New Modernities: Reimagining Science, Technology and Development

SHEILA JASANOFF

John F. Kennedy School of Government
Harvard University
Cambridge, Massachusetts 02138, USA
Email: sheila_jasanoff@harvard.edu

ABSTRACT

'Development' operates as an allegedly value-neutral concept in the policy world. This essay describes four mechanisms that have helped to strip development of its subjective and meaning-laden elements: persistent misreading of technology as simply material and inanimate; uncritical acceptance of models, including economic ones, as adequate representations of complex systems; failure to recognize routine practices as repositories of power; and erasing history and time as relevant factors in producing scenarios for the future. Failure to take these elements into account has led to inequality, injustice and unintended consequences in many development projects. Interpretive analysis of development tools and concepts is a much-needed corrective.

KEY WORDS

Development, progress, technological determinism, capacity building, science and technology studies

PROLOGUE: THE PATCHWORK OF MODERNITY

Item: In July 1999, the British biotechnology company Zeneca Limited reports that vandals have destroyed an experimental plot of 150 genetically modified trees at its agricultural research station in Berkshire. The episode reflects rising concern about the introduction of genetically modified crops and foods in Europe. The company says the trees were being grown as part of a study

Environmental Values **11** (2002): 253–76

to reduce pollution in the paper industry and adds that it is a sad day for both science and environmentalism.

Item: On November 30, 1999, the World Trade Organization begins its Third Ministerial Meeting in Seattle, Washington. The meetings are disrupted by a cacophonous coalition of environmentalists, human-rights activists, labour representatives and students protesting the evils of globalisation, including pollution and the loss of biodiversity induced by genetically modified crops. Tear gas, curfews, police in riot gear, and a declaration of civil emergency recall the heady atmosphere of the 1960s. Heavily policed anti-globalisation demonstrations also mark the June 2001 European Union ministerial meeting in Gothenburg, Sweden and the July 2001 G8 summit meeting in Genoa, Italy. The WTO's Fourth Ministerial Meeting in Doha, Qatar in November 2001 proceeds without disruption but under unprecedented security.

Item: On September 11, 2001, nineteen young Islamic militants hijack four civilian aircraft from three US airports and separately crash them into the World Trade Center's 'twin towers' in New York, the Pentagon, and a field in Pennsylvania. All aboard the planes die, the towers in New York collapse in fire and smoke, a portion of the Pentagon is destroyed, and more than 3,000 people are estimated dead. The United States launches a retaliatory war in Afghanistan and topples the reigning Taliban regime which has given refuge and succour to the Al Qaeda terrorist network suspected of mounting the attacks.

Item: On December 20, 2001, Argentina's President Fernando de la Rua resigns, followed within a week by his immediate successor, amid a deepening economic crisis that includes sharp drops in real income, steep spending cuts, severe restrictions on private bank withdrawals, and an unconstitutional declaration of a state of siege. Blame is frequently pinned on, among other factors, the draconian fiscal policies of the International Monetary Fund which critics deem inappropriate for restoring long-term monetary stability in low-income countries.

Item: As if to remind the world of more conventional risks, explosions at a military ammunition dump in Lagos, Nigeria set off a stampede that kills up to an estimated 1,000 people, many of them children, in January 2002. Government authorities say they will conduct more systematic analyses of risks to buildings and infrastructure in the heavily populated region to make sure that no new tragedies of similar dimensions will occur.

It is the end of the twentieth century and the beginning of the twenty-first. People around the world are living with technology and sometimes dying of it. Modernity, that singular term for a most complex reality, displays itself in giddy variety from one location to another. A random selection of headline news from

the turn of the century reveals striking anomalies in the day-to-day circumstances of contemporary societies. There is a stickiness to the disparate routines of culture and nationhood, a resistance to homogeneity, although images from the world's remotest outposts instantly and effortlessly circle the globe, provided only that they can be caught by the camera's near-ubiquitous eye.

Ambiguity rules the day at this transition between millennia. In the advanced nations that spearheaded the industrial revolution, innovation speeds on, but there is also uncertainty, sometimes morphing into fear, about the long-term consequences of meddling with the fundamentals of nature or of human belief. In less developed societies, the most familiar feats of technological enterprise – explosives and railroads for instance – stubbornly refuse to be domesticated, producing periodic catastrophes. Science and technology have brought hope of liberation from hunger, toil and disease, but their impacts can still prove devastating, especially for those without the capacity to guard against error and accident. The rapid reshaping of global economies and cultures around scientific and technological change arouses confusion and resistance. The extraordinary events of September 11, 2001 in the United States underline the absence of a global consensus on what counts as progress. The news about development at this particular *fin de siècle* is most definitely mixed: rising income levels in many ports of the world underline the uneven distribution of vulnerability, while disasters of varying magnitude make plain that no society, rich or poor, can hope to avoid confrontation with the risks of modernity (Beck 1992).

Events like those reported above reveal enormous contradictions in the accommodations that human beings have made, and continue to make, with the fruits of their technological ingenuity. New capabilities for shaping the human condition continually appear on the horizon. Yet, anxiety, despair and death shadow the bright lines of knowledge and invention, like dark threads in the shot-silk shimmer of progress. The transnational movement of science and the artefacts that embody scientific knowledge gives rise to distinctive social and political problems, especially when societies that played no part in the design or construction of new technologies are forced to engage with technology's widening reach (Bijker et al. 1987; Jasanoff 1994). The internationalisation of science and technology, no less than the spread of legal regimes and financial markets, constrains people's power of self-determination, even as it facilitates new, more enabling forms of life. The astonishing demonstrations against the World Trade Organization in Seattle in 1999 expressed a widely felt discontent with the processes of globalisation and technology transfer. The optimistic equation of science and technology with progress that was almost universally accepted at mid-century seems to have yielded, just fifty years later, to an uneasy recognition that the material world cannot be governed and manipulated in new ways without also profoundly reordering society. And in these grand sociotechnical realignments, not all societies or actors can count on equal voice or agency.

In such a world, what are the consequences of harnessing science and technology to the cause of global development? After so many decades of effort, have we acquired a more mature understanding of what it properly means for human societies to be *developed*? How in particular does the idea of development relate to progress in science and technology, and why have attempts to promote development through technological means so often proved controversial or disappointing, if not downright disastrous? What, finally, can humanistic and social studies of science, technology and the environment offer to enlarge our understanding of these questions? Can such work usefully contribute to reimagining the courses of modernity in ways that will do more justice to the varieties of human culture and experience? These are the questions with which this essay engages, along with the papers that follow.[1]

The authors in this special issue approach the topic of development from various disciplinary perspectives and research sites: not only from 'standard' locations within economically disadvantaged societies, but in one case from inside an industrial society, looking at urban-rural technology transfer in America in the1930s (Kline, this issue). Common to their work is the determination to tell more complex stories about what is involved in going from one state of development to another, no matter where and in what direction that transition takes place. The hope is that these accounts, taken together or separately, will enhance our ability to imagine alternatives to the multiple predicaments of modernity.

