
**Science as a
Socially Responsible Community**

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Introduction

As human beings, we continually seek greater knowledge and understanding about ourselves and the world we inhabit. In these efforts, we attribute considerable value to scientific inquiry and accord substantial prestige to scientists. While scientists and engineers no longer bask in the uncritical admiration of an adoring public, people still recognize the enormous power of expert knowledge and the influence that it can have on their lives. All of us still look to scientists and engineers for authoritative answers to complex and serious problems of the day; we continue to depend on them to help us respond to our most pressing human needs. But science and technology, as we are all well aware, are not an unmitigated blessing, and the public is increasingly demanding greater accountability on the part of the scientific community. For some scientists and engineers, it must, with apologies to Dickens, surely seem like "the best of times and the worst of times."

One of the true statesman of science, Alvin Weinberg, has remarked,

Of all the traits which qualify a scientist for citizenship in the republic of science, I would put a sense of responsibility as a scientist at the very top. A scientist can be brilliant, imaginative, clever with his hands, profound, broad, narrow— but he is not much as a scientist unless he is responsible.¹

Apart from those we all share as citizens, specific responsibilities are linked to particular professional activities or relationships. Many of these duties are acknowledged by society through public policy or law and by scientists in codes of conduct. These responsibilities are generally of two types. First are those

internal to science, which require keeping faith with the standards of practice agreed upon by members of the scientific community. The second type of responsibility is aimed outward toward the larger community; these duties are referred to as scientists' social responsibilities.

At least four pillars form the foundation of scientists' social responsibilities. Please note that unless I specify otherwise, when I use the term "science" or "scientist," I am also referring to "engineering" and "engineers."

1. Professional autonomy.

Autonomy is sought by all professional groups because it represents freedom from direction by others; it reinforces one's control over one's work. But autonomy for scientists has never been a one-way street; freedom must be coupled with responsibility. If the larger society perceives the scientific community as rife with corruption, or driven by an excessive zeal for personal gain, or indifferent to the risks posed by research and technology to social values and traditions or to the welfare of humanity and its environment, it will impose stricter mechanisms of accountability. The privileges associated with professional autonomy carry a concomitant responsibility to ensure that scientists share a commitment to the highest standards of ethical practice and the resolve to live up to them.

2. Special expertise.

Society has a need for an independent and reliable scientific voice when making policy decisions with a strong technical component. By virtue of their special knowledge and technical skill, scientists are particularly qualified to point out

opportunities and dangers associated with their work and to offer advice on such matters. Indeed, they are often called on by society to do just that, and they have generally embraced this role with conviction.

3. Impact of science.

Science is not only knowing, it is doing as well. The *conduct* of research can directly affect humans, animals or the environment, and the *application* of science can have profound effects on humanity and lifeboat earth. It is a fundamental principle of morality that we are responsible for the consequences of our actions for others, and scientists cannot escape the implications of this association between responsibility and action in their own work.

4. Public support of science.

Societies invest in the education and training of scientists as well as the conduct of research and the infrastructure essential for sustaining scientific research. Scientists have eagerly embraced, indeed sought, such social support, thereby acquiring responsibility to give something back in return. Given its considerable social investment, society has every right to hold scientists accountable for what they do.

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Scientists' social responsibility is tied to the nature of science and its relationships with others. The notion of science as a "socially responsible community" is not meant to be a substitute for the responsibility that each scientist assumes for his or her actions. Rather, it recognizes that, because of changes in science as well as the context in which science is

practiced, it makes more sense in some cases to speak of a collective responsibility on the part of a scientific community and of efforts to discharge that responsibility at the level of organized science. As one observer of science has noted, "Expectations of social responsibility have been shifted toward collectives of experts, rather than remaining with experts as individuals, and attempts have been made to codify those expectations."²

All of us are immersed in a tangle of relationships, so that what we do in our lives is influenced by our ties to others. We develop relationships with people with whom we share a common purpose. People need ties to a community both to accomplish more and better things than they could achieve by themselves and to help them build a more satisfying and rewarding life.

