Reflections on Current Issues in Science and Technology

Anna J. Harrison

It has been the custom for *Science* to publish at this season of the year a biography of the incoming president-elect of AAAS. I have bargained instead with the Editor to use this space to explore with you some of my interests and prejudices, hopes and fears, related to science, technology, scientists, society and, of course, AAAS. The only biographical information that is of significance to you is that I am a physical chemist by training with a modest track record in research and long experience in a liberal arts college that takes science, research, and the development of its students seriously and that I have served the larger community of scientists and society as a member of the National Science Board, 1972–1978, and president of the American Chemical Society, 1978.

Through cooperation with its approximately 300 affiliated societies, AAAS has unique potential to serve an integrative function in issues of general interest and concern to the scientific community. The focus here shall be primarily on some of those general issues: the integrity of science, the impact of science and technology on society, the impact of society on science and technology, the culture of a realistic environment for science and technology, the participation of scientists and scientific societies in public decisions, and the culture of scientific manpower. It is not important whether you agree or disagree with my perceptions. It is important that we seek to understand our profession in its current context and to take actions with due regard to the future.

Surely all of those who read *Science* understand the integrity of science and are diligent in their efforts to ensure it is not violated. However, observations of what we do and what we say suggest that we are not acutely aware that science is two things, process and the body of knowledge generated by that process, and we may not appreciate that to understand the integrity of process is to understand the integrity of the body of knowledge generated.

By process, I mean all of those things that are involved in the design of experiments or programs of observations, the execution of these experiments or programs, the processing of information and assessment of the validity of results including models that may have been generated. What are the assumptions on which the work is based? What are the assumptions and approximations introduced in the generation of models? Scientific studies have been extended to more and more complex systems using more and more complex methodologies, higher and higher levels of sophisticated instrumentation, and more and more prepackaged computer programs. We have continuously expanded our capabilities and productivity and, in so doing, we have compounded the problems associated with the assessment of the validity of the product. By process, I also include the scrutiny, testing, and revision to which scientific knowledge is continuously subject.

It is generally accepted that the free exchange of scientific know-how and scientific knowledge is a basic tenet of the scientific community. At the same time, it is well known that an individual may create barriers to retard the flow of information within an institution, that an institution may create barriers to inhibit the flow of information to other institutions, and that a nation may regulate the exchange of information with another nation. Herein lie very thorny issues, the resolution of which has a great deal to do with the environment in which the scientific community proceeds. Actions to restrict flow of information reflect the perceived short-term advantage of proprietary scientific know-how and knowledge but discount our mutual dependency and the long-term benefits of the free exchange of scientific knowledge. The long-term costs of mistrust and stagnation are significant indeed. Three types of situations that justify careful consideration are the relation of national security considerations to the free exchange of scientific information with Soviet scientists, the relation of the proprietary interests of industry to the free flow of information within and from academic laboratories, and the impact of the practices of individual scientists upon their colleagues and students.

If we are to understand the environment in which we work, we must understand the impact of science and technology on our intellectual perception of life and the world about us, on the quality of life, and on the quality of the environment in which we live. Undoubtedly, the greatest impact of science and technology is on the first. I suspect that those magnificent photographs of Earth from space brought about an irreversible change in our perception of our planet and its resources and this changed perception broadened and intensified the environmental protection movement.

I suggest three premises:

1) every technological innovation, regardless of how great its positive impact on society, also has a negative impact on society,

2) the benefits and the negative impacts may be experienced by different subsets of society, and

3) the benefits and the negative impacts may be experienced in different time frames.

The term "benefit/risk analysis" is consistent with the first premise, and historians tell me that this sweet/bitter consequence of technological innovation is a characteristic of all social, economic, and political change. Some of the long-term consequences of technological innovations can be surprising. Spectacular advances in medical technology have enabled us and our descendants to live longer: two consequences are the escalation in the rate of consumption of resources and the escalation in pollution. We must be alert to the total consequences, both positive and negative, both short-term and long-term, and be willing to seek courses of actions to minimize and more equably distribute the negative consequences of technological innovations.

