about choices regarding new and emerging technologies and about kinds of problems to look out for in the future.

Resonance, meaning, and identity

Perhaps the most important aspect of science fiction for broad public engagement in technological decision-making is the challenge of resonance and meaning. Why should the public be engaged in deliberations about technological choices? It is not always clear how technological choices may impact the things people care most deeply about. Even today, after two decades of voluminous reports from the Intergovernmental Panel on Climate Change, the significance of many decisions about technologies that impact the Earth's climate remains unclear to the large majority of people around the globe. Science fiction, by virtue of the centrality of narrative and myth — the very quality most despised by the technical realists, and yet crucial to effective public communication — can help overcome this barrier and engage people's deep-seated, cultural sensibilities about what is significant and important in life. It is not accidental that Orson Scott Card's novels of Ender Wiggin are bestsellers.⁵ People resonate with

the depth of his characters, whose moral struggles remind us of our own and suggest ways of thinking about the latter in new light.

Enduring symbols and problem framings

However problematic it may be for those who seek to carry out technology assessment according to a model of technical rationality, science fiction is also a source of powerful enduring symbols and problem framings in the pursuit of democratic governance of new and emerging technologies. Mary Shelley's *Frankenstein*, for example, set the public stage for much of the current debate over biotechnology and genomics. Searching for a readily recognized symbol to capture the public imagination in its battle to highlight what it perceived as the risks of genetically modified foods, Greenpeace adopted the term 'Frankenfoods' and, spoofing Kellogg's, deployed a genetically modified Tony-the-Tiger, drawing on a century of feature film portrayals of Frankenstein. Likewise, for those concerned about the privacy implications of new and emerging surveillance and information technologies, *1984* has provided a poignant set of symbolic and conceptual resources for shaping the democratic imagination about the dangers of governments or corporations who seek to become the 'Big Brother' of this world.

Capacity building for reflexive governance

Reflexive governance implies the capacity to reason about socio-technological systems and change at the leading edge of the innovation frontier. It entails the capacity to reflect on and systematically inquire into and manage current and future technologies, based on a thorough understanding of technological forms of life. It means assessing the kinds of technological societies we are building, and the political economies that are building them. It means deliberating in depth about the future of technological societies and the potential for human meaning and wellbeing within them. It means identifying not only what gadgets might arise but also how gadgets intersect in society, with one another and with people, how people identify with, make use of, oppose, reject, apply, transform, or ignore various gadgets.

How then to achieve these capacities? Technological assessment in its current forms seems wholly inadequate to the task, especially if the task is understood to demand the capacity to think and deliberate on the part of broad swaths of the public as well as narrow communities of experts. Yet, in many ways, science fiction already accomplishes much of this objective, albeit without a clear sense of directedness. As we will describe in greater detail below, we believe there is very real potential for science fiction, if deployed with these goals in mind, to help provide the foundations for an alternative approach to enhancing reflexive engagement with the futures of technological societies.

Illustrations and examples

Even if science fiction offers an alternative approach to fostering thinking about longer-term developments in technology — one that focuses as much or more on the social dimensions of technological change than the technological — new kinds of socio-literary techniques would still be needed in order to exploit this approach in public engagement or technology assessment exercises. In the past two years, we have undertaken or participated in several exercises that have explored how aspects of science fiction might be used in interesting ways that we describe in brief here. We do not mean these to rise to the standard of proof of concept, by any stretch of the imagination. Nevertheless, we offer them as illustrations of a couple of possible approaches we have taken, early on in our explorations of how we might use science fiction-inspired techniques to advance the objectives of societal reflection on technological futures.

Such techniques can be divided into two categories: one consists of the creation of the art, the writing of the stories; the other is the consumption, where reader shares the visions of the author. From the perspective of using science fiction inspired techniques as tools for engagement, both of these components have possible use.

