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ABSTRACT

Descriptions are included to illustrate the workshop objectives, participants, agenda, and sessions. The five sessions were concerned with the following aspects: (1) "Why Public Understanding of Science at All?" (2) "What Publics Should Understand What Science, for What Reasons?" (3) "The Experiences (including problems) of Science Communicators;" and (4) "What are the Most Important Research Questions Which Could Guide Public Understanding of Science Activities?" Five papers distributed to participants prior to the conference are included in appendices with headings: Publ c Understanding of Science: The Data We Have; Problems, Publics, and Stages of Development in Public Understanding of Science; Why Should the Public "Understand" Science? Public Understanding of Science: the Problems and the Players; and The Obstinate Audience. Also contained is an agenda of the conference. (CC)

MATERIALS RESEARCH LABORATORY

FINAL REPORT

Workshop on

GOALS AND METHODS OF ASSESSING THE PUBLIC'S UNDERSTANDING OF SCIENCE

November 29 and 30, 1972

Palo Alto, California

The National Science Foundation
Grant No. GM35058

Final Report

on

Workshop on "Goals and Methods of Assessing the Public's Understanding of Science"

November 29 and 30, 1972

Palo Alto, California

to

The National Science Foundation

(NSF Grant No. GM35058)

by

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January 26, 1973

Workshop on

"Goals and Methods of Assessing the Public's Understanding of Science"

Locale, Participants, Agenda

As an aid to formulating various NSF programs of research in the area of public understanding of science, the subject workshop was held in late November, 1972, at Rickeys Hyatt House, Palo Alto, California. The conference was supported by the Office of Government and Public Programs of the National Science Foundation, was organized by G. Ray Funkhouser, Rustum Roy, and Ernest M. Hawk of The Pennsylvania State University, and was chaired by E. G. Sherburne, Jr., Director of Science Service. This same group together with R. E. Stephens was responsible for planning the agenda and selecting participants.

The participants were selected to represent their respective specialities: working scientists, professionals engaged in communicating science to the public and communication researchers. They were:

James Butler, Director of Communication Programs on the Public Understanding of Science, AAAS

G. Ray Funkhouser, Assistant Professor of Communication Research, The Pennsylvania State University

Ernest M. Hawk, Research Assistant, The Pennsylvania State University

Eric Kay, Director of the Materials Science Laboratory, I.B.M.

Philip Klass, Associate Professor of English, The Pennsylvania State University and science fiction writer "William Tenn"

Hillier Krieghbaum, Professor of Journalism, New York University

Margaret MacVicar, Associate Professor of Physics, M.I.T.

Harold Mendelsohn, Chairman, Department of Mass Communications, University of Denver

Frank Oppenheimer, Director, "The Exploratorium," San Francisco, California

David Perlman, Science Editor, San Francisco Chronicle

John Platt, Assoc. Director, Mental Health Research Institute, U. of Michigan

David Popoff, Board of Editors, Scientific American

David Prowitt, TV producer, N.E.T.

Walter O. Roberts, Director, University Corporation for Atmospheric Research

Rustum Roy, Director, Materials Research Laboratory, The Pennsylvania State University

Wilbur Schramm, Director, Institute for Communication Research, Stanford University

E. G. Sherburne, Jr., Director, Science Service

Richard Stephens, Program Manager, Public Understanding of Science, N.S.F.

James W. Swinehart, Associate Professor, School of Public Health, University of Michigan

Phillip J. Tichenor, Professor of Journalism and Mass Communication, University of Minnesota

Serena E. Wade, Associate Professor of Communication, California State University, San Jose

Charles Weiner, History of Physics, American Institute of Physics

Robert Wilcox, Dean, Graduate School of Public Affairs, University of Colorado

The program for the two days is included in the appendix.

Pre-Conference Preparation

Prior to the conference, four papers were prepared and distributed in order to provide all participants with some common background on the problem area. The complete texts are appended to this report, and the principal themes of each paper are abstracted below.

"Public Understanding of Science: the Data We Have," is a research review by G. R. Funkhouser. It summarizes empirical research to date regarding public knowledge and attitudes toward science, and also describes existing research on the process of communicating science to the public. Additionally, since a number of different publics are included in the sphere of "public understanding of science," the paper describes important demographic differences between the general public and other publics such as scientists, intellectual elites and concerned citizens.

E. G. Sherburne's paper, "Problems, Publics and Stages of Development in Public Understanding of Science," develops a model of public problem solving involving six developmental stages: Preparatory, Problem Definition, Solution Formulation, Decision-Making, Implementation and Evaluation. He goes on to hypothesize that in each stage there are varying degrees of involvement of five different publics -- the Leadership Public, the Communications Public, the Interested Public, the General Public and the Young Public.

Rustum Roy's paper, "Why Should the Public Understand Science?" develops the thesis that American citizens are "tourists" in their own culture -- that they can cope with it, but have no true familiarity with or feeling for the scientific and technological aspects which are coming to dominate it. Unlike other aspects of culture (philosophy, art, etc.) there is a real and growing need for increased programming of the public's understanding of science, since it is new and expanding rapidly. Further, because of its newness, it has not had time to be incorporated into the myriad other ways by which a society gets its citizens 'on board' in important facets of culture.

"Public Understanding of Science: the Problem and the Players" is a review by R. E. Stephens of current programmatic efforts in public understanding of science. In addition to projects being supported by the National Science Foundation, he describes efforts by such groups as the Department of Agriculture (extension agents), NASA, AEC, EPA, the Ford, Markle and Russell Sage Foundations, the AAAS, the AIP, the ACS, the IEEE, the AIAA (American Institute of Aeronautics and Astronautics) and SIPI (Scientists Institute for Public Information).

In addition to the above, a copy of the "The Obstinate Audience" by Raymond Bauer was included in the pre-workshop materials. Originally published in The American Psychologist, this article is an overview of the possibilities of achieving societal changes via communication. A tentative list of research questions and a supplementary bibliography on the topic of public understanding of science rounded out the pre-conference package.

Content of Sessions

The workshop was conducted in five sessions, following (somewhat flexibly) the set agenda. Given the diversity of the participants and the goals of the workshop, no attempt was made to develop any consensus except in the area of the priorities for needed research. Rather, as wide a range as possible of ideas and opinions were solicited by the chairman. No attempt was made to define "science," nor to differentiate it from "technology," on the grounds that no such distinction is made by the general public, which, taken as a group, has a broad, loosely defined conception of "science." Also, the decision was made not to discuss the role of secondary schools in public understanding of science, since this is a topic which receives the continuing attention of very large organizational units, as well as being the topic of periodic conferences. It was noted, however, that the products of the secondary school system become the target audience for all later science understanding efforts, and hence changes in their characteristics are important.

The following reports on the individual sessions reflect these strategies, and hence contain what may seem occasionally to be contradictory information or a lack of sharp focus or central theme. Rather than shaping the proceedings of the sessions into coherent packages, an effort has been made to treat them in rapporteur fashion, as a means of re-creating the environment out of which the proposals for research emerged.

Session 1: "Why Public Understanding of Science at All?"

Although this topic appears rather philosophical, the organizers reasoned that it is generally neglected in discussions of public understanding since people usually want to move quickly to the "real action." In fact, this sentiment was voiced more than once during the workshop also. A number of reasons were offered as to why the public should understand science. One group of concerns reflected the feeling that the public is out of touch with the culture in which it lives (of which science is a pervasive and important component) due to its lack of understanding of science and technology. Possibly this disharmony has even reached the point of being a disaffection with not only science but with intellectual pursuits in general. More public understanding of science could help correct this and possibly enable more citizens to appreciate the philosophical and aesthetic qualities of the scientific enterprise and their relation to societal, national, and human goals.

It is easily demonstrable that in the political sphere, more and more decisions are being made which involve technical considerations, and thus it would be well if the general public were better informed, if for no other reason than that our political system places a high value on "an informed citizenry." Also, since a significant fraction (about 6%) of the Federal budget is allotted to research and development of one sort of another (a large part of this money appears under defense and space), the public has a right to know in more detail how its money is being spent. Possibly, a public with a better understanding of science _might_ be inclined to allocate more of its taxes to scientific research and development towards nationally approved goals.

From the point of view of industry, the public needs to understand science and technology better to help it to buy and use products involving new technologies wisely. Also, as more and more jobs demand technical skills and understanding, better public understanding of science would contribute to a labor force more suited to the demands of modern industry.

Instrumentally, the public needs science information as a tool in their lives, for making decisions regarding consumer products, medicine and political issues (especially, in recent years, involving ecology). There may be some anomalies and irrational aspects in the way that "Middle America" views science. For example, it may connect the rise of science in the past few decades with a concurrent deterioration in the quality of their lives, a notion which might be mitigated by a better understanding of science. In the extreme case, the public might have to be able to understand science and technology simply in order to survive in a hostile environment.

Finally, there are institutions such as the AAAS and the NSF which take as part of their missions keeping the public informed on developments in modern science, both the results and the enterprise itself, both the good and the bad aspects. False images of science held by the public ought to be corrected, falsely negative impressions as well as falsely high expectations.

Some points were raised, however, in disagreement with the above reasons for communicating a better understanding of science to the public. The point was made that the notion that better public understanding of science would lead to more positive feelings was an untested assumption -- that dismay, rather than satisfaction, might be the outcome of the public's learning more about the modern scientific enterprise. It was also suggested that no public has ever understood science as well as does the U.S citizenry of today, and that this knowledge, rather than ignorance, might be responsible for current public disaffections. Both these assumptions were challenged, however, because currently available (but highly limited) research evidence tends to indicate that the public has relatively positive feelings toward science and scientists with little evidence but impressions and anecdotes to demonstrate any kind of broad public disaffection with science or its correlation with increased understanding.

It was further suggested that, in the short run, the average citizen really doesn't have to understand science and technology very well in order to get by in his daily life, and probably not in the realm of policy decisions either. Also, it was noted that too zealous an effort at increasing the public understanding might be perceived as a "public relations job," and have a "boomerang effect" of decreasing the public's regard for science and scientists.

Session 2: "What Publics Should Understand What Science, for What Reasons?"

In an attempt to describe the components of what may be held to constitute the "science" which should be communicated, a list was compiled of different aspects of "science" which together would be a fair representation of science.

This list included the following, which were not ranked in any way in the discussion itself, (the grouping was done during the write-up phase).

A. Content of Science

1. The great generalizations of science -- existing theory.
2. Awareness of the changing nature of the scientific enterprise.
3. Harmony of science with the total cultural environment.

B. Nature of Science

4. The viewpoints inherent in science.

5. How science works.
6. The beauty, elegance and aesthetic qualities of science.
7. How real scientists function.

C. Impact of Science on Individuals and Society

8. Threats and promises of science.
9. The impact of science on nature and on our lives.
10. The applicability of science to the audience itself.

Following the chairman's presentation as outlined in his paper, several specific audiences or "publics" were delineated and discussed, and an effort was made to relate each public to those aspects of science which it needs most urgently. The general public, it was suggested, should: (1) be told scientists are human, (2) be made aware of the unavoidable responsibilities of science, (3) be given a framework for understanding nature, not just isolated facts, and (4) be given a reasonable introduction to science so as, especially, to clear away myths and bogeymen. It was noted that public interest and knowledge often seemed to be tied to events -- Sputnik, Eisenhower's heart attack, moon walks, etc.; and the question was posed as to whether a "crisis approach" to public understanding of science might be misguided -- that a broader, longer-range perspective might be a better idea. A recurring theme which started here was that any program should try to provide at least that science which the public itself felt it needed, hence we ought to find out from the public what it wants to know.

The young public was considered to be important, since it is apparently during the developmental years that interest in, and appreciation of, science is engendered. Of all the publics, children and adolescents are the only ones to which basic science can be conveyed very well, or in which the ability to learn in later life can be fostered. The opinion was expressed that recent developments in science curricula have been directed too much toward future scientists and too little toward future citizens, with two possible outcomes: (1) a much greater sophistication among the top science students, and (2) a diminishing of the fun, the interest and the wonder of science among the average students. The possibility that we have too high an expectation of what schools can accomplish was, however, also raised.

It was felt that the leadership segment of the public, which makes policy decisions, definitely needs to be informed on content and implications with regard to the scientific components of the decisions they are concerned with. The communication segment of the public -- that is, editors, publishers, reporters, writers, producers, managers, etc., in the information dissemination business -- was felt to be important, since it controls to a great extent the flow of information to the public. Their needs included the concept of a continuing science information resource and possible teaming up with technical people. The "intellectual elite" have a significant hand in the selection of important political and social issues, and on the directions and style in which these issues are discussed. This particular segment is highly educated, very articulate, politically leftish and humanities-oriented; and their opinions may be the source of most of the currently perceived "public disaffection with science." But they tend not to be very familiar with science, nor are they representative of, or in touch with, the general public. Their need is for a much more thorough understanding of the philosophy, content, and methodology of science, at least remotely commensurate with their intellectual attainments in other areas. However, their antipathy to science and technology appears to be deeply ingrained and possibly difficult to modify.

The interested public was seen as a segment that is relatively well educated and already interested in science and technology at a layman's level. This segment, it was thought, would appreciate more information, more written and broadcast material about science and more general conclusions. It was suggested that the current treatments of science in newspapers and television are really aimed primarily at this "interested public," rather than at the general public, which is at least 10 times as large.

Scientists themselves were seen as another public -- relatively small, but very important in this context. In addition to finding out from scientists what they think should be communicated to the public, and what they think about science (as an additional basis for determining what picture of science to present and also as a gauge against which to measure the public's notions), it was suggested that perhaps some understanding of the nature, numbers and education of the general public should be communicated to scientists (various spokesmen of the scientific community have, in the context of public understanding of science, evinced an understanding of the average citizen which is, to put it mildly, highly imperfect).

One participant suggested as a general rule "tell people what they want to know, or what you want to teach them, but never what you think they ought to know." This is in line with another point brought out, that people don't usually pay attention to a message unless there is something in it for them -- whether it be a material, instrumental, emotional, intellectual or aesthetic gratification. What special interest parties feel they "ought to know for their own good" rarely supplies such gratifications. On the other hand, the history of public education establishes that a certain fraction learns even that which it may not originally have wanted to know. However, the schools enjoy a captive audience, while the public information media do not.

Session 3: "The Experiences (including problems) of Science Communicators"

The workshop included several participants professionally involved in communicating science to the public via newspapers, television, magazines, museums and science fiction. While one cannot assume that the views of our participants represent statistically the views of all their colleagues, they all are eminent and experienced in their respective areas, and their experiences, successes and problems are likely to be indicative of those of others in their professions.

A few problems in communicating science to the public via television stand out. One is the expense -- a single 90 minute special can easily cost a quarter of a million dollars, and a 26 week series of 1/2 hour programs would cost in the neighborhood of $1.25 million. Also, the television producer has to work with the audience's definition of "science," which is considerably broader than that of academic scientists. Not counting weather programs (the most widely-known application of the science of meteorology), there have been recently only about 12 total network hours per year (not including news coverage of space shots) of science programming, of which 8 are on PBS. According to our representative from television production, it is media executives and intellectuals who have been negative about science -- science specials on television are very well received by the general public. Audience surveys on nationally broadcast programs could easily determine the facts.

The amount of science reporting in newspapers has stayed at about the same level since 1960, although there is about twice as much space given to science now as there was in 1950. News coverage tends to center around major (sensational) events, to the neglect of the non-news "events" that make up the bulk of science. There are some problems with fitting science into the format of a "news medium" -- making science into "news." Sometimes different segments of a large project (e.g., research in Antarctica) are separated out and emphasized for different audience segments. Another problem is in knowing how to play political stories that have elements of science in them -- ecology, drugs, ABM and so forth. Should they be played as political news, or as science? Until the era of "Yellow Journalism," scientists wrote science news themselves. Even now most science reporting is done by general reporters, not scientists or science writers.

Magazines tend to be aimed at special interest groups, and as the focus of a magazine changes, the composition of its audience may change. Psychology Today began by approaching professional psychologists, then went for a general audience. Its circulation skyrocketed, but it probably lost much of its original audience in the process. Saturday Review picked "Science" as one of its sub-magazine headings because a survey found a great reader interest in the topic, and Scientific American (which used to be aimed at specialists) is now trying to broaden its audience to include more educated laymen. Magazines often take surveys of their readers to determine their interests and their reactions to the magazine as a guide to content and editorial policy. There seems to be a tendency that as magazines such as Physics Today become more political, they go down hill. Although under Abelson the introduction of "news and comments" gave the Science audience a better look at the science-government-society interface, a survey of readers of Science found that "news and comments" was still not as widely read as the research reports and the editorial.

People who go to science museums do so because they like it -- but little is known about people who don't go. Last year 250,000 people visited "the Exploratorium," 30% of whom had been there a previous time that year. The average length of visit was 1.25 hours. Science museums don't usually provide much depth, and could with good advantage be combined with other experiences such as reading or television. Some problems with museums are that (1) putting up an exhibit takes time, so museums can't keep up with the forefront of science, (2) exhibits can be expensive, and (3) there is a lack of rotating exhibits that pass from one museum to another. One particularly bad problem is when the people who run a museum get tired of the exhibits in it. The casual impression is that the average person doesn't get very much out of a museum visit, but effects may be long range -- career choices in science, for example. Several functions served by the science museum were mentioned: (1) it provides a physical place where one can go to learn about science, (2) it can be a focal point for interested groups such as environmental organizations, (3) it can be a place a person can buy books and other paraphernalia having to do with science, and (4) it can be a place where people can participate in actual scientific work. The science museum is claimed to have an advantage over other media in that its lack of time restraints and its openness can help draw in a wide range of people.

Science fiction was described as a popular art, more recently taken seriously as literature. The two original streams of science fiction -- gadgets and gimmickry a la Jules Verne, and the philosophical approach of H. G. Wells -- have been transcended by a "new wave" that deals with questions of dangers, social problems and anti-Utopias. Following the A-bomb there was a great expansion of science fiction, but the circulation of science fiction magazines dropped sharply after Sputnik. At least in the early 60's, the audience of Analog mainly comprised applied scientists, engineers and science students. Two problems that have recently emerged in science fiction writing: (1) science and technology have now restricted the scope of science fiction by actually doing many things that used to be the topics of science fiction stories, and (2) writers have found that technology can be predicted very well, but that the social effects of technology can't be. Science fiction on television is probably, over the long term, one of the most widely disseminated forms of science in the nation, and is apparently experiencing a rapid growth at present. Influencing or working through this medium could pay very rich rewards.

A general problem was noted with regard to the institutions involved in communicating science (or for that matter any "serious" topic) to the public. They tend to want such presentations to be "dignified," regardless of the effects of this on the audience. Typically, they prefer an approach beginning with "Here Comes Science!" even though the effect often is, "There Goes the Audience!"

