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Science policies for reducing societal inequities

Edward Woodhouse and Daniel Sarewitz

In an effort to move social justice issues higher on R&D policy-making agendas, we ask whether new technoscientific capacities introduced into a non-egalitarian society tend disproportionately to benefit the affluent and powerful. To demonstrate plausibility of the hypothesis, we first review examples of grossly non-egalitarian outcomes from military, medical, and other R&D arenas. We then attempt to debunk the science–inequity link by looking for substantial categories where R&D is conducive to reducing unjustified inequalities. For example, R&D sometimes enables less affluent persons to purchase more or better goods and services. Although the case for price-based equity proves weaker than normally believed, R&D targeted towards public goods turns out to offer a reasonable chance of equity enhancement, as do several other potentially viable approaches to science policy. However, major changes in science-policy institutions and participants probably would be required for R&D to serve humanity equitably.

LONG AGO, "who gets what, when, and how" is the way Harold Lasswell (1936) defined the domain of politics. Technoscientific knowledge clearly helps shape who gets what in everyday life, and scholars of science and technology studies have documented the manifold ways that science and technology are political in the sense of encoding some values and perspectives more than others (Collins and Pinch, 1998a; 1998b; Jasanoff *et al*, 1995). Curiously, however, social conflict has rarely been an important part of the political discourse around science policy. This is true even though every scientist, every staff member of the National Research Council, every mission agency administrator, and every other participant in science policy making pursues not *the* public interest but their own syntheses of public and private objectives. Nobody takes account of every plausible perspective; everyone champions some interests and ignores or actually acts against others.

In *Science and Social Inequality*, Sandra Harding (2006) suggests that those advantaged by the *status quo* tend to operate in a state of denial about the maldistribution of costs and benefits of technoscience. Those most engaged in R&D policy deliberations obviously come disproportionately from advantaged classes and from powerful nations, and the standpoints they bring to science policy reflect whatever biases come with their social roles. Some academics who write about technoscience and policy-making actually "service the 'conceptual practices of power'" by providing ways of justifying gross disparities in command of material resources and social control (Harding, 2006).

Part of the neglect of social conflict can be traced to reigning myths of scientific progress, which depict an almost entirely positive social role for new knowledge, together with more or less automatic translation of research into benefit for all (Sarewitz, 1996). This renders moot any inquiry into whether the direction, pace, products, or other consequences of science might contribute to injustice (for instance, Lepkowski, 1994; Pardes *et al*, 1999). Thus, for example, the National Science Board's (2005) *2020 Vision* statement contains no mention of poverty, environmental justice, global disparities, or any other words conveying concerns about winner and losers.

In the rare instances when science-policy influentials do mention the subject, as in the case of the digital divide, they do not point out that previous technoscientific research helped contribute to the problems. At best, we hear bland notions that science

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ought to contribute "to better health, greater equity and social justice, improved living standards, a sustainable environment ..." (National Science Board, 1997: 9). Motherhood and apple pie might be added, so toothless and uncontroversial is the conventional discourse with regard to who gets what from technoscience.

A more meaningful recognition of social conflict would not imply that all inequalities are unjustifiable, of course, and we certainly do not mean to imply that the authors have a special position from which to judge when unequal becomes undesirable, unfair, or unjust. We also acknowledge that an ethicist might wish to distinguish more precisely than we do among various types of inequality, and might wish to systematically compare libertarian, utilitarian, contractarian, and communitarian approaches to distributive justice (Cozzens, 2007: in this issue). We also agree with Eubanks (2007: in this issue) that technoscientifically mediated activities shape people's life chances in myriad ways going well beyond distributive justice.

However, because we are not seeking to specify who should get what from technoscience, but are merely making clearer some of the ways equity issues are implicated in science policy, we simply refer to the set of potentially problematic inequalities under the general term "inequity." Our intention is not to resolve the issues around science and inequity but to move equity considerations higher on science-policy agendas.

Building on the work of a very few others who have conducted scholarship on the subject (Cozzens *et al*, 2002; Cozzens *et al*, 2005; Cozzens, 2005, 2006; Bozeman and Sarewitz, 2005; also see other papers in this issue), we attempt to think through some of the ways that the priorities, pace, and organization of science have significant consequences for who gets what, when, and how. We begin by reviewing the main reasons for believing that scientific research could be helping to maintain, or even to exacerbate, social inequities. We then propose the general principle that research and development normally will maintain or worsen inequities, and go on to identify important possible exceptions to the rule. We conclude by reflecting on opportunities for science-policy intervention aiming to enhance societal equity.

How science contributes to inequity

That science advocates routinely emphasize capacities for enhancing societal equity, yet rarely mention the opposite possibility, raises a strictly logical issue: does the rhetorical imbalance mean that science policy must by its nature always lead to greater equity, never to greater inequity? Or does it mean that science-policy dogma encompasses a painfully obvious internal contradiction?

