The Future of Technology Assessment

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Woodrow Wilson International Center for Scholars
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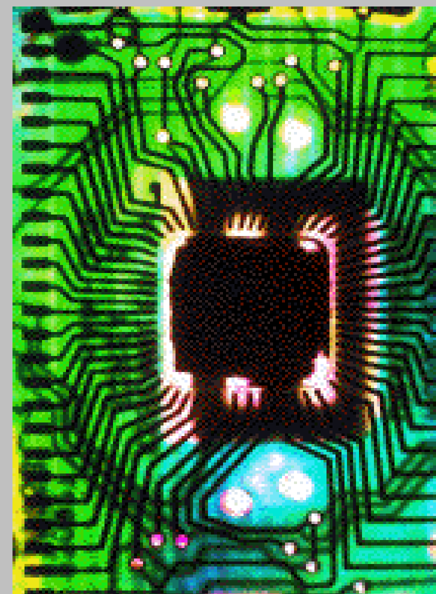

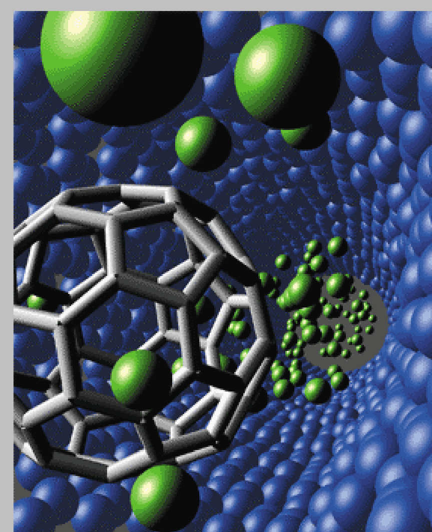

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About the **AUTHORS**

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Introduction

On September 29, 1995, the U.S. Office of Technology Assessment (OTA) closed its doors after 23 years of serving the U.S. Congress. During its existence, OTA provided members of Congress and others with non-partisan advice on topics ranging from fertility treatments to global climate change, producing a total of 750 reports and technical assessments.

Over the past ten years, there have been periodic attempts to argue OTA back into existence. Predictably, these occur in the wake of some flap over the possible social or ethical impacts of a new scientific breakthrough that then stimulates some journalist or pundit to lament the demise of OTA's assessment capacity. The doors remain closed, though the larger questions of whether OTA's function is needed, and by whom, remain largely unaddressed.

After OTA disappeared, we went on to complete the Decade of the Brain, finished sequencing the Human Genome, and launched a multi-billion dollar nanotechnology initiative. Policymakers found themselves dealing with debates around cloning and stem cell research, the ethics of brain scanning, and evolving questions about the health and environmental impacts of nanotechnologies. As nano, bio, and information technologies increasingly converge, the complexity and range of social, ethical, and legal issues are likely to expand, not contract. In addition, the government faces a public that has grown more suspicious of both public and private sector motivations concerning technological advances and a scientific community that remains largely isolated, and often oblivious, to public concerns.

The issue of technology assessment has been transcended by larger questions concerning governance in the 21st century. A recent report by the General Accountability Office (GAO) made the point that "In many cases, the government is still trying to do business in ways that are based on conditions, priorities, and approaches that existed decades ago and are not well suited to addressing 21st century challenges." The debate over OTA has become a mirror into a larger world where questions are being asked about the adequacy of government organizations, functions, and policies to address everything from disaster recovery to terrorism.

This collection of three essays is designed to explore the issue of technology assessment from multiple perspectives and with a look towards the future -- a future that will be radically transformed by our investments in science and our technological choices.

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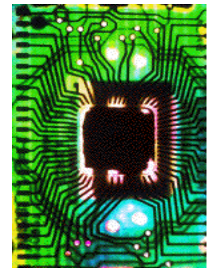

Back to the Future: Revisiting OTA Ten Years Later

Michael Rodemeyer

It's been ten years since the demise of the Office of Technology Assessment (OTA). In a town of notoriously short attention spans, few in Washington will mark the anniversary of the passing of a small and obscure office that used to help Congress understand and address the far-ranging impacts of technology – from implications for the environment and health care to national security.

That's unfortunate. For if anything, the power of technology to transform virtually every aspect of our lives has never been more evident, and the need for informed policymaking has never been more important. In the last ten years, technological change has continued to accelerate, and governments around the world continue to grapple with the policy consequences.

The sense that we are living in a time of unprecedented technological change is, somewhat ironically, not new itself; it's been a common theme of writers for at least 200 years. Yet it is hard to put aside the sense that change today is truly different. Perhaps it is not so much the rate at which new transformative technologies are introduced as much as it is the speed with which new technologies are widely adopted and the global scale on which it occurs. Technology is the gas pedal on the free-market engine of "creative destruction." Networked telecommunications and information technology have revolutionized manufacturing, trade, and whole economies. In the last decade, cell phones and computers have become a ubiquitous consumer item throughout the developed world. Agriculture has been transformed by insect- and herbicide-resistant crops created through rDNA biotechnology, the most rapidly-adopted agricultural technology in history. Indeed, the entire history of the commercial Internet has been written in a post-OTA world.

Meanwhile, scientists, probing ever deeper into the recesses of life and matter, are busy building the foundations for the next round of new technologies. The sequencing of the human genome, the cloning of mammals from adult cells, the synthesis of viruses from scratch, the production of drugs from bioengineered bacteria are all developments stemming from breakthrough discoveries in genetics. The rapid increase in federal funding for nanotechnology research promises a similar explosion of new technologies arising from the design and manipulation of matter at the molecular and atomic level. Many observers believe that the convergence of information technology, biotechnology, and nanotechnology will result in unimaginably powerful new applications in health care, agriculture, and manufacturing.

While people clearly value the convenience and benefits of new technologies, technology also generates plenty of anxiety. Some of that anxiety stems from the dramatic economic changes accelerated by technology and trade. Moral, religious and ethical concerns get raised about scientists "playing God" with the building blocks of life and matter. People are also concerned about long term adverse environmental or health effects and are skeptical that scientists and industry fully understand the risks of the technologies they are so rapidly deploying. Part of that anxiety stems from a lack of trust in those who control the technology to use it for good rather than ill. And in a world focused on terrorism, the potential of a technology that promises great benefits has to be weighed against its potential for great harm (Joy 2000).

It should come as little surprise, then, that the introduction of technology often generates conflicts that find their way into policy debates. Should scientists be prohibited from publishing research that could be used by terrorists? How should the radio spectrum be re-allocated to accommodate wireless growth? How do we manage global trade in commodity crops grown in the U.S., when some countries refuse to eat genetically-modified varieties out of concerns about safety? Should missile defense systems be deployed given the current level of testing and questions about how well they will work? How do you protect intellectual property rights and privacy in a digital world? How will new technology change job opportunities for Americans? How do you protect privacy in a time of global computerized databases? Should life forms be patented and owned by companies? Should federal research on stem cells derived from human embryos be prohibited? Should we ban human cloning? Should we regulate attempts to create artificial life? What are the environmental and health impacts associated with our energy choices?

