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Scientific and Educational Society Activity in the Environmental Sciences

The nature of the work done on environmental problems at the American Chemical Society depends, of course, on the nature and purpose of the society. The society is a nonprofit scientific and educational society with a membership of 110,000 chemists and chemical engineers. Founded in 1876, the ACS has become the world's largest membership organization devoted to a single science. It operates under a national charter granted in 1937 by the seventy-fifth Congress and signed into law by President Franklin D. Roosevelt on August 25, 1937. Under the provisions of the charter, the objectives of the society are: (1) to encourage in the broadest and most liberal manner the advancement of chemistry in all its branches; (2) the promotion of research in chemical science and industry; (3) the improvement of the qualifications and usefulness of chemists through high standards of professional ethics, education, and attainments; and (4) the increase and diffusion of chemical knowledge, and by its meetings, professional contacts, reports, papers, discussions, and publications, to promote scientific interests and inquiry. It should thereby, foster public welfare and education, aid the development of our country's industries, and add to the material prosperity and happiness of our people.[1]

The charter also imposes an obligation on the ACS to provide technical advice and investigative and research assistance to the federal government on public issues and problems. The ACS's pursuit of these objectives is facilitated by its unique network of 175 local sections serving members in the United States and Puerto Rico, its 26 technical divisions dealing with the principal fields of chemistry and chemical technology, and a board range of scientific and educational activities, public affairs programs, technical meetings, and authoritative journals.

The ACS does not operate any chemical research or production facilities. The distinctive characteristic that it does have is a reservoir of intellectual, scientific and technical resources represented by our diverse membership. This paper begins with a brief description of how ACS focuses these resouces on environmental questions, followed by a discussion of the results achieved, including the recommendations developed for specific environmental problems.

The ACS has been active in environmental chemistry for many years, but the work discussed here started in 1965. At that time the environment was beginning to accelerate as a national issue. More and more people were demanding clean air and water without worrying very much about how these laudable goals were to be achieved. I suspect that a lot of people have attacked environmental problems without much forethought, but that trend seems to be ending. The solutions to environmental problems are difficult enough when one knows what he is doing.

Historically, the ACS's activities in matters of the environment have largely been conducted through its technical divisions and committees. These activities involve primarily the organization of scientific and technical meeting programs. More recently, with the support of the Division of Water, Air and Waste Chemistry, the ACS founded the monthly publication *Environmental Science and Technology*, whose first issue appeared in January of 1967. Edited for scientists and engineers engaged in the study and maintenance of our natural environment through the use of chemical principles, *ES and T* was the first journal to serve this important field.

Through scientific papers on fundamental research and technology in water, air, and waste chemistry, authoritative news reporting, interpretive articles by invited experts, and staff-written commentary on the political and industrial aspects of environmental management, *ES and T* offers the widest range of information available. Each monthly issue presents new knowledge and promotes scientific inquiry in such areas as the chemical nature of the environment, environmental changes through pollution or other modifications, beneficial technological control of the environment, and the chemical nature of water, air, and waste as they affect urban, industrial, and agricultural activities.

The membership of the divisions includes many of the people trained in chemistry and closely related sciences who are working on problems of environmental quality in the United States. Other ACS members are knowledgeable in the chemistry of the problems that need to be solved. However, the divisional programs and the new journal provide services largely for the expert—the trained chemist or engineer who is working in some phase of environmental chemistry.

In 1965 the ACS's board of directors established the American Chemical

Society Committee on Chemistry and Public Affairs to provide a more coordinated approach to fulfill its obligations as an organization under its national charter. In so doing, the ACS board recognized the ACS's responsibility to exert more effectively the influence of the discipline of chemistry in the solution of major problems of vital importance to the national health, welfare and defense.

The Committee on Chemistry and Public Affairs saw in environmental improvement an area in which it might perform the kind of specific public service that was its proposed mission. The committee decided that an analysis of the important chemical aspects of pollution, backed by extensive documentation, could be developed into a coherent chemical picture that would refresh the expert working in the field and also inform the involved and educated layman. This project was begun early in 1966 under the aegis of the Committee on Chemistry and Public Affairs, which sponsored a task force of some twenty-five experts drawn from the technical divisions and committees of the ACS. This expertise, as well as that of a number of other authorities who are both members and nonmembers of ACS, has been taken advantage of in efforts to develop dispassionate and specific analyses and solutions of the chemical problems involved in managing the environment.

