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RISK/BENEFIT ANALYSIS IN THE
LEGISLATIVE PROCESS

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JOINT HEARINGS
BEFORE THE
SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
AND THE
SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE
OF THE
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE
AND
CONGRESS/SCIENCE FORUM WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE
NINETY-SIXTH CONGRESS
FIRST SESSION

JULY 24, 25, 1979

[No. 71]

(Committee on Science and Technology)

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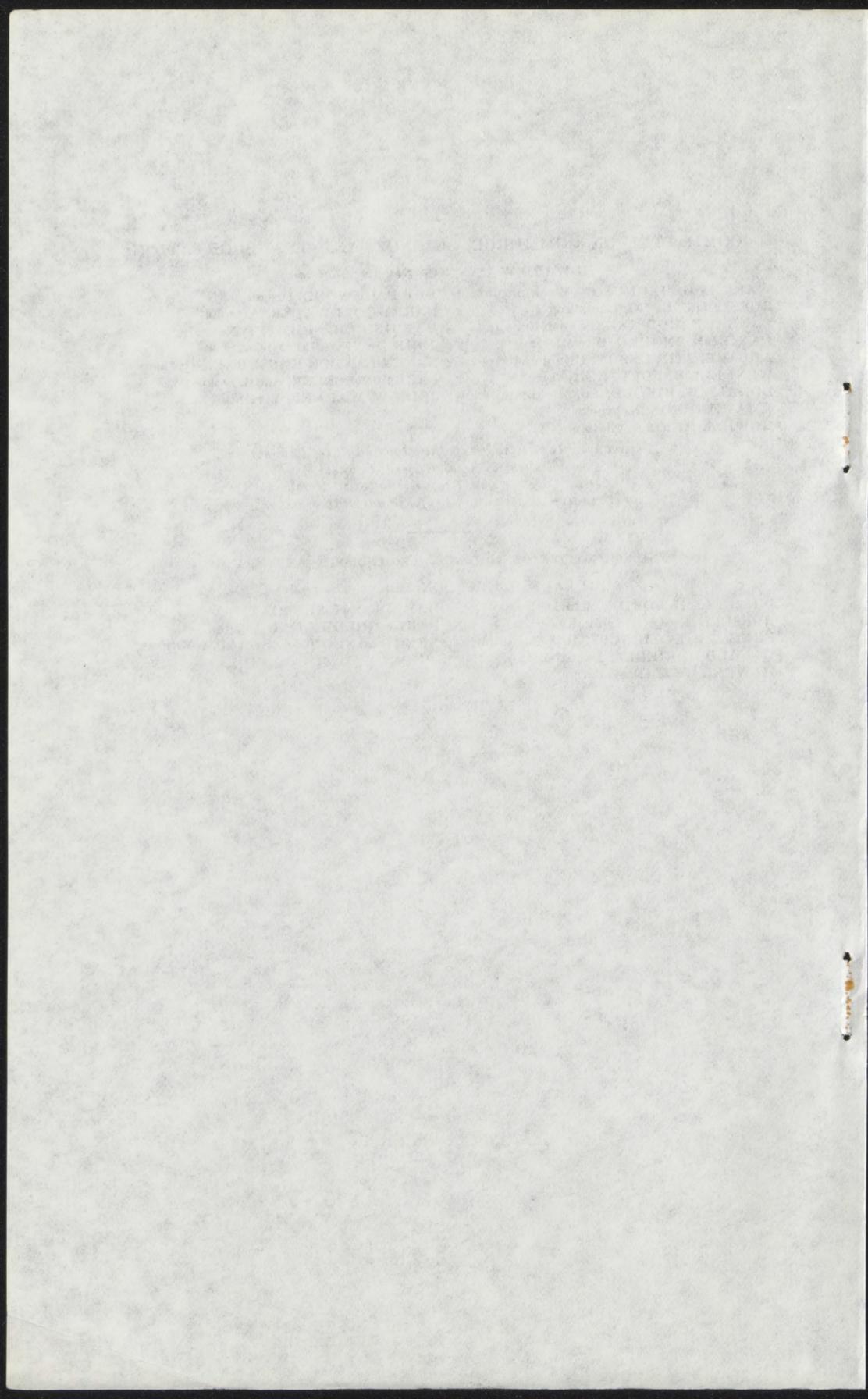
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RISK/BENEFIT ANALYSIS IN THE LEGISLATIVE PROCESS

TUESDAY, JULY 24, 1979

HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, SUB-
COMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
AND SENATE COMMITTEE ON COMMERCE, SCIENCE AND
TRANSPORTATION, SUBCOMMITTEE ON SCIENCE, TECH-
NOLOGY, AND SPACE,

Washington, D.C.

MORNING SESSION

The Congress/Science Forum on Capitol Hill convened at 9:10 a.m., in room 1202, Dirksen Senate Office Building, Charles A. Mosher (public programs manager, American Association for the Advancement of Science) presiding.

OPENING STATEMENT OF CHARLES A. MOSHER, PUBLIC PROGRAMS MANAGER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Mr. MOSHER. My name is Charles Mosher, and I am speaking for the AAAS. It is my privilege to welcome you here this morning.

All of you are very welcome, more than welcome. However, I must admit that at times in the next two days we may be embarrassed by your number. We originally contemplated a meeting here of about 100 people. We thought it might conceivably reach 150. There are well over 150 here this morning, and there will be times during these sessions when there will be well over 200 or even 250. So that is great. You are extremely welcome, no matter how many numbers you total up to.

As you know, our general purpose for these two days will be to examine a dilemma, or a class of dilemmas seemingly applicable to all of today's decisionmaking, and especially policies having to do with science and technology; namely, how shall we balance the risks against the benefits. And particularly here in the Congress, how can these necessary risk-benefit trade-offs be determined wisely and effectively, and with some adequate degree of foresight.

The response to our invitation certainly indicates the widespread interest in this general subject, and we are delighted that you are here.

Now we don't pretend that our 2-day program as arranged is sufficiently rigorous or well balanced, and it's certainly not sufficiently rigorous and well balanced to provide any definitive answers. I suspect every point of view is represented among you as participants and it's important that during the two days any of you feel free to take

an active part particularly in the discussions, which will have no spurs attendant to those points of view not represented here. We don't expect any final answers these two days. In fact, I am positive that more questions will be raised than answered; necessarily so at this stage of the game. I personally have long evidenced that all of us are only neophytes in our understanding of these matters, in our understanding of how the scales and methodologies of science, the engineering and the academic scholarship involved here, can best be applied in policymaking. I think we are only beginning to learn, and basic in the assumptions behind these two days is that we can only hope to focus some increased attention on the subject. Get it out here on the table to begin to point the way to further consideration.

Is there a place in the congressional process for so-called risk benefit analysis, in any systematic or logical sense? Many of us very frankly have our doubts. But obviously, both those kinds of trade-offs are being made in some form every day here on the Hill. How? By whom? Perhaps we will go away understanding that a little better after these two days, and I would like you to have in mind the question: Will not all voting decisions here in the Congress forever be more intuitive than logical?

I think, personally, I am convinced that is true, but keep that assertion in mind and test it against what you hear here.

It is our intention that the mode of these two days shall be rather informal. No coats or ties are required. The agenda is not strictly structured, and this agenda is very much an experiment. We believe it is a unique experiment in that it is held here on Capitol Hill rather than downtown at some hotel or at some center. It's a matter between the AAAS and two of the congressional subcommittees, Senator Stevenson's, and Congressman George Brown's subcommittee in the House. At the morning hearings, one held in this room at 10 o'clock today, and one tomorrow morning at 10 in the House, congressional members will hear experts from outside the Congress, and questioned by the members and staff. Then we will have the reverse of that in the afternoon, where our principal speakers will be congressional members with panels of discussants, and each one of you have the opportunity to question the Congress.

An underlying purpose, consistent with a very important goal that the AAAS has, is the role that the AAAS would like to play, as a catalytic agent in inventing ways to improve the interaction between scientists and engineers and academics, the community, to improve the interaction of the education and understanding between the community on expertise and the community policymakers, the political community. This is only one small step we begin here today.

The AAAS attempts in many other ways to accomplish this, but we particularly hope in these two days to have the scientists, engineers, and scholars more aware of the realities on Capitol Hill. We at the AAAS look on these two days as only a precursor, sort of a springboard, to a variety of other means we will attempt to use in the months down the road to move closer to that goal of increased communication and increased understanding.

Now before I introduce our morning speaker, a couple of brief announcements.

The Senate hearings will begin in this room at 10 a.m. The last minute change of room was made because there are so many of you. This change of room may make it difficult for hearing; I am not sure how that will affect the attendance of Senators.

When the hearing adjourns at 12, we will head across Capitol Hill to the Rayburn Building where we will have an excellent luncheon and further discussion.

The afternoon symposium will be held starting around 2 p.m. It will be held in the Rayburn Building in room 2318, which is the principal hearing room of the House Committee on Science and Technology.

Now at this point we are scheduled to hear some keynote remarks from Congressman Udall from Arizona. The fact is President Carter has intervened, preempted Mr. Udall. At this very moment he is down at the White House—I don't pretend to know for what reason—he is down at the White House consulting with the President. So you are not going to hear Mr. Udall now.

But we are extremely fortunate in that, thanks to the wonderful friendship and generosity of one of Congressman Udall's closest friends in Congress, we are going to have some remarks from Congressman John Anderson from Illinois. Some of the most interesting pieces of legislation in previous recent years in Congress have been Udall-Anderson bills or Anderson-Udall bills. One is a Democrat, one is a Republican; they have cooperated excellently, they are great friends; and Mo, I know, is delighted that John Anderson is willing to pitch in for him here.

John has had no chance to prepare since we drafted him last evening. But I haven't the slightest doubt that what he will have to say is interesting, stimulating, and significant.

John Anderson, I think, as most of you know, is active on the Rules Committee, an extremely important part of the committee. He has been in the Congress nearly 20 years; 10 consecutive terms, elected from that very important Illinois district. He was until very recently chairman of the Republican Conference in Congress. About 2 months ago he resigned that position of leadership because at that point he announced his candidacy for the Republican nomination for the Presidency and his decision to go into the New Hampshire primary. I am getting into politics here, but I think you deserve to know this background.

John also—of particular significance for this group—was for many years a very active member of the Joint Committee on Atomic Energy. So he has very important ideas on energy problems and some of the other problems related to it.

John, I assume in making your decision to go to New Hampshire you have to consider some of the risks and benefits. So, you are welcome here.

**STATEMENT OF HON. JOHN B. ANDERSON, A REPRESENTATIVE IN
CONGRESS FROM THE STATE OF ILLINOIS**

Mr. ANDERSON. Thank you very much, my good friend and former colleague in Congress, Chuck Mosher.

Ladies and gentlemen, I can assure you that it is an honor to be selected even at 5 o'clock on the previous afternoon to address such a very prestigious gathering of scientists from all over our country.

Yes, indeed, there are some risks and benefits involved, some risks that I will have very little to say that is of much meaning and consequence, and accordingly of very little benefit to you. Those were really the risks and benefits I had in mind.

Incidentally, it gives me a certain sense of amusement, speaking on technology in front of an audience of scientists, that I am addressing you from a podium which consists of an inverted wastebasket, but since so many of my good ideas have ended up there over the last 19 years, perhaps there is something symbolic about the fact that I address you in this fashion.

I wish I had had more time to prepare because in the few hours that I have contemplated this, and there were other things that occupied my time yesterday evening, I have come to realize that your meeting and the discussion topic that you undertake is a very significant one indeed. It will test at the very outer limits my ability at extemporaneous speaking, I assure you. As Winston Churchill once said, my best, extemporaneous remarks have always been very carefully prepared. I can't even make that claim this morning.

I brought with me, however, a report, a familiar document here on Capitol Hill entitled "The Department of Energy Authorization Act for Fiscal Years 1980-81, Civilian Application." Incidentally as you know my part of the jurisdiction on energy matters falls to my distinguished friend and colleague who is down at the White House this morning, Mr. Udall, who is chairman of Interior and Insular Affairs. And you speculated why he was there, Chuck, three Cabinet openings, maybe he is down talking about one of those, or he may be talking about his opposition to the breeder program which is, of course, authorized under the bill in question.

But why I brought the report along was simply to read a line or two from page 20 which says:

Inflationary Impact Statement. In accordance with Rule 11, Clause 214 of the Rules of the House of Representatives, this legislation is assessed to have a minimal inflationary effect on prices and costs in operation of the National economy.

Several years ago, in connection with a new budget process that now obtains in the Congress, we did change the Rules of the House to require committees when they report legislation like this to discuss the cost-benefit ratio from the standpoint of its inflationary effect on prices and costs. It would be nice I guess if we could in similar manner amend the Rules of the House to require committees that are reporting on legislation to somehow try to quantify for us what the risks will be and what the benefits will be. In a sense we do that, as Chuck knows, in connection with one class of legislation that comes out. Public works projects that come out of the House Public Works Committee do

carry in the report accompanying those bills a cost-benefit ratio in proportion to the cost of the project. Be it a dam or something of that kind, what are the benefits, what are the ratio of benefits to be derived from the cost of that project in terms of flood control, in terms of recreational value and so on?

When you get into more general matters and particularly those involving the scientific community it would be very helpful, I repeat, to have a neat, precise, mathematical formula. We have the ability to quantify for Members of Congress before they vote what the risks involved will be in comparison with the benefits that will be conferred.

I think in the introductory remarks of your presiding officer this morning you have perhaps been alerted to the fact that our decisions on important questions where scientific judgment could well be involved, are nevertheless often made on less elevated ground than that. The President in his speech a week ago last Sunday night had a few remarks you will recall about the Congress of the United States. He lamented the fact that Congress is being twisted and pulled in a thousand different directions by oil interests competing for their share of the budget or for some attention from the Congress, and as a result developed rather plaintively that in some instances irrational provisions were being defended almost to the last breath by certain people in our society, as I recall what he said. But I came across an interesting little article in the current issue of the Congressional Quarterly for the week of July 14, and I suppose maybe I might be offending the rules of comity if I referred by name to the individuals who are involved, but the article, I think serves to be kind of an illustration of one of the points that I would like to make. It's called "Tightening Tangled Incentive, Bumper Standards Disputes", and it says that the Senate minority leader called up a bill which was authorizing money for traffic and motor vehicle safety and pushed through an amendment that would help the steel bumper industry in his State of West Virginia. The amendment, however, the article goes on, was approved at the expense of aluminum, a major industry in the home of the chairman of the Senate Commerce Committee.

The amendment would require the Federal automobile bumper standard to be rolled back to protect the car body against crash damage at speeds up to $2\frac{1}{2}$ miles per hour. The existing standard of 5 miles per hour had gone into effect a year ago September 1978, and as indicated the new standard would favor steel bumpers. The major producer of steel bumpers is in West Virginia.

The article goes on to say neither Senator referred to his interests on the floor: Yet certainly in the backs of the minds of these two gentlemen were the interests that they represent in their respective States. And there is, I suppose, nothing really less than legitimate about a Member of the House or a Member of the Senate taking into consideration economic interests that represent prosperity and employment for his State. And yet that example, I believe, serves to illustrate the difficulty that we face.

Presumably what you had here was, shall I call it, a scientific question: Would a certain standard and the use of a certain material more clearly be designed to protect the health and safety of the American people, and if so should that not take precedence over the eco-

conomic interests referred to? If the schedule goes according to present plan, we will have on the floor of the House of Representatives later this week the Department of Energy authorization bill and in it will be a very controversial authorization for funds to continue the breeder reactor project down there in Tennessee. I think again that whole controversy is an illustration of our inability to date to really come to grips with problems like that in terms of what the risk-benefit is, what the tradeoff should be.

As you know there is great conflict even among the experts on the extent of our uranium reserve. I think it was the National Academy of Sciences that several years ago came out with a report which said that the statistical probability was about 5 percent that the figure on which the administration was relying was correct, that is, that they estimated we had perhaps 3.6 million tons of uranium reserve. And people in the uranium industry were insisting that our uranium reserves were only about half that, or 1.8 million tons.

But again, the question as it revolves around the breeder reactor is not just the economic health of the nuclear power industry and our ability to have assured supplies of fuel to continue to participate in world markets as a reliable supplier of enriched uranium. The question has to be dealt with in terms of many other issues as well. The administration initially put great stress on its fears that there was the danger of proliferation, that if we went to a breeder economy and to a generation of reactors that were burning plutonium the fear of terrorism, the fear of diversion of plutonium supplied from the reactor site to terrorist groups that would in turn use it to fashion bombs and proliferate the danger of nuclear annihilation, ought to be the paramount consideration; that this risk was so great we should not go into a breeder economy.

More recently, as I am sure many of you are aware, former Secretary, although he is not quite departed, Jim Schlesinger, took up the argument that the kind of breeder reactor the Government had originally decided to build was not economic and that we should go ahead with a base research program. It meant a couple hundred million dollars rather than investing \$2 billion in constructing a plant not to be ready until 1989 and by the time it came on line it would be uneconomical.

But I think the whole controversy over the breeder is illustrative of the many arguments that can be used against a project of that kind and how difficult it is to neatly quantify by some precise mathematical formula what the risks are, what the cost would be as opposed to the benefits to be derived from that particular system.

I have one other example that I brought with me. We passed by voice vote on the floor of the House yesterday afternoon a little measure that would continue a moratorium for the next 2 years on the ban that had been placed initially on the use of saccharin. You may recall that controversy, and what this bill did was to extend to June 30, 2 years hence, a ban that would prohibit HEW from restricting or forbidding the sale and distribution of saccharin, or from amending their interim food advocate application that is applicable to saccharin.

There were a couple members of the committee who had different thoughts however. The committee that actually considered this bill

was the Interstate and Foreign Commerce Committee, and in their dissenting views two members said, "Due to the serious risks involved, it is more important to restrict public access to saccharin through its use as a prescription drug than to give the public freedom of choice on this issue" and they went on to suggest that there was a great deal of evidence that countered the claim that the carcinogenic risk from saccharin remained unproved.

But there again I think you have an example of some of the arguments that have to be considered by Members of Congress in trying to establish what this trade off should be. These two Members felt that it ought to be made a prescription drug, that there was some validity to the earlier studies that had been made on the carcinogenicity of saccharin.

Another very interesting view on this particular piece of legislation was expressed in the additional views of some other members. They said that "As to capability of science to detect, infinitesimal degree of carcinogenicity increases, the absolute nature of the Delaney clause will lead to the banning of more and more food additives that are vital to the safety and availability of the food industry," and they urged Congress therefore to give very serious consideration to revising our food safety laws and support for the bill which would add an additional proviso to the Delaney clause authorizing HEW to approve a food additive found to induce cancer in test animals if it poses no significant risk to human health, and if the benefits to be derived outweigh the potential risks.

That I think is interesting to show that members of the Congress increasingly are beginning to think at least in these terms, rather than thinking purely in terms of the soft drink industry and the economics of using or not using saccharin as a sugar substitute in Pepsi Cola or some soft drink. They are beginning at least to talk about trying to weigh the risks to human health against any benefits to be derived.

Some additional views that were submitted I found interesting because they make the point, and I incidentally happen to agree with that point, that the Delaney clause which makes no allowance for the degree of risk or for any consideration of benefits, is an absolute obsolete safety feature in U.S. food additive laws, and that the original logic behind the clause has not kept pace with modern technology which is now able to detect a contaminant at a parts-per-billion level. Changes in the food safety laws must be made carefully to prevent public exposure to any significant danger. But then they make the recommendation that they support legislation, H.R. 3778, which authorizes the issuance of food additive regulations on the basis of a risk benefit evaluation.

So again, I don't know how far that particular bill, H.R. 3778 is destined to go in the current Congress, locked as it is in controversy on a lot of other things. But I think it attempts to show we are at least beginning to move in that direction, of trying to provide a risk benefit evaluation.

Very frankly, I was asked by Chuck to say a word about some service I had up until several years ago on the Joint Committee on Atomic Energy, which was originally established in the act of 1949 but went out of business back at the beginning of the last Congress when juris-

diction over nuclear power and all of the programs was given over to other committees. But over the years I did serve on that committee I know that initially as we considered what was called the cooperative power demonstration program begun 25 years ago in 1954, the one which led to the present generation of boiling water and reactors, we talked largely in terms initially of the great economic benefits that were going to be derived from the use of nuclear power; power as you have read many, many times was going to be so cheap you wouldn't even have to meter the power. The great emphasis I think back when that program was started at least, was that this was one peaceful use of the atom that would be very economical and should be done on that basis.

I think one time former Chairman Holifield estimated \$2 billion had been saved the electric consumers of this country—comparing economic costs of nuclear power to power coming from fossil fuel fired plants, coal- and oil-fired plants, that we were achieving that kind of economic benefit.

Then I think as time went on, gradually within that committee there did develop proper concerns about safety. About 3 or 4 years ago, the Rasmussen report was commissioned—a report that took about 3 years to compile, I think cost about \$3½ million, and was designed to address specifically the question of what were the risks of continuing nuclear power programs. Again, however, even though that report will appear to be very definitive, its methodology was strongly criticized by those who were against the nuclear power program. Even though it found that your chance, for example, of being killed in an automobile accident was 1 in 5,000, and your chance of being wiped out in a maximum credible type of accident or melt-down of the core of a reactor was 1 in several billion, as I recall it, I think that report has not really done as much certainly as its author and those who participated in the study hoped it would do to quell public fears over continued expansion of the nuclear power program.

Let me close these brief remarks by again saying that I think you are focusing on a topic that is going to be of increasing interest and concern to the Congress. I have, as Charles, your presiding officer this morning indicated, been a generalist in my two decades in the Congress, having served on the Committees on Rules, which is kind of the funnel which pours out on the floor the work of all the other 21 to 22 standing committees. Perhaps for that reason more than any others I do feel the need of getting the advice of the scientific community on some of these difficult issues where we should be weighing very carefully what the risks to the environment, what the risks to human health, are in comparison to the benefits to be derived. I say that because we now stand on the threshold of massive governmental efforts to try to solve the energy crisis by resorting to the production of synthetic fuel, and already we are beginning to hear some cries of alarm from environmentalists around the country about whether or not that is going to foul the environment, and to that extent be a detriment rather than a help to the advancement of our society.

These are difficult judgments to make. How do you equate the importance of relieving this country from the kind of overdependence on important OPEC oil that we have today with all the deleterious consequences that that can have for our foreign policy, for our national

security? How do you weigh that against the argument that by building a huge \$1½ billion or \$2 billion synthetic fuel plant that will pour contaminants into the air, that you are risking the lives of millions of people and perhaps even having genetic effects on the generation yet to come. And yet those are decisions that are going to have to be made, and we ought to make them not on emotional grounds; they ought to be made not on an emotional basis, but they ought to be made on the kind of empirical evidence that the scientific community is uniquely equipped to provide.

Thank you very much.

Mr. MOSHER. I know John would respond to questions, but there isn't time. And he is awful good at them, by the way; he would have a lot more to say.

I suggest you stretch and get ready for the hearing which will begin in about 10 minutes.

STATEMENT OF HON. ADLAI E. STEVENSON, CHAIRMAN, SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE

Mr. STEVENSON. The meeting will come to order.

This is the first of two hearings by the Senate Subcommittee on Science, Technology, and Space, and the House Subcommittee on Science, Research, and Technology, in conjunction with a Congressional Science Forum organized by the American Association for the Advancement of Science.

We welcome you. It's a pleasure for me to be here, more so because for the last 3 months I have been presiding over hearings in this room in very difficult circumstances, hearings of the Senate Ethics Committee.

The Congress considers many issues that require its Members to weigh competing claims of benefits and risks, from the conduct of recombinant DNA research in San Francisco to fall of Skylab in Kalgoorlie, Australia. Technology creates risks and scientific research uncovers hazards previously unsuspected. The recombinant DNA issue in particular impressed scientists that even their own research activities can become matters of national controversy.

In Congress, too, we face increasingly strong cross-pressures. The public assigns high value to health, safety, and environmental protection. On the other hand, the business community and some in Congress point to the high costs of regulation and claim that too many technological opportunities are forgone as a consequence of policy uncertainties and potential liability.

This is the scientific, political, and philosophical quagmire into which we venture today. These dilemmas account in some measure for the attractiveness of risk-benefit analysis, but its techniques and uses are themselves controversial. We need to understand better the strengths and shortcomings of such analysis. We need to improve the collection and communication of empirical data that can enlighten public debate. And we need to consider the mysterious process by which some risks are perceived as requiring legislative action, while some more serious fail to achieve a crisis threshold in public consciousness.

These are the purposes of this conference. But before we begin let me suggest three caveats. First, we must not confuse the responsibilities of scientists and public officials in matters of public policy. Theirs is to analyze, to caution, or exhort and recommend; ours is to decide.

Also, let us not be carried away by rhetorical claims that we have become a "zero risk" society. For one thing, collective decisions are almost always compromises. Generally speaking, the particular risks that have exercised the American public, though not necessarily the most serious, or even serious, are nonetheless risks we can afford and have the means to do something about.

But finally, let me suggest that there is a possibility that the cumulative effect of risk aversion and regulation is to infect business and government with technological timidity and discourage the taking of risks that would serve our social and economic needs. As far as I am aware none of these issues has been subject to rigorous analysis and debate. They are of great importance.

And now let me turn to my colleague and good friend, Congressman George Brown.

STATEMENT OF HON. GEORGE E. BROWN, JR., CHAIRMAN, SUB-COMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

MR. BROWN. Thank you very much.

I have a prepared statement which with your permission I will insert in the record. I would just like to add my welcome to those the Senator has expressed and to make the comment that possibly his three months in the chair here presiding over the Ethics Committee was another example of risk-benefit analysis and that can be looked at from many different ways. Actually ethics is that part of philosophy that deals with value. There is also a part of science which deals with value, sometimes called axiology and which has been inadequately treated by most scientists. I would suggest that one of the things we should look at in examining risk-benefit analysis is the relationship of axiology to risk-benefit analysis. We may find out that this is the most important factor in making risk-benefit analyses. It is worth some thought, I think, as we listen and participate for 2 days in this effort to better understand what the Senator has indicated and as John Anderson indicated earlier, is becoming a more and more important consideration to the deliberations of Congress.

Welcome and let's proceed.

MR. STEVENSON. Thank you, Congressman Brown. Without objection the statement will be entered in the record.

[The prepared statement of George E. Brown, Jr., follows:]

OPENING REMARKS

Hon. GEORGE E. BROWN, Jr.
Chairman

Subcommittee on Science, Research and Technology
Committee on Science and Technology

U.S. House of Representatives

July 24, 1979

Chairman Stevenson, distinguished guests.

We on the House Subcommittee on Science, Research and Technology are delighted to join with Senator Stevenson's Science, Technology and Space Subcommittee and the A. A. A. S. in sponsoring this Forum and hearing on Cost/Benefit Analysis in the Legislative Process.

I especially want to join with you in welcoming the joint sponsorship of our Forum by the A. A. A. S. Much of the credit for initiating this 2-day Forum goes to our former colleague in the House, Chuck Mosher who is now with the A.A.A.S. His energy and enthusiasm are really what have made possible the thorough review of this important and vexing question which we begin this morning.

In the Congress, questions requiring us to study and weigh the risks and benefits of technology are increasingly before us. We have tried to deal with those questions in a variety of ways. The hearing process is, of course, the most important one. It allows to hear experts such as those who will give us the benefit of their thinking and experience today and tomorrow.