Session 4 and 5: "What are the Most Important Research Questions which Could Guide Public Understanding of Science Activities?"

The first day of the conference established an information basis for asking questions about the process of communicating science to the public, and provided a common background for the participants on which to base the discussion of research questions. The entire second day was devoted to posing questions which need to be answered if the process of communicating a better understanding of science to the public is to be improved.

From the outset it became clear that one could not wholly separate research questions from the pilot or test-vehicle programs which could be used for studying some of the research questions. The suggestions have been grouped into four categories: (1) Overall research and policy strategies, (2) The various publics, (3) Science and society, and (4) The process of communication. Taken in this order, the questions listed by the group were as follows:

Overall Research and Policy Strategies

There should be a more coordinated programmatic effort in Public Understanding of Science. Presently there is considerable fragmentation in this area. Agencies such as AAAS and the National Science Foundation should make an effort to define a more general framework for the program of Public Understanding of Science.

Priorities are not crucial -- many things can be done in parallel. Programs should have specific objectives having to do with the publics to be reached, kinds of information and the relative values of the various media.

Our assumptions in this area should be challenged and tested: Can we really effect significant changes by manipulating symbols (that is, by doing nothing more than sending messages to the public)? What is the cost-effectiveness of a Public Understanding of Science program, or of the absence of the program? Does "more science understanding" lead to "better outcomes?"

At least part of the research or programmatic efforts should be done on an adequately supported, continuing, long-term basis. Individual studies, done at different places at different points in time, do not tell us much of general value.

The Various Publics

A. The General Public

1. Current State of Public Understanding of Science

We need to go beyond the "Gallup poll" type of measures of public science knowledge and get a much deeper understanding of the interface between science and the public. Knowledge, awareness, comprehension, attitudes, opinions, images, expectations and priorities of the public regarding science must be measured. Scientific influences on cultural and individual behavior could be measured as well. There is as yet no scientific evidence for a general public disaffection with, or mistrust of, science, and some research should be done in this area -- either dispelling such notions, or, if they are true, possibly demonstrating their origins and hence suggesting ways to correct them. Any research in this area should be done on a longitudinal basis so as to provide a way of gauging changes in public understanding of science over time.

2. Public Interest and Information Needs

Before any full-scale programs in communication of science to the public are launched, we need to find out the aspects of science in which the public is interested and what the public would like to know more about (although the public may not always know that it would like to know more about something to which it has not yet been exposed). Some research should be done into how interest in science is developed, maintained, or fostered.

Research should be done on the available sources of information on science and how the public uses them -- what people want to find out, where they look for the information, and what they do with it. Related to this, the major science-related concerns of the public should be identified and perhaps tracked longitudinally.

We need to take a closer look at what public information campaigns on science are supposed to, and can be expected to, accomplish. Is increased understanding of science sufficier to lead to desirable changes, or must there be concurrent social, economic, legal and/or ethical changes as well? Will increased understanding of science generally lead to desirable outcomes, or undesirable outcomes? How much time and effort can we expect the public to devote to learning information "for their own good," and how much information from other fields (health, politics, education, culture) is competing with science for the public's attention?

B. Scientists

Studies should be done to find out what scientists and engineers, in both the academic and industrial worlds, think about science -- primarily their attitudes, images, beliefs and expectations. This would serve as a guide as to which sort of information and image might best represent modern science and technology (to be used in conjunction with expert opinion on what it should be), and also would serve as a benchmark against which to compare the general public's understanding of science. (It is possible, for instance, that the professional scientist is really not much more favorable toward science than is the layman - some data suggest this.)

It would probably be beneficial if some data on the research on the general public could be communicated to scientists who are concerned about Public Understanding of Science, so as to bring their notions about the nature of the public closer to reality.

C. Other Publics

Research regarding other publics would be desirable, including: more research on how interest in science is fostered in young people; what the leadership segment knows and thinks about science, and what it needs to know for more rational policy-making; what influence disaffected intellectual elites have on "public understanding of science;" how different publics view different problems at different times; and how better information on public interests and information needs can be delivered to communicators and editors in the media.

Science and Society

A. Science and Public Policy

Research should be done into the processes by which information about science is used in the formulation and implementation of public policy. Case histories should be written up on topics such as smoking, cancer, SST, ecology, etc., from the recognition of the problem to the present status -- including such aspects as what act on the part of whom made a difference, and the role of science and scientists in the decision-making process. Studies should be made of needs and mechanisms at the state and local level for technical information dissemination to ad hoc "publics" at the moment of need. We should find out more about the effects of massive information inputs into the community decision-making situation, and should find out to what extent findings on community decision-making can be extrapolated to the national and international level. Studies of decision-making and the role of technical information at these higher levels should be studied as well. There are research implications in recent movements toward "adversary science," and "science for the people." Studies should be made of the nature of such movements, their possible effects on policy and on the enterprise of science itself, and the nature of the support for them -- is it really for "the people," or will it benefit only a small, self-serving elite? Finally, studies should be made of the impact and effects on public images of science brought about by government programs involving science and technology, for example the Environmental Protection Agency and the RANN program of the NSF.

B. Science in a Cultural Context

To gauge public understanding of science in a reasonable perspective, a better idea of its cultural contexts should be obtained. We should analyze our culture to see how science fits into it, to what extent our current articles of "common sense" are more scientifically based than the common sense of the past (for instance, it is now "common sense" that the world is round, even though this is not directly perceivable, nor was it always "common sense"). In addition, we should analyze our cultural behavior to see how "scientific" it is compared with the past -- for example, we now consult meteorologists, not fortune tellers, for the weather forcast. Solid studies should be made of just exactly how the daily lives of people have been changed by science, and what the overall effects of these changes have been. Studies should be made of scientific vis-a-vis cultural values: how was the development of science affected by our values, and how were our values affected by science? As an additional perspective on the public understanding of science, studies should be made of public understanding of other, comparable facets of our culture and of other prominent social institutions, including art, history, religion, the military, education and so forth. It may be that, comparatively, the public understands "science" better than we suspect.

C. Establishing a Reference Point

One of the most difficult problems in the field is the fact that after all the research is done to determine what the "public" knows or feels about science or scientists, we will have to judge whether it is adequate or not. In Item B a suggestion was made to compare it with other branches of our own culture, but in addition we ought also to make a comparison with other countries. A cross-cultural survey should be made of the public understanding of science in a representative set of nations such as the USSR, Japan, Germany, and various semi-developed and developing nations. These should be measured both as a reference point for comparing public understanding of science in the United States, and also so that some insight can be gained into the process of how science is assimilated into a culture, and how effective the different total systems of TV, newspaper, social systems, etc., are in achieving various levels of public understanding of science.

The Process of Communication

A. The Current State

A comprehensive inventory should be taken of the dissemination of information about science to the various publics. We should delineate what science is being communicated to whom, by whom, for what reasons, and through what channels. Content analyses should be made of science information in such media as newspapers, television, magazines, and consumer advertising, as well as other informal media like movies, cartoon strips, popular fiction, the underground press, and special interest groups like churches, unions, environmental groups, etc. Not only the content, but the "tone," of these communications should be investigated; and some effort should be made to determine who sets the "tone" for the discussion of science and technology (currently, for example, it seems to be strongly influenced by ecologists and "doomsayers"). The effectiveness of various formats for communicating science should be studied, and also we should study the total process of communication in our society today -- how it currently operates, how it is changing, what impact it has, and what new communication technologies are emerging.

B. Ways of Improving Communication of Science to the Public

Studies should be made to determine the feasibility, demand and possible forms of local, regional and national centers for the dissemination of science information, so as to make such information more accessible to the secondary source as well as the man on the street. The possibilities should be studied of resource centers so as to maximize the use of high cost films, TV programs, etc. Work should be done on models of the process of communicating science to the public, since currently our thinking is based on rather simple models. We should have a better idea of what the barriers to Public Understanding of Science with regard to writers, scientists and media managers are, and what can be done to mitigate them. Studies are needed on the planning of science programming and production, for example getting scientists and writers coupled on a project, or getting communication researchers together with producers. Formative research -- that is, evaluating material before it is disseminated -- should be done to a greater extent than it currently is being done in this area. One important improvement, which could be highly cost-effective, might be to pressure the TV networks into improving the 'image' of science and scientists, perhaps establishing a research center to work with them on this.

C. Monitoring the Effectiveness of Communication of Science to the Public

Some retrospective studies of successful and unsuccessful campaigns that attempted to change public attitudes and behavior would be most valuable, as would be studies of attempts to communicate science to the public. Changes in science curricula in the schools (for example, "New Math," chemistry and physics courses in high schools) should be assessed with regard to their impact on public understanding of science. The present use by the public of science information in the news, on television, science fairs, in the popular arts, etc., should be measured adequately and tracked over time. Virtually all major public understanding programs should have an evaluation component built in from the inception.

Research Priorities

To attempt to arrange a list of research recommendations such as the foregoing into a prioritized order would be virtually impossible. As was noted earlier in this report, many things can be done simultaneously, and most of them would be in no way mutually exclusive. Budget limitations will, of course, govern the set that can be started first.

Yet, given the current state of knowledge regarding public understanding of science, the needs for research of those concerned with this problem, and the volume of resources available for research in the forseeable future. it is fair to report a rough consensus of the workshop that a good, comprehensive measurement of the current state of public understanding of science is the most urgently needed research right now. Specifically, a national, in-depth survey of what the public knows, feels, believes, expects and wants concerning science and technology is called for.

This sort of national survey would tell us what the true state of public understanding of science is -- something which, in spite of all the claims and counter-claims, nobody knows right now. Also, it would provide a beginning for a longitudinal study of public understanding of science, a study which would show us how public attitudes in this area change over time.

It would constitute a baseline for assessing the effects of campaigns and other efforts to make changes in the public's understanding of science. And it would provide programmatic guidance by locating areas of genuine public disaffection and concern, as well as areas of misinformation and misunderstanding. Findings of the former type would suggest policy changes, while the latter type of findings could be used as a basis for informational and educational efforts.

APPENDICES

1. Agenda of conference
2. "Public Understanding of Science: The Data We Have," by G. R. Funkhouser.
3. "Why Should the Public Understand Science?" by Rustum Roy.
4. "Problems, Publics and Stages of Development in Public Understanding of Science," by E. G. Sherburne, Jr.
5. "Public Understanding of Science: The Problems and the Players," by R. E. Stephens.

Agenda for

Workshop on "THE GOALS AND METHODS
OF ASSESSING THE PUBLIC'S UNDERSTANDING OF SCIENCE

Objectives:

We hope to end the two day session with

a) A list of specific needs, especially in research, of a national program in the public understanding of science.

b) A brief report on this conference to NSF including the above.

c) Reports addressed to various constituencies concerned with this problem, disseminated via their media.

Schedule:

Wednesday, November 29

Morning (9:00 to 12:00)
- Introductory Remarks (Stephens, Sherburne, Funkhouser, Roy)
- 1st Topic: "Why Public Understanding of Science at All?"
  - *Open Discussion*

Afternoon (1:30 to 5:30)
- 2nd Topic: "What Publics Should Understand What Science, for What Reasons?"
  - *Open Discussion*
  - *Break up into small groups, each concerned with a different public.*

Evening (7:00 to ?)
- 3rd Topic: "How Needed 'Science' Should be Communicated"
  - *Continue small working groups*

Thursday, November 30

Morning (9:00 to 12:00)
- Reports of Working Groups
- 4th Topic: "What are the Research Questions Regarding the Facilitating of Public Understanding of Science Activities?"
  - *Open Discussion*

Afternoon (1:30 to 4:00)
- 5th Topic: "List of Needed Research and Recommended Priorities"
  - *Open Discussion*

PUBLIC UNDERSTANDING OF SCIENCE:
THE DATA WE HAVE

G. Ray Funkhouser
Assistant Professor of Communication Research
The Pennsylvania State University

Prepared for the Workshop

on

"The Goals and Methods of Assessing the Public's Understanding of Science"

The Materials Research Laboratory
Pennsylvania State University
September 1972

PUBLIC UNDERSTANDING OF SCIENCE: THE DATA WE HAVE

by

G. Ray Funkhouser
The Pennsylvania State University

Compared to topics such as political preferences, consumer behavior, education, racial discrimination and opinions on various topical issues, the public's understanding of science has received the short shrift from social scientists. In spite of the importance of science and technology at every level of our society--from daily living to the philosophical underpinnings of our culture--data on what the public knows, understands and feels about science and technology are embarrassingly scarce. While the results of national and local surveys on political preferences and current issues have for years been published regularly in newspapers and magazines across the nation, a major review of research on public science knowledge[1] was able to summarize the results of practically all survey research on this topic in six typewritten pages (the summary including not only the responses, but the questions as well). Data on opinions and attitudes toward science are equally scarce, although a major study on the process of communicating science to the public was conducted in the late 1950's.[2]

There are no doubt a number of reasons why public science knowledge and understanding have received such scant attention from social science researchers. Among the more important might be the following: (1) the researchers themselves, primarily sociologists and political scientists, have little competence or interest in the "harder" sciences; (2) public understanding of science is of relatively little importance to the organizations that fund most of this kind of research--the news media, political parties, industrial and marketing concerns, and federal agencies such as the Office of Education, the National Institutes of Health, etc; (3) the organizations that fund research in the hard sciences have competence in that area, but have shown relatively little interest in the social aspects of science and technology; and (4) perhaps most importantly, science is not generally seen as a "gut" national issue in the same way that crime, drugs, race relations, etc. are, nor does it often spark controversies that capture the attention of the news media, the popular news magazines, the intellectual journals or their respective audiences. The attention currently being paid to "ecology" is one glaring exception to this, and just possibly is a harbinger of a basic change in the 'needs' of the public.

If we accept the premise that the better a public understands the world in which it lives, the more effectively it can deal with that world, then it is clearly desirable to strive for improvements in public understanding of science--not only in the United States, but in all nations. However, it is important to know, before any large-scale efforts are launched toward this goal, what the public knows, understands and feels about science and technology right now. In the first place, knowing the present state of the public mind will provide a basis for making programmatic decisions by locating areas of genuine disaffection and conviction, as well as areas of misinformation and misunderstanding. The first of these would suggest changes in science policy, while the second would indicate directions in which educational efforts might well be directed.

In the second place, knowing the present state of the public mind would establish the necessary baseline for evaluating the effectiveness of various programs and efforts to increase public understanding. If, for instance, an evaluation study showed that a national television "science spot" campaign had no measureable impact on the audience, this would suggest that other approaches should be tried. With no baseline it is, at present, impossible to judge the impact of any public information efforts. It is unfortunate that no national baseline data of this sort were taken in the mid-1950's, since great changes were instituted in primary and secondary science education in the post-Sputnik period. As it is, there is no reliable way to measure the effects, if any, of these changes in national science education policy on overall public science knowledge and understanding. Did they improve the quality of science in America, as their promoters intended; did they "turn off" a generation of students, as some critics have alleged; or was the effect on the general public's understanding of science essentially zero?

WHO COMPRISES THE "PUBLIC?"

To discuss the public's understanding of science in a realistic perspective, we ought first to define the public, or publics, to which we are referring. Too often, concerned spokesmen from the scientific or intellectual communities[3] speak of "the public," apparently having in mind people very much like themselves--that is, well-educated, articulate, concerned and well informed about current issues, committed to a career that involves fulfilling and relatively well-paying work. Indeed, in an academic setting one has to fight the impression that "everybody goes to college," since in that setting just about everybody does.

In Table 1 there is a comparison of the public at large with other "publics" pertinent to this discussion. The data for the public at large were taken from <u>Statistical Abstracts of the U.S., 1971</u>, except for the

TABLE 1 Demographic Data on Various Publics

	Public at Large (N=130 million adults)	*Psychology Today* Subscribers (N=250K)	Academic Physicists	Academic Engineers	Academic Social Scientists
Age:					
less than 18	33%	---			
18 - 25	12%	23%			
25 - 34	12%	38%			
35 - 44	11%	23%			
45 - 59	16%	13%			
60 and over	16%	3%			
Race:					
White	85%	96%			
Negro	11%	3%	virtually all these would be white		
Other	4%	1%			
Family Income:					
less than $5000	20%	6%			
5K to 10K	34%	31%			
10K to 15K	27%	33%	virtually all these would be in the above-10K range		
over 15K	19%	30%			
Education:					
less than high school	35%	} 27% (less than high school, high school grad, some college)			
high school grad	34%				
some college	10%				
college grad	7%	20%			
more than B.A. or B.S.	4%	52%	100%	100%	100%
Political Orientation:					
Liberal	24%	55%	44%	24%	64%
Middle of Road	27%	26%	18%	17%	17%
Conservative	41%	18%	36%	52%	20%

political orientation figures. These were reported by the Roper organization in 1972. The subscribers to Psychology Today magazines were surveyed in 1968[4] and are included here as an example of a "concerned and aware" public--the readerships of New Republic, Commentary, Atlantic, etc. are probably not too different in many respects. The political data for the academic scientists and engineers were published recently by Ladd and Lipset in Science[5], and some of the other figures are seat-of-the-pants estimates.

While not an ideal set of data, the figures in Table 1 make the point. Clearly, the people with whom the participants in this workshop are personally most familiar are not very representative of the public at large. The public is much less affluent, not nearly as well educated, and somewhat less liberally inclined than the academic-professional-"concerned citizen" milieu. It also is vastly more numerous: adults who have never been to college outnumber college graduates by about 6 to 1 and those who have gone beyond the bachelors degree by about 18 to 1. All college and university faculty constitute less than 0.5% of the adult population. As an additional perspective on education (since this is a crucial variable with respect to public understanding of science), we should note that although the official rate of illiteracy in the U.S. currently is 1%, estimates of the prevalence of "functional illiteracy" have run from 13% to 50% of the total population, depending upon the criteria used to define "functional illiteracy." The former figure, according to a Harris Poll, depends on the ability to fill out the forms necessary for getting a social security card, while the latter study (done at Harvard) involved the ability to comprehend a standard driving manual.

The level of education is rising in America, of course. In 1970, 38% of people from 20 to 24 years had attended at least some college (9% BA or more), with 31% from 25 to 29 (16% BA or more) and 28% from 30 to 34 (15% BA or more). Thus as time goes on a larger proportion of the public will have college degrees. However, it will be many years before anything like even one-fifth of the public will be college graduates. Also there has been concern about the quality of college education that has been given to these increased numbers of graduates. It is safe to say that for the foreseeable future, the majority of the public will not be "well educated" in the sense that the term is used by well educated people.

Audiences for various information sources are a particular type of "public," and these can vary in level within a considerable range. For example, Reader's Digest boasts an audience of about 40 million, of which about 13% are college graduates. On the other hand, Scientific American has a circulation of less than half a million, of whom about 85% are college graduates[6]. The public reached by Science is quite different from that reached by the New York Daily News, although I suppose one could contend that the two publications are equally "public," since, in theory at least, they are equally available to everybody. A similar observation could be made with regard to the respective "publics" of the commercial networks and the Public Broadcasting Corporation.