In a democratic society, it is the public, through its surrogates, that has the right and responsibility to make decisions in matters concerning the quality of life and the quality of the environment. Such decisions involve value judgments. Many other value judgments, internal to industry, determine the course of innovations. There has been some tendency to believe that if we all understood the

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science involved, we would all make the same decisions concerning the use of science and technology. This is, of course, not true as has been amply demonstrated in regard to the use of nuclear power technology. Equally informed individuals may make entirely different value judgments and take quite different positions in regard to a particular technology. Science education clarifies technical matters but it is not a route to unanimity in decisions involving value judgments.

If we are to understand the environment in which we work, we must also understand the impact of society on science and technology. It is evident that

1) the direction and the rate of extension of scientific knowledge are to a large degree determined by social, economic, and political factors, and

2) the direction and the rate of development of technology are to a large degree determined by social, economic, and political factors.

The allocation of public monies to the support of basic research is an act of faith that the research results will, on balance, enhance our national image, lead to the development of goods and services essential to the public welfare or at least to the benefit of some influential subset of society, or expand our intellectual perception of ourselves and all that surrounds us.

The allocation of funds among the various disciplines and within the disciplines is very significant in the determination of both the direction and the rate of extension of knowledge. Herein lie thorny issues. If the scientific community cannot or will not provide the leadership in establishing relative priorities, congressional committees and private foundations will, by default, set priorities among the competing interests with probable long-term disadvantage to all. We must plan for new thrusts and the development of promising innovations. Inequities are highly probable. Some disciplines are more skilled than others in presenting a united front, and funding for some disciplines is much more strongly challenged than for others by individuals who may minimize the potential of those disciplines to contribute to the public good and may, to some degree, fear the extension of knowledge in some areas.

The characteristics of the marketplace, patent laws, tax structures, tariff barriers, and a host of regulations are manifestations of the social, economic, and political forces that shape the development and productivity of technology and the research supported by industry.

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I am convinced that a realistic environment for science and technology is essential for the welfare of the nation and that the entire scientific community should devote its best efforts to the culture of such an environment. I propose that the basic elements for a realistic environment are:

1) the public understanding of the powers and limitations of science and scientists,

2) the public understanding of the powers and limitations of technology and technologists, and

3) the public understanding of the processes involved in making public decisions concerning science and technology.

The word public is used here to encompass all of those who have the right to influence public opinion and participate in political processes. This, of course, encompasses the scientific community.

It is my impression that some time in the past, either the scientific community oversold or the public overbought science and technology. There are questions that science cannot address and things that science and technology cannot accomplish. We cannot guarantee a zero-level concentration, produce a riskless technological option, or solve societal problems. We can alleviate a societal problem such as waste management by recycling, conversion to less toxic or more manageable materials, and designing containment facilities and special-purpose incinerators, but it is the public, through its surrogates, that makes the social and political decisions.

I believe that to understand the integrity of the process of science and the integrity of the body of knowledge that the process generates is very close to understanding the powers and limitations of science and scientists. I am delighted to see that an increasing number of TV science specials focus on process and suggest that we should rethink the goals of science education, particularly science education at the precollege level. It is my experience that individuals who have some concept of process can absorb new knowledge without great difficulty but that individuals who have no concept of process have great difficulty absorbing new knowledge and are incapable of being rationally critical of positions presented as having scientific validity. It is quite possible that those who have had experience with science and those who have not perceive our world quite differently and that this difference in perception is greater than we realize.

The American public knows remarkably little about technology and the steps involved in technological innovation. There are a few instances in which the mass media have indicated a potential to rectify this; there are also groups endeavoring to define goals and develop mechanisms to introduce technology into the precollege educational system and the liberal arts components of college and university curricula. All of these will require time to make a significant contribution. To me, the first step in the culture of a realistic environment for technology is to recognize that each technological innovation has the potential to have both positive and negative impacts on society and then get on with the public discussion of whether the total benefits justify the total risks. Total impacts encompass a wide range of social, economic, and political changes the consequences of which are extremely difficult or impossible to evaluate quantitatively with confidence.

If value judgments concerning the impact of science and technology on the quality of life and the quality of the environment and the consequent decisions are the prerogative of the public, what is the role of scientists and professional societies? This is another thorny question to be addressed by each scientist and each professional society. In most areas, I am quite clear on my own position. First and foremost, a scientist is an individual and has the same responsibilities and privileges as any other individual. This includes the right, as an individual, to espouse values and join others in political action.