The rate of change gives little time for policy makers and institutions to react to all of the consequences. Technology is often established and even entrenched before Congress has time to get its shoes on. And efforts to control technology through policy measures are increasingly ineffective in this age of globalization, since technology developers can react simply by moving to a more welcoming haven somewhere else in the world.

So how does Congress get the information it needs to help make policy on issues involving science and technology? For the most part, it gets it exactly the same way it gets all its information: from a cacophony of competing voices in the form of lobbyists, think tanks, policy shops, advocacy groups, media reports, agency officials, interested parties and even, from time to time, the public. Congress is awash in information, including information on science and technology (Wagner & Stiles 2003). In general, politicians are used to sorting through all this information to balance competing interests and values and to make judgments about policy outcomes. Why shouldn't this process, untidy as it is, be sufficient for decisions about science and technology?

In part, the answer is that science and technology reflects a specialized body of knowledge – and an approach to obtaining knowledge – that is different in many respects from the knowledge that most members of Congress bring with them. Most members come from a law or business background; few have scientific or technical expertise. When scientists testify before Congress, Members are often quick to disclaim their lack of expertise about scientific matters – an admission that would be extraordinary in other contexts. Imagine a politician happily confessing in a hearing that he or she doesn't understand economics or the law!

To be sure, policy decisions are almost always based on factors other than science – even issues with scientific and technological components (Sarewitz 2004). Scientific and technical information is rarely sought for its own sake, but rather to support policy ends. As Bimber (1996) puts it, "Unlike the researcher or analyst, the politician does not seek knowledge in order to know, but in order to do." Legislators certainly need not master the details of atmospheric chemistry or human genetics to make policy decisions.

But many decisions require at least *some* understanding of the science or technology involved if for no other reason than to ensure that the policy measures chosen are reasonably likely to achieve the desired outcome (Morgan & Peha 2003a). If policymakers want to end pirating of copyrighted materials over the internet, they need to know something about how digital technology and the internet work; otherwise, the attempted remedies may be useless or even harmful. If policymakers want to improve public health outcomes, they need to understand what factors affect public health. Protecting the environment requires some understanding of factors that contribute to environmental risks. Effective policy responses require some knowledge of how things work, and for that, Congress inevitably turns to experts to provide scientific or technical advice.

But what kind of experts? First, policymakers need advice from experts who are, in fact, competent in the subject matter -- those who can speak credibly and authoritatively about the relevant scientific and technical issues (Smith & Stein 2003). Second, the advice should be balanced and objective, without bias toward a particular policy objective. Together, these two attributes constitute what has been called "neutral competence" (Bimber 1996).

But policymakers need something more than balanced, neutrally-presented scientific and technical facts. They need knowledge – an analysis and synthesis of information that is timely, relevant and responsive to policy issues (Morgan & Peha 2003a; Hill 2003). This intervening step is one that requires familiarity with political institutions and policy debates and an understanding of the information needs of policymakers, an understanding that academic scientists often lack. This work of analysis and synthesis is one that requires "boundary organizations" – organizations that have, in effect, a foot in both the scientific and policy worlds and can credibly talk to both (Guston 2001).

To be sure, there are a plethora of Ph.D.'s at think tanks, policy shops, and advocacy groups all across the political spectrum who are all too happy to give Congress the benefit of their wisdom on science and technology policy related issues. The difficulty, as Morgan and Peha (2003a) have said, is that "careful, impartial, well-balanced analysis that is also sensitive to congressional needs is a scarce commodity."

The National Academies of Science are unquestionably a critical source of credible, balanced scientific and technical information for policymakers. And it's encouraging that the number of Congressionally-requested NAS studies has generally increased since OTA's demise (Ahearne & Blair 2003). But there are limits to what the NAS can do. As Smith and Stein (2003) have said, NAS reports are appropriate "when a high-end, 'Cadillac' treatment of an issue is called for and the prestige and depth of talent available to the academies are thus particularly suitable." The NAS peer review process ensures quality and balance, but it takes time -- often several years – to produce a report (Ahearne & Blair 2003). For the most part, the Academies respond to requests from agencies and Congress, who pay for and shape the scope of the NAS work. While this process helps ensure relevance, the Academies have only a limited independent capacity to raise questions that no political sponsor has an incentive to want answered (Kelly *et al* 2004). Finally, the NAS recommendations sometimes fail to take sufficient recognition of the *political* needs of Congress and other policymakers.

Observing this landscape, a number of institutions and scholars have called for the recreation of some form of Congressional technology assessment capability (Morgan & Peha 2003b; Kelly et al 2004; Chubin 2000). To date, however, Congress' response has been lukewarm. That is not necessarily because Congress sees no need for improved scientific and technological advice. Indeed, the current debates about "sound science" and "politicized science," along with the increased number of Congressionally-requested NAS studies, are evidence that there is still a Congressional demand for objective scientific and technological advice on a wide range of issues.

But the political leadership in Congress has little motivation to second-guess its prior decision to close OTA ten years ago or to increase legislative branch spending. Moreover, relatively few Members of Congress serving today actually had any experience with OTA; they can hardly miss what they never knew they had. In part, this is due to turnover in Congressional membership. But another reason is that OTA, when it existed, responded to requests for studies only from Committee chairs. As a result, rank and file members had little direct contact with OTA (Bimber 1996).

It's unlikely, then, that Congress will reestablish its own internal technology assessment capability in the near term, at least on anything like the scope and scale of OTA. In that case, could the need for such a capability be met or supplemented by external organizations not directly controlled or funded by Congress? Many observers are skeptical, assuming that only an internal organization can be relevant, responsive, and credible to Congress (See, *e.g.,* Epstein & Carter 2003). But Congressional control and funding brings its own problems, and the question is worth exploring in more detail.

As noted above, technology analysis must be timely and relevant to the policy questions and issues of concern to Congress. Obviously, any organization funded and controlled by Congress will have an advantage in understanding Congress' needs and timelines. But Congressional control also raises the "dilemma of expert independence" (Guston & Bimber 1998). On the one hand, expert advice is supposed to be neutral and objective; on the other hand, it is supposed to be relevant and responsive to political issues. An objective, independent source of expert advice would not only answer the questions Congress asks, but also raise those questions that Congress hasn't yet thought to ask – or doesn't want to. In the long run, policymakers are best served by expertise that will "speak truth to power" (Wildavsky 1979). But in the short run, an organization has to be responsive and useful to its funding source for its own preservation. A technology assessment capability funded and controlled by Congress will be hesitant to raise topics that will be politically inconvenient to whatever party is in power at the moment.