One error made all too often is to mistake the contents of the news media for an expression of "the public." In the first place, editors' ideas of what the public thinks have been shown to be measurably in error[7]. In the second place, there is evidence that the amount of attention paid by the news media to various issues has no necessary relationship either to what is actually going on in the world, or to public opinion concerning the issues[8]. The news media may select the agenda of issues that public figures such as political candidates must address[9], but it is axiomatic in communication research that their direct impact on anything but the most superficial aspects of public opinion is limited[10]. Finally, the coverage given to demonstrations and protests often is construed as evidence of "public" concern, even though such activities characteristically involve small, vocal and unrepresentative segments of the public. The moratoria on the war in the fall of 1969 were widely interpreted as a forceful expression of public sentiment; however, a Gallup poll found that unfavorable comments on the November moratorium outweighed favorable comments by about three to one, apparently because less than 20% of the public approved of the demonstrator's goals. Examples of this relevant to science would include "Earth Day," protests over sites for nuclear power plants[11], objections to Department of Defense-sponsored research, etc.

Legislative bodies and governmental agencies constitute "publics" which are small but extremely important. I think it would be naive to assume that these groups actively carry out the wishes of their constituencies (that is, "the public") in any sort of direct fashion. For in addition to the electorate (which has virtually no direct influence on executive agencies at all), the individuals comprising these groups must base their decisions also on pressure groups, special pleaders, political supporters of one sort or another, the news media, their own individual and collective self-interests, and to some extent, the facts of the matter. The current spate of environmental legislation, for example, seems to be as much a response to clamor by the media, pressure groups and superficial public opinion as a reasoned approach to the problem, in many cases having little to do with deeply felt "public needs" and desires, or for that matter with sound, scientific reasoning and evidence. Most legislators are college graduates, but most are lawyers by training--very few of them are scientists or engineers.

Another public of interest here is what Kadushin, et al[12] call our "intellectual elite," a self-defined set of people who dominate the nation's intellectual journals and who are judged by other "intellectuals" as being especially influential. This is a relatively small group, numbering only a few hundred. However, they are the people who write and/or edit the book reviews and "think pieces" in publications such as Commentary, Harpers, the New York Review of Books, (the old) Saturday Review, New Republic, New Yorker, etc. This group tends to be university professors in English, Economics, Sociology, Political Science and History, or editors and employed writers--scientists are conspicuously absent from their ranks. Obviously highly educated, and affluent, they are unrepresentative of the general public in other ways as well. They are almost unanimously on the left end of the political spectrum, and seem inclined to take up the various "causes," (including, among others at present, "ecology" (although their favorite issue during the '60's was race relations)). And as Kadushin[13] put it, "depending on your expectations, they are only, or fully, 50% Jewish and only, or fully, about 50% of them live within 'lunch distance' of New York City."

The reason this public is of interest is that it has some influence in the selection and discussion of social and political issues, at least among the concerned, intellectual community. While their influence may be relatively small among the public at large, it is likely that they do have influence among media gate-keepers, political decision-makers and political activists. Materials primarily aimed at this "intellectual elite" group have been construed as "public discussion." Relevant to the present context, I suspect that some of their opinions have been interpreted as evidence of a "public disaffection with science."

An awareness of the segment of the public that is professionally involved in science is also important in our present context because it constitutes the source of the science information to be disseminated to "the public," as well as the source of most of the concern over public understanding of science. While the data in Table 1 tell us something about academic scientists and engineers, we should keep in mind that the majority of this group in this country are not at universities, but rather work for industry. The non-academic scientists are less highly-educated than their academic counterparts, with higher percentages holding B.S. degrees rather than M.S.s or Ph.D.s. They are probably less liberal than the groups represented in Table 1. I think it is important to remember that academic scientists/engineers, while predominating in discussions of public understanding of science, are a minority group among scientists (although they have been and continue to be responsible for training all the others). Industrial scientists/engineers, while not as visible or articulate in this regard, have legitimate interests in this topic. And some of these interests may differ in important ways from those of the spokesmen for their colleagues in academia.

In any case, the purpose of this section is to emphasize the fact that the term "public" should not be used without further qualification. While we do not necessarily have to mean the entire population of the United States by the term "public," in the absence of any further qualification that is probably the most appropriate meaning for that term. If we mean and say: "the college educated public," fine. Ditto the "scientifically-trained public," the "intellectual public," "the readers of Time," the "Public TV audience," etc. Let us say what we mean more precisely.

The cultural milieu in which most of us, here, live is not the same as that of the "public." If we want to talk about a small, unrepresentative segment like ourselves and our friends, fine--only let us not speak in terms of "the public." When we want to talk about "the public," we might as well try to maintain in our minds a more faithful picture of it. One of the best ways I know of doing this is to spend a Saturday afternoon people-watching in a discount department store.

PUBLIC UNDERSTANDING OF SCIENCE

The public's "understanding" of science includes a number of different components. Of these, the three most important are knowledge, opinions and attitudes.

Knowledge, as the term will be used here, has to do with command of facts--bits of information on which there is a high level of expert agreement. Opinion has more to do with beliefs, unsubstantiated information or personal interpretation of complex or controversial situations.

Attitude generally refers to a predisposition to respond in some way, or to a degree of positive or negative affect associated with some psychological object. Thus a person may know that a nearby plant's water effluent contains matter that exceeds the amount permitted by the state's pollution laws. His opinion might be that the importance of the plant to the local economy outweighs the harm caused by its pollution. And his attitude might be that he does not favor closing down the plant if it cannot meet pollution standards by the deadline. We recognize, of course, that these are imprecise definitions, and that even if they were made more precise there would still be many instances in which we could not unambiguously determine whether something qualified as knowledge, opinion or attitude.

Additionally, we need to consider terms such as interest, image, awareness and comprehension as being parts of public "understanding" of science. A person may know that light travels faster than sound, but does he comprehend why? The distinction here would be rote learning versus true understanding. Also we should distinguish between awareness and knowledge: a citizen may be aware that we have sent a space probe to Mars, but what does he know about it? Awareness is in that sense imprecise or vague knowledge. Interest is important, since the more a person is interested in science, the more he is likely to know about it, like it and seek information about it[14]. An "image" of science would be the general picture a person has in mind when he thinks of it.

PUBLIC KNOWLEDGE OF SCIENCE

The major study in this area, "Knowledge and the Public Mind," by Schramm and Wade[15], summarized the findings of 54 surveys that contained items on public knowledge in three areas: science, health and public affairs. Their general findings were that the public knows more about public affairs and health than about science. A rough index gave scores of 32% in public affairs, 18% in health and 14% in science, the scores expressing the percentages of people with "high information" in the respective areas. Education was found to be a strong predictor of science knowledge--the more education, the more science knowledge. Men were found to know more about science than women, with education level held constant. (However, an experimental study[16] found that, in a large college population, female students were every bit as well able to handle specialized science information as comparable male students.) Other variables correlating with science knowledge were: income, print media as major information source, occupation and the number of high school science courses a person had taken.

So far, so good. There are, however, two major shortcomings in the measurements of public science knowledge to date. First, even in the voluminous body of data searched by Schramm and Wade, only 48 items concerning science knowledge could be found, of which 26 were part of a C.B.S. "National Science Quiz" in 1967. A summary of survey research from 1935 through 1946[17] contained not a single item having to do with science knowledge. Apparently, since systematic survey research began in mid-1930's, an average of less than one single item per year has been used to measure public science knowledge in the United States. For the sake of perspective, a national survey can contain over a hundred substantive items, and dozens of these surveys are taken each year.

The second shortcoming of prior studies of public science knowledge is the level of information tested. Of the 22 non-C.B.S. items reported by Schramm and Wade, six asked for identification of personalities (Einstein, Freud, Oppenheimer, the inventor of the telephone, etc.). Five had to do with science policy (Is the U.S. trying to get other countries to agree to international control of atomic energy? What is the purpose for launching space satellites?) Seven items essentially measured awareness of current science news (three of the seven asked whether the respondent knew what "fallout" is).

The remaining items were more closely concerned with the substance of science. The results of these items are as follows:

(Minn poll, 1957) "About how far from the earth would you guess the moon is?" -- 4% correct

(Minn poll, 1957) "Compared with the earth, about how big would you say the moon is?" -- 38% said "much smaller"

(AIPO, 1955) "What is the largest bird in the world?" -- 26% correct

(AIPO, 1955) "Which planet is nearest the sun?" -- 7% correct

(AIPO, 1956) "Do you know of any uses of atomic energy except for war purposes?" -- 49% mentioned some legitimate purpose

(AIPO, 1950) "Have you heard anything about the new H-bomb? What do you know about it?" -- 48% heard, with information.

In other words, virtually no attempt has yet been made to measure in any substantive way what a national sample of the American public knows about science. Most of the knowledge questions pertaining to science deal with awareness of current topics in the news, famous personalities or the most superficial level of rote knowledge. To the best of my knowledge, not one question has ever been asked of a representative nationwide sample that dealt with any sort of comprehension of scientific principles, processes or procedures.

The 26 items used by C.B.S. in a 1967 telecast called the "National Science Test" were more oriented along substantive lines, but unfortunately were not administered to a representative sample. Also, the questionnaire had methodological difficulties. First, they were true-false questions, which meant that a person's actual understanding was not measured, only whether or not he thought a statement was true or false. Second, they often confused theoretical and practical understanding: that is, a person who knew the principles of physics might have given one answer, while a person who relied on empirical observations would have given another--both, technically, correct. Third, they often confused common sense or everyday experience with science. Some examples of these items (including these shortcomings) are:

Does cutting up potatoes make them cook faster? (92% yes)

Can bananas be prevented from getting overripe too fast by refrigeration? (47% yes)

The oceans are the major source of rainwater. (64% true)

You see lightning before hearing thunder because the sound has to travel further (34% false)

If you push a child on a swing, does a big or a little push make any difference in the number of swings back and forth? (Big push, more swings - 62%)

The picture on TV is made by a beam of light projected from inside the picture tube. (71% true)

A rocket is lifted off the pad by the force of the exhaust gases pushing down. (75% true)

An astronaut in orbit has no weight. (81% true)

Has science developed an equivalent to a ray gun? (71% yes)

Has science developed a machine that thinks for itself? (41% yes)

An experimental study[18] on effective science writing had some findings that pertain here, although they do not represent a cross section of the American public. This study involved short articles on three topics--Enzymology, Polymer Chemistry and Plasma Physics--and three audiences--junior college students, university students and professional scientists. Tests of ten multiple choice items on each topic were given to each audience on a before-after basis. Table 2 shows the mean percentage scores for each audience before and after reading materials on the subjects. In this case the baseline for knowledge is 25% correct, the score that a random number table would achieve. Going on their prior knowledge of science, the junior college students do not score much better than that, and presumably that is approximately how a cross-sectional sample would do also. The university

TABLE 2

Information Test Scores for
Three Audiences, on Three Topics

Topic	% Correct Before Reading Material	% Correct After Reading Material
Enzymology		
Junior College Students (N=62)	31%	46%
University Students (N=60)	47%	66%
Professional Scientists (N=40)	50%	84%
Polymer Chemistry		
Junior College Students (N=60)	23%	48%
University Students (N=58)	33%	62%
Professional Scientists (N=37)	49%	90%
Plasma Physics		
Junior College Students (N=59)	32%	56%
University Students (N=56)	47%	74%
Professional Scientists (N=43)	66%	83%

students (Stanford) did somewhat better than chance, and the professional scientists (half of them had Ph.D.'s) scored in the range of 50% correct on a tough test, from their background knowledge of science alone. Interestingly, although the scientists knew more to begin with, they also learned more from the materials they read, as shown by the "after" scores, than did the junior college students. The university students were approximately halfway between the others.

A massive study[19] was done in 1969 to assess the educational attainments of Americans. It covered a number of subject areas, with science stressed heavily. Four objectives of science education were tested: (1) the Fundamental Facts and Principles of Science, (2) Abilities and Skills Needed to Engage in the Processes of Science, (3) Understanding the Investigative Nature of Science, and (4) Attitudes about and Appreciation of Scientists, Science, and the Consequences of Science that Stem from Adequate Understanding.

This study, conceived from the point of view of educators, involved testing large numbers of people in four age groups--9 years old, 13 years old, 17 years old and young adults (ages 26-35, a national sample). Multiple-choice items were used, some of which overlapped two or more age groups. The purpose of this study was to establish baselines for gauging future progress in American education, but several of the findings are worth mentioning in their own right.

Each succeeding age group had more correct answers than the previous group up to age 17, at which age a peak in science information apparently is reached. The "young adult group" actually had less science information than the 17 year old group. One reason for this might be that science information, as well as test-taking, is less salient to people no longer in school, and it also is possible that the "young adult group" contained an appreciable number of people who never got as far in their educations as the 17 year old group (who were all students) did.

Girls and boys at age 9 seemed to be about equal in science information, but boys outperformed girls with an increasingly large gap in subsequent age groups, to a 10% difference in correct answers between men and women in the "young adult group." The amount of education a person's parents had had, made a large difference in science knowledge: subjects, either of whose parents had been educated beyond high school, did considerably better in all the age groups than did subjects whose parents had had less education. Subjects of all ages from affluent suburbs had better knowledge scores than children from other types of communities, with subjects from extreme rural or extreme inner city communities doing least well. Black subjects did considerably worse, on the average, than White subjects.

Overall there were many items which most subjects answered correctly, as well as some which most subjects didn't. Since the ability to answer test questions depends to a large degree on the nature of the questions themselves, it is hard to judge the results of this study by any kind of absolute standards (which wasn't the intention of the study anyhow). But as an objective test of science knowledge it is a much more comprehensive instrument than what was used in anything else cited here, covering as it did the four educational objectives noted above.

From the evidence available, it seems that

(1) no adequate measurement of general public science knowledge has ever been attempted;

(2) the few measures that have been taken nationally suggest that the general public does not know many facts about science; but

(3) what the public "knows" about science is to a large extent a matter of how the measurement is taken. Scores were much higher in the educational assessment study than in the experimental study described just before it, for example.

Related to knowledge, awareness of science has been measured occasionally, mostly in connection with "science in the news." For example, a study[20] done after the launching of Sputnik found that awareness of the event ranged from 97% of the people in Norway aware it had happened, to 57% in Brazil. The author noted that the only other recent event comparable to this awareness level was the atom bomb, in 1945. Another study[21] found that, whereas prior to the launching of Sputnik 54% of the U.S. public had never heard of space satellites, after the launching only 8% had never heard of them.

The crime rate is reported to have dropped while the first landing of men on the moon was in progress, due to the extraordinarily large number of people who were staying at home to watch it on television. Thus we can assume that the public will be aware of spectacular events vaguely related to "science." Clearly, this sort of awareness does not in most cases represent any sort of "science knowledge" beyond the superficial connection to the bare fact of the event. For example, it is a safe guess that of the many who were aware of space satellites after Sputnik, only a miniscule percentage could give a scientifically acceptable explanation of why they don't fall down.

ATTITUDES TOWARD SCIENCE AND SCIENTISTS

Questions regarding science knowledge and awareness are of considerable value to various groups interested in philosophical or programmatic consideration of improving the situation. Political judgments, on the other hand, often turn more on public attitudes towards science. We now turn to these.

In his paper[22] reporting some of the findings of the surveys taken by the Survey Research Center at the University of Michigan, Withy says:

> "Probably not more than 12% of the adult population really understands what is meant by the scientific approach. For about 2/3, science is simply thorough and intensive study, which is, in a way, an adequate label. But the sensitive reader of interviews is aware, in the responses of most people with this point of view, of a lack of insight and understanding...A full quarter admitted that they did not know what was meant by studying something scientifically."

These surveys, before and after Sputnik, did contain two batteries of attitude items, one pertaining to "science" and the other to "scientists." The results of the later survey were:

Concerning Science	% agree
The world is better off because of science	83%
Science is making our lives healthier, easier and more comfortable.	92%
One of the best things about science is that it is the main reason for our rapid progress.	87%
One trouble with science is that it makes our way of life change too fast.	47%
Science will solve our social problems, like crime and mental illness.	44%
The growth of science means that a few people could control our lives.	40%
One of the bad effects of science is that it breaks down people's ideas of right and wrong.	25%

Concerning Scientists	% agree
Most scientists want to work on things that will make life better for the average person.	88%
Scientists work harder than the average person.	68%
Scientists are apt to be odd and peculiar people.	40%
Most scientists are mainly interested in knowledge for its own sake; they don't care much about its practical value.	26%
Scientists always seem to be prying into things they really ought to stay out of.	25%

These results suggest that, at the time of the survey, the public had a rather favorable view of both science and scientists. (Perhaps a cynic might say that some of these attitudes demonstrate a decided lack of understanding about science and scientists!!) There is, of course, a confounding of science and technology implicit in these items, although I suspect that most scientists don't routinely differentiate these two thrusts much more rigorously than the public does.

The above data were taken in a survey before Sputnik. The same items were used in a survey after Sputnik, and showed practically no change in these attitudes in spite of the momentous event that had occurred in the intervening period. The only item in this battery that exhibited a significant difference between the pre- and the post-Sputnik survey was "The growth of science means that a few people could control our lives." The 'before' measure found 32% agreeing with this item, whereas in the 'after' test, 40% agreed[23]. Perhaps this lack of change is a result of little genuine interest in the event. In spite of the amount of awareness, only 4% of Americans had bothered to go out and look at either of the two Sputniks, and other data showed that many citizens were more concerned with their own affairs, the World Series and events in Little Rock than they were with Sputnik[24].

With regard to general attitudes toward science and scientists, these results were replicated experimentally[25]. Semantic differential attitude scales composed of items like:

Timely.......Untimely
Comprehensible.......Incomprehensible
Relevant to me.......Irrelevant to me
Important.......Unimportant
Meaningful.......Meaningless
Interesting.......Uninteresting
Beneficial.......Harmful
Practical.......Theoretical
Imaginative.......Unimaginative
Successful.......Unsuccessful

were administered to over 700 college students, some before reading professionally-written articles on enzymology, and some after. Attitudes toward science and scientists were found to be quite favorable; however, no measurable change in these attitudes resulted from reading the articles. Attitudes toward enzymology did change significantly--every one of the ten articles used brought about improvements in attitudes toward enzymology, in several cases to a higher level of favorability than attitudes toward science in general. This latter finding was replicated in a later experiment[26], which showed that the reading of materials (which presumably increased knowledge) on the topics of enzymology, polymer chemistry and plasma physics resulted in improved attitudes toward these areas of science, again approaching the level of audience favor towards science in general. Apparently, lack of information about unfamiliar areas of science causes less favorable attitudes, and the difference between before- and after-measures is the result of attitude formation, rather than attitude change.