We know the former to be false in at least one high-profile case. Biomedical research priorities have long been skewed away from the most serious needs of the poorest people in poor nations, and toward the less urgent health problems of affluent populations. This phenomenon has been characterized as the '10–90 problem': less than 10% of health research worldwide is directed towards problems accounting for over 90% of the global burden of disease (Global Forum for Health Research, 1999).

Recent initiatives by the Gates Foundation and others have escalated research on tropical diseases and, in so doing, have demonstrated that there is nothing inherent in biomedical science that requires a focus on further improving the condition of relatively healthy, affluent people. The fact that mainstream biomedical research priorities are shaped substantially by government science policies, coupled with the fact that those policies tilt toward the affluent, demonstrates one causal link between science policy and societal inequity.

Given the high profile of medical research and that it would be surprising if the 10–90 problem proved unique to biomedicine, why is there general neglect of the science–inequity problem? One contributing factor is that many people think about inequity in economic terms: the digital divide, the Lipitor divide (between those who have access to purportedly advanced medicine and those who do not) and other unequal outcomes associated with science and technology are usually interpreted as emerging from patterns of distribution, access, and affordability, not from the structure of the research and development (R&D) enterprise itself. Access to new products naturally costs money that some people do not have, the argument goes, so the solution must come via foreign aid, economic development, more jobs, or at least national health insurance. Scientists, therefore, can go about their tasks while leaving equity issues to others (Bozeman and Sarewitz, 2005).

Yet there are reasons to expect that science policy deserves to be part of the story as well. First, the ratio of private to public investment in science has been increasing rapidly over the past several decades, especially in the USA, where a plurality of the world's R&D is conducted (National Science Board, 2004). Except for R&D and science-based interventions supported by foundations, 'private' investment tends to be shaped by corporate priorities, which are oriented towards potential customers with wealth and access more than towards the poor and disenfranchised.

The World Trade Organization and other components of neoliberal intellectual property regimes amplify the increasing privatization of scientific knowledge (Commission on Intellectual Property Rights, 2002). Moreover, while linkages between businesses' innovation efforts and public science have always been strong, recent science policies and policy recommendations have strengthened public support for corporate endeavors (for instance, Branscomb *et al*, 1999; Committee on Prospering in the Global Economy of the 21st Century, 2006). The decreasing proportion of R&D that is publicly funded, therefore, is at the same time increasingly influenced by the innovation priorities of the corporate sector.

Another reason for expecting scientific inquiry to sometimes lead to increased inequity is that knowledge-intensive innovation is prized for economic growth, which rarely has stood out as an egalitarian enterprise. Especially in an era of deregulation and trade liberalization, those with education and skills are best positioned to benefit in the so-called knowledge economy (Frank, 1994; Bluestone, 1995). By contrast, low-wage jobs proliferate in the information-technology-enabled service sector (Card and DiNardo, 2002; Crompton and Jones, 1984). Thus, science policy is implicated in helping create a digital divide in the workforce as well as in homes and schools (Wyatt *et al*, 2000).

The knowledge and innovation wants of the affluent world also tend to be quite different from those of most people living in poor countries — across the board, not just in regard to medicine (Sen, 1992; Meridian Institute, 2005). The history of science policy is very much a history of interests vying for power and influence over resources and agendas, and those with little economic, political, and scientific clout are unlikely to have much say over what science gets done and who benefits from it (Black, 1999). To expect otherwise would require that science agendas differ from every other human enterprise, somehow arising spontaneously in response to a natural and benign ordering of priorities and possibilities.

Yet everyone who has observed and reflected on the everyday realities of science policy and professionalized R&D knows that agendas actually evolve via complex processes implicating everything from hardball politics to instrumentation technologies to environmental headlines. Problems, policies, and programs combine to gradually open up new lines of inquiry for those who have sufficient influence to win a share of the funding (Baumgartner and Jones, 1993; Kingdon, 2002; Greenberg, 2001).

A fourth way that science links with inequity is via the technological sophistication of forefront military technologies, which means that casualties during warfare increasingly are borne by the technologically inferior side. In the 1991 Persian Gulf War, Iraqi casualties were roughly a thousand times greater than those of the US military (DaPonte, 1993). Much of the history of technological innovation can be written in terms of military competition, where reducing one's own casualties and increasing those of the other side is precisely the goal (McNeil, 1982). Nevertheless, given that the USA spends "three times more than the next six powers combined" on military R&D (Brooks and Wohlforth, 2002: 22), and that the military portion comprises well over half of US public R&D, we can hardly avoid examining this sector as a contributing source of inequality; opinions will differ as to whether the inequalities are undesirable ones.

Closely connected are economic 'sanctions of mass destruction' against so-called rogue states. These are imposed by the world's technologically sophisticated and powerful nations with the aim of bringing into conformity with international norms the Cubas, North Koreas, Irans, and other technologically inferior nation-states whose authoritarian leaderships make threatening noises. Such sanctions probably caused the death and immiseration of more (predominantly poor) people in the past century — people who bore little culpability for the behavior of the regimes under which they lived — than have all weapons of mass destruction (Mueller and Mueller, 1999).

