RISK: Health, Safety & Environment (1990-2002)

Volume 5 | Number 4 Article 5

September 1994

# Trace Substances, Science and Law: Perspectives from the Social Sciences

James F. Short Jr.

# Trace Substances, Science and Law: Perspectives from the Social Sciences*

James F. Short, Jr.**

## Introduction

A few years ago, I was invited, as an outsider to the field of natural disaster studies, to contribute a commentary on a series of papers written by insiders to that field on the role of taxonomy in disaster research. I titled my paper, *On Defining, Describing and Explaining Elephants (and Reactions to Them): Hazards, Disasters, and Risk Analysis.*[1]

In his introduction to the special issue of the journal in which the papers were published, the editor noted that "because the range of hazards facing humankind is broad and arguably increasing, the research agenda of researchers and practitioners purporting to understand them must keep apace."[2] Concerns with trace substances are a major reason for the arguably increasing range of hazards facing humankind. We now know — more importantly, we have the capability of knowing — vastly more about possibly toxic substances in the food we eat, the water we drink and the air we breath. We know, or can know, about these and other hazards in the home, the workplace and in local communities throughout the globe. This "good news," however, has several consequences, and that basically is my topic.

* Prepared for the Am. Assn. Adv. Sci. Symposium on "Trace Substances: Impact of Recent Instrumental Advances on Regulatory Affairs," Feb. 23, 1994. I am grateful to Eugene Rosa, William R. Freudenburg & Lee Clarke for guidance and incisive comments. Remaining faults in the paper are, of course, my own.

** Dr. Short is Professor Emeritus of Sociology at Washington State University, and a past president of the American Sociological Association. He has a B.A. from Denison University and M.A. and Ph.D. from the University of Chicago — all in Sociology.

1 7 Int'l J. Mass Emergencies & Disasters 397 (1989).

2 Gary Kreps, *The Boundaries of Disaster Research: Taxonomy and Comparative Study,* 7 Int'l J. Mass Emergencies & Disasters 213 (1989).

Most readers of this paper surely will agree that advances in trace element discovery have at least two benefits: they increase awareness of hazards (old and new), and they are critical to the remediation, reduction and prevention of such hazards. While granting these benefits, and granting also that we are, on average, healthier and safer than our forebears, it appears nevertheless that the U.S. public is more, rather than less, concerned about risk than at any time in recent history.

Several years ago, a lighter side of this seeming paradox was discussed in an Art Buchwald column that described his visit to Flagstaff, Arizona. At 8,000 feet, Flagstaff enjoys relatively pollution-free air. Buchwald reported that shortly after his arrival he began to feel ill. The feeling persisted until he walked past an auto repair garage and caught a strong whiff of exhaust fumes, after which he immediately felt better! He sustained himself for the remainder of his visit by periodically returning to get his fix of fumes. While this "case study" may be subject to a variety of interpretations, nevertheless, many beleaguered citizens feel that, to the old adage, "Everything I want to do is either illegal, immoral, or fattening" must be added, "or risks toxic exposure." As my wife said to me while we were discussing this paper, "You can't live without being at risk." Precisely, and, of course.

What to do with and about the knowledge gained by advances in trace element discovery must be an important agenda item for the larger society and for individuals, institutions and organizations with special interests in such discoveries. Here again I find myself in the role of an outsider to the scientific and technological advances being discussed. And once again the parable of the blind men and the elephant seems appropriate, as it is to so many cutting edge scientific and technological issues. For how one views trace element discoveries — and how one reacts to them — depends on many considerations, e.g., which elements are at issue and what is known about their health effects, what interests are affected (e.g., corporate, environmental, governmental interests), and how they are affected, as well as by the nature of one's personal stake in them (e.g., whether one's health or job

may be directly affected). It depends, also, as numerous studies have demonstrated, on the extent to which people feel they have control over the possible consequences of such discoveries.