Relevance also implies usefulness in the politically meaningful (i.e., short-term) time scale. Focusing on the urgent issues of the day may ensure usefulness, but that often means reacting to a set of problems that have already been created rather than preventing or mitigating problems by anticipating them. The founders of OTA believed that it was important for Congress to have a "foresight" capability – an ability to look at longer-term issues associated with technological change, to serve, in part, as an early-warning system for legislators (Bimber 1996). The concept was that foresight capability could give policymakers the ability to get ahead of issues, not just simply react to them.

But as documented by Bimber (1996), OTA largely abandoned such efforts in the face of Congressional criticism. Some of the factors were practical; some Members simply felt that such studies were of little practical worth. Other concerns were more ideological. Many conservatives concerned about government interference with markets were deeply distrustful of efforts to forecast technology trends and impacts as a prelude to regulation and control (Keiper 2005). In fact, they argued that markets and technology were so dynamic that any forecasts would be doomed to failure, much like Edison's prediction that the phonograph would be used primarily to record the last-minute bequests of the dying.

In theory, at least, the value of independent expert analysis is to inform policy makers about issues of national concern, regardless of political expediency. But independent expertise will not last long in any political institution if it is seen as undermining the policy goals of the institution that funds it. This problem of balancing independence with relevance is hardly a new issue. Congress has grappled with similar questions about other Congressional support agencies in the past. And academics have studied the problem of "politicization of expertise" in a number of other political institutions (Bimber 1996).

Finding non-governmental support for policy-relevant technology analysis could be one way to help provide greater flexibility and independence. In addition, non-governmental entities could not only explore a greater range of issues, but would have more flexibility to explore alternative methods of "assessment" that go beyond the traditional "analysis by expert" approach. In the last ten years, there has been considerable thought and not insignificant experience in methods of "interactive" assessment that incorporate public participation (Guston 2003). In addition, other methods that seek to link analysis at an early stage of a technology development have been proposed (Schot & Rip 1997; Guston & Sarewitz 2001).

Of course, any external organization can provide Congress with independent policy-relevant advice on scientific and technical issues; the question is whether Congress should pay serious attention to it. The difficulty here is that Congress lacks the ability itself to judge the competence and neutrality of the expert advice it's receiving from outside groups. Plenty of studies can look like "sound science" but be little more than cherry-picked data intended to sell a policy outcome under the banner of science.

While a high hurdle, it's not impossible for an outside organization to earn a reputation for nonpartisan objectivity and balance. The NAS' reputation for scientific credibility, its peer review processes, and its requirement for balanced panels, all help ensure that its reports are taken seriously. To have any credibility with Congress, an external technology analysis would need to emerge from a similarly rigorous set of procedures intended to root out any perception of bias, partisanship or preconceived political agenda. Principles of peer review, balance, and transparency would need to be scrupulously observed. An analysis should adopt OTA's policies of refraining from making specific policy judgments or recommendations and instead lay out policy options in the context of a variety of possible policy outcomes, leaving the choice of the outcomes to Congress to make as a political, not a scientific or technical, decision. Such an approach provides helpful information to more members of Congress, while at the same time reducing the suspicion that there's a hidden policy agenda.

Since the demise of OTA, significant attention has been given to the recreation of some of OTA's analytical capability, both within Congress and outside of it. (Morgan & Peha 2003; Kelly *et al* 2004; Chubin 2000; Brademus 2001). Many of the studies have concluded that there is no single perfect institutional solution. Indeed it is questionable whether, if OTA were to be created today, the model for OTA used 35 years ago would still be appropriate. OTA's own experience, together with related efforts in national governments around the world, provide a fertile ground for new models.

The recognition that there is no single best institutional arrangement for technology analysis is a significant one. It helps move the discussion from stagnant nostalgia for the OTA toward a thoughtful and more creative reengagement of ideas for providing technology analysis to Congress in the 21st century. Given that Congress is unlikely any time soon to reestablish an organization of OTA's former scope and size, it's important to explore alternative approaches that, taken together, can still make a significant contribution to informed public debate. The point, above all, is the need is to move on and experiment with a variety of approaches and different institutional arrangements, learning what works as it goes.

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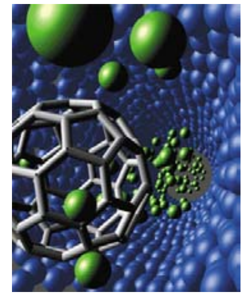
This Won't Hurt a Bit: Assessing and Governing Rapidly Advancing Technologies in a Democracy



Daniel Sarewitz

I. To Whom It May Concern:

I am writing to thank you for participating as a subject in the experiment. As a matter of full disclosure, I feel it only right to inform you that the experiment is likely to have very profound impacts on your life. These impacts may be quite positive—indeed, I presume that the anticipation of positive impacts explains why you are willing to take part. For example, many participants, perhaps including yourself, will become considerably more wealthy or healthy as an indirect consequence of the experiment. But I must also point out that the impacts may also be negative. Others may lose their jobs and otherwise find themselves increasingly at a disadvantage within our highly competitive society.

In the interest of openness I want to inform you that the experiment does not conform to the standard methods of rigorous scientific conduct. There is no control case. The experiment will go on, and we will see what happens. And the experiment cannot be replicated. We will be unable to determine what would have happened had we carried out a different experiment, or no experiment at all.

Nor are the subjects of the experiment—that is to say, you, among pretty much everyone else—protected by the ethical safeguards typically used by the scientific community for experiments involving human subjects. For example, prior informed consent is not required of the participants. I am writing to thank you for participating, but that is really more of a courtesy, a formality, than an acknowledgment that you have made a free choice to take part. In reality, you have little choice in the matter. In theory it might be possible to opt out of the experiment, for example by moving to a remote place, or adopting the lifestyle of a hermit, but in practice it is unlikely that you would be able or willing to do so.

The experiment deviates in other ways from accepted scientific norms. No one is really monitoring, in a systematic way, the progress of the experiment. Our understanding of the cause-and-effect relations between inputs (for example, funding for research) and societal outcomes is primitive at best. We lack a system of measurements to assess whether the experiment is or is not succeeding. To be honest, we don't even have a good sense of what "success" actually means, besides not destroying ourselves.

In some sense, it is fair to say that the experiment is really just basic research, a fundamental investigation into the question of what happens to humans and their surroundings when exposed to continuous, exponentially increasing rates of knowledge creation and innovation that move rapidly into society via economic markets and government activities. Yet, as I've already suggested, our ability to assess and measure the cumulative results of the experiment are limited to a few very indirect and coarse sorts of observations, such as changes in average per capita gross domestic product, or changes in the average temperature of the earth's atmosphere.