Communities confer upon their members a sense of identity; they nourish, preserve and reinforce the distinct traditions and values of their members. They respect and foster individual freedom and responsibility, but do so within a framework of group obligation. Group standards are never imposed on individual members but rather emerge out of a conscious collective decision that the community will be better off if those standards are not contingent upon individuals deciding for themselves what is right and wrong.

Science is such a community. Like other professions, scientists are bound together by common aspirations, values and training, and in varying degrees "develop social and moral ties among their members who enter into a community of

[common] purpose."³ It is a community whose members "are distinguished as individuals and as a group by widely shared goals, beliefs about the value of those goals,...about the appropriate means for achieving them, and about the kinds of relations which in general should prevail among themselves, and in many cases between themselves and others."⁴ The group, then, is a major normative influence whose values and standards of appropriate conduct serve as guides by which individual practitioners organize and perform their work and by which outsiders can understand and evaluate their performance. While the professional community "does not produce the next generation biologically, it does socially,"⁵ and over time the character and behavior of individual members can be -- and are -- explained by references to it.

Indeed, to place exclusive emphasis on the individual scientist ignores the importance of social structures in shaping the ethical climate in which scientists work and in influencing their behavior. As citizens, we place our trust not only in individual scientists. We also rely on the group to ensure that its members perform competently and according to high ethical standards. For a timely illustration, I refer you to the recent revelations of research fraud in the National Surgical Adjuvant Breast and Bowel Project managed by researchers at the University of Pittsburgh. In noting what she termed "an ethics lapse" in the study, Congresswoman Olympia Snowe aimed her criticism not at any particular researcher, but rather remarked that it "shatters our confidence in the medical and scientific establishment and clearly undermines our trust in the ability to conduct accurate and fair study trials."⁶

In large part, "We trust professionals because the exercise of professional discretion at the individual level is governed by rules which are prescribed and enforced by the group."⁷ In fact, what gives credence to claims for scientific autonomy is not some lofty sense of the moral rectitude of individual scientists, but rather the self-regulating and communal structure of science. The professional community, as a more visible and enduring entity than any single practitioner, has a collective responsibility that is nondistributive; that is, a responsibility borne by the profession as a whole.

This conceptualization is consistent with both the historical and changing face of science. Traditionally, knowledge has been viewed as a product generated *collectively* by a system that has championed openness and sharing so that the work of any one scientist builds on and is connected to the work of many. In recent years, science has increasingly taken on the character of a large-scale, interdisciplinary, collaborative enterprise, where teams of scientists pool their intellectual and material resources to generate new knowledge. And the problems now challenging science -- such as educational reform, economic competitiveness, sustainable environmental development -- are often so massive, diffuse and complex, that even extraordinary efforts by highly committed individual scientists working separately will rarely be up to the task. What follows next are three examples of challenges facing science for which the social responsibilities of scientists can most effectively, if not only, be discharged as a "community of common purpose."

National Goals and Priorities for Science and Technology

The first example is the increasing demand on scientists to assist the nation in setting national goals and priorities for science and technology. In the past, the scientific community has been reluctant to engage in setting priorities, claiming a lack of reliable methods for comparing and evaluating different scientific fields, but also perhaps fearing that setting priorities would affect their particular share of R&D resources. But today, science faces new challenges, and old assumptions about how to allocate increasingly limited resources are no longer satisfactory.

In an era of restricted budgets, demands for linking science and technology to national goals and to design more precise ways to define and evaluate priorities come from many quarters. For example, the Government Performance and Results Act of 1993 (P.L. 103-62) requires federal agencies to develop strategic plans linked to national goals and to evaluate annual performance in achieving those goals. In November 1993, President Clinton issued Executive Order 12881, which established the National Science and Technology Council, the principal purpose of which is "to establish clear national goals for federal science and technology investments and to ensure that science, space, and technology policies and programs are developed and implemented to effectively contribute to those national goals." And Congressman George Brown has referred to "a research system that arches, bends, and evolves with the society's goals."⁸