The aim of this report was to set down in one place an objective account of the current status of the science and technology of environmental improvement: what is known and how it is being used; and what must be learned and how it might be used. We did not attempt to write an all-encompassing textbook or primer. We stressed, instead, those problems that we believed to be at the same time important to environmental quality, and accessible to attack on the basis of current and prospective chemical knowledge. The report did not dwell too long on the dimensions of the pollution problem, except where one or more of those dimensions was specifically germane to the point at hand in the social, political, economic, or organizational questions that it raised. The intent, rather, has been to focus strongly and specifically on chemistry, chemical engineering, and the related disciplines, and thereby to stimulate the chemical awareness and the flow of chemical know-how that are essential to any long-term rational approach to understanding and controlling the environment.

We stressed the fact that a strong vein of chemistry runs throughout environmental science and technology, and we stressed that fact without fear of being accused of displaying excessive self-interest. We tried to stress it without obscuring, or appearing to obscure, the undeniable complementary fact that solving the technical problems of environmental management will require the best efforts of scientists and engineers from many disciplines. The ACS speaks with special concern to the world of chemistry, however, and believes that environmental problems do provide, at the very least, a fit

intellectual match for the talents of those chemical scientists and engineers who wish to work at the worthy mission of making a cleaner world.

Those who have worked on such a project know that in some ways it is not unlike being disemboweled with a dull spoon. We have been fortunate enough to find the results well worth the intermittent agony. The 250-page document, published in September 1969, is entitled *Cleaning Our Environment–The Chemical Basis for Action*,[2] and covers air, water, solid wastes, and pesticides, and includes more than 500 literature citations.

As a public service, the ACS distributed about 21,000 copies of the book, including copies to every member of Congress, state governors, pollution control agencies, conservation organizations, and others. The initial printing was 25,000, and the remaining 4,000 were made available for public sale. The book is now in its sixth printing and more than 50,000 copies have been sold, and sales remain at about 700 per month. Translation into Italian, Arabic, and Japanese has been authorized. The report is being widely used as a text in more than a hundred university and college environmental science courses.

The publication and its seventy-three recommendations also aroused interest in the government. In the fall of 1969 the recommendations were discussed in a general way with the President's Science Advisory Committee and its Panel on Environmental Quality. As a result of these meetings it was decided that the ACS could serve a useful purpose by selecting the more important of the recommendations, updating them, and putting them in order of priority for immediate action. This has now been done in the form of a supplement to the original document. It contains twenty-six recommendations, along with updated supporting discussion, and was published in 1971.

Before discussing these recommendations I would like to place this discussion in perspective regarding ecology and environmental science. Ecology is that branch of science concerned with the interrelationship of organisms and their environments. The scientists who wrote the two ACS documents in fact had very little to say about ecology as such. Their attitude can be summed up with a brief quotation:

> Several problem areas emerge as explicit themes in this report. One such theme is the primitive condition of our fundamental knowledge of how living things are affected by long-term, low-level exposure to pollutants.
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> Partly related to this theme is a second, the even more primitive condition of our knowledge of the effects of pollutants on the ecology, that is, on the aggregate of living things as they exist together in nature. The relationship of contaminants to the ecology is very nearly a total mystery, and scientists are just beginning to study ecosystems on the multidisciplinary basis that is clearly required.[3]

These statements certainly were not saying–nor am I saying–that ecologists know very little about ecology. They were saying that the ecological effects of specific contaminants simply are not well understood. That situation

needs to be corrected, and we have so recommended. As a consequence of the existing situation, however, the recommendations I will discuss deal only sparingly with ecological effects.