Also noteworthy in this experimental study was the comparison of attitudinal data between the scientists and the two student audiences. While the scientists had the most favorable attitudes toward science in general and the three specific sciences, the two student audiences were almost as favorable. All three groups (after reading the materials) were between 5.0 and 5.5 on a 7-point scale, where 7 was the most favorable score possible, 1 the least favorable, and 4 the neutral point. These data were gathered in the late 1960's at the height of the student protests, and they emphatically contradict the notion of a general disaffection with science among this particular public--West Coast college students.

A study conducted recently in Germany[27] demonstrated a wide divergence between public preferences for research expenditures and actual government expenditures. In fact, the two sets of priorities were practically reversed, with defense, space and nuclear research the most heavily funded areas, but near the bottom of public preferences. On the other hand, the highest public preferences--medicine, nutrition, pollution and education--were near the bottom in funding priorities. Level of education did not make too much difference in public preference, except in four areas: more educated people preferred more research in education and computers while less educated people preferred more research in energy and nutrition. An experimental variation of this study showed that the preference gap between students and "funding experts" closed with the introduction of information on the research situation. However, the students still tended to rate the chances of success in some areas of research (e.g., education, pollution, medicine) more highly than did the "experts."

Aside from these studies, there has apparently been no attempt to measure general attitudes about science and technology. Most of the other measurements of public science attitudes have concerned specific, highly visible topics--space, computers and ecology.

Surveys and polls regarding space essentially began with the launching of Sputnik. A summary study on various data collected in the wake of that event[28] concluded with the statement:

> "In summary, the opinions held by many Americans regarding this first step into space were sometimes inconsistent, occasionally rich in <u>non sequiturs</u>, and frequently illogical. Also, these opinions did not indicate unanimous psychological shock or national loin girding, as the press and many issue makers have insisted. It has become commonplace in the pages of this journal to acknowledge that the press and its readership are frequently not as one, and these data are submitted in part as one more attempt to shatter the myth to the contrary."

Some of the opinion data gathered in the context of space had to do with the "race" between the U.S. and Russia. A study primarily concerned with the defense aspects of space[29] found that after Sputnik, most nations' publics felt that Russia was ahead of the U.S. However, after the initial U.S. successes, these same publics shifted predominately to feeling that the U.S. was in the lead. The author made the interpretation that "this demonstration of Soviet superiority represents a significant foreign policy victory for the Soviet Union." Yet, according to a Gallup Poll[30], the shift from Russian to U.S. predominance has apparently stuck. In 1970, with 12 nations polled, about 36% felt that the U.S. was ahead in science, with 22% giving the edge to Russia. In 1959, these figures had been virtually reversed.

Public opinion on the space budget probably has more to do with taxes than with scientific matters, but for whatever it is worth, in August, 1965, the Gallup poll found that 16% of the public favored increasing funds for space, versus 42% leaving them the same and 33% decreasing them. In March, 1969, the Gallup data showed 14% in favor of increase, 41% for leaving them the same and 40% for reduction. However, in August, 1969, 39% favored setting aside money for landing a man on Mars. A Gallup poll in April, 1967, found 33% saying that they felt it was important to send a man to the moon before Russia.

A poll conducted for the Wall Street Journal in 1971[31] on the general topic of the U.S. being "number one" found that 67% of the public agreed that the U.S. should strive to be "number one." Specifically, "more than 80% felt that the U.S. should be first in medical science, manufacturing technology, social reform, general military preparedness and world political leadership. More than 70% want to be first in missile defense or the uses of atomic energy, and about 65% want to lead the world in aerospace technology. However, barely half (51%) believe the U.S. should try to be No. 1 in sports or space exploration...and more than 62% said they felt Congress made a wise decision in junking the supersonic transport." This last item is apparently inconsistent with previous items, unless we assume some sophistication on the part of the public.

In the past decade computers have received considerable attention, no doubt due to the ever-increasing role they play in the day-to-day lives of just about all U.S. citizens. The source of occasional inconveniences and confusions, they have become the subject of numerous cartoons in newspapers and magazines. Several studies have been done on public attitudes regarding computers. One, by Robert S. Lee of I.B.M.[32], found two independent constellations of attitudes toward computers. They are seen as being beneficial tools, and also as being awesome thinking machines. However, many more people see them in the former (positive) light than in the latter (negative) light; and higher education was found to be related to less negative attitudes. Two psychological variables--alienation and intolerance for ambiguity--were found to be strongly correlated with negative attitudes. Other variables such as receptivity to new ideas, trust and optimism in people and social institutions, curiosity about mechanical things and familiarity with the world of business were found to correlate with positive attitudes towards computers. The author especially stresses the fact that there was no correlation between the "beneficial tool" and the "awesome thinking machine" perspectives, making the point that it would be inadequate to try to measure attitudes toward computers on a simple "pro-con" scale. People can be both pro and con, or neither pro nor con.

A nationwide survey done in 1972 for Time and the American Federation of Information Processing Societies[33] contacted 1001 people by telephone. The topic of the survey was computers, and the findings were generally favorable to the "computer establishment." That is, 81% of the respondents felt that computer mistakes are really mistakes made by people who use computers, 75% had had no problem getting a computer-generated bill corrected, 65% felt that computers were helping to raise the standard of living, and 60% felt that business would be in serious trouble without computers. However, 55% agreed that people were becoming too dependent on computers, and the same number felt that computers were dehumanizing people and turning them into numbers. 38% felt that computers represented a real threat to personal privacy, but only 36% agreed that computers create more employment than they eliminate. In the realm of "science fiction" (as the authors called it) 12% thought of computers as being able to think for themselves, 30% thought that computers could produce more accurate information than they were given (in direct contradiction to the Law of "Garbage in, Garbage out"), 17% believed that computers of the future will be able to read your thoughts, and 23% felt that computers might disobey the instructions of the people who run them. Overall, 71% of the sample felt that life is much or somewhat better because of computers, as opposed to 15% who felt that life is much or somewhat worse becauce of them.

Another survey, on a sample of Minnesota residents[34], contained several items pertaining to computers. The following results were obtained:

> Two thirds of the respondents agreed that "the relationship between businesses and their customers has become too impersonal because of the computer."
>
> About one-third said that they had "ever had a mistake in a transaction that was hard to get cleared up because billing was handled by a computer."
>
> 41% agreed that "American society is threatened by the increase in information that the government collects about individuals from the census, tax returns, social security, and so on."
>
> Two-thirds felt that for society to function properly, the individual's right to privacy was more important than the government's right to know.

The author interprets these results (and their relationships to demographic variables) in terms of an overall structure of experiences, values and attitudes. He concludes by saying: "The profile for the future suggested by these data is a populace more concerned for rigorous privacy related guarantees but simultaneously approving computer technology and related development."

The volume of news media coverage given to space during the 1960's without a doubt establishes that area as the most heavily publicized area related to science, in history. Yet, "space" never emerged as an important political or social issue to the extent that "ecology" now has. In less than a decade, the problems of population, pollution and the ills brought about by technology have moved out from esoteric books and technical articles to front page news and institutional advertisements. The reasons for this are complex and no entirely straightforward explanation is at hand. Although the problem is very real, it has not in fact worsened rapidly. A crucial factor, undoubtedly, has been the articulate pressure exerted in the late sixties by activist groups such as the Sierra Club, coupled with a willingness of the media (including magazines and book publishers) to highlight exposure to this issue. Also, on the face of it, ecology is a uniquely "safe" issue -- what kind of scoundrel would be in favor of pollution?

Because of its sudden importance as a social issue, a good deal of data has been gathered recently concerning public opinion and attitudes regarding ecology. In fact, Public Opinion Quarterly devoted space in two consecutive issues[35] to data on ecology, since there was too much material to cover in one.

In 1965, a nationwide poll found that 28% and 35% of the sample felt that air and water pollution, respectively, were "very" or "somewhat" serious problems in their area. By 1970 these figures had risen to 69% and 74%. Big city residents were about 20% higher at all times than the overall sample (of which they were a part). Another poll in 1969 found that 51% of the sample felt they were "deeply concerned" about environmental problems like pollution, erosion and destruction of wildlife. In 1970, a Minnesota Poll found that 87% of its respondents thought that life as we know it today will be in serious trouble if nothing is done about pollution.

In 1970, pollution and environment showed up for the first time as "the most important problem facing America" in the Gallup poll--6% felt that it was, compared to 27% mentioning the Vietnam War, 27% for campus unrest, 13% for race relations and 10% for inflation. Also in 1970 a Harris poll found 58% of a national sample saying they thought that pollution will be "extremely important" in the thinking of people who vote in November for a candidate for Congress. A number of polls in the late 1960's and early 1970's found large majorities of people of the opinion that Federal expenditures for pollution control and natural resources should be increased (along with crime and law enforcement, education and job training). The same polls found majorities in favor of cutting funds for the space program, the Vietnam war and foreign aid.

However, putting their money where their mouths were, was a different matter for survey respondents. In 1965 a survey found that over 60% of the public was not willing to pay anything to have air or water pollution reduced, and that less than 30% would be willing to pay an additional $100 per year in taxes in return for great reductions of these problems. Another poll, in 1969, found similar sentiments: 32% were willing to pay as much as $100 to solve pollution problems, but 56% were unwilling. While 55% were willing to pay an extra $20 per year, 35% were unwilling to pay even that much. About three out of four were unwilling to pay an extra $2 per month on their electricity bills to pay the cost of reducing pollution from power plants. Perhaps the most telling pair of questions was asked in 1971. While 48% of a national sample agreed that the American people can afford whatever it takes to clean up pollution, only 22% were personally willing to pay any extra taxes or higher prices toward this end. An ironical twist to this is that the public is already paying higher prices and taxes for the purification of their environment, whether they are "willing" or not.

In 1970, a poll found that the public felt that the chemical industry and the oil industry are the chief industrial contributors to air and water pollution, with the electric power, steel, pulp and paper, auto and rubber industries mentioned as lesser contributors. Pollutants from natural sources (pollen, dust) were seen as much less important. Furthermore, public opinion as to the causes of pollution has changed substantially in the last few years. In 1965, 34% felt that factories and plants were an important source of air pollution, with 27% blaming automobile exhaust and 16% blaming garbage and trash dumps. By 1970, these figures had changed to 64%, 62% and 34%, respectively. In 1965, the chief causes of water pollution were seen as wastes from factories (42%), sewage (33%) and insecticides (33%); and by 1970 these percentages had increased to 69%, 58% and 46%.

As for solutions for these problems, most people felt that controlling auto exhaust, controlling chemical and industrial wastes, providing smoke control devices, enforcing present laws or passing new laws were the best ways to cure air pollution. Stopping industrial pollution, keeping sewage out of water and enforcing present laws or passing new laws were seen as the best ways of curing water pollution. Majorities of citizens did not think that industries were doing very much to control pollution, and were of the opinion that the government ought to step in and force them to stop polluting. However, about 70% of the public did not know anything at all about anti-pollution efforts in any specific industries. A majority of respondents in 1965 could not venture an opinion when asked which industries were doing the best job in trying to cut down on air pollution in their part of the country.

On the question of jobs vs. pollution, about two-thirds of samples taken in 1967, 1970 and 1971 agreed that if industry is to provide jobs in an area it is likely to cause some air pollution. However, polls taken in 1967, 1968 and 1971 found that about 70% of national samples held the opinion that a plant which continually violates laws regulating pollution should be closed down until the problem can be solved. And a poll in 1971 found 45% of a nationwide sample feeling that severely polluting plants in their own neighborhood should be closed down to stop the pollution, even if it put many of their neighbors out of work. About as many people (two out of five) volunteered that they should not have to make that choice. Unfortunately, the pollsters neglected to ask respondents how they would feel about the situation if their <u>own</u> jobs were at stake, nor was any differentiation made between respondents who actually were experiencing this problem and those who were viewing it from more comfortable circumstances (in terms of both pollution <u>and</u> employment).

A general question was asked of a nationwide sample in 1972: "what are the two or three biggest problems you feel science has created as far as you are personally concerned?" Pollution was mentioned by 45% of the respondents, and the next nearest rival was "none," chosen by 34%. Space can create health problems (a la <u>The Andromeda Strain</u>?) was mentioned by 9%, atomic bombs by 7%, man's loss of inspiration or values (4%), too much automation (4%), poor quality food (3%), drugs and control of life and death by medicine (3%), cars go too fast (2%), over-population (2%), birth control pills unsafe (1%) and insecticides used the wrong way (1%).

To summarize this section: it appears that no real effort has been made to assess the public's attitudes towards the sciences. The majority of attitude and opinion data gathered have been related to newsworthy issues only when they become newsworthy, the foremost example being "ecology." There is some evidence that opinions on this level are little more than reflections of the contents of the news media[36], and from the data presented here on the issue of ecology one could conclude that the public has a definite, if superficial and uncommitted, interest in this problem, and virtually no awareness or understanding of the scientific and technological issues involved. Since many of the people most active and vocal concerning "ecology" appear not to have any better understanding, perhaps one should not be too hard on the public in this connection.

There seems to be no evidence for any public disaffection with science and technology *per se* in the attitudinal data available on the subject. It would be interesting to ask the same attitudinal items now as were used by SRC in 1958 and 1959, to determine whether the public has changed in its general attitudes toward science and scientists. Except for a heightened awareness of the ecology issue, the public is probably not too different in its regard for science. However, since there are no comprehensive baseline data on public attitudes and opinions concerning science and technology, we really have no way of finding out how more than a limited set of attitudes has changed. The best one could do is properly measure present attitudes, then make educated guesses based on the data collected in the past.

In the social sciences, to say of a problem that "we don't yet know enough about it, we need more research" is almost a cliche. However, in most other areas, such as political behavior, race relations and education, at least there is a voluminous literature to substantiate this claim. The foregoing pages have reviewed, to my knowledge, virtually all available empirical data on public knowledge and attitudes regarding science and technology; and as far as I am concerned, they fully justify the claim that "we don't know enough, we need more research." Really, we know next to nothing about the public's knowledge, awareness and attitudes toward science and/or technology in terms of what they are, how they are determined or influenced, how they change over time, what their significance is, and what ought to be done about them, if anything.

COMMUNICATING SCIENCE TO THE PUBLIC

There has been somewhat more attention by researchers to the problem of how science is, or should be, communicated to the public. The milestone in this line of research was the survey done by SRC in 1958[37], which investigated media behavior and demographic descriptions of a nationwide sample. This study found that the public was basically favorable towards science and scientists, that education was a strong predictor of science knowledge and science interest, that print media (newspapers, magazines) were the most important sources of science knowledge, and that most people had some awareness of science in the news and wanted more of it.

While more educated people tend to know more about science, they also tend to learn more. One study[38], using data from news diffusion studies, time trends, a newspaper strike and a field experiment, found that as more science news is made available, the knowledge gap between the "well-informed" and the "poorly informed" grows. The same research team also investigated accuracy in the contents of science news articles as a function of the articles and the kinds of reporters that produced them[39]. They found that articles assigned by editors or originating from other written reports resulted in the greatest communication accuracy, with lower accuracy in articles originating from public meetings or on a reporter's own initiative. Social science articles tended to be lower on communication accuracy than either medical or other non-medical science articles. No relationship was found between readability of the articles and human interest material, and message accuracy.

Another study[40] found a tendency for science reporting in newspapers to contain more factual errors than reporting on general topics does, and that the errors predominately were in the direction of "sensationalizing" the material. Accuracy was measured by having the scientist with whom the story originated note the errors he perceived in the story. These scientists (193 of them) were also given a series of attitude items, which among other things found 92% of them agreeing that "newspaper coverage of science is important for the public," 31% agreeing that "science news coverage is generally accurate," and 65% agreeing that "too much emphasis is given by newspaper reporters to the uniqueness of scientific results."

A case study[41] was done by a group of graduate students on press coverage of environmental issues in the San Francisco area. The study approached this area from several directions, related more to the process of communication than to the effects of the communication on the public. The topics covered included sources of environmental news, editorial policies in this area, public relations tactics of polluters, and prescriptions for curbing the excesses of (institutional) environmental ad campaigns. This study was apparently done with the premise that environmentalists are the "good guys," and industries are the "bad guys," an understandable bias in light of the timing and circumstances of the study.

Several studies[42] have looked at media editors' attitudes as compared to those of their prospective audiences. The consensus seems to be that editors tend to incorrectly estimate both their audiences' interests and their capacities for dealing with science materials.

A study done in Poland[43] found that a series of popular science programs on television aimed at satisfying educational needs of listeners were more than twice as popular as a series that had been designed according to scientists' conceptions of popularization. In Poland, as in America, people with higher educations tended to watch science programs more, and this was especially true of programs popularizing science according to the specialists' concepts of popularization. The author says: "In my investigation I found that the layman is not so much interested in the knowledge integrated around individually or socially important problems, but more in the practical knowledge. The public is not composed of persons in search of knowledge for the sake of knowledge." Data already presented suggest that this would apply as well to the U.S. public. Allowances should be made for the somewhat broad definition of science used here. In general, science seems to be more broadly defined among Europeans than among American scientists.

One pair of studies[44] found that stylistic variables do have significant influences on audience effects such as information gain, enjoyment of the material, attitudes toward specific areas of science and impression of difficulty of the material. Without changing the content of articles on enzymology, polymer chemistry and plasma physics, it was possible to manipulate variables such as sentence length, percentage of science words, vocabulary difficulty, and expository devices such that better (or worse) communication of science resulted in audiences of junior college and university students. However, the textual manipulations made no difference to an audience of professional scientists.

The Summer, 1963, issue of Journalism Quarterly was devoted almost entirely to science in the mass media, with articles focused mostly on the process of communicating science to the public[45-52]. A later study[53] noted the large amount of coverage given the Gemini space shots, and another[54] analyzed stylistic levels of writing aimed at audiences of different levels of education.

Mental health is not generally thought of as an area of science in the same sense that physics, biology, etc. are. However it is germaine here because a comprehensive study was done in the 1950's on popular conceptions of mental health and strategies for changing public attitudes concerning mental health and its treatment[55]. This study, practically a microcosmic example of what ought to be done with regard to the entire area of public understanding of science, systematically explored existing states of public information and attitudes, what experts in the field of mental health thought, the picture of mental health presented in the mass media, and the effects on knowledge and attitudes of various strategies and styles of communication. The study found that the public was not so much misinformed as <u>un</u>informed about mental health, that public attitudes were amorphous and weakly held, and that the public was receptive to more information in this area. However, the mass media presented information about mental health that generally tended to be more entertaining than factual and was further afield from expert opinion even than what the public believes. Information, even when oversimplified or downright incorrect, was found to improve public attitudes about mental health. Some terms (e.g., "insane") were found to lead to less favorable attitudes than others (e.g., "emotionally disturbed") and thus were detrimental to effective communication. Certainty of information, the presentation of solutions, a positive tone and an easier writing style were all found to contribute to better attitudes in the area of mental health.