Even the scientific establishment has joined the rising chorus of voices calling

for a more rational connection between science and technology and national goals. The Committee on Science, Engineering, and Public Policy -- a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine -- recently issued a report subtitled, "National Goals for a New Era," in which it explicitly "recognized that public support of science and technology is justified by the eventual benefits to humanity. . . [and] society's concern that scientific and technological progress should demonstrably lead to improvements in the quality of life."⁹ A specially constituted Commission on the Future of the National Science Foundation has declared, "In accepting society's support, the scientific community naturally assumes an obligation to be both responsive to national needs voiced by society as well as the intellectual priorities solely initiated by the scientist or engineer."¹⁰

The fact of the matter is that this notion of science in the service of human needs is by no means a new phenomenon. In his 1861 presidential address to the British Association for the Advancement of Science, W. Fairbairn observed, "The history of man. . . shows that he has been chiefly stimulated to the cultivation of science and the development of his inventive powers by the urgent necessity of providing for his wants and securing his safety."¹¹ The contemporary demand that science be socially useful merely reflects this historical reality.

Concomitant with this call for linking science to national goals is an equally strong urging that the scientific community assume more responsibility for setting research priorities that will contribute to

the nation's ability to achieve those goals. A December 1993 editorial in *Science* declared that, "The scientific community needs to debate vigorously the best use of resources. . . . There is a limited research budget and. . . researchers need to set their own priorities or others will do it for them."¹² The U.S. Congressional Office of Technology Assessment has offered its view: "Since progress begets more opportunities for research than can be supported, setting research priorities may be imperative for the success of science in the 1990s."¹³

Consistent with Congressman George Brown's call "to enlist science and technology with a broader and more benevolent perspective in the service of a humane society,"¹⁴ the scientific community needs to embrace a socially responsible role for itself in setting priorities for science and technology to advance national goals. Because of their specialized expertise, scientists are well positioned to contribute to the priority setting process in at least two ways: (1) establishing criteria by which priorities may be ranked, and (2) developing mechanisms for evaluating the performance of science in light of those criteria. Both of these tasks carry with them implications that cut across scientific fields and are unlikely to be successful without the goodwill and commitment of organized science.

Alvin Weinberg's distinction between internal and external criteria continues to frame contemporary science policy discussions.¹⁵ Internal criteria are intrinsic to science and include such considerations as the competence of the researcher and the extent to which the research would

advance knowledge or lead to new discoveries. On such matters, input from the scientific community is essential. Scientists are better positioned than any other community to determine what is possible and feasible scientifically and to assess the degree of difficulty in achieving stated goals.

External criteria arise from broader considerations and are linked to such values as justice and utility. Will the research promote social goals? How readily will it lead to useful applications? What will be its effects on the infrastructure of science? Will it help educate and produce more scientists? Will it create opportunities for underrepresented populations in science to participate in greater numbers? How will it affect the distribution of resources for science among various research institutions? On these matters, scientists can also contribute, but their voice does not necessarily ring louder than that of any other community.

Setting priorities for science and technology and choosing the criteria for doing so are heavily value-laden and consequential. The stakes are high -- for scientist and engineers as well as for the entire country. One should not, therefore, underestimate the importance of establishing reliable and valid criteria that, if constructed properly, can endure the prevailing political winds that will inevitably produce dramatic changes in priorities.

Once decisions are made about the criteria by which science should be judged, there remains the task of evaluating and identifying the most promising research and the scientists with the most potential

for producing high quality work. There are several reasons for evaluating research. One is to determine the degree of congruence between performance and expected outcome, which will enable performers to learn how well they are doing and, if warranted, to adjust their effort. For others, especially those supporting the research, this assessment offers a basis for holding researchers accountable for their work. Both performance and accountability can then be used to make decisions about further support. In principle, it would appear to be advantageous for scientists to support valid and reliable methods of evaluation in order to demonstrate to others that their work deserves support. Any effort to identify national goals and to set priorities will ultimately depend on the availability of accurate data and reliable methods for measuring and evaluating research and technical performance. That is where the scientific community presumably has much to offer.

