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Dialogue

Public Science and Social Responsibilities

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ABSTRACT *Daniel Sarewitz argues that science and technology constantly remake the world, and that each new wave of remaking has brought with it both enormous advances and huge challenges. Faced with the prospect of great, culturally disorienting and transforming changes across multiple dimensions, the question he asks is how, in the face of such changes, we can understand the responsibility of science and scientists.*

KEYWORDS *Einstein; public investments; innovation; social responsibility; values*

Einstein, technology and the role of the scientist

In thinking about the responsibility of science in light of rapidly emerging technologies today, Einstein presents us with a problem. He, of course, embodies both our image and our ideal of what it means to be a 'scientist'. At the National Academy of Sciences in Washington D.C., the self-proclaimed 'temple of science', a bronze Einstein watches benignly over the grounds. This statue seeks to show Einstein as a familiar human being, ruffled sweater, droopy eyes, oversized hands and feet, wise, avuncular, worldly, and a bit tired. In his left hand is a notebook, etched with a few of his most famous equations, the manifestation of his brain.

Let us say this is the real Einstein. Certainly this is the mythic Einstein. Yet almost no scientist is really like this, at least not anymore. Einstein did his research in his head; he transformed the way we understand our world, and became a sort of moral compass for humanity; he sought truth, fled oppression, pursued peace. Einstein equalled what we wanted science, and scientists, to be. But there can be no more Einsteins.

In the century since Einstein, science has changed, and our understanding of science has changed. Today, something like 8 million scientists work in the world: in universities, corporations, governments, civic organizations. Some of them are geniuses, some are leaders, some are loners, some make a difference in the world, and advance noble ideas and causes. But, really, the idea of an individual scientist is now pretty much an abstraction and an anachronism. The world has become a global innovation machine. Scientists are gears in this machine. They are part of a disseminated, complex process that is constantly remaking the world itself. What can one say about the scientific responsibility of such a gear?

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Five facets of science and technology today

It is true, of course, that science and technology have been constantly remaking the world for some time now, and that each new wave of remaking has brought with it both enormous advances and huge challenges. But important things seem to be different now.

Most obviously, the scale and reach of the enterprise has grown enormously. Many aspects of the scientific endeavour, such as numbers of scientists, numbers of papers, and numbers of publications, display exponential growth. Moore's law is perhaps the most famous of these exponential curves, and stands as a surrogate for the growth of both data gathering and data processing capabilities. Obviously the global annual investment in research and development today, which I would estimate as roughly a trillion dollars per year, dwarfs expenditure levels of Einstein's day.

Second, the distinction between science and technology is increasingly blurred, to the point where it confuses more than it clarifies. Technological advance drives science in various ways, for example, by constantly raising challenges that demand new scientific exploration, and also by providing scientific tools that create their own demand for use. Public sector investments in scientific research are often justified in the context of technological application, while intellectual property rights are extended farther and farther upstream to capture the fruits of scientific discovery, and scientific advances in some fields are instantly translatable into marketable innovations. So, not only are science and technology blurring together, but so are their public and private aspects.

Third, science and technology now act on a world already created by science and technology. This is what Ulrich Beck (1992) termed 'reflexive scientization': 'the sciences are confronted with their own products, defects, and secondary problems … scientific skepticism (extends) to the inherent foundations and external consequences of science itself' (p. 155). These foundations and consequences help to constitute everyday existence; they are not perceived, indeed are not comprehensible, as something added on. As a consequence of this integralness, science also descends from its pedestal to become part of the everyday. Science's claim to disinterest, which we see in Einstein, and privilege, which we afford to him, are undermined. Beck says: 'Science becomes more and more necessary, but at the same time less and less sufficient for the socially binding definition of truth' (p. 156).

Fourth, and related to the previous, is this: we are moving farther away from any sort of grand synthesis. From our studies of the climate to our mapping of the genome, we just keep on finding more complexity and more uncertainty. This is just science doing its work, of course, but it means that the prospects of an Einstein changing the way we see everything are pretty much vanished. When a scientist is sufficiently impudent to try to posit a grand theory, as the biologist E.O. Wilson (1998) did in his book *Consilience*, it seems more like desperation, or at least religion, than science. Similarly, the idea that physics can provide us with a 'theory of everything' attests mostly to an absurdly limited notion of 'everything'.