THE PROGRESS OF INVENTION – THE INVENTION OF PROGRESS

For much of the twentieth century, a single grand narrative has underwritten most of the ambitious, planned interventions undertaken by rich, technologically advanced nations to improve the condition of poorer societies, in short, to promote *development*. This is the story of progress, driven largely by advances in science and technology. As time's arrow points inexorably forward, so too, it was unproblematically assumed, do scientific discovery and its technological spinoffs, bringing only the possibility of gain and betterment. After all, human welfare in the leading industrial nations depends at every point on the blessings of technology: increased power to control the vagaries of nature, together with dramatic gains in health, longevity, communication, mobility, reproductive choice and many other forms of personal freedom. Signposts of this triumphant march include in the twentieth century alone the discoveries of antibiotics and contraceptives in medicine, the Green Revolution in agriculture, the momentous unravelling of the genetic code, the development of genetically-based biotechnology, and the myriad breakthroughs in physics and materials science that fuelled the explosive growth of electronic communications. Through this extraordinary flowering of knowledge and ingenuity, human beings have

succeeded in replacing disorder with design on previously inconceivable scales. Science even seems poised, as some believe, to unravel the deepest mysteries of consciousness and life.

The chronicle of progress through science and technology is so lightly taken for granted in advanced industrial societies that it is difficult to trace it to specific texts or works of scholarship. One of its simplest and most influential expressions was the report of US presidential adviser Vannevar Bush (1945), *Science – The Endless Frontier*, which laid out both a rationale and a recipe for state support of scientific research at the end of World War II. Looking back at America's brilliant successes with the technologies of war, Bush argued that the government could no longer count on importing scientific expertise in times of need – for instance, through chance immigration from Hitler's Europe – but should seek instead to build up national reserves of 'basic science'. Investments in university-based research would translate in due course into jobs, technological improvements and increased social welfare. Although Bush's linear model of technological development has been challenged by later analysts (Guston 1999; Hart 1998; Stokes 1997; Smith 1990), few in the policy world have taken issue with its core premise: that basic scientific research is the fountainhead from which flow not only growth in knowledge but also technological advances and associated benefits for society. The questions posed by science policy analysts have largely focused on how governments can effectively fulfil their missions with respect to science and technology (see, for example, Jasanoff 1997) – not whether they need to rethink at a foundational level the connections between science, technol andand human betterment.

The theme of progress has found especially eager audiences among elected national governments, international organisations and private foundations, in short, all institutions whose mission not only is to do good, but to be seen as doing good in the world. Instrumental uses of science and technology directed at visible endpoints – such as the polio vaccine, the Green Revolution or the space race – have helped governments to demonstrate that they can recognise and solve public problems and can do so, moreover, in ways that satisfy the core democratic values of transparency and accountability (Ezrahi 1990). Technological successes offer concrete and easily measurable indicators of performance. For democratic governments answerable to informed and increasingly sceptical citizens, technological innovation has therefore proved useful in peace as well as war. Church bells rang across America when the cure for polio was announced in 1955, and the 1969 moon landing became an instant metaphor for a nation's capacity to overcome all the odds when spirit, leadership and material resources are joined together.

Technological achievement provides in this way a powerful repertoire of legitimation for the practice of statecraft. Among publics captivated by the spectacle of technology, only the occasional booster-shot of another successful demonstration is needed to restore faith in the possibility of progress through

science and technology. Gifted politicians and administrators intuitively understand technology's instrumental uses. Indeed, knowing when and how to deploy science and technology publicly has become an important dimension of tacit political knowledge. Thus, recent US presidential campaigns by both major parties promised medical breakthroughs for people with AIDS and spinal cord injuries, enlisting support from such charismatic victims as the paralysed 'Superman' star Christopher Reeve. When Gro Harlem Brundtland, former Norwegian prime minister and chair of the respected World Commission on Environment and Development, assumed the post of Director-General of the World Health Organization (WHO) in May 1999, she vowed both to strengthen the scientific 'evidence base' for policy and to direct the agency's efforts toward tangible targets such as the eradication of malaria.[2] A shattered and anxious US public rebuilt its confidence after September 11, 2001 through a successful military campaign in a distant land, a feat that sent a formerly weak president's popularity soaring to record heights. At the same time, European governments' demonstrated *in*ability to protect their publics against the risks of production, most dramatically illustrated by the outbreak of 'mad cow disease', led at the turn of the century to a vastly increased preoccupation with the relations between science, society and government.[3]

Long before these upheavals, however, while policymakers around the world were still enchanted by the simple plot line of progress, historians and social theorists had begun to tell a different and in many ways a more pessimistic tale. Technology, as seen by its critics, frequently exacerbated what was already wrong with society; it heightened inequity and operated as an instrument of control, a prison, trap or 'iron cage' (Ellul 1964). One strand of critique with roots in European social theory, and further imprinted on analysts' minds by the Nazi Holocaust, focused on the pathological effects of rationality and technical expertise in modern life. Some saw in modernity's insatiable thirst for order and governability a force that destroys the very qualities that make human lives most worth living – intimacy, emotion and creativity – and undermines broad civic engagement in public affairs. Others described the uncontrollable thirst of the ordering instinct that reaches into the most private spheres of human behaviour (Foucault 1978a,b) and, when allied with the state's destructive potential, obsessively classifies and weeds out the 'undesirable' manifestations of humanity (Bauman 1991). Still others have written of the hubris of the planning mentality that imposes 'legibility' on complex spaces, emptying them of individuality and local variation, and eliminating those forms of life that do not easily bend to the planners' will (Scott 1998).

Another harsh counterpoint to the theme of progress has dwelt on technology's power to inhibit rather than liberate human capacity. Technologies, as many historians and social scientists have observed, are never developed in morally neutral spaces but are conceived and deployed within previous configurations of wealth and authority. Existing hierarchies reinscribe themselves with the aid of

new instruments, except in those rare cases in which the lower echelons actually summon up the resources to resist or rebel. Thus, neo-Marxists have argued that giant corporations, helped by a compliant legal system, used innovative technologies to deskill independent-minded workers and tighten control over the workplace (Noble 1977). Class and gender biases were seen to perpetuate themselves subtly in the design and distribution of technologies. Strikingly, for example, a century of mechanisation in domestic technology did little to alter the basic division of labour in the family or reduce the time that women spent on housework (Cowan 1983). Accounts of the Green Revolution similarly tell of a hardening of lines between rich and poor in exchange for an aggregate increase in the food supply (Scott 1985). In other cases, the operation of complex technological systems, such as nuclear power, called for organisational conditions that excluded meaningful democratic supervision and debate (Winner 1986). Scholars in non-western societies similarly have drawn attention to the perpetuation of old hegemonic structures through practices such as the indiscriminate north-south transfer of hazardous technologies and the appropriation of indigenous biological knowledge as protected intellectual property by rapacious multinational corporations (Shiva 1997).