Recognizing that experts themselves occasionally have their preferences and perhaps even biases, the Congress several years ago established the Office of Technology Assessment. Both Chairman Stevenson and I are privileged to serve on the Technology Assessment Board, OTA's board of

directors. The OTA has begun to build a solid record of providing the Congress with evaluations of technology, including evaluations of the secondary, often risk-yielding consequences which we must take into account.

I think it would be fair to say that Risk/Benefit analysis today is at an important stage of development. As a result of what we have learned in the fields of energy, food, environment, and drugs, and the individual cases with which Government has had to deal in these areas, we have learned a lot.

We have learned that there is no such thing as a risk-free technology. We have learned that while risks frequently can be scientifically evaluated, their social acceptability is a much more complex problem. On the other hand, we have learned that the risks of rare events, such as the falling of a Skylab, is sometimes more difficult to pin down, and that public concerns about such rare events may be higher than concern about familiar, well-known risks. We have learned that the risks associated with established technologies, such as the driving of an automobile, appear to be more acceptable than the perceived risks of brand new technologies such as DNA research. And we have come to recognize that public perceptions of risks is strongly influenced by their treatment in the media as was the case with the Legionnaire's disease and the Three Mile Island accident.

But there is much yet to be learned. The need to make careful tradeoffs is well recognized. The worldwide ban on DDT was justified because it eliminated a substance toxic to both man and animals. But the ban on DDT also has reduced the chances of eliminating malaria and of controlling crop destroying pests thus increasing the risk of famine in some countries. In this and in similar cases we recognize these factors

but we have no clear way of weighing one against the other.

In much of the current debate we hear suggestions to the effect that the fear of risk has become even greater than risk itself. It is said that, especially in the United States, our concern with risk reduction and risk avoidance is serving as an undue restraint on technological innovation. Just yesterday, in another hearing, an official of a large manufacturing company testified that "incremental improvements that incur smaller risks and require less front-end technical effort to meet more demanding societal standards now represent a larger fraction of (industrial) R & D effort".

As a society we must learn to deal with risks. This Forum and these hearings will serve to widen our understanding of the many complex questions which arise when we try to do so. I look forward to the exchanges of views with our witnesses and the participants in this joint effort.

Mr. STEVENSON. And let me call also on our colleague, Congressman Ritter.

Mr. RITTER. I will be before that witness table myself tomorrow morning. I would just like to introduce myself. I am rather different in terms of the background that people bring to the U.S. Congress. I have been a scientist's engineer myself. I have been an engineering professor, I have a doctorate from MIT, and I might say I have been considering this business of risk and the different trade-offs among risk and the comparisons of risks for about 10 years.

So I am just delighted to see my distinguished subcommittee chairman and the distinguished Senator from Illinois putting this panel together along with AAAS, and I am delighted that former Congressman Mosher has taken such a strong leadership role in putting this together.

I think it's so essential for the decisions that we face right now to have this kind of dialog. To me it is the most important question that we as a later 20th century society, dependent upon technology, face. To the extent we can open this debate up and create a greater public understanding of how decisions can be made regarding the different risks that we face, by not making these decisions unilaterally, I feel we will have done a service to the American people, to our children, and to our country.

Thank you, Mr. Chairman.

Mr. STEVENSON. Thank you, sir.

We have as witnesses three distinguished and perceptive observers of American institutions. They are Harold Green, attorney and former professor of law at George Washington University; Aaron Wildavsky, professor of political science at the University of California at Berkeley; and Edwin Diamond, a former editor of Newsweek, who is now on the political science faculty at MIT.

If there is no objection from my colleagues, we will proceed with all of your statements and then come back to the panel with questions for all of you.

Dr. Wildavsky.

STATEMENT OF PROFESSOR AARON WILDAVSKY, DEPARTMENT OF POLITICAL SCIENCE, UNIVERSITY OF CALIFORNIA AT BERKELEY, BERKELEY, CALIF.

Dr. WILDAVSKY. The title of my talk and the paper I will submit in about 10 days is "Richer Is Safer." If the proverbial man from Mars were to come to the United States and to look at us only by observation, he would have to conclude that the youth of America is dropping like flies in the streets because otherwise how would he explain to the people back home that hundreds of billions of dollars are being contemplated being spent in what appears to be a desperate effort to increase life expectancy. If he looked at the record of the past 100 years, he would see an almost unallayed increase in health and life expectancy all over the world and a corresponding decrease in accident rates and injury, and he might well wonder, and we don't wonder nearly enough why this entire movement began in contradiction of the most basic and elementary facts known to everyone.

The most important assumption underlying the current concern and public policy over risk is first of all that poorer is safer and therefore methods should be undertaken deliberately to decrease economic growth so as to improve safety.

The second assumption so important it's never discussed is that the way to reduce risk is by direct legislative action risk by risk, group by group.

My purpose here is to challenge these assumptions in the most fundamental way I know.

I believe that richer is, of course, not only better but richer is also safer and more humane. How, we may ask, did the United States become so much safer in the last 100 years if it was not the province of any bureaucracy except possibly the public health people to make us so. How come we did so well without benefit of legislative clergy.

Has it occurred to anyone that like many other things in life safety might better be perceived as a byproduct of actions undertaken on other grounds rather than as something only achieved if legislature or a bureaucracy directly seeks it? What is the evidence? If you array the countries of the world by level of economic development, except at the very highest levels the answer is unmistakably clear from the question. Richer is safer.

If you were to array the citizens of the United States by economic level, again except at the very highest levels of income, richer is safer. By that I mean much greater life expectancy, much greater levels of health, much smaller accident rates.

The critical question then is this: What levels of safety would we achieve by moving the countries of the world up one notch in income, or the strata of income in the United States up one notch by allowing economic processes to operate, than by taking direct action? I suggest to you that under almost any conceivable calculation, richer will turn out to be safer.

When we have our usual discussion of risk-benefit analysis, it goes something like this: One side wants to keep kosher, life is priceless, don't you dare mix it with money, you are vile, despicable, and mean.

The other side says, but people won't want to give up their standard of living, what you say is idealistic but people won't go along with it by making the necessary sacrifices. Anyone engaged in discussions of risk benefit knows that a certain soft answer does turn away wrath; if instead of talking about lives in terms of something vulgar called money, you talk about how many lives could be saved from an equivalent amount of money, comparing life with life, then they don't nip at your heels, and at least you can have a discussion without immediately being accused of being a moral monster.

But those who are partisans of a policy of anticipating risk realize immediately that this argument is entirely specious. They know that there is no such thing as a safety budget; that you are really not going to spend that money on safety though you talk, you economize as if you were, and therefore the whole discussion has an air of unreality.

Moreover, the economically minded really don't mean that they would like to spend the entire GNP on safety only more efficiently than those other fools. They really mean they don't want to spend this money at all, but they don't understand how to put that argument

without appearing inhumane. And I would like to try to proceed to tell them.

Richer is safer; indirect methods of improving safety are far more efficacious than direct methods. Of course, I can't go into the entire panoply, but consider nutrition: One of the major reasons that people in the United States are so much healthier and less accident prone than they used to be by far is a higher standard of nutrition. Yet when we had the mechanization of agriculture and the other developments which have greatly increased productivity, that was not done to improve anybody's safety. Safety was a byproduct. When we have had the explosion in mass education in this country, I presume that was not done also to make anybody safer; yet it turns out that the more educated people are by and large, the safer they are, the longer they live, and all the rest. When through the most vigorous forms of social interaction, including market methods, we increase greatly the variety of life, this means that all sorts of things that nobody contemplates are done, most of which fail, some of which succeed, and a smaller portion of which turn out to be actually useful for safety even though they were not sought for that purpose.

And while no one necessarily seeks safety for its own sake, or at least they didn't use to, things, processes, mechanism are not ruled out just because they are safe.

When you have a life with greater reliability and greater redundancy, when you have more variety in it, the possibility of being safe and of finding things that are safer, of finding things that are safer that nobody is looking for, is vastly increased. The implication for research is this: Instead of spending all our time studying risk, we should spend a lot more of it studying what has made us safe. I think the results will be quite different.

As to the Congress itself, it should consider in the most serious way the implications of a case-by-case, risk-by-risk, group-by-group approach. I don't believe there is one legislator who does not understand the implications. If you ask who has the right to live and who has the right to die, the answer can only be if it's you and me, we are priceless to ourselves and to others who are for us. Going case by case is not an incremental approach, it is an exponential approach. The only thing that can happen by the usual processes of logrolling is geometric increases in expenditure. The possibilities of disaster are unlimited. No one can anticipate all the things that might go wrong.

In the past we relied on resilience. We anticipated the worst and we relied on a general capacity to be flexible and to respond. By attempting a politics of anticipation, we shall not only destroy any potential we have for growth and for group accommodation, but we will make people poorer and sicker.

How will evolution occur if everyone is held risk free? You have endless impact statements. Any impact statement is OK; it means the environment is constant and everything else varies. But if we have health and welfare, and urban and rural, and employment and inflation, et cetera, impact statements, when it comes time for the period of evolution, who will bear the burden of adaptation? We have now had a brilliant example of this. No one is to suffer from oil price increases. The poor don't suffer; therefore, the rich don't pay either. Regions

don't suffer, ecology doesn't suffer, no one suffers. What is the result of it? A board or a committee is now composed whose main purpose is to abolish all those other risks reduction routines, to make decisions in a more centralized way, and to bring in a technology that is not only dearer but dirtier. This is the inevitable consequence of refusing to impose risks on any one earlier. It means much greater risks, of course, must be imposed on everyone later.

A good philosophical way to look at this is a question of the part versus the whole. The late John Von Neumann used to say that it was possible to have systems whose parts were more reliable than their whole. By introducing measures of redundancy and execution of variety and competition, it would be possible for the whole to last longer, to perform more effectively and reliably than the parts. The movement of safety here is based on the opposite doctrine of insulating every part against change. Oh, no, not me; you can't impact on me, on somebody else.

As we go from one group for consideration after another that can't be impacted, the only result will be every part in America will be very strong. It's only the whole that will collapse.

When we think about this matter from the point of view of congressional consideration, I conclude in this way. I think that risk-benefit analysis and risk assessment are not appropriate levels of consideration for Congress. We know too much about the past history of cost-benefit analysis to believe that there won't be double and triple counting, that the benefits won't be overestimated, that the costs won't be underestimated, and that we won't be able to agree about whether you should be in this business at all. If you did have something such as a safety bucket, we know this, that the citizens of this country, including our legislators, would never vote for a single item anything near the amount that will result from the cascading of these case-by-case approaches. You have the history of medical care. If we had as in Britain a single bullet item at the top, nobody believes that would be anything like the combination of medicare and medicaid and comprehension insurance and the private sector. We know concerning the individual case by case he is at odds with collective rationality. What you should be considering at the larger level is whether a political body should leave itself open as Congress used to do in tariffs and regulations to a case-by-case approach. Rather than thinking about all the new things you could be doing, you might well be thinking about those principles which would prevent these matters from coming to you in this form. No matter what would be said in public, anyone with experience in political life knows what will happen if we go case by case. We will not only spend enormously, which is not really what troubles me, for I suppose we are rich enough to overcome most things. We will hamper the variety and interest of our life, and we will end up with our people poorer and sicker than they were before.

[Paper entitled "Richer Is Safer" follows:]

RICHER IS SAFER:
RISK ASSESSMENT IN THE LARGE

BY AARON WILDAVSKY

The proverbial man from Mars, observing our behavior in the past decade, could not help but conclude that the youth of America were dropping like flies in the streets and that, therefore, the United States Federal Government was engaged in a desperate multi-billion dollar effort to increase life expectancy. Observing more closely, the Mars historian of safety in the hundred years from 1870 to 1970 would note that every increase in industrialization and wealth, except possibly at the highest levels, was accompanied by a corresponding increase in personal safety. Since personal safety and economic growth advanced together, our man from Mars must wonder, why is present policy based precisely on severing that link by deliberately decreasing wealth in order to remove risk?

Unbridled economic growth, the standard argument says, has hurt the natural and human environment. The land has been despoiled, the seas polluted, the people diseased. Some of the advantages of quantitative growth, therefore, have to be sacrificed to improve the quality of life. The usual question is about how much wealth should be sacrificed for how much health. Answers vary but none are enlightening because they ask the wrong question.

Discussion on the subject of risk is about costs and benefits. Some say that human life is priceless and should not be contaminated by discussions of vulgar matters of money. Others say that citizens would not willingly reduce their standard of living by much in order to reduce

risk a little. Immediately, as everyone knows, the objection arises that life and nature are being bought and sold and that the whole exercise is immoral.

Tired of what appears to them to be an irrational argument, because income stands for all sorts of other things that might improve peoples' lives, proponents of risk-benefit analysis convert the currency of discourse to a common denominator--lives saved or accidents prevented. They try to show that many more lives could be saved or accidents prevented by far more efficient alternative uses of the same sum of societal resources. Having done the same sort of thing, I can testify that this soft answer does indeed turn away wrath. For the moment, at least, an argument about who is most morally monstrous may be turned into one about which means are efficacious to the same or similar end. Ultimately, however, the argument neither satisfies nor suffices. It does not suffice because the opponent of risk-benefit comes back with what appears to be a conclusive rejoinder, namely, that the choice is illusory because no one is proposing to spend money on safety per se. There is, in fact, no safety budget from which such sums might be allocated to higher order uses. And, in the nature of the political process, where it is not health in general but people suffering from specific diseases that generate support, and not risk in general but reduction for particular people that galvanizes them into action, the argument appears self serving. In the guise of efficiency, the proponents of lower level risk believe, the amount spent will be radically reduced.

The argument that expenditures on safety should be compared across the board also does not satisfy because the people making it really don't want to spend that much and they don't know how to explain why. Do they

really want vastly increased expenditures on safety so long as these sums are spent in ways they consider more efficient? Consuming the entire national product to reduce risk (in the most efficient way, of course) is not exactly what they have in mind.

A radical reorientation of risk assessment requires an enormous expansion of the classic concept of opportunity cost. Assessment asks whether the alternatives forgone by a certain expenditure are worth what is paid for them. Assessment should also ask what the total of all expenditures to reduce risk would be worth in terms of increasing safety if they were allowed into the economy.

The issue should be confronted head on: How much reduction of risk by direct expenditure on that very purpose versus how much increase in safety by expanding the national product? Existing public policy is based on the belief that the way to reduce risk is to do so directly for each and every group of people adversely affected. What are believed to be excessive risks are identified and policies are proposed to reduce them by direct action of government. This view may be mistaken. Though efforts to reduce risk in individual instances may be successful, the very same actions may increase risk for more people. To the current conventional wisdom that the way to reduce risk is deliberately to make the nation poorer than it would have been, I counterpose the perception of our parents that, having tried the alternative, "richer is better" and, I would add, safer too.

How might the effort to directly reduce risk for specific groups result in an increase of risk for other and larger elements in the population? First I shall outline in general the processes through

which increase in national income leads to decreases in risk, and then I shall explain why the effort to decrease risk here and there leads to its increase almost everywhere.

Health and Wealth

Consider the condition of poor countries. Death rates go up as income goes down. Though they show considerable improvement after inexpensive public health measures are introduced, they still lag not only behind richer countries but among themselves on the basis of relative income. The same is true within the United States where health and income remain highly related. Increasing the income of nations and classes is evidently one way of improving safety.

In a study of some five countries in 1953, Irma Adelman shows the usual "negative long run association between death rates and economic conditions." She goes on to state what everyone then took for granted:

For it stands to reason that such factors as better nutrition, improved housing, healthier and more humane working conditions, and a somewhat more secure and less careworn mode of life, all of which accompany economic growth, must contribute to improvements in life expectancy. In addition, as pointed out by Spiegelman, 'Fundamentally, health progress depends upon economic progress. By the rapid advance in their economies in the postwar period the highly developed countries have produced wealth for the development of health programs. Also, more efficient technologies in industry are releasing the manpower needed for an extension of medical

care and public health services. The intangible contribution of economic progress to lower mortality is derived from the advantage of a high standard of living - abundant, better and more time for healthful recreation.*

The classic study of England and Wales in the 1920s by Jean Daric led him to conclude that social class was a more powerful predictor of mortality rates than risk of work.**

Within the United States, Evelyn Kitagawa and Philip Hauser reach the same conclusion about "a strong inverse association between mortality and income."

Over the years mortality has declined by reason of a number of factors, including increased productivity, higher standards of living, decreased internecine warfare, environmental sanitation, personal hygiene, public health measures, and modern medicine climaxed by the advent of the pesticides and chemotherapy. Programs aimed at the reduction of death rates have been primarily based on biomedical epidemiology and biomedical ameliorative programs. This analysis of socioeconomic differentials in mortality may be viewed as documentation of the need for increasing attention to socioeconomic epidemiology. The evidence indicates that further reductions in death rates in the United

*Irma Adelman, "An Economic Analysis of Population Growth," The American Economic Review, p. 321.

**Jean Daric, "Occupational and Socio-Economic Status," National Office of Vital Statistics, Special Reports, 1951, Number 10.

States may be achieved more readily through programs designed to improve the socioeconomic conditions of the disadvantaged elements of the population than through further advances in biomedical knowledge.*

The data on life expectancy and economic level for more recent times all point in the same direction: the lower the income, the higher the death rate at earlier ages. The two tables presented,** with data from quite different sources, show that in a large number of countries, life span increases with the level of economic development (as measured by consumption of energy), and within the United Kingdom, the poorer the

TABLE 1

AVERAGE LIFE-SPAN IN SOCIETIES WITH DIFFERENT ENERGY CONSUMPTION IN 1950, 1960 AND 1970

Average energy consumption kg. coal- equivalent per person	Average life span (years)		
	1950	1960	1970
10	45.	52	56
100	48	53	57
1,000	64	66	65
10,000	67	71	72

L.A. Segan and A.A. Afifi, "Health and Economic Development". Reports RM-78-41 and RM-78-42, International Institute of Applied Systems Analysis (1978).

TABLE 2

EFFECT OF RELATIVE INCOME ON THE RISK OF DEATH FROM VARIOUS CAUSES BEFORE AGE 65 IN THE U.K., 1970-72

Cause of death and age group	Standardized mortality ratios for five social groups				
	(high) 1	2	3	4	5 (low)
Infant mortality and stillbirth (age 0-1)	66	77	89	111	174
Childhood mortality (age 1-14)	82	82	96	116	159
Adult male mortality (age 15-64)	77	81	103	114	137
(circulatory disease)	(85)	(89)	(108)	(110)	(118)
(cancer)	(75)	(80)	(102)	(116)	(131)
(respiratory disease)	(37)	(53)	(93)	(123)	(187)
(violent deaths)	(78)	(78)	(89)	(122)	(197)

Note: where the income of the adult male varied from £44 per week average in social group 1 to £20 per week average in social group 5 in 1970-1972. The average mortality ratio for all persons in each horizontal line is 100.

"Occupational Mortality, 1970-1972, England and Wales". Government Statistical Service, Her Majesty's Stationery Office, London (1978).

*Evelyn Kitagawa and Philip Hauser, "Trends and Differentials in Mortality," Cambridge: Harvard University Press, 1973, pp. 149, 153.

**Taken from D. K. Myers and H. B. Newcombe, "Nuclear Power and Low Level Radiation Hazards," Atomic Energy of Canada, Ltd, March 1979, AECL-6482.

people, the worse their chances of survival. As Ernest Siddall puts it, "It appears that the creation of wealth leads to the saving of lives in very large numbers at a net long-term cost which is zero or negative."* Moving countries or classes up on income increases their safety more than new efforts to reduce risk.

The conclusion stares us in the face: if health and wealth are positively related, sacrificing one for the other may not only lead to less wealth but also to less health.

The "Hidden Hand" In Safety

How, we may well ask, did the United States become a safer place to live in the past century without anyone directly intending to achieve that result? With the partial exception of the sanitation and public health movement, there was no department of safety, no one in charge of seeing that Americans lived safer lives. The small moves in this direction, like meat inspection and housing standards at the local level, possibly raised prices but they certainly are not responsible for improved standards of housing or food. Whatever was done was done indirectly on the basis of other considerations with safety a by-product or a resultant of decisions taken on quite different grounds.

Is it conceivable that risk may be reduced and safety increased by actions in no way intended to achieve that effect? As a general proposition, unintended consequences are a staple of social life, just as finding one thing when looking for another is a staple of science. Our actions are intended to achieve direct consequences but that does not mean they may not achieve unintended ones as well. That individual action is based on intention does not necessarily signify that society

*Ernest Siddall, "Nuclear Safety in Perspective," Ibid., June 1979.

is a product of design. If we think of social life as an extraordinary chain of complex adjustments, each action ramifying out in innumerable directions, bumping into others unforeseen, causing consequences described as sixth and seventh and 'umpteenth order effects, all the while adjusting to the latest development, it may not seem surprising that no one is fully in touch with what is happening. Indeed, the connection between initial causes and subsequent effects may have become so attenuated, criss-crossed as it has been by so many other forces, that no one can be quite certain what has become of it. Admitting all of the limitations of inferring causality, it is still possible to provide illustrations of how actions that did not have safety in mind nevertheless appear to have helped increase it.

So far as I am aware, the great industrial revolution that led to (or was produced by) the mechanization of agriculture was not designed by anyone to improve the health and safety of the general population. Yet the extraordinary improvements in diet that resulted from cheaper and more plentiful food, which was a major consequence of mechanization, has done much to improve health and life expectancy and also to reduce accidents. Since inputs determine outputs, it is perhaps not necessary to explain in detail why nutrition is related to health and life expectancy. Even over-eating and other abuses of plentiful food do not denigrate health to anywhere near the extent it has been improved for almost everyone in society. Better food, with more calories and protein, undoubtedly also increases alertness, which helps prevent accidents. Good nutrition also improves education, which enables people to learn and therefore to avoid some of the more disagreeable situations that lead to premature death or unfortunate accidents.

The more capital per unit of production, the less labor, and the less labor the fewer the accidents. As far as anyone knows, most accidents in the work place are related to something a worker has or has not done. The less laborers there are per unit of output, and the less hand-manipulation in which they engage, the safer they are. Though machines are often dangerous, they are less dangerous to fewer workers than if similar efforts were engaged in under more primitive conditions by more people. The shorter the work day, moreover, the less tired the worker, the fewer the accidents, the greater the longevity. While hard labor is no doubt good for all of us in moderation, extreme amounts over long periods of time are deleterious.

The higher the level of economic activity, the larger and more varied are the alternatives pursued. Though the rates of failure are high, so are rates of initiation. Diversity flourishes. Many more alternatives for doing things than would occur to any one person or any one organization are tried in different contexts. Thus there is a high probability that devices, processes, and practices will be tried that do in fact increase safety though they were not intended to do so.

The Parts Versus the Whole

If it were true that pursuing our paltry pleasures increases death and desolation for other human beings, the moral argument would be over before it began. The proper perspective is: How much safety can come from measures to reduce it for particular populations and how much from overall improvement in the standard of living? Can we improve the whole by giving each part a veto over change?

In a different era, John Von Neuman postulated the possibility that the whole might be made more reliable than the parts. Though any particular part might fail, there would be a sufficient number and variety of alternatives so that the system as a whole had a higher probability of performing than did any of its constituent elements. American society appears to be moving in the opposite direction by seeking to insure each part against failure. Can the parts be made stronger, we may ask, by weakening the whole?

What are the consequences of removing the risks from the parts? Recall the dilemma that faced Consolidated Edison before the New York City blackout of 1977. There were not one but two potential problems: reducing the risk the entire city would be blacked out compared to the risk a single neighborhood would have to do without. The greater the willingness to "dump" loads by blacking out a neighborhood, the less the likelihood the entire city would be overloaded and break down. The safety of the whole is a function of the willingness to sacrifice a part, the particular part being unknown, and the occasion unforeseen. If there is unwillingness to risk a shutdown in any specific site, as events proved, the city system itself may be at stake.

The recent history of environmental impact statements, for present purposes, may be read as saying that the values being protected by each part should remain constant. The environment is to remain inviolable and the economy is to vary to suit it. No problem, at least not much. But when one adds health, safety, employment, inflation, urban, rural, and other impact statements, the world of public policy is in danger of becoming one of all constants and no variables.

What is government to do, for example, when the price of oil goes sky high and its availability is in doubt without impinging upon the economy or environment or inflation or health? Not much. After the multiple price increases of 1973, the price of oil was controlled; evidently, poor people should not be asked to pay, so no one paid the real cost. The import of oil was subsidized at the same time the inviolability of the environment became an important value. So did health and safety. The cost of new sources of energy increased as did the time to complete these facilities. Risk was retarded for some people but so was growth of supply for all. The energy system was rendered less capable and less flexible. Imports doubled between 1973 and 1979 but reserves declined. What, we may well ask, has been the consequence for energy policy of trying to protect everyone from everything? First, a huge synthetics program, not only dearer but dirtier than anything now going. Second, a new bureaucracy whose sole purpose is to override all the other risk reduction routines previously introduced. A central authority, hitherto unknown and unnecessary, rides roughshod over risk. Instead of evolution or devolution, there is only resolution by central command.

Suppose every sub-group in society--farmers, workers, old people, youngsters, on and on--were guaranteed against risk. No matter what happened their safety would have to be secure. Who then would pay penalties? Presumably, risks would have to be allocated over the remainder. But if there were no one left, how would shocks be absorbed? How could risks be run to increase national product if the losses could not be assigned to anyone? Since the social system would cease adapting, the evolutionary implications of removing risk are horrendous.

Up till now social risk reduction has been an indirect process, hence it has not been possible to predict who will be protected against what at which time. This is highly desirable. Everyone has to take their chances; everyone can hope to share in general risk reduction; but no one can hope to protect him or herself in a particular way. Once risk reduction is up for grabs, a decision instead of a result, a deadly process by which individual or group safety is bought at the expense of the whole will be put into effect.

Directly Deciding "Who Shall Be Saved?"

Makes Most of Us Less Safe Than We Were Before

Each of us would do less for ourselves than we would insist the government do for us. Individuals will not, for instance, buy flood insurance, though they might well be wiped out. For whatever reason, individual interest in risk hardly appears to have declined. Indeed, organizations of all kinds exist to satisfy the desire for the strenuous life. If all individual effort to increase personal safety were added up, it would hardly be greater than it was in times past. What is new is that the collective urge to risk reduction is so much greater than the individuals it claims to represent. The place to look for an explanation is not in private motives but in the possibilities of public policy.

Public spending on safety for particular people would exceed, I believe, any conceivable estimate of private benefits. Let us recall how this happens. Personal benefits are palpable while public costs are diffused over anonymous taxpayers and consumers who hardly know they are paying the bill. Consequently costs are never internalized. But realizing that the payers and the receivers are not necessarily the same is only the beginning.

Suppose we ask the innocent sounding question of "How much safety is enough?". The answer is that there can never be enough. The possibilities of risk reduction are virtually infinite. Where the principle is that everything that can (is technically possible to) be done, should be, the only limits are physical. Even there, though, limits may be illusory. Every part of a mechanism can fail; every substance is a potential carcinogen when combined with others as yet unknown. Someone might be saved by more frequent inspections of more parts. Where the only principle is perfection, ("Don't Be Half-Safe!") there is always more to be done.

Life and health are precious to all of us. So long as the debate over safety is about removing risks, the outcome will continue to be unbalanced. Suppose life expectancy were expressly allocated by government: How much should be spent on all lives together? No doubt a huge amount. But since other purposes must also be served by government, there would be a form of resource allocation. But if the question were rephrased to ask how much should be spent on you or me, the only answer could be "everything," for to ourselves and our loved ones, we are precious and irreplaceable and priceless, i.e., of infinite worth. So long as we don't pay directly, so that one act takes away from others, we would almost always be foolhardy not to take this or that precaution; no matter how expensive. Divorced from any consideration of alternative uses, that is from our fellow human beings, each of us is likely to demand much more of government than were we the government that decided for all.