My point, of course, is that trace element discoveries do not simply enter the storehouse of knowledge, to the enlightenment and benefit of all. They often raise more questions than they answer, questions that have often unknown implications for individuals, and more importantly for families and other organizations and institutions. Why "more importantly"? Because families are what people care about most, and organizations and institutions (including governments) define the terms in which the discovery of trace elements are interpreted and acted upon, as they do in virtually all risk-related matters. Anthropologist Mary Douglas observes, "individuals have no other way to make the big decisions except within the scope of institutions they build."[3] Moreover, only organizations and institutions have the power to define the significance of discoveries and to make decisions concerning how they are used and with what consequences. Elaine Draper's research concerning how these matters are handled in the workplace illustrates this point most effectively.[4] Among the most important of the institutions interpreting and acting are science, engineering and medicine, as well as legislative bodies, regulatory agents and agencies, corporations, mass media and public interest groups.

*Trace Element Discovery and Cultural Lag*

Trace element technology and discoveries present us with special cases of cultural lag, a term introduced by my mentor at the University of Chicago, William F. Ogburn, many years ago.[5] He noted that the many elements of culture do not change at the same rates. Of particular relevance, science and technology tend to change more rapidly than do institutions that must adapt to them, institutions such as business and industry, government, education, the family and religion. Adaptation is

3 How Institutions Think (1986).

4 Risky Business: Genetic Testing and Exclusionary Practices in the Hazardous Workplace (1991).

5 Social Change (1922).

not a one-way street, of course, and it is the interdependence of institutions that makes cultural lags important. Note, however, that advances in science and technology, along with economic and national security interests, are especially powerful engines of social change that often require adaptations by other institutions.

Cultural lags lead to social dislocations and to other problems, e.g., when the ability to discover traces of toxic elements outstrips knowledge of their medical or public health significance or when the ability to create new chemicals proceeds more rapidly than knowledge concerning their toxicity. Consider, also, the recency of technologies for the discovery of trace elements, and the vast improvements that have been made in these technologies, compared to the much slower development of knowledge of toxicity and health significance. The National Academy complex of Science, Engineering, Medicine and the National Research Council (NRC) has been much concerned with such matters. A NRC panel concerned with identification and testing of toxic and potentially toxic chemicals reported that "of tens of thousands of commercially important chemicals, only a few have been subjected to extensive toxicity testing and most have scarcely been tested at all."[6] Moreover, of 664 toxicity tests evaluated, only 27% were judged by the panel to be acceptable. A decade later the toxicity of chemicals — and what to do about it — remain among the most controversial issues facing science, medicine, government and public interest groups, as well as business and industry.[7] What to do about recent advances in trace element discovery is at least as significant an issue as are the discoveries themselves.

My colleague Kai Erikson has labeled "toxic emergencies" "a new species of trouble."[8] Why new, and how different? Toxic

6 Pepper Leeper, *Finding the Bad Actors in a World of Chemicals,* 34 News Report National Academy of Sciences 4 (1984).

7 Phillip H. Abelson, *Toxic Terror; Phantom Risks,* 262 Science 407 (1993); Michael D. Green, Letter, 262 Science 638 (1993); BernardWeiss, Letter, 262 Science 638 (1993); David Redfield, 262 Science 638 (1993) (letter).

8 *A New Species of Trouble,* in Communities at Risk: Collective Responses to Technological Hazards 11 (Stephen Robert Couch & J. Stephen Kroll-Smith eds. 1991).

contamination affects the air, the aquifers and the soil on which we are dependent. Some toxic emergencies seem never to end and to be irremediable. They are "not bounded" as most natural disasters such as floods and earthquakes are bounded in time and in space.

Also, toxic contamination often betrays the senses, proving false our sense of security in our ability to see, hear, smell, touch or taste danger. Disasters of all sorts often undermine self confidence in one's ability to protect self and loved ones — witness reactions to recent earthquakes in California. Toxic contamination may be especially pernicious in this regard because, so clearly associated with human agency, it may undermine confidence in institutions that have been erected to protect us from harm. In all of these ways, toxic contamination seems especially threatening to our ability to control danger.

Most toxic discoveries do not, of course, signify immediate danger or emergency. They may, however, contribute to the sense of vulnerability to forces beyond personal, if not beyond human, control. Paradoxically, they may contribute also to distrust of science and technology; even to distrust of logic and reason as ways to explain and control what is going on. And that may be the most fearsome possibility of all — loss of trust in the institutions — including science — that must cope with problems of toxic contamination on behalf of all of us.