The successful imposition of sanctions would have been impossible without the scientific and technological capacities possessed by the USA and its sometime allies. Inasmuch as contemporary

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science-policy processes are institutionally insulated from effectively taking sanctions and other tertiary consequences of science into account (Sarewitz *et al*, 2004), those concerned with international equity and other societal outcomes arguably ought to be seeking major changes in the institutions by which science is governed.

Inequities enabled by new knowledge and technologies rarely come about without a combination of other factors, of course. For example, health problems in poor countries are a consequence of many interacting variables, including: geography and climate; histories of colonial dominance; poor institutions and feckless governments; and inadequate public health and educational infrastructures. Nevertheless, given that 'more science' is the conventional prescription for societal inequities of many types, and seeing that even our brief overview demonstrates obvious contraindications for the prescription, a practical question emerges: is there a set of potential science policies that might help ameliorate societal inequities?

We will be tackling the question systematically in subsequent sections. To frame the effort, we want to sharpen and extend our analysis so far by distilling it into a general 'law' that can be investigated and potentially falsified:

> New technoscientific capacities introduced into a non-egalitarian civilization will tend disproportionately to benefit the affluent and powerful.[1]

Some may find this idea outrageous, whereas others may say the point is too obvious to even bother writing down. To date, however, we have encountered few observers of science policy who clearly fall in either camp; most seem not to have thought deeply about the issue. So we invite readers to join us in probing the matter: What sorts of clear exception to inequity-maintaining/worsening can we identify? Could the equity-enhancing approaches to technoscience policy be substantial enough to undermine the believability of the 'law' proposed above? Do the equity-enhancing policy changes appear to be relatively feasible? Consider with us six categories of policy that might reduce inequity:

- R&D focused on poor people's problems;
- Broader participation in decision-making;
- R&D focused on creation of public goods;
- Research that reduces the price of goods and services;
- Greater honesty about equity implications; and
- Slowing down the pace of technological change.

R&D focused on poor people's problems

Actions designed to address the problems of poor or disenfranchised people around the globe are the most obvious category of science-policy activities that should be conducive to fairness rather than unfairness. Exactly what should be included in this category is contestable, and nobody has a very good estimate of how much contemporary R&D presently is targeted in this direction, but the percentage clearly is small. Given that resources for conducting research are concentrated in affluent countries, it would take some combination of enlightened self interest and genuine altruism to lead affluent-country technoscientists and funding agencies to redirect resources and energies.

The global biomedical arena offers a glimpse of how this conceivably could become feasible. A confluence of high-level yet non-traditional players has emerged in the global health arena, ranging from the United Nations and the World Health Organization, to the Rockefeller Foundation and Bill Gates (Mihill, 1998). The strategy they are pursuing on the 10–90 problem centers on new institutional approaches, especially public–private partnerships not dependent on tax dollars or governmental institutions, but still focusing on a public mission (Buse and Waxman, 2001).

While there is some perhaps predictable controversy surrounding these new approaches (for instance, Birn, 2005; Piller *et al*, 2007), this activism, philanthropic attention, and institutional innovation suggest that it may be possible to redress other inequitable research policies in creative ways. For, although one may doubt that this phenomenon is likely to be replicated across the board for a broad set of worthy purposes, the dramatic reorientation of biomedical research to address malaria, childhood diarrhea, and other problems of the very poor should put to rest any lingering thoughts that forefront research has its own immutable trajectory.

In contrast, the challenge of global climate change offers a telling example of scientific research that has *not* been targeted toward poor people's problems. As demonstrated by the Asian tsunami in 2004 and by Hurricane Katrina in 2005, the effects of 'natural' disasters tend to be disproportionately borne by poor people. Yet the environmental movement in affluent nations has joined with influential research communities to induce government officials to spend huge amounts on high-prestige, fundamental science aimed at tracking climate changes and untangling the causes.

This approach has provided little assistance in actually coping with the impacts of climate, as might have been achieved via restrictions on coastal construction. As climate scientists pursued their interests, vulnerable coastal areas worldwide increased in population by approximately one billion people. Whereas 28% in the USA lived in a coastal county in 1980, for example, by 2003, some 53% did, thus totaling more than 150 million residents (Crossett *et al*, 2004). Not only has most of the scientific research not been very helpful in counteracting the increased risks, the focus on climate modeling actually has absorbed both scientific and political attention that could have been productively applied to the practical challenge of coping with natural hazards. (This argument is more fully developed by Pielke and Sarewitz, 2002; Sarewitz and Pielke, 2007; and Lemos and Dilling, 2007: this issue.)

Global dependence on oil and coal for energy, chemicals, and materials likewise exacts a substantial toll that is distributed unequally via high energy prices, environmental impacts, warfare, and geopolitics tolerant of repressive, oil-rich states. Most knowledgeable observers believe that the world is seriously under-invested in energy R&D (for instance, Runci, 2005), and more than half the current investment is devoted to traditional fuels and nuclear energy. Increased inquiry and innovation applied to replacing coal and oil with cleaner, less geopolitically potent technologies clearly could contribute to global equity. Why energy R&D has not received the public profile or the level of investment of biomedical science is rather mysterious to us; nor do we understand why equity considerations play such a small role in energy conversations.