If they are permitted to proliferate, direct demands for reduction of risk group-by-group, case-by-case, are inexorable. For one thing, the politics of anticipation requires that all possible sources of risk be

eliminated or mitigated. Since these sources are virtually infinite in number, subject only to the fertility of the imagination, there is no limit on what can be spent on them. For another, there is no principled reason why risks that affect certain groups should be reduced while others potentially affecting other groups are not. Accommodation by log rolling will lead to the usual coalition of minorities. The result will be more "safety" than anyone would choose to buy.

By now it should be clear I believe that a case-by-case approach will not reduce but merely redistribute risks in ways not yet foreseen. What will be increased is not safety but subsidy. Each item may reflect what the people involved would want others to spend on them but the total of all items is bound to be more than citizens would want to spend or legislators to vote were they to consider all such activities together. Individual choice is at odds with collective rationality. As inconsistencies among cases accumulate, moreover, we can expect them to be resolved in accord with current practice for entitlements, i.e., upgrading the lowest category of benefits to the highest level and overlapping categories of eligible people so that none who might be deserving are left out. Cascading cost increases are the inevitable result, increases that were they left in the private economy, might well have superior effects in increasing safety, especially for people of lower income.

The greater the effort to reduce risk, moreover, the less equally risk is distributed among the population. At the outset, the idea is that people who lead less risky lives will subsidize those who live more risky lives, so the two groups will grow toward each other in safety. In order to achieve this result, however, the original asymmetry in risk

must be maintained. Once the process of direct risk reduction for specific groups is initiated, however, benefits (and beneficiaries) expand by well known devices. Those who enjoy benefits succeed in raising them by forming coalitions with others, and those originally left out get in on a good thing. Either way, the initial safety programs are bound to grow larger as are the proportion of the people they cover. Hence, as the population of recipients comes to resemble the people who pay, the reduction of inequality in risk is bound to decline.

If it is the country that must continue, rather than just you or me, some of us must still take risks. Is it better, then, for government to allocate these risks directly, or are we better off, when choosing the rules under which we must live, if future failures are unknown? That is what the debate on risk is about.

Implications For Public Policy

Congress is not the right forum, in my opinion, to discuss the techniques of risk-benefit analysis, whose terms of discourse are always changing and whose outcomes are subject to innumerable special circumstances. It is a technical issue in the sense that its operations are subject to broader principles. Congress is the right arena to discuss the grand principles of risk and safety. Congressmen are also the right people to estimate how the political process is likely to affect legislation on safety group-by-group, case-by-case.

If one might be allowed to distinguish between macro and micro risk assessment, Congress should be interested in the larger rather than the smaller side. Its knowledge principle might be that understanding safety is a prerequisite for coping with risk. Its political principles

might be taken from its experience with tariffs, price supports, disaster insurance and a host of activities designed to reduce risk for particular people--it is easy to get in but hard to get out; once you start, it's hard to stop. What to do is less important than whether to do it at all.

Knowing what will happen, Congressmen can protect the nation (and themselves) from exhaustion by anticipation. Unless they take steps to prevent themselves from determining who will undergo risk and who won't, the nation will surely be less safe than it was. Everyman may not always understand why seeking safety increases risk but knowing themselves and their colleagues, Congressmen do. They should share this self understanding with their fellow citizens.

Am I not aware that there are current dangers against which immediate action may be required? Yes, but if we were talking about current dangers there would be very little discussion. If the country is being asked to ward off dangers only dimly perceived, whose effects, if they occur, will not be felt for long periods, then it is only reasonable to counter these claims with the indirect effects of the opportunities missed to improve safety in ways as yet unforeseen.

Do I recommend laissez-faire? Only if that is the only alternative. But it is not. The dice should be loaded against any right to protection against risk. Only if risks are palpable and remedies ascertainable and populations limitable and dangers unavoidable--should government regulate risk. "Killing people with kindness" is only a slightly subtle form of verbal aggression. Killing people with safety would be one of the supreme ironies of our time.

Let me put my position positively: Instead of focusing all our attention on risk, effort should also be devoted to understanding how and why we have become safer than our predecessors. Instead of assuming that risk may be reduced only by direct action, we should consider whether indirect action stemming from economic growth may not be more efficacious.

Mr. STEVENSON. Thank you.

Mr. Green.

**STATEMENT OF HAROLD P. GREEN, ATTORNEY, PROFESSOR OF
LAW, GEORGE WASHINGTON UNIVERSITY, WASHINGTON, D.C.**

Mr. GREEN. Mr. Chairman, I am pleased to appear before you today to discuss this important question which has occupied much of my time and energy for the past 15 years.

At the outset, I would like to stress the importance of recognizing that risk-benefit assessment is used in two broad categories of public policy decisions, and we must distinguish between these categories because there are somewhat different risk-benefit considerations in each case.

I shall refer to these categories as regulatory and promotional.

In the regulatory context, the question is whether—and if so, how—Government should restrict or control activities that may involve hazards. Some of the hazards may be reflected in the dollar cost to the purchaser, since the potential liability of those engaged in the activity is reckoned as a cost of doing business. If these costs are very high, they may drastically reduce the market or result in prices that are too high to gain market acceptance.

Thus, the market system is, to the extent that costs incident to hazard are internalized, a first line of society's defense against hazardous activities. Government regulation is the second line of defense that is superimposed upon the market system, and it operates to restrict the availability of benefits people want. Clearly a decision to impose regulation is based on some kind of risk-benefit assessment. It is equally clear that such assessments, including those made by Congress, can be and usually are highly unscientific, based more on qualitative, emotional, or political considerations than on any kind of real scientific assessment. For this reason many regulatory measures may appear to be irrational.

It can be argued that the quality of regulation would be improved if congressional decisions were based on authoritative and objective risk assessment benefits based on current scientific knowledge. But the fact is that the Congress really does not suffer from a lack of data about risks and benefits. In my view, Congress is almost suffocating in an excess of information.

Proponents of regulation can always be relied upon to provide you with data that exaggerate risks and underplay benefits, and opponents of regulation will do exactly the opposite. There may from time to time be more balanced risk-benefit assessments from persons or groups with no ostensible axes to grind, but who can say reliably that any particular assessment is objective and authoritative, let alone correct and objective? It is moreover, difficult to understand why any risk-benefit assessment should be regarded as so objective and authoritative as to be given decisive weight in the legislative process. Neither benefits nor risks can be identified, let alone quantified, independently of the values and/or the philosophical outlook of the assessors.

The technicians who do the risk-benefit assessments can make no claim that their values reflect those of society as a whole. But members

of Congress have presumably been elected because their values reflect those of their constituents.

A risk-benefit assessment performed in the public policy context must focus on benefits desired by the public and on risks the public is willing to bear as a part of the costs of having those benefits. On the benefit side we can draw some conclusions as to what benefits at least some segments of the public are interested in by looking at market data, public opinion polls, or surveys, but the question of what is a benefit can't be divorced from the question of cost and alternative benefits, including alternatives that serve a completely different function. Everyone would regard the availability of enough electricity to operate all the devices in her home as a benefit, but some, if faced with a choice, might opt for less electricity and for more or better medical care. The problem is further complicated by the fact that it is really meaningless to consider benefits and costs in gross terms, since the important consideration is the marginal cost incident to incremental benefits.

It is, I believe, inescapably true that when a risk-benefit assessor identifies and quantifies benefits, he is doing so solely on the basis of his own perceptions of benefit, or at best on his perceptions of the public perceptions of benefit.

With respect to risk, it is possible to identify respects in which an activity is or may be hazardous only by reference to the existing body of scientific knowledge and existing experience with the activity or related activities. It is rarely possible to reach a conclusion that there is zero risk. The fact that existing knowledge provides no basis for concern does not mean there is zero risk, since future experience or scientific knowledge may demonstrate that a present activity, either by itself or synergistically, indeed involves hazards. This raises the difficult question as to how risk inherent in uncertainty can or should be given weight. The identification and assessment of risk necessarily turn upon conclusions as to the adequacy of existing knowledge, and the significance and weight, pessimistic or optimistic, that is given to uncertainty. These are consequences of the value systems and the philosophic outlook of the assessors.

Our society has with some notable exceptions generally not permitted purely hypothetical risks that may never in fact materialize stand in the way of achieving technological benefits. The prevailing view has been that there is time enough to take regulatory action if and when the risks become real. As a consequence, in numerous situations society has sustained significant injury for long periods of time before effective regulation could be imposed. In recent years, however, there has been an increasing tendency to require some demonstrations that a possibly hazardous activity will be safe before it is permitted.

A word about regulatory agencies. When Congress delegates responsibility for regulation to an administrative agency, one would hope that the agency decisions would be based on objective assessments of risks and benefits. The fact is, however, that administrative agencies are political institutions and the agency heads are, and should be, politically responsible to the Congress. Their funds are subject to political control and their actions are, and should always be, subject to correction and reversal by Congress.

Moreover, it is important to recognize that since the primary function of the agencies is to protect the public against hazards, they are subject to more criticism if they are permissive than if they are strict. Their actions must in any event always be tempered with a sense of political reality. The important consideration is that they resolve conflict in the optimum—by that I mean politically sound—manner, and not that they make objectively correct decisions.

Let me pass briefly to the promotional mode. In the promotional mode the question is whether the Government should support, usually with expenditures of public funds, an activity that promises important benefits, where the activity would not occur, or would be delayed, in the absence of Government support. In this situation the market system does not provide a first line of defense to screen out hazardous activities because the market system is not operative. The very reason for Government support is that the market does not provide incentives for an activity that promises important benefits on a time scale the Government regards as desirable. The problem of identifying and quantifying benefits is more difficult in the promotional situation. Even if, for example, the question is whether the Government should support development of a supersonic transport plane, and an authoritative and objective assessment demonstrates that the benefits far outweigh the costs, including risk, Congress may well prefer to spend the money on alternative transportation benefits such as rapid transport to airports, improvements of air traffic control, or improvements of the railroad system, for example, or on benefits that have no relation to transportation at all such as more aircraft carriers, finding a cure for cancer, or feeding starving Africans. Something can't be termed a benefit without considering alternative ways the same money can be spent.

Making decisions of this kind involving choices among the full range of benefits for which public funds may be spent is the ultimate function of the political process and of Congress.

With respect to the assessment of risk in the promotional context, there usually has been very little, if any, experience with the proposed activity at the point in time when relevant decisions must be made. Assessment of risk in such cases is entirely a theoretical exercise performed by experts who have no economic stake in the validity of their judgments. Their assessment is necessarily based on educated predictions, which are in turn based on assumptions as to the behavior of people, nature, and things many years into the future. Such predictions are characteristically optimistic, assuming that everything that can possibly happen has been taken into account; that people will behave as they are expected to, because procedures and controls have been designed to make sure that they do; and that nature will behave as expected because there is no reason to believe otherwise.

Although assessment of risk necessarily involves two factors: the probability of an injurious event and the magnitude of potential injury flowing from such an event, the former is much more amenable to manipulation than the latter. It is important to understand that when we multiply even a very large number by a quantity approaching zero, the optimistic assumption that human beings and their systems can be infallible generally leads to the conclusion that the

probability of the injurious event is so low that, regardless of the magnitude of potential injury, the product, that is the risk, is found to be very low.

Finally, there is always a tendency in the promotional mode to overstate the benefits since they are relatively obvious and immediate, and to understate the risks since they are inherently remote and hypothetical. There are powerful vested interests, Government agencies and punitive contractors who can be relied upon to press the benefit side, but only rarely do we find any strong voice with the interest and competence to press the risk side. The temptation is great to opt for the benefits until the risks are to be shown to be more than hypothetical, with the avowed intention of dealing with the risks if and when they arise. This approach is of course politically unrealistic because it is extremely difficult to turn off or to restrict a technology once it is underway because of the expectation of those who seek profit from it or who desire to enjoy it. Paradoxically, however, it would appear that in promotional context more weight should be given to risks than to benefits. Government has no duty to spend public funds to provide technological benefits for the public, but it does have an obligation not to inflict injury. The effect of a decision to proceed may be to provide benefits but also to cause injury. The effect of a decision not to proceed is only that enjoyment of the benefits is postponed and no one is injured.

A decision to support or not to support a new technology should be made in the crucible of the political process through the individual judgments of politically accountable Members of Congress. It should not be controlled by, or even heavily influenced by, purportedly scientific risk-benefit assessments.

Let me conclude by saying that risk-benefit assessments in the decisionmaking process in Congress are useful only if they are not taken too seriously. The interplay of political forces may lead to a decision that is erroneous in terms of scientific fact. But democracy does not promise correct results. The greatest danger that lies in excessive reliance on scientific risk-benefit assessments is that it may promote an orthodoxy that will make more difficult the kind of political compromise that is the *sine qua non* of an effective legislative process.

I have been rather critical of risk-benefit methodology, and pessimistic as to its value to Congress, and I would like to conclude on a more upbeat note.

The methodology involves inadequacies that are probably not amenable to resolution, and we should also not expect that any particular assessment will be, or that it should be, accepted as a matter of course, thus pointing the way to correct decision. I believe also, although I don't think this has ever been shown empirically, that no two risk-benefit assessments on the same subject performed independently by separate groups with equivalent compositions will result in identical conclusions. Indeed, a somewhat different conclusion would probably be reached if the identity of only one or two members of the assessment team were changed. This suggests to me the desirability and usefulness of multiple assessments performed by diverse groups. As a matter of fact, it would be useful to have these diverse groups be special interest groups with special axes to grind. This would at least enable decision-

makers to pick and choose among the assessments and to accept inputs from more than one of them.

This would reflect the existence of competing social values that may underlie the assessment of any subject matter.

If however Congress were to experiment with a purportedly objective assessment, the quality of such an assessment could be enhanced in the following ways.

First, assessment panels should include members drawn from an appropriate range of disciplines, including nonscientific disciplines, and should include members reflecting diverse viewpoints.

Second, the assessment should not place excessive emphasis on quantification of consequences that can't meaningfully be quantified. I doubt for example that there is any way to place a reliable numerical value on human life, health and amenities for purposes of public policy decisionmaking. Attempts to quantify the unquantifiable produce conclusions that are at best misleading and at worst deceptive. In such cases qualitative discussions will be more useful than quantitative.

Third, to the extent that there is quantitative consideration, there should be a candid disclosure of the underlying assumptions and value judgments with an indication of how alternative assumptions or value judgments might change the numbers.

Fourth, more weight should be given to potentially enormous or irreversible injury than to scientific estimates that the probability of occurrence is very, very low. At the very least, assessments should describe the magnitude of potential injury under pessimistic assumptions, instead of treating this magnitude as irrelevant because of an estimated low probability.

Risk assessment, as I mentioned before, is useful only if it is not taken too seriously by either Congress or the assessors. Even the most purportedly scientifically objective assessment is useful only as another input along with data from myriad other sources, interested and disinterested, informed and uninformed, rational and irrational, into the decisionmaking process. The object of risk-benefit assessment should be to produce data for use in political discussion and debate, to elevate the level of such discussion and debate, to inform and enlighten, but not control, the Congress.

Thank you.

Mr. STEVENSON. Thank you.

And Professor Diamond.

STATEMENT OF PROFESSOR EDWIN DIAMOND, DEPARTMENT OF POLITICAL SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

Dr. DIAMOND. Mr. Chairman and members of the committee, I thank you for this opportunity to appear in such distinguished company. I have been a reporter, writer, and editor for 25 years working in every news medium in that time. There is not a bad habit of the press that I don't know; I have had all of them myself.

Since 1970 I have been teaching and doing research at MIT, so I have looked at life from both sides now. I have pursued scientists and officials for stories and I have been pursued for stories myself. I think

it's particularly appropriate that I sit here in the middle this morning between Professors Wildavsky and Green. This is symbolic in my view of the press' role in risk-benefit analysis. The distinguished, eloquent experts disagree and the press is supposed to inform the public and the Congress, the public representatives, about the issues.

I speak then as a working journalist who has had the opportunity to step back and analyze his own work and the work of other journalists. My attitude about the press is I can neither love it nor leave it. We are too imperfect to be loved and we are too important to be left to be ignored or to be dismissed.

Let me deal with a question I believe to be on the minds of the members of this committee. How does the press inform the public and the public's representatives, the Congress, on issues of science and technology such as risk-benefit analysis? This is where I locate part of our current crisis of information. The information crisis I think can be expressed in three statements.

One, the press has traditionally relied on authority—Government officials, scientific leaders, men and women in white coats—for its information, briefings, studies, reports, background, and facts; in short, for its news. Professor Herbert Gans of Columbia University in his new study cites one analysis of 2,850 foreign and domestic stories in the *New York Times* and the *Washington Post*, our 2 best newspapers. Almost 8 in every 10 of these stories came from public officials.

Two, these authorities, so well quoted by the press, have been steadily losing their credibility. This loss of credibility has occurred in part because of the now familiar record of official deceits on the part of some, though not all, officials over the last three decades. This record goes back to the less-than-honest governmental and scientific statements about the effects, for example, of nuclear atmospheric tests in Nevada in the 1950's, tests that I happened to cover as a young and completely trusting reporter. But this trust is only part of the problem. Even when seemingly credible sources of official and scientific news are sought out by the press for information, they may disagree among themselves. After the Three Mile Island accident our research study group at MIT asked two nuclear scientists about the acceptable risks. Both men were eminent physicists; they were tenured, professors at leading world universities. Both experts were presented with the same scientific data. One of them told us nuclear power plants were unsafe and posed unacceptable risks. The other looked at the same data and told us nuclear power plants were safe and acceptable. How then is the journalist to judge among contradictory sources? What does the nonexpert do when the experts disagree?

Well, the press' traditional answer has been to be neutral and objective, to push out all the conflicting statements and let the public decide for itself. This is the greengrocer approach to information; put out all the wares on the fruit and vegetable stand and let the customer pick and choose. But this objective approach implies even less responsibility than the corner fruit vendor shows. A good grocer throws away the spoiled or overripe fruit. The increasing deluge of information—good, bad, indifferent, plain rotten—overloads the public and its critical facilities. The all too human response is to dial out of news and information consumption, and also to dial out of public participation of all kinds. Anyone who doubts this can consult

the figures showing the relatively declining number of Americans engaged in the simple act of reading a newspaper or even watching television news. No one here needs to be reminded of the downward trend of those participating in voting.

The press' traditional response to the public confusion has increased public confusion and doubt in the name of objectivity. We offer people time for both sides; on the other hand journalism. The Boston Globe writer, Ellen Goodman, once called this the flat earth side of newscasting, two minutes for NSAA to say the earth is round, two minutes for the other side to say the earth is flat, then break for a commercial. Cronkite, Reasoner and Mudd have done their objective duties. Sometimes we need to say *on the only hand*. One result of *on the other hand* coverage is a double turn off of the citizen viewer. The inability of the experts to come to even a rough agreement leads the public to turn away from the debate. *If the experts can't agree what can I do?* And the inability or unwillingness of the press to declare that this scientist is right or this course of action is proper leads the public to tune out the news and public affairs.

This public attitude I believe is not only understandable, it may be necessary to preserve sanity. But it's bad for representative democracy. The theory of American Government revolves around *perfectibility*. If information is available in understandable form and citizens are able to absorb and understand this, then these citizens will make perfectly wise decisions on matters of public policy or will choose good representatives to make such decisions. Of course perfection is an ideal never to be obtained but always to be sought. Education in the schools must produce citizens capable of analytic thought. The press, for its part must produce, in the words of Walter Lippmann, a steady supply of trustworthy and relevant news, and the experts must speak the truth, not their biases or their politics. As it happens the public has been ahead of the experts and the press in this regard. Despite all the muttering about schooling in America, someone has been doing a good job of preparing young men and women for citizenship. I know it's politically conventional especially these days to talk about the goodness and wisdom of the American people. The failures I detect come from institutions like ours.

Let me give an example. A television station I know two years ago did an audience survey about its news program. The station was surprised to learn one of the features the people like most about the news was the Dow Jones averages. As you know the Dow Jones averages on television are a throw away piece of garbage. So the station was intrigued and decided to ask some more questions.

Yes, it turned out that the Dow Jones item of 10 seconds was useless to viewers but these viewers were, in effect, saying we want more news about the economy, anything you tell us would be appreciated. The station is now attempting to do more serious reporting, as are stations and networks all over the country.

But the point is, the public interest and the audience concern was there. People knew that economic news was important and wanted more coverage well before television got around to doing its duties in a serious sustained way. As usual the press was reacting to events rather than anticipating them. As with the economic news, so it is with the coverage of science and technology. The public interest is there,

it hasn't been fully met even with Dow Jones style fluff, let alone in the way the Founding Fathers and Walter Lippmann thought it had to be met.

Let me conclude by addressing two questions. Why doesn't the press give sufficient relevant and trustworthy information about science and technology, and what can be done to change the present situation? First, on press performance, obviously there are individual news outlets that do a good job of covering science and technology and risk benefit analysis stories. My remarks are meant to apply to the press in general and in no particular order these are the problems.

One, the press moves in a pack. We are like blackbirds. One blackbird lights on a telephone wire and they all light on the wire. One blackbird flies away and all the blackbirds fly away. Through the 1950's and early 1960's the press' approach to science and technology was dominated by a gee whiz attitude, and I was one of the worst offenders. The atom, radar, rockets—they would all take us to the Moon and beyond, they could do no wrong. If science and technology made mistakes, we buried them, and I participated in some of these coverups. Now, the press is disenchanted with science and technology. The gee whiz has been replaced with skepticism. You trust your mother but you make her cut the cards. Three Mile Island, DC-10, Skylab, computer data banks . . . the attitude is, they can't get anything right. As the pendulum in the press swings wildly, the public feels that science and technology mistakes will bury us.

Two, science-technology is a foreign language to most news editors. We can play gee whizzers or Chicken Littles, but more sophisticated roles are hard to perform. It is hard for a number of reasons. Most journalists are liberal arts majors; promotions in the news business tend to go to those who have taken the political route of city hall coverage and Washington assignments.

Three, specialized journalism is expensive and seems to be hard to do. Of course, editors never say outright that science-technology coverage turns them off or requires extra effort. What they say is, of course, that the readers and viewers are at fault, that the audience is not interested. That science and technology itself is interesting. But that is simply not true. The turnoff follows from the way the press presents the material. There are no tired stories or old stories, only tired, old storytellers.

Four, finally the doctrine of objectivity has become, in my view, an excuse to avoid the hard work and thought required for doing *on the only hand* journalism. The question then becomes: How do we get a press willing to step back, reach judgments and present trustworthy, relevant information? I am afraid the answer will not surprise anyone. There are no shortcuts or slick packaging answers. News reporters need training in specialized fields; but so do news editors. It doesn't do any good to report a DNA if editors kill the story to make room for monster movies or disco doings. News managers must invest more money in the news, including money to hire outside consultants and experts whose advice will be free of special interest pleadings. Nobody's advice is completely free. If news organizations know how to rent blimps for crowd shots at football games, then they ought be able to find room in their budgets for a consulting nuclear physicist.

Finally, there is one important needed quality that can't be learned in schools for journalism, or schools for publishers. That quality can't be represented or contracted for. The news business needs first of all to take on complex issues, and then to communicate them in a clear, calm, intelligent way.

Some people have raised the idea of the scientific priesthood to decide on the complex technical issues in our society. We put that idea to a vote at some of our classes at MIT, the seminary, if there is one, for such a priesthood. No, the students said, don't turn over the hard decisions to the scientists or the technicians. Let the people and politicians responsible to the people decide. They have the breadth of judgment. I agree, but do they have the information needed? Has the press done its job? Not really, and for it to do so would require courageous redefinitions of journalism by journalists.

Thank you.

Mr. STEVENSON. Thank you, sir.

Now before we weigh in the press' view let me suggest you weigh each other. Mr. Wildavsky, do you have any comments on Mr. Green?

Dr. WILDAVSKY. I think the idea Harold expresses that risk assessment, if taken seriously, might make political bargaining difficult is correct. I would like to ask him about the implications of his remark. I was not thinking myself of activities undertaken primarily by the Government. For example, if the heads of great steel companies come to Washington with their tin cup out asking essentially for a guaranteed living, I personally, were I in your place, would think that they would not deserve a salary, certainly somewhere between the assistant secretary and on welfare, since I understand the purpose of enterprise is to play the competitive game. If they are going to come here and say take away all my risks, wipe them clean, then I couldn't understand why since they partake of public largess they should be paid more than the most minimal wage.

Would your ideas, Harold, mean that if the Government undertakes an activity and it requires risk assessment, the answer is no, it probably shouldn't since it's bound to hurt somebody. Probably this would lead to less government, or am I mistaken in what you are saying?

Mr. GREEN. I am not sure I understand your question.

Dr. WILDAVSKY. Are you making a plea for less government? Surely if you apply risk—

Mr. GREEN. I suspect that deep down under everything I said there is a bias against regulation and more government. I was talking about risk-benefit analysis only with respect to congressional decisions in the area of science and technology.

I think it's kind of interesting we have a kind of ethnocentric approach to this. We don't talk about cost benefit assessments in the area of tax policy or economic policy or who should sit on the Supreme Court, which are really important congressional decisions. But in the area of science and technology, public policy decisions have been elevated to this exalted degree that we think that Congress needs some help from external sources in marshaling and balancing facts as risks and benefits.

What I am saying is that I like the way Congress behaves generally. I don't say this is ideal. I am perfectly willing to accept more regula-

tion if Congress gives it to us, and less regulation if Congress gives it to us. I am not talking about my own personal ideology but only about how I think the public's business ought to be conducted.

Dr. WILDAVSKY. There is a vast difference, Harold, between your concept of opportunity and mine. You are talking about the usual kind of middle marginalism where when one asks for any specific item whether, at the margin, there is more cost risk than benefit. I am suggesting a much larger view of opportunity cost in the sense of the opportunities foregone not only directly but indirectly by preempting resources in endless efforts to anticipate risk. Would you suppose, knowing what you know about Congress, that over the larger round of industries, case by case, the question is who deserves to live and die, what kind of answer can they give?

Mr. GREEN. You know, Ed commented he was between two opponents. I was rather surprised, because I did not think that anything that I had said was inconsistent with what you said, Aaron. If there is any difference between us, you seem to believe that it is possible to know in a public policy sense what the better decision is, what the wiser decision is, and I don't. I may have personal opinions about it, but I would not say that a decision reached by Congress that is contrary to my own views is wrong.

Dr. WILDAVSKY. But consider for instance the implications are what I would sum up as trial without error. It's like Three Miles Island, one mistake and you are out. The impetus is now on those who would do things to show there will be no harm. Instead of trying to do some good, and if you ever succeed in that asking if there are best consequences one must first demonstrate that there is nothing bad before one is allowed to do anything good. That has the most incredible consequences for scientific endeavor, for diversity and complexity in society.

It would mean for example, that you will have larger and larger organizations because only very large ones can afford to go through the endless steps to make these demonstrations. There is a lot at stake here.

Mr. GREEN. On a personal level I agree with you. I think we are spending too much time doing what I think are, on balance, foolish things about the environment, and safety, and the like. I agree with you on that, but that isn't what I really was testifying about this morning.

Dr. DIAMOND. For two people who are in such agreement they seem to argue a lot.

Mr. STEVENSON. We searched far and wide to put this panel together and may have discovered the only remaining defender of Congress. Let me first invite Congressman Ritter to make any point he wants. But I would like to make an observation and pose a question or two myself.