A third challenge to the promise of Vannevar Bush's endless frontier of science and technology has come from the recognition of invention's unintended consequences. Nothing so dramatically illustrates this problem as the succession of environmental problems that imprinted themselves on human consciousness during the last third of the twentieth century: pollution from pesticides and hazardous substances (Carson 1962), acid rain from power plant emissions, ozone depletion through the use of seemingly benign chemical refrigerants, and climate change as a consequence of energy-consuming industrial and agricultural development. But troubling manifestations of discovery gone awry are not limited to environmental damage. From the homely catastrophe of innumerable traffic deaths around the world to the novel spectre of crime on the Internet, all kinds of activities at first deemed beneficial have been shown to harbour within them the ingredients for their own misuse. Even when technology is expressly designed to serve progressive 'focal' purposes, the designers seem unable to guard against the possibility of appropriation and use in contexts that they had never imagined in their schemes of orderly management (Sclove 1995; Wynne 1988). The very successes of technology often produce perverse outcomes, in the form of unpredicted threats to life, health, nature and social cohesion.

Where do these observations lead the search for progressive development policies at the turn of history's most technologically sophisticated, yet disaster-prone, century? Curiously, although both celebratory and critical accounts of science and technology can claim considerable empirical ballast, it is the former that have exercised disproportionate influence on thinking about development. Somehow, the theme of unending promise has had the power to drown out its discordant counterpoints: *inequality*, *hyperrationality* and *unintended conse-*

quences. Progress has been held forth as the whole truth about a tapestry of events that resists, as we have seen, any neat uniformity of interpretation. How has this simplification been achieved, and how have policymakers around the world accepted, with uncritical abandon, the reductionist linkage between technology and progress? Is it possible to restore a plurality of meanings to contexts from which complexity has been routinely excluded? Exploring this question could pave the way to richer conceptions of development as a global civil society struggles to construct from its disparate histories the blueprint for a viable common future.

BETWEEN DISCIPLINE AND MEANING

Development policies in the past several decades have drawn primarily on the natural sciences and engineering and on those social science disciplines, most importantly economics, that look at human behaviour in the aggregate, closely emulating the conceptual paradigms of the natural sciences. Common to these approaches is a search for simple, lawlike forms of explanation and theories of human behaviour and rationality that easily lend themselves to the construction of policy instruments. With prediction and control as their central objectives, these disciplinary frameworks have little patience for the ambiguity of history and experience, the variability of cultures or the uncertainty of knowledge.

There has been relatively little interest until recently in asking how the humanities or the interpretive social sciences – for example, history, cultural anthropology or science and technology studies (S&TS) – could contribute to the alleviation of poverty and its social consequences (for a partial exception in the area of global environmental policy, see Rayner and Malone 1998). In development studies, as elsewhere in academia, the gulf between the 'two cultures' of intervention and interpretation has, if anything, deepened with the years. Econometric models and survey research reign supreme in lending institutions and policy schools, while critical theory is relegated to literature departments or programs in cultural studies – in short to enclaves seen as of little practical significance for policy. Yet, C.P. Snow himself, who not only named but also astutely observed this great intellectual divide, saw development as the paramount reason for wishing to bridge it. Asked in 1971 for a large enough cause that the two cultures could jointly help to surmount, Snow said, 'Peace. Food. No more people than the Earth can take. That is the cause' (Snow 1993 [1959]: lxxi).

A look at today's disciplinary structures suggests that cross-talk of the kind that Snow advocated has become, if anything, more difficult to initiate than in his day. The cognitive gulf seems entrenched and of long duration. Snow's lecture was delivered in 1959, two years before President Eisenhower's famous speech decrying the power of the 'military-industrial complex' and the threat it posed to democracy. In that cold war environment, worry about mutual

incomprehension between the sciences and the humanities formed part of a more general uncertainty about the possibility of exercising democratic control over technology. Later years and writers have raised other concerns, centring on fundamental cleavages in the ways that different disciplines conceptualise the world. The eminent British historian E.P. Thompson (1993 [1971]: 187), for example, offered the following characteristically pungent reflection on the gap between (quantitative) economic history and (interpretive) social anthropology in his celebrated essay on the moral economy of the crowd:

> We know all about the delicate tissue of social norms and reciprocities which regulates the life of Trobriand islanders, and the psychic energies involved in the cargo cults of Melanesia; but at some point this infinitely-complex social creature, Melanesian man, becomes (in our histories) the eighteenth-century English collier who claps his hand spasmodically upon his stomach, and responds to elementary economic stimuli.

Incomprehension reached a new low in the mid-1990s, when some US scientists began to question publicly the capacity of non-scientists to comment intelligently on the affairs of science, giving rise to a bitter interdisciplinary dispute known as the 'science wars' (Gross and Levitt 1994; for some rebuttals, see *Social Studies of Science* 29(2): 199–259 [1999]). Interpretive analysts, in the meantime, became absorbed in a reflective self-criticism that led many to question the foundations of their own authority (see Apffel-Marglin, this issue).

Yet, although exiled by choice and practice from the ranks of those who make decisions, critics of the ideology of science-as-progress have offered numerous transforming visions of how science and technology could connect to human welfare. The unifying premise is that scientific and technological innovation can be cut loose from histories of domination and geared toward redressing ancient imbalances of power, whether in the home, at work, or among nations. Feminists, for example, have imagined an ecological science that might investigate nature holistically (Keller 1983), as a potential ally, instead of as an object of dismemberment, intervention and control (Cuomo 1998; Mies and Shiva 1993; Merchant 1980). People's science movements in various parts of the world have agitated for a discovery process that begins with the needs of the poor and dispossessed in place of one driven either by scientists' ambitions or, worse, by state imperatives of military or economic conquest (Scott 1998). Postcolonial scholars have urged the abandonment of a 'western' scientific enterprise that was built from the start on projects of subjugation and national self-interest (Nandy 1988; Visvanathan 1997). The Andean development project, PRATEC, that Apffel-Marglin describes in this issue belongs in this tradition, particularly in its embrace of 'deprofessionalisation' as a necessary corrective to failed western ideas of development. Workable alternatives to current development strategies, however, have rarely been sketched with the same passion and acumen as the critiques. With decades of scholarly creativity behind us, can we do better?

If humanistic and social studies emphasise the subjectivity, contingency and malleability of the scientific and technological enterprise, then they should also be able to illuminate how these aspects are elided or glossed over in processes of technocratic, top-down decision-making. Interpretive work, whether contemporary or historical (such as Kline's in this issue), can open up the black boxes of technology to reveal inside the concealed, taken-for granted workings of human agency. It can display the means through which the unruliness of reality gets smoothed out by models and numbers. It can restore the texture and diversity of lives rendered flat and indistinguishable by decision-making methods that focus on ends more than means and on collective outcomes at the expense of individual experiences. It can remind us of the historical acts, or failures, of imagination that underpin development trajectories which seem inevitable only *after* societies have definitively embarked upon them. In turn, analysis that humanises or socialises the techniques of modernity can give rise to alternative ways of imagining the future. Let us turn now to four areas in which humanistic and technical modes of thought have classically been separated, hoping in this way to learn how the two may be reconnected in shared constructions of progress.