Although the communication research literature abounds with evidence that mass media publicity campaigns have limited influence, let us end on a positive note with two studies that give us hope. One[56] concerns an intensive media campaign on mental retardation in a Wisconsin community involving numerous news stories and feature articles, radio spots, speakers at clubs, items in church bulletins, posters, displays and "Mental Retardation Week." This campaign was successful in bringing about large gains in information on the topic of mental retardation and in fostering more positive attitudes (there was a positive correlation between information gain and attitude change among the people tested, as well). The author's conclusion is that successful campaigns such as this may well be limited to topics on which informed people are unlikely to differ--but certainly there are areas of science of which this is true.

The other study[57] describes several successful public information campaigns, and offers the following prescriptions for others who seek the same results: (1) settle for a specific target audience--don't expect everybody to be interested, (2) aim for middle-range goals such as heightened awareness, information gain or a moderate level of behavioral response, (3) analyze your target audience thoroughly and tailor the message to <u>it</u>, (4) involve both communications researchers <u>and</u> practitioners, in the process of producing the material, and (5) in evaluating the campaigns, pay as much attention to delineating specific aspects of the communications process which contribute to success, as has been previously allotted to demonstrating failure.

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WHY SHOULD THE PUBLIC "UNDERSTAND" SCIENCE?

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WHY SHOULD THE PUBLIC "UNDERSTAND" SCIENCE?

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INTRODUCTION

American tourists in America

In this brief note I want to put down some thoughts in answer to the very legitimate question posed in the title, and to attempt to do it in a systematic manner starting with the most general reasons and moving to the more specific. The question is not posed in the abstract but in the concrete cultural situation of the USA in the early seventies, and before attempting the answers it is necessary for any observer to provide his picture of this situation.

"Tourists in their native land:" that is the situation, I believe of most Americans with respect to their total cultural milieu. Those tourists who have been to London or New York a half dozen times, and have become familiar with all the mechanical necessities for the comfortable operation of their visits - are my models for such "tourists." Such "tourists" have become thoroughly familiar with JFK or Heathrow, the 'hotels in the right price range, the most suitable restaurants for lunch and dinner, the interesting museums and escape resorts, best ways to get theatre tickets, etc. They are thoroughly at home in the city for a week and even take a proprietary pride in it back on their home turf in Los Angeles or Keokuk, Ill. Yet they are by no means "natives." They have no concern about or understanding of the 'soul' of the city. They are unfamiliar with the unmelting pot of traditions, of what it meant to be a Jewish lad at bar-mitzvah time in Brooklyn or part of the less mobile German community in the east eighties or the patrician WASP establishment. The tourist does not need to know what makes the city tick. He is unconcerned with the politics of Tammany Hall or the traffic problems created by the World Trade Center to enjoy and utilize all that New York can offer him: The tourist of course need not, while being a citizen requires that one know his city in this way. Does the American citizen know his 20th century culture? I submit that he does not and is, in fact, a tourist in it.

The philosophical vacuum

It is the principal thesis of this proposal that one of the most deep-seated problems of contemporary American society is the failure of that society to assimilate the scientific world-view into its psyche while so much of its economic, social and even political life have been dramatically altered by (and are now wholly dominated by) the fruits and faults of that same science.* We assert that the problem of the alienated younger generation[1] is but the most vivid manifestation of the profound dis-ease and malajustment felt by a much wider segment of society. This is a society that cannot comprehend most of our science and technology - and hence are afraid of it and cannot fail to control it for the benefit of man. We claim that while it is of great importance that our society get on with the job of ameliorating the neglected or impacted areas (where the harmful effects of science and technology have been poorly managed) it would be extremely short-sighted if we limited such concern only to the symptoms, but took no action at the root cause of our malaise.

One does not need to take as critical or pessimistic a view of technology as Jacques Ellul[2] to assert that part of the general problem of our society is that the basic processes of democracy are being obsolesced by the pervasive ignorance and misunderstanding of some of the most important forces shaping our lives. How can a democracy function when the elector is unable even to understand the complexity of many of the issues facing it, and the demagogue can capitalize on over-simplifications which distort the issue out of recognition. There is little doubt that new forms of the democratic process itself may have to be developed, but in none of these areas can we hope to make substantive progress till the blight of cultural illiteracy is removed from the land. Tens of millions of children go through high school, millions graduate from college, thousands become professors and priests and legislators and executives, believing

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[1] In a recent article by Bruno Bettelheim, Encounter 33, p. 29 (Sept. 1969), the theme is developed that it is the dominance of a complex technology in our culture that has made the younger generation feel superfluous and hence 'alienated.'

[2] The Technological Society; Alfred A. Knopf, Inc., New York (1964).

* We will use 'science' to cover the "science-technology" blob perceived by the general public.

in the crudest eighteenth century picture of a closed system of scientific facts, and neither understanding how a light bulb works nor how space ships are powered. The same people wield enormous power over the few who understand the issues. This is not new in history: illiterate kings and generals have long dominated the learned ones - it is only strange that we should for so long have tolerated the evil of such "illiteracy" in a world so fervently committed to education. The public's education in, and understanding of science as part of the whole of man's knowledge is hardly the icing on the cake of education, but sits at the long neglected core of the whole enterprise of "seeing large the things which are large."

Status of science in the U.S.

Subjective views and scattered observation suggest that the national climate for science has not been as low at any time since WW II as it is now. This is caused in no small part by the careless rhetoric of politicians and the press. Even the successes of the scientific enterprise have the unhappy consequence of widening the chasm between the scientific community and the non-technical segment of society. It is becoming increasingly apparent that unless this gap is bridged by wholesome communication and interaction between the two 'cultures,' the pace of scientific progress will be greatly reduced, possibly to the detriment of mankind in view of the physical requirements for survival of mankind on earth.

The interpretation of science to the many special publics which constitute a nation, the balanced explanation of science's potential for serving mankind, its limitations and its problems, needs many attempts and diverse strategies. There are no well-trodden successful paths. What is needed are wide-ranging studies of the useful content and methodologies of communication of that "science" which each segment of the Public can both understand and effectively utilize.

Present activity in the field

It is fair to say that the total activity in the field is so small as to be nearly zero compared to the effort required. For a total national R & D effort of 25 billion, the identified programs on the Public Understanding of Science, (chiefly in the NSF and the Sloan Foundation) amount to less than $1 million per year. To this must be added much of the understanding and misunderstanding conveyed by company and commercial advertising. The types of "P.U.S." programs range from publishing magazines (e.g. Environment) to summer courses for special groups, training in science writing, TV specials, newsletters, environment-action programs, etc. In most instances, however, the effort operates at the point of one issue (e.g. pollution) rather than on a broad scope. Furthermore, these efforts are reaching a very small number of people and a limited segment of soceity. Such efforts overlie the main contribution to such science-understanding which should come via the public school system.

Why single out science?

The claim that the various publics are "illerate" about science is not unique. They are perhaps also equally uninformed about art or philosophy or history. Should not these areas receive as much emphasis as science? A justification that "science" deserves a special place may perhaps be made on the basis of the following arguments:

(1) Our total culture with which inhabitants come into some equilibrium over a period of generations has a myriad way of achieving this "education." The laws, mores, customs, the myths and legends, the architecture and the art are all such cultural enforcers which demand such an adaptation. But science has not yet seeped deeply into culture so that these many other channels by which the public could acquire an understanding are not yet available.

(2) The context of most formal vehicles of the most general education changes relatively slowly. It is in the area of science and technology that exceedingly rapid change has occurred in the last few generations and hence even if all change were suddenly frozen, it would take a generation or two to find the appropriate content and the best means for its delivery in communicating science. Instead of being frozen the rate of change itself is increasing. Obviously also, with such rapid change, the twelve years of formal education are but a snapshot of the moving stage of history and the need for continuing

education is most acute in this area where todays relevant material may not have been even conceived a decade or two ago.

(3) "From each according to his abilities, to each according to his needs." This Biblical original of the Marxist maxim is cited by our colleagues in Poland as their guideline in selecting what science the public should know about science. The public involved should know that science which it needs. The man in the street needs to understand the rudiments of the operation of his household gadgetry, something about the broadscale issues of environment or defense. Most importantly he needs to come into an accurate affective relationship with this worldview rooted in his own traditions yet threatening many of them. That specialized public - the legislature - needs in addition a much more detailed understanding of certain parts of science or technology, and especially of the complex interweaving of science with the economic and social fabric. Why single out science? Because in a mundane, utilitarian sense the various public(s) need it for their day-to-day operation.

(4) A fourth reason is another aspect of 'need.' In a world of inter-cultural competition, national health and survival - emotional, economic and social - may well depend on how well and how fast a nation adjusts to the moving escalator of science and technology. There is no grounds for complacency that because the U.S. once led and even shaped this adjustment that we are doing as well as many other cultures now.

(5) A final reason is implicit in our thesis that one part of the alienation, the national anomie, is caused by the average man's failure to come into a more wholesome relationship with his culture. Here the 'need' is more subtle - it is not a felt need. This is a matter of judgement which only the national leadership can render and act upon. If "doing science" is modern man's ~~s ca~~thedral building, if there is no return to the simple man-nature relationship but one must bring the scientifically enlarged perceptions to fully appreciate, and design a contemporary man-environment symbiosis, then all the publics need a much deeper appreciation of science than they now have. This is not to answer that other needs do not exist. (I, personally, would say that an analogous need exists even more intensely for a contemporary national working philosophy to update or replace the Judaeo-Christian framework of culture which is slowly being eradicated from within.)

SUMMARY

In answer to the question posed it has been asserted that:

1. The general public of the U.S. does not understand a large part of the physical, cultural and philosophical world in which it lives; and that contributes to a national impedance mismatch between people and their own culture.

2. That the effort to eliminate the ignorance or 'illiteracy' of the various publics - general, opinion formers, legislators, etc. - is pitifully small and hence the attitudes of these publics is subject to non-rational change.

3. The reasons developed why science deserves special attention at this time in history (since the publics may be equally ignorant about philosophy or art) are:

a) Because science is such a recent human activity it does-not yet have the many ways of being infused into the life of a people that the other fields have.

b) Because science expands and changes so fast (absolutely and as compared to other fields) it needs special vehicles to reach the many publics with whatever cognitive or affective learning desired or needed.

c) Because the general public and special publics (such as legislators) need more science understanding for the conduct of daily affairs (in a way which cannot be claimed for other fields).

d) Because international 'rivalary' and 'competition' force each culture to come to terms with the international unifying econo-technical environment, and we could be far behind already.

e) Because'doing science' is modern man's cathedral building and he 'needs'it - along with other activities - for spiritual survival.

PROBLEMS, PUBLICS, AND STAGES OF DEVELOPMENT IN PUBLIC UNDERSTANDING OF SCIENCE

by

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PROBLEMS, PUBLICS, AND STAGES OF DEVELOPMENT IN PUBLIC UNDERSTANDING OF SCIENCE

Introduction

The research questions we ask are to a substantial extent determined by our conception of what it is we are studying. And yet, if one looks at the literature of public understanding of science, from survey research on the one hand to what Polykarp Kusch calls "ceremonial oratory" on the other, we see that there has been very little effort to describe what is meant by "public understanding of science".

The most common assumption equates public understanding of science with a knowledge of facts. This carries with it the belief that facts determine action, and that if we could teach people more facts of science, a whole series of problems would be taken care of, from support of basic research to smoking to water pollution.

But is this really what we mean? Obviously, facts are an element in any kind of science-related situation. But what facts? A knowledge of science as a whole? Of physics? Of the effects of DDT on the golden eagle? And who says they are facts? How accurate are they really? And what about attitudes? And who wants what facts communicated for what reason?

When one starts asking questions such as these, it becomes rapidly apparent that describing public understanding of science is more complex and difficult than it seems at first glance. In this paper, I would like to propose a preliminary and tentative description which will perhaps suggest some research questions that might not have been asked before, and which may serve as a starting point for a more careful consideration of the whole question of definition.

One Possible Definition

What does the phrase "public understanding of science" mean? Taken literally, the three key words might be defined as follows.

The "public" is the population of the country, roughly 200,000,000 people, with about 150,000,000 adults and about 50,000,000 young people under 18 years. The adults can be grouped into a number of subpublics: men, women, Democrats, lawyers, purchasers of aspirin, people with cancer who don't know it, readers of newpapers, mayors of small towns, or conservationists. The young people can also be grouped into subpublics: boys, girls, students enrolled in high school physics courses, members of science clubs, future nonscientists, drug users, or high school dropouts.

The "understanding" that the public is to have is that which is sufficient to achieve some purpose, the purpose usually carrying with it the implication of some effect, some action such as supporting basic research, getting a chest X-ray, stopping smoking, voting, writing a letter of protest, appropriating corporate funds for pollution control, or using a less dangerous pesticide. These actions fall into several categories. The first is individual voluntary action, brought about by simple information or by persuasion. The second is action brought about by a change in the environment, such as with a car with a buzzer that won't stop until the seat belt is fastened. And the third is one in which the action is brought about by coercion, such as the threat of fines in water pollution control.

"Science" is first of all a body of knowledge which is the equivalent of some 10,000,000 books on science and its applications. This body is increasing at a very rapid rate, perhaps 1,000,000 book equivalents per year. However, science is not just knowledge. It is also a methodology, an assortment of procedures and techniques enabling the scientist to theorize, study, experiment, predict and verify. Science is also a philosophy and ideology, a way of looking at the world and the people and institutions in it. And science is a social institution, made up of people and organizations of a widely varying nature.

Today it is necessary for the citizen to understand far more than pure science, for the impact of science arises from its uses. And so when we say public understanding of science, we often mean an understanding of the uses of science in engineering, medicine, agriculture, and increasingly in technology as well. Technology is the application of knowlege to practical purposes. It can be thought of as a tool, as a body of knowledge developed for specific purposes, or as a methodology which can be brought to bear upon a specific problem.

Thus, taken literally, "public understanding of science" might be defined as the job of putting everything we know about all aspects of science and its uses into the minds of 200,000,000 persons in order to bring about a wide range of voluntary and involuntary actions. Such a definition is so all-encompassing that it is useless for most purposes, and so we must look for means of intellectual organization which will enable us to sort out and arrange the large number of elements involved into some sort of more meaningful relationship.

A Proposed Model

One means of intellectual organization is a social model. The one that I propose assumes that the chief need for public understanding of science is because there are important problems which a better understanding of science on the part of the public might help to solve. Thus, the science-related problem is the key element in any consideration of public understanding of science (see Appendix A for a list of problems), and the proposed model focuses on how a problem appears and is handled in society. The model is one which is equally applicable to the individual, but in this paper I shall concentrate on the aspects dealing with society.

A problem involving public understanding of science is not a single event taking place in a short period of time, but rather something which gradually develops, is recognized, and is dealt with in some manner. Sometimes the problem continues despite the action taken, sometimes it disappears, and sometimes it disappears to reappear for the whole sequence to take place all over again. The entire public never participates in considering and dealing with problems at any stage. Instead, portions of the public are involved at varying times in different ways and to varying degrees depending upon the problem.

The proposed model suggests that the development of any particular problem in society involves six key stages in which five different publics are involved.

The six developmental stages are the Preparatory Stage, prior to the recognition of the problem; the Problem Definition Stage, in which the problem is recognized, defined and accepted as a problem; the Solution Formulation Stage, in which alternative solutions are proposed; the Decision-Making Stage, in which a solution is accepted; the Implementation Stage, in which the solution is applied; and the Evaluation Stage, in which it is decided whether the solution has successfully solved the problem.

In each of these stages, there are varying degrees of involvement on the part of portions of five different publics. These publics are the Leadership Public, made up of national, state, and local leaders; the Communications Public, made up of members of the mass media, educators, members of the church, and so on; the Interested Public, made up of persons who are interested in and pay attention to some aspect of science; the General Public, made up of the majority of adults; and the Young Public, made up of persons under 18 years of age.

Of course, the whole business is never as clean and simple as the description. Solutions may be formulated and decisions made before the problems are clearly understood, as in drug abuse. Decisions may be made before adequate solutions have been formulated, as in automoblie pollution control. But even in these cases, a consideration of the various stages and various publics does enable one to see the whole problem more clearly.

The Five Publics

The Leadership Public

The Leadership Public consists of the President of the United States, members of his Cabinet, the Congress, state governors and legislatures, top level management in industry and business, top labor leaders, high placed educators, church leaders, and so on.

Bell, Hill and Wright, in their book on Public Leadership (1) divide public leaders into those with positional or formal leadership (elected political leaders, higher civil servants and political appointees, business leaders, military leaders and officeholders in voluntary associations), leaders identified on the basis of reputation through the opinions and judgements of others, leaders identified on the basis of social participation, leaders identified on the basis of personal influence or opinion leadership, and leaders identified on the basis of their being involved in key decisions at a community, state or national level.

The number of persons in the Leadership Public would depend very much upon the extent to which one includes personal leadership on a local level. Let us simply assume that there are 1,000,000 persons in the Leadership Public.

The Leadership Public has the following characteristics:

1. It is an extremely heterogeneous group.

2. The leaders are often different for different problems, and there is not a great deal of overlapping.

3. Leaders probably receive a much greater proportion of their information on an informal or face-to-face basis than do most of the rest of the public (advisors, testimony, committee meetings, knowledgeable acquaintances, etc).

4. Most of the leaders do not have a very good background in science, though it has improved over the past few years.

5. Leaders are interested in solving the problem, and science is generally a means to an end.

6. Leaders tend to move only after some group has defined the problem and offered some solution.

The Communications Public

The Communications Public is made up of persons in the mass media (newspapers, magazines, books, radio, TV, films, recordings, museums, etc.), persons in education (elementary, secondary, university, university extension, industrial training, etc), the church, agricultural extension, doctors, dentists, and by no means last, scientists and engineers.

Again the number in the group is subject to variations depending on one's definition. Let us assume that there are about 5,000,000 people in this group.

The Communications Public has the following characteristics:

1. It is an extremely heterogeneous group.

2. The members play a double role - that of receiving communications, and that of selecting, repackaging, and recommunicating.

3. Their understanding of science varies tremendously.

4. Their reasons for communicating vary tremendously.

5. The audiences which they address may be quite different, or may have extensive overlap.

6. The group has many of the same characteristics as the Interested Public, and when not playing their communications role, could be considered a part of the Interested Public.

The Interested Public

The Interested Public tends to be made up of the better educated higher income segment of the public, and contains the persons who are more interested and active on a local, state and national level. These persons are important in that they are the influential-group to whom the leaders speak, and who both respond to the leaders and communicate down to other members of the public.