As a member of this body, my main complaint about the Congress and our Government is that we continually act on the wrong issues and then usually make the wrong choices, or so it seems to me. This is not unrelated to some of Mr. Diamond's comments about the press.

Nowadays the public only knows that which the press permits it to know. The framework is narrow, it focuses on the sensational, and it produces a rather narrow debate. Every issue, however unrelated it

may be to our real condition and I think it is a parody of our condition, is cast in a yes or no. That is the way we vote here, a liberal position or a conservative position or a Republican position or Democratic position.

If the President goes on TV with a program, in the name of fairness somebody has to go on with a opposing program. It is a simplistic yes and no. The answer frequently is the third choice, but it is beyond our competency. It isn't Republican, liberal or conservative. From where I sit I sense that both sides in these debates are usually wrong. How, to begin with, can the public or you, Professor Diamond, judge the press if all you know is what it reports? Is there anybody, including the editors, who know anything except what they print? Is there anyone outside of the news media in a position to judge the press? One quickly discover in this busines that the last thing you do if you want to remain in it is to question the press. It is the most powerful institution in our country and the only unaccountable institution—unaccountable to the public, unaccountable internally. It is one of the few institutions or professions that has no internal procedures to regulate its accountability.

Would you like to respond?

Dr. DIAMOND. I would. I said instead of on the other hand journalism we should have on the one hand. But we also have to have on the many hands. You are right, there are three and four sides of stories and we have to tell them—first we have to start telling them. You are right that the press is powerful. You are not right that it's completely unaccountable. There has been a movement over the last 10 or 15 years, and I can very quickly sketch it, very, very quickly.

As every institution came under question in the 1960's, the military, the Congress, the Presidency, the courts, the schools, so too the press institution came under scrutiny and question and there have been efforts at internal correctives. There are in Washington, for example, both the Washington Post and Washington Star have a people's representative, someone who listens to complaints from the public, writes a column called the News Business, does sometimes internal memorandums. That is the hardest part, writing internal memorandums. There are journalism reviews. There is a livelier interest in the press itself.

It may be perhaps the last institution to come under accountability but it is belatedly coming under accountability. There is something called the National News Council.

Mr. STEVENSON. How can it make itself accountable to itself when it doesn't know anything except what it prints? The most severe critics of the media are members of the working press, who know what the difference is between the truth, between the actions of Government the movements that are at work in the world and what they hear and read. They see it rather clearly.

But they are not the ones who are going to hold the press accountable.

Dr. DIAMOND. If they are enlightened they will hire and nurture on their staffs an independent man or woman who will criticize the performance of that newspaper, the medium. I make my living of a sorts saying the press pull up your sox. I have tried not to wear any man's collar. It was the executive editor of the Washington Post who

said in this town we print what we are told and what we find out, therefore we print lies.

Dr. WILDAVSKY. I don't want anybody to think that I especially right now, think the press is unfair. I don't see anything in the press that prevents Congress from making intelligent choices; nothing whatsoever.

Mr. STEVENSON. Let me interrupt at that point because I neglected to say this. You are right as far as you go, but Congress only acts in response to pressure. That is an historical fact. The President can create pressure, he can lead, but the Congress by and large responds to pressure from a strong President. The President generates those pressures by forming public opinion. The Congress reflects public opinion. And the public gets its information from the media.

Dr. WILDAVSKY. Yes; but there is after all a sense in which these people put its legislators into office to act more wisely than the people would if the people had time. If one thinks one lacks say good information per se, and you ought to put out endless reams of data that is different, but if you assume the real limit in the world is human time and attention, then in one respect the press is more responsible I think, that they have to really choose what is more or less important.

One of the great lapses in the field of safety is that it isn't good per se to put out safety regulations. Before I make up my mind on Three Mile Island, for example, I would like to know how many communications those people received from various Government agencies. I would like to know how many regulations they were supposed to attend to. There is a need not only for other people to have priorities, but for the Government to have a sense of value. Is there anything inherent do you think in the Congress that prevents the exertion of some sense of priority in these matters, anything to which the press is some impassable barrier?

Mr. STEVENSON. Yes. We anticipated the energy crisis in the 1960's, but it wasn't news until it was too late. We were dealing with it but we weren't acting because nobody paid any attention.

Congressman Ritter?

Mr. RITTER. I might add that one of the great risks in being in Congress is being over on the Senate side when the House is in session and voting. Having just come out on the short end of that stick I can go on.

I was intrigued Dr. Wildavsky, by your comment on richer is safer, and the theme of economic advance as being a central historical driving force for increased safety. It occurs to me through my own experience that is certainly true. I can recall working in university laboratories or industry or doing consulting, and I can recall the way safety programs are thought of. Safety programs are always about the 14th or 15th priority in an organization, and that is not because the people are not thinking about being safe or don't want to be safe. You are right, it is not in actual day-by-day consideration a central theme. It may be, however, that in certain endeavors where the public perception of safety is so enormous, and nowhere is this truer than in, for example, the nuclear power industry, that very, very special considerations of safety from a mechanical standpoint, from a political standpoint, and from a communications standpoint with the people, must be taken because the perception is such that they are demanded.

So yes, indeed, the driving force for safer is the driving force for richer. But I think we face some unique situations today where the priority of safety, both from a technical point of view and from a social point of view, needs great attention. I look upon the hypothesis that both you and Attorney Green have, Dr. Wildavsky, that by tying up Government in the assessment of risk, you can run the risk of nothing happening at all. You may turn off the central theme of the advance of safety, and that is the basic market health and economic health. But I would like to point out to you that presently the Government, whether it likes it or not, is really involved in these questions, and from a legislative and from a policy point of view there may be no turning back. To the extent that involvement is not contributing toward the solution of some of these problems, I think we find ourselves in many cases at an impasse.

Nowhere is this impasse more true than in the question of nuclear waste disposal. We have gone through hearings upon hearings upon hearings. We know technically there are a variety of quite acceptable solutions, and you will get not just one expert on one side and one expert on the other side. But I think if you review the total body of experts, a great majority do feel we have the available technology to do the job; that the risk that one runs by not doing this job is greater than leaving things alone. That is, we continue to build up more of these wastes and we continue to put an obstacle in front of what might be the safe evolution, or the safer evolution, of the technology itself.

So we know that people have looked into these risks. We just don't have a social and political mechanism at the present time to move forward with a national policy. Now we are tripping over a controversy on risk that is not resolved. We are tripping because it seems to me that the public information, the public perception, the public's ability to perceive that risk in conjunction with its total emergence in risks, is nonexistent. You will continually bump into the general public who feel that the problem, that is if there is opposition to going ahead, is the way it's presented. Yet if you really take all your experts and put them into a room and take a vote, you are going to come out with an opinion that technology exists.

Now why is Congress falling down and unable to go ahead? Where is the press and its ability to communicate? Where are they falling down? Why are we stymied when we most probably should be going ahead, or at least most probably be coming to some kind of conclusion or another. What we have is straight, flat-out impasse. And I think in many of these technological risk areas, whether it's from the steel industry or the chemical industry or from the energy industry, we are at impasse. Our hands are tied, and I would like to hear some of your opinions on that.

Dr. WILDAVSKY. The consideration you raised in your question has led me to move from the economics of risks into the anthropology of risk. The efforts to destroy the nuclear power industry at this moment in history is as good an example of determination of thought irrespective of environment as anything that can be found. But that is not helpful to you here.

Let me put it to you this way: How could we deal with this question where the scientists are opposed to one another, not majorities and

minorities, but you will find distinguished people who will claim the opposite and yet practically be beside themselves at the thought the majority have decided this. It is clear that they don't understand each other; they don't understand why they disagree and so on.

Mr. RITTER. If you take those scientists who have really put the time in, in an effort to deal with the problem, you will find almost unanimous agreement that going ahead is better than standing at impasse.

Dr. WILDAVSKY. I look at it how could we decide this matter so it does not become a precedent that stultifies us on others. Not for 1 minute do I believe the people who oppose the nuclear power industry, whether it's waste or some other thing, are going to love coal, for example; or if they love coal, they are going to become ecstatic over synthetics. On the contrary, since everything tells us coal is more dangerous than nuclear and synthetics than coal, we can expect escalation of this. In order to stem this tide I would give the opponents any three things they want, just not everything. If they want to stop nuclear, OK; but then you can't stop coal, synthetics, and all the rest. I think from the point of view of Congress what should begin to be thought about is some limiting principles so we limit both the amount of good with damage that we can do. If you want another answer, then there is always the Hippocratic oath, do no harm; or a simple thing, if you don't know what to do, let the damn thing go.

Well, that doesn't seem to you to be a solution. It's a hot question and it has to be decided. I presume that is what the people are paid for.

I see no way of arriving at a kind of consensus here. I would be more interested in understanding why we can't arrive at a consensus, and I would be more interested in limiting the number of areas in which Congress feels it has to make decisions in this area.

Dr. DIAMOND. Can I ask a question? In all the megamillion words I read of Three Mile Island, a few sentences stuck in my mind. One was since year 1 of nuclear power reactors, no one has figured out conclusively how to dispose of the first pound of waste. The issue still has not been resolved. Now that impression I had from reading the stories may be erroneous. It seems to be at odds with what you are saying.

Mr. RITTER. That impression that you have is erroneous, and it is the general public impression that we don't know what to do. But we do know what to do. The French have gone ahead and done it and they are contracting with other European countries to make this a central facility. The technologies, perhaps a half dozen exist. Everybody who has ever testified in front of our committee, one of the subcommittees of the Science-Technology Committee has said it is far, far better to go ahead than to stay where we are, the technologies are available. Yet the perception of danger is there and I agree you have it. I guess somebody in the area of communications is not doing the job.

Now here is another thing. The press will cover like a blanket the latest disaster, but when you have grown men who have been active all their lives in dealing with a certain activity, the coverage is almost nonexistent. I recall the hearings on low level radiation and the hearings on nuclear waste disposal we had. These are interests of grave concern to the average American person yet none of the general public was there. There were a lot of people there who were either pro or con but there was very little connection to the general public. I guess it

was because no one blasted this or blasted that and it just doesn't make news.

But people, if you go out and talk to them, and I spend enormous hours just talking and listening at home every weekend, are interested in these things. They are interested in the economy beyond the Dow Jones average. I am wondering if there is some mismatch going on here between those who are active in professional media and those who are simply sitting there waiting to find out what's going on around them.

Mr. GREEN. May I comment on this question? I think the question raised by Congressman Ritter is an interesting and instructive one, as is the point raised by Aaron Wildavsky. I personally agree with Aaron that one of the most serious problems our society is facing today is the effort to kill nuclear power, and I think it's instructive to think about why that situation exists. It's difficult to talk about these things when one comes into the middle of a story and just looks at the present situation. But the story of nuclear power is a classic story in which the Government has done everything wrong. I can't, as one who has watched atomic energy for many, many years, ever since 1950, think of one public policy decision that has been made in the atomic energy area that has been a good one, or that I personally would regard as correct.

There is a long political history and one of the key elements in that history is the institution of which Congressman Anderson was an important member in its latter phases, the Joint Committee on Atomic Energy. The fact of the matter is that there are substantial segments of the public that do not have confidence in the Government institutions that deal with atomic energy. I remember in the old days a member of Mr. Diamond's profession, the press, would go to a press conference at the Atomic Energy Commission, or read AEC press releases, and they would roar with laughter because they did not think that anything they were hearing there was the truth. The reasons for this are complex, but they boil down to public confidence.

There is an interesting juxtaposition between Three Mile Island and the DC-10 story. When one looks at these two examples, how the Government and the public have reacted to each there is a great deal to be learned about the reasons for the malaise that afflicts atomic energy. I think it calls for very vigorous action to try to straighten out the decisionmaking processes.

Mr. RITTER. I find difficulty though in comparing the Three Mile Island and the DC-10 the way you did, and that somehow Government agency responsibility defines the public confidence or the lack of public confidence. There may be that history to the Atomic Energy Commission within Government but for so long, atomic energy came out of a weapon, a defense, a military environment. Indeed, we do produce nearly half a billion barrels of oil equivalent each year at a time when we are searching, groping for domestic American energy that is not going to cloud us in pools of smoke.

The DC-10 is much more finite in its boundaries. It's much more visible as a unique and isolated experience. You do not have the science fiction dimension to this area. The emotional response to the radiation that you can't see and can't touch is very different from the fact you

yourself will be flying in that DC-10 within the next 21½ months. You need to believe in it because you are about to be in it. This other thing is far more removed from the human experience, the daily human experience.

Mr. STEVENSON. More than 20 years ago I visited Dr. Schweitzer at his hospital in what was then French Equatorial Africa. He said that the world had become ever more dangerous because man had acquired control over the very elements but not over himself. In that hospital people were being healed. Previously they had never received medical help.

Dr. Wildavsky, is the world safer or is it safer and more dangerous?

Dr. WILDAVSKY. I think from the military viewpoint we know that it is more dangerous, but we are talking about the advanced industrial countries and we compare it to others that are not as economically developed or to any others that have lived in world history so far as I know, we have the prospect of making something out of our lives because the real problem in life is that we are living so long, not that we are living so short.

The real problem is that there may not be enough interest and diversity in life rather than that people should be shaking every 5 minutes. I mean why all of a sudden in 10 years people are afraid of the land on which they live, the water they drink, the air they breathe, the food they eat, the energy they use? This can't be explained by any purported increase in physical risk. This kind of invading miasma is cultural. If we want to understand what's happening we should go back to those we used to regard as strange peoples and come to understand that the same cultural processes that affect everybody else in the world also affect us. The answer is in advanced countries we are a hell of a lot safer and healthier.

Dr. DIAMOND. Safer? Certainly we are smarter, all of us, and we are more aware of the complexity of things. We are more aware of the many hazards of things. Aaron has mentioned several times now and I am about to rise. I have recently completed a study on media coverage on Three Mile Island and some of the things I found out I will sketch very briefly—you refer to they, they want to stop nuclear energy, they this and they that.

Well, I went out and found out about them. What we found out was that at the beginning most journalists were prepared to say it's minor, they called it a mishap, a malfunction and everything is going to be OK and the question is what happened. The story was buttoned up on day 2. Sometimes there is a reality. I have dumped on journalism all morning but sometimes there is a reality that journalism reflects. And what happened after day 2 and day 3 and so on was the journalists began to see that the officials were confused, and one of the highest officials said we are men stumbling around in the dark not knowing what we are doing.

The Nuclear Regulatory Commission Chairman to the Governor of Pennsylvania, two men responsible for the people of Pennsylvania. They said we are two men stumbling around in the dark, confusing statements among the operators of the plant, the Government, the officials in Washington, officials in Pennsylvania; confusion, contradiction, and plain scared, don't know what they are doing, never had the situation before.

And people went from a kind of pronuclear, yes American technology, one World War II that does all these great things, to—these people don't know what they are doing. You could say it's paranoid but sometimes the paranoids are right. The reality was they didn't know what they were doing and their confusion, contradictoriness, and ineptitudes, dials over 14 feet high and couldn't be read, that reality was reflected and people began to change their opinions. They were presented facts, and they said if it looks like a dog and acts like a dog, it's a dog.

Dr. WILDAVSKY. I did watch TV coverage and I must say the fear was absolutely enormous: aren't you worried, aren't you going to die, why are you running away.

Dr. DIAMOND. That was toward the end. At the beginning it was; everything is safe, everything is buttoned up. At the end it was; Cronkite said, 12 days of terror of Frankenstein, yet, at the end, but at the beginning it was everything is OK, the people from Washington have arrived and everything is under control. I am from the Government, I am here to help you.

Mr. STEVENSON. Before this gets completely out of control, let me invite the audience to start thinking about questions. We don't have much time but I would like to call on the audience for any questions you may have before we break up.

Now did I interrupt something, I hope?

Dr. WILDAVSKY. There are lots of different ways to look at this. Just take one. Safety is a product of error. Without error there is no worry, without mistakes nothing could happen at all. When you undertake something new your safety is a function of two variables, the number of other activities of the same kind, because the more errors that are made by the others the more they will learn, pass it on to you, and the number of succeeding generations. So that all together you are exponentially increasing the number of mistakes and learning and difusing risks. When you say one strike and you are out, you are not just doing something neutral to reduce risk, you are vastly increasing it for anyone who begins a new activity here. The only thing anyone can learn from this, about starting new activities is don't.

Mr. GREEN. May I say one sentence? The real problem with nuclear power is that for the last 25 years the Government nuclear power establishment has not left any latitude for the actual occurrence of error.

Mr. STEVENSON. The world is getting poorer, Professor Wildavsky. In the United States real incomes are shrinking as they are in many parts of the world, the trade balance is in serious deficit, growth is declining. Can the world be poorer and safer? It is going to be poorer. Can it be made safer?

Dr. WILDAVSKY. No.

You are talking really about last bites here. It's the rich countries saying to the poor, you can't catch up and it's the richer people saying to the poor, I have my job, I am not going to put up with that. There may be some people in this country, upper middle class and above, whose lives may not be improved by greater technology and who might be improved by creating bad resources, avoiding all sorts of evils, but for most people in this country their safety and the interest of their lives would be far more improved by improving the

general standard of living than by any or all of these actions taken together.

Mr. STEVENSON. How do you explain that those countries which tend to enjoy the highest rates of growth, productivity, and living standards tend to be the most regulated? For example, they devote larger percentages of their GNPs to regulation.

Dr. WILDAVSKY. One answer is they have much more. A second answer is they started much earlier and incrementally have increased it. The third and more important answer of course is they don't do this in the process of accumulation. There are great debates in Sweden and elsewhere as to whether the progress they have made in this direction can possibly continue as more and more of their people opt out of the official economies. I don't think that argument will stand.

Mr. STEVENSON. Congressman Ritter.

Mr. RITTER. Yes; I would like to just touch on that comment you made that productivity is decreasing, that real incomes are decreasing. It occurs to me that the very subject we are discussing here in this room is the ability to deal effectively with one of the causes of sinking productivity. In other words are we losing our national nerve? Where does inventiveness come from? It comes from taking risk. The idea of risking capital, risking yourself in an endeavor that may not insure your pension to be solid for the next 20 years is the very essence of the word risk. It implies going from status level A to status level B because there is something out there that you want to achieve, you are willing to take the risk as an individual, as a corporate entity, as an institution, really as a nation. A nation that takes no risks can't really better itself.

The question then becomes what are the acceptable levels of risk, and within a context of a world which is not risk-free, which ones do you take and which ones don't you take? What are the comparisons between risks such that we as legislators, you as the public can make best possible choices?

I would like to note from a technical point of view here, we are in an age where the detection prowess far exceeds either our ability to understand the results of what we have detected, or once we have understood the results of what we have detected, what to do about it, how to interpret those results. I guess it's part of understanding. The policy implications of very, very accurate electronic beam microanalysis are great and probably not well understood at all. The fact is that we can detect down to cubic angstrom volumes, things like arsenic, things like heavy metals, things that we normally associate with skulls and crossbones and we may even find them in human cells. Scientifically we have a tremendous magnifying glass which allows us to envision things which in our normal cognizance we have thought to be dangerous. But the question now arises. how much of this stuff really is dangerous? Or what is the risk that we uncover by finding this, and at what level? Now that we know how much is there. at what level does it become relevant for public policy to eliminate it? Scientifically there is no such thing as absolute purity, yet politically, emotionally, and socially we are able to detect levels of harmful substances. it could be carcinogenic or whatever. that are minute. A radioactive element is one of the most detectable things, we use it to trace numbers of atoms. We can get down to a fine level.

So we are really at the very beginning of our ability to understand what to do with this revolution of information that relates to detection, and what to do with it in terms of public policy. You can't achieve absolute purity, yet we can almost detect it or levels near to it.

Mr. STEVENSON. Are there questions or comments from the audience?

When I call on you, please state your name and your affiliation clearly for our record.

Mr. MACRAE. Yes, sir. I am Duncan MacRae from the University of North Carolina at Chapel Hill. I would like to ask a question of Professor Green.

Professor Green recommended that risk-benefit assessments be done by various special interest groups competing with one another. Congressman Ritter stated we need a nonemotional empirical study. We are continually faced with a choice, to be objective or subjective. Most of those who participated and recognized the risk-benefit analysis involved values but the question is whether these values have to be the selfish interests of a particular group, or whether as you suggested later in your remarks, if we elevate the level of public discussion we could deal with the underlying assumptions that are made.

I wonder whether you would agree that systematic notions of the public interest might elevate the level of public discussion of risk-benefit analysis more than the mere statement that those who are participating represent this or that particular interest?

Mr. GREEN. I don't think there is any such thing as a nonemotional empirical study. If I were convinced that such a thing existed, I might agree with you. Nor do I think there is any way ever to eliminate what you call the selfish interests of particular groups from the legislative process.

It is indeed what makes the world go around. Congressman Anderson in his remarks this morning, for example, referred to the case of two Members of the Senate who were concerned about automobile bumpers, whether they should be aluminum or steel. I don't think you are ever going to get rid of that kind of factor. It would be a sad day if we did, because it would preclude a kind of political compromise that is just about the only way, in this imperfect Congress, of ours that Senator Stevenson referred to, that legislation could be enacted.

Mr. STEVENSON. Yes, sir, on the right.

Mr. MOORE. I am William Moore of the World Future Society and I would like to ask whether we should not make a distinction between a material standard of living which has been mentioned this morning, and which apparently involves a great deal of energy, and the quality of life which I think should be defined. It would be helpful to define it, but certainly it includes beside a high material standard of living, such things as security, safety.

Perhaps making that distinction between the material standard of living and the quality of life is germane to the discussion this morning.

Mr. STEVENSON. Any volunteers?

Dr. WILDAVSKY. I think the evidence is absolutely clear that the higher the level of material development, the greater the security of citizens on any dimension practically that you can measure. Now, of course, a larger material development does not imply a larger moral

development. What you do with that security and safety is quite another matter.

I personally do not believe that the two have to go together and often I think they do not, but this question is older than time.

The reason that we are asked to undertake these endless so-called safety programs is ostensibly, because physical risks are increasing in the world. And I say overall they are not, otherwise we would have to be explaining why we are all living shorter and why we are not living longer.

Mr. STEVENSON. In other words, full steam ahead, with caution.

Dr. WILDAVSKY. Yes, sir.

Dr. ASHFORD. My name is Nicholas Ashford, MIT Center for Policy Alternatives.

Since this is somewhat a fact-collecting experience I can't let two or three statements go by without making a comment.

The assertion made that the nature of risk has not really changed is absolutely incredible. I think we ought to set it straight for the record. It is an inappropriate thing to talk about a 100-year time framework, about how much better we are off in 1979 than we were in 1909. The relative time frame within which to work is what has happened since the end of the Second World War. In the 30 years since the end of the second World War we have had quadrupling of petrochemical production, a factor of 4 every 10 years. What that means is in 1975 we have 64 times per capita consumption in economic terms than we had in 1945.

The asbestos workers that are getting cancer now were exposed at the end of the Second World War in the shipyards. The radiation danger to produce cancer is coming right now. In fact in objective terms things have drastically changed since 1945. We can't be left with the impression that things have not changed drastically. Barry Commoner quite rightly warns us about the nature of chemical production and its incompatibility with our evolutionary soup.

The second misconception I am afraid is a crisis has been created by the evolution in science and defense. We are not going after minute quantities of arsenic in natural food. We are trying to solve problems such as nitrites, saccharin, asbestos in hairdryers, and I appeal to Senator Stevenson's statement we not reduce this discussion to an absurdity as if anyone were advocating a risk-free society.

Finally the Three Mile Island and DC-10 experiences are an example of the crisis in the public confidence in management of risk. The issue wasn't whether cost-benefit analysis was exercised in terms of the agencies in those cases. The question is did they pay attention to the signals, did they meet in the case of the agencies their public responsibility, or were other things going on? I think what we see is not a crisis of public confidence in technology but a crisis of public perception of whether that is going to be managed properly.

Mr. STEVENSON. Any further comments or questions?

Ms. CLARK. Mary Clark from San Diego State University.

I have a question which I think I would like to direct mostly to Professor Green but to anyone else who is interested in commenting. I see one of the important problems of government in terms of technology today as being taking the slack of development of technologies which no industry is willing to take the risk to undertake, for whatever reason. Either they think it is going to go out of existence or the

capital investment is higher than that particular industry. Here I think alternative energy is one example although there are obviously others.

I would like to go back to the prospective of the early 1950's when nuclear power was first developing toward an energy resource. Are we not now in danger of doing more or less the same kind of thinking that we did 25 to 30 years ago in saying we must have a solution, not what is the best way in terms of diversifying our possibilities of getting ourselves forward from where we are now. If we indeed had stopped 25 years ago and said perhaps nuclear power will be a way of getting energy but there are alternative ways, and not put all of our eggs in one basket we may first of all have not arrived at the breeder reactor yet and therefore not even know the problems to the economy that are potentially hazardous. Because we were diversifying, we might also have arrived at a more practical area of energy development.

So I would suggest the reason we didn't do this was because the Government had already put a lot of eggs in one basket, that energy utility companies and engineering companies and so forth were not able to do. The Government at that point took a calculated risk benefit that it really didn't have any answers to because it was 25 years down the road before we knew what the problems were going to be.

But in other words, they have already made a decision that in the future would be for our alternative energy. We knew oil would give out sooner or later, tending to be a little sooner perhaps than later. So one of the things we should think of is not what is the risk of postponing a technology, but what are the risks in not postponing; having a number of diverse alternatives in case we don't have the right one.

Mr. STEVENSON. Professor Green.

Mr. GREEN. That is a complicated question. To begin with in 1946 when the atomic energy program got underway I don't think there was any feeling on anybody's part that atomic energy was badly needed. I think it was more in the nature of kind of a throwaway major benefit that the Congress wanted to confer on the public, perhaps to salve consciences about the atomic bomb or something.

One of the great tragedies is that in 1946 no one had the foresight instead of setting up an atomic energy commission and a joint committee on atomic energy, to set up a solar energy commission and a joint committee on solar energy. If we had, we would probably have a solar energy economy today.

With respect to where we are going now, I don't know. I must say that I have misgivings about a major Government-sponsored synthetic fuels program. On the other hand, when we have the desperate energy situation that we have today, I don't see any reasonable alternative to doing that.

Mr. RITTER. I would just like to comment. I would disagree with the fellow from MIT Center for Policy Alternatives, there has been a revolution, and we are that much more aware of elements which are potentially harmful. It's just fact. The question remaining for public policy as we legislate and regulate is how we deal with whether the threshold danger and therefore the onset of regulation is 1 part per million, is 10 parts per million, is 100 parts per million. We are either going to turn off the 20th century, or we are going to be able to make intelligent decisions.

I would suspect that in the workplace, we are safer now than we were in 1945. But you have to ask yourselves also, how many people have died in wars since World War II? We have had a dozen occasions to have locked horns with the Soviet Union that in previous years prior to the nuclear terror might have created the third world war. But the fact was everybody now is involved. The leaders can't send their troops out. There is something almost to be said for this umbrella which prevents the generals from avoiding the result of war along with the Prime Ministers, with the Presidents.

And to that extent we have not seen world war III, nor probably will we; the risk of that conflict is far more reduced today in 1979, even though the threat of destruction is greater than it was in 1939.

Thank you, Mr. Chairman.

Mr. STEVENSON. Thank you, sir.

Thanks to our witnesses this morning and to our audience for a lively if somewhat inconclusive discussion. That is one of the risks of discussions of this sort.

Thank you; the meeting is adjourned.

LUNCHEON SESSION

WILLIAM T. GOLDEN, MEMBER, AAAS BOARD OF DIRECTORS, PRESIDING

Mr. GOLDEN. Welcome. It is my privilege to introduce Secretary Eula Bingham, who will have several important things to say.