Thus, R&D potentially could be targeted towards inquiries with better direct and indirect payoff for those who now are underserved by science. That such research is not a high priority is due in part to the domination of some voices rather than others in science-policy decision-making.

Broader participation in policy decisions

A second way to reduce inequitable outcomes from science policy would be to reduce the extent to which relevant choices are made by those who are politically and socioeconomically privileged. From the US House Science Committee to National Science Foundation (NSF) review panels to most mission agencies, proximate policy makers tend to be highly educated, affluent males of the dominant ethnic group in northern hemisphere nations. Likewise, scientific inquiry, teaching, and public commentary are carried out overwhelmingly by the advantaged.

We are hardly the first to suggest that, if science-policy deliberations reflected a greater diversity of perspectives, then funded inquiry might better serve a wider spectrum of humanity (for instance, Sclove, 1995; Gibbons, 1999; Stilgoe *et al*, 2005; Harding, 2006; Eubanks, 2007: in this issue). Indeed, philosopher Philip Kitcher (2001) has formalized the claim through his ideal of "well-ordered science," which is based on a deliberative democratic process that fairly represents everyone who deserves to be included.

Greater diversity of perspectives generally is regarded by political theorists as leading to a greater diversity of policy options to choose among; such diversity also makes it tougher for insiders to garner enough support to pass their programs unless they take into account outsiders' needs and perspectives (Lindblom and Woodhouse, 1993). If science-policy processes included people and institutions more committed to advancing societal equity than, say, to advancing military technology or scientific research for its own sake, then moves aiming to reduce inequity would become more probable.

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Interest groups including AIDS and breast cancer activists have occasionally been successful in steering scientific research and technoscientific practice in previously under-served directions (Epstein, 1996; Lerner, 2001). Politicians, acting partly on behalf of constituents, have sometimes pushed R&D in potentially equity-enhancing directions, for example, with congressional action requiring reluctant administrators and scientists at the National Institutes of Health to conduct serious research on alternative and complementary medicine.[2]

So, while we can hardly doubt that a more representative science-policy process could be equity enhancing, three cautionary notes are appropriate. First, the AIDS, breast cancer, and alternative medicine successes were motivated by politically empowered groups, not by the politically or economically disenfranchised. Second, opening up the decision-making process to greater influence from various interests could make science policy less undemocratic without necessarily enhancing equity — it all depends on which interests gain improved representation. Working-class Americans, social scientists and humanities scholars, and Ethiopian elites may arguably all deserve better representation in setting priorities for global science, but they are already relatively advantaged, so the increased inclusiveness might do little in combating the world's most severe inequities.

Third, given that scientific knowledge is one of many contributors to societal inequity, it might or might not be a more important route than other approaches open to equity-seeking interest groups. Thus, from the perspective of AIDS sufferers able to afford sophisticated pharmaceuticals, AIDS activism was a true triumph in directing resources to research and accelerated clinical testing. Yet we might wonder if, in the mid-to-late 1980s, the politics of AIDS research had been strongly influenced by representatives of poor African and Asian nations, might policy discussions have contextualized the problem better from their perspective? Rather than high-tech pharmaceutical treatments for affluent consumers, perhaps the focus would have been on affordable interventions for people living in regions with inadequate public-health infrastructures? We do not mean to say that both should not be done, just that, as things now work, one of those approaches tends to trump the other, time after time.

We have thus far focused on the question of R&D policy priorities — might different policies, made through different processes, lead to reduced inequity? In the next two sections, we consider the problem from a different perspective. Are there some attributes of technoscientific products that we would expect to be equity enhancing? Might science policies that focus on these attributes contribute to greater equity?

Focusing R&D on creation of public goods

A third route to reduced inequity would focus on creation of new public goods, which usually are paid for from taxes that come from affluent taxpayers more than from the less well-off. Public goods also tend to be available without cost to the user, or at least are subsidized, so access to them typically is more equitable than goods and services available through ordinary buying and selling. This category of activities is larger in socialist countries and in welfare-state democracies than in the USA and other nations where public expenditure accounts for a smaller fraction of total spending. Nevertheless, every national science enterprise feeds some public innovation.

Environmental research and innovation are partially public goods, and the less well-off generally suffer disproportionately from polluted air, water, or soils, or an unhealthy built environment. Exposure to lead paint and proximity to toxic waste dumps is stratified by socioeconomic status (Pastor *et al*, 2006), and research contributing to exposure mitigation therefore should be equity enhancing. Yet the matter is not straightforward, because, for example, well-off people are likely to have more leisure time and other resources required to benefit from some environmental public goods, such as restored or natural wildlands (Foley and Pirk, 1990).

Seasonal climate forecasting seems like a quintessential public good, but those already advantaged have better resources to obtain and utilize the information, and some of the world's most vulnerable have become worse off by trying to adapt their agricultural practices to forecasts of droughts and rains (Lemos and Dilling, 2007: in this issue). Cole (2007: in this issue) demonstrates that "the superficial image of DNA profiling as an inherently equalizing (public good) technology does not withstand deeper analysis."