I should also mention two other characteristics of the twenty-six recommendations in the ACS supplement: (1) we have not concerned ourselves to any degree with administrative questions; and (2) we have tended to favor areas in which defects in our knowledge must be corrected by further research and development. We have not, for example, made any recommendations related to the lead in gasoline. Our original document included such a recommendation, but our experts believe that sufficient momentum has since developed in this area to obviate the need for further recommendations at this time. It appears, furthermore, that the problem of lead in gasoline can be worked out on the basis of *existing* knowledge. That being the case, the problem does not appear to require further intensive research and development.

The ACS scientists see no decline in the importance of four overriding themes that were evident in our original document. I have already mentioned one of these—the primitive condition of our knowledge of how living things are affected by long-term, low-level exposure to contaminants.

The second of these overriding themes is the fact that we have a very large amount of existing knowledge that can be applied today to environmental problems. All that is required is sufficient effort and money—although getting the money is not a simple task. Low lead and no-lead high octane gasolines are made using existing knowledge. Sewage treatment plants are built on the same basis.

The third overriding theme is the inadequacy of many of the analytical chemical methods that must be depended on to monitor, to control, and to study the environment and the related phenomena. Better analytical methods are needed in several areas, including global air monitoring, ecological research, and the study of trace metals in water and of eutrophication.

The last of the four overriding themes is the lack of the sort of data needed to define normal trends, upward or downward, in the concentration of contaminants in the environment. For most contaminants, we simply have no reliable baseline concentrations.

With those overriding themes in mind, I will discuss the twenty-six specific recommendations of the supplement. I will not cover all of them in detail, but I will try to indicate the thrust of most of them as well as some of the thinking involved concerning them.

For the air environment, first was recommended a program of systematic measurement of a number of relatively long-lived substances in the general atmosphere. These substances include carbon monoxide, nitrous oxide, methane, carbon dioxide, fluorocarbons, and sulfur hexafluoride. Systematic

measurement of the general turbidity of the atmosphere was also recommended. The point of these recommendations is that we really have no sound idea of which air pollutants (except carbon monoxide) are truly worldwide in scope. To get such data would require that a program of the type recommended be continued for several decades. We think that a network of twenty to thirty monitoring stations, worldwide, could do the job. We foresee a total initial cost of about $300,000 and a total long-term operating cost of up to $200,000 per year.

Another problem seen is that the complete pollution envelope of a single city has never been studied in what we believe to be adequate detail. This fact poses a serious problem to logical planning of environmental management of the air resources. One recommendation is that the air pollution of a single city should be studied intensively in all of its ramifications–chemical, meteorological, and biological. A diversified group of federal and other agencies has planned such a study for St. Louis, Missouri, but the problem is obtaining funds. The project could cost up to $30 million or even more. This is a great deal of money, but ACS scientists believe that such a study is absolutely essential to breaking the bottleneck of piecemeal information about urban air pollution. We believe that the results of such a study could be generalized to most cities in the world and would provide an invaluable base of data for the future. This study is now underway.

I have already touched on the ecological effects of pollutants. Our recommendation on this point calls for an integrated, carefully coordinated, multi-disciplinary research program on the ecological effects of air pollutants, with a strong input on water and soil contaminants as well. A great deal of work is required in this area. The effects of pollutants on individual plant and animal species have been demonstrated under controlled conditions, but in no case has such an effect been traced through to its final impact on an entire food chain.

A good deal of momentum has developed in the control of automotive pollution. For this reason our priority recommendations retain only one of the recommendations in this area that were made in the original ACS document. That recommendation calls for the development of improved instrumentation for analyzing motor vehicle exhaust. We see a serious problem in the lack of economical means of doing such analyses. The exhaust emission control devices installed on new cars today do not operate properly unless adjusted regularly. National Air Pollution Control Administration data have shown that too many cars equipped with such devices begin to exceed their certified emission limits when they have been on the road for a while. One of the difficulties is that when the devices are adjusted, the effects on the exhaust gases are not checked. One reason is that the necessary equipment costs several thousand dollars–more than either garages or state inspection

stations can usually afford. The problem will grow more serious as the allowable levels of exhaust emissions decrease, which they must to meet the standards of the mid-1970s.