Fifth, the pace, breadth, and depth of scientific and technological change seem to outstrip anything that has come before. 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: the structure of manufacturing and labour; the ways that we acquire, transmit, and use information; our manner of interaction with fellow humans in venues ranging from bedroom to battlefield.

Human identity and technology

Perhaps many of these changes will be no more culturally profound than the social disruptions caused by, say, the convergence of the steel and railroad industries, or the proliferation of electricity and the telephone. This is still saying a lot. Yet something new does seem to be emerging in terms of the relation between technology and the human species itself. Technology has always been about enhancing the power of the human being, yet the enhancement has been external to our es-

PPL.DEV.D1-49-4

sence – prosthetic, as it were. Eyeglasses, telescopes, running shoes, guided missiles, supercomputers, these are all magnifiers or extenders of human reach. But on the horizon now is the potential disappearance of any conceptual stability to the idea of human identity and the distinction between humans and machines. Steroids and other performance enhancers in athletes are just the trivial foreshadowing of, say, ubiquitous in-body sensors, implanted memory expansion, and even virtual immortality. As just one specific example, the inventor and technological visionary Q1 Ray Kurzweil (2002) believes that in the next 50 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' (p. 51). If, as some scientists suggest, germ-line enhancement therapies become possible as well, then we will finally be able to reconcile Darwin and Lamarck. Beck's 'reflexive scientization' will become literally internalized, as we remake ourselves. We have hardly begun to consider the implications of these changes for our society.

So we are faced with the prospect of enormous, culturally disorienting, and transforming changes across multiple dimensions, and the question is how, in the face of such changes, we can understand the responsibility of science and scientists.

Science and society

Existing concepts are just not appropriate. In the years following World War II, as the US began a gradual and unprecedented ramping up of its commitment to publicly funded science, the responsibility of the scientist was widely portrayed simply as a responsibility to science itself. Often spoken of in terms of a social contract, the responsibility of the scientist was just to do honest science. The trick here was that the fruits of science in society were supposed to be unpredictable, yet automatic. Through the unfettered exploration of nature, and the serendipitous translation of insight into innovation, science made the world better. The logic of the progression, though, was only visible in hindsight. It could not be planned.

Symbolically, then, we can trace wave after wave of transformational innovation and wealth creation in the decades after World War II to the massive Cold War commitment to publicly funded science, a commitment made compelling by the cathartic wedding of basic science to national defence in the development – and use – of the atomic bombs that ended the war with Japan, which in turn finds its origin in Einstein's famous letter to Roosevelt about the feasibility of nuclear weapons, itself made possible by the most famous equation of them all, $E = mc^2$.

Thus, did post-industrial society spring from the head of Einstein and other mythic figures, in the apparent absence of human intent and agency – and thus, responsibility. Society needed only to provide resources for scientists, and scientists needed only bring integrity and openness to their work. To do more was not only unnecessary, but, as Karl Polanyi (1962) liked to argue, entirely counterproductive. Scientists would operate in a self-regulating, autonomous republic, and the world would unfold. If, of course, it did not blow itself up in the process. But in either case, to suggest that responsibility for long-term outcomes lay in individual scientists was incoherent.

Thus, questions about the social responsibility of science were addressed within the context of the social contract. During the Cold War, some scientists expressed their social responsibility outside the laboratory, as social activists, opposing the arms race, or within the laboratory, by refusing to participate in classified research programs. But the ideal of the autonomous republic of science was not called into question. The burden of responsibility always fell on the world outside of the republic.

Public investments, social responsibilities

In the 1980s and 1990s, some significant attention was paid in the United States to instances, real and alleged, of 'scientific misconduct'. The research community, embodied in such organizations as the National Academy of Sciences,

PPL.DEV.D1-49-4

constituted committees to study the problem, while politicians wondered whether scientists could, after all, be trusted to meet their internal responsibilities. The deep anxiety expressed by leaders of the scientific community on this issue was also a fear that the supposed social contract might be called into question – as it was. But the solution – greater independent oversight of various funding bodies and research activities, plus codes of conduct, and classes on research ethics, only served to maintain an inward focus. The problem was about ensuring the integrity of a still-autonomous republic, not about the validity of the ideal itself.