About 20% of adults have been to college for one year or more and about 10% have undergraduate degrees. Since education is one of the prime predictors of interest, we can estimate that the Interested Public is perhaps 20% of the adult population, or 30,000,000.

The Interested Public has the following characteristics:

1. It tends to be well-educated. As Schramm and Wade (2) comment, "When persons have had less than a high school education, they have apparently picked interests and skills that lead them to continue seeking information and enable them to understand."

2. It has a better than average knowledge of science. Again quoting Schramm and Wade, "So powerful is education as an indicator of public knowledge, from it alone one can predict as much as from all other demographic characteristics."

3. While it is not homogeneous, it is the least hetereogeneous of

all of the publics.

4. It tends to specialize in problems (conversation, etc) and is not equally interested in all problems.

5. It is the principal consumer of the mass media with the exception of commercial television.

6. It does contain some people who are not well-educated but who are also interested in science. It is not known how people acquire such an interest.

7. It is the chief recipient of the science information now being communicated.

8. It is not representative of the public as a whole, being underrepresented in terms of women, blacks, Chicanos, the young, etc.

The General Public

The General Public is made up of all other adults, and contains a wide range of individuals who have on the average less education and less income than the other publics mentioned.

By subtracting the numbers in the other categories, we can arrive at roughly 115,000,000 persons in the General Public.

The General Public has the following characteristics:

1. It is the most heterogeneous of all the publics.

2. It is not well educated as a whole.

3. It does not know a great deal about science.

4. It is not very interested in science.

5. It is the major consumer of commercial TV, reads some newspapers and magazines, and reads few books.

6. It is usually not the group reached or involved when someone is communicating to "the public".

7. Its principal means of feedback is through the public opinion poll. It tends to be apathetic about most issues and not active.

8. Its attitudes are relatively stable and hard to change.

9. It tends to look for cues and mood responses in communications rather than facts - in other words, it listens to tone rather than content.

10. The activities that one individual member has in common with other members are watching TV, voting, purchasing and using new products, having children, working, etc.

11. It tends to turn to leaders for guidance on public issues.

12. It is more interested in football, food prices, new styles, TV stars, etc.than in science-related problems.

The Young Public

The young public is made up of all persons under 18, admittedly an arbitrary definition. This includes young people in school, those working, dropouts, and those too young to go to school. It includes about 50,000,000 individuals.

The Young Public has the following characteristics:

1. It varies widely in years of education and in sophistication and interests.

2. Its two major waking activities (except for the very young) are going to school and watching TV.

3. It is a major consume of TV but does not read much until high schoo. It probably reads less than previous generations.

4. It starts out without any knowledge of or attitudes toward science.

5. It feeds into the general public and the interested public at a rate of about 3,000,000 per year.

6. It is a very different group from persons of similiar age 20 or 30 years ago.

The Stages of Development

The Preparatory Stage

The Preparatory Stage is one in which the individual is doing at least two things. First, he is storing up information for possible use later on. Some of this he selects deliberately because he believes it will be of value. Other information he simply acquires because of intellectual curiosity and the satisfaction of knowing. Secondly, the stage provides a frame of reference for evaluating information and problems or questions. No person can be knowledgeable about everything, nor can he be concerned about everything. This stage helps him to see the total picture, and so to put problems in some sort of priority, deciding what he will pay attention to and learn about.

For the young, most of this stage involves his formal education, and to a secondary degree, the messages he receives from the mass media. For the adult, most of the information comes from the mass media.

Based on what we know about the impact of education, we can suggest that the most active persons in the Preparatory Stage are those with a college education - thus those in the Leadership, Communications, and Interested Publics and older members of the Young Public. It should be noted that even though these people may have had an education with some science in it, new developments in science and the applications of science are occurring with such rapidity that they must keep up, for much of the science they need to know will have been discovered and used after the completion of their formal education.

The Preparatory Stage is highly important in that the more prepared the members of the public are, the better able they will be to assimilate the new information which they will need to deal with some particular problem, and the more rapidly they will be able to do it. If their preparation is not adequate, it may be that they will not have the time or energy to be able to learn the necessary new information, and consequently will not be able to participate actively in dealing with some problem.

For this reason, a large portion of the total public simply does not participate at any stage of the development process until the Implementation Stage (as targets for change), and even there, lack of background knowledge may prevent them from assimilating and using new information necessary to carry out a solution to a problem.

The Problem Definition Stage

The basic need for public understanding arises from some sort of a problem. The problem might be physical, as with dental caries, to be solved by fluoridation; or it might be psychological, a feeling of uneasiness because a person does not understand what is going on in a rapidly changing world. It might be an actual problem, such as water pollution, or it might be a potential problem, as with genetic control.

A problem may have existed for a long time, but it does not get attention until it bothers enough people sufficiently for them to want to do something about it. At this point, there needs to be a definition of the problem -- causes, effects, persons affected, etc. There are a number of groups which define problems for us - the mass media, study committees, societies, citizen groups, youth groups, etc. One of the most interesting developments in public understanding of science is the growth in the institutionalization of problem definition. There are now groups which do nothing else, ranging from the Institute for Ethical Problems in Science to Public Interest Research Groups to the newly-formed Office of Technological Assessment.

An important aspect of problem definition is to get the problem clearly defined. For example, there still exists great differences of opinion as to what constitutes drug abuse. And there was a great deal of difference of opinion regarding the potential dangers of sonic boom and pollution of the upper atmosphere resulting from the use of supersonic transport planes.

In the past, most problem definition was focused on current problems, ones which were causing difficulties at the present time. However, there has been an increasing demand for definition prior to the actual fact, so that the problem can be dealt with by simply not permitting actions which would bring it about. The Office of Technology Assessment is an organization which defines prior to the existence of a problem.

There also may be problem redefinition, where there is a disagreement with a previous definition of a problem. Now an increasing number of experts are saying that marijuana is not as dangerous as previously thought, and that consequently the solutions formulated and decisions made are not correct. Redefinition is extremely difficult, as apparently once a problem definition is accepted, there is great resistance to acceptance of a new definition.

A very important aspect of problem definition is gaining acceptance, that is, getting a sufficient number of people to accept the fact that there is a problem as defined. This is not simple or easy to achieve. First, there are many problems already, and many groups interested in the solutions to the problems. Thus, they do not want more problems, since these might intefere with the plans they have made for the solution of their problems. In addition, there are other problems being defined concurrently with other groups pushing for their acceptance. Lastly, there are too many problems already for most of us, and we don't want any more if it is possible for us to deny or ignore them.

A great deal of data may therefore have to be gathered, and many arguments made before a problem becomes accepted. It is interesting to speculate on how problems become accepted, and what the threshold level is. For example, there had been much writing and discussion about pesticides before Rachel Carson published Silent Spring. Why did this book have the impact that it did? Was it timing? Was it the preparatory communications? Was it the quality of the writing?

There also can be organized resistance to having a problem accepted. This was the case with pesticides. It was also the case with the SST, in which a number of industrial and business groups tried to disprove the contentions that there would be enough sonic boom damage or upper atmosphere pollution to constitute a problem.

Acceptance of a problem comes when enough persons agree that the problem exists and that some action should be taken to alleviate it or prevent it. Acceptance is gained through a number of means: rational arguments through reports, speeches, newspaper articles, magazine articles, etc., actual events confirming rational arguments (earthquakes, increase in cancer of the lung, viewing a polluted river, etc.); irrational arguments (predictions or catastrophe, appeals to prejudice, etc.), and possible gain on the part of an individual or organization (sale of pollution equipment, increased appropriations, etc.).

It should be noted at this point that the "public" does not define problems nor does it participate to any great extent in the definition. This is true even in the cases where the entire population might be affected. It seems that for each problem, there is a group of definers with a segment of the interested public and the communications public who work to try to get a large enough segment of the population to accept the problem so that the leadership will be willing to support action. In this regard, groups that define problems are not necessarily those who will be entrusted with the responsibility for carrying out the solution.

The Solution Formulation Stage

Solution formulation involves deciding what should be done once a problem is accepted. Solutions to problems are formulated by competing groups, usually from the leadership and interested publics. For example, in the case of pesticides, these groups included conservationists, the Department of Agriculture, industry, some scientific societies, scientists, Congressional committees, and consumer groups. For a different problem, most of these groups would be different.

The competition among alternative solutions generally takes place through the media and through personal communication (speeches, testimony, etc.). It involves individuals from the leadership public, the communications public, and the interested public. The number and mix vary with the problem.

It is important to note that here again, the public as a whole does not participate in solution formulation, but at best, selects from a variety of alternatives offered. Even then, most of the public does not participate, but rather only those interested and concerned, drawn largely from the Interested Public. The public as a whole accepts a particular alternative solution unless it is exceptionally undesirable, relying on the leaders to make the final decision.

At a later date, the public or some portion of it may decide against the solution or resist it. In some cases, this is because the solution formulation took place without public knowledge (the knowledge of groups interested in the problem) or because the solution was not adequate, as in the case of cigartette smoking.

Solutions can vary widely, and may be aimed at bringing about changes on the part of a relatively small or very large group of persons. These persons may include the ones who propose the solution, but in many cases, they do not, as with drug abuse. It is important to emphasize that solutions may involve something other than communicating science information to the public, as in the case of legal controls on pollution or a buzzer in a car to force the use of seat belts.

The kinds of actions involved in solutions include:

- Voluntary individual action, such as taking birth control pills, stopping smoking, using non-leaded gasoline, or eating a varied diet. Persons may take these actions because of factual information given to them, or may only do so after being subjected to some form of persuasive communication.

- Involuntary individual action, such as fastening a seat belt to stop a buzzer, drinking fluoridated water because there is no other choice, or not using as much electricity because the power is cut off. The reason for such action can be a change in the environment (fluoridated water) or coercion (laws, higher prices, etc.).

- Organizational action, such as a company installing pollutant emission control equipment, spraying for the gypsy moth, or cutting back on nuclear warheads. Action can be voluntary or the result of coercion.

Most of the thinking about solutions in public understanding of science tends to be in the area of voluntary actions brought about by communicating factual information or by persuasive communications. Since the desired results often involve getting people to change habits or do something which they don't particularly want to do, many of these communications solutions have not worked. It is not possible to say at this point whether the solutions themselves were unrealistic in view of our present level of ability to communicate, or whether change simply cannot be brought about by communication. But it suggests that while people may not be able to act without information, more than information may be necessary to bring about change.

The Decision-Making Stage

The general acceptance of a solution does not mean that action will be taken. Action only follows some sort of decision-making, that is, a decision to carry out a particular solution.

Decisions may be made by organizations other than those who carry out the implementation, or they may be made by the same organizations which will carry out the implementation. In the first category are Congress, the courts (by legal decisions), a foundation which provides funds for a program, etc. In the second category are scientific groups, citizens groups, industrial corporations, Federal agencies, etc.

The decision-making may be on an open basis, with discussions in the media, meetings, etc., or it may be done on a closed basis, with the decisions made internally and only the results being communicated. In this latter case, the decision is usually made and then presented to the public in an attempt to sell it as in the case of the Department of Agriculture fire ant program or in the case of siting of some nuclear plants.

Again, the public at large does not participate in decision-making. If the decision is an open one, there will be involvement with some part of the leadership, communications, and interested public. In the case of a closed decision, only a portion of the leadership public will be involved until the decision is announced. At this time, there may be negative feedback on the part of the communications and interested public, depending upon the decision and the manner in which it is presented. But at no time does the public at large participate.

Implementation

Implementation involves the carrying out of the action described in the solution, and decided upon in the decision-making. This stage is by far the most varied and complicated of all stages.

Implementation requires a plan, an organization to carry out the plan, and funds. The purpose of implementation is to bring about some desired action on the part of some portion of the public. This action may be voluntary or involuntary, and may involve individuals or organizations.

Voluntary action takes place because of some sort of incentive that is strong enough to bring about the required action. Such incentives include satisfaction, recognition, imitation, self-protection, safety, tax incentives, duty and ethical values. As previously indicated, these actions may be based on factual information or on some form of persuasive communication.

Involuntary action takes place when there is no other choice, because of the threat of a mild annoyance, or because of the threat of a major sanction or punishment. The causes of involuntary action include modifying the environment (fluoridated water), mild annoyances such as seat belt buzzers and possible punishments such as fines or jail sentences.

In the cases of both voluntary and involuntary actions, there may be resistance caused by "disincentives" such as apathy, loss of self-esteem, cost, dislike of social change, habit, etc.

It can thus be seen that in solution formulation and in implementation, we must focus not only on the scientific information that is essential to the solution, but on the social, psychological and economic elements that act to facilitate or prevent change. Most of the thinking about public understanding of science has assumed that facts dictate action, and that people will react logically to facts. In many actual cases, the situation is just the opposite, as with smoking.

There are other potential blocks to implementation. There may have to be a new organization to carry out the program (such as the Environmental Protection Agency). There may be research needed in order for the program to operate effectively (just what level of radiation is safe?). There may have to be equipment or chemicals or some other materials for the program (X-ray machines, pollution monitoring equipment). And people may have to be trained to carry out the program.

Evaluation

In any sort of program, evaluation is important to determine the degree to which the problem has been solved. One of the most important aspects of evaluation is the person or organization deciding on what success implies and whether success has been achieved.

One of the most important points of view is that of the persons who defined the problem. However, there may be other groups whose definitions were not accepted, and so they may not wish to accept success as accepted by the original problem definers. A second important group is that formulating the solution, and again, if there were competing solutions, there may be difficulties in accepting an evaluation. The group implementing the solution of course has a very great concern about evaluation, and depending on how successful the program was, may or may not accept the evaluation. And of course, there is the target group, and all or part of the various publics.

The point here is that evaluation of the solution of a social problem is not a straightforward scientific process, but rather some may involve a considerable amount of disagreement and argument.

Another important aspect of evaluation is the criteria of success that are used. The total estimate of success comes from an evaluation of both the benefits and the costs of the program.

Benefits can be defined in a number of different ways. The first major category is where an actual change takes place in terms of behavior, environment, quality of life, etc. Here we could measure such things as number of deaths, number of injuries, illness of various sorts, days lost at work, smog level, types and amounts of contaminants in the water, noise level, food eaten, cigarette sales, birth rate, birth defects, etc.

A second category of benefits are not really direct, but imply that something beneficial will happen. These include knowledge of facts, attitudes toward science or technology, amount of science in newspapers, content of science coverage in magazines, tone of science coverage in newspapers, minutes of science on TV, type and number of books published, etc.

Costs can be put into two different categories. The first involves anticipated costs, those taken into consideration in the solution formulation stage. These might include dollars spent, radiation, increased possibility of accidents, reduced agricultural production, increased population, longer travel time, illness, etc.

The other category of costs are unanticipated costs or "side effects". These can include poisoning of birds, poisoning of human beings, birth defects, lingering death, having to decide whether to have a baby or not, blocking of communications, food shortage, etc.

With the large number of possible benefits and costs in any particular problem, it is often the case that only one aspect of the problem is evaluated at any time. Thus, evaluation is not something that is a single discrete event, but rather something that takes place over a period of time which for some problems can be considerable.

Some Conclusions

A description (rather than a definition) of public understanding of science has been presented, suggesting that the key element in public understanding of science is the problem, and that this problem is dealt with in a series of stages by individuals and groups from a number of different publics. The description given suggests a number of conclusions.

1. Public understanding of science is far more complex than is generally assumed.

2. The chief participation in public understanding of science comes from the Leadership, Communications, and Interested Publics. The General Public or the public at large participate very little. (For a more detailed analysis of this and a number of other relevant points in the field of foreign policy, see The Press and Foreign Policy by Gabriel A. Almond, Frederick A. Praeger, New York, 1960, and The Press and Foreign Policy by Bernard A. Cohen, Princeton University Press, Princeton, 1963).

3. There is not an equal need to understand on the part of all people. Different persons need different information at different times for different reasons.

4. Some stages of the public understanding of science process involve very few people.

5. Different portions of different publics are involved in different problems. The problem to a substantial extent selects the publics.

6. Some important stages of public understanding of science take place between the Preparatory Stage and the Implementation Stage. Previously, the focus has been on Preparation and Implementation (communicating science information) and the other stages have been taken for granted or ignored.

7. There is an increasing interest today on the Problem Definition Stage, particularly on defining problems ahead of their actual occurrence.

8. Solutions to science-related problems involve a lot more than the communication of science information.

9. There is not a limitless need for all information, but rather a need for a general base level for a wide range of information plus selective need for limited specific information.

* * * *

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Appendix A

Some Problems Involving Science and Technology

- Energy supply
- Raw materials supply
- Food supply
- Hunger
- Nutrition
- Environment
- Conservation
- Air pollution
- Water pollution
- Noise pollution
- Overpopulation
- Birth control
- Unemployment
- Working conditions
- Technological obsolescence in job
- Atomic and nuclear weapons
- Chemical weapons
- Weather control
- Radiation and fallout
- Smoking
- Fluoridation
- Old age
- Death and prolongation of life
- Health
- Race prejudice
- Mental health
- Genetic control
- Genetic counseling
- Control of the mind
- Educational technology
- Testing and surveys
- New consumer products
- Image of science and technology
- Lack of basic research funds
- Impact of science on religion
- Transportation
- Biological weapons
- Wiretapping and privacy
- Siting of nuclear reactors
- Alcohol
- Drugs

PUBLIC UNDERSTANDING OF SCIENCE:

THE PROBLEM AND THE PLAYERS

Richard E. Stephens
Program Manager
Office of Public Understanding of Science
National Science Foundation

PUBLIC UNDERSTANDING OF SCIENCE:

THE PROBLEM AND THE PLAYERS

Science today seems to be under increasing challenge from within and without. Recent years have seen mounting criticism from within the scientific community, primarily by young scientists, of the whole course and direction of science and scientific research in this country. The attitudes of the general public towards science, on the other hand, range from outright indifference to aggressive criticism of priorities, funding levels, and even specific areas of research. A recent Harris survey, although suffering from the same problem as other general surveys of its type, indicated that two-thirds of those surveyed had little or, at the most, only moderate "faith" in the scientific leadership of the country.

One of the interesting studies which should be undertaken, probably either by an anthropologist or a social psychologist, is why scientists, as individuals and as a community, are so notoriously "thin-skinned" and tend to over react when it comes to both criticism and what is perceived as a lack of understanding (appreciation?)on the part of the lay public. Science, like medicine and war, is believed to be too "complicated" to allow the non-professional laity to rule upon it. On the other hand, the increasing problems into which science (and its step-child, technology) have led us have caused many thoughtful people to believe that science, again like war, is too important to be left to the scientists. One indication of this is the increasing control being exerted by non-scientist policy makers in Washington not only over the funds made available to science but the actual research which will or will not be supported and the directions that research shall or shall not take.