A second problem exists with routine exhaust emission checks. One obvious time to make such checks, of course, is during routine auto safety inspections. But as of fall 1971, only about thirty-one states required such inspections. One of them was Colorado, which has some 3,700 authorized inspection stations. We do not believe that effective periodic emission tests could be made at that many stations at any reasonable cost.

The combustion of fossil fuels in stationary installation poses a number of difficult environmental problems which can be classified in terms of particles, sulfur oxides, and nitrogen oxides. The technology of removing particulate material from stack gases is relatively well developed, and we made no recommendation on the topic. In power plants, as the sulfur content of the coal goes down, particulate matter becomes more difficult to remove with electrostatic precipitators, but it can be done.

A considerable effort is underway on the sulfur oxides problem, but there still is no commercially proven technology for controlling sulfur oxides produced in combustion processes. The ACS scientists have recommended further stimulation of first generation processes, particularly to provide control options for existing power plants.

For small, stationary combustion sources, and in some cases for large ones, the sulfur oxides problem might better be solved by shifting to fuel of low sulfur content. Low sulfur coal and natural gas are limited resources, and probably they should be reserved for use where no economical alternative exists for controlling sulfur oxides as in individual homes. Fuel oil is being desulfurized, and more of that will undoubtedly be done, but heavy fuel oil today accounts for only an estimated 12 percent of the sulfur oxides emitted by stationary sources. The major problem is coal, which accounts for an estimated 65 percent of such emissions. The problem seems likely to grow steadily worse, unless our living habits change markedly, since the use of coal to generate electricity is expected to triple by the year 2000. At any rate, we have recommended a strong development effort on processes for desulfurizing fuels, particularly coal. We call also for more thorough definition of the amounts and locations of coal that can be cleaned economically of pyritic sulfur.

Nitrogen oxides emissions come almost entirely from combustion, and about a quarter of the total originates in steam-electric power plants. The latter figure is rising steadily, of course, as production of electric power increases. Nitrogen oxides emissions in power plants might be reduced relatively easily by modifying the combustion process. We have recommended that conclusive data be developed on the economics and effectiveness of such

modifications. We have also recommended a comprehensive research and development program on the abatement of nitrogen oxides emitted by stationary sources. The processes that do exist for this purpose are still in the laboratory.

Besides these recommendations aimed at specific emissions from stationary sources, the ACS supplement calls for two broader measures: (1) the needs of present and future urban areas for low pollution fuels for space heating should receive due consideration in the development of national fuels policies and inventories; and (2) the economics of centralized production of heat for space heating should be thoroughly evaluated. Heat energy might be distributed in the form of hot air, steam, or high-pressure hot water. The point, of course, is to combine a number of small stationary combustion sources into a single large source whose pollutant emissions can be abated economically.

ACS foresees the distinct possibility of an electric power crisis in the United States as a result of the limited supplies of low sulfur coal, oil, and gas; the desirability of reserving natural gas for small users; and the lack of methods for abating nitrogen oxides. Gasification of coal at the mine should be able to produce large amounts of relatively clean-burning pipeline gas when existing technological problems are solved. The use of nuclear energy should continue to grow, providing problems with radioactivity and thermal discharge can be resolved; the latter being, of course, a growing problem for conventional power plants as well. Because of these two problems–thermal pollution and radioactivity–it is not too extreme to suggest that one day we may find ourselves turning to solar energy for much or most of our power. Meanwhile, we have our work cut out for us in minimizing the environmental impact of continued combustion of fossil fuels.

The ACS supplement makes five priority recommendations on the water environment. The first of these is that our methods of treating public water supplies should be upgraded. For fiscal 1970, less than $160,000 in federal support was available for research on the treatment and distribution of public water supplies. We believe that a minimum of $2 million per year should be budgeted for research on treatment of public water supply and on the effects of the quality of public water supplies on human health.

There is a good deal of excitement over mercury, cadmium, and certain other metals in water. The fact is that virtually nothing is known about how these metals are affected by the processes normally used in public water supply treatment plants. The fate of viruses and the effects of disinfection on viruses and other organisms in such a plant are open questions. These plants often draw their raw water from a source that receives treated waste water. We need to do more research on the removal or destruction of low concentrations of harmful substances and organisms that now pass through the waste treatment process unchanged or whose fate in the process is unknown.