Animating the Inanimate

Once, in a relatively well-appointed regional environmental agency in India, I saw a set of instruments for measuring water quality that had been donated some years before by the World Health Organization. At the time, these grey metal boxes, offered as a reward for the Indian agency's superior technical ability, no longer functioned. Parts were missing or broken and could not be replaced locally. Possibly, the expertise required to use them had also vanished. The instruments were lined up against a wall, occupying space and gathering dust, mute witnesses to the risks of transferring 'inappropriate technology'. Stories like this are commonplace. No one who has ever worked on a development project, or indeed in any form of technological exchange between countries with different histories of development, can have come away without registering such examples, often in droves. And yet such unproductive exchanges endlessly repeat themselves, with results ranging from comical to catastrophic. As recently as 1984, a chemical plant's failure to operate in Bhopal, India as it had done in its country of origin, the United States, wrought havoc among the city's poorer citizens, killing as many thousands as the US attacks of September 11, 2001 and injuring hundreds of thousands more.

Several decades of research on technological invention have given us many conceptual tools for preventing errors of Bhopal's magnitude (for further commentary, see Rajan in this issue), and yet there is little sign that these are being deployed systematically by state or corporate decision-makers. We know, for example, that the shape of artefacts is determined not only by the constraints

of physical materials, but also by user preferences (Bijker et al. 1987), manufacturers' efficiency needs, regulatory prescriptions and prevailing political ideologies (Winner 1986). Technologies do not, as Kline importantly reminds us in this issue, transform society wholesale through their inbuilt imperatives; rather, they are actively adapted and used by people in different contexts to create new forms of life. US farm people in the 1930s did not buy more modern electrical appliances simply because they were there, but picked and chose among them instead, with marked regional variations, to correspond to a firm sense of how farm life ought to be lived.

Technologies, through the operation of human agency, are socially constructed. They are not mere physical artefacts but socially and materially stabilised heterogeneous networks of actors, institutions, norms, discourses and non-human elements (Bijker et al. 1987, especially chapter by J. Law, pp. 111–134; Callon 1986). The most mundane of the objects with which we facilitate our lives, a paper coffee cup or a ball-point pen, bears multiple traces of the social and cultural contexts that produced it. In turn, the archaeologist's work can reconstruct from such inarticulate material remains the social orders of vanished civilisations, for example, their gender relationships or their trading patterns. In hi-tech consumer cultures, however, the very novelty of technology is continually fetishised, so that products are invested with a value independent of the politics or norms that produced them. Detached from their locally specific meanings, technological artefacts come to be seen as lying outside culture, and hence as impersonal and value-free assistants in the development project.

The controversy over genetically modified crops that spilled across the globe in 1999 provides a striking contemporary example of conflict between such decontextualised interpretations of technology and critics' efforts to read social meanings back in. On the side of leading producer nations, much of the talk about agricultural biotechnology has focused on the benefits that its products might bring to consumers in developing countries, from higher-yielding corn and cotton to vaccine-bearing bananas and vitamin-enriched rice.[4] Consistent with the grand narrative of progress, risks were either denied or dismissed as trifling by comparison with the benefits. A more complex story has gradually unfolded, but characteristically not through the leadership of scientific, corporate or policy elites in manufacturing countries. It has become clear, for example, that not all the products of biotechnology are designed even nominally for the benefit of growers or consumers. Perhaps most notable is the technology of sterile seeds that would not reproduce beyond a single growing season. Farmers who plant such seeds would need to go back to the manufacturer annually to get new stocks, thus abandoning in many parts of the world the established custom of saving seeds from year to year.

In a very public turnaround in the summer of 1999, the biotechnology-industry leader Monsanto declared that it would no longer seek to develop and market sterile seeds, although it had earlier been interested in doing so. A key

factor in Monsanto's decision was a campaign headed by the Rural Advancement Foundation International (RAFI), a Canadian NGO that has led the fight against globalisation and agricultural biotechnology. One of RAFI's most successful tactics was to label the sterility-inducing gene the 'Terminator', in reference to the extremely popular science fiction movie series of that name. By deploying a widely recognised resource from mass culture, RAFI was able – literally, in a word – to reinvest the new technology with complex social meanings that had been lost in the euphoric discourse of progress.

Modelling Progress

The promise of development derives much of its power from the expectation that aggregate human welfare will automatically increase along with economic growth, both deterministically propelled by advances in science and technology. For instance, it is widely accepted that wealth creation through technological innovation will lead in due course to reduced demand for children and a consequent levelling off in birth-rates and the rate of population increase. Some believe that birth-rate stabilisation is but one aspect of a more far-reaching sustainability transition, through which richer, more technologically advanced human societies will eventually be able to live in harmony with their environments (NRC 1999). The current apostles of economic globalisation do not necessarily endorse such utopian visions, but they are nonetheless persuaded that trade between more and less technologically advanced nations is the most effective means of raising the standard of living world-wide. Those countries are predicted to gain most who do the most to lower their barriers against others' innovations.

Against these optimistic visions, S&TS research has counterposed a more sceptical set of investigations, stressing the contingency, and hence the potential unreliability, of conventional measures and models of progress. One source of disquiet is the recognition that the allegedly objective methods used to assess various dimensions of social welfare are laden with values and judgements that reflect particular times and cultural contexts. For example, quantitative techniques such as cost-benefit analysis (Porter 1995) and risk assessment (Jasanoff 1986) produce numerical results that turn out on closer inspection to incorporate hidden professional biases and untested, possibly erroneous, assumptions about natural and social phenomena. Far from capturing simple reality, a number such as the estimate of global mean temperature rise from greenhouse gases operates as an 'anchoring device' that holds together an expert consensus over two decades, although the number's theoretical justification varies across scientific disciplines and over time (van der Sluijs 1997). Counting, it appears, not only *enumerates* things actually present in the world but in salient ways *constitutes* the very phenomena whose magnitude the numbers seek to represent (see, for instance, the account of child abuse statistics in Hacking 1995). And this

constitutive process imports some of the subjectivities of the counting culture into the apparent objectivity of what is being counted.

A further trouble with technologically driven development programs is that they are founded on models of management and control that invariably underrate the complexity of the systems they simulate. Both the errors of policy and the unintended consequences of technology flow in large part from relying on such models without acknowledging, let alone compensating for, their essential incompleteness. In one well-known example, British nuclear energy experts erred in predicting when lamb grazed on radioactively contaminated soils in northern Britain after the Chernobyl reactor accident would be fit to eat (Wynne 1996). Their predictions were based on the uptake rates of radioactive caesium in the clay soils of southern England rather than the acid, peaty soils of the north. Unbeknownst to the modellers, however, the caesium remained chemically mobile longer in the acid soils, permitting its migration into vegetation and thence recycling back into the food chain. While this particular modelling exercise led to an underestimation of risk, other commonly used models in the policy system, such as General Circulation Models for climate change or animal bioassays for detecting carcinogens, have been charged with overstating the degree of risk. The analytically important point, however, is that models used in the policy process tend to become naturalised, that is, to be taken as functioning images of the reality they only imperfectly mimic. It frequently takes a catastrophe to reveal the model's flaws; more benignly, a critic situated outside a particular modelling community may recognise the disjunctions between the model and the world and identify the patterned beliefs and ideologies that gave rise to them (Taylor 1992; Ashley 1983).