Before that though, I feel somewhat like Jack Benny did on a similar occasion when he remarked, "Lord knows I don't deserve this distinction, but then I have arthritis and I don't deserve that either."

Dr. Eula Bingham, who was born in Kentucky, has been Assistant Secretary of Labor for Occupational Safety and Health for more than 2 years since her appointment by President Carter in March 1977. In that position she is responsible for setting and enforcing workplace safety and health standards under the Occupational Safety and Health Act of 1970. Actually, her functioning has covered a much broader field as she probably will comment.

Prior to her present appointment, Secretary Bingham was a professor in the University of Cincinnati School of Medicine, concerned with environmental health and kindred matters. Her doctorate from the University of Cincinnati is in zoology. Before joining the faculty of the university, she spent some 10 years in industry as an analytical chemist and in research.

She is no stranger to Washington, having served on numerous committees of the Federal Government, of the National Academy of Sciences, of the National Research Council, and of other agencies.

Secretary Bingham must be rather busy these days ministering to occupational hazards in Washington.

Secretary Bingham. [Applause.]

STATEMENT OF DR. EULA BINGHAM, ASSISTANT SECRETARY OF LABOR FOR OCCUPATIONAL SAFETY AND HEALTH, U.S. DEPARTMENT OF LABOR

Dr. BINGHAM. I suppose there are hazards associated with every job. It is a pleasure to be here this afternoon. When I was asked to do this, some comment came to me that this was a luncheon meeting up on the

Hill. And then I found out that it was AAAS. Now it is impossible for a zoologist to refuse to talk to a group of people like the AAAS. So thank you for inviting me. I always enjoy it whenever I can slip off to talk with individuals who are scientists. It is a welcome relief.

I was asked to talk with you today about risk assessment. The Congress, OSHA, risk-benefit analysis—all these things were in the little paragraph that was sent to me in a letter, and I think it is a very tall order. I assure you that this will be a rather short luncheon speech.

First, let me frame each of these topics. Let's talk about personal risk assessment. Personal risk assessment, as determined by each individual, has sometimes been promoted as an alternative to social regulation. Congress, though, has determined that social regulations are necessary and has passed legislation mandating the development and enforcement of such regulations. The Occupational Safety and Health Administration performs its legislative function by developing and enforcing standards in the health and safety area, and actually uses risk assessment techniques in this process.

We maintain, though, that the use of risk-benefit analysis requires considerable caution. As I have said, personal risk assessment has sometimes been promoted as an alternative to social regulation, and some individuals would argue that those of us in a capitalist economy perform our own risk assessment in selecting certain occupations over others. Actually, it is argued that this has been done as a *de facto* risk-benefit analysis. If true, this would actually reduce the role of the regulator to merely disseminating information. The problem, of course, is that even the cleverest individual has neither perfect knowledge of dangers and options nor perfect freedom to act, let alone the ability to assess personal risk.

In addition, relating wage differentials to a willingness-to-pay approach to health and safety constitutes an automatic ratification of the status quo distribution of wealth and income.

I won't take your time today discussing equity, efficiency and distributional aspects of policies based on the assumptions of individual freedom in the pure market economies. I will, however, point out problems with individual risk assessment that make public intervention necessary for the protection of working men and women in this country.

There was a recent article in *Science* by Tversky and Kahneman, 1974, which treats the biases of judgment.¹ The variations in how people assess the probability of uncertain events are enormous, they say. Many studies have been made attempting to relate the manner in which information is presented to individuals and how it affects their assessment of risk and probabilities. And while we are still at the frontiers of studying this, I would like to point out some of the findings of these authors that were presented in *Science*.

Those of you who are familiar with this, I ask your indulgence. Marvin probably is one of those.

For example, the authors point out that when worthless evidence is given, people will ignore prior probabilities even though they use those probabilities properly when no evidence is given. In addition, the authors found consistent insensitivity to sample size. Also, the form in which information is presented affects anticipations of outcome. When

¹ *Science*, vol. 185, Sept. 27, 1974, pp. 1124-1131.

shown two pictorial representations of the outcomes of six fair coin tosses, people consistently pick the series with three heads alternating with three tails as more likely than one with three heads followed by three tails. Furthermore, many studies have shown that people will predict outcomes consistent with very unrepresentative data. There are numerous other problems observed in statistical studies of individual risk perception. But let me end this section with a couple of examples the authors gave of adjustment and what might be called anchoring effects.

Two groups of students were asked to estimate the value of a numerical expression in 5 seconds. The expressions had an identical value, but one series' components were presented in descending order $8 \times 7 \times 6 \dots 2 \times 1$; the other, $1 \times 2 \times 3 \dots 7 \times 8$. The median estimate for the series beginning with the highest number was $4\frac{1}{2}$ times greater than the estimate for the series beginning with the lower number, and even the high estimate was an understatement by a factor of 18.

Studies of choice among gamblers and of judgments of probability indicate people overestimate the probability of conjunctive events, for example, drawing more red marbles 7 times in a row; and they underestimate the probability of disjunctive events. The point of all this is that people do not assess risks accurately, and therefore, even without all the other problems associated with attempts to use wage differentials as a substitute for safety and health protection, it has generally been agreed that worker safety and health protection is a societal responsibility.

Now for the larger question—the role of risk assessment in public policy making. The Occupational Safety and Health Administration has always performed qualitative risk assessments at the initiation of any standards development process, as does the National Institute for Occupational Safety and Health when it evaluates health and safety data on specific agents to provide us, in OSHA, with criteria for setting standards. Even the National Cancer Institute and the National Institute of Environmental Health Sciences make qualitative assessments in evaluating the toxicology of chemicals.

When data permit, OSHA may quantify its risk assessments. Unfortunately quantification is not always possible, at least not with absolute certitude of accuracy. Nor has most research on toxic chemicals addressed this issue and provided scientific data on which to base such calculations.

OSHA recently participated with the Consumer Product Safety Commission, the Environmental Protection Agency, the Food and Drug Administration, and the Food Services Quality Section of the Department of Agriculture in an IRLG study of risk assessment of carcinogens. This study was recently published in the July issue of the *Journal of the National Cancer Institute*.

Certain shortcomings of risk assessments were noted, some of which I will repeat:

Quantitative risk assessment of human cancer risk may be based on epidemiological or animal data. In either instance, methodological problems arise because of the need to extrapolate from effects observed under one condition and level of exposure, and in one population group or biologic system, to arrive at an estimate of the effects expected in the human group or individual.

This study goes on to note that "current methodologies, which permit only crude estimates of human risk, are designed to avoid under-

statement of the risk making cautious and prudent assumptions whenever they are needed." And by the way I would like to point out that it has not always been the case that public health agencies have tended to act with caution because we have had repeated instances where standards have been set and we have had to go back 10 and 20 years later and find out that we still had populations developing an enormous amount of disease.

Furthermore, "whether based on data from animals or humans, there is uncertainty about the shape of the dose-response relationship at the usually low levels of actual human exposure." This study goes on to say that "the most favorable foundation for quantitative risk assessment is based on well characterized responses in human populations with well defined exposures, unfortunately, the exposure estimates are often unavailable or crude." In addition: Although extrapolation from the observed human population group to other groups carries less uncertainty than extrapolations from animals to humans, the possibility of significant differences in the characteristics and conditions of exposure of two population groups must be recognized.

The estimation of total population exposure to a given substance—and/or to its decomposition and metabolic products—requires consideration of the following aspects: Sources of human exposure occurrence, production, uses, and environmental distribution; analytical methods for detecting and measuring exposures . . . ; routes and conditions of exposure; duration, frequency and intensity of exposure; and, size and characteristics of the exposed populations. During examination of exposure data, important qualitative and quantitative factors beyond numerical values of dose level and population size will emerge; although such information may not be usable directly in a mathematical calculation of risk estimate, it will frequently provide additional perspective and insight during risk evaluation.

During the examination of exposure data it is very important to notice such things as the limit of detection of analytical methods which have been used, and how specific they are and the conditions of analysis. "For a given substance, the usefulness of dose-response data obtained from a specific human population group or from animal tests for [the] estimation of risk in the general population is limited by the consideration that general population exposures is to only one substance, whereas in the case of carcinogens there is certainly a total carcinogenic burden derived from multiple sources and in some cases with multiple interactions. This report discusses many more aspects of risk analysis such as the fact that even though we have problems with risk estimation, we would not do away with risk-estimating. We have to look at different conditions of human exposure, attempt to form these risk assessments very carefully, while keeping in mind the inherent limitations in using this information.

Last, a few words about risk-benefit analysis. One may think of risk-benefit analysis in terms of a series of not-so-hypothetical questions. For example, is the risk of a nuclear accident worth the benefit of increased nuclear energy availability? Is the risk of a massive oil spill worth the increased availability of imported oil? Are the risks of chronic disease, premature death, potential damage to future generations worth possible short-term financial benefits accruing to unregulated individual firms and their customers? Are the risks of a Kepone or Love Canal where the medical effects are long lasting—probably over a lifetime—the environmental effects are multigenerational, and

the economic effects last decades, as in the fishing industry—are these worth the temporary financial benefits to individual firms and their customers of not taking preventive measures?

I think that more and more we will face such questions in risk-benefit analysis when we look at the great increase in the volume of synthetic organic chemicals and the nature of the chemicals that are presently with us at this point in history compared to what we had available in the 1930's. Certainly decisionmakers want their actions based on as much information and analysis as possible. Nevertheless, there are a number of obvious difficulties with attempts to rely uncritically on any form of risk-benefit analysis.

Different groups are at risk from those—at least temporarily—benefiting from nonregulation, and often they are from different generations. The benefits of not regulating—that is, the cost of regulating—are far easier to monetize and present with at least the appearance of accuracy than the risk of not regulating.

How can risk be valued? What does worth, what does the term “worth” mean in terms of pain, suffering and family dislocation? Not only is monetization on risk conceptually difficult; it is often logically and ethically impossible. In short, risk-benefit analysis can embody many of the pitfalls of a rigid and traditionally narrow cost-benefit analysis. Attempts to arrive at mathematical ratios to be used as decision rules are clearly foolhardy in the arena of health and safety protection. On the other hand, commonsense requires that we carefully gather and analyze information on the impacts of alternative regulatory strategies.

I would like to close by making several points. First of all, Congress has reflected society's will by mandating the maximum feasible protection of workers. I would like to point out to you that “feasible” in the Occupational Safety and Health Act has a connotation for technology and economics. It so happens that some of the standards that have been promulgated by the agency will not protect workers to the fullest extent because it was not technologically or economically possible to promulgate such a standard. That may be the case so far as coke oven emissions are concerned. Certainly if we look at the data of Dr. Selikoff, the current asbestos standard which was set on the basis of feasibility back in 1972 may not be protecting all workers to the extent feasible in 1979.

In developing and promulgating standards, OSHA does consider the financial and health impacts of a regulation. First of all we carefully assess the health and safety risks of the workplace. Then we evaluate the costs of alternative strategies. Next we endeavor to select the most cost-effective method of complying with the standard. And fourth, we consider among other things the timing of implementation of the standard because of the whole problem of cost. However we do not attempt to measure the immeasurable, quantify the nonquantifiable, nor monetize the nonmonetizable.

We assess the costs, we assess the risks and we assess the benefits, but we do it humanely and without any misplaced sense of concreteness or a false inference of numerical accuracy. Congress in passing the Occupational Safety and Health Act of 1970, the Food and Drug Protection laws, the Clean Air Act, the Clean Water Act, and in creating the Consumer Product Safety Commission, has in effect per-

formed the ultimate risk-benefit analysis itself and found in favor of maximizing the protection of the men, women, and children of this country, and of minimizing health and safety risks to the extent feasible.

It is no wonder when we consider what we are faced with currently in the environment, whether it's in the workplace, whether it's in water or air, that the Congress has passed these pieces of legislation.

While the Occupational Safety and Health Administration is trying to promulgate regulations on hazards that we have known about for 200 years, there are more chemicals accumulating out there, chemicals that are coming off the synthetic assembly line, that are being used as activators, being used as catalysts, and sometimes we even have epidemics in the workplaces as a result of this. So we indeed had a Congress that knew what it was doing when it looked ahead.

As an agency we are conscious of the finitude of America's resources and we are committed to protecting our most precious natural resource, the American worker, and by extension their families throughout this country, on the basis of the best, the most prudent and cautious use of scientific data and analyses available to us.

It's been a pleasure to be here and I wish you good fortune in your discussions this afternoon. Thank you.

[Applause.]

Mr. GOLDEN. Thank you all. We are recessed.

SYMPOSIUM

J. THOMAS RATCHFORD, ASSOCIATE EXECUTIVE OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, PRESIDING

The symposium convened in room 2318, Rayburn House Office Building, at 2:45 p.m.

Dr. RATCHFORD. Good afternoon. My name is Tom Ratchford. I am a colleague of Charlie Mosher's at the American Association for the Advancement of Science. I work for Bill Golden, whom you met at lunch today, and Anna Harrison, another member of the board of directors, whom we will meet later on, as well as the other 130,000 members of AAAS.

This is the first of two symposia imbedded in this Congress science forum. It is well known that scientists have two hands, and Congressmen seeking answers have in fact asked for one-handed scientists on occasion. The press, as we were told this morning, thrives on differences in opinion between experts. But just as it is important for Congress and the press to understand the scientific and technological aspects of issues that face our Nation, scientists and engineers need to understand better the political process in order to relate to it more effectively.

The dual character of this forum was referred to by Charlie Mosher in his opening remarks. We then heard experts share their wisdom with congressional decisionmakers.

This afternoon we hear from such decisionmakers. Perhaps what is said today and tomorrow will contribute to a better understanding of the political process by the scientific community. Some scientists may even get to understand Congress as well as Congressmen understand

the scientific and engineering communities, leading eventually to a more effective interchange of information and ideas between these disparate traditions.

It is appropriate that we hear first from someone in Congress whose roots are in science. Congressman James G. Martin was born in Savannah, Ga. He received his B.S. in chemistry from Davidson College, in a vintage year. I might add. He completed his Ph. D. at Princeton University in 1960. He was elected to the Mecklenburg Board of County Commissioners and worked his way up to the Congress. He arrived here in 1972, joined the predecessor to this Committee on Science and Technology, the Committee on Science and Astronautics, but then later was promoted to the Committee on Ways and Means.

Without any further introduction, and about 2 minutes before he has to leave for a vote it looks like, I give you Congressman James Martin. [Applause.]

STATEMENT OF HON. JAMES G. MARTIN, A REPRESENTATIVE IN CONGRESS, FROM THE STATE OF NORTH CAROLINA

Mr. MARTIN. Thank you, ladies and gentlemen.

I had the pleasure of joining you at lunch today where we were told that the American people are poorly equipped to make risk decisions for themselves. There goes the basis for our democracy down the tubes.

I also noticed, as perhaps did you, that there was no saccharin anywhere to be found on the tables and that it could be provided if you asked specifically for it. We will fix that in about 14 more minutes. This particular vote, ironically enough, is on adopting a resolution to extend for an additional 2 years the moratorium which bombed the ban on saccharin a little over 1½ years ago. So you will have to forgive me—you have no choice—when a few minutes after the next bell I will be on my way to vote and then come back to enjoy the discussion.

You may have also noticed that while saccharin was not provided for you, sugar was, though it has been found to be carcinogenic as well as an equivalent feeding dose greater than saccharin. Dr. Schneiderman says no because he hasn't found it in his epidemiological studies yet. Nevertheless, if you are going to conclude that feeding studies and massive overdoses have some meaning, one of the things that you have to face up to is that they mean if you apply the Delaney clause, that absolute zero safety stricture, to all substances that are found to be carcinogenic upon massive overdose feeding, not just food additives, but to all chemicals, natural as well as synthetic—you contemplate banning the food supply, you contemplate banning the workplace, you contemplate banning the marketplace. You will tell people that it is not safe, absolutely safe for them to go outdoors, nor is it absolutely safe for them to stay indoors.

It seems to me that the Delaney clause is an idea whose time has come for a change, and I have been advocating this for the last couple of years, since March of 1977 when the then Acting Director of the Food and Drug Administration announced to us that because of the Delaney clause, the last of the artificial sweeteners must be banned. I am able to speak about that, and I have been able for the last couple of years because it was the last of the artificial sweeteners.

Prior to that time, no one, certainly no politician, and few scientists for that matter, dared to speak in favor of shaking the Delaney clause

because they know that they would be assaulted with the intimidating refrain that means you are in favor of a little bit of cancer. The subject could not be touched; it could not be discussed in polite company. But once the last of the artificial sweeteners fell under that clause, it became an open discussion among politicians as well as many scientists.

The subject, of course, is not just saccharin. The subject is how do we protect the public from risk. Do we choose a standard of absolute zero risk which anyone who has given any thought to the matter will surely understand is an unattainable goal, or do we try to wrestle and deal with the difficulties outlined for you at lunch with making relative risk judgments.

I recall that the Delaney clause was passed at a time when I was an organic chemistry student, as has been mentioned, at a time when among other things I was learning the Sarett reaction named after one of our panelists here today. And I remember being aware of the Delaney clause and the curiosity that we felt regarding that mode of dealing politically with a scientific issue.

That was the second bell. I am going to have to compress the rest into just a couple minutes. Until 1958, we knew our food supply was safe because analytical chemists could tell us that they could detect as little as one part per million of impurities and there was nothing there to be afraid of. Since then, not out of mischief but just pursuing their trade, they have reduced that threshold of detection to parts per billion, and today it has reached in a few cases parts per trillion, and we can't afford to be so smug any more.

Not only did you notice there was sugar on the table, we also provided ashtrays for you. We provided leafy vegetables. We provided a little packet of dairy product which assures you that it had 10½ percent butterfat. We provided you with tomatoes; we provided you with overcooked chicken. A host of naturally occurring or naturally produced carcinogens. We left out the peanuts. [Laughter.]

But you could go through a whole range of substances. And there are those who think that absolute standard should be extended to the workplace as you will get into in discussion with one of the later speakers.

Because of this problem of how to deal with it, I have drafted legislation which I would introduce into your record and be happy to discuss with you as soon as I return. Basically, it provides an amendment to the Delaney clause which would allow an exception to be made if after a study by an ad hoc panel of people whose expertise leads this panel to a recommendation, and after that recommendation the Secretary of Health, Education, and Welfare, who may defer to the Food and Drug Administration, of course, makes a finding that the substance has benefits which outweigh the risks.

Quite aware of the fact that benefits are often difficult to assess, as the National Academy of Sciences has found specifically to be the case with regard to saccharin, I also know that risks are very difficult to assess. But I know that it is scientifically obsolete and patently absurd to say that because there is a difficulty of assessment, we must therefore ban anything which has any certifiable risk whatsoever.

My bill further provides that where you find that the risks are so remote on the basis of the evidence, so small as to be well within the range of risks which people take without any concern for the consequences, it is not serving the public good to squander our resources

chasing after and banning all such substances. I am speaking of such risks as sunbathing, eating natural foods, risks of flying in airplanes—the cancer risks, I am talking about, not the crash risk, but the cancer risk associated with flying at high altitudes in airplane. The further risks are so low as to be below a threshold of 1 in a million or 1 in 10 million. In this case, the public should be made aware of the risks, the public should be alerted to the remoteness of the risk, and then allowed to make its own decision.

Finally, there is a provision in the bill that says where the animal experiments employ such large doses that the defense mechanisms of the animals are overwhelmed—the kidneys, the DNA repair mechanism—where the doses are so large that it is demonstrable that those defense mechanisms are overwhelmed, and that is the only level at which cancer is found with animals, and further, that where the ordinary exposure of humans is well below the level which impairs the animal's defense mechanisms, then that shall not be taken as evidence of a risk to humans.

Now if you will forgive me, I will run and vote and run right back and try to pick up where you are at that time.

It wouldn't do for me to have someone say where were you when the vote was on saccharin and to say I was off defending the vote on saccharin. [Applause.]

Dr. RATCHFORD. While the Congressman is voting, we will have a chance for our panel members to ask him some questions in absentia.

First of all, let me introduce the panel.

MARVIN SCHNEIDERMAN, THE ASSOCIATE DIRECTOR FOR SCIENCE POLICY OF THE NATIONAL CANCER INSTITUTE; LEWIS H. SARETT, VICE PRESIDENT FOR SCIENCE AND TECHNOLOGY OF MERCK & CO.; SAMUEL W. GREENHOUSE, PROFESSOR OF STATISTICS AT GEORGE WASHINGTON UNIVERSITY; NICHOLAS ASHFORD, ASSISTANT DIRECTOR OF THE CENTER FOR POLICY ALTERNATIVES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. RATCHFORD. I would suggest to the panel members that during the absence of our speaker, a short but forced absence, that they try to identify issues which can then be brought to his attention on his return.

Dr. ASHFORD. I would like to make some remarks that deal with saccharin, since Congressman Martin brought it up, and then try to view that problem within the context of the larger issue: The role of risk assessment in environmental, health, and safety policy.

The defeat of the Delaney amendment is a symbol. None of you should really believe that it represents a concern about food additives, per se. You heard Congressman Martin refer to the fact that it will have implications for how we look at workplace safety, how we look at other areas where there is a congressional mandate to weigh very heavily the potential consequences of not regulating against whatever economic or other dislocation that occurs. This is especially important to realize in the case of saccharin. And I don't want to take sides on that issue. But you should know that even if the Delaney amendment didn't exist, saccharin would be regulated anyway. It would never make it through existing drug laws which require a food additive to be

proven safe. That requirement has nothing to do with the Delaney amendment. So you should understand that this is a symbol.

The issue of free choice and democracy and liberty is a very appealing one. When a regulatory agency's actions seem to challenge something dear to the hearts of Americans, the right to eat sweet food, we hear the reaction, "Now they are trying to tell us what to eat." Instead, we are asked to support consumer preference, with the assumption that people always know what is best for themselves. A very appealing thesis. Let the people judge whether the risks are worth the benefits with regard to carcinogens has a ring of Americanism beyond refutation.

Leaving aside the wisdom of that viewpoint, we are asked in fact to let consumers make up their minds for themselves. And it is interesting to note that in support of this freedom ring, we are asked to allow saccharin on the market because diabetics and overweight people in fact do not act in their best interests; they do not voluntarily reduce their sugar intake. That is, the argument that we ought to provide saccharin because diabetics and overweight people will suffer if saccharin is not available, rests on the fact that these people don't choose what is best for themselves.

Now, if you think about these statements, you realize there is something terribly inconsistent about the two positions. You cannot on the one hand say let consumer sovereignty prevail because people know what is best for themselves, and yet at the same time say let us allow saccharin on the market because people do not know what is best for themselves. You can't have it both ways.

Now, I don't know how to resolve that apparent contradiction except to ask perhaps whether there is something else at play here.

The overriding theme in this proceeding is what is the role of cost-benefit analysis and what does it mean for science and technology. The very question: "Should the benefits outweigh the costs?" Is perhaps the wrong question. It ignores the issue of whose costs and whose benefits. It also ignores questions of the ability to compare those costs and benefits. And now I am not talking about the usual argument raised about the difficulty of monetizing benefits. Let's talk about food additives. If there is in fact a health benefit to be derived, then depriving people of substances like saccharin causes a health detriment, while using it causes a health risk. I really don't know how to compare those two kinds of health benefits and costs.

What is very clear is that equity and the possibility of misuse has to be dealt with. Perhaps the most significant thing about the saccharin problem comes from its use by children who consume far greater proportion of saccharin per body weight than adults do. Now you can't argue that they are making these decisions rationally, nor can you easily argue that you could prohibit the sale of diet food to anybody under 21. The issue is terribly complex.

By the way, the saccharin risk may, according to some observers, be very severe. Not only is it an initiator of cancer, but very likely it promotes cancer initiated by other materials, of which there are many around. Now, it may be these many low-exposure cancer initiators that are being promoted, and that may be the problem. As I said, we don't need to decide saccharin here today. But it is not a minnow.

We heard this morning about what appeared to be two opposing views of dealing with this area, one having to do with a logical ap-

proach and one having to do with an intuitive approach to answering these questions.

Now, we have been told by others that the logical approach is a cost-benefit analysis where we maximize the excess of benefits over the costs. There is an intuitive approach which goes to what I call the Halloween apple problem, and I ask you to think about the Halloween apple problem, and ask whether the intuitive approach is really in opposition to what you would call a logical approach. Your kid goes out on Halloween, comes back with 25 apples in his bag. You have heard that one in 10,000 contains a razor blade, and you have to decide whether or not you are going to let your child have those apples. Now, there are many ways you make that decision. One is you don't think about it and you let the kid eat the apples. One is that you say I have no idea what the risks are that a razor blade can be in that apple, and since I don't know, I am not going to take a chance.

Last, you can do a cost-benefit analysis. You can calculate the probability of finding a razor blade in the apple and the cost of corrective surgery, and you can calculate the cost of the apple. If you do a cost-benefit calculation I assure you this is one case where everyone will agree it is absolute nonsense to throw the apples away. What do you in fact do? You throw the apples away. Why do you throw the apples away? Because you are risk averse, because it is not worth the chance. You heavily weigh the possibility that that one idiot who put a razor blade in an apple on Halloween is going to end up putting that apple in your kid's basket. Is that irrational, is that illogical, and aren't we asking the regulatory agencies to act in our behalf as ordinary citizens who are risk averse rather than maximizing a cost/benefit ratio?

Thank you.

Dr. RATCHFORD. Perhaps we can now get a report on the vote and an extension of Congressman Martin's earlier remarks.

Mr. MARTIN. Thank you, Tom.

When I left the vote was about 250 to 23, and there were still aye votes left to be cast, but pretty clearly you will have another 2 years of grace during which time the Congress will have further chances to address itself substantively to the need recommended by the National Academy of Sciences to rewrite the food safety laws.

I would be very happy then at this point to yield such time as I have for discussion. There are other things that I can say, but that will come out, I think, during the remaining time.

Dr. RATCHFORD. Dr. Schneiderman has been mentioned by name both by Professor Ashford in his remarks, and Congressman Martin. Dr. Schneiderman, would you like to respond with either a question or a statement?

Dr. SCHNEIDERMAN. I think I will probably give you a mixture of questions and statements and I will ask questions and not give anybody else a chance to answer them. I will answer them myself. I have had experience as a university teacher, and you know you don't dare let students answer questions when you want a certain answer to a question.

There are several things I have been thinking about in relation to our discussions here today on risk/benefit. First, I was involved very early on with some of the people who are doing some of—at least proposing

some of the risk computations. The first of these, as probably all of you here now, was a proposal by Mantle and Brian of the Cancer Institute in 1961 on—talking about a virtually safe dose of something or other. They published a paper in the *Journal of the National Cancer Institute*, this very popular journal, and it got worldwide circulation, and hardly anybody paid any attention to what they had said for many years. Worldwide means a circulation of 3,000.

After a while people began to look—I remember talking with Alvin Weinberg at Oak Ridge, who told me that far as he knew nobody had ever done anything on this, and I suggested that something had been done, and that he might want to look at that paper. After a while people began looking at the Mantle-Brian procedure; it got extended, got enlarged by some of the people at Merck, by the way, and then it began to get criticized. It was criticized on two sides. I was criticized first that it led to such potentially low levels of an allowable material to be used—to be introduced into the environment—that it essentially led to zero-zero levels, and in that sense it was no different from the Delaney clause and what the Delaney clause permitted. On the other hand it was criticized that it had no biological basis; it was an empirical approach derived from bioassay considerations and an assumption of a distribution of sensitivities in population, and for this we had no data whatever.