Our second recommendation on water calls for expanded and accelerated research on eutrophication. A number of studies of the subject are underway, but our fundamental knowledge of the chemical and biological processes involved is well below the level needed to develop sound, long-range control measures. More must be learned in several areas: mass balances for significant nutrients in specific lakes and rivers; the forms in which these nutrients exist in water; the dynamics of natural plant and animal populations; potentially limiting nutrients in specific situations; and the physiology of the relevant algae, bacteria, and plants. The debate of the past few years over detergent phosphates certainly owes some of its less rational features to various kinds of politics, and sounder fundamental knowledge of the process of eutrophication might help to produce more effective action with considerably less wheel-spinning.

The largest single cost in treating waste water lies in handling and disposing of the residual sludge, which can account for 25 to 50 percent of capital and operating costs. The sheer physical volume of such sludge is a problem in itself—Chicago alone produces more than 900 tons of dry solids daily. Nationwide, the amount of sludge produced will grow steadily as secondary waste water treatment becomes more common. As a result, we have recommended expanded research on new methods of handling sludges from waste water treatment. Such research should include work on the fundamental process parameters involved in using synthetic polymers and polyelectrolytes to improve flocculation, sedimentation, and conditioning of such sludges.

One of the goals of water chemists is to be able to understand quantitatively the flow, dispersion, and degradation of water pollutants. To support such an understanding, more needs to be known of the specific chemical compounds in waste discharges and natural waters. Such information is also needed to support rational assessment of the pollutant potential of specific compounds on a local or regional basis. To ease these problems, we have recommended that inventories be made of pollutants from all sources known or expected to be important. We recommend that this be done on a selective, watershed basis. A comprehensive, nationwide study could consume a great deal of money and effort, and we may not be sophisticated enough yet in other scientific areas to be able to interpret the data collected.

Even a selective program of the kind recommended might have turned up the mercury pollution that suddenly has become a recognized hazard. Another problem is organic compounds: one of the relatively few analyses that has been made of domestic sewage could account for only 75 percent of the organic carbon. The number of synthetic organic chemicals that can enter the environment is growing rapidly: one estimate puts the rate at more than 500 per year.

The ACS supplement's last recommendation on water calls for the assembly of comprehensive information on the technology of joint municipal-

industrial treatment of waste waters. This information then would be made widely available to companies and municipalities which might wish to consider joint treatment.

The same technology often can be used to treat municipal and industrial waste waters, and joint facilities tend to ease the overall cost of treatment. Indirect evidence suggests that a trend is developing toward more joint treatment. Among the technological problems is the fact that normal municipal secondary treatment processes may not be able to handle the high biochemical oxygen demand found in some industrial wastes. Such problems can often be solved, and data for 1968 show that municipal sewage treatment plants treated approximately equal volumes of municipal and industrial waste waters.

The four ACS recommendations on solid wastes involve mainly existing capabilities, and we have said little that has not been said before. The recommendations could be implemented simultaneously and very nearly as rapidly as the necessary resources could be mobilized. Solid wastes are not inherently mobile—unlike air and water pollutants—and they tend as a result to be a local problem. A large part of that problem is simply the difficulty of persuading the responsible parties to pay for what needs to be done.

In any case, our recommendations stress the continuing need for education, research, demonstration, and local and regional planning for solid wastes management, utilization, and disposal. Continuing effort also is required in methods of collecting and transporting municipal solid wastes; these functions typically account for about 80 percent of the cost of the total waste disposal system. We also see a need to encourage and support the use of known peripheral science and technology in developing improved methods for sanitary landfill and incineration. Composting has succeeded economically in only a few instances, but we believe its true potential could be assessed more accurately if the process were put on a more scientific basis. This is particularly true of the biochemistry of the degradation process.

Our recommendations on solid wastes also cover junked automobiles. Disposal of discarded vehicles appears to be largely a problem of using technology to produce a marketable scrap at a reasonable cost. Our recommendation deals with the several aspects of this problem: transportation, processing equipment, air pollution control equipment, and the demand for higher quality ferrous scrap.