Caution about the advantages of public goods is warranted also because publicly funded scientific inquiry does not always *remain* a public good. Much has been made of intellectual property claims by universities and by faculty with businesses on the side, but probably more important is the routine utilization of publicly funded science by businesses (Leydesdorff and Etzkowitz, 1996). Federally funded research on fungi and mold, ionization, and related topics now is showing up in products used by the affluent. As an advertisement for the 2007 Toyota Camry puts it, "Any car can have a navigation system, but what about an immune system?":

> A new HVAC system ... uses Plasmacluster ionizer technology to help reduce airborne mold spores, microbes, fungi, odors, germs and bacteria inside the passenger cabin. The plasmacluster ionizer does this by artificially creating positive and negative ions that seek out and surround harmful airborne substances. The system also features a micro dust and pollen filter, along with an antibacterial coating designed to minimize the growth of mold spores. (*Forbes*, 2006; Toyota Motor Corporation, 2006)

Given the rising incidence of asthma and allergies among children in many parts of the USA (Pope, 2000), is science helping to turn what should be a public good — clean air — into a scarce, private one? Is the new technology likely to turn up anytime soon on mass transit used by the less affluent?

Such observations are at odds with the common portrayal of scientific knowledge as an archetypal public good (see Callon, 1994, for a critical discussion), a portrayal that perhaps underlies the common assumption that science is always equity enhancing. Certainly some products of science, such as polio vaccines, can be viewed as *de facto* public goods that were equitably distributed. Some people would add the intangible benefits of space exploration and the more concrete benefits of transportation infrastructure or national military security, whereas others might interpret some of these as public 'bads'. In either case, the distributional inequities do not loom large.

Even in a market-oriented society, there could be ways of increasing the fraction of science policy aimed at public goods. We have already mentioned energy and environmental quality R&D. Consumer protection, likewise, is a partially public good and the less well-off are more vulnerable to predatory banking and ordinary business schemes and less resilient after being scammed. Making automobiles less repair-prone and cheaper to repair could be considered an equity-enhancing public good deserving of government-supported R&D, because the marginal contribution to less affluent car owners would be greater.

We must admit, however, that most of the examples we have been able to think of do not seem like the kinds of research that 'real scientists' would want to pursue. However, that may be partly because too few scientists, business executives, science-policy influentials, social scientists, and interest group staff have thought seriously about the possibilities. One huge domain for forefront basic research with equity implications from the environmental realm, for example, was called for recently by the director of the American Chemical Society's Green Chemistry Institute, who challenged chemists and toxicologists to work toward "a molecular level understanding of the nature of chemical synergisms in the body and the biosphere" (Anastas *et al*, 2006: 678). Still, it is obvious that public goods offer, at best, only limited opportunities for equity-enhancing R&D policies; our fourth category therefore explores access to private goods.

Reducing price

Science policy makes an indirect connection with social justice when R&D leads to increasing affordability of goods and services. When less well-off people can more easily purchase products already consumed by the affluent, discrepancies between haves and have-nots are reduced, and the marginal benefit of increased affordability often will be greatest for the poorest. Unfortunately, we know of very few instances where reduced costs have proven an unalloyed good; however, there sometimes may be gains in terms of equity even if there are losses in terms of other values.

Consider the case of agricultural science, which has been enormously successful at increasing productivity and decreasing the direct costs of food. Real prices for all agricultural commodities have declined over the past four decades, with cereals and tropical beverages falling the most, and meat and dairy falling the least (UN FAO, 2004). The up side in terms of affordability is obvious. On the down side, agriculture-related policies have been so successful in stimulating supply that:

> Government policies in both developed and developing countries have seriously distorted the over-supply problem in agricultural markets ... The vast majority of the world's poor and hungry, who live in rural areas of developing countries and depend on agriculture, suffer losses in income and employment caused by declining commodity prices which generally outweigh the benefits of lower food prices. (UN FAO, 2005: 1)

The agricultural sciences have also been implicated in environmental degradation including overemphasis on chemical inputs, and in sociocultural destabilization of both US farm communities and rural social structures in many poor countries (Gray *et al*, 2006). Ample food supplies coupled with low prices have helped stimulate problematic urbanization and suburbanization, and those with fewest resources often bear the brunt.

The equity implications of R&D policies relating to agriculture thus cannot be held up as generally exemplary, but several attributes nevertheless merit attention. First, agricultural research typically has not been administered according to the elitist approach pursued, say, by most professional astronomers who have very little to do with the sizeable worldwide network of amateur astronomers. Rather, agriculture has often been funded with attention to regional equity and to maintaining capacity in less-technological nations, such as via the Consultative Group on International Agricultural Research. Moreover, agricultural R&D has often been conducted at institutions with close connections to local farmers, albeit with the intention of advancing agricultural productivity more than the interests of the farmers themselves.