In taking issue with models in this way, we should not restrict ourselves to the formal mathematical models or computer simulations, such as integrated assessment techniques, that are currently popular in environmental decision-making. Broadly speaking, the critique of models applies equally well to any systematic master narrative of the workings of nature and society (tacit or explicit, formal or informal) that provides support for technology transfer or other policies of development. Much interpretive work in the social sciences, particularly in the field of science and technology studies, has drawn attention to the recurrent blind spots that affect the making of such narratives. Thus, the proponents of the Green Revolution did not consider the environmental implications of the high chemical and energy inputs that would be needed to support optimal yields in rice, wheat and corn. Neither the Indian state nor the US corporation, Union Carbide, considered the full range of human factors required to make a hazardous pesticide plant operate without harming local populations. Sugar manufacturers in colonial Mauritius were oblivious to the role of subsidies in allowing two cultures of sugar cane production, based on very different crop varieties, to coexist peacefully (Storey 1997). In these and many similar cases, the tight interdependence of machines, humans, norms and natural objects

escaped the notice of the actors who crafted the dominant development strategies. In each instance, it is possible through historical reconstruction to locate some decision-maker whose vision was fatally occluded, some specific decision point where mistakes were made. This has led analysts to conclude, optimistically, that surprises provide 'opportunities to increase social capacity to manage problems in the future' (NRC 1999: 264). Yet, the puzzle in retrospect is why people were surprised in the first place. For these stories suggest in aggregate that what is most to blame for development failure is not the contingent mistakes or incapacities of particular agents, but the planning culture's persistent, unreflective faith in its imperfect, judgement-laden models. We need then to approach with a more questioning mind the very idea of models for development.

The Practices of Power

In development controversies, as in many areas of contested social policy, states and international organisations have grown weary of shouldering blame for decisions that arouse significant resistance or, worse yet, produce visibly disastrous consequences. Two standard responses have evolved to shift responsibility away from the primary decision-maker. One is to enrol the impartial authority of science, either through high-level expert consultation or by actively supporting the acquisition of new knowledge. Science, however, has proved to be an unreliable ally, as new findings fracture along the fault lines of older social cleavages, without necessarily ameliorating conflict. Sometimes, moreover, the need for action is immediate, and then controversy migrates to questions about appropriate remedies. Should one conserve water by building large dams or by fostering traditionally decentralised water harvesting techniques (Agarwal and Narain 1997)? Should fishing be banned or should it be managed through carefully monitored restrictions on catches? Should governments adapt to the consequences of climate change or seek to mitigate them, when these actions would entail substantially different distributions of benefits and burdens? Scientific research alone seldom provides real time answers to such persistent questions.

A second, newly popular strategy for directing controversy away from states and state-like entities has been to diffuse authority for decision-making among multiple actors. National governments and intergovernmental organisations alike have sought to empower nonstate actors (Weiss 1998), promote negotiation among divergent stakeholder interests, and capitalise on knowledge and practices not accessible to central authorities. The strategy of decentralisation corresponds to a growing recognition that most states (and state-like actors) possess neither the knowledge nor the capacity to implement ambitious, top-down regimes of environmental control.[5] At the same time, a persuasive body of research on the management of common pool resources has suggested that local users are quite capable of designing long-lasting, well-managed systems of

environmental protection that function more efficiently than rules imposed from above by distant officials (Ostrom et al. 1999). Thus, there has been a tendency in recent years, in both developed and developing countries, to modify draconian command-and-control measures for environmental protection in favour of strategies that explicitly seek inputs from those whose environments are at risk.

In the United States, for example, the absolutist provisions of the Endangered Species Act have been softened through habitat conservation plans which allow landowners and environmentalists to negotiate over development projects that contain provisions for biodiversity protection. In a number of developing countries, community forestry programs that allow villagers to obtain forest products and participate in decision-making have replaced former, largely unworkable, attempts to keep people out of protected lands. Even in highly charged contexts, such as the preservation of African elephants under the international treaty on endangered species, Thompson's contribution to this issue shows the supplanting of black-and-white concepts of species preservation by more nuanced approaches that acknowledge the elephant's shifting value across different geographical, social and cultural contexts.

While these are widely regarded as progressive developments, there are numerous indications that solutions based on decentralisation, without more, may simply perpetuate pre-existing hierarchies and structural inequalities by other means. Studies of community forestry groups (CFGs) in South Asia provide instructive examples. Research initiated by the United Nations suggests that the costs of new management programs fall disproportionately on women, who do not necessarily share equitably in the benefits (Agarwal 2000). Women have played a negligible role in the CFGs responsible for forest management decisions, showing that the mere devolution of power to substate organisations, even newly formed ones, does not erase the disenfranchising effects of surrounding social orders. Such findings stand in interesting contrast to observations about the efficacy of locally constituted norms in the literature on common pool resources.

Work in science and technology studies, as Sivaramakrishnan's paper in this issue persuasively documents, may shed further light on the prospects for institutional innovation in response to global environmental problems. In keeping with an important methodological turn in science and technology studies, he revisits joint forest management in India from the standpoint of the practices sanctioned by such programs. In this case, it is not gender inequities but bureaucratic traditions that reinscribe themselves on the new institutional arrangements. The example thus usefully refocuses attention on the ways in which the technologies of modernity encode power relationships, with the further reminder that the technologies in question are not merely the materially embodied systems, such as nuclear power plants, that come to mind when people speak of technology, but also the less tangible social instruments with which complex societies manage and discipline themselves (Foucault 1978a,b).

Formal, institutionalised methods of reporting, analysis, or even of group interaction, show themselves from this vantage point as technologies of power. Administrative routines do not only, as is sometimes assumed, eliminate discretion and render decision-making more transparently accountable – although they *can* do these things under appropriate circumstances (Porter 1995). But they can equally well hide the normative choices that underlie supposedly impersonal ways of making order in the world; as such, the practices of development agencies are fitting subjects of interpretive analysis.

Plural Visions, Plural Lives

Environmental understanding today continually eludes consensus. Plurality is its essence. An apt metaphor is that of the blind men and the elephant. Rope or serpent, wall or tree trunk – the observers disagree because they cannot see the thing whole. Their evidence is limited and their theories correspondingly underdeveloped. They sense only the parts, which they both 'see' and interpret in the light of the little they actually know. Gifted with perfect vision, they would all have agreed that it was, in truth, an elephant.