The fourth and final section of the ACS supplement concerns pesticides in the environment. Our first recommendation on pesticides calls for an extensive program of education, at all levels of government, to teach all users of pesticides the optimum methods of pest control. Considerable progress in the more intelligent use of pesticides can be made by starting such a program at once.

Optimum methods of pest control involve careful integration of chemical, biological, and cultural methods. As far as chemical methods are concerned, contamination of the environment can be reduced by using better application techniques and formulations; by applying the available knowledge of the effects of pesticides on insect parasites and predators and of population dynamics; and by using eradication techniques such as release of sterile males. Economic control of pests on crops and animals can be achieved in this way with minimum environmental and ecological impact. To implement such concepts, however, requires extensive education among research workers, extension and regulatory entomologists, and farmers.

The ACS task force recommends that persistent pesticides be used only in minimum amounts and under conditions where they have been shown not to contaminate the environment extensively. By "persistent" pesticides is meant those whose concentration tends to be magnified in the food chain. We do not mean those that are designed to provide, let us say, season-long protection against particular pests. The persistent pesticides include mainly the chlorinated hydrocarbon insecticides such as DDT.

The actions taken by the U.S. Department of Agriculture and, later, by the new Environmental Protection Agency, should deal effectively with persistent pesticides. Continued attention should be paid, nevertheless, to pesticides that are magnified in the food chain. We recommend that current programs of monitoring pesticide residues in all phases of the environment be continued. We see no reason to expand the monitoring program on human food, but we do call for expansion of the monitoring programs on air, water, soil, and wildlife. We recommend also the development of better methods for separating and determining minute amounts of pesticides in air and water. Until this is done, it will not be possible to expand the existing monitoring programs.

Biological and chemical methods of pest control are being studied extensively, and such work should be continued. We believe also that chemical methods should be integrated into such research programs, since we visualize future pest control as using optimum combinations of biological, chemical, and other tools.

The ACS considers it extremely important to do more research on the relationship and interaction between environmental pesticide contaminants and biological systems. Many conclusions on the effects of pesticide residues on biological systems are based on circumstantial evidence only. It is important to confirm or refute such conclusions by doing the experimental work required to establish definite cause and effect relationships. The original recommendation on this score dealt only with wildlife. Its importance is such, however, that it has been broadened by replacing "wildlife" with "biological systems." Humans have been harmed, sometimes fatally, by most of the highly toxic pesticides as a result of accidents and misuse, and such episodes

are relatively clear-cut. Not so clear-cut is the task of evaluating the effect on humans and other forms of life of exposure to relatively low levels of many pesticides in the environment and in the body itself. We have recommended continued research on the impact of long-term, low level exposure to pesticides on humans and other forms of life. We see a particular need to study the dose-response relationships of pesticides that are suspected of being carcinogenic.

One characteristic of the ideal pesticide is that it should be specific—as effective as possible against its target organisms, as safe as possible to all other forms of life. We are not fully exploiting today the specificity of a number of existing pesticides, but we do see a need to develop still more specific compounds. The last of our recommendations on pesticides calls for further research on more specific compounds, which can help greatly to decrease both environmental contamination and undesirable side effects.

I do not believe that the ACS people who worked on the original document on environmental chemistry, and on the supplement just described, will claim that either contains a profusion of brilliant insights. What we *did* set out to do was to produce an objective treatment of the subject in language that the educated layman could understand. We believe this is the kind of service that scientific and engineering societies such as the ACS are uniquely qualified to undertake. They have the intellectual resources at their command. They are in a position to organize them so as to cancel out individual and institutional biases to a very large extent.

The experience of ACS in the development of this report has led to some organizational changes which will place it in a better position to more effectively respond to environmental challenges, both on a technical basis and on a policy development level. The Committee on Chemistry and Public Affairs will continue to exercise its responsibility in the development of policy recommendations in the field of environmental improvement.