In considering methods for evaluating scientific research, peer review remains the chief mechanism. Many believe that it has served science and the public well. Peer review reflects the principle that scientific claims be accepted or rejected on the basis of merit, and it accords considerable autonomy to scientists in determining the criteria and procedures for evaluating scientific work. It reinforces the notion that scientists are in the best position to judge such factors as whether a scientific field is ripe for exploitation, whether the work is technically sound, and whether researchers have the requisite credentials to do the research. It governs access to publication, research monies, and professional status, all three of which are

crucial to advancing one's career and to determining the composition of research institutions. In the larger social context, it serves both as "a mechanism of scientific self-regulation that preserves the autonomy of science and as a symbol of professional accountability that insures democratic control of science."¹⁶ In this latter sense, peer review presupposes that scientists are able to reach consensus on the criteria and procedures for evaluating scientific work and that they will apply them honestly and fairly, without regard to personal self-interest. The introduction of peer review thus creates both a need and an opportunity for scientists and engineers to develop a consensus on the criteria to be used in evaluating and validating scientific work, a process that is integral to the emergence of a socially responsible, self-regulating community.

Peer review is not without its shortcomings, however. Some critics argue that the changing scale and organization of science have increased the need to bring values other than merit to bear on the allocation of resources to science, such as equity considerations in the geographical and institutional distribution of funds.¹⁷ Others fault the peer review system for failing to safeguard adequately against conflicts of interest and bias.¹⁸ Some critics have accused the system of bias against women, younger scientists, minorities and liberal arts colleges. Still others lament the lack of accountability in a system shrouded in anonymity, a criticism reflected in a current lawsuit against the National Science Foundation that challenges the agency's practice of not releasing peer reviewers' comments with the identification of the reviewers.¹⁹

Growing recognition of the shortcomings of peer review has led some to call for the use of more precise quantitative bibliometric indicators, which are perceived as less subjective measures for evaluating scientific research. Such indicators are based on the counting of papers and citations in the scientific literature; these quantitative data are then used to evaluate the work of individual scientists, research groups, institutions and even the status of science in entire countries. *Science Citation Index*, created in 1961, forms the basis for an index to the published scientific literature that contains a list of publications that have been cited and the sources of the citation. Other similar indices have been established. "As a result, it is now becoming accepted practice. . . to employ numbers of publications in leading refereed journals as an *indicator* of the scientific production of an institution, while citation counts are used to gauge the overall impact of its research output on the scientific community."²⁰

Bibliometric indicators used for evaluations are basically of two types: those based on publication counts and those based on citation counts. Publication counts are assumed to be an indication of research productivity, but they are only a rough measure. "Mere aggregation of publications is. . . problematic, because, obviously, all publications are not of equal importance and value."²¹

Citation analysis is based on an assumed linkage between two documents, the citing and the cited, and the assumption that all citations have equal value. As with publication counts, such measures are also problematic. For example, different

scientific fields can have different citation requirements, thereby making it difficult to compare the impact and quality of different fields. Nevertheless, a correlation has been demonstrated between citation counts and other performance measures, such as professional awards, peer assessments and Nobel Prizes.²²

Clearly, the data are available, but, as suggested above, it is their interpretation, use and consequences that trigger a cautionary yellow light. A number of concerns merit attention by the scientific community, policy makers and the public before these techniques are fully embraced.

One such concern relates to the meaning of the citation. Interpretation of citations as a measure of quality assumes a relationship between the citing and the cited documents as that of an intellectual debt. But it is not always clear that the citation reflects approval of the original material. Indeed, very little is known about scientists' citation behavior.²³

Citation may have less to do with quality than with the "struggle over credit for the discovery" in a highly competitive field²⁴ or with a "halo effect," whereby authors cite the work of eminent scientists with the hope of increasing the credibility of their own work. The citation count is a measure of the use of a particular document, but not necessary of its value or quality.