While the particular societal consequences of the experiment are unpredictable—in fact, that is what makes it an experiment—there are a few things we can say at this point. Most obviously, society fifty years from now will look radically different than it does today, and these changes will dwarf those of the past fifty years. Accelerating trends in computer power and machine miniaturization coupled with advances in materials, energy systems, communications technologies, and robotics will transform all aspects of society, from the structure of manufacturing and labor to the ways that we acquire, transmit, and use information. Social interaction may be profoundly altered in venues ranging from the bedroom to the battlefield. Advances in our ability to manipulate the genome of humans and other species will lead to enhanced power to intervene in developmental processes of individuals and probably in the evolutionary processes of entire species. The nature of birth, procreation, and death are all subject to radical change. (Taxes may thus remain the only certainty.) Hybridization of computer technologies and human intelligence will lead to rapid increases in information processing ability of humans and a blurring of the boundaries between the virtual and the real, and between the biological and the electronic. As just one specific example, the inventor and technological visionary Ray Kurzweil believes that in the next fifty years: "Brain implants based on massively distributed intelligent nanobots will ultimately expand our memories a trillionfold, and otherwise vastly improve all of our sensory, pattern recognition, and cognitive abilities." [1]

This experiment has profound moral implications, because it transforms the way we live and work and even think; because it transforms our perceptions, our values, our capabilities, and our social relations; because it creates winners and losers; and most of all because it is carried out by a rather small number of human beings making choices about the creation and use of new knowledge and technologies that profoundly affect the lives of other human beings—some of whom may live thousands of miles away, and have absolutely no idea that they are subjects in the experiment. This is not the weather we are talking about—it is a force of our own making.

II. Rationalizing the Political: Conventional Technology Assessment

Now this question of human agency raises an interesting problem. On the one hand, the scientific and technological transformation of society is a creation of humans making choices; on the other hand, once you begin to subject these choices to scrutiny of their potential impacts, people begin to get sort of uncomfortable. There seems to be a strong tension between a democratic society's commitment to self-governance based on widely shared interests, values, and aspirations, and its faith in the autonomy and benignity of scientific and technological advance. In order to hold this tension in check, the rhetoric of science and technology has relied on an apparent contradiction: science and technology were invariably justified by the promise of unalloyed societal benefits to come; but these benefits were said to be unpredictable, and therefore not subject to democratic scrutiny. Yet in the decades following World War II, the experiences of the nuclear arms race, of the despoliation of the

[1] Kurzweil, R., 2003, "Promise and Peril," in A Lightman, D. Sarewitz, and C. Desser (eds), Living with the Genie: Essays on Technology and the Quest for Human Mastery (Covelo, CA: Island Press), p. 51.

environment, of energy crises, and of failed development aid, made such rhetoric increasingly untenable.

One apparent solution to this tension, manifested in the technology assessment movement of the 1960s and 70s, was to forecast the directions and implications of new areas of innovation, thus providing information that could allow anticipatory decisions to be made democratically about specific types of technology.

As conventionally construed, technology assessment (TA) ran up against three insuperable barriers:

First, while plausible (although always uncertain) forecasts can be generated for very specific and fairly evolved technologies (e.g., the supersonic transport; a nuclear reactor; a particular pharmaceutical product), the radical transforming capacity of technology comes not from individual artifacts but from interacting suites of technologies that permeate society along many dimensions.

Second, interdependence among various components of such technological suites makes it very difficult to change them, especially once they are well-established in society and in the marketplace (for example, think of the incredible difficulties of moving away from a hydrocarbon-based transportation system).

Third, the medium- and long-term social implications of complex technological suites are practically impossible to predict with accuracy. Thus, the goal of anticipatory decision making based on predictive knowledge was illusory.

Unless conventional technology assessment was confined to a more narrow consideration of very specific technologies in very specific contexts (ranging from the incinerator in your back yard to, say, the viability of a specific space exploration mission), it was so subject to deep uncertainty that any results would be infinitely contestable. Indeed, what had originally been seen as the goal of technology assessment—prediction of technological futures as a basis for making democratic decisions—soon became the realm of the more marginal practice of "futurism."

From this perspective it is important to recall that the Congressional Office of Technology Assessment (OTA) very quickly moved away from conventional notions of TA to an approach that mostly provided surveys of the technical components of important and often controversial issues—such as economic competitiveness or the state of alternative energy technology. OTA brought together diverse groups of experts to develop what were often excellent summaries of the state of knowledge relevant to a given issue at a particular time. OTA also was in the business of addressing controversial but highly focused issues (Do alternative cancer therapies work? Is climate change real?). While OTA's reports often ended with a list of policy alternatives framed as "if-then" statements, it was really never in the business of providing technological forecasts aimed at supporting decision making.

So let's get back to the problem at hand: society seems to be on the threshold of a technological revolution whose implications equal, and may well exceed, those of previous technological revolutions. What appears particularly to distinguish this emergent revolution from previous ones is the potential transformation not just of human activities (warfare, work, recreation, travel, communication, etc.), but of the abilities and characteristics—and perhaps the evolutionary future—of human beings themselves. It is a grand experiment whose prospects are breathlessly extolled by some and fearfully derided by others, an experiment which from either perspective embodies the enormous contradiction between the ideal of democratic governance and the momentum of scientific and technological advance.

The conventional notion of TA won't help very much, for reasons I mention above. Put somewhat differently, conventional TA embodies a sort of hyper-rational approach to decision making whose greatest error lies not in its unrealistic expectation of accurate predictions, but in its linear view of how decisions should be made. As explained by Harvey Brooks (1976), who for 30 years was the clearest thinker we had in the realm of science and technology policy: "Ideally the concept of TA is that it should forecast, at least on a probabilistic basis, the full spectrum of possible consequences of technological advance, leaving to the political process the actual choice among the alternative policies in the light of the best available knowledge of their likely consequences."[2] First analysis, conducted by experts, then decisions, made in democratic fora, leading, one hopes, to more desirable outcomes than would have been achieved in the absence of the analysis.

From this perspective, the deepest problem is not analytical (after all, you can always assign a probability to a scenario), but the political end of the equation. As Brooks wrote: "The record on the implementation of TA has not been particularly happy. The outcome, whether negative or positive, tends to be more determined by political momentum and bureaucratic balance of power than by a rational process."[3]

In other words, the separation of rational analysis from political decision processes was integral to conventional TA. Crucially, this separation was not just conceptual but institutional: TA was something added on to the innovation process, done in different places, like OTA. TA also bought into the notion of science and technology as essentially autonomous enterprises that could be governed by introducing new technical information into political discourse as a basis for regulation. Thus, TA harbored the expectation that decision makers would potentially be willing to make controversial decisions on the basis of highly contestable, non-verifiable probabilistic statements about the future of a technology. And that such decisions would yield desired outcomes. It was destined to disappoint.