In 1970 the society established a new Joint Board-Council Committee on Environmental Improvement. This committee is responsible for the coordination of the internal technical programs of the ACS relating to the environment. One of the initial projects of this new committee calls for the establishment of an extensive information center and technical clearinghouse on the environment. This center will accumulate and disseminate information on the nature of the problems and questions being raised about the environment, house a compilation of established areas of ACS competence in the field of environmental improvement, and maintain a file of experts in the field, cross-referenced with their areas of competence.

A second phase of this project is the establishment of a series of panels to provide technical, investigative and research assistance in specific fields. This effort will be coordinated through the ACS technical divisions most directly involved in environmental work.

The environmental improvement report is considered by many members familiar with the ACS's achievement record as one of the most significant accomplishments in its history. ACS leaders regard the report and the organizational changes described above as the starting point from which the ACS is launching full scale into the task of seeking chemical solutions to the world's environmental problems.

The Committee on Environmental Improvement is now beginning to prepare a second edition of *Cleaning Our Environment–The Chemical Basis for Action*. The new report will be expanded to include not only chapters on air, water, solid wastes, and pesticides, but also chapters on toxicology, energy, analysis and monitoring, and radiation. The new report is expected to be ready for publication in 1974 and will be a five-year update of the 1969 report and will broaden its scope considerably.

Other ACS activities which serve as environmental science resources include the Chemical Abstracts Service, the Advances in Chemistry Book Series, tape recordings dealing with pollution and with solutions to environmental problems, and the "Men and Molecules" radio program.

Chemical Abstracts is a weekly journal containing abstracts of documents relevant to chemistry and chemical engineering. The *Chemical Abstracts* orientation to environmental problems is fundamentally chemical. Coverage of these topics is confined to substances and their relation to, or interaction with, the environment. Environmental effects of other agents (heat, noise, vibration, light) are included in *Chemical Abstracts* coverage only if they, in turn, cause a chemically related effect on the environment. Chemical effluence from an industrial plant is covered in *Chemical Abstracts*. However, thermal discharge from an industrial plant, whether a chemical industry or not, is covered only if the study is extended to include resultant chemical effects upon the area influenced by the discharge. Although *Chemical Abstracts* covers the theory and technology of heat exchange and heat exchangers as they relate to chemical engineering, coverage is extended only to related chemical effects on the environment but not to effects on the environment per se. *Chemical Abstracts* will cover an estimated 20,000 abstracts annually related to chemistry and its environment. This represents about 5 percent of the total chemical abstracts.

The ACS Advances in Chemistry Book Series are the published form of symposia presented at the American Chemical Society meetings. Many of these symposia provide a broad picture of the progress in various fields of environmental research and development. The books make this information widely available, and include references for each paper.

The Committee on Chemistry and Public Affairs initiated, in 1966, a series of public issue and policy symposia at ACS national meetings in order to broaden the spectrum of member interest and responsibility. This program

has been quite successful in catalyzing other units of the ACS, and we now have a growing program of public and professional symposia (many dealing with environmental problems) in addition to the strictly technical papers presentations. Most of these public interest symposia are tape recorded and have received wide distribution and are available upon request. Feature articles on these symposia also appear regularly in *Chemical and Engineering News*, ACS's weekly news magazine, and multiple copies of the reprints are available for distribution.

"Men and Molecules" is the ACS's 15-minute weekly radio program heard on more than 400 stations across the country. It is primarily an interview program which concentrates on a continuing report on current issues in science by the leaders in various fields. Increasingly, leaders in the environmental field are being heard on the program. This program is available on audio cassettes by subscription.

Finally, I should mention the ACS short courses in chemistry and chemical engineering. More than forty different courses are now available. They are concentrated, naturally, in the classical chemical fields, but in the last few years interdisciplinary subjects have been covered. A specific series of courses dealing with pollution control and environmental science are now under development. These courses are conducted in the traditional manner and also in the form of individual and group audio courses. Research and development is also being carried out on videotape short courses.

In summary, the ACS recognizes a responsibility as a scientific and educational organization to marshall its total intellectual and physical resources to effectively contribute to the solution of public problems such as the environmental issue.

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3. Committee on Chemistry and Public Affairs. *A Supplement to Cleaning Our Environment—The Chemical Basis for Action*. Washington, D.C., American Chemical Society, 1971.