Further limitations are imposed by the databases from which the citations are collected. Bibliometric databases are primarily constructed from journal literature; books, conference proceedings and reports are not well represented. The use and value of these different publication media differ across fields, leading some to

question "the validity of using bibliometric techniques in the social sciences, . . . because much research in the field is published in book form. . ." ²⁵ It is also unclear how the increasing use of electronic technology will affect communication patterns among scientists and thereby influence the content, use and interpretation of print databases.

Judgments about the importance, impact and quality of publications also raise concerns. For example, journals apply different standards in accepting or rejecting papers. Citing articles appearing in journals with more or less rigorous standards will mean quite different things. And one must be sensitive to self-citation, not an uncommon practice in scientific publication,²⁶ where scientists tend to build on their earlier work. Furthermore, while citations reflect what scientists believe is currently interesting, they are unlikely to reflect work whose significance has not yet been recognized.

An additional question is whether a citation indicates quality (i.e., some intrinsic merit of the work) or impact (i.e., its immediate, short-term influence on current scientific work). An article may have more impact on the research community because of the visibility of the author or his/her institution than because of its enduring quality.

Finally, we must be concerned with the effects of increasing use of bibliometric indicators on science and scientists. If such indicators are used to judge performance and, hence, determine future support, scientists might be expected to adjust their behavior in order to enhance the appearance of their performance. At

least one commentator has referred to "citation engineering," whereby scientists consciously choose to publish in journals with higher average citation scores.²⁷ Might this approach lead to greater emphasis on short-term studies, with greater opportunities for publication, at the expense of longitudinal and perhaps more valuable research? Will researchers be tempted to engage in fragmented publication, reporting on what is essentially a single study in two or more thinly sliced articles in order to increase the number of publications that can be cited? Such practice, often referred to as "salami science," not only clutters the literature and wastes the resources of the peer review system; it also "debase[s] the value of a scientist's bibliographic record as a measure of his productivity."²⁸ And what impact will these strategies have on "pressures to publish," often cited as a factor that has led scientists to cut ethical corners in their research? Greater emphasis on publication counts and citations is inconsistent with current efforts to focus on the quality rather than quantity of a scientist's publications when awarding government research grants or deciding on academic promotion and tenure.

Because these quantitative indicators are only an indirect measure of research performance, they are perhaps most useful when combined with peer review assessments. Paper counts and citations indicate research productivity, but they do not necessarily reveal much about the productivity of newly created units that have no track record as a unit but may claim to be at the cutting edge of a breakthrough. It is one thing to evaluate past performance; it is quite another matter to predict quality when evaluating

proposed research in support of some determined set of priorities. If decisions are based on citation data alone, mistakes in the allocation of resources can be made, leading the U.S. Office of Technology Assessment to recommend that the evaluation of research investment "be augmented by using ex post review by peer researchers and citation evidence jointly."²⁹

A Multicultural Science

A socially responsible scientific community is one also committed to diversity in its ranks and multicultural perspectives on the window of research and its applications. Deliberations over the value of science and technology in a society such as ours are marked by varied, and often competing, moral positions. Moral judgments are shaped in large part by the moral life of communities; what people are likely to consider morally important is shaped in turn by an ethic actually operative in their lives. In her work on moral development, Carol Gilligan reminds us, "Moral values are human constructions, conventions of thought that inevitably are tied to the conditions in which people live and in which they must act."³⁰ How we judge the value of a particular line of research or the introduction of a new technology depends on the way we see, interpret and evaluate information or events -- that is, our perspective, shaped by the experience and culture of the community in which we live and act. For example, the ethic of science places a high premium on hard data, and scientists have viewed the remains of Native Americans as items to be catalogued, classified and studied. But the ethic of their community drives Native Americans to view those same remains as

sacred links to their ancestors that should be interred with dignity, rather than preserved in research laboratories and museum basements. The differing experience and cultural traditions of the scientific and Native American communities have led to a clash of cultures that has had a profound effect on archaeological and anthropological research.³¹

One way to respond to these challenges is to broaden the pipeline into science and engineering for underrepresented groups and to expand the breadth of resources allocated in support of these communities, whether it be educational scholarships or research dollars. Indeed, there are many efforts, public and private, underway in this country to do just that. But that is not sufficient. What is needed is a parallel effort that defines the scope and nature of scholarship, professional practice and public policy to be more responsive to multicultural perspectives on science and technology. There are, I believe, sound moral, intellectual and pragmatic reasons for doing so.