One approach is to help people visualize how technologies may play out in their future. Co-author Bennett helped coordinate a science fiction writing workshop developed by Rosalyn Berne, a professor at the University of Virginia, in the spring of 2006. Dr Berne runs workshops aimed at scientists and engineers involved in nanotechnology research and has emerged as a leader in the effort to use science fiction as a tool to explore values, beliefs and ethics (Berne, 2008). Since participating in Dr Berne's workshop, co-author Bennett has used science fiction writing as an educational tool with a variety of student audiences ranging from both undergraduate and graduate natural science and engineering students to in-service math and science high school teachers.

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of their lives or the lives of people of the future. The format starts with a few short writing exercises to help the students find their voice; then stories are assigned as homework. The assignment can be open, allowing students to write about the future in any way they see fit, or more constrained. In an example of the latter, Bennett has organized workshops involving graduate student scientists and engineers in which these students are asked to write science fiction stories that focus on a technology that might potentially result from their graduate research or the research of their lab. The final part of all the workshops is a reading where the participants read and the stories are critiqued in a group.

The collection of stories from these workshops involving graduate student scientists and engineers provides an interesting view into the thinking of researchers who are developing the technologies of tomorrow. Many of the stories were very dark, exploring issues of dual use and of misuse. However, many of the stories also included an underlying theme that no matter how invasive we make technologies there is something human about people that won't be changed or can't be 'fixed'. The stories showed that graduate researchers have a much more nuanced view of the non-technical questions that surround emerging technologies than it may sometimes appear or perhaps that they may realize. Through the writing of science fiction the researchers were able to explore dimensions of their own and others' research that do not typically arise in scientific or engineering discourse.

On another occasion, Bennett conducted a similar but more open-ended workshop with undergraduate science and math students. The group of stories that resulted from this exercise included a much broader range of themes. One story painted a picture of a perfect world awaiting an awakened patient of cryogenic preservation. Another explored the last stand of humanity against a wave of nano-enhanced zombies. Perhaps most interesting, as we think about what such stories might mean in terms of larger societal themes, several of the stories engaged themes of increasing isolation of humans as a result of increased communication with and through technological interfaces.

Many similar themes also arose in the stories written by high school teachers. The stories written by the teachers tended to not be as dark, and the misuses of technology, while still important to the story, were not as dire as the ones imagined by scientists. One of the most important outcomes of this exercise was a collective realization by the teachers of the differences in the way people view the future. Perhaps because they had much less of a handle on the technology than the scientists, the teachers were better able to elicit their personal perceptions of the future in their stories. In their mutual conversations following the reading of the stories, several in the group indicated that they thought of the future as using the same technologies as the present, just 20

years later, although they realized (and welcomed) that technological advances would take place. Several of the stories involved increasing distraction by personal communication devices: an increasingly prevalent real-world problem with mobile phones and messengers in their classrooms and an important potential insight into the kinds of worlds we are building through such technologies.

The activities described illustrate the power that science fiction can have for individuals participating in the creative process. These activities are intensive and high impact but due to the time and instructor effort may be difficult to scale up to large populations. Other possible approaches, such as those we plan for future activities, instead draw on the ability of science fiction to ignite the imagination, to help contextualize technologies that people may be living with in the future. By using visions of the future developed today and visions of today developed in the past, we are designing these projects to explore how the future has been envisioned in the past and how important past societies have treated the future. In this fashion, we also plan these exercises to explore how much control participants see societies as having — and not having — over how the future develops.

One project planned for the near future — the Technospeakeasies Project — focuses on elderly participants. Technological visions often focus on children and younger adults who will live with future technologies. Yet, the elderly are frequently dependent on technology for health and comfort. How do older adults feel about technology? Do they feel dependent or left out? How do older adults perceive their future, and how does technology fit into that perception? The project will offer participants an opportunity to engage these questions by exploring descriptions of how people in past decades imagined the world of today (e.g. in science fiction stories or World Fairs) and also by encouraging participants to draw on their own experiences in thinking about — and then living through — the futures that they have experienced. Contemporary science fiction will then be used to contextualize technologies and prompt reflections on their potential impact on the lives of participants, their children, or their grandchildren in the coming decades. The discussion will focus on what sort of future the participants would like to inhabit, how technologies fit into that vision, and how participants might help achieve it.