From this perspective, the evolutionary descendent of conventional TA was the Ethical, Legal, and Societal Implications (ELSI) program of the Human Genome Project. In the early 1990s, ELSI was grafted on to the Genome Project to support research by social scientists and humanists on some of the complex dilemmas raised by the coming proliferation of genomic information. Unfortunately, ELSI included no mechanisms for feeding back into decision making about science, or feeding forward into decisions about genome politics. It codified the separation of the science from the study of the social outcomes of science, and it marks the end of the first era of Technology Assessment.

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[2] Brooks, Harvey (1976). "Technology Assessment in Retrospect," *Newsletter on Science, Technology, and Human Values*, no. 17 (Oct), p. 20.
[3] Ibid, p. 21.

III. Politicizing the Rational: Real Time Technology Assessment

In reconceptualizing TA, the key reality to keep in mind is that the products of science and technology do not appear magically; rather, they emerge from choices made by people working in institutions designed by people. Most broadly, in the United States after World War II, a series of strategic decisions were made about which areas of science should be advanced, and those decisions led, over a period of several decades, to revolutions in such areas as computer science, solid-state physics, materials science, molecular biology, genomics, and electrical engineering, and to linked technological revolutions in weapons, communication, information, transportation, and bio- technologies. This did not happen accidentally, serendipitously, randomly, or surprisingly. It was all a product of decisions made in government, in industry, in universities, by people with a strong, if evolving, sense of what they were trying to accomplish over the long term, enabled by close relationships among a small number of leading universities, corporations, and government agencies.

Whether the long-term results of some specific discovery or line of research actually are predictable is thus irrelevant; the point is that decisions were made with a view toward future outcomes, not by tossing dice, and that such decisions strongly determined what types of knowledge and innovation would be created, and who was likely to benefit from that knowledge and innovation. Decision makers were acting in response to values, interests, aspiration, power, etc., just as decision makers always do. *The keys questions, then, are these: who is making the decisions? And how do these decisions emerge from the social context within which they are being made?*

If we understand that we are all participants in a great experiment in social transformation being carried out without our consent or even our understanding, the self-imposed limits of TA now become almost painfully obvious. If we understand technological transformation as emerging not from the autonomous, automatic advance of science and technology but from a complex set of decisions made within a variety of institutional contexts, then a different way to think about and implement TA can emerge. This new approach to TA will reflect the following realities:

1. The pace and direction of advancing knowledge and application is determined by human choice.

2. The specific directions in which technoscience is steered, and the pace of its advance, reflect who is making the decisions—their interests, values, motives, and perspectives.

3. The decisions that are made are determined within a complex social setting that encompasses a range of socioeconomic, cultural, and political components.

4. This complex social setting interacts with the results of technoscientific advance to create social outcomes. The setting, the science, and the outcomes mutually evolve over time.

These realities raise the following questions:

1. What is the range of choices available to people making decisions about science?

2. What are the interests, values, motives, and perspectives of people making decisions about science?

3. How do these interests, values, motives, and perspectives relate to the complex social setting within which decisions are made?

4. How do the results of scientific advance interact with socioeconomic, cultural, and political factors to yield social outcomes?

These questions can be researched and understood to various extents and would constitute *both the intellectual and the operational agenda* for the new approach to TA (an agenda that could build considerably on the past 30 years of research about the complex co-evolution of science, technology, and society). The idea is to build a capacity for *reflexiveness*—social learning that expands the realm of conscious and available choice—into science and technology institutions and decision processes themselves. The key point is that the process of understanding the dynamics of decision-making about science and technology simultaneously provides knowledge and insight that can improve decision making processes and enable the participation of a broader and more diverse community of decision makers.

At Arizona State University we have recently been funded by the National Science Foundation to prototype this approach at the level of a single national Center for Nanotechnology in Society. We term the approach "real-time technology assessment" (RTTA)[4] to indicate that the TA activity is integral to the innovation process itself. As a practical matter, RTTA includes four major components:

1. Understanding and communicating the direction, pace, and promises of the existing research enterprise;

2. Understanding and communicating the publics' and scientists' values and attitudes;

3. Engaging in a variety of participatory deliberation and design activities that build upon what is learned in 1. and 2.;

4. Understanding how decisions about nanotechnology may change based on greater individual, institutional and societal capacities to reflect on social context.

(In terms of timing, RTTA demands to be implemented at a very early stage in the evolution of a new area of technoscience, *before* social outcomes are well understood, and economic and political interests are reified. By comparison, our effort focusing on

[4] Guston, D & Sarewitz, D 2002. "Real-time Technology Assessment," *Technology in Society* 24 (2002) 93-109.

nanotechnology might correspond to an intervention in nuclear power R&D in the early-to-mid 1950s, or genetically modified foods in the late 1970s to early1980s.)

RTTA is located inside the knowledge creation and innovation process itself. RTTA demands that social scientists and natural scientists work hand-in-hand to develop a new type of environment for research and innovation. As such, it also demands institutional change that runs against the grain of traditional cultural separation (not to mention mistrust and sometimes even hostility) between those who engage in frontier technoscientific research, and those who seek to understand the conditions for and implications of such research. But our own experience is that a combination of institutional leadership, open, direct, and enthusiastic communication, and, needless to say, new money, can go a long way to cultivating the necessary change.

RTTA reflects four design principles:

1. *Expand contextual understanding*: Awareness of the complex social setting in which science is conducted and applied enhances understanding of the implications of decisions about science.

2. *Expand participation*: A broader range of science decision makers (i.e., more diverse interests, values, motives, and perspectives) is the key to enhanced awareness of the diverse values and interests that science may serve. People who fund, create, use, and are influenced by technoscience are all potentially legitimate decision makers.

3. *Expand choice*: More contextual understanding, and broader participation, will expand the realm of choice available to science decision makers seeking to advance public values.

4. *Get smarter over time*: Science decision-making should incorporate feedback and social learning processes so that decisions can reflect what is continually being learned from the mutual evolution of science, its social setting, and consequent outcomes.

Whereas conventional TA focused on generating information intended to allow decision makers to react to emerging technologies, RTTA focuses on improved decision processes that can enable learning, cultivate deliberation, signal emerging problems, and allow more conscious choice as research and innovation occur. The focus is on opening up the innovation process, rather than managing it after-the-fact. Rather than depending on the willingness of politicians to overcome their values and interests in making decisions about technology, RTTA seeks to build learning into the innovation process itself. This does not mean, of course, that regulation will no longer be necessary, but it could mean that it would be *less* necessary, and less surprising when it did become necessary.

What are the practical prospects of introducing an RTTA-like capacity across an entire innovation system? If we return to the notion of technological revolutions as great social experiments, then we can start by reflecting upon the robust societal consensus that demands prior informed consent as a basis for individual participation in an experiment.