Beyond agriculture, innovation processes activated partly by market competition have led to progressively decreasing prices for technologically enabled consumer products from plastic bags to televisions to washing machines. Most of the incremental innovation takes place in the business sector, but it often takes off from publicly funded research in areas such as materials science (car tires), chemistry (fire retardants in televisions), and electricity storage (Ni-Cad batteries). Science-related policy making likewise provides social support for such incremental innovation, including intellectual property law, international standardization, and health and safety regulations. Even the rise of mass-market, low-price retailing exemplified by Wal-Mart has been built on a foundation of scanners and bar codes, containerization, and electronic databases, all of which were derived partly from military and other governmentally funded R&D.

The R&D that contributed to greater productivity in the manufacture of consumer goods also disrupted the roles of skilled workers. Whether the dispersed equity benefits of cheaper consumer goods from increased science-enabled productivity outweigh the concentrated and severe harm suffered by displaced workers is hard to calculate and inherently contestable. However, it makes us pause, and putting the consequences for workers together with the other problems associated with low prices, we doubt that a

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strong case can be made for justifying science policies on the basis of equity-enhancing price reduction. This complexity of cause–effect relationships that link science policies, prices, and equity reinforces our initial suspicion of standard claims that science policies are inherently equity enhancing, and leads us to our next category.

Greater honesty about (in)equity

Is it honest to try to justify science policies, explicitly or implicitly, in terms of enhancing societal equity? Agricultural biotechnology has long been promoted as a solution to world food problems (Conway, 1999). Nanotechnology is now being promoted partly on that basis (Salamanca-Buentello *et al*, 2005) and various enhancement technologies are promoted for their ability to eliminate disabilities (see Wolbring, 2004, for a critical discussion).

Yet all such claims are, in an important sense, necessarily false: science *per se* cannot achieve *any* particular societal outcome, because university and government researchers, as well as technoscientists employed by business, all work within a broader set of social, cultural, political, and economic forces and institutions, co-making both problems and partial solutions to problems. In the jargon of philosophers, a promise that science will lead to a given societal outcome is fatally underdetermined.

One of the factors left out is that there may be better routes to the goal than to invest huge amounts via the expensive and indirect activity known as scientific research. Just because a line of scientific inquiry conceivably might help with a given problem does not mean that it is the best approach. Thus, a recent report argues that nanotechnology could help with important problems suffered by poor nations (Meridian Institute, 2005), and some advocates actually are touting 'nano' as the long-sought solution to the world's water, energy, health, and food problems (Salamanca-Buentello *et al*, 2005). Given that many such problems probably could be ameliorated more simply and cheaply using existing technologies such as wells and pumps, the promise of science-derived nanopore filters implicitly is a way of displacing accountability, which serves political elites and influential components of the scientific community.

Moreover, those who speak optimistically about the benefits of R&D seem to assume that new capacities will be distributed equitably. They rarely even discuss the socioeconomic context where the projected knowledge actually may be deployed, and they certainly offer no compelling reason to believe that equitable distribution is probable.

Yet, equity implications can only be assessed in the light of a broader context, as in the 2004 California ballot initiative (Proposition 71) to allocate US$3 billion of state-bond funds in support of embryonic stem cell research. A coalition of venture capitalists, scientists, entrepreneurs, and disease advocates spent US$24 million to promote this voter initiative, boldly predicting that the resulting research would rapidly lead to cures of conditions and diseases ranging from spinal chord injuries and Alzheimer's to diabetes and Parkinson's (Vogel, 2004).

Had the promoters of Proposition 71 been concerned about honestly communicating with voters, their predictions might have looked something like this: while a small number of significant therapies might result over the next decade or two from embryonic stem cell research funded by the initiative, cures for most of the specific diseases potentially subject to stem cell therapies will remain elusive because of unanticipated technical complexities. For example, understanding and controlling cell development and differentiation processes probably will remain rudimentary during this period.

Scientists, however, will use up the US$3 billion fairly soon, and presumably will seek additional public investments. Meanwhile, the rising price of medical care may disenfranchise increasing numbers of Californians from the health-care system that would deliver the new therapies, while significant income from patenting advances funded by the initiative is likely to accrue to institutions and persons conducting the R&D.

If voters had considered Proposition 71 in these terms, they might well have rejected it — and that is precisely our point. Science honestly discussed would be depicted not as an autonomous and inexorable path towards desired outcomes, but as one element in a complex web of causes and effects, sometimes including greater inequity, sometimes lesser. If science were promoted and discussed honestly, science-policy decisions might be made more cautiously; certainly they would be made with greater awareness of the complexity of their implications. Then those who care about inequity might have a better chance of raising questions about scientific trajectories that help maintain inequity. However, would it not be terribly inefficient to routinely introduce such considerations into science-policy deliberative processes? This possibility points us to a final category.

Slowing down

As a strictly logical matter, we could redress inequities by focusing on science policies that may adversely affect those who are already well off. For example, affluent people probably have been at greater risk from side effects of newly approved but incompletely understood pharmaceutical products such as Lipitor, Fosamax, and hormone replacement therapy, because the affluent tend to have the information, resources, and expectations that foster early access to innovative products. Yet such reverse inequities are almost certainly trivial compared with the disadvantages suffered by those who do not enjoy the benefits of expensive new pharmaceutical products.