### *Lags Among Sciences, Technologies and the Law*

Some cultural lags within science are especially pernicious in matters related to regulation. Among these are the lag between basic knowledge (e.g., concerning carcinogenicity) and the success of technologies such as those that are involved in trace element discovery; lags between discoveries of associations between toxic substances and cancers and knowledge of fundamental mechanisms involved in cancers; and what might be called lags between "production science" and "impact science" — e.g., knowledge about how to produce chemicals and technologies versus knowledge about associated impacts and risks.

These lags are special for a variety of reasons. The spectacular successes of science and the dominance of scientific approaches to economic production and governance in modern societies[9] have resulted in higher expectations and, increasingly, in some circles, cynicism concerning science, scientists and the technologies they spawn. Some of these problems result from governmental decisions, as when regulations require testing on a broad scale, thus giving rise to a host of problems, among them opportunities for fraud and incompetence, testing by technologists with little understanding of the science involved, and further lags as new scientific knowledge supersedes that upon which regulations are based.[10] "Bad science" experience with public and private laboratories in these respects is not encouraging.[11]

Regulation is not the only government-related issue that is affected by cultural lags. Nor is it always the most important. Consider, e.g., issues of funding priorities and levels. Governmental initiatives are, by definition, "political." As a result, science, and scientific effort, are often compromised. Indeed, they may be misdirected, by the best scientific lights; witness "Star Wars" and a variety of domestic front "wars," on cancer, crime and poverty, and NASA's continued pursuit of the space station. I do not suggest, of course, that the scientific community is united in such matters. Among other important science/government issues the role of "expert witnesses" in courts, and judicial policy and practice in both criminal and civil trials also have received a great deal of attention.[12]

Uncertainty is inevitable when basic science is translated into application. Controversy is inevitable when such translations take the form of social policy. Why this is true is hardly a mystery. Uncertainties and large margins of error abound when experimental findings are extrapolated to real world conditions, especially when the

9 Adrian R. Tiemann, *Risk, Technology, and Society,* 7 Risk Anal. 11 (1987).

10 Phillipp H. Abelson, *Incorporation of New Science into Risk Assessment,* 250 Science 1497 (1990); Abelson, *Federal Impediments to Scientific Research,* 251 Science 605(1991).

11 Symposium on Scientific Evidence, 84 J. Crim. Law & Criminology 1 (1993).

12 *Id.*

experiments have been conducted on laboratory animals. Causal inferences from epidemiological data — real world and valuable as they are — are fraught with uncertainty. Uncertainty is compounded when such inferences are translated into social policy, and compounded further still in the course of policy implementation.

Many laypersons misunderstand these uncertainties and are unimpressed by the precision in terms of which risk assessments are expressed. They are more impressed with other issues, and they are more concerned when science and technology are shown to be — or when they appear to be — culpable, as when ethically and morally questionable experiments are revealed, or when technological production processes result in degradation of the environment. Moreover, many are distrustful of the organizations (in government, industry and universities) in which science is carried out and technology is produced — all bearing a heavy charge of responsibility for protecting the public interest.

### *Science and Technology Under Attack*

The lag between basic and applied knowledge is also special because it contributes to current attacks on both science and technology. The underlying theme of Michael Crichton's, **Jurassic Park** — emphasized more in the novel than the motion picture — is that scientists have sold out; that they will do anything to promote themselves, their scientific interests and their economic well being. The motion picture, too, has "antiscience undertones," as Richard Nicholson reminded us in a **Science** editorial.[13] Novelist John Ralston Saul, turned essayist in *The Dictatorship of Reason in the West* (the subtitle of his book), argues that the purity of science, in which neither secrecy nor social interest have a place, has been subverted by application:[14]

> The line between... disinterested work and applied science is theoretically clear. In practice it is confused. Many scientists find themselves on both sides. Once across on the side of application, a whole other set of rules applies. Application involves the interests of race,

13 *Postmodernism,* 261 Science 143 (1993).

14 **Voltaire's Bastards: The Dictatorship of Reason in the West** 301 (1992).