For example, in the United States, every publicly funded research project involving human subjects is monitored by an institutional review board (IRB) that must approve the research before it can be conducted, and ensure that ethical principles such as prior informed consent are enforced. There are thousands of such boards operating in the United States, thus demonstrating that comprehensive governance is a reasonable goal. While IRBs certainly impose a cost in terms of the efficiency of conducting research, they are an accepted element of a scientific infrastructure that respects and protects human dignity.

The IRB experience shows us that comprehensiveness is possible when the stakes are high. And the stakes associated with emerging and converging technological revolutions are enormous and radical. Just as the IRB process is an accepted part of *all* human subjects research, institutionalizing RTTA as part of the publicly funded science and technology enterprise would best be done by requiring an RTTA component of all federally funded programs and projects related to transformational technoscience. The cost would not be trivial, but there would also be considerable economies of scale once an RTTA capacity was built within a comprehensive research institution like a university, and a considerable capacity to share certain types of information and activities (for example, data about the direction and pace of specific lines of research; organization of participatory deliberative activities like consensus conferences and scenario workshops) among multiple institutions. I would estimate that a decade-long ramp-up to an effort of about $100 million per year—or about 1.5 percent of the federal civilian R&D investment—would be adequate to build a significant national RTTA infrastructure.

Paddling Upstream: New Currents in European Technology Assessment

James Wilsdon

A novel experiment in science and democracy recently ended in northern England. From April to August 2005, a group of twenty people from Halifax in west Yorkshire met regularly to discuss the social and ethical implications of nanotechnology. Drawn from all walks of life, they were selected at random to participate in the UK's first citizens' jury on these new technologies. Like a jury in a court, the 'NanoJury UK' heard evidence from experts and debated the issues before reaching a verdict.

On 21 September 2005, four of the jurors traveled to London to present their findings to a meeting of scientists, policymakers and journalists. Mohammed Alyas, a Halifax taxi-driver, explained the process. "At first, when people said to us 'nano,' it meant nothing. But when we got together, heard witnesses and had a chance to question them, we unpacked a lot of it."

The jury's conclusions were balanced and sensible. They made recommendations about the use of nanotechnologies in healthcare and renewable energy, where they saw potential benefits. But they also called for better labeling and safety testing of manufactured nanoparticles, which some scientists regard as potentially toxic. Above all, they wanted the public to have a greater say in the direction of research. Richard Jackson, a Halifax businessman and another of the jurors, explained why: "I got the impression that even the scientists don't know where we're going with this technology. This isn't necessarily a bad thing, but we should be having a public debate about some of these questions."

Three phases in the science-society relationship

Such experiments reflect a wider shift in the culture and practice of science. After a decade punctuated by a series of scientific and technological controversies – over Mad Cow Disease, genetically-modified crops and now nanotechnologies – there is now a growing recognition across Europe that public voices need to be heard early, at a time when they can help to shape scientific priorities. In the Demos report '*See-through Science*', we argued that we are at the start of a new phase in science and society debates:

Phase 1: Public understanding of science (PUS)

The initial response of scientists to growing levels of public detachment and mistrust was to embark on a mission to inform. Attempts to gauge levels of public understanding date back to the early 1970s, when annual surveys carried out by the US National Science Foundation regularly uncovered gaps in people's knowledge of scientific facts.[i] Walter Bodmer's 1985 report for the Royal Society placed PUS firmly on the UK and

European policy agenda, by arguing that "It is clearly a part of each scientist's professional responsibility to promote the public understanding of science."[ii]

Phase 2: From deficit to dialogue

However, implicit in the language and methods of PUS was a flawed understanding of science, a flawed understanding of the public, and a flawed understanding of understanding. And it relied on a 'deficit' model of the public, which assumed that if only people were told more about science, they would fall in line behind it. In 2000, an influential UK House of Lords report detected "a new mood for dialogue".[iii] Out went PUS, which even the UK government's Chief Scientific Adviser now acknowledged was "a rather backward-looking vision".[iv] In came the new language of "science and society" and a fresh impetus towards dialogue and engagement.

Phase 3: Moving engagement upstream

The House of Lords report detected "a new humility on the part of science in the face of public attitudes, and a new assertiveness on the part of the public."[v] And in the five years since it was published, there has been a perceptible change. Across Europe, the science community has embraced dialogue and engagement, if not always with enthusiasm, then at least out of a recognition that GM and other high-profile controversies have made it a non-negotiable clause of their 'license to operate'.

Yet despite this progress, the link from public engagement back to the choices, priorities and everyday practices of science remains fuzzy and unclear. Processes of engagement tend to be restricted to particular questions, posed at particular stages in the cycle of research, development and exploitation. Possible risks are endlessly debated, while deeper questions about the values, visions, and vested interests that motivate scientific endeavor often remain unasked or unanswered. And as the GM case vividly demonstrates, when these larger issues force themselves onto the table, the public may discover that it is too late to alter the developmental trajectories of a technology. Political, economic and organizational commitments may already be in place, narrowing the space for meaningful debate.

As a result, in the past two years, there has been a wave of interest in moving public engagement 'upstream' – to an earlier stage in processes of research and development. For example, the 2004 report on nanotechnologies by the Royal Society and Royal Academy of Engineering acknowledged that "Most developments in nanotechnologies, as viewed in 2004, are clearly 'upstream' in nature"[vi] and called for "a constructive and proactive debate about the future of nanotechnologies [to] be undertaken now – at a stage when it can inform key decisions about their development and before deeply entrenched or polarized positions appear."[vii] Similarly, the UK government's new 10-year strategy for science and innovation includes a commitment "to enable [public] debate to take place 'upstream in the scientific and technological development process, and not 'downstream' where technologies are waiting to be exploited but may be held back by public skepticism brought about through poor engagement and dialogue on issues of concern."[viii]

A window of opportunity

This new vogue for upstream engagement may prove ephemeral, or may develop into something more promising. Andy Stirling, one of the UK's leading thinkers on public engagement, is optimistic. In a recent paper, he predicts that "New political arenas look set to open up, as 'upstream' processes of knowledge production, technological innovation and institutional commitment begin to acquire their own distinctive discourses on participation."[ix]

Yet it is also important not to overstate the novelty of moves in this direction. Attitudes and openness to public engagement varies across different EU member states, and some have been experimenting with 'upstream' techniques for many years. For example, in the Netherlands, social theorists such as Arie Rip spent much of the 1980s and 1990s developing methods of 'constructive technology assessment' (CTA) for use by the Dutch government, in an effort to embed social values in the design stages of innovation.[x]

However, across many European countries, there is now a sense that GM and other controversies have created a window of opportunity, through which we can see more clearly how to reform and improve the governance of science and technology. Most immediately, policymakers and the science community are desperate to avoid nanotechnologies becoming "the next GM." The wounds of that battle are still raw, and there is little appetite for a rerun.