An encouraging trend in recent years, however, has been the growing numbers of scientists and scientific organizations who, setting aside self-interest, are becoming involved in communicating to the general public the problems, potential, thrusts, and accomplishments of science and technology. These activities range from formal classroom programs in "science for non-scientists" to museum exhibits, television and film programs, and informal discussions and workshops on science for the general public. The feeling on the part of many scientists is that science and technology have become so interwoven with the fabric of our society that to be an effective citizen, one must increasingly know more about the scientific and technological components which are part of many of the major social and economic issues facing the country today. A major barrier in this, of course, is the fact that many people are not only "turned off" by science but that they feel science is just irrelevant to their own lives. If you are an inner city black or a poor farmer in Appalachia, the world of basic science is as remote (and with about as much influence on you) as the planets.

There are a relatively large number of formal and informal "public understanding of science programs" in this country--some are broadly conceived and operated; others have specific interests in mind; still others are self-serving to a large extent. The remainder of this paper will briefly describe the various "players," in this arena beginning with the National Science Foundation and then moving to other government agencies, private foundations, professional societies, and industry.

The National Science Foundation

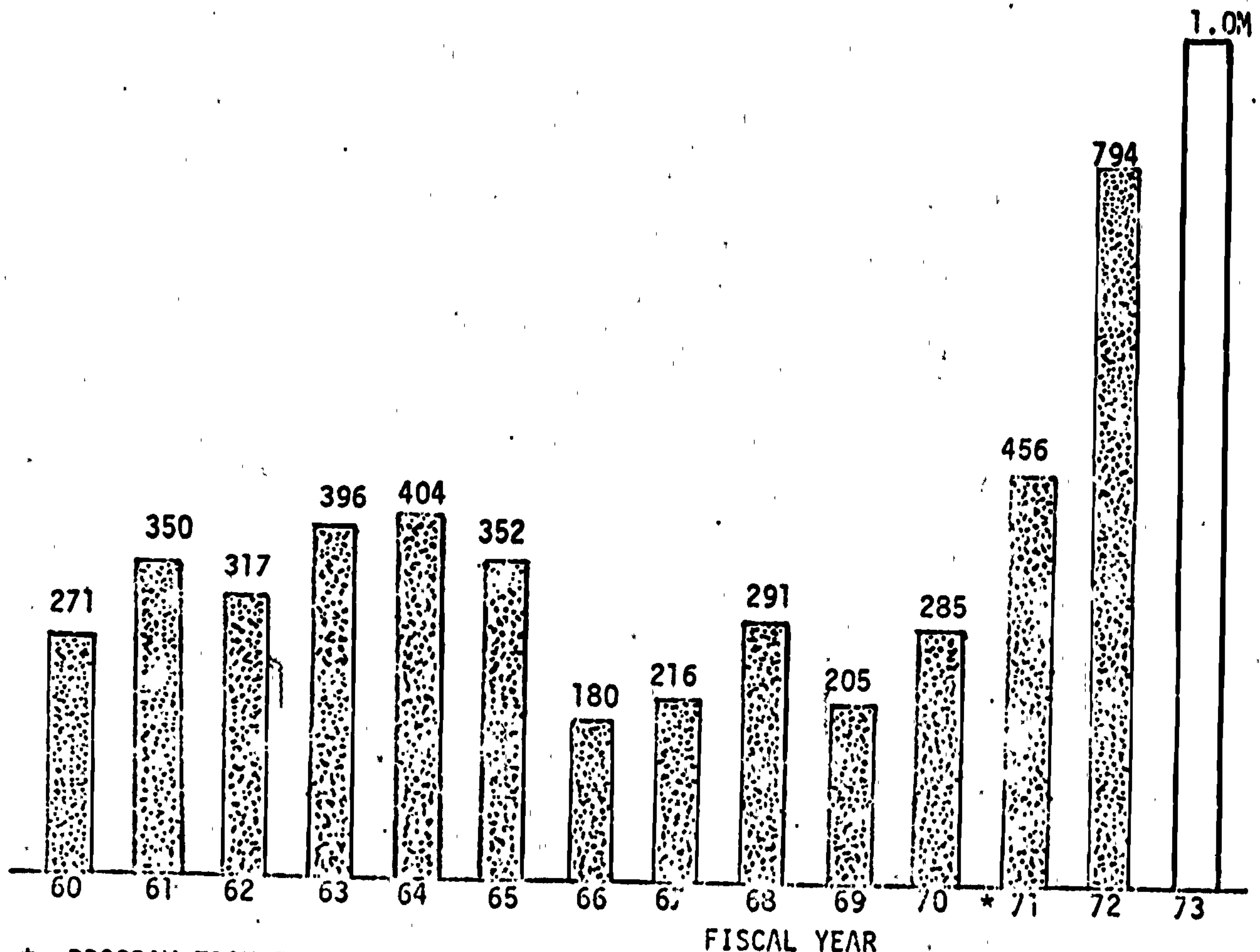
The National Science Foundation has had a formal program in public understanding of science since 1958. This program was initiated following the Sputnik crisis as a response to the increasing need for better science education both in the formal classroom sense and for the general populace. The funding history of the program is shown in Figure I. The program supported a small number of projects during its first ten years which included such things as seminars for science writers, conferences where scientists talked among themselves on the problem of public understanding, and special lay-oriented publications and exhibits. The largest award during this period was to the Seattle World's Fair in 1962 which supported the scientific planning and exhibit design for what has become the Pacific Science Center.

In 1971 the program was transferred from its previous home in the Graduate Education Division to its present location in the Office of Government and Public Programs. Additional funds were made available and a new approach was begun.

The rationale behind this program at NSF is the strong belief that the scientific enterprise in this country ultimately depends on an informed and aware citizenry. Science itself will therefore be strengthened if the

Figure I

PUBLIC UNDERSTANDING OF SCIENCE PROGRAM FUNDING HISTORY AND PLANS



* PROGRAM TRANSFERRED TO OGPP

public is able to make more informed judgments on the course and conduct of science. Our conceptual approach to the program is shown in Figure ?. The pyramid shows the various levels of public response to science and the various approaches that can be made to reach those members of the public at any given level. As can be seen, the specific areas of NSF concern are for that audience at the levels ranging from "general interest" to "awareness" and "understanding." These are the levels which demand serious attention and have commanded all of our resources up until this time.

The program as presently structured is broken down into four main categories of support:

I. Research and Methodological Studies--Special studies of methodologies for public understanding of science, program and media effectiveness, the communications process, and public attitudes toward and knowledge about science.

II. Communications Projects on Science and Technology--Single-focus projects in public understanding of science and technology including special lay-oriented publications, museum exhibits, television and film programs on science, lectures, conferences, etc.

III. National, Regional, and Community Programs--Includes support for multi-faceted programs encompassing several specific public understanding activities designed to reach audiences at the national, regional, or community level.

IV. Special Programs--Includes support for cross-national programs, public awareness of moral, ethical, and policy issues in science, special adult education programs, student-conducted programs, and other unique or innovative approaches to public understanding of science.

NATIONAL SCIENCE FOUNDATION

CONCEPTUAL MODEL - PUBLIC UNDERSTANDING OF SCIENCE PROGRAM

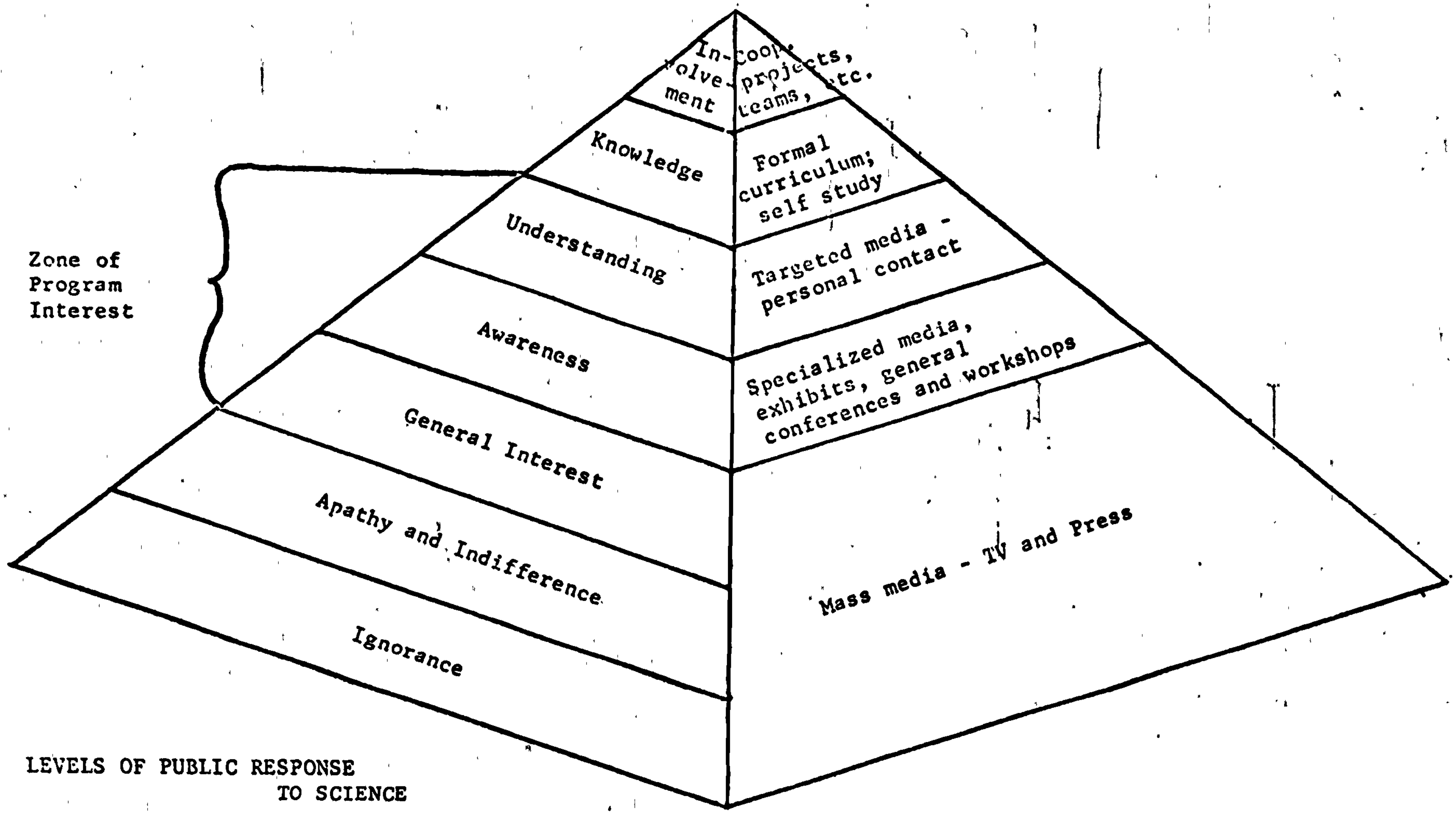


Figure 2

Projects which have received support in the past two years have ranged from individual films, publications, and conferences for laymen to broadly-based national; regional, and community programs where the intent is to reach specified publics through a variety of media. Appendixes I and II include summaries of all the projects receiving support in FY 1972 and FY 1973 to date.

In the future the program will tend to emphasize more locally originated and regional programs where it is hoped that scientists and non-scientists can work together in their own communities on problems of mutual interest and concern. Increased emphasis will also be given to differentiating between science and technology, a misconception which has led to much of the current popular mistrust of science. Looking ahead to the 1976 Bicentennial, efforts will also be made to support local projects which emphasize the contributions of science and technology to the development of this country--past, present, and future.

Other Federal Public Understanding of Science Programs

While NSF has the only specific program in public understanding, there are a number of other activities and projects scattered around the federal government which are worthy of some attention.

Perhaps the most successful example of a "public understanding" project has been the Department of Agriculture's Extension Agent, one of whose functions is to keep the people he serves abreast of new developments in agricultural science and technology. As a point of interest, this concept is now being studied for possible application in technology transfer whereby a knowledgeable scientist or engineer might cover a specific region to aid small businesses in benefitting from developments in science and technology nationally.

The largest public understanding programs, in terms of dollars, in the government are at NASA and AEC. NASA for years has made available to local groups exhibits and other information packages on the space sciences. This includes the circulation of space artifacts including spacecraft and astronaut-related material. AEC has sponsored a highly successful program entitled "This Atomic World" which is conducted by the Oak Ridge Associated Universities. In this program specially outfitted vans travel to community centers, high schools, and other locations where a trained lecturer performs experiments and demonstrations designed to inform the audience on atomic energy. This program has now suffered a sad fate at the hands of the budgeters, however.

Other federal agencies which have some interest in what we might call "public understanding" are the Environmental Protection Agency, the National Endowment for the Arts, and the Smithsonian Institution. EPA has begun to sponsor a small number of seminars and conferences for the media on environmental science and environmental problems and has also developed a small number of circulating exhibits illustrating various aspects of the environmental crisis. The Endowment has increasingly supported museum programs, primarily exhibits which illustrate the relationships between science and culture. The Smithsonian has also increased its attention to science and is now developing a series of traveling exhibits on science which would be used for small and medium sized museums. A series of special films on science are also begin developed.

Private Foundations

Most of the major private foundations have at one time or another supported public understanding-related projects. The Ford Foundation has had a major interest in environmental education over the past several years and has supported a number of small local programs wherein scientists and local citizens meet and work together. Ford has also supported several academic-based studies on the relationships between science and technology. Smaller projects at Ford have included support to the AAAS for their annual television programs and support to several other groups for films on science including a project at Harvard for the production of two films on the life of Enrico Fermi. The major interest currently at Ford is in public broadcasting, and some further support for science on public television may be forthcoming.

The Rockefeller Foundation and the Carnegie Corporation have also supported a few projects in this area including support for the AAAS television programs. Carnegie is also planning to significantly support the creation of a science programming group in public television.

Two smaller foundations have also had interests in this field. The Markle Foundation has major interests in the field of journalism education and in cable television, both of which are related to communications about science. The Russell Sage Foundation, despite its small size, has perhaps supported the largest number of projects in public understanding although in this case the focus is entirely on the social sciences. A number of press briefings on the social and behavioral sciences have been sponsored by Sage. In addition, several one-day briefings for editorial writers have also been conducted. Other Sage supported projects have included the training and research programs in the social sciences and the mass media at the Graduate School of Journalism at Columbia University, a planning study on the development of multi-media and interactive exhibits, and the subsidization of a number of articles based on social science research for publication in national magazines. The Sage Foundation has also given serious thought to the establishment of a "social science information clearinghouse" which would serve the purpose of regularly informing the media on developments in the social sciences.

Professional Scientific and Technical Societies

Most of the major scientific and technical societies have organized programs in public understanding as related to and on displinary interests. The largest of the scientific societies, the AAAS, has organized the most comprehensive public understanding of science program, including such projects as special publications on the media and science, science programming on television, and seminars on and about science for local and state officials.

Other societies which have conducted programs in this area include the American Institute of Physics and its affiliate societies and the American Chemical Society. AIP has developed, with NSF support, two films for public television distribution; one film on stellar evolution, the other on research in the biosciences. AIP has also taken the lead in encouraging the other professional societies to work together on problems of mutual concern and interest. The main interests of the American Chemical Society have so far been in chemical education for non-science students. Several individual chemists have conducted a number of projects on their own including one at Indiana University where a traveling lecture-demonstration program on science has been developed for use in the state parks of Indiana during the summer.

The two largest technical societies, the Institute of Electrical and Electronics Engineers (IEEE) and the American Institute of Aeronautics and Astronautics (AIAA), have also begun to sponsor a number of public education programs. Both societies have local chapters and much of their work in this field is based on the interests and talents of local chapter members. The AIAA, for example, sponsors a speakers bureau through each of its local chapters.

One cannot leave the subject of professional societies without mentioning the pioneering work of the Scientists Institute for Public Information (SIPI). This group, of perhaps all the scientific groups, has been at the forefront in relating science to societal needs. SIPI regional commi s have worked in generally close cooperation (although there have been some notable exceptions) with state and local agencies and groups, particularly on environmental matters. Unlike most other professional scientific groups, SIPI does take policy positions on critical issues confronting the country.

In conclusion, while the number of people and organizations interested in funding public understanding of science have certainly increased over the past several years, still far too many tend to communicate to the public what they, the scientists, want to communicate which is not necessarily what the public wants or needs to know. The future seems bright, however, for an increasing "public consciousness" on the part of many scientists, and the potential for a truly effective relationship between science, scientists, and the society in which both reside is very high indeed.

APPENDIX 1

NATIONAL SCIENCE FOUNDATION

OFFICE OF PUBLIC UNDERSTANDING OF SCIENCE

FY 1972 PROJECT AWARDS

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Rockefeller University
New York, New York

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
Mr. Eugene H. Kone

TITLE OF PROJECT
Basic Research and Human Welfare

An article of faith among scientists and people interested in science is that scientific research has led to considerable benefits to men and society. The cataloging and description of such benefits has, however, not as yet been done on a systematic and comprehensive basis. The purpose of this project is to begin such a cataloging and to provide documentation to help support the thesis that science has materially contributed to many different areas of social progress.

Working with the results of a survey sent to leaders of professional scientific societies, scientist-authors at Rockefeller University will prepare a book illustrating examples of how basic research has contributed to the solution of problems facing society. This book will not be an encyclopedia but rather will be selective and attempt to cover the broad realm of science, stressing examples which can be documented accurately and completely from basic research. Those examples selected by scientist advisory groups will be representative, understandable, and translatable into lay language. Material in the book will be presented clearly but at no time will scientific accuracy be sacrificed to readability.

Duration: 9 months
Amount: $99,820
Date of Award: 10/1/71

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
American Institute of Physics
New York, New York

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Dr. Lewis Slack

TITLE OF PROJECT
Film Production in Physics and Astronomy

The American Institute of Physics, in cooperation with the Public Broadcasting System, will undertake the development of two films on science designed for general audiences. The new attitudes of contemporary scientists, as contrasted with their predecessors, will be reflected in the films, their new approaches to problems, new areas of research and new results. Member societies of the American Institute of Physics will be involved in the design and development of the films with leading scientists in various disciplines participating as advisors.

The first film will show the relationships between research in two widely separated areas of the Universe: the sun and the distant stars. Further relationships between the stars, the sun, and conditions for life on earth will also be illustrated. The second film will show the strong relationships between physics and other natural and social sciences.

Facilities of the Public Broadcasting System will be used in the production and distribution phase.

Duration: 12 months
Amount: $94,800
Date of Award: 10/15/71

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
American Association for the Advancement of Science

NSF FUNDING ORGANIZATION
Office of Government and Public Programs, Public Understanding of Science

PRINCIPAL INVESTIGATOR
James C. Butler

TITLE OF PROJECT
"Science '71: A Report to the Nation"

This award provides partial support to the American Association for the Advancement of Science for five one-hour, full-color, live television programs to be broadcast nationwide over the Public Broadcasting Service in conjunction with the Association's Annual Meeting in Philadelphia on December 26-31, 1971.