Public investments in science have always, of course, been justified explicitly in terms of meeting social needs, and from time-to-time, politicians have lost patience with the metaphysical model connecting autonomous knowledge creation to societal benefits. In the US in the 1960s and 1990s, for example, scientists were called upon to more explicitly devote themselves to research that addressed urgent social challenges ranging from environmental degradation to emerging diseases to economic competitiveness. Science policy experts meanwhile have sought to resolve the apparent tension between the requirements of scientific autonomy, and a responsibility for contributing to social betterment, through theoretical constructs with names like 'use-inspired basic research' (Stokes, 1997) and 'Jeffersonian science' (Sonnert and Holton, 2002). The idea was that fundamental science could as well be carried out in the context of a particular societal problem – say, some type of cancer; or global climate change – as it could in the context of no problem at all. The autonomous republic of science could thus be preserved, while also serving explicit social ends. Social responsibility for the scientist could still be conceived very much in terms of the relationship between an individual scientist and her or his work. Is the science of high quality? Is he doing research in an ethical manner? Is she choosing projects that are likely to be beneficial?

But the individual scientist has little if any meaning in the global innovation system. There are millions of such scientists, and more coming on line each day. The scale, complexity, aims, and outcomes of the enterprise may be completely opaque to an individual scientist, but this does not compromise their ability to perform. To locate scientific responsibility in the individual scientist is thus to render it meaningless as well. It's not that we shouldn't expect scientists to behave ethically, its just that such behaviour, even when considered cumulatively across a community of scientists, has little or probably no connection to the dynamics and impacts of the innovation system. Or, put somewhat differently, we can populate our innovation system with scientists pursuing truth and behaving ethically, and still end up with outcomes that we cannot manage, or that challenge our values and principles. So, the key question is this: is there some notion of scientific responsibility that can play a useful role in confronting the waves of technological transformation that seem likely to inundate society in the next few decades?

Science in context

In my previous list of how the science enterprise has changed since Einstein's heyday, I did not mention one important thing: we now have a considerably deeper understanding of how this enterprise actually works. We know that scientists negotiate not only with nature to advance knowledge, but with each other, with their funders, with politicians, corporate executives, various publics. We know that the directions and velocities of science reflect decisions made by people, and decisions emerge within a context. We know that context is strongly embodied by the institutions where science is conducted and planned. These understandings have not yet been brought to bear on new notions of scientific responsibility, but, if we are to have any prospect of guiding the accelerating technological change that engulfs us, now is the time to consider how this might be done.

There is huge inertia and low predictability in the global innovation system, so my intent is not to be particularly optimistic about, say, ensuring the public value of emerging technologies, but rather to suggest where we might intervene if we are to move toward a meaningful notion of scientific responsibility – and thus accountability. It seems unavoidable to me that responsibility must be located in the processes by which decisions about science are made and implemented in the institutions of public science, rather than in the motives and norms of individuals who conduct science. What we need to aim for is a capacity for reflexiveness – for social learning that expands the realm of choice available within public research institutions. This means, above all, that scientific institutions, broadly defined, will have to build the capability for scientists and technologists, as well as research planners and administrators, to understand where their research agendas come from, what interests are embedded in the agendas, who supports the agendas, who opposes them, and why.

Institutions need, in other words, to enable consciousness – consciousness of the contexts within which scientists do their work and make their decisions. This quest for consciousness can emerge from persistent collaboration with social science and humanities researchers, from open and informed engagement with various interest groups and publics, and from unflinching reflection and deliberation about motives and values. These things need to be built into research institutions. In the ideal, the creation of consciousness can help signal emerging problems, support anticipatory governance, and enable better choices to be made about the directions and pace of knowledge creation.

Public science and public values

There is a weak but valuable analogue for what I am suggesting here, and that is the private sector laboratory. Corporations go to great lengths to understand the market context that can justify – always in terms of profitability, of course – the research being pursued, while economic performance indicators provide feedbacks for accountability. Can public science engender a commitment to understanding its social and cultural context that matches the commitment of private science to understanding its marketplace context?

What I am suggesting is somehow less satisfying than simply demanding that scientists take moral ownership of their work and its consequences, and do the right thing. But if such an individualistic approach ever made sense, it no longer does. If we are to have any prospect of guiding and modulating the advance of rapidly emerging transformational technologies in accord with goals, values, and interests other than those dictated by the marketplace and the military, then the responsibility of the scientist must expand from doing the right thing as an individual, to participating in the reflexive process of creating institutional consciousness. This, in turn, demands a radical shift away from the constricting notion of science as an autonomous republic, to embrace the realization that science and society are moving together in an intimate, co-evolutionary dance.

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PPL.DEV.D1-49-4