Moreover, with clinical trials of new medicines "going global," it is "the world's poorest patients" who increasingly are exposed to pharmaceutical side effects prior to regulatory approval and sale (Shah, 2006). Even in the USA, structural inequalities and an absence of universal health insurance mean that studies of new pharmaceuticals "are overwhelmingly conducted on uninsured and impoverished citizens," who participate in order to obtain access to treatment (Fisher, 2007: in this issue).

If deliberately disadvantaging the affluent is ruled out as a way of helping level the playing field among potential technoscience winners and losers, an alternative approach would be to modify the pace of technoscientific change, in order to create time for politically disadvantaged groups to recognize, and respond to, equity threats. The potential benefits of slowing down are well illustrated in the realm of human enhancement technologies, where access and equity concerns surround what appears to be a rapidly emerging capability (Parens, 1998). Who will get enhanced attributes ranging from strength to intelligence? Will these new technologies push humanity toward a bifurcation along enhanced/non-enhanced lines, where some get to be stronger, more beautiful, and smarter, while others of us are stuck with the limits of our old-fashioned normalness because we cannot afford what biotechnological innovations catalyzed by science have to offer? An exacerbation of inequalities resulting from the advent of enhancement techniques seems all but inevitable, and one appropriate science-policy intervention would be to slow the rate of such inquiry and innovation, to allow time for learning, political organization, and appropriate compensatory policy development.

Science policy has little experience with serious discussion about slowing down the pace of advance (debates over nuclear weapons and recombinant DNA stand as exceptions), but allocating R&D resources routinely involves choices to accelerate some areas of technoscience rather than others. Science policy makers take such actions in small ways whenever they make decisions; over time, a huge discrepancy is created between science that is and is not funded. We have already noted the societal choice to favor biomedical science over energy research in the USA; the relative neglect of green chemistry is another such arena of "undone science" (Woodhouse *et al*, 2002).

By acknowledging that choices are inevitable, and by making future choices more explicit, the notion of deciding to slow certain areas of research should seem less heretical. Indeed, if the reasons for doing so are rooted in well founded and widely shared concerns about equity, perhaps a heresy can be reframed as an imperative?

We are not unaware of the moral issues lying in wait here. Sarewitz has been accused of being willing to consign sick people to an early death when he has publicly suggested that responsible governance of science sometimes might entail slowing the pace of technical advance. We do not reach this issue here; we merely argue that participants in science policy making ought to face up to tradeoffs between equity and other considerations.

Conclusion

This essay's basic spirit should be hard to quarrel with: make social justice a primary consideration in deliberations about science and technology policies pertaining to research, innovation, human resources, and regulatory matters (Cozzens *et al*, 2002). Even elite voices of the science-policy apparatus at least tacitly endorse such a stance. For example, the National Science Board (1997) wrote that:

> To ensure the most effective use of Federal discretionary funding it is essential that agreement be reached on which fields and which investment strategies hold the greatest promise for new knowledge that will contribute most effectively to better health, greater equity and social justice, improved living standards, a sustainable environment, a secure national defense, and to extending our understanding of nature. It is intrinsic to research that particular outcomes cannot be foretold; but it is possible, indeed necessary, to make informed choices and to invest wisely. The need for better coordination and priority-setting is not related to cycles of fiscal constraint alone. It is, rather, an integral aspect of a sound, future-oriented strategy for the investment of limited Federal dollars.

We are not asking much more than that such good words be taken seriously.

Actually acting in accord with the rhetoric would turn out to be more difficult and contentious than many R&D administrators may have realized. Many who articulate aspirations for publicly beneficial outcomes probably have not deeply pondered the possibility that scientists' business-as-usual tends at least to maintain, and in some cases even to exacerbate, hard-to-defend inequities across the globe and within many nations.

To return to the biomedical arena: "Despite an overall decline in death rates in the United States since 1960, poor and poorly educated people still die at higher rates than those with higher incomes or better educations, *and this disparity increased between 1960 and* 1986," during a period of unprecedented public investment in biomedical research (Pappas *et al*, 1993: 103, emphasis added). Similarly, the USA continues to have infant mortality rates higher than most other affluent nations, with poorer families bearing the brunt of the losses (Hamvas *et al*, 1996; Gortmaker and Wise, 1997). Even biomedical research has a long history of mistreatment of have-nots (Fisher, 2007: in this issue).

The pattern is sufficiently clear, pervasive, well-publicized, and long-lasting that participants in science policy and in scientific inquiry cannot credibly allege not to know. We presume most readers will join us in considering some of the inequalities not just unfortunate but immoral. Opinions will differ as to whether biomedical scientists who go about their work without challenging prevailing inequities in medical care demonstrate a *de facto* willingness to perpetuate them; similarly uncomfortable questions arise regarding the work of other technoscientists, such as the information technologists who arguably assist indirectly in oppression of people enmeshed in social service bureaucracies (Eubanks, 2007: in this issue).