> politics, sex and age, just for a start. Nonscientific choices must be made. Secrecy becomes a tool of the knowledge holder.
>
> It is the confusion over how to deal with crossing the line from theoretical to practical science which so troubles the scientists. If, once across, they surrender all power over knowledge, they quickly find themselves forced by public and private authorities to do things which disturb them for nonscientific reasons. The virtue found in theoretical work is the disinterested purity of the laws of nature. However, human civilization is always "interested" and all the choices surrounding scientific application eventually touch moral questions.

John Polanyi, 1986 chemistry Nobelist, calls Saul's book "a passionate and personal tour of the follies of our age."[15] Polanyi argues that "society, with the aid of scientists, must develop mechanisms of choice which apply common sense, public interest and morality to the development of scientific breakthroughs."[16]

None of these criticisms are unfamiliar to the scientific community. Most are debated regularly in Science and other public media. Of particular relevance to the topic of this paper, the *quality* of scientific work in many areas, particularly of science with broad applications to and implications for the larger society, has been severely criticized, from within as well as from outside the scientific community (see, in addition to almost any issue of Science, many NAS/NRC assessments and exhaustively researched reviews of scientific work in areas such as identification and testing of toxic materials,[17] forensic use of DNA technology[18] and geological disposal of high level nuclear waste.[19]

The judgment of scientists and those who develop and apply technologies based on their work has also come under attack, as have their ethical and moral sensibilities. The principal villain here is not the "mad

15 Frontispiece in the paperback edition (quoting prior statements by reviewers).

16 Paperback edition, at 304 (Saul quoting Polanyi).

17 *See supra* note 6.

18 Committee on DNA Technology in Forensic Science, Forensic Science (1992).

19 Kristin S. Schrader-Frechette, Burying Uncertainty: Risk and the Case Against Geological Disposal of Nuclear Waste (1993).

(or bad) scientist" of fiction, but concern over the *social distribution* of hazards and attendant risks.

*How Fair is Safe Enough?*

Until recently neither risk assessors nor risk managers have paid much attention to the social distribution of health risks or of economic costs and benefits associated with scientific applications. This is changing in the risk analysis community, just as it is changing in the scientific community, as evidenced by the attention given such issues at recent meetings of AAAS and other professional associations. I had sketched the major themes of my paper before the 1994 AAAS preliminary program alerted me to the number of symposia devoted to such topics as "Science, Ethics, & the Law," "Environmental Justice," "Public Perceptions and Scientific Reality in Environmental Risks," as well as "Science Education and Reform," "Communicating Science" and "Science for Everyone" — all eloquent testimony to the ascendancy of "people problems" on the science agenda — and to the importance of cultural lags represented by each of these areas of concern.

But why do these issues command such attention at this time? Probably for many reasons, but let me suggest at least three: First, again, spectacular successes achieved in several scientific and technological areas in recent years, notably in molecular biology, genetics and biotechnology, have raised fundamental issues of ethics, morals and values. Second, problems associated with past scientific and technological activity, chief among which are high- and low-level nuclear waste disposal and clean-up of other toxic wastes, followed closely by a host of other environmental concerns, which appear increasingly to be shared in many nations throughout the world, are seemingly intractable.[20] Both of these are exacerbated by a third problem, past and recent failures of government agencies to perform effectively[21] and by disclosures of radiation releases and experimentation on human populations that were long kept secret.

20 Riley Dunlap, George H. Gallup, Jr. & Alec M. Gallup, *Of Global Concern: Results of the Health of the Planet Survey,* Environment, Nov. 1993, at 7.

21 Lee Clarke, Acceptable Risk? Making Decisions in a Toxic Environment (1988).

These and other instances of scientific dissembling and outright deception, together with sometimes spectacular technological failures, in turn poison public views of science and hamper productive dialogue that might lead to solutions to these sorts of problems.[22]

In a seminal article published in 1987, Steve Rayner and Robin Cantor (anthropologist and economist, respectively) argued that the most "critical question facing societal risk managers is not 'How safe is safe enough?' but 'How fair is safe enough?'"[23] While their exploratory research concerned "the market acceptability of new nuclear-power reactor technologies," research concerning public reactions to other scientifically advanced technologies suggest that their argument may have broader significance. Briefly, they argue that public constituencies worry most about procedures by which consent is obtained for policy decisions, the acceptability of principles used to apportion costs and benefits of such decisions, and whether those who make decisions and manage and regulate technologies are worthy of fiduciary trust.