In controversies over environment and development, people similarly disagree about the meanings they should attach to events, even when, like the blind men of the fable, they see in some sense the same things: rivers and fields drying in successive seasons of drought; fish catches that do not match the hauls that older generations brought in; song birds that do not return to old haunts (Carson 1962); too many children dying of illness in one small neighbourhood. It could be an act of God, an accident of nature, human greed, or unintentional contamination of natural resources through fundamentally beneficial efforts to meet human needs. The choice of explanation provides insights into a society's deepest moral and political arrangements. The stories people tell to explain unfortunate events are neither whimsical nor unfounded. They are linked in many instances to remembered and continually re-enacted societal commitments about how to apportion authority, acknowledge kinship, express identity, or decide whom to trust and whom to blame (Douglas 1966; Cronon 1992).

The observation that people reconstruct their pasts in different ways is not new to historians, cultural anthropologists (Apffel-Marglin, this issue) or students of science and technology, but it has hitherto made little impact on the design of policies for development. From the grand, and now substantially discredited, dam-building projects of the mid-twentieth century to current efforts to open global markets, development policy has tended to assume that people's futures should converge, even if their pasts have followed radically different courses. The standard for convergence has generally been that of the wealthy industrial nations; not merely their income levels, but also their social and political institutions and forms of life have been taken as the logical endpoints of progress. Thus, when the cold war ended, economists from the west

prescribed instant privatisation as the solution for all former east bloc nations. Only when startling differences appeared among various transition economies (for example, between Russia and China) was there an acknowledgement that perhaps, at least in the short term, the one-size-fits-all approach to market reform had been counterproductive. A consensus slowly grew that each nation's institutional characteristics – in other words, the formal embodiments of its political and cultural practices – should have informed more deeply its particular trajectory of economic liberalisation.

But the very discourse of development continues to deny the relevance of the past; it is the present, as imagined by development agencies, that sets the standards for what needs to be accomplished. Do the food and energy needs of the world's poorest people need to be addressed? Why, then, the solution is 'technology transfer', a process that aims to bring lagging societies up to date with what has already been achieved by those in the lead. Is it inappropriate for less developed nations to live through the discontents of the industrial revolution, including environmental pollution and unsustainable resource use? In that case, the remedy surely is 'technological leapfrogging', which implies that progress can be attained in discontinuous leaps rather than incrementally. Is it governance deficits that need to be redressed? Then, the answer is 'capacity building', a term whose very blandness denies that there could be any question either about who will do the building or about what capabilities need to be built. The baseline, in any case, is that which obtains at present in economically and technologically advanced societies; others are simply to be brought forward to that fortunate state. Each of these concepts (technology transfer, leapfrogging, capacity building) assumes that the goals of development are given and black-boxes the process of getting from one stage to another. It is hardly surprising that none has given rise to rich theorising or active moral and social inquiry.

There are two difficulties with the assumption that development policy does not need to look to the past, both of which have been illuminated by interpretive work in the social sciences. The first is that, even in developed societies, the present is never singular but plural. Democratic societies not only sustain multiple forms of life but engage in continual contestation about which versions are most consistent with the public good. The answers offered, moreover, remain markedly different even across relatively homogeneous western societies; for instance, continental Europe, Britain and the United States disagree profoundly on the role of the state in providing for such basic needs as health, education, security or a clean environment. In debates about technological risk, citizens of industrial nations reveal widely divergent preferences not only toward particular technologies but, more importantly, toward particular governmental strategies of analysis, persuasion and control (Gaskell et al. 1999; Jasanoff 1986). These variations in turn stem from deeply entrenched, historically rooted commitments to ways in which people wish to understand their conditions and relate to one another. The past, in other words, remains a meaningful prologue to the lived

present of progressive societies, whose vitality stems in no small part from a tolerance of many possible retellings of the past, each implying a different design for the future.[6] Yet, in developing societies, the value of collective memory and historical practice in constructing solutions for present problems has been largely ignored (Agarwal and Narain 1997). The assumption seems to be that modernity, once attained, has nothing valuable left to learn from tradition.

A second, related difficulty has to do with the compression of time that development policies seem to demand, and the social and political implications of such short-circuiting. Implicit in the very notion of 'leapfrogging', for example, is a denial of the significance of time in relation to social change. Institutions and orders are conceived as modular units that can be assembled together in functioning wholes, more on the model of a jagged, postmodernist collage than a seamless, woven tapestry. We know, however, from E.P. Thompson's (1993) masterly account of time-telling that this indispensable technology of modernity itself took time to gain acceptance across the world. As recently as the early 1900s, the Irish playwright John M. Synge found his old woman servant on the Aran Islands serving tea at erratic clock times because her rhythms were still dictated by 'natural' time, as marked by the shadow of the door-post on the kitchen floor. In his provocative essay on the moral economy of crowds, Thompson similarly paints a picture of the time-consuming normative and political adjustments that had to be made in order to accommodate a new system of food production; bread riots in eighteenth-century Britain were indicators of the friction in that process. These landmark works of social history foreshadow the many contemporary studies of scientific and technological innovation that also stress the work – and the sheer *time* – involved in fitting together people and material, norms and practices, institutions and imaginations in order to make things that work on more than local scales. By compressing time, then, the politics of development denies to citizens of less developed societies full use of a resource that industrial societies have amply exploited in arriving at their own, contested and plural, accommodations with progress.

A REQUIEM FOR DEVELOPMENT?

Development is a flat word for a world of contradictions. Its appetite is voracious. It consumes meaning and seeks to remedy the multiple varieties of human misery and disempowerment through a single, undifferentiated, technocratically certified model of forward movement. It denies ambiguity and takes values for granted. How could the children of the Enlightenment question the need for development when failure to develop, economically and technologically, is so often accompanied by terrible deprivations and human rights abuses? Development, moreover, sits in a field of meaning created by a web of words with very similar resonances: reform, progress, restructuring, liberalisation, modernisa-

tion and the like. These terms take for granted the very issue around which most conflicts swirl: whose vision of the good should provide the compass for public policy? They are thus a blessing to policymakers wishing to make improvements in deeply divided societies. Development, with its seemingly unshakeable understanding of which way progress lies, begs the need to engage in visceral political conflict.

I have suggested in this essay that the persistence of 'development' as an allegedly value-neutral concept has to do not only with its instrumental utility for policymakers, but also its close coupling with science and technology. Like science and technology, development is intimately associated with discourses of betterment. Curiously, however, it has escaped much of the critical scrutiny that interpretive scholars have lately brought to the processes of knowledge creation and technological change. Commentary on the contingency and situatedness of science and technology, as well as their power to order and classify human relationships, appears as yet to have had little impact on the dominant discourses of development. In looking for reasons, we have observed four mechanisms that help to denude development of its subjective and meaning-laden elements: the persistent misreading of technology as simply material and inanimate; the uncritical acceptance of models (importantly including economic ones) as adequate representations of complex systems; the failure to recognise routine practices as repositories of power; and the erasing of history as a relevant factor in producing scenarios for the future. All these processes have contributed to the view that, despite a variety of regional shocks and setbacks even in technologically advanced societies, there is a strong global consensus on the basic directions and instruments of development.