Increasingly in recent years, the Annual Meeting of the Association has become a forum for debate about some of the most difficult areas in the relationship between science and technology, on the one hand, and society on the other. The meeting is a major source of scientific and science-related information. This is the fifth year in a row in which the proceedings of the meeting are covered on public television. Interviews with leading scientists, panel discussions between scientists, students, journalists, and lay citizens, and live coverage of particular sessions of the conference are among the activities included in this year's programming.

The proposed five subject areas to be covered by this year's programs are:

1. Can Science Solve Problems of the City?
2. Quality of Life
3. Power
4. Science and Morality
5. Several options
   a. Health care
   b. Cancer
   c. Space exploration

In addition, funds are provided for an audience impact survey to be conducted simultaneously with the broadcast of the program.

Duration: 3 months
Amount: $25,000
Date of Award: November 5, 1971

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Greater Washington Educational Television Association
2600 Fourth Street, N.W.
Washington, D.C.

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science

PRINCIPAL INVESTIGATOR
Mrs. Cherrill Anson

TITLE OF PROJECT
Documentary Profiles of Contemporary American Scientists

The Greater Washington Educational Television Association, owners of the Washington area Public Broadcasting station Channel 26, proposes to develop a series of thirty minute documentary films on contemporary American scientists. Each profile will allow for candid revelations of personal attitudes as well as for expalnations of the potential effect of scientific research on the quality of human life and on the solution of major problems confronting mankind. The scientists chosen as subjects will demonstrate the variety of settings and circumstances in which contributions may be made to the pursuit of science through work in universities, government and industrial laboratories, and other research facilities. Scientists at the peak of their professions will be included as well as a select number of younger scientists.

This series when complete will initially be shown over the facilities of the Public Broadcasting System and then made available for further distribution to schools, other educational groups, and the civic associations.

This award supports initial script development for a pilot show.

Duration: 6 months
Amount: $4,800
Date of Award: 12/30/71

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Battelle Memorial Institute
Columbus Laboratories
Columbus, Ohio 43201

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
George W. Tressel

TITLE OF PROJECT
Filmed Report on the "State of Science"

The Battelle Memorial Institute will develop, produce, and distribute a one-hour television report on the state of science in the seventies. This film will be suitable for presentation to a general lay audience and will emphasize the interrelationships between science, technology, and society. The viewer will be made aware of the current status of science in this country, the variety of organizations and forces that control the thrust of science, and progress being made in the innovative application of scientific knowledge to society's needs.

A distinguished advisory committee composed of scientists, media representatives, and lay leaders will work closely with the project director. The scientific accuracy of material presented in the film will be of paramount consideration.

Duration: 12 months
Amount: $53,210 (FY 1972); $36,530 (FY 1973); $89,740 (Total)
Date of Award: February 18, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
D.C. Council of Engineering and
Architectural Societies
Washington, D.C.

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
David H. Moran

TITLE OF PROJECT
Televised Forums on the Role of Engineers in Modern Society

The District of Columbia Council of Engineering and Architectural Societies will produce two televised forums on the role of the engineer and of the engineering sciences in modern society. The original shows will be broadcast through the facilities of WETA-TV, the Public Broadcasting Station in Washington, D.C., and then distributed nationwide to educational TV stations.

The format for the broadcasts are planned around a nationally known critic of technology and its application debating several of the most able spokesmen from the professional engineering societies. Participation from an audience consisting of representatives from labor, business, government, civic groups, and legislators will also be included. Following the broadcasts, a summary of the discussion will be prepared and distributed nationally through appropriate technical and policy-oriented journals.

The first forum is scheduled for the week of February 21, 1972, with Mr. Ralph Nader as the critic. The second forum will be held in June, 1972, with an as yet unnamed but also nationally known critic.

Duration: 7 months
Amount: $12,500
Date of Award: February 18, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
University of Hawaii

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
Howard P. Harrenstien

TITLE OF PROJECT
Environmental Conferences on the Public Understanding of Science for Hawaii

The Center for Engineering Research of the University of Hawaii will undertake a two-year conference series designed as a medium through which citizens in Hawaii may gain an understanding of science and the way in which it can assist in the solution of problems facing the state. The particular focus of the series will be on various environmental problems now facing Hawaii and potential solutions which might be provided by science and technology.

Twelve conferences are planned in all, based on the general underlying theme of the application of science and technology to solutions of a particular current or future problem of environment or ecology facing the state. Topics for the first six conferences are solid waste management, aquaculture energy conversion, off-shore technology, coastal ecology, and pollution control. Participants in the conferences will be broadly representative of Hawaiian society including government, industry, universities, public schools, and citizen groups. Workshops and task force formats will be used where possible to help facilitate continuing working relationships between participants after the close of a particular conference. The conference series is designed to be an integral part of a broader state-wide environmental education program supported by other sources and involving the community colleges of the state.

Amount: $43,100
Duration: 12 months
Date of Award: May 4, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Thorne Ecological Institute
Boulder, Colorado 80302

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
Beatrice E. Willard

TITLE OF PROJECT
Partial Support for Seminar on Environmental Arts and Sciences

This award provides partial support to the Thorne Ecological Institute for their sixth Seminar on Environmental Arts and Sciences to be held at Aspen, Colorado, June 30-July 5, 1972. The basic purpose of the seminar is to help national, state, and local decision-makers acquire a deeper, more extensive up-to-date understanding of ecological principles and to equip them to be able to apply these principles in their work. The Seminar annually brings together civic leaders, businessmen, labor representatives, students, journalists, government officials, environmentalists, and community activists in working sessions with professional ecologists. Participants fully contribute to and participate in the seminar which progresses from broad ecological principles to specific applications of these principles to human problems.

The purposes of the seminar are accomplished through field trips, formal presentations by ecologists, think sessions, and informal communication and interaction periods. Case studies of local environmental problems are also used to focus theory with practical application. Approximately 100 people plus staff will attend the 1972 seminar.

Amount: $15,000
Duration: 6 months
Date of Award: May 10, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
American Association for the Advancement of Science
Washington, D.C. 20005

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Office

PRINCIPAL INVESTIGATOR
James C. Butler

TITLE OF PROJECT
Communications Program in the Public Understanding of Science and Technology

The American Association for the Advancement of Science (AAAS), the world's largest federation of scientific societies with a total membership of more than 135,000 individual scientists and non-scientists, will undertake a major program in the public understanding of science and technology over a thirty-month period. This program will be supported by funds from the Association itself, the National Science Foundation, and private foundations and industry. This award represents support for the planning and development phase of the program in addition to certain selected projects which will be initiated during the first six months of the program. NSF will support approximately one-third of the total costs of the program over the next thirty months.

The AAAS has selected five major target audiences in the development of its program, These are: communicators, the scientific community, decision-makers, young people, and the general public. Activities will be selected which are broadly conceived, national in scope, long term, and integrated. These will include science information services for the media; seminars and conferences for editors and broadcasters; special seminars on scientific issues for national and state legislators, other elected officials, business, and civic leaders. Special studies will also be initiated on the feasibility of new kinds of science programs on television and on the opportunities for international cooperative programs in public understanding of science. A catalogue of current films on science suitable for non-scientific audiences will also be provided.

Duration: 6 months
Amount: $150,000
Date of Award: May 19, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
St. Louis Aquacenter, Inc.
St. Louis, Missouri 63101

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Henry C. Kendall

TITLE OF PROJECT
Feasibility Study on Conversion of Spanish Pavilion to an Aquarium/Ecology Complex

A group of interested citizens in the St. Louis area plan to establish an aquarium/ecology complex which will be financially self-supporting and owned and operated by a not-for-profit corporation. The Spanish International Pavilion is proposed as the site for this complex. The Pavilion was first constructed at the New York World's Fair and was given to the people of St. Louis following the Fair by the Spanish Government. The Pavilion is now located in the heart of the St. Louis waterfront area.

Before proceeding with the conversion of the Pavilion, a detailed engineering, architectural, and economic feasibility study is needed to estimate the total costs of the conversion and to develop and prepare data necessary to determine the appropriate exhibits and other educational facilities. This award represents one-half the costs of this feasibility study. The remaining funds have already been raised through local sources. If the decision is made to proceed with the conversion of the Pavilion, based on the results of the feasibility study, the necessary funds will be raised through local public and business subscription.

Amount: $15,500
Duration: 12 months
Date of Award: May 30, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
University of Mi ouri, Columbia

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Office of Public Understanding of Science

PRINCIPAL INVESTIGATOR
William Stephenson
Roy Fisher

TITLE OF PROJECT
"Seminar Series on Science for News Editors"

The School of Journalism at the University of Missouri has a long-standing commitment to science communication in both research and practical application. Building on this experience, and in consort with scientists at the university, the School proposes to conduct a series of symposia on science and technology for key newspaper editors on television broadcast executives from the six-state Midwest region. The programs will be designed as a two-directional learning process--the editors will be as much learners as teachers, gaining a more realistic understanding about current developments in science; the scientists, while explaining new developments in their respective fields, will be exposed to the questioning of editors who daily serve as "gatekeepers" in deciding what information about science will reach the public and in what form. Concurrent with the seminar series, a planning study will be conducted on the possible establishment of a "Regional Science Communication Center" to more broadly serve the Midwest.

Duration: 9 months
Amount: $50,000
Date of Award: 6/27/72

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Sonoma State College
Rohnert Park, California

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Paul V. Benko

TITLE OF PROJECT
Promoting Public Understanding of Science Through Environmental Education

The objective of this project is to experiment with methods to bring both scientific expertise and environmental awareness into a discrete community via the twin vehicles of television and citizen involvement in college extension programs. The ultimate purpose is to bring to the community (here defined as the Napa Valley region of Northern California) a new awareness of what science is doing and what it can be encouraged to do in the future in meeting environmental problems.

Specific activities will include interdisciplinary teams of scientists from Sonoma State College and Santa Rosa Community College working with groups of citizens in workshop format to explore the relationships between science and current environmental problems facing the region. Audiovisual programs will be prepared and broadcast over local cable television stations to reach a broader audience. "Town hall" meetings will be held to further develop citizen understanding of environmental science. Emphasis will be placed on involving school age children, as well as community residents in the project. Extension credit will be offered those citizens interested in pursuing environmental science on a more formal basis.

Duration: 15 months
Amount: $51,200
Date of Award: 6/28/72

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Pennsylvania State University

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
G. Ray Funkhouser
Rustum Roy

TITLE OF PROJECT
An Appraisal of the Nation's Awareness of, and Attitudes towards, Science

Many scientists, policymakers and educators agree that the improvement of public knowledge and understanding of modern science is a desirable goal. However, there is a decided lack of consensus among concerned parties as to what, exactly, this means, and how this goal ought to be pursued once it is defined. Furthermore, it is obvious that if we are to expend substantial resources in attempts to improve the present state of the public understanding of science, then it is imperative that we develop some quantitative measure of that state, and remeasure it periodically after various efforts. The whole field of assessing the present state or assessing the impact of any particular effort has received very little attention, whether it be through a national survey of the country's awareness of science or a measure of the readership of a single cover story on science in TIME magazine. What is proposed here is an intensive study session on the objectives, worth, methodologies and limitations of surveys and other evaluational techniques in the field of public understanding of science. This session will be held in November, 1972, and involve leading scientists and communication research specialists.

Duration: 6 months
Amount: $17,500
Date of Award: 6/28/72

APPENDIX 2

NATIONAL SCIENCE FOUNDATION

OFFICE OF PUBLIC UNDERSTANDING OF SCIENCE

FY 1973 PROJECT AWARDS

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Harvard University

NSF FUNDING ORGANIZATION
Government and Public Programs
· Public Understanding of Science

PRINCIPAL INVESTIGATOR
Dr. Gerald Holton

TITLE
A Research-and-Publication Proposal to Increase the Level of Public Understanding of Science

It is widely acknowledged that the state of public understanding of science in the U.S. is in need of fundamental reexamination and repair. Public confidence and interest in science and technology is felt by many thoughtful people to be in marked decline. Some intellectual historians go as far as to point to this current challenge to the role and place of science in society as a significant turning point in Western thought.

In an attempt to study these problems in great depth and propose possible approaches towards their solution, Dr. Gerald Holton, Professor of Physics at Harvard University, proposes to convene a number of distinguished collaborators ranging ranging across the sciences and humanities to engage in planning, discussion, research, and publication in the need for an improved public understanding of science. Research will be undertaken on changing values and beliefs in science and technology among youth using the extensive data base of the Harvard Project Physics Program. Conferences and planning sessions will be held and individual commissioned research pursued by the collaborators. This effort will culminate in the publication of a special issue of Daedalus, the highly regarded Journal of the American Academy of Arts and Sciences. Publication costs for the issue will be borne by the Academy.

Amount: $49,400
Duration: 12 months
Date of Award: July 21, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
St. Mary's Dominican College

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Paul H. Chatelain

TITLE
Developing Creative Planetarium Programs

St. Mary's Dominican College, through its Frank J. Lewis Planetarium, proposes to produce a set of six illustrated taped astronomical programs for ultimate use by small planetariums in offering basic astronomical education to school-age children and the general public. The programs will be developed and audience tested at the Lewis Planetarium.

The first three of these programs will provide direct instruction to the young from the earliest grades through senior high school. The next two programs will give instruction to elementary school teachers. The sixth and final program, aimed at the general public, will demonstrate the foundations of the modern science of astronomy in the ancient art of astrology.

It is hoped that these six programs as a package will constitute the beginnings of a basic library for small planetaria which lack the resources to develop their own programs.

Amount: $5,000
Duration: 6 months
Date of Award: July 28, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Maryland Academy of Sciences

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Edith B. Whiteford

TITLE
Public Lecture Series on Science and Its Contributions to the Quality of Life

The Maryland Academy of Sciences plans to continue their highly successful program of providing associations and groups in the State of Maryland with knowledgeable and highly qualified scientists and engineers who will speak about their own particular disciplines or the accomplishments of science and technology in general and their effect on the daily lives of citizens in the state.

Particular emphasis this year will be placed on special audiences including minority groups, young people, senior citizens, and decision makers at all levels of government. Specific subject areas will also be concentrated on, including such topics of concern to Maryland as the energy crisis, community health planning, and environmental quality, including particularly the Chesapeake Bay.

Amount: $24,900
Duration: 12 months
Date of Award: August 21, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Battelle Memorial Institute
Columbus, Ohio 43201

NSF FUNDING ORGANIZATION
Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
George W. Tressel

TITLE OF PROJECT
Filmed Report on the "State of Science"

The Battelle Memorial Institute will develop, produce, and distribute a one-hour television report on the state of science in the seventies. This film will be suitable for presentation to a general lay audience and will emphasize the interrelationships between science, technology, and society. The viewer will be made aware of the current status of science in this country, the variety of organizations and forces that control the thrust of science, and progress being made in the innovative application of scientific knowledge to society's needs.

A distinguished advisory committee composed of scientists, media representatives, and lay leaders will work closely with the project director. The scientific accuracy of material presented in the film will be of paramount consideration.

Duration: 12 months
Amount: $53,210 (FY 1972); $36,530 (FY 1973); $89,740 (Total)
Date of Award: September 8, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Michigan Technological University

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
David D. Geddes

TITLE OF PROJECT
Planning Study on Public Understanding of Science Program for Northern Michigan Region

Michigan Technological University proposes to develop a program that would foster public understanding of the causes of social and environmental problems and enhance knowledge and understanding of the potential and limitations of science in solving these problems in the economically disadvantaged rural areas of Michigan. The initial planning period of one year will determine which of several methods to reach this public would be most practicable for implementation. One concept to be studied would focus on the use of a portable planetarium and a series of instructional exhibits on the physical and natural environments, energy, and pollution. This program would be transported by truck and trailer, assembled in a few hours, and would remain in each rural community for the duration of one week. The program would leave the campus for the rural areas of Michigan's Lower Peninsula and work northward through the Upper Peninsula. On a pre-arranged schedule presentations would be made to secondary school students and adults in the communities. Approximately 25,000 students and adults would participate in the program annually.

Support for the planning study will enable the Michigan Technological University group to determine the appropriate methodology to achieve the objectives of the project and develop sources of funding for the operational phase of the program.

Amount: $29,500
Duration: 12 months
Date of Award: October 4, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Rensselaer Polytechnic Institute, Troy

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Chandler H. Stevens

TITLE OF PROJECT
An Experiment in Science/Citizen Interaction through Participatory Television

With so many critical issues facing the country today, the need for better communication between government and citizens is never more important. This is as true for those issues involving science as for other fields. The difficulty of achieving an adequate level of both communication and understanding between scientists and non-scientists, let alone sustaining them, is well known.

Rensselaer Polytechnic Institute proposes to work on this problem by conducting an experiment in science/citizen interaction through the use of participatory television. Two specific occasions will be involved in this experiment: one will be a university-wide exposition called "Archimedia" which is an attempt to foster better communication of ideas across disciplines and across university-community lines. The other will be the 1972 Annual Meeting of the American Association for the Advancement of Science in Washington, D. C. At both events, a series of issue questions involving both science and societal concerns will be prepared and distributed to the public through general circulation magazines and newspapers. Television will then be used to provide citizens the chance to respond on-the-air to the issues raised at the AAAS meeting where four one-hour programs on science will be telecast over the Public Broadcasting System. The RPI staff will assist the AAAS in designing interactive feedback on the programs. The results of this experiment in citizen interaction will be thoroughly documented and given wide dissemination.

Amount: $30,000
Duration: 5 months
Date of Award: October 16, 1972

NATIONAL SCIENCE FOUNDATION
PROJECT AWARD SUMMARY

NAME OF INSTITUTION
Museum of Science and Industry
Chicago, Illinois

NSF FUNDING ORGANIZATION
Office of Government and Public Programs
Public Understanding of Science Program

PRINCIPAL INVESTIGATOR
Victor J. Danilov

TITLE OF PROJECT
Science Playhouse - Cooperative Program with Goodman Theatre

In a cooperative venture, the Chicago Museum of Science and Industry and the Goodman Theatre of the Art Institute of Chicago plan to produce a series of science-oriented plays for school children in the Chicago area. The plays will be produced and presented by the Goodman Theatre in the auditorium of the Museum. Scientific consultation and guidance will be provided by the Museum staff and outside consultants.

Four plays will be presented in the initial series. Two will be adaptations of existing plays and two will be originals, including one play, tentatively titled "Discovery" which will heavily involve audience participation. Each play will be presented twice daily for a week with the admission being free. It is expected that more than 50,000 children and adults will see the entire series during the 1972-72 school year. Audience impact measurements will be taken periodically to determine the effectiveness of the plays as a media for communicating scientific information to young people.

Amount: $37,000
Duration: 12 months
Date of Award: October 27, 1972