Issues of fairness lead inevitably to issues of trust. Many of the issues raised by advances in science and technology bear on one or another aspect of trust. Defining trust in terms of "expectations that social actors have of one another in social relationships and social systems," sociologist Bernard Barber delineates three kinds of expectations that involve the most fundamental meanings of trust: 1) expectations of technical competence, 2) expectations that fiduciary obligations will be discharged properly; and 3) the expectation that the "natural and moral social orders" will be preserved.[24]

Surveys of the general public suggest that, compared to most other institutional segments of society (business, labor, Congress, the executive branch of government) scientists have enjoyed, and continue to enjoy, high levels of trust. Public trust is, of course, related to

22 William R. Freudenburg, *Perceived Risk, Real Risk: Social Science and the Art of Probabilistic Risk Assessment,* 242 Science 44 (1988).

23 *How Fair is Safe Enough? The Cultural Approach to Societal Technology Choice,* 7 Risk Anal. 3 (1987).

24 The Logic and Limits of Trust (1983).

demonstrated technical competence. But it is also related to the tradition of the disinterested scientific pursuit of knowledge. Both of these aspects currently are under attack, for a variety of reasons but primarily, it appears, because of the association of science with technologies that produce, or are perceived to produce, hazards to public health and safety, and because of the alliance of science, government and economic production That alliance increasingly includes institutions of higher learning which, for a variety of reasons — chiefly economic — have become more applied in their research programs, with ties to major corporations.[25] The "disinterestedness" (and therefore the fiduciary accountability) of universities thus also become suspect. For many in the general public, advances in molecular biology, and particularly in biotechnology, also are perceived to threaten the preservation of the moral and social orders.

*The Problem of Recreancy*

As knowledge has become more esoteric and specialized, we human beings have become more dependent on specialized knowledge and applications. We have all become dependent on specialists who have command and control over technologies related to specialized knowledge. One result of both types of dependency is that trust in all of its meanings assumes greater significance with respect to a broad range of issues that are clouded with uncertainty and risk.

My colleague, Bill Freudenburg, has recently shown that support for a high level nuclear waste facility is more closely related to trust in the institutions that are charged with building and managing such a facility than are traditional demographic categories (age, race, gender, social class and political ideology).[26] Trust in these institutions is also more closely related to support for such a facility than are even high levels of proposed economic compensation, as economist Howard Kunreuther and his colleagues discovered.[27]

25 Henry Etzkowitz, *Entrepreneurial Scientists and Entrepreneurial Universities in American Academic Science,* 21 Minerva 2(1983).

26 Freudenburg, *Risk and Recreancy: Weber, the Division of Labor, and the Rationality of Risk Perceptions,* 71 Social Forces 909 (1993).

27 Howard Kunreuther et al., *Public Attitudes Toward Siting a High-Level Nuclear*

Freudenburg's analysis is compelling. While his empirical case concerns a different public policy issue than that of primary concern here, his theoretical argument is both more general and pertinent. Briefly, he argues that, because of greater dependency on technical expertise and performance, public evaluations and judgments in risk-related matters are based primarily on whether people trust those with the power and responsibility for making decisions in a socially responsible way. Freudenburg proposes the concept of "recreancy" to denote the failure of institutional actors to carry out responsibilities with the vigor and integrity necessary to warrant the trust that underlies all institutional life. It is these types of failures, and beliefs and suspicions regarding competence, the discharge of fiduciary obligations, and even preservation of the natural and moral orders that underlie many of the people problems now facing the scientific community.[28]

*Perceived Risk, Trust and Democracy*

Psychologist Paul Slovic has argued recently that the most fundamental basis for conflicts and controversies regarding risk management is not public ignorance or irrationality, but rather "our remarkable form of participatory democracy, amplified by powerful technological and social changes that systematically destroy trust".[29] He notes that many studies suggest that "government and industry officials who oversee the management of nuclear power and nonmedical chemicals are not highly trusted."[30]

*Waste Repository in Nevada,* 10 Risk Anal. 469 (1990).