People then introduced some other ideas which had somewhat better biological bases than Mantle-Brian. Those ideas turned out to yield even lower “safe” exposure levels than the Mantle-Brian technique gave you. Those are the straight line, no threshold concepts that came out of ionizing radiation damage considerations and other similar biological considerations.

Armibage and Doll formalized the mathematics of the multistage concept of cancer, cancer being a disease which involves multiple steps in its production, Nick Ashford referred to this by talking about saccharin as a possible promoter, which would be the last step in one of these processes. You go through the mathematics of that concept and at low doses the mathematics says behave as if the response curves were a straight line with no threshold. The question of no threshold is a question of consequence. It relates to Congressman Martin’s remarks about doses of materials being given at such a level that defense mechanisms were overwhelmed. If there are defense mechanisms that are not overwhelmed that does imply the existence of a threshold. If there are thresholds we don’t know what they are for specific individuals, and we don’t know what the distribution of thresholds would be. We would not know, for example, and I think one of the defects in Congressman Martin’s proposal lies in talking about animal evidence at which doses were given at more than threshold levels, that is, defense mechanisms overwhelmed. The question is how do you translate that into what goes on in humans. We work with highly inbred strains of animals, which means these mice are all very much like each other. We try to make them very much like each other so that we can work with very much smaller experiments. Humans, in some respects, are very much like each other. Each of us has on the average one head, things of that sort. But on the other hand there is a fair amount of diversity and a fair range of difference among us. We know our friends and colleagues who love strawberries and we know our friends and colleagues who break out in hives when they eat strawberries.

So there is a broad range in humans that we don't quite know. I would hope some of the research might lead us into finding out how we could extrapolate from the mouse inbred strain to the human outbred and widely divergent, strain whose responses probably are very much mediated by what he eats, where he lives and whatever else he is exposed to. We really need to know and I think Congressman Martin agrees with me on this—we really do need to know what it is that affects the threshold, if there is one. As Dr. Bingham asked earlier today, does exposure to multiple materials modify the threshold for the next material? Have the doses that exist in the world around us, in some way already consumed those liver enzymes that are capable of detoxifying the new materials? We don't know any of the answers.

That would then imply to me that this particular part of Congressman Martin's proposal probably would not be capable of being applied because we would not know the specific things that you would have to know to make it work. You would have to know that a threshold dose had been exceeded in the animals. You would therefore have to know what the threshold was. You would have to know whether this was comparable in some way to threshold doses in humans. We would have to know the distribution of threshold levels in humans. We would have to know that conditions modify a threshold in humans. So there are problems. There are real scientific problems. I think there are scientific problems with using additional information beyond what the Delaney amendment permits us to use today.

Dr. RATCHFORD. Dr. Schneiderman, in a sense you have asked a very complicated question. I wonder if we might give Congressman Martin now an opportunity to respond to what by extension one could describe as a question.

Mr. MARTIN. I will address, Tom, just the question that Dr. Schneiderman has raised regarding the dysfunctional threshold. I would say there is no scientific or political or regulatory problem whatsoever with what I am proposing because I am not proposing to extrapolate erroneous evidence to humans. I am proposing to reject that evidence.

If the only evidence that you have that a substance is associated with cancer in animals is evidence that is obtained above that dysfunctional level, then that evidence has no meaning for the regulatory process. You don't have to decide how the distribution of thresholds is with humans. All you have to do is show that the substance in question causes cancer at doses below that dysfunction level. If it doesn't if you have no evidence below the dysfunction level, then your evidence is not regarded as being of any significance to humans if the human dose is well below that level as well.

Dr. SCHNEIDERMAN. There is a scientific problem and the scientific problem is: Is this a dysfunction level for humans comparable to this dysfunction level that we are talking about for animals? Is it at the same high level? Is it at a different level? How do we find out? Would we do some experiments on humans to find out what a dysfunction level was? Certainly we would not. We would have to develop in some other indirect ways knowledge first of what a dysfunction level in animals means for humans. And parenthetically I am not certain that I know of any material in which a dysfunction level has been demonstrated in animals.

There are some arguments concerning vinyl chloride, but it is obvious, to me at least, that with the testing in vinyl chloride, that while the processes at very high dose levels seemed to be somewhat different than at low dose levels, there are still doses at the low dose levels that lead to activation into a carcinogenic product. Though the processes are different at high dose and low dose there seems to be a continuity between them. We would have to argue there is zero conversion at levels below this so-called dysfunction level, and I think in our present state of knowledge we don't know this. I would hope we could find out.

I like the idea of a "safe"—or below dysfunction—level, I really do. I don't like living with the idea that we are living in a sea of carcinogens. I don't like living with the idea that each of these carcinogenic effects adds to the carcinogenic effect of existing materials. This is scary.

I am pleased to see, for example, that our cancer death rate in this country, while still increasing—by the way cancer is the only major disease for which death rates have been increasing after we take into account age changes, from 1960 to the present that the rate of increase is decreasing. I think some good things are happening here.

My colleagues who are involved in research and treatment tell me it is because they are treating so much better. I am not really sure that that is true. Incidence of some forms of cancer have gone down, and this implies prevention—which I very much like.

Mr. MARTIN. Could I have a one-sentence rebuttal. If your view prevails with regard to the threshold, I am confident ultimately there will be only three classes of chemicals, natural or synthetic, to wit: Those chemicals that have already been shown to be carcinogenic by massive dose testing; secondly, those that will ultimately be shown to be carcinogenic by massive dose testing; and third, those that are so toxic that no one can overdose the animal long enough to find out whether it is carcinogenic or not.

Dr. SCHNEIDERMAN. I think Congressman Martin is disregarding some of the evidence.

Dr. RATCHFORD. This is a very interesting proposal Congressman Martin has made. It even has some statistical overtones.

Dr. SCHNEIDERMAN. May I remark most of the materials tested so far have not been shown to be carcinogenic, even after massive dose testing. I think we have to add a fourth class.

Mr. MARTIN. You are overlooking the ingenuity of the rat breeders and the ingenuity of the rat feeders.

Dr. SCHNEIDERMAN. No; I was counting on the ingenuity of the scientists that if there is such a thing as an overdose level, an overwhelming level, that they will be able to show it. So far we haven't, and I think my colleagues are very bright and very competent, and if there are such things, I hope they will show it. When they do, I would hope we would try to write legislation to take it into effect. Before that is shown, I think the legislation is sort of theoretical, like some theoretical science.

Dr. RATCHFORD. Since we have some serious time constraints, I would like to give an opportunity to some of the other panelists to comment or ask questions.

Dr. Greenhouse.

Dr. GREENHOUSE. I must say this has been a rather difficult day for me. The discussion thus far has seemed to stray from the stated purpose of this symposium as announced by the AAAS. This aim was to present to the Congress the characteristics and properties of risk-benefit analysis in order for the Congress to decide whether systematic risk-benefit analysis should replace the Delaney amendment. My impression is that the previous speakers this morning seemed to take positions against the general use of risk-benefit analysis, although this view may be incorrect for one of them. It is certainly clear that Congressman Martin is for legislation mandating the use of risk-benefit analysis as the basis for decisions by the appropriate regulatory agencies.

My own position is somewhat mixed—sort of a hedge. During all my years in the National Institutes of Health, I was against tampering with the Delaney amendment. I considered it, and still do to a large extent, as the major protection of the American public against a completely uninhibited addition of external agents to the foods we eat. The amendment is playing it safe on behalf of the public in a clear, definitive way. For sure, questions are raised about the meaning of the evidence that the agent causes cancer in animals. But let that be argued out while the agent is off the market.

However, I have come to recognize that the question as to whether such a position isn't playing it too safe is important and not trivial. The case of the nitrosamines is most significant in modifying my position. Although the risk for cancer has been reasonably well established, it is also true that the removal of the nitrates from food would most definitely result in a risk for botulism. Thus, some risk-benefit analysis may be necessary for arriving at just decisions.

However, I feel reluctant to go all the way in advocating risk-benefit analysis as the major policy of the Government—if by risk-benefit analysis is meant the systematic, detailed procedures of figuring risks, costs, and benefits. The reason is not that given by the previous speakers but the simple, logistical difficulties of doing such an analysis each for the hundreds or thousands of situations that may arise every year. Many of these problems are of the same kind raised by Dr. Bingham.

Now, with regard to Congressman Martin's remarks, I should like to pose two questions. First, I am surprised that Congressman Martin is introducing a bill which does not eliminate the Delaney clause. In fact, what his bill proposes is the amending of the Delaney clause to allow for exceptions. Am I correct?

Mr. MARTIN. That's correct.

Dr. GREENHOUSE. To allow for exceptions. And an exception would then be studied by a panel which would make recommendations to the secretary.

The first question I have then is whether the bill mandates the use of risk-benefit analysis. If not, it is not clear then what this symposium can contribute to the issue.

Secondly, who will be responsible for deciding what agent is to be excepted? Will these decisions be left to the reaction of industry to an action taken by a regulatory agency on an individual basis? Or are the exceptions to be made on a systematic basis regarding all additives to foods or even the use of drugs? If it is to be either on an individual basis or on a systematic basis, who will have the responsibility of conducting the risk-benefit analysis? One might argue that it is industry

that should have the primary responsibility for performing these difficult analyses. But will industry accept this? After considering the magnitude of the task and the volume of such studies needed every year, my guess is that industry will decline.

As the Associate Director for Evaluation and Program Analysis in the National Institute of Child Health and Human Development, I performed one of these analyses in evaluating the risks and benefits in the use of the oral contraceptives. Without going into the details at this time, the difficulties in doing this study well were tremendous. The assumptions about costs to the individual and costs to society of an unwanted child, the costs involved in the risks of side effects, benefits to the individual, benefits to society, and so on were all gross approximations.

On the other hand, simple indications of risks and benefits without the precise detail of dollar equivalents may be the significant information for panels to possess in order to arrive at decisions. That is, a qualitative sense of the risk and benefits pertaining in a given case rather than an intensive quantitative study, may play a role in future decisionmaking about food additives and even the introduction of therapeutic agents.

Thank you.

Mr. MARTIN. Thank you.

Since my colleague, Senator Tsongas, is here, I will just address the particular questions Dr. Greenhouse raised to me, and beyond that invite his help in further perfecting the legislation which I have introduced.

First of all, why not repeal Delaney? There is a practical reason and that is Jim Delaney was chairman of the Rules Committee at the time. He is no longer, of course. But let's face it, that would be the wrong statement of policy to give to the people without replacing it with something, without an amendment. And my feeling is that the Delaney clause had to be modernized in a modern way and I think that is what I have done.

As to the panel, the panel would be instructed to consider risks, to consider benefits with emphasis on health benefits and nutrition benefits, and to consider alternatives, and to consider a public hearing, what they hear from people that come to speak to their panel. They would then give a report to the Secretary of Health, Education, and Welfare, who of course acts for the President within his entire range of responsibilities. The report of the ad hoc panel would include a minority report, just as we do here with committee reports in the Congress.

I think that is very important because anyone can say that I might choose one panel stacked one way and someone else could choose a panel that would be stacked another way. But if you at least allow the minority to have a chance to have its say recorded in the same document, it is able to marshal whatever arguments it has.

The secretary would then consider that. Bear in mind that this is essentially what the National Academy of Sciences did with its saccharin report, including a minority report with that. The NAS panel found that for saccharin the risks were very small—real, but very small. The benefits, while not clinically demonstrated, were perceived to be very great by the people who actually use the stuff. And by doctors, and their conclusion, their recommendation was don't ban it.

I think that is a very good model for what I have in mind.

That report would then go to the Secretary of HEW who would make the decision and give the reasons for it. The report would be public. The reasons for the decision, which may not agree with the panel, would be published as well.

The alternative to this is for Congress to make every decision on every subject. And I think that would be wrong, Congress should set the policy, the Congress should reserve the right to take exception from time to time but should not be expected to try to master every chemical entity that is brought up for a decision. The other alternative is to stick with what we have got, which is an absolute zero risk/benefit policy that says there is no benefit, no matter how great, that can justify any risk, no matter how remote. And that is no longer a viable policy, in my opinion.

Dr. RATCHFORD. Dr. Sarett, if you have a short question for Congressman Martin, we can take it now and then get you first on our next go-round with Senator Tsongas.

Dr. SARETT. Because the evaluation of risk and benefit is a very complex matter and because we have heard a number of Congressmen and Senators in the past and present day indicate that they accepted the assignment with understandable reluctance, I would like to ask you, Congressman Martin, how you feel about a partially alternative proposal which I am sure you are familiar with, a science court, in which scientific issues would be debated presumably by scientists and the logical basis for it would be to separate science from politics.

Congressman MARTIN. Although the question before us is not purely a scientific matter, I think the suggestion that Dr. Sarett is making, and which others have advocated of a science court to weigh the questions of science, is a very good one, and to do it on their own terms without prebiasing the result that they would come up with by telling them in advance what they can consider and what they can't consider. We have had too much of that kind of thing around and I think the suggestion is a very good one.

But ultimately the decision is going to have to be a decision of public policy. I think we have to agree we can't just rely on scientists to tell us what public policy is and, as I have said before, we shouldn't rely on anyone else to explain the meaning of the science. And that is what that science court would do. They would not make a finding—or a decision, but they would make a finding and a recommendation as to what the meaning of the science was on their own terms.

Dr. SARETT. Right. Thank you.

Dr. RATCHFORD. Thank you, Congressman Martin. Thank you, panel members.

We move now from risk/benefit tradeoffs in food and drug policy to risk/benefit tradeoffs in environmental policy. Our next speaker is Senator Paul Tsongas, who was born in Lowell, Mass., studied at Dartmouth College, Yale Law School, and the Kennedy School of Government at Harvard. He was a Peace Corps volunteer, Deputy Assistant Attorney General in his home State, and engaged in private law practice. Elected to the U.S. House of Representatives, representing the Fifth Congressional District, he is now a freshman Member of the U.S. Senate. His Senate committee assignments include the Committee on Banking, Housing, and Urban Affairs and the Com-

mittee on Energy and Natural Resources. He will speak to us now on risk/benefit tradeoffs in environmental policy.

STATEMENT OF HON. PAUL TSONGAS, A SENATOR FROM THE STATE OF MASSACHUSETTS

Mr. TSONGAS. Thank you very much.

Let me start out by saying that it is a good idea to have the scientific community and the political community interact. The record of scientists in political activity is dismal. Only doctors show a greater disdain for the legal profession than you people do. And although that may be comforting, we all happen to inhabit this earth together and we also are constituents of the same political system.

I for one find the attitude of scientists to be offensive, and I would think that there is no reason why scientists cannot get involved, work in campaigns, run themselves for political office. Jack Schmitt, who as you know is a former astronaut, was elected to the Senate. You might consider it as well. And I suspect that you would find a vacuum that you could fill very quickly in terms of expertise. So I would hope that part of the fallout—that is perhaps not the correct word these days—part of the impact of these discussions is that you will arrive at the conclusion that you are as bright if not brighter than the people who have spoken to you and that you would consider politics yourself—except in Massachusetts, of course. [Laughter.]

Let me talk about the energy issue and the issue of the environment. And as I understand it, I can only speak for 15 minutes or so and then we have rebuttal, indignation, whatever, for 3 or 4 minutes. Four minutes, if it is rebuttal, 3 minutes if it is indignation. That's the rule.

The problem of the Congress, as you know from the President now that the blood has stopped flowing, is the energy issue. I think we have to look back and recognize that far more important than "irreplaceable" Arab oil is the ingredient of time. And time is something that we have lost. The answers to the energy crisis in 1979 obviously will cost more, both in terms of economics and in terms of the environment, than they would have in 1973. You can look back in the last 6 years when we first had the energy issue, you see an interesting example of political and human behavior.

This Nation made a great number of decisions—mostly nondecisions—about the energy issue. Although the cards were obviously on the table, Congress and the White House, both of them, were not prepared to make the decisions that were necessary. And why it happened cannot be explained by natural science or economics—the so-called dismal science—but by an unnatural science—political science.

It is nothing more than human behavior as reflected in institutions. Congress decided that if they took an offensive on the energy issue, it would offend too many people. Since the Congress has a 2-year perspective and the Senate a 6-year perspective, there would seem to be no long-term interest in, if you will, assuming the role of "Chicken Little."

I think officeholders underestimate the public's capacity to withstand bad news. One of the problems we have around here is that many Members don't believe that there is indeed life after Congress and are

not prepared to take unpopular stands that may result in a kind of nonexistence.

So 6 years have gone by and there isn't a great deal that you have done because you have not got the support from Washington. So what I want to talk about today is economic analysis as it has been used, unused, and abused in the policymaking decisions relative to energy and the environment.

Let me start off with the mood in the Congress. As you know, we are the so-called Oversight Congress, which is a euphemism for the Do Nothing Congress. We are not supposed to initiate anything; we are supposed to make sure that everything runs well.

Budget balancing has been the big issue, as domestic energy supply versus demand slipped further out of balance. Then the Shah of Iran came apart and the Saudis decided they were not as enthralled by the U.S. support as they had been in the past, and you had a most unusual psychological phenomenon, waiting in gas lines and pondering the question who is to blame. The question went from "Is there an energy crisis?" to the question "What are we going to do?"

Here we are, the most sophisticated society ever to inhabit the earth, arguing for 6 years about a finite resource as to whether there was indeed an energy crisis. And finally people sat in gas lines—including my wife and myself—for an hour and a half and decided it was time to do something. The thin-skinned Congress broke out in a rash of proposals which we have been dealing with.

The most recent is, of course, synthetic fuels, so-called synfuels. "Synfuel fever" is spreading like wildfire both in the Senate and the House.

Last month the House passed a bill permitting the Congress to buy half a million barrels of synthetic fuels a day by 1985 and 2 million a day by 1990. I can assure you that the Senate is not going to be lagging behind on this, and we have a bill that would authorize \$5 million to build 15 synthetic fuel demonstration plants.

The President has talked about an \$88 billion Energy Security Corporation. Remember that when Vice President Rockefeller proposed this a couple of years ago, everybody laughed. Well Rockefeller has come back to the White House in a strange way, and we now have this big-buck, big-system approach to energy. We must talk about the impact on the environment.

The advantage of the synfuels euphoria, or the advantage of synfuels that leads to the euphoria, is that it promises a continuation of our lifestyle. If God is insistent that we run out of crude, then let's make synthetic fuels and we will just keep on going; we won't have to interrupt our lifestyle, we won't have to look at difficult changes in the way we live. I have always supported the rapid R. & D. of synthetic fuels. And I think clearly there is a lot to be said about developing that technology.

The problem, however, is that the risks are not being considered adequately either by the President or by the Congress. And let's go through a few of them.

Air pollution: How in the world can you burn those quantities of synthetic fuels and not have to start thinking about particulates and sulfur dioxide and nitrous oxides, hydrocarbons and other pollutants.

When it is burned, it doesn't go away. It remains within the biosphere. But that is something that no one is discussing.

The so-called greenhouse effect: There are many people who believe if you continue to burn hydrocarbons and we have more carbon dioxide that you create a "greenhouse effect"—which is all right in the winter in New England, but when the Wheat Belt moves up to Canada, we have got serious problems with the Congressmen from that part of the country. Of course, by then it is too late. It is too late to talk about—too bad, you lost because of the greenhouse.

You also have water pollution and supply. Synthetic fuels demand a vast amount of water, much of which is already committed to farming and other uses. The oil shale technology is particularly subject to water pollution.

Solid waste: All plants would create large amounts of solid wastes, containing many toxic substances and carcinogens.

Other costs: These include the disruption of land from strip mining, and the social problems of energy boomtowns.

Well, how do you put into the equation the environmental risks that are involved? That comes down to a question of how you cost out environmental quality. It is very difficult, as you know, to quantify, because bad consequences cannot be totally anticipated, as we heard in the discussion earlier. They can take decades to develop. So obviously, if you are a consumer today, you are not going to make a habit of worrying about getting cancer 30 years from now.

So we end up hearing—especially from the conservatives—the costs of regulation. I would submit there are also costs of nonregulation. Let me give you a couple of examples:

Kepon. A word never heard of until a couple of years ago. The Life Science Co., as you know, allowed it to pollute the James River in Virginia. It cost an estimated \$8 billion to clean up that particular project. It would have cost that company \$200,000 in pollution control equipment initially to protect the 70 people who suffered various combinations of brain damage, kidney damage, and sterility.

When you talk about balanced budget, you talk about cutting costs, the chances of your being one of those 70 people is very small, so you opt out for it, figuring it will happen to somebody else.

I happened to grow up in a city called Lowell, and right next to the neighborhood I grew up in are the Sileresin sites you may have heard about. Sileresin was a company into the recycling of chemicals except they went under and the chemicals didn't. The chemicals stayed on the surface and there was all kinds of damage to that area. If you look at any aerial map of that site, it is something like 300 yards from where I grew up. It is something that I find not to be just an academic issue. It obviously is something that is important to the people who live in that area.

The Clean Air Act of 1977 is another example where a problem of quantifying issues like quality of life is very difficult. With the demand for a balanced budget, why inflict regulations on companies simply for something like clean air? I don't think the Clean Air Act will ever be seriously downgraded in Washington because we voted for that in the summer. I run in the morning. I have to read the Post and see what the air quality index is before I decide to go out and run.

As Members of Congress hack their way through their pollution to vote for clean air, I suspect we are safe at least for the short term. When economists look at environmental risks in various technologies, it seems to me there is only one possible conclusion, that the "answer" to the energy issue is conservation. It is simply the nonuse of the finite resource. Now, the problem with conservation is it sounds "rinky-dink." That's what is written here in my speech, which is not a bad term. It sounds quaint. It sounds as if there were a bunch of basket weavers sitting around devising energy policy.

Now there are three reasons why the benefits of conservation are underutilized and the risks are not appreciated. First of all, it is diffuse. You know, we are really into the Apollo-type program, a massive coming together of resources to do one big, dramatic thing. That's part of the American way. Conservation is just the opposite. It is everybody doing a little thing that is not dramatic. It lacks any kind of thing that I would write to your sister about.

The second reason is that conservation explicitly means a change in lifestyle. It's very much like the argument that you can take a man's wife but don't take his car. We are into a certain lifestyle in this country, and conservation suggests that it is going to change, that you cannot get into your car on the weekend and drive 500 miles to see what the coast looks like and then drive back. You cannot have, as you see on television, insurance where this couple talks about how fantastic whatever the company is that has single coverage for their motorboat, their car, their camper, their skimobile, and their motorcycle. I think it is a major step forward that we have one company that gives us the insurance coverage on these five sources of pleasure. Well, I'm not opposed to the production of this machinery—I just don't want them to be used, I think. [Laughter.]

There was once the argument on the House floor that we could not mandate the efficient use of energy in automobiles since Detroit would go under. One out of six people employed in the United States is employed in the auto industry, and so we could pass a law mandating that you buy a car from Detroit every 4 years, put it in the garage and buy a more efficient foreign import. We would have the best of both worlds, a viable industry in Detroit and finally conservation of our finite resources.

The third reason is that there is no conservation industry. How often do Members of Congress get lobbied by the neighborhood insulation installing company. The guy probably doesn't contribute more than \$25 to anybody's campaign. Whereas when you have the oil lobby, now there's power. I mean, how can you expect a neighborhood insulation dealer to take on Exxon? He can't. And so the system keeps on going. So the basket weavers are in the throes of frustration and being accused of not knowing what they are talking about. Then all of a sudden Harvard Business School comes along—which is hardly a basket weaver as you know. The school's energy project sends experts into the automobile and oil corporations. They come out with a study called "Energy Future," which I would commend to all of you, and which says what we have been saying for a long time: The only way out is conservation and renewable sources of energy; we ought to treat the finite resources as precious and maximize conservation and maximize renewables and only then go into the finite resources and nuclear.

So now we have an ally which fortunately comes from my State. And so it is not a few of us ranting and raving but a distinguished business school at an outstanding university that has arrived at the same conclusion. And more and more people in the Senate Energy Committee feel exactly the same way. It is no longer one or two people. It is a majority.

Let's talk about how we analyze risks and benefits and use Detroit as an example of the laissez-faire system. Consider the automobile. Detroit is indeed the dinosaur of the laissez-faire economy. Industry's indifference to health and safety and fuel efficiency has guaranteed Federal intervention, and major advances in car technology. The fact is that without Washington and in this case Ralph Nader, the danger of death inside the automobile would have remained very high. Seat belts. Remember the fight on seat belts? They were imposing something on the consumer, like life, which opponents did not want to do. Consider auto emissions. Remember when they swarmed over Capitol Hill? It was very effective. The unions took care of the Democrats and the corporate executives took care of the Republicans, and the pinch we were in was very effective.

Well, Congress had enough sense to go to reasonable emission standards. Now the issue is fuel efficiency. You go back to Detroit where they make the money. They make their money on larger cars; they don't make their money on small cars. You know, the Volkswagen came a couple of decades ago. And what happened eventually was the high muckymucks in Detroit would look out at the parking lot and their employees would come in in Toyotas and Volkswagens and they knew something was wrong. They talked about fuel efficiency.

Well, if you look at what the Japanese have done, the Germans—especially the Japanese with their very central planned economy—they have done much more than we have. My staff—which is under pressure from me to buy American—a majority of their cars, all fuel-efficient, are foreign-made. In fact, I once sold a foreign car when I came to Congress in favor of an American car so I would not be embarrassed. And at that time most of the Members of Congress were driving Volkswagens, so I don't know what I gained by that display of "Buy American."

Anyway, the American automobile manufacturers—sensing they were losing the market to foreigners—came to Congress and tried to get Congress to bring the fuel efficiency standards for the future down—not up, but down—and Brock Adams, you remember him [Laughter] was right in resisting that pressure. And so what we have done in essence is foist on Detroit the mandate not to build better gizmos that open the windows or better tail fins, but the remarkable thing called a fuel-efficient automobile.

We have had hearings here on the Senate side on the so-called Moody Mobile which you may have read about. This fellow showed up in overalls from Florida—he didn't have the tan or the \$300 suit of a Detroit executive. He came in overalls and his fingernails were dirty. But he had an 85-mile-per-gallon automobile. He had no success in dealing with Detroit except during the hearings he got a call from Detroit and we stopped the hearing so he could go have a conversation

with Ford who was interested in finding out what this contraption was all about. The Moody Mobile is nothing more than the same kind of thing as a Perkins diesel turbocharger. It drives like a lawnmower, I drove it, and it's not comfortable, but that can be worked out. It was on a Pontiac Capri and not uncomfortable. Not obviously 85 miles a gallon, but something like 60, 65 was acceptable in the automobile.

Yet you have advertisements on the radio station both here and in Massachusetts where they advertise Cadillac. A Cadillac is now 46 percent—or what ever it is—more fuel efficient than it was back in 1973. Of course in the end you are getting 10 miles a gallon but at least you have the comfort of knowing it is more fuel efficient than it was a few years ago.

In 1957, the average miles per gallon of an automobile was 14, and it was 14 miles per gallon in 1967. It dipped after 1957, and then came back. But what is interesting is that Detroit in a pure laissez-faire system decided that the risks of investing in fuel efficiency were too great, that America was into luxury, America was into lifestyle, America was into consumption. That is what they did. They took the best minds out of MIT, the best minds out of our technical schools, some of the people in this room, as you may know, and sat them down not to develop a fuel-efficient car like the Japanese and Germans were doing, but the do-dads.

It's remarkable that so few people sit in a gas line and contemplate the fact that their car gets 12 miles per gallon.