Some who wish to import more of the richness and subjectivity of human experience into talk about humanity's future have suggested that we may need to jettison the very notion of development. The word, they forcefully argue, smacks too much of the arrogance of societies that have attained prosperity by ignoring others' values and exploiting others' resources. Yet, poverty and hunger remain real enough, and most unevenly distributed. Moreover, the liberating impulses of modernisation – from hunger, poverty, environmental degradation and social oppression – should not be lightly dismissed. It is no kindness for scholars and intellectuals to reject interventions into the lot of the world's poorest citizens simply because this project has so often been misguided. If the concept of modernity toward which development policies have been oriented in the past seems flawed, then our aim should be to put alternative visions, based on less reductionist readings of the human condition, in their place.

There are several things we can say with confidence if we do not wish to discard meliorative projects out of hand. The knowledge gained from close, interpretive studies of science and technology supports a growing consensus that large-scale planning exercises – material, economic or social – should be

conceived with humility and implemented with respect for the contingency of what we think we know of the world at any given moment. Acknowledging contingency should go hand in hand with a respect for plurality, for if no single way of understanding complex phenomena is ever adequate, then it is foolish indeed to rule out inputs from diverse sources of knowledge. Science, in particular, should not repudiate other socially sanctioned forms of knowing, such as the tacit knowledge of traditional communities whose skilled environmental management has not been certified through canonical processes of scientific fact-making. More time is needed as well for people outside the cultures of rapid technological innovation to consider how novel things and practices can usefully be integrated into their present forms of life. Supplementing the top-down processes of expert analysis – formerly the staple of development work – with more bottom-up, consultative forms of deliberation (NRC 1996) may lead to more sustainable, as well as more democratic, approaches to living well on the earth.

Accommodating plurality and complexity will not come easily to many existing institutions of governance, which were conceived in a simpler time when truths about nature and society were deemed to be largely self-evident. Emerging global institutions, in particular, will have to engage in painful self-scrutiny, as the World Bank has done in connection with its environmental policies, to discover which of their assumptions are ethically and empirically supportable and which are rooted in unthinking ideology. It will be technically and politically difficult for the international system to pursue laudable universalist aims, such as free trade or environmental sustainability, while admitting that science is neither univocal nor value-free, and that communities may reasonably differ in their assessments of risk and safety. New access points for democracy will have to be found in decision-making contexts, such as corporate research or expert advice, that were once thought to be apolitical and hence exempted from the discipline of deliberation. None of this will be straightforward, but it is unavoidable if the next century is not to repeat the mistakes of the one past.

And what will remain of development policy if it is shorn of its claims to privileged knowledge, predictive capability and unique right to formulate scenarios for the future? Perhaps not enough to justify the centrality of *development* as the primary conceptual driver for interactions between the rich and the poor. It is time to invent other, more discursively open-ended concepts around which to crystallise our dreams and projects of human betterment. Not one modernity, but as many *new modernities* as the citizens of the earth can responsibly imagine should be the goal. We can only be led there through an energetic and unabashedly humanistic contemplation of *alternative democratic futures*.

NOTES

[1] The papers in this special issue were originally presented at a workshop on *Science, Development and Democracy* held at Cornell University's Department of Science and Technology Studies in November 1996. The workshop was supported by the Department's Rockefeller Foundation Humanities Fellowship Program on Humanistic Studies of Science, Technology and the Global Environment. It was organised by S. Ravi Rajan, one of the fellows in the program, in collaboration with Sheila Jasanoff, the program's director. The authors gratefully acknowledge the Rockefeller Foundation's support.

[2] There is an interesting footnote to this story, highlighting again the unpredictability of development. WHO's malaria and polio eradication programs seek to emulate the organisation's earlier, brilliant success with the official eradication of smallpox as a disease. Yet, in May 1999, an advisory panel to the organisation again recommended against destroying the last remaining known stocks of the disease virus. Panellists and governments of some member states agreed that there were likely to be secret stocks of smallpox virus that could be used in the future by bioterrorists. In an unvaccinated world, any such attack could have devastating effects. The US Secretary of Health and Human Services, Donna Shalala, noted that this once 'obscure' problem had now emerged as one of the thorniest of the post-cold war era (Miller and Altman 1999). The notorious US anthrax attacks, which followed the September 11, 2001 tragedy and remained unsolved as of this writing, helped underline the concerns about bioterrorism.

[3] The response was especially notable in the United Kingdom, site of the 'mad cow' epidemic. In the last year or two of the 1990s, the UK government issued a major policy statement on science advice, convened select committees of both houses of parliament on science and society, and formed several new committees to examine science-society issues connected with human genetics, agricultural biotechnology and food safety. By 2001, both the UK government and the European Commission had issued substantial reports on these topics (UK House of Lords 2000; European Commission 2001).

[4] A speech given at the February 2000 annual meeting of the American Association for the Advancement of Science in Philadelphia, Pennsylvania by US Senator Christopher Bond (R-MO)offers one example. Deploring the public opposition to biotechnology at the 1999 Seattle meeting of the World Trade Organization, Bond said, 'I am passionate because I believe the greatest risk associated with biotechnology is not to the Monarch butterfly larvae, but from the naysayers, who may succeed in their goal to undermine biotech and condemn the world's population to unnecessary malnutrition, blindness, sickness and environmental degradation. I believe strongly that while hysteria, intimidation, opportunism, misinformation, protectionism and short-sightedness have met with some tactical success in Europe, it would be a gross irresponsibility to allow that to happen here.'

[5] Advocates of market reform, too, have advanced the centre's knowledge deficits as a prime reason for economic decentralisation, diversification and experiments. See, for example, the comments by Nobel laureate Joseph E. Stiglitz at the 1999 Annual Bank Conference on Development Economics (Stiglitz 1999). However, these calls for decentralisation underestimate the extent to which experimentation may be constrained by invisible social codes and practices. See below.

[6] Consider, for example, the vigorous interpretive disputes over the meaning of the late eighteenth-century US Constitution in relation to such contemporary technological issues

as environmental risk, ownership of human tissues and cells, and the patentability of living organisms. Numerous US Supreme Court decisions have wrestled with the relevance of 'old' constitutional language to new scientific and technological circumstances. A notable example is *Diamond v. Chakrabarty*, 447 US 303 (1980), in which a 5–4 majority held that the US patent law drafted by Thomas Jefferson was broadly enough conceived to encompass the products of modern genetic engineering.

REFERENCES

Agarwal, Anil and Sunita Narain 1997. *Dying Wisdom*. New Delhi: Centre for Science and Environment.

Agarwal, Bina 2000. 'Group Functioning and Community Forestry in South Asia: A Gender Analysis and Conceptual Framework'. Working Papers No. 172. Helsinki: UNU World Institute for Development Economics Research.