28 Langdon Winner's comments regarding the models used to forecast and assess risks associated with a quite different social policy area (rebuilding the nation's infrastructure, including the "communications superhighway") are consistent with these themes, adding fuel to suspicions and distrust of science and technology, and of scientists and technologists; *see How Technology Reweaves the Fabric of Society,* Chronicle of Higher Education, Aug. 3, 1993 (letter).

29 *Perceived Risk, Trust, and Democracy,* 13 Risk Anal. 675(1993). Sheila Jasanoff also points to the participatory nature of the U.S. system of governance as an important factor in risk-related controversies and policies, Risk Management and Political Culture (1986).

30 *Id. See also* (beyond nuclear power studies), D. B. McCallum et al., Public Knowledge and Perceptions of Chemical Risks in Six Communities (1990); John Graham, Laura Green & Marc Roberts, In Search of Safety: Chemicals and Cancer Risk (1988).

The fragility of trust has long been known. "Trustworthiness" requires a great deal of confirming evidence, while its destruction requires little.[31] Slovic and his colleagues asked college students to indicate which of 45 news events concerning a large nuclear power plant in their community they thought would increase or decrease trust in the management of the facility. Events judged to decrease trust were endorsed by much higher percentages of the students than were those judged to increase trust. For example, 60% rated falsification of records as having a very powerful *trust-decreasing* impact versus the 18% who opted for the single most powerful *trust-increasing* event. Given the exploratory nature of this research one must view the data only as suggestive. Their consistency with other studies adds to their importance, however. Moreover, that single most powerful trust increasing event is most interesting: "An advisory board of local citizens and environmentalists is established to monitor the plant and is given legal authority to shut the plant down if they believe it to be unsafe."[32] Recall my earlier observation that people place a great deal of value on control over risks.[33]

In drawing this paper to a close I note one other suggestive area of analysis. Anthropologist Willett Kempton[34] studied the values underlying lay perspectives on environmental problems. By means of deep ethnographic interviews, Kempton found that respondents often did not understand technical issues related to, e.g., global warming, and they tended to relate concrete, personal experience in defining their concerns (rather than abstract principles or scientific findings). When probed as to the nature of their concerns, however, what they worried

31 Lee Clarke & James Short, *Social Organization and Risk: Some Current Controversies,* 19 Ann. Rev. Sociology 375 (1993); Eugene Rosa & William Freudenburg, *The Historical Development of Public Reactions to Nuclear Power: Implications for Nuclear Waste Policy* in Public Reactions to Nuclear Waste (Dunlap, Kraft & Rosa eds. 1993).

32 *Perceived Risk, Trust, and Democracy,* 13 Risk Anal. 675(1993).

33 *See supra* note 27.

34 *Lay Perspectives on Global Climate Change,* 1 Global Env'l Change: Human & Policy Dimensions 183 (1991).

about most was the effects of environmental degradation on future generations. Surveys conducted by Howard Kunreuther and his colleagues also found that "concern for risks to future generations" was more critical to willingness to support a repository than were proposed compensatory financial packages.[35]

## Conclusion

The concerns of this paper are much broader than trace element discoveries. The fact that I have discussed nuclear-related issues at some length reflects both my own work and the fact that more research has been done on this issue than on any other.[36]

We have been warned against generalizing across biotechnology risk areas[37] and caution surely must be exercised when generalizing across other risk areas. Still, social science research on risk has found enough similarities across a variety of risk areas to warrant a measure of confidence in what has been learned about perceptions, decision making processes and behaviors of individuals and organizations under conditions of risk and uncertainty.

Briefly, and in part only, these studies converge on a set of public concerns regarding risks and uncertainties that are associated with advances in science and technology. Cultural lags are background for these concerns, often exacerbating their problematic nature and leading to further confusion as other institutions adapt, resist, and at times distort the meaning and the significance of scientific discoveries. Unless checked, they are likely to become more problematic and more general across more areas of science. The nature of science, technology and institutions virtually guarantees that this will happen.

Public concerns center — to a greater extent than on issues of narrowly defined self interest — on such issues as the fairness and trustworthiness of institutions (including science), and concern for future generations. People fear what they cannot apprehend and what

35 *See supra* note 27.

36 *See* Public Reactions to Nuclear Waste, *supra* note 30.