Scaling up

Our relatively limited exercises to date offer cautious optimism for believing that science fiction may offer potential for enhancing the capacity of democratic societies to govern emerging science and technology and imagine and construct future technological worlds. The next step is two-fold: to experiment with these and other innovative socio-literary

techniques that draw on aspects of science fiction to explore possible ways to think longer term about technology, while also taking the next step of beginning to contemplate how novel socio-literary techniques might be integrated effectively into broader deliberations about the futures of technology and society. A great deal of reading and discussion of science fiction stories takes place throughout society, yet this activity is rarely brought to bear on technological decision-making (Greenpeace's use of the Frankenstein myth is a rare exception that is never, for that matter, explored in depth). The challenge, therefore, is to find ways to bring the construction and deliberation of science fiction narrative productively into engagement with technological assessment and decision-making — to add to current modalities of science fiction writing and reading new kinds of socio-literary forms of production, consumption, and deliberation that allow for alternative and additional approaches to democratic engagement with possible technological futures. This challenge is open to all participants in technology assessment. We offer a few suggestions.

Enhancing public capacities to imagine and reason critically about technological futures

Public understanding of science is often assumed to be primarily a question of whether individuals can recite pertinent facts regarding particular fields of science. This is too narrow a conception, however, if we understand the problem at hand to be one of the democratic governance of emerging science and technology and the construction of technological futures. For these tasks, public understanding of science and technology must be widened to include understanding of science and technology as human enterprises and elements of larger social, political, and economic contexts. The task, therefore, for both formal and informal science education must be defined significantly more ambitiously than usual. One approach to consider is the integration of science fiction writing exercises into formal and informal science education programs. Students exploring informal and formal science education websites might be offered the opportunity to draft short stories about science and technology. Future visitors could then read and comment upon these stories. This model could also be adopted more broadly as part of science outreach programs, with kids and adults being encouraged to exercise their critical science fiction writing skills. Science fiction could also become part of the K-12 science classroom.

Promoting critical science fiction writing as a socially valuable profession, and one that interacts with both science and engineering and social and humanistic studies of science and technology

Many science fiction writing courses and workshops exist. By and large, however, these efforts focus

primarily on writing skills and insights about the profession of fiction writing. These are essential, of course, but they do not exhaust the potential skills necessary to take maximal advantage of science fiction as a public good. A valuable supplement might be to enhance the skills of writers in interacting with scientists working on the cutting edge and to increase the opportunities for these interactions to take place. Indeed, the embedding of fiction writers might provide useful outcomes in terms of stories and novels that place laboratory ideas and projects within a larger societal context. Recent work by Erik Fisher at Arizona State University has found that the presence of individuals in the laboratory asking questions about the societal implications of new and emerging science and technology can prompt substantive and fascinating revelations and reflexive insights among scientists working in the laboratory. One limitation of Fisher's work, however, is that it contains no mechanism to share the insights gained beyond the laboratory community. Were writers depicting possible technological futures stemming from cutting-edge science, one might begin to create greater public transparency for both what is happening in the lab and what it might mean for society. The National Science Foundation, which has by and large not been in the business of supporting science fiction, might be encouraged to fund training and/or networking exercises that would foster greater interaction among scientists and fiction writers.