Stuck in the shallows

In *See-through Science*, we argued that upstream engagement would fail if it simply moves the same set of 'downstream,' risk-based questions to an earlier point in the research process. Instead, it needs to open up new questions:

> Why this technology? Why not another? Who needs it? Who is controlling it? Who benefits from it? Can they be trusted? What will it mean for me and my family? Will it improve the environment? What will it mean for people in the developing world? The challenge – and opportunity – for upstream public engagement is to force some of these questions back onto the negotiating table, and to do so at a point when they are still able to influence the trajectories of scientific and technological development."[xi]

Yet although the notion of upstream engagement has found favour in some parts of the scientific and policy community, the reality does not always live up to the rhetoric. It is sometimes portrayed as a way of addressing the *impacts* of technology, be they health, social, environmental or ethical – rather than helping to shape the trajectory of technological development. The hope is that engagement can be used to head off controversy – a prophylactic that we swallow early on and then stop worrying about. There is no recognition that the social intelligence generated by engagement might become outdated or irrelevant as technologies twist their way through the choices and commitments that make up the innovation process.

We see this tendency in the otherwise admirable report on nanotechnologies from the Royal Society and Royal Academy of Engineering. This recognises that 'public attitudes play a crucial role in the realisation of the potential of technological advances'[xii], but nowhere suggests that peoples' values could themselves become the source of alternative research trajectories. The choice we are presented with is advancement or not, faster or slower, but with no real option to change course. This effectively rules out a role for public engagement of a more complex kind, in which scientists and engineers, sensitised through engagement to wider social imaginations, might for themselves decide to approach their science and innovation differently.

Those who see upstream engagement as a means of providing earlier and better predictions of risks and impacts are missing the point. It is not a matter of asking people, with whatever limited information they have at their disposal, to say what they think the effects of ill-defined innovations might be. Rather, it is about moving away from models of prediction and control, which are in any case likely to be flummoxed by the unpredictability of innovation, towards a richer public discussion about the visions, ends and purposes of science. The aim is to broaden the kinds of social influence that shape science and technology, and hold them accountable.

Scientism resurgent

Despite the progress of the science and society agenda, there are still those who maintain that the public are too ignorant to contribute anything useful to scientific decision-making. In the UK, one of the most vocal critics is the Liberal Democrat peer, Lord Taverne, founder of the pressure group Sense about Science. In a letter published in *Nature* (November 2004), Taverne rejects "the fashionable demand by a group of sociologists for more democratic science, including more 'upstream' engagement of the public and its involvement in setting research priorities." He concludes: "The fact is that science, like art, is not a democratic activity. You do not decide by referendum whether the Earth goes round the Sun."

But Taverne is setting up a straw man. Upstream engagement is not about members of the public standing over the shoulder of scientists in the laboratory, taking votes or holding referenda on what they should or should not be doing.[xiii] This agenda is not about imposing cumbersome bureaucratic structures on science, or forcing lay people onto every research funding committee. Questions about structures do need to be considered, but are a sideshow compared to the far more important – and exciting – challenge of building more reflective capacity into the *practice* of science. As well as bringing the public into new conversations with science, we need to bring out the public *within* the scientist – by enabling scientists to reflect on the social and ethical dimensions of their work.

We need to break down some of the false oppositions between scientists and the public that critics of engagement seek to perpetuate. Those scientists who take part as expert witnesses in public engagement exercises, such as citizens' juries, are frequently surprised at the insight and common sense that ordinary members of the public bring to such interactions. At its most effective, upstream engagement can help to challenge the stereotypes that scientists and policymakers have of the public. But it is important to start by wiping the slate clean of assumptions about who the public are and what they think.

The end of the line

When all else fails, critics of upstream engagement tend to resort to arguments based on a linear model of innovation. They grudgingly concede that technologies and applications may merit some public discussion, but insist that 'basic science' should be kept apart, as a unique domain governed by curiosity and 'science for science's sake'.

Yet like deficit models of the public, linear models of innovation are a default, unthinking response to the complexity of the subjects they purport to describe. As John Ziman observes, despite the fact that 'the linear model of technological innovation is obviously over-simplified… it underlies what most politicians, business people, civil servants and journalists say about science.'[xiv] Rhetorical arguments about linearity have created some powerful myths in the popular imagination.[xv] The idea that the discovery of new knowledge is the basis of innovation, and that science and technology are inevitable, but distinct, points on the same line. There is no questioning of *what* science, or *which* technology - the only issue is how fast we can move from one end to the other.

But of course, innovation doesn't happen in a line. Successful technologies are the products of networks of interaction between inventors, scientists, engineers, users and business people. For every technology that seems to spring from a clear advance in our scientific understanding, there are others that are prompting new lines of scientific enquiry, or whose powers of observation, calculation and analysis are allowing new types of science to be done.

Basic research is an attractive idea. And the idea of 'science for science's sake' may still motivate many researchers. However, the intellectual curiosity of individual scientists does not aggregate into the structures, expectations and funding opportunities that shape collective patterns of research. Scientists who would consider themselves to be doing basic research are frequently asked by funding bodies to justify their work in terms of its possible future benefits to society. As Helga Nowotny has described: '…It is not Nature whispering into the ears of researchers which problem they should address next, but an intricate mixture of opportunities and incentives, or prior investments and of strategic planning mixed with subversive contingencies.'[xvi]

If we visited a nanotechnology lab, we might observe an experiment designed to understand how nanoparticles could improve drug delivery, or an attempt to develop longer carbon nanotubes. In both cases, the researchers would be relying on highly advanced microscopes. In such a setting, what counts as basic science and what as technology? As one top nanoscientist says:

> 'The basic science argument is a red herring... Maybe if you're working in theoretical mathematics or particle physics, the idea has some meaning. But for everyone else, we now find that the science in the lab one week can pretty much be in the shops the week after. The process from basic science to applications has accelerated enormously.'[xvii]

The cycle of engagement

In criticizing the linear model, we also need to acknowledge the linearity of our metaphorical stream. A limitation of the notion of 'upstream' engagement is its implication that we can move up and down innovation processes at will, inserting a bit of public engagement where we judge it will be most effective.[xviii] Needless to say, we do not mean it to imply a one-off fix: that we can do public engagement early but not often. Rather, upstream engagement – at a point where research trajectories are still open and undetermined – should be the start of a process of *ongoing* deliberation and social assessment, that embeds dialogue between scientists, stakeholders and lay publics within all stages of the R&D process. Roland Jackson and colleagues have produced a diagram which conveys this idea of an ongoing cycle of engagement:[xix]