37 Henry I. Miller & Douglas Gunary, *Serious Flaws in the Horizontal Approach to Biotechnology Risk,* 262 Science 1500 (1993).

they comprehend as technological failure and the lack of scientific candor. The lament of scientists that "when we are right, no one remembers, but when we are wrong, no one forgets" is in my view misplaced. To err is human, for scientists as well as others. More serious are the lack of candor, secrecy and suspicions that some scientists — even if, objectively, only a few — are willing to "sell out" to promote their own interests, as well as occasional instances of scientific fraud, all of which are more damaging to credibility, legitimacy and trust than is error. These in turn give rise to protest and to demands for control over technological development, demands that are, after all, consistent with democratic governance.

While they are sometimes intemperate and extreme, pronouncements against science may also reflect deep convictions and fears among a broad spectrum of citizens, from the intelligentsia to persons on the street who may not understand either the technical or the philosophical bases for controversy and are too busy coping with everyday problems to be much concerned. Many eminent scientists and policy makers caution against overselling science, while urging greater recognition of its limitations.

The authors of **In Search for Safety**, a product of the Harvard University Scientific Conflict Mapping Project, conclude a chapter on scientific evidence concerning benzene and cancer with a question: "*What institutions and processes can society create to disentangle all the factors that make up 'scientific' results* — and to what extent can one even hope to do so?"[38] In his Foreword to that book, physicist Harvey Brooks writes that its most important conclusion is that regulatory problems result in part from "excessive and unrealistic expectations of science."[39] He continues:[40]

> We tend to exaggerate what we really know through science unless we are challenged by the social consequences of the findings. When the interpretation of

38 *Supra* note 30 (emphasis added).

39 *Supra* note 30, at *viii* (1988).

40 *Id.* (emphasis added).

> scientific findings has large distributional consequences for different groups — health risks for some and economic dislocation for others, for example — we become more aware of the large uncertainties in our knowledge and of the inadequacies of our theories and models... the first instinct of the scientists is to close ranks and produce a consensus that papers over their disagreements and the underlying uncertainties. This course of action is powerfully reinforced by regulators who need seemingly objective information to defend the decisions they must make.... Yet, to the extent that scientists suppress uncertainties, they are in effect arrogating to themselves a political decision for which they are not accountable, since *each choice of information within a wide band of uncertainty creates different winners and losers and hence is inherently political*.... Only if they are completely honest about the extent of their ignorance are they playing a role appropriate to democratic polity.

So, how do we extricate ourselves from this conundrum? And is there any hope? The research reviewed in this paper suggests an even broader mandate than the question raised by the authors of **In Search of Safety**, viz. what James Coleman refers to as "the rational reconstruction of society" by means of the design or the redesign of institutions.[41] By virtue of rapid social change, institutions are continuously being reconstructed, whether by design or by necessity, usually unguided by design. Coleman's argument is complex, and I cannot here do it justice. Briefly, however, it involves creating formal organizations that bring together different stakeholder interests and provide incentives for building the consensus necessary to confront and solve problems. Consensus is achieved by creating formal structures that promote the development of social capital and informally arrived at incentives for problem solving.

Coleman cautions that simply tinkering with existing institutions is not likely to solve many of the problems created by the decline of primordial institutions such as religion and the family. It is not much of a stretch to add other institutions in decline — independent scientific

41 *The Rational Reconstruction of Society,* 58 Am. Sociological Rev. 1 (1993).

investigators, political parties, family farms, and small businesses, all of which continue to occupy important niches in society, but none of which is capable of solving mounting problems such as those that are involved in STS relationships.

If Coleman's proposal sounds a bit like "reinventing government," it certainly has implications for the way governments function. If it sounds utopian, it is nevertheless consistent with research indicating that when those with conflicting interests are brought into decision making on a collaborative basis, they are more likely to work cooperatively toward solutions to problems. Problems such as those being discussed at these meetings do not admit of final solutions — all the more reason to design, construct, and institutionalize organizations that can bring together parties to controversies driven by advances in science and technology, on the one hand, and on the other by broader social concerns. Some existing organizations may provide models for new constructed organizations designed to address science-technology-and society problems — the Office of Technology Assessment comes to mind — and "natural experiments" in problem solving are being attempted in many places. There is hope, and we must get on with the tasks at hand.