Ashley, Richard K. 1983. 'The Eye of Power: The Politics of World Modeling'. *International Organization* 37(3): 495–535.

Bauman, Zygmunt 1991. *Modernity and Ambivalence*. Ithaca, NY: Cornell University Press.

Beck, Ulrich 1992. *Risk Society: Towards a New Modernity*. London: Sage Publications.

Bijker, Wiebe, Thomas Hughes and Trevor Pinch (eds) 1987. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Bush, Vannevar 1945. *Science – The Endless Frontier*. Washington, DC: US Government Printing Office.

Callon, Michel 1986. 'Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay'. Pp. 196–233 in John Law, ed., *Power, Action, and Belief: A New Sociology of Knowledge?* London: Routledge and Kegan Paul

Carson, Rachel 1962. *Silent Spring*. Boston: Houghton Mifflin.

Cowan, Ruth Schwartz 1983. *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic Books.

Cronon, William 1992. 'A Place for Stories: Nature, History, and Narrative'. *Journal of American History* March 1992: 1347–1376.

Cuomo, Chris J. 1998. *Feminism and Ecological Communities: An Ethic of Flourishing*. London: Routledge.

Douglas, Mary 1966. *Purity and Danger*. London: Routledge.

Ellul, Jacques 1964. *The Technological Society*. New York: Vintage Books.

Ezrahi, Yaron 1990. *The Descent of Icarus: Science and the Transformation of Contemporary Democracy*. Cambridge, MA: Harvard University Press.

Commission of the European Communities 2001. *European Governance: A White Paper*, COM (2001) 428, Brussels, July 27, http://europa.eu.int/eur-lex/en/com/cnc/2001/com2001_0428en01.pdf.

Foucault, Michel 1978a. *The History of Sexuality, Volume 1*. New York: Pantheon.

Foucault, Michel 1978b. *Discipline and Punish*. New York: Pantheon.

Gaskell, George, Martin W. Bauer, John Durant and N.C. Allum 1999. 'Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S'. *Science* 285: 384–387.

Gross, Paul R. and Norman Levitt 1994. *Higher Superstition: The Academic Left and Its Quarrels with Science*. Baltimore: Johns Hopkins Press.

Guston, David 1999. *Between Politics and Science: Assuring the Integrity and Productivity of Research*. New York: Cambridge University Press.

Hacking, Ian 1995. *Rewriting the Soul: Multiple Personality and the Sciences of Memory*. Princeton, NJ: Princeton University Press.

Hart, David 1998. *Forged Consensus: Science, Technology, and Economic Policy in the United States, 1921–1953.* Princeton, NJ : Princeton University Press.

Jasanoff, Sheila 1986. *Risk Management and Political Culture*. New York: Russell Sage Foundation.

Jasanoff, Sheila (ed.) 1994. *Learning From Disaster: Risk Management After Bhopal*. Philadelphia: University of Pennsylvania Press.

Jasanoff, Sheila (ed.) 1997. *Comparative Science and Technology Policy*. Cheltenham, UK: Edward Elgar.

Keller, Evelyn Fox 1983. *A Feeling for the Organism: The Life and Work of Barbara McClintock*. New York: Freeman.

Merchant, Caroline 1980. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper and Row.

Mies, Maria and Vandana Shiva 1993. *Ecofeminism*. Halifax, NS: Fernwood.

Miller, Judith and Lawrence K. Altman 1999. 'Health Panel Recommends a Reprieve for Smallpox', *New York Times*, May 22.

Nandy, Ashis (ed.) 1988. *Science, Hegemony and Violence: A Requiem for Modernity*. Tokyo: United Nations University.

National Research Council (NRC) 1999. *Our Common Journey: A Transition toward Sustainability*. Washington, DC: National Academy Press.

Noble, David F. 1977. *America By Design: Science, Technology and the Rise of Corporate Capitalism*. Oxford: Oxford University Press.

Ostrom, Elinor, Christopher B. Field, Joanna Burger, Richard B. Norgaard, and David Policansky 1999. 'Revisiting the Commons: Local Lessons, Global Challenges'. *Science* 284: 278–282.

Porter, Theodore M. 1995. *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton: Princeton University Press.

Rayner, Steve and Elisabeth L. Malone (eds) 1998. *Human Choice and Climate Change*. Washington, DC: Battelle Press.

Sclove, Richard 1995. *Democracy and Technology*. New York: Guilford Publications.

Scott, James C. 1985. *Weapons of the Weak: Everyday Forms of Peasant Resistance*. New Haven, CT: Yale University Press.

Scott, James C. 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press.

Shiva, Vandana 1997. *Biopiracy: The Plunder of Nature and Knowledge*. Toronto: Between The Lines.

Smith, Bruce L.R. 1990. *American Science Policy Since World War II*. Washington, DC: Brookings Institution.

Snow, Charles P. 1993 [1959]. *Two Cultures and the Scientific Revolution*. Cambridge: Cambridge University Press.

Social Studies of Science 1999. Special Issue, **29**(2): 199–259.

Stiglitz, Joseph E. 1999. 'Whither Reform? Ten Years of the Transition'. Keynote Address, Annual Bank Conference on Development Economics, Washington, DC, April 28–30, 1999.

Stokes, Donald E. 1997. *Pasteur's Quadrant*. Washington, DC: Brookings Institution.

Storey, William K. 1997. *Science and Power in Colonial Mauritius*. Rochester: University of Rochester Press.

Taylor, Peter 1992. 'Re/constructing Socioecologies: Systems Dynamics Modeling of Nomadic Pastoralists in Sub-Saharan Africa'. Pp. 115-147 in Adele Clarke and Joan Fujimura, eds., *The Right Tools for the Job*. Princeton: Princeton University Press.

Thompson, Edward P. 1993. *Customs in Common*. New York: New Press.

United Kingdom, House of Lords Select Committee on Science and Technology, Third Report, *Science and Society* (2000), http://www.parliament.the-stationery-office.co.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm.

Van der Sluijs, Jeroen 1997. *Anchoring Amid Uncertainty: On the Management of Uncertainty in Risk Assessment of Anthropogenic Climate Change*. Utrecht: University of Utrecht.

Visvanathan, Shiv 1997. *Carnival for Science: Essays on Science, Technology and Development*. Delhi: Oxford University Press.

Weiss, Thomas G. (ed.) 1998. *Beyond UN Subcontracting: Task-Sharing with Regional Security Arrangements and Service-Providing NGOs*. New York: St. Martin's Press.

Winner, Langdon 1986. *The Whale and the Reactor*. Chicago: University of Chicago Press.

Wynne, Brian 1996. 'Misunderstood Misunderstandings: Social Identities and Public Uptake of Science'. Pp. 19–46 in Alan Irwin and Brian Wynne, eds., *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.

Wynne, Brian 1988. 'Unruly Technology'. *Social Studies of Science* 18: 147–167.