We had people come before the Energy Committee demanding an energy solution on distillates. Four people testified, and I asked them what kind of car they drove. One drove a pickup. He got 7 miles per gallon. One refused to tell me but said it was a middle-sized car. And the next one drove a Cadillac and the fourth one drove a Lincoln. Now you tell me how it is possible someone can be outraged by an energy crisis and feel not the least bit embarrassed to drive a Lincoln Continental that gets 11 miles per gallon. How can they decide for a forum where the risks of that kind of comfort are no longer worth it. And I suggest the time has finally arrived.

It is interesting because Detroit now for the first time has a real chance of developing the so-called world car—a fuel-efficient, durable car that for the first time can be sold around the world.

When you mandate fuel efficiency out of Washington, thunder rolls in. And as you know, they came before us to try to remove it. But how do you suggest that this country whose national security is jeopardized by our importation of foreign crude can continue to manufacture fuel-inefficient cars?

Jim Martin and I served on the energy committee together on the House side. I had an amendment to ban the manufacture of fuel-inefficient cars. That was objected to by a Congressman from Detroit, Mich., obviously. And it was ruled "nongermane" to the Energy Act because that is where the politics were in that situation.

It seems to me at some point we have to recognize—and I think the point is finally here—that this country is in serious trouble. I mean very serious trouble. And there is a serious question of the survival of our society.

Realize, if you knocked off—there was a discussion on the news this morning—the Straits of Formosa where 70 percent of Japan's crude,

20 percent of ours and 70 percent of Western Europe's flows out of the Persian Gulf, the entire Western world would virtually come to a halt. We don't think of that. We want to have our comfort.

The last thing I would say is that this country is going to have to make some changes, and it is going to have to make some sacrifices. Whether we choose them or they come upon us is the only issue.

I understand from my father, who just returned from a visit to Greece, that the government there recently ordered that citizens can drive their cars on alternate Sundays only. (The ban is from 5 p.m. Saturday to 6 a.m. Monday.) Imagine trying that in these United States and survive the next election, which is the other question.

Finally, I would simply say that if it is the divine mandate that this country is not to evolve, is not to look at its Earth and understand it and live in peace with it, that's all right. We are all adults and we make these decisions and we are free to suffer the consequences of them. But it seems to me that we have a responsibility to our children.

What I have asked audiences to do is to listen to me or the other side, think about it and go home and look at your kids. If you can look at your children and justify buying an LTD, I will bow to you. I think that is where it's at. I have two kids, 2 and 5, and I am not sure we are going to leave anything but chaos to them.

When we talk about the environment and the carcinogens spewing into the atmosphere or the depletion of the finite energy resources, I think we have an incredible obligation for the first time in American history. The responsibility of our generation to the next generation is pronounced. What we want—which is the continuation of lifestyle—and what we want for our children are in conflict. One of the reasons I do not support this President, although I haven't made up my mind for 1980, is that I don't think he understands that. I don't think this country does.

The tragedy is that the people who understand it the best are the people in this audience who by definition are the least political. And that is very unfortunate. [Applause.]

Dr. RATCHFORD. Senator Tsongas, by chance we happen to have one of the best minds at MIT on our panel and I would like to ask Professor Ashford to lead off with the first question.

Dr. ASHFORD. I am not sure I have any since I have a great deal of empathy for what Senator Tsongas says. I would like to pick up on one thing which might instill a word of optimism in what has to be necessarily a very difficult picture.

We were asked in this symposium how society should assess or choose wisely the essential risk benefit tradeoffs and what do such choices mean for science and technology. How strong a signal we give the planners of industrial production in this country will determine what kind of changes we make. Regulation is not about saccharin and benzene and asbestos; regulation is about changing the nature of industrial production in this country. Whether it is the automobile, consumer chemicals, food additives or what-have-you. Unless we give a signal which says you've got to change the nature of industrial production, including the energy use, we are not going to be able to say two decades from now as Senator Tsongas says, we thought about our kids.

You know, take the issue about nitrites about which there is a seemingly possible scenario that Dr. Greenhouse talked about. But there is an alternative, and that is to change the nature of food production. That is, you don't have to transport bacon from California to Rhode Island. We are ingenious enough to develop new technological approaches.

However, it might mean dispersing the profits from those industrial production systems a little bit differently.

Mr. TSONGAS. I never rebut MIT. That is a rule in my State.

Dr. RATCHFORD. The Senator also mentioned the greenhouse effect. We happen to have a person with that name on our panel today.

Dr. GREENHOUSE. I really don't have any questions, which means I do have a question, directly on the subject, but I don't want to leave that class that the Senator originally designated as offensive, so I would want to ask one question, which is really outside of my field as an expert, but certainly informed in terms of reading the paper, congressional reports, and so on.

When a Senator arrives at a decision that conservation is the way to go, was he rational in arriving at this decision by using some kind of risk/benefit analysis of conservation vis-a-vis increased production? And it is immaterial what that increased production is whether it is synthetic fuels or oil in the ground, but that "production" which is the alternative to this conservation. Or is this an intuitive, qualitative way in which he arrived at his decision?

Mr. TSONGAS. Well, what I have done both in the House and now in the Senate is when you represent a state like Massachusetts, you have enormous resources available to you. On the issue of energy and the issue, for example, of the SALT Treaty, the issue of health care, African policy, I set up advisory committees. Basically what I do is I take the best minds I can on different sides of the issue, put them in one room, turn off the air conditioning and let them go at each other. I sit back and listen.

I find it very difficult to make decisions based on the one person's analysis because I am not educated enough in the sciences to be able to understand what I am being told. So I put them both in the same room at the same time, and we go on for hours. I finally arrive at a position where I am comfortable with what I believe in.

Now, on the very complex issue, for example, the SALT Treaty, it has been very valuable. Also the energy advisory committee did all the work for me on the energy amendments that I have introduced. All of them passed, so that is the process that I for one use.

Does that answer your question?

If I can give just an addendum, the discussion did include observation vis-a-vis the alternatives of increased production, what kind of reserves are possible, what kind of transition time is needed to get into conservation, fusion, second-generation coal technology, those kinds of things.

Dr. GREENHOUSE. OK.

Dr. RATCHFORD. Dr. Sarett.

Dr. SARETT. I certainly endorse the approach of using conservation to the maximum extent. I am a little confused, however, by an analysis of our total energy resources by the year 1990 at which time the forecast that I have seen predicts a 26-quad shortage even with maximal con-

servation in the United States and using all of the available sources of energy and extrapolating them insofar as one can.

Mr. TSONGAS. How many quads was that? Do you remember?

Dr. SARETT. Twenty-six quads.

Mr. TSONGAS. What was the total consumption in quads?

Dr. SARETT. The total consumption of quads, I can't remember the exact amount, but that represented a sizable proportion. It probably was of the order of 15 percent, I would guess. And we recognize, of course, that the OPEC oil embargo of 1973 produced only 1-quad deficit and introduced with it a tremendous amount of industrial confusion and distress. I just wondered, in other words, whether you foresee that conservation will really go all the way or whether we are going to have to tool up again with an expanded nuclear reactor program to fill this 26-quad gap.

Mr. TSONGAS. Well, as strong a conservationist as I am, I do not exclude a nuclear option. I think anyone who thinks you can has not looked at the figures. But we talk about energy consumption by the year—did you use 1990, 2000? Let's take 2000 where a number of institutions have done analyses. The Council of Environmental Quality predicts a possible consumption of 85 quads. The National Energy Act plan No. II, I believe, is something like 115 quads. So there you have two Government institutions arriving at consumptive patterns by the year 2000 that are off by 30 quads. So I think in terms of conservation and the alternative sources, the Harvard Business School study and the President's own policy review option paper suggest you can have 20 percent—we think 25—dependence on renewables by the year 2000. But that is simply a function of commitment. We have put something like \$200 billion into conventional nuclear sources of power.

So I do think the figures we would use on both consumption and alternative sources in terms of quads is a function of our will to see it happen.

If you look at the learning curve, for example, for technologies it is much more dramatic than we anticipated. Fusion is a centralized system, and I strongly support R. & D. in it and in other promising technologies.

But I do think that what we are going to see in the future is a much more human scale lifestyle which embraces conservation, mass transit, that kind of thing, and which I think we will find easier to live with.

Those of you who are from New England look back with nostalgic on the very human-scale weekend of the blizzard. If you drive a car down that same street now, it is very impersonal.

I do think if you look at man as evolved from animal and the explosion that technology has brought to him, I think there is a limit to how much future shock can be absorbed.

Dr. SCHNEIDERMAN. One or two very short comments. I share with you the concern that my fellow scientists do rarely engage in the political process. My fellow scientists really seem to be afraid of the political process, don't want to get involved in it. I, for example, am delighted that Dr. Martin has become Congressman Martin. We may disagree, but by gosh, we talk to each other. And we do, in language that each of us understands.

I think there really is a problem on science, between scientists and politics, and I think it is that most people in politics are very strongly language oriented. They are people who deal with language, who work

with language, who understand language: lawyers and people of that sort. Scientists are much more "thing" oriented. Especially those who work in a laboratory or those of us who are mathematically oriented are sort of abstract thing oriented and I think there is a real difficulty because of this dichotomy in the way we think for us to get together.

I do hope that there will be more scientists in the Congress. I do hope there will be more involvement, more exchange between us.

One of the things the Cancer Institute would like me to do is spend more time with people like you, hearing what you have to say, bringing it back to us and saying to my fellow scientists, "You know, there is concern about thus and so that you are doing. You guys talk to each other and you do very well in talking about immunology and molecular biology and so on, but you are not hearing what a lot of people in this country are saying. Certainly support of science in this country is very much a political process."

The money that the Institutes of Health and National Bureau of Standards get derives through a political process. A lot of scientists are not aware of that. So I very much share your concern, and I hope there will be ways to get my fellow scientists, our fellow scientists, involved.

Mr. TSONGAS. Let me just comment if I may.

I think the potential is enormous because the party system has broken down, yours and mine, in terms of capacity of the functionary to rise up through the system. People entering Congress now are much more issue oriented, much more pragmatic, much more free thinking. I think that kind of atmosphere lends itself to the kinds of scientific, if you will, approaches that you people represent. I wish you would send us a few liberal scientists though. [Laughter.]

Dr. SCHNEIDERMAN. Perhaps we will try.

Dr. RATCHFORD. We have another exception to the rule about scientists and politics on the podium this afternoon. Congressman, or Dr. Ritter, do you have a comment?

Mr. RITTER. This is indeed a unique situation because right at this moment two-thirds of those of us presiding here at this podium have Ph. D's. I think before George Brown left we even had an undergraduate degree in physics here, which made three-quarters of the congressional group with technical degrees. So it is probably not going to happen again soon but it happened today. Of course, that shows you how statistics lie. Because when you come right down to it, we are the only ones in the entire House of Representatives plus Mike McCormack—4 out of 435.

The distinguished Senator Tsongas' remarks about the performance of the scientific community actually getting involved in politics are dismal, but there is hope—

Mr. TSONGAS. Let me say just to clear the record, I was a chemistry major for 2 years at Dartmouth. [Laughter.]

Mr. RITTER. Like so many who took the legal route, he couldn't stand taking those science courses so he moved along.

Dr. SCHNEIDERMAN. I do have a question too in addition to this arguing back to scientists, or a suggestion that there should be more of us in the Congress.

Concerning the conservation idea, part of the problem in addition to the fact that as you remarked it is kind of rinky-dink, is how do we reinforce conservation activities positively? How do we create positive reinforcement? Why should I get involved, in conservation aside from my patriotism and things of that sort? I have been driving my automobile much less than ever before. I took two buses to get down here today instead of driving in my fairly large automobile. I believe in conservation. But that is not going to make it any easier for me to get gasoline on Friday when I probably will have pretty nearly run dry in contrast to those people who have driven a great deal. How are you going to help all the rest of the people like me who would like to put in storm windows which might cost \$4,000 in my too large house?

Mr. TSONGAS. You sound like a national menace with your life-style. [Laughter.]

I too have a large house in Massachusetts, so I cannot complain. I think there is a limit to volunteerism. People do not volunteer for discomfort. Two things will happen. One is the Government should bring the conservation technologies to the front. For example, if you are going to build a home, in New England or anywhere in the country, why not use passive solar? It is a simple design. And bringing them to the marketplace can use Government assistance.

Second, people choose out of self-interest. If you can make it in your economic interest to move in a particular direction, be it through tax credits or whatever, you are going to do a heck of a lot more than bringing in Joan Baez to sing songs about conservation. A new ethic will be developed where consumption will be frowned upon, but you also have to make it in your own self-interest to move in that direction.

How can you get a person in Massachusetts to leave his car at home and take a train if there is no train, or if the train has cracked glass and has been vandalized and so forth. I do think there are a lot of things we can do.

Dr. SCHNEIDERMAN. By the way, my house has passive solar.

Mr. RITTER. I might add my house has passive solar. It is on a south-facing hillside. There are these things we can do as individuals. They often reflect the marketplace of energy and the price of energy.

I would like to get back to the tack of risk and the risk associated with some of our alternatives. On the one hand, the Senator from Massachusetts mentioned Amory Lovins. On the other hand he mentioned fusion. There is an enormous difference in just the basic economic structure that is required for one or for the other. I guess what I would like to say is that many people and many institutions and many corporate entities and many States would go in a variety of directions. The biggest risk of all is trying to pick out one road toward this kind of reasonable self-sufficiency and reasonable independence. All of these actions will be prominent in our energy future. The conservation action will be most prominent or it will be very prominent but it will not be the only alternative. To make our system work we need energy productivity. You cannot melt a steel ingot with "soft energy." You cannot build a Mack truck with "soft energy."

Go into these plants. The machines are whirring, they are stirring, there is no doubt that the energy productivity of our society has contributed to the ability for many, many jobs to be created. The risk of cutting out energy productivity is a deep economic risk. The risk of cutting down the productivity of this country, of reducing the levels of productivity is a deep economic risk.

Now, I know the study says that theoretically we don't have to lose productivity in this country and we can make a productive society with less energy. Frankly, I don't believe it. I believe it is theoretically possible but we already have so many built-in institutional forces that opt against increased productivity that one of the positive sides, one of the positive gains from productivity has been increases in energy productivity. People said to me well, you know, if you go solar you have got all these jobs, all these sheet metal workers out on houses building on the rooftop there. They will be falling off that rooftop and having essentially the same accident rate as the construction industry. I would assume that would be true.

In the meantime, where is the energy produced from those rooftop systems that allows us to build the mass transit or allow us to provide the steel for the mass transit, or to provide the mineral resources for the cars, to provide the capital-intensive activity that switching from big gas guzzlers to small cars entails?

Conservation needs to be optimized, but conservation in itself can be very energy-intensive. I will describe how if you want to refurbish a truck production plant, or, for example, a steel mill or a chemical plant that is making chemicals, there is an enormous amount of machinery, equipment, and I guess you could put it into one large category called capital investment that is going to be needed. It takes a lot of energy. It takes a lot of energy productivity to make these new engines and to sort of try and phase out the old ones as soon as humanly possible.

The environment question has—in protecting the environment there are substantial risks. For example, you take a truck engine that used to get 500,000 miles, and because of a variety of air quality standards—we will not debate the health effects of those air quality standards, but you could debate the health effect of those air quality standards—that truck engine now gets 250,000 miles.

Now, they have made ostensibly on the surface on one part of the full industrial cycle a contribution to clean air. But the fact that you need now two engines to provide the same amount of service means that the production of that second engine, steel, the other metals, the various chemicals, the various industrial processes and plants that are active, is now doubling the original pollution and environmental degradation, dumping of chemicals and what-have-you, of that first engine.

So these are fuel cycle activities and those of you who are thinking about environmental quality and about conservation try to fill up your matrix. It is complex, it is not just a superficial end product saving or end product pollutant saving. One has to consider the fuel cycle of the production.

Senator TSONGAS. Let me respond to some of those points. One is the falling off the ladder on the solar installers. The Federal Government makes no payments for solar lung disease as it does black lung disease.

Mr. RITTER. The safety of the individual is still at stake.

Mr. TSONGAS. Oh, no one would argue that. If I had my choice of lifestyle, I would rather install solar equipment than go into a deep mine.

The other point—remember one of the dogmas used to be that a 1-percent increase in GNP would require 1-percent increase in energy consumption. That was a given. Well, that has been disproved. I don't think anyone seriously argues that that is still the case. The idea that consumption equals production equals a thriving economy is in question.

Mr. RITTER. Would the gentleman yield just for a moment. To differentiate between productivity and production, I think, is also important because productivity defines how much output an individual can provide.

Mr. TSONGAS. Let me get into that because if you look at what has happened since the Arab embargo, the serious conservation that has taken place, the deficiency in production has not come out of the transportation field nor the residential field; it has come out of the industrial field. And so the capital reinvestment in equipment has turned out to be good in terms of conservation, and good also in terms of productivity per unit of energy consumed.

Second, in terms of the issue of the need for the fossil fuels which I am not in opposition to, that is certainly part of it. I don't think anybody would argue differently. But what was spoken of in terms of the interruption of productivity, what happened during the coal strike? What happened during the natural gas shortage? What happens if the Straits of Formosa are suddenly cut off? There is no energy to be consumed. Productivity as you know takes a rapid nosedive.

The instance of the truck engine, I think, is a good one except, I remember, this is another rinky-dink case. I introduced an amendment to the Energy Act. It was one of the things that came out of that energy advisory committee—a minor amendment that dealt with bicycles. All I was saying was that if you are going to build a highway, at least provide a bike path, because in urban areas where you people and other people are moving into the city, a significant number would actually commute to work using bicycles. It was no big deal. Obviously the Department of Transportation could do a study to decide whether that was worth pursuing. It became a major issue of contention in the ad hoc energy committee. It was the only issue that divided the Republicans right down the middle and the Democrats right down the middle. Generally the old ones said it was ridiculous and the other ones—some of whom actually rode bicycles—said it was worth looking into. It went to the floor. The Energy Act has three titles. One I believe was the tax title, the second was the production title, and the third one was the bicycle—title 3. And it generated a great deal of bitter debate on the House floor and I could not seriously believe I was making an amendment for a bicycle study.

One argument was if indeed people turn seriously to bicycles as the method of commuting, what would that do to the auto industry. And a Congressman said what would it do to our GNP, and I said well there probably would be some dropoff in people in cardiac arrest incidents and that sort of thing, but I didn't think it would have any serious

impact. The idea was that somehow you would not have people bicycling as they do in every other country in the world because of the impact on the gross national product. By the way, we won that amendment by the skin of our teeth.

Can I make one final point in terms of the policy? I am not imploring you necessarily to run, although I think that would be a good idea, but to meet with and to lobby your Member of Congress. It is one thing for a Member of Congress to vote for something that is wrong because of the politics and reelection. It is another thing if you people go in to him and say look, these are the facts, and if you vote against it at least we want you to know what you are voting on and to seriously understand the implications of what you are voting on. If you turn your back on reality, you go ahead and do it, but we know that you have done that. You know, meeting with a Member of Congress is not a health hazard as far as I know, and can probably be done without any kind of social stigma, I would think.

Once you develop that relationship, a Member of Congress knows that people are watching how he or she votes on very technical issues, and you can have enormous impact because on most issues we don't get much mail and we are like weather vanes. If all the pressure is coming one way, even if it is irrational we tend to go that way. If there are serious rational scientists who are willing to sit down and spend the time, you can provide the pressure the other way. You may indeed pursue scientific inquiry into the decisionmaking process. I think it would be healthy.

The scientists that I use up in Massachusetts take their Sunday mornings and spend 4 hours with me. It works and I think I am more responsive and less skittish perhaps than I might be, and I would entreat you to consider the same possibility.

Dr. RATCHFORD. Senator Tsongas has invited you to communicate with Members of Congress. We have three Members of Congress sitting here and they would be pleased—I am sure any of them would be pleased—to receive questions from you. I would ask that when you ask your question, please stand and for the record give your name and institution; then speak loudly so the recipient of your question as well as the others in the room can hear.

Are there questions from participants?

Ms. BEALL. Paula Beall, Baylor College Medicine, Houston.

I too am concerned about changing my lifestyle just as an American, not necessarily as a scientist. But I find that every time that is mentioned it is assumed that we are going to have a worse style of living, that we won't have air-conditioning, that we won't have enough to eat, and we won't be able to do freedom things. Why don't you turn loose the imagination and innovation of groups of people like this all over the country into selling a change of lifestyle as being better, more fun, more freedom. For example, public transportation will actually give the average American more freedom of movement and ability to move around the country.

I am just suggesting that you instigate some kind of program to draw on the imagination of the educated scientific people, the social science people to sell a change in lifestyle as being better rather than worse.

Mr. TSONGAS. I could not agree with you more. I gave a number of commencement speeches recently. It is fascinating to talk to young people about lifestyle changes. It is a high. I think the parents need to understand that it is their lifetime we are talking about. You are quite correct, I think lifestyles indeed can be positive.

We are a presidential system. You can have 40 or 45 scientists and a hundred swimming majors in the House and the Senate and, you know, it will make a difference. But in the last analysis it is the President who moves public opinion. I do think there is a lot to be said for an involvement in the system—whatever your candidate might happen to be. I can get up and speak at a Northeastern University commencement and get to several thousand people; the President gets on television and has 60 million people who are open to this kind of discussion. But I do think that it is important to have a grass roots. It is not just something that is being said in Washington, but something a neighbor or somebody respected in your community is saying as well. I am very encouraged.

I have been involved with this issue for 4½ years and this is the first time I see an energy constituency, the first time in all the time I have been involved with this issue. I think the people are finally ready. I think the gas lines of last month plus a lot of other things have finally coalesced to the mass of people who understand that survival is what we are talking about. I may be wrong.

Dr. RATCHFORD. Question in the back.

Ms. CLARK. Mary E. Clark with San Diego State University.

First I would like to ask Congressman Ritter if he doesn't think that nuclear power plants themselves are energy-intensive in construction. That is a very short question, and perhaps rhetorical.

The other question is perhaps to the Congressman—Senators and the Representatives both. And that is we have been talking about changing lifestyles and I think indeed both what Congressman Martin had to say about food has to do with our lifestyle just as much as perhaps our changes in our energy behavior have to do with it. In other words, we don't have to have a sugar-intensive diet, that kind of a diet. So this is another lifestyle change that obviously is something that a great many of our changes in how much stuff we put into foods anyway is determined by our predilections which are a lifestyle matter, not by nutritional requirements. So what I would suggest is that if we are going to have a lifestyle change, first of all what do Congressmen want from scientists in order to help bring this about; and second, don't you think that we all, both of us, as politicians and scientists ought to be thinking not in terms of the ultimate goal but in terms of short-term jumps where you get from point A to point A-prime before you can think about going to point B. Where you say all right, we have to cut on energy and the first thing we are going to do is to have something that creates a very small change but with a time scale involved. Subsequent to that as people get used to rationing or doing whatever they have to do in order to meet this, you begin to think of alternative things that then begin to tighten up the system so that people's minds are already attuned to the fact that there will be a new change coming along down the road.

Now, I realize that on a 2-year or even a 6-year congressional cycle this is very difficult. Some of us are tenured, and this makes it a lot easier. And I would suggest that maybe Congress can send out some things to university faculties that can help us to persuade the coming generation to support some of these long-term changes that could be made feasible provided that it was done in a sort of not—you know, tomorrow suddenly the rule is stop driving cars, walk everywhere. Most of us would all have—podiatrists would have a great time.

You know, these are not things that are done overnight and the educational process is a slow one. I think it has begun, I think it is very strong, I think it is growing fast.

There was a time 5 years ago when environmental magazines were only bought by Sierra Club members, and you know, this was it. It was the people who were converted, were thinking. Now it is spreading and these things are happening. But in order to speed up this educational process I think that it needs to be done between the educators, and feedback in the educational process of the general public, and do that all the time between scientists, educators and politicians. I think a step-wise program ought to be something that perhaps politicians could think about as a very practical matter.

Dr. RATCHFORD. Dr. Martin.

Mr. MARTIN. Did I understand you to propose tenure for members of Congress? [Laughter.]

Mr. TSONGAS. It sounds like the Politburo.

Mr. MARTIN. Both you, Mary, and Paula, mentioned lifestyle, and that is a very important factor in the cancer picture that my remarks were addressed to. It has been estimated that 60 to 70 percent of human cancer is attributable to lifestyle factor. Now, that includes excessive smoking of high-tar cigarettes, it includes excessive consumption of fat-rich diets, it includes excess alcohol, sunbathing, sex, a number of other things, all of which are lumped within lifestyle. And if you really want to address cancer risk, that is where you have got to do it.

You are just fooling people and creating an illusion of safety if you put your entire national effort to direct itself at saccharin and hair dryers and red dye No. 40 and so forth, because that is not going to change the total number of people who die today from cancer in this country. You waste enormous resources going after those when you do much better to educate the people about the serious risks that they choose to accept. Let me make better choices.

Mr. RITTER. The question was asked of me about energy intensive-ness in constructing a nuclear powerplant and I would like to answer that.

We really don't want to get too many facts in here to interfere with our day's work, but the fact is that the energy payback, the construction of a nuclear plant, is 1 year, and conservation has more like an 8 to 10-year pipeline and so does solar.

I also want to make a comment about lifestyle. I want to tell you, that lady mentioned sugar and sweets, and I just love my Haagen-Dazs chocolate chip ice cream and am not going to give it up for anybody.

Thank you.

Dr. RATCHFORD. Senator Tsongas.

Mr. TSONGAS. Well, I wonder what the energy payback of Three-Mile Island is going to be.

Mr. RITTER. I think that will depend upon the public policy that either brings Three-Mile Island back in an unemotional, rational period of time, or lets it hang out there debated till death do us part.

Mr. TSONGAS. Until death do us part? [Laughter.]

Mr. RITTER. That's what the man said.

Mr. TSONGAS. That is a probability.

Mr. RITTER. But the probability of that accident is still very low.

Mr. TSONGAS. Well, it reminds me of the discussion about unemployment rates. It is either zero or a hundred, depending on whether you are unemployed or not.

Mr. RITTER. We can go through this statistical game and after talking about three out of the four Congressmen up here with technical degrees, you can see how statistics just don't mean much.

Mr. TSONGAS. I think it is unfortunate, as I said, there are only four scientists in Congress. There are five Greeks, and there is no reason why the Greeks should be more.

Mr. RITTER. Being a lover of Greek food, anytime you want to get together for mousaka, just call on me.

Mr. TSONGAS. I have to go. I have an interview with the Boston Globe in my office at 4:45, and obviously I am not going to make it.

But the only thing I would suggest is that in the political process, obviously people have different views. I spend a lot of time with conservationists in Alaska and Minnesota—nothing to do with my State—and for me to end up saying you have to have nuclear power as a component is one hell of a big step. People have forced upon me the realities of what we are dealing with and what I find difficult in some respects to accept is the implication that there are any panaceas out there. This issue is tough enough dealing with it in a purely rational way.

The problem with the conservatives is the approach to production, that somehow you can produce your way out of a dilemma by using our finite resources. That is by reason absurd. Everybody is talking about oil production. And oil is a finite resource. And so we sat in the office one day and said people want production, let's give them production. Well, how do you produce oil? It is very simple. You take some dinosaurs, put them in a pit, cover them over, and in 2 million years you produce oil. I am going to introduce the first dinosaur oil production bill in history. We will domesticate dinosaurs, put them in a pit, cover them over, and in 2 million years our descendants will be pleased with the foresight by this U.S. Congress. And I would love to support that bill. Thank you very much.

[Applause.]