Morally, racial and ethnic minority populations must be given the opportunity to influence the course of science and technology because of the way they impact on their lives. There is considerable evidence, for example, that certain minority populations are subjected to a disproportionately large exposure of environmental risks to their health, and claims of disparate environmental quality between minority and white communities are supported by numerous studies.³² For racial and ethnic minorities, it appears that, at least until now, the nation's environmental agenda has failed them.

President Clinton acknowledged the reality in his February 11 Executive Order requiring that federal agencies make environmental justice a part of their mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its activities and policies on minority populations.³³

Minorities have also suffered exploitation at the hands of researchers. Many are familiar with the infamous Tuskegee experiment, a study of syphilis beginning in the early 1930s that involved 600 black research subjects. None of the 399 men in the study already affected with syphilis were treated, even after penicillin was discovered to be an effective treatment in the early 1950s. To make matters worse, subjects were unaware of their participation in an experiment.³⁴

To ignore the perspectives attached to race and ethnicity can also lead to poor policies or treatments with a strong scientific component. For example, there is ample evidence that our policies in response to the AIDS epidemic have failed in many instances because they did not take into account the experience and culture of ethnic minority populations.³⁵ Studies have also shown that drugs and vaccines can elicit different responses in people of different ethnic backgrounds. For example, the antidepressant desipramine metabolizes more quickly in Caucasians than in Asians, thus exposing the latter to a possible higher risk of toxicity or other side effects that can materially affect prescribed therapy.³⁶ These differences make it inappropriate and dangerous to generalize findings based on research that has largely excluded

members of minority populations. As a result, whether people of racial or ethnic minority origins are helped, harmed or unaffected by available medical therapies often is not clear. The recent policy decisions by the U.S. Congress and the National Institutes of Health mandating the inclusion of ethnic minorities in clinical trials constitute an admission of past neglect by the research community.³⁷

Intellectually, more inclusive participation in science promises new and valuable sources of insight and creativity. All scientific inquiry requires perspective, for research is not only investigation but also interpretation. As Stephen Jay Gould reminds us, "Science. . . is socially embedded activity. . . . Facts are not pure and unsullied bits of information; culture also influences what we see and how we see it."³⁸ Ideally, a researcher's choice of methods and rigor of analysis, as well as other scientists' scrutiny of findings, should be dispassionate and free of cultural influences. But in reality, it often does matter whose values are considered, whose voices are heard and whose research agenda is endorsed. To the extent that the perspectives of minority populations are excluded from the work of the scientific community, then science will produce knowledge that risks being divorced from the realities faced by a growing part of this country's population. Greater diversity can reveal insights undetected by the prevailing paradigms or orthodox approaches and can help correct for distortions in earlier interpretations and understanding in science. By listening more diligently to what such perspectives can tell them, scientists may discover new ways of thinking about, looking at or solving problems.

To move toward a multicultural science and technology, we must not only train more minorities as scientists and engineers, but we also must support more research on the distinct problems experienced by minorities. We need to give minority scientists and engineers the resources needed to challenge well-entrenched assumptions and to develop alternative perspectives on research findings or proposed policies. Scientists must broaden their "community of common purpose" by ensuring that minority colleagues participate in academic, professional and policy discussions on science and technology. They must have greater access to the professional and social benefits that come from careers in research, including more service as journal editors and on scientific review panels. Such participation can empower minority scientists by reinforcing their belief that they are doing important work and by strengthening their sense of personal and professional identity in a world where they are constantly challenged to prove themselves worthy. It can also enrich the ways in which science is defined, practiced and applied so that the values of science are more closely aligned with the values of a multicultural society.