The systematically unequal outcomes from R&D policy seem to be in tension with the professional ethics that most scientists and engineers would want to uphold, and with which they often justify their own claims to public trust and support. Because the problems are structural and therefore beyond the capacity of individuals to rectify (Fisher, 2007: in this issue), we believe that professional organizations have a responsibility to create a dialogue of such prominence that scientists and engineers can hardly avoid exploring what they may come to believe are their ethical obligations to support science policies that work for social justice.

Ethical reflection on such a scale is, admittedly, difficult to imagine. Perhaps even less likely is for scientific elites to reexamine their ideologies in regard to 'progress' and prevailing power relations. Yet the pattern of inequitable outcomes arguably is so central to the future of technological civilization that people in and out of science are morally obligated to reexamine who gets what from science and technology.

For a brief period in the 1970s, inquiries did begin into relationships among science, business, the military, and a consumer culture dominated by those in the upper quintile of humanity in income and wealth (Primack and von Hippel, 1974). Whether these will be revisited and refreshed, nobody can say for sure, but scholars surely have an obligation to press for such discussion and reflection.

Our analysis has pointed to ways that doing scientific research or innovating technologically can contribute to reducing societal inequities, or at least to not helping maintain them. Before summarizing those exceptions to the rule, we want first to say that what we initially considered the most important exception simply did not stand up to scrutiny. It intuitively seems that price-reducing incremental innovation would enhance equity, and certainly sometimes does so, but high-end innovation for the affluent comes out of the R&D process along with lower-end cost cutting, and we see little basis for any generalized claim of net gain.

Moreover, even those facets of the process that actually do work for equity almost invariably exact other tolls, such as the environmental cost from the need to manufacture, deliver, and dispose of the increased number of units. When R&D does succeed in putting, say, plasma TVs into many more homes, the diffusion rarely actually reaches the poorest quintile of humanity, and meanwhile the partial success probably helps build a cultural expectation that market-oriented, price-reducing technological innovation can be a pretty good substitute for public efforts on behalf of those most in need. We readily acknowledge that there is a need for more research and thinking on this category of R&D outcome, but we provisionally strike it from our list of possible exceptions to the 'law' that new technoscientific capacities introduced into a non-egalitarian society will tend disproportionately to benefit the affluent and powerful.

Even taking off the table this category of exception, those who seek reduced inequity still have at least five approaches they can adopt to partially counteract science-catalyzed inequities:

- Specifically address problems of the poor, while shying away from R&D clearly serving affluent elites.
- Reflect the aspirations, values, and interests of a more diverse set of potential stakeholders worldwide, rather than carelessly assuming that political and economic elites are relatively good representatives of 'the public.'
- Focus on R&D that will go into public goods paid out of tax dollars.
- Justify endeavors in terms of an honest appraisal of the socioeconomic context within which the results of research will be applied.
- Deliberately slow down R&D trajectories that threaten to erode equity.

In addition to these general exceptions, there are numerous context-specific actions that could help science-policy influentials and everyone else to think more deeply about the equity implications of R&D. Although there is no substitute for actually challenging grossly misdirected priorities, fairly innocuous moves can also contribute. For instance, the US President's science advisor and the National Science Foundation in 2005–2006 called for improving "the social science of science policy," and their vision included improved science and engineering indicators (Marburger, 2005). We applaud the idea, and believe that improved indicators of the social outcomes from R&D ought to be among the highest priorities, especially indicators pertaining to (in)equality (Cozzens, 2006).

Indicators alone are not nearly enough, though, because better information is less important than better motivation and improved decision-making institutions for retargeting science policy. Nevertheless, better information about science outcomes could certainly help focus attention on the complex and sometimes contradictory types and causes of technoscience-catalyzed societal inequity, and could help make concerns regarding equity more legitimate within science-policy discussions.

In closing, we acknowledge again that 'doing research' or 'applying technology' to solve a given problem often is not the best way to go about reducing inequity. In recognizing the tendency to rely excessively on technological fixes, however, we ought not to overlook instances where a good technological fix is exactly what is needed. Childhood vaccines offer a powerful example of such an equity-enhancing technology. Technical fixes sometimes are easier to implement politically, and sometimes are more potent than sociocultural fixes at ameliorating human suffering.

The challenge is to figure out what future fixes might actually be equity enhancing, and to target science policy in those directions. Although we suspect that this will be infeasible under prevailing distributions of authority, those who seek to defend the existing system can easily prove us wrong simply by retargeting science policy towards global equity.

Notes

1. Not all new technoscientific capacities emerge directly from science policy *per se*, but the big changes in the past half century in computing, electronics, biomedicine, and most other domains would have been improbable or impossible without scientific research trajectories relying on government funding.
2. As our selection of examples reveals, it is much easier to come up with equity stories from biomedicine than from most other realms of R&D. Within the technology-focused US medical system at least, we suspect this is because the anticipated links between technoscience products and actual outcomes are explicit, and inequities in health outcomes can be effectively measured. Inequitable outcomes therefore can be directly attributed to science-policy priorities within a very high-profile realm of public policy.

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