Integration of science fiction into technology assessment

Over time, the most important project may be to try to identify mechanisms through which science fiction could be meaningfully integrated into society's practices and institutions for public engagement and technology assessment. This will not be easy. American political culture is deeply oriented toward the present, especially with regard to the framing of its regulatory gaze. As highlighted by the dissenting opinions to the recent Supreme Court ruling forcing the Environmental Protection Agency to regulate carbon dioxide and other greenhouse gases, US regulatory culture is founded on the axiom that only harms that are actual or imminent are generally

Were writers depicting possible technological futures stemming from cutting-edge science, one might begin to create greater public transparency for both what is happening in the lab and what it might mean for society

subject to regulation and redress. Thinking prospectively about the kinds of technological risks we may face in the future is, at best, not central to the framing of US risk assessment or technology assessment enterprises.

And yet, it would seem that finding ways to be more future-oriented would add substantial value to our assessment processes. In some cases, growing attention is being given within assessments to the practice of scenario-building — which in many ways is a form of science fiction writing. Judicious mixing of science fiction writing sensibilities into scenario writing practices could substantially enhance the public engagement possibilities associated with scenarios. This fact was recognized by the Millennium Ecosystem Assessment, a major international scientific assessment, which used drama to communicate scenarios to a range of publics in Africa. We should learn from this experience.

But science fiction can be more than just a communication tool. Citizens could be given new opportunities to contribute creatively to assessments through science fiction writing exercises, perhaps working with scenarios, perhaps in other ways. Experiments with citizens writing scenarios in an ecological assessment conducted by the University of Wisconsin showed that these methods have considerable power in facilitating citizen buy-in to the assessment process, results, and policy recommendations. They also shaped the scenarios in directions unexpected by the expert participants. Likewise, as a forerunner to a formal assessment process — such as the UK GM Nation exercise, where citizens were asked to meet and dialogue about their preferences with regard to genetically modified organisms — writers might be asked to develop multiple stories and dialogues that could be shared with the public alongside more technical reports.

Conclusions

Many scientists and engineers who love science fiction in their own personal reading habits also seem to deride it with regard to the public understanding of science. Michael Crichton's heavy-handed criticism of scientists in many fields, for example, has damaged the positive relationships that have long bonded science fictions writers with the scientists and scientific fields that they write about. Crichton's recent novels have pilloried scientists involved in climate research, nanotechnology, and genetic engineering. Ultimately, however, we believe that scientists' current disparagement of the role of science fiction in public life is misplaced. Where this rejection stems from a sense of loss of control over social narratives about science, generally, as well as about specific scientific ideas, scientists need to recognize a broader societal obligation to create joint narratives with society. Science has become one of the most powerful forces of social

transformation, a fact that the atomic scientists recognized at the first testing of the weapon they created. Once science leaves the laboratory, it can no longer be controlled by scientists — a fact we are reminded of every day as more and more nations develop and deploy nuclear weapons. What is of concern in science and technology are the collective futures of all of us on the planet.

All of us, therefore, should have some call on what is happening in the laboratory — at least to know what is being proposed and researched and what it might mean for our lives. We need, therefore, to develop new tools that can help the public engage vitally with scientific and technological futures, which increasingly are caught up not only in the physical transformation of matter but the biological transformation of life. One such potential tool is new socio-literary techniques built on the strengths of science fiction.

Notes

1. We are grateful to the editors for this formulation of the problem.
2. <<http://www.locusmag.com/index/yr2003/stats.htm>>, last accessed 17 March 2008. Wikipedia lists 23 science fiction films released in 2003, in eight countries. Overall, during the 2000s, directors in 24 countries released science fiction films. <http://en.wikipedia.org/wiki/List_of_science_fiction_films:_2000s>, last accessed 17 March 2008.
3. <<http://www.alternateuniverses.com/stats.html>>, last accessed 17 March 2008.
4. See e.g. Orson Scott Card, *The Worthing Saga* (New York: Tor Books, 1992): 'I believe in these tales. I have lived with them in my memory since I was in my teens. It took me a long time to acquire the skill to tell them as I wanted them told, yet I never ceased caring about them over the years. Now I offer them to you in the hope that you will find them powerful and true.'
5. Card was one of the hard science fiction authors whose literary elements Peterson so blithely dismissed in her lecture.

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