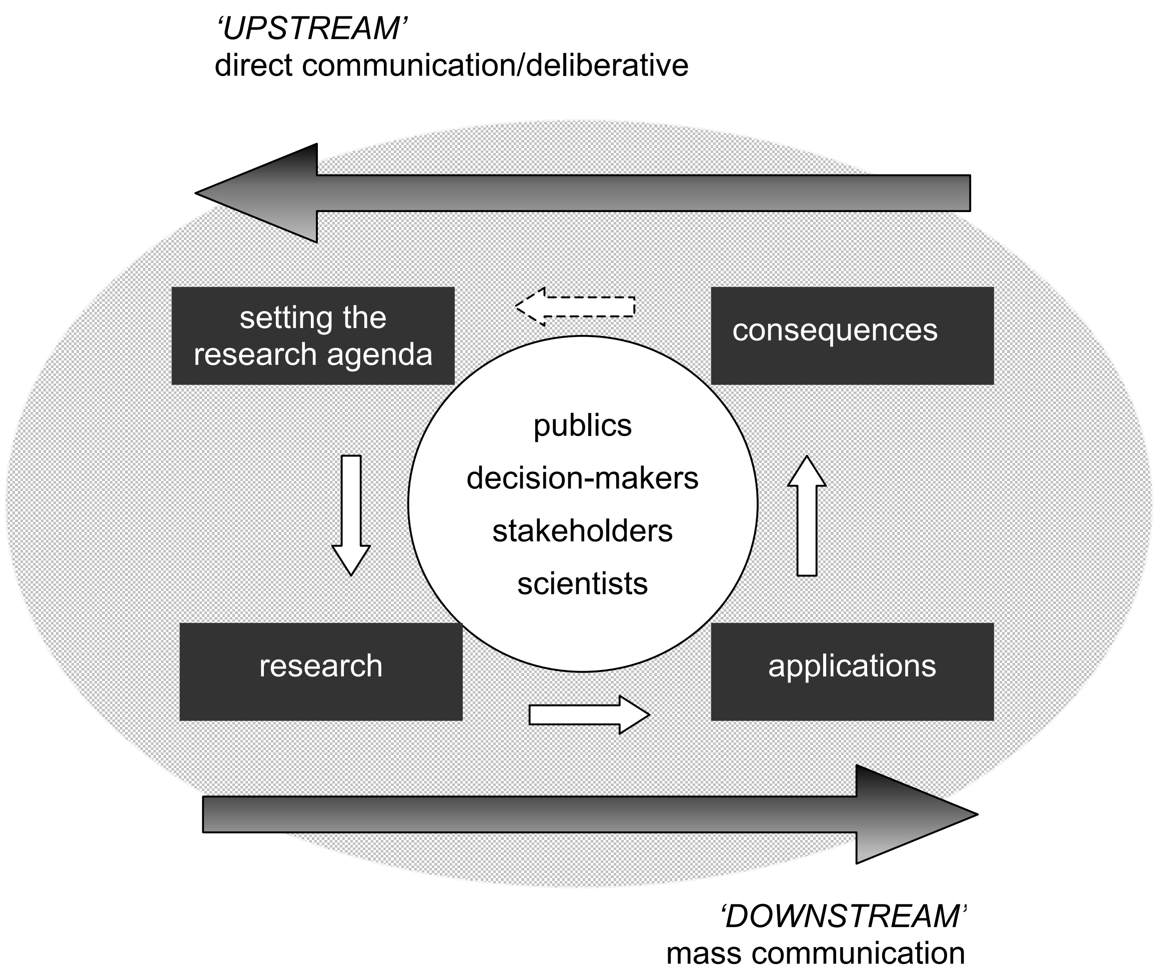

Figure 1: When and how should public engagement take place?

Jackson and colleagues explain the diagram as follows:

> 'If we imagine a cycle…it seems evident that different models of engagement are suitable at different stages. In general, where the research is in early stages and

especially where it is leading-edge and complex and there is great scientific uncertainty about outcomes, benefits and risks, small scale deliberation between scientists and others will tend to be most appropriate. Once applications and consequences are more evident, either anticipated or already realised, mass participation methods become more relevant."[xx]

Across Europe, a growing number of organisations are experimenting with new forms of upstream public engagement. These are all embryonic processes, and their eventual outcomes and effects cannot be predicted. But such experiments provide a glimpse of a more accountable model of science and innovation. Developing a more authentic debate on these questions is in the best interests of science, and of an enlightened democracy.

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[i] B Wynne 'The public understanding of science' in S Jasanoff, G E Markle, J C Peterson and T Pinch (eds) *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage, 1995), pp 361-88

[ii] The Royal Society *The Public Understanding of Science* (London: The Royal Society, 1985)

[iii] House of Lords Select Committee on Science and Technology *Science and Society* (London: House of Lords, 23 February 2000)

[iv] Ibid, paragraph 3.9. This quote comes from Sir (now Lord) Robert May's evidence to the committee.

[v] Ibid, paragraph 5.1

[vi] The Royal Society & Royal Academy of Engineering *Nanoscience and nanotechnologies: opportunities and uncertainties*, p.64

[vii] Ibid, p.xi

[viii] HM Treasury/DTI/DfES *Science and innovation investment framework 2004-2014* (London: HM Treasury, July 2004), p.105

[ix] A Stirling 'Opening Up or Closing Down? Analysis, participation and power in the social appraisal of technology' in M Leach, I Scoones and B Wynne (eds) *Science, Citizenship and Globalization* (London: Zed Books, forthcoming)

[x] A Rip, T Misa, J Schot (eds) *Managing Technology in Society: The Approach of Constructive Technology Assessment* (London: Thomson, 1995)

[xi] J Wilsdon & R Willis, *See-through Science: Why public engagement needs to move upstream*, p 28

[xii] The Royal Society & Royal Academy of Engineering, *Nanoscience and nanotechnologies: opportunities and uncertainties* (London: The Royal Society, July 2004), p 59

[xiii] J Wilsdon & R Willis, *See-through Science: why public engagement needs to move upstream*, p 61

[xiv] J Ziman, *Real Science: What it is and what it means* (Cambridge: CUP 2000), p 15

[xv] Brooks, H (1994) The relationship between science and technology, Research Policy 23, pp 2477-486

[xvi] H Nowotny, 'Society in Science: the next phase in an impetuous relationship' Keynote speech at the Science and Society Forum, Brussels, 9-11 March 2005

[xvii] Interview with Mark Welland, 22 June 2005

[xviii] We are grateful to Andy Stirling for his thoughtful insights on this point.

[xix] R Jackson, F Barbagello & H Haste, 'Strengths of Public Dialogue on Science-related Issues', *Critical Review of International Social and Political Philosophy* Vol. 8, No. 3. September 2005, pp 349-358

[xx] Ibid p 353