Mr. RITTER. I would like to make one comment on the distinguished Senator's passing remark on production. Seventeen percent of the electricity produced in this country is produced by oil. There is no real need to burn that black gold to heat water, to make steam to turn turbines to generate electricity to transmit over long lines into

your home to heat electric resistance elements. It's stupid. And yet as you feel the slowdown of the entry of nuclear power, the utilities are buying up more and more crude to burn to produce electricity. We have got to get rid of that about 550 million barrels a year worth of black gold inefficiently to produce electricity. This winter, I hope localized, you are going to see heating oil shortages. It is so much more efficient to burn heating oil directly in your home—four times the efficiency. It is so much more efficient to cut out some of these gas lines and use that crude to find transportation. It is not doomsday. We have made a lot of stupid decisions in this country over the last 15 years which we are paying for now and a lot of those decisions have come right out here from the U.S. Congress.

[Applause.]

Dr. RATCHFORD. I saw a hand up here toward the front a moment ago. Yes.

Mr. MOORE. William Moore. There have been several remarks about lifestyles. We all have excellent ideas about what other people should do to improve their lifestyles. But I want to suggest one way in which I have improved my lifestyle, and that is, I no longer use an automobile, and I no longer use mass transportation. I walk to work, and it is a great improvement because I walk 3 miles down through a beautiful park beside a flowing brook, through a zoo, from my home to the office every day, including this morning. And it is delightful, much better than the bus. There are no fumes, and it is excellent exercise. And I am a lot healthier because I do this. I recommend it as a way of improving your lifestyle and conserving fuel.

Mr. RITTER. That gentleman makes an excellent point. I had a lifestyle discussion with a bunch of middle-class friends not long ago. I asked this individual, who was talking about changing his lifestyle, a prominent attorney, mayor of a town, what kind of car do you drive? He mentioned a big gas-guzzling car, and I asked him, do you drive to work? He said yes, and I said, how far do you live from work, and he said, 8 blocks.

Changing your lifestyle is far more than rhetoric.

Dr. RATCHFORD. Are there other questions of lifestyle or risk/benefit analysis?

Mr. PRUITT. Ken Pruitt from Birmingham. There has been argued there is no such thing as the intrinsic American lifestyle, that Americans buy what they have been conditioned to buy. And if there is some truth in that, doesn't that suggest that conservation is really a marketing problem, and in the absence of some sort of intensive organized and effective marketing effort, it is not going to go?

Dr. GREENHOUSE. Exactly.

Dr. ASHFORD. Exactly.

Dr. RATCHFORD. I am sure the answer is, we need a lot of ads in science magazines to sell conservation.

Mr. MARTIN. Incidentally, there is a parallel to that and what my good buddy Schneiderman said before. How do you change the ethics? One way to do it is the same way Europeans have done it, and that is to stop artificially holding down the price. That may be unpopular, but the policy isn't working to actually achieve that right now. The price increase policies we have had, while some have not

produced any change in American lifestyle, I think given a little bit of leeway and the time to turn over automobiles and living conditions, are beginning to show an effect. The used car auction, for example, is a very sensitive mechanism to show what kind of choices people prefer, because if they don't want it, they don't bid as high. If they do want it, they will bid more. What it is showing is that prices of old energy-efficient cars are going up from month to month. The 1970 more efficient car has the price bid up month after month instead of depreciating. Very sensitive recognition that there is beginning to be such an effect.

Dr. RATCHFORD. Mr. Ashford.

Dr. ASHFORD. The word payoff and payback and kind of tete-a-tete about what the payback period is brings us back to cost/benefit and I have to tell you time is against you in the following way. The costs of installing preventive measures in solving some of these problems have to be imposed now. The benefits accrue far in the future with regard to reduction of chronic disease or what we leave to the next generation. I just want you to put yourself for a minute in the shoes of an insulation factory making asbestos. The owner has two choices. He installs a ventilation system today at today's prices, maintains it for as long as it needs to be maintained to provide safety, for as long as the capital exists, or he does nothing, waits 30 years for his workers to develop cancer, and pays workers' compensation. He can bury the worker in a gold coffin, send his kids to school and still be ahead, because of the time value of money that he has for 30 years. Now, if we don't find a way to calculate the payoff in a different mechanism than has been used using discount rates, then no regulations whose payoff is in the future and whose costs are incurred now can ever be justified on a cost/benefit ground at all. You have to realize that is a major problem no matter how you cut the mustard.

Dr. RATCHFORD. I see the head of high interest rates has raised itself. There is a question here in the center.

Mr. KELLOGG. Tom Kellogg from Mississippi State. I would simply like to emphasize that if we do get down to enforcing conservation in the marketplace by pricing the price of energy high enough that we conserve out of our pocketbook, the people who are going to pay the most are the people who are going to be least able to. We have got an awful lot of people in Mississippi and the southeast who are living on \$5,000, \$6,000 and \$7,000 a year income. Those people are going to be putting two-thirds of that income into gasoline and fuel oil while the rest of us are still going to be setting here on our \$30,000 and \$40,000 incomes driving around. That is not the way to do it.

Mr. MARTIN. I have to say in reply that very same problem would relate to the poorer people who live in Europe. Yet if you want to look at a society which has gotten more out of its energy consumption; that is, greater productivity per unit of energy or lower energy cost per unit of productivity, Europe has done it, because they have paid the real price for fuel whereas we have been conditioned to cheap fuel. Now, there is an answer for those folks and the President has proposed it. That is you fly around in an airplane and you dump money out of airplanes so that they can scoop it up.

Dr. RATCHFORD. Dr. Anna Harrison, Mount Holyoke College.

Dr. HARRISON. Thank you. Congressman Martin, you referred to rewriting the food and drug law. I am aware of the bill that you are introducing. If you could approach this not bothering about the practicalities of the politics of getting the bill through Congress, would you care to comment on your concept of what would be a part of a Food and Drug Act that is appropriate to the age in which we live?

Mr. MARTIN. Yes. The bill that I drafted was a particular response to the difficulty we have gotten into with the Delaney Clause.

Dr. HARRISON. That I understand.

Mr. MARTIN. This of course relates to the question Dr. Greenhouse asked earlier. I think the recommendation of the National Academy of Sciences would be a good place to start. They have recommended a general rewrite of the food safety laws which treats risks as risks, which treats natural foods the same way as artificial food additives, which treats the vested interests in natural foods the same way that it treats the vested interests in artificial chemicals that are added. Chemicals are chemicals as my distinguished colleague, the former president of the American Chemical Society, very well knows. So it would treat them the same. It could treat similar risks the same. It would provide that if there is a great risk associated with a substance, then regulations would be in order, including bans. If there was a very low risk associated, regardless of whether it was cancer or botulism or whatever, that if there were very low risk, then a ban would not be in order but relevant education would. And I think that was a very good starting point.

But it will take several years of hearings before the Congress will be in a position to draft such legislation, and as Mary asked earlier what do we expect to do, we expect you to speak up and define what kind of legislation. Meanwhile, if we have to do it just to save the interests of diabetics and people who have heart disease or hypertension, whatever, we will have to deal directly with the Delaney Clause as a stopgap measure. But even that debate helps sensitize the Congress to the general question that has been raised by the National Academy of Science.

Dr. RATCHFORD. Was there a question over here?

Ms. TRUBATCH. Just one comment.

Dr. RATCHFORD. Would you give your name, please?

Ms. TRUBATCH. Ms. Janett Trubatch.

Congressman Martin, when you say the problem in Europe was decontrol the price of gasoline and therefore everything was solved it is really not quite fair to compare that to the United States. All over Europe there is cheap public transportation and when the price of fuel goes up people can still get from place to place. In southern California there is no cheap public transportation and people must have gasoline to get around. I think when the country can come up with the first, then it can easily go into the latter.

Mr. MARTIN. I think you just reinforced my statement, though you didn't intend to. The point is why were Europeans willing to spend the money for public transportation? It may be cheap to the person who rides it. It was not cheap to build those systems. Why was the public conditioned to be ready to support that kind of expense? Because the alternative was very high gasoline prices. That is the very

simple reason they choose small automobiles to speed down their highways, because gasoline prices are much higher than here. The question is how do you reinforce the conservation ethic. You pay what the replacement value is.

Dr. RATCHFORD. I believe our panel members have comments?

Dr. Ashford?

Dr. ASHFORD. I think you better be careful to consider what might be very large adjustment problems. It is one thing to have an industrial system developed with high-priced energy so those alternatives get developed. It is another thing to say OK, let's convert ourselves into Europeans and raise the price of gasoline with no consideration for equity and the poorer part of the population. You have to consider adjustments which cause pains.

The problem with regulation today with regard to these risks issues is not really a long-term problem. Energy is a long-term problem, these risks are not a long-term problem. What people are screaming about is that they previously didn't have to include the costs of regulation in their corporate profit-and-loss statement, and now it causes adjustment pains and that is the problem.

Dr. SCHNEIDERMAN. I have a comment on several things that have gone on, people talked about. We are concerned—we have expressed a large concern about the environment, and enlarging on Congressman Martin's remarks, people have estimated that 70, perhaps 90, percent of cancer is related to the environment, and now some people recently have decided that that part of the environment which you have control over, some control over yourself, may constitute a major portion of that. I would like to suggest the environment really consists of three parts. It consists of a part that you can manipulate yourself directly, do something about. Some of that is cigarette smoking, sunbathing, sexual activities. Then there is a part of the environment that you can't manipulate yourself, over which you have little or no control. That is the air pollution, the water pollution, the stuff on the job, things that may be in food that you don't need. I didn't know that there was saccharin in my toothpaste. I really didn't need saccharin in my toothpaste to protect me against diabetes which I don't have.

So there are things of that sort. Finally, the third piece of the environment is essentially the internal environment over which you have no control. That is your genetic constitution. And none of these are really independent of each other. The first environment, the one over which you have some control, is also in large part controlled by the Government. In this country we raise wheat in a certain way and we have subsidies for this. High-fat-containing beef is labeled "prime" and commands the highest price. And some people think high-fat beef may be leading to some forms of cancer. A modification of the Government policy in terms of farm prices or subsidies or things of that sort would modify that environment over which it appears that I have complete control, over which I really don't have very much control. Similarly, and it is a difficult thing to say to a man from North Carolina, but taxation policies with relation to tobacco might modify whether the teenagers who may have a fair amount of lawnmowing money available will go out and buy cigarettes. If we are going to have price rationing, high taxes on cigarettes would give us price

rationing for the most susceptible group, the teenagers, the people who are starting to smoke. In that sense price rationing through high taxes would probably be the most effective thing in reducing the 300,000 or so deaths a year that may relate to cigarette smoking.

Finally, there are other aspects of things over which I have voluntary control; I was once a blue-eyed blond. Going out in the Sun may have very different effects on me than it would have had on Paul Tsongas, who had brown eyes, dark hair, dark skin. I would very likely develop some skin cancers; he very likely would not. So even those things over which you appear to have specific control, you may or may not. I don't know how much of cancer is related to each separate piece of the environment. I know that these things interact with each other enormously. If only 40 percent of cancer is related to things over which I don't have any control, that's 40 percent of 400,000 deaths each year, that is a lot. So I think we ought not neglect any of these things. I think we have got to pay attention to all of them. I think we have got to devote our energies to all of them. I think to suggest that all the energies are devoted in one direction and not in the other is really inappropriate; the energies are not directed all in one direction. There are people who are concerned with cigarette smoking; they may lose their jobs if they are Cabinet members. But there are other people who are concerned with trying to do something about exposure to sunlight. Not much is being done to reduce sexual activity in this country, but I won't get into that issue at all.

Dr. RATCHFORD. We have time for two more questions. There was one here at the front a moment ago.

Mr. BEYREIS. Just a comment, really. I am Jim Beyreis, an executive from Underwriters Laboratories spending a year at the National Bureau of Standards. I just wanted to comment that it occurs to me that we have had 25 years of congressional or Presidential or governmental of one sort or another acts and mandates on energy which in the long run basically or over that whole period has fundamentally done two things: one, keep up supply; and two, to keep down price. The observation that I make and it has to do with some of the other comments that were being made here has to do with a house that I bought about 8 years ago that was built about 20 years ago in Chicago that had not one stitch of insulation in the sidewalls for the simple reason that at the point in time that that house was built, there was no way you could ever economically justify in the lifetime of that house putting in insulation. And yet at that point of time, 20 years ago, the economics were such that there was cheap energy available, artificially cheap, and just think what we would have today had we started then thinking a bit more seriously about the issue.

Dr. RATCHFORD. Yes.

Mr. RHOADES. This question may be inappropriate, but I am going to ask it anyway since it is the last one. It seems that all afternoon here we have been pretty much talking about human behavior or the social sciences, and it has puzzled me for quite some time since that seems to be as much a problem as the material technology aspects—social technology. The question is, why did the House pass the Ashbrook amendment to the NSF bill which pretty well, if it does go through, would gut the social science basic research program at NSF?

Dr. RATCHFORD. First of all, a response might bring the questioner and the others in the audience up to date as to what actually happened. I believe the Senate has now approved the final NSF authorization, and I believe the Ashbrook amendment was removed from the final product.

Mr. MARTIN. That will have to go to conference before it comes back.

Dr. RATCHFORD. I believe the conference report has been cleared with the President.

Mr. MARTIN. It has, without the Ashbrook amendment.

Dr. RATCHFORD. Only a very small reduction was retained by the conferees. But perhaps since Dr. Ritter and Dr. Martin both participated—

Mr. MARTIN. I and McCormack and some others were involved in trying to offset the debate which carried that particular measure. On the House floor, we are not supposed to characterize our colleagues' motives for offering various legislation, but I think you can see that there is a feeling abroad about the country that arose over the funny-sounding research titles that the National Science Foundation was paid for. There have been news conferences, Senators presented with the Golden Fleece Award, and so forth, that have made up that response of the public as to why they should waste their money on these esoteric basis research questions that have such funny titles. A year and a half ago when a similar amendment was offered by my colleague, Mr. Ashbrook, it addressed itself at scientific research generally and we were able to defeat that one. I am pointing out the importance of basic research—I won't belabor the point, but at that point we were successful in persuading a number of our colleagues not to vote for that superficially appealing kind of amendment. This year we were caught by surprise, all prepared to defend basic research generally, those of us who are in the natural sciences, and Ashbrook caught us by surprise and limited his reference only to the humanities. Of course we still stood our ground but not perhaps so effectively. So those of you in human and social sciences need to speak up and help to educate our colleagues more effectively than we were able to do on the floor off the cuff at that particular time.

Dr. RATCHFORD. Mr. Ritter?

Mr. RITTER. I think my good colleague from North Carolina has hit the nail on the head. There is a real mistrust of the average working American about the social sciences, the research titles and the kinds of political games I guess that are being played with these titles. But I have noticed that one of the ratings—voting record, you had that amendment in there. So there is a selling job. I think people in the social sciences have got to come across to their own neighbors and, again, their own Congressmen. The social sciences are not trusted by the large population out there. People think they go around doing strange things. I wish I knew how we get around that. It is an educational process in your own communities, perhaps.

Dr. RATCHFORD. The adjournment time has arrived but we shall be able to take a short summary statement from any of the panel members if he would, in a sentence or two, like to summarize his comments.

Mr. MARTIN. An excellent summary.

Dr. SCHNEIDERMAN. I was going to say fools rush in and I was going to demonstrate that. In attempting to summarize what has gone on here, I would say that we have raised issues concerning how we might behave as scientists, as legislators, in a somewhat more rational fashion than behaving purely in terms of our own intuition.

It has been proposed that techniques like risk/benefit analyses would enable us to behave in a more rational way when we are confronted with rather serious and difficult issues. Having set out that premise, we have spent more of the day talking about how it is very difficult to do risk/benefit analyses. I think we have a nascent science, a new science, a new field of work, and we don't really know how to handle it yet. I hope that the day will come when we can use cost/benefit considerations and use them well and take into account all the difficulties the people have talked about here. I don't think that day is here yet. I hope we don't delay its arrival by asserting that it is here prematurely and thus finding ourselves directing the needed research into some other areas. This is, I think, an immature science so far. I hope we don't try to push the immature science into doing what a really mature science is needed for. I think these are areas in which we have to work. I think that some of the differences that were expressed here today and some of the concerns will come together.

Dr. RATCHFORD. Are there other comments by panel members? If not, let me, on behalf of the American Association for the Advancement of Science, thank Congressman Martin, Congressman Ritter and, in absentia, Senator Tsongas and Congressman Brown, for being with us this afternoon. In case any of you are wondering about the strategy for this seminar, questions have been raised today that will be answered tomorrow.

We will now adjourn to the same rooms in which we had our lunch for the reception and dinner. Our speaker this evening will be Chief Judge Howard Markey of the Court of Customs and Patent Appeals. Thank you for your attention. I hope you appreciated at least some of the questions, even if answers were not always forthcoming.

[Applause.]

EVENING SESSION

ANNA J. HARRISON, MEMBER, AAAS BOARD OF DIRECTORS ; MOUNT HOLYOKE COLLEGE, PRESIDING

Dr. HARRISON. Good evening. I don't want to interfere with your dessert. On the other hand, I think it would be desirable for us to go ahead so that we can hear our speaker of this evening.

I am Anna Harrison. I am one of the two freshman members of the board of directors of the AAAS, and so I suppose this is part of my initiation ceremony. Anyway, it is with great pleasure that I introduce the speaker for this evening.

I sometimes think our speaker tonight is really three men. As a soldier, he was engineering test pilot for America's first jet in World War II. And after two wars, he retired as a major general in the Air Force Reserve with 16 medals for heroism in service. I asked him why he didn't come in full regalia tonight with all his 16 medals, and I didn't get much of an answer from him. I judge he thought maybe the question was a little inappropriate.

As a lawyer with a J.D. cum laude and a master's degree in patent law, he dealt daily for 20 years with science, technology, and the law. The Chicago Tribune quoted his prediction in December 1947, that man would walk on the moon in his lifetime. You gave them more time than they needed, sir. [Laughter.]

Now as a judge, he is the first acting judge in our country's history to have sat on every Circuit Court of Appeal in the land. He has now sat on over 1,000 cases and written over 200 opinions for the circuit courts in every field of the law. This is in addition to the more than 1,500 cases and 300 opinions required in his own court.

In addition, he is a member of the Judicial Conference of the United States, Chairman of the Judicial Ethics Advisory Panel, Chairman of the Science Liaison Task Force of the Federal Judiciary, and a member of the National Conference of Lawyers and Scientists sponsored by the American Bar Association and the American Association for the Advancement of Science.

I have learned his secret. He doesn't golf, he doesn't bowl, he doesn't play cards. He is totally happy, devoted and dedicating his life to the law, the management of his court, to his judicial work, and to giving speeches on law and justice, of which this will be the 135th in the last 6 years.

Ladies and gentlemen, it is a pleasure to present the Chief Judge of the U.S. Court of Customs and Patent Appeals, the Honorable Howard T. Markey. [Applause.]

STATEMENT OF HON. HOWARD T. MARKEY, CHIEF JUDGE OF THE U.S. COURT OF CUSTOMS AND PATENT APPEALS, WASHINGTON, D.C.

Judge MARKEY. Thank you, Dr. Harrison. That was such a beautiful introduction. It was so nice it makes me anxious to hear what I have to say.

I suppose, too, that every speaker begins by talking about how glad he is to be here tonight and what a great privilege it is to be with you and how honored he is and all that sort of thing. And I dare say I am no exception. I think, however, I may have one or two extra unusual reasons for really meaning it when I say I'm glad to be here this evening. As Dr. Harrison mentioned, I happened to have been one of the early group of jet plane test pilots in World War II, and as near as anyone can find out, anyway, there are just a few of that early group of seven who are still alive. So I am glad to be anywhere. [Laughter.]

Next I had the pleasure of flying in 1943—1943, before any of you ladies were born, I had the pleasure of flying—that is habit in this town. You always say things like that in Washington—flying from Milwaukee to Chicago, in 1943, in 7 minutes. Seven minutes, Milwaukee to Chicago. It took my dear wife Beth and me 22 minutes to drive across the city tonight from our courthouse to this building, and we came by dangerous automobile. So I am very, very glad to be here.

It is a pleasure to welcome you, too, those of you who are not already Washingtonians. It is a pleasure to welcome you to Washington, the entertainment capital of the world. You notice I avoid referring to Washington as Fantasy Island.

Well, I am not so sure I should give this speech. When I walked in I heard one gentleman say did you hear Judge Markey's last speech? The other one said gosh, I hope so. [Laughter.]

They say, you know, the very best after-dinner speech consists of only five words: "I will take the check." You are not going to get it that fast. But on the other hand, I am aware of the old saying that nice guys finish fast, so I will be finishing fast.

You know, I said to my wife also as I came in, gee, I ought to say something ludicrous or funny or humorous at the outset, and my dear darling after 37 years of marriage said, "Why don't you read them one of your opinions?" [Laughter.]

We both have a job to do in the next few minutes. I have the job of giving a little talk and you have the job of listening. And if you finish before I do, why—

[Laughter.]

Judge MARKEY. [continuing]. Just sneak out quietly. Don't disturb the others who are sleeping. Nothing comes, Dr. Harrison tells me, after this, so you won't miss a thing.

I never worry about anybody going out the back. It is when the audience starts coming toward me that I have a problem.

I want to talk about something I have titled "Let This Cup Pass." Balancing the risks and benefits of continuing or initiating an activity—what Lawrence calls "deciding what risks are acceptable"—is a matter for decision by the people through their Congress. The courts should stay the bejabbers out of it. Thus, my plea tonight is "Let This Cup Pass."

You will notice that I propose to speak of the law, the courts and the administration of justice. Because I wear the silencing robes of a judge, nothing I say will be even remotely political. I always used to say even when I was capable of being political, that was before my appointment, before I became like the rooster who got neutered and became a consultant. [Laughter.]

Before that happened, I used to say I am not a member of any organized political party. I am a Republican. [Laughter.]

You can hear the Democrats laughing at that one.

Your forum title is "The Role of Risk/Analysis in Congressional Science and Technology Policy Decisions." I think you have heard enough of that all day; you will hear more tomorrow; and I am sure you already know all there is to know about it anyway. So I propose to talk to you tonight in your primary roles as American citizens.

I will say this, however. "Science" is merely a synonym for "search." That which is found is no longer science but technology. Of course Congress has a role in deciding what searches to fund, but it wisely named its "Office of Technology Assessment." I trust and hope that neither Congress nor the courts will ever undertake to assess science. Throughout history there have been some who would prohibit particular searches, the most recent example being the effort to prohibit all research related to recombinant DNA. Researchers today must rely on the first amendment's freedom to publish and the derivative right to gather the data to be published. I think, and trust, that if our forefathers were writing the Constitution now they would include a clause reading "Congress shall make no law abridging the freedom to learn." [Applause.]

As you all know, knowledge never hurts. It is the use of knowledge, what we call technology, including the technology of learning, that can heal or harm. And technology is merely a synonym for "tools." The stick used by the caveman to reach the high fruit and the rocket used by the astronaut to reach the moon differ only in degree, not in kind. And technology is neutral. In the hands of a Carnegie, a furnace makes steel. In the hands of a Hitler, it burns corpses.

Now back to my subject. Why do I say "Let this cup pass" when it comes to engaging the courts in analyzing risks and benefits? There are many reasons. We have time to consider only the main ones.

First, and though it may sound strange in this power-oriented town to hear anyone decline the offer, the sociological-technological risk/benefit type cases, unless limited to questions of law, give us judges too much power. I speak, of course, only for myself. Other judges may not agree. Indeed, it seems decades since a court has said "This is a political, nonjusticiable question" and refused to hear the case on that ground. But the cases of which I speak involve broad public policy, future direction of large segments of society, level of acceptable risk, group preference, type questions, the very thing legislatures were designed to decide.

If our republican form of democracy means anything, it means that the people, through their representatives, shall make the basic decisions controlling their lives. The type and extent of the risks acceptable in their lives is perhaps the most basic of all those decisions. The power to make those final decisions should not be even indirectly vested in a few unelected bureaucrats, who have virtual life tenure in their jobs, under review by a few unelected judges who have a constitutional life tenure.

The argument that the people and their representatives are incapable of making risk/benefit decisions simply won't wash. In the first place, that argument throws the American dream, the dream that man can govern himself, right out the window. In the second place, if that were true, the solution is to design a decisionmaking mechanism that will insure that the tradeoff assessment can be and is made by the people through their representatives.

So the first and primary reason for letting the what-risk-is-acceptable cup pass the courts is that to let us decide is to preempt the people's right to govern themselves. The second reason is that it can injure the very heartbeat of a free society, the administration of justice.

The business of the Federal courts is to secure constitutional rights, to interpret Federal statutes, and to set forth the law in clear terms for the guidance of a society attempting to live free, under a government of laws, not men. In a word, the business of the courts is the administration of justice. That business is impeded and may be destroyed when the people rush to the courts for broad public policy decisions in every phase of life, when both legislative and judicial powers are handed to us robed beings on raised benches. Unlike the beings who inhabited the cloud-draped heights of Olympus, we judges are not gods.

The administration of justice will be severely if not fatally wounded when the people find out a big secret. Judges can't do the public policy

job. That job requires legislators responsive to the people and assisted by investigative staffs gathering factual and political input from all sides. It also requires recognition that there may be no answer yet learned by science. When a body of experts had to conclude that the effect of fluorocarbons on the ozone would require years of study; when the NAS panel couldn't agree on whether saccharin posed a high or moderate risk, or even what it meant by "high" and "moderate," how can a scientifically untrained judge be asked to decide? Happily, the Congress yesterday resolved the saccharin risk question, at least until 1981. The courts are simply not equipped to administer justice and, at the same time, respond to the people's expectations when all the people's eggs—all their hopes and dreams—and are placed in the Federal judicial basket.

That the basket is already overflowing is clear. The current national slogan is no longer "love thy neighbor," it is "sue thy neighbor." Last year 172,000 suits were filed before 373 Federal district judges. Do you want to hear those figures again? 172,000 cases, 373 judges.

Also last year there were 20,000 appeals filed before 30 appellate judge panels. In the last few years Congress passed 47 statutes, like the Clean Air and Water Acts, setting forth broad goals, authorizing the bureaucracy to write regulations having the force of law—such regulations numbered 35,000 last year alone—and ending with the instruction, "For review, take this to the nearest courthouse."

Whenever a judge talks like this, some good-hearted souls say he is trying to slam the courthouse door on the people. But on the contrary, he is trying to open the door that is not slammed but jammed by the crowds—the crowds who need not be there who are keeping out those who do need to get in. As Attorney General Bell has pointed out, it is no good saying anyone can go to court if nothing happens when they get there. A good clever remark, but it is so tragic as to be so serious.

Facing a 144-percent increase in workload with no increase in their number, the judges have done yeoman service, modernizing their procedures and now deciding almost three times as many cases annually as they did just 10 years ago. But there is a point when that contradiction in terms, "bargain basement justice," creeps in. Adding judges like rabbits is not the answer. It may produce more rabbits, but as Justice Frankfurter put it, that "merely deflates the judicial currency." Even with 152 new judges coming on board, there is no way, under present trends, that the people can expect justice undelayed, or that judges can give each case the careful, contemplative, considered care it deserves, unless the role of the Federal courts is reduced to proper size.

I fear the effect upon the administration of justice from a massive reaction of a disappointed public. That is why I speak to you as citizens tonight. Don't make us the only game in town. Be chary of the power you give us. Too much will only impede the exercise of our proper power—to restrain the other branches of Government from unconstitutional action. The trick, if freedom is to be preserved, is to keep the elements of Federal force in balance—to keep the three branches of Federal power in equilibrium—and, as our forefathers so carefully intended in the Constitution, to insure that no branch, including the judicial branch, acquires excessive power.

Free us