Scientists, either individually or collectively, as scientists have the responsibility to provide technical expertise based upon training and experience and to endeavor to provide that expertise in a manner comprehensible to those who need the information. In the role of experts, scientists do not have the right to make a value judgment and then selectively present scientific information to support that value position. To do so is to negate the integrity of science.

Two types of situations are particularly troublesome. In one, rational decisions require technical information that is not available and cannot be generated through validated studies in the time available: in the other, scientists are asked to propose courses of action to solve societal problems. Both go beyond the technical expertise and, in some cases, way beyond the level of maturity of the science.

There are two choices. One is to refuse to go beyond technical competence and the other is to provide what I call informed judgment, an opinion based upon related knowledge and experience. The first is to deny the public the benefit of informed judgment, the second may jeopardize personal creditability and possibly the creditability of the discipline. In both, the scientist has responded to a request to go beyond his or her level of expertise, and the difference between opinion and knowledge must be established in the response.

The culture of scientific manpower is fundamental to everything we do. The term is being used here in a very comprehensive sense to include the entire professional life-span of scientists as well as the recruitment and early development of scientists, but space is limited and I shall simply propose that

1) current science education distorts the recruitment and development of scientists,

2) the current reward system within the profession distorts the distribution of scientific talent within the profession,

3) and both distortions are to the detriment of the scientific community and the public's well-being.

If academic education provides the environment that enables a student to accomplish something, then we must rethink what it is students should be enabled to do. I nominate for the top of the priority list "discover the integrity of science."

In conclusion, attention is called to some of the more visible AAAS activities related to issues touched on above: the annual review, in collaboration with a number of affiliated societies, of the federal budget for research and development, the consortium of affiliated societies involved in international programs, the activities of the committee on scientific freedom and responsibility, the publication of *Science 82* for the reading public, and the recent AAAS long-term commitment to the improvement of science education.

1981 Annual Report of the Executive Officer

William D. Carey

In 1981, despite deepening recession and a wholesale reorientation of government's budget policies, the AAAS had a positive and upbeat year. Membership continued to grow. Federal budget cutbacks had little direct impact on the Association due to our planned low exposure. Both *Science* and *Science 81* turned in strong performances. The Annual Meeting in Toronto and the June R & D Policy Colloquium were lively and well attended. AAAS's cooperative ventures with our affiliated societies grew in effectiveness. The three regional divisions demonstrated vitality and utility. Uncompensated volunteer work by members was again given generously in every facet of the Association's activities. And at the year's end the financial position of AAAS was sound.

The success achieved by *Science 81* in its second year as a publication of the AAAS has been striking. Its circulation grew from 500,000 to 700,000 giving it the largest U.S. distribution of any science magazine except *Popular Science*. In addition, about 100,000 copies per issue are distributed overseas in English and Italian editions, and other foreign language versions may follow. Subscribers are renewing at an exceptionally high rate for a new magazine. *Science 81* received three national awards for science writing and 11 for design and illustration in 1981. Thus, a major publishing venture has turned out well, for which its editors and staff deserve full credit. With a probable gross readership of 2.5 million, supplemented by radio broadcasts over eight stations, *Science 81* (now *Science 82*) represents a very substantial input to better public understanding of science and technology.

However reassuring may be the state of the AAAS, 1981 was a troubled year for the advancement of science in other respects. Adverse government decisions dealt serious blows to public investment in science education, the social sciences, international scientific and cultural cooperation, space exploration, energy conservation, and environmental protection. A new danger to the quality of science teaching in the public schools took the form of aggressive efforts to force "creationist science" into science classrooms. And within government, concerns for national security and trade protection rekindled pressures for constraints on scientific exchanges and the unclassified scientific literature. AAAS has not hesitated to take strong policy positions in opposition to these developments.

Three matters of internal business require brief mention. First, members are aware that suits in libel have been brought against the AAAS for material that appeared in the News and Comment section of *Science*. One suit was settled out of court. Two others are pending and will be stoutly defended if they reach the trial stage. It should not be supposed that our century-old journal has acquired a belated penchant for the sensational, nor that it has grown careless. Rather, the era of litigiousness has caught up with science journalism and will make the work of able science writers more difficult.

My next point concerns our annual