Scientific Literacy and Public Understanding of Science

The final matter that I will discuss is the responsibility of the scientific community to increase scientific literacy among the citizenry and improve the public's understanding of science. We are all familiar with the surveys that show dismally low rates of scientific literacy among the American population. We all need to be genuinely concerned when less than half of the adults in the United States

believe in the evolutionary descent of humans from earlier species; when fewer than half know that the earth travels around the sun once a year; when only 20 percent of Americans are able to link DNA to genetic inheritance; and when only 15 percent of Americans appear to have a basic understanding of how science works.³⁹ We need to worry when students consider a "catalyst" to be an alphabetized directory of cats, or when they believe that "nuclear methods of dating" refers to a dating service for single nuclear engineers!

Ignorance, misunderstanding and misinformation are no friends of science and technology. They can lead to unfounded and exaggerated fears about the impact of research or to inflated expectations of contributions, either of which can threaten public confidence in and support for science. Perhaps the best long-term solution to increasing scientific literacy and improving the public's understanding of science is more effective science education in the pre-college and college years. If an interest in science and an appreciation for how it works can be instilled early in life, then people will be much more receptive and understanding of scientific communication. Several ongoing private and public sector efforts on the part of organized science point in this direction, including Project 2061 at AAAS. But the scientific community can and should do much more that can have a more immediate impact.

An essential component of the accountability of science is to explain to the society that supports it the nature and significance of science. In 1960, a specially appointed Committee on Science and the Promotion of Human Welfare of

the AAAS urged that the "scientific community ought to assume, on its own initiative, an *independent* and *active* information role" in its relationship with the public.⁴⁰ Specifically, it adopted the position that in

providing citizens with the knowledge required to make informed decisions on science related public issues, the scientist and his organizations have both a unique competence and a special responsibility. As the producer and custodian of scientific knowledge the scientific community has the obligation to impart such knowledge to the public.⁴¹

"A citizenry thus informed," continued the Committee, "is, we believe, the chief assurance that science will be devoted to the promotion of human welfare."⁴²

Almost thirty years later, a special Committee of the National Academy of Sciences elevated the role of the scientific community in educating the public to the level of a "fundamental responsibility."⁴³

This responsibility has many components. It includes providing essential technical details and advice when needed to evaluate research or emerging technology; undertaking efforts to counter misrepresentations by colleagues or others who communicate science to the public; disclosing one's own biases in reporting research; engaging in empirical research related to the public's understanding of science and to the communication patterns and strategies used by science; alerting the public to the potential consequences of research and its applications, including the level of uncertainty associated with such projections -- and it includes conveying the challenges and wonders of doing science. The rewards for fulfilling these responsibilities are considerable, both for science and for the larger society. It

should produce decisions and policies less likely to be influenced by exaggerated fears or overblown expectations; it should increase public trust in science; and it should make science and engineering more attractive career choices. Public criticism of science will not end; nor should it. But it should lead to more informed debate on the issues that concern us all.

Efforts to increase the public's scientific literacy and understanding are not likely to achieve very much if handled in an ad hoc manner by a few highly articulate popularizers of science. Rather, organized science must commit resources to these efforts and must be willing to establish standards on matters ranging from the reporting of scientific findings to the reform of science education.

Conclusion

We have come a long way since Michael Polanyi's 1962 ringing declaration that "Any attempt at guiding scientific research toward a purpose other than its

own is an attempt to deflect it from the advancement of science."⁴⁴ We no longer shy away from a view of science as a socially embedded activity in which organized science engages in negotiations with the larger society over the boundaries of scientific freedom and responsibility. The conceptualization of science as a "community of common purpose" enables scientists to think beyond the self-interests of any particular practitioner and to articulate a professional ethic that reflects the group's collective conscience and responsibilities. Those responsibilities must constantly be redefined in light of the nature of science and its relationships with others. I have described three such responsibilities; no doubt, others could add to the list. The length of the list is not important, however. What is important is that the scientific community organize itself in a way that will enable it to apply its collective intellectual and material resources to the problems of the day, and in doing so, serve the interests of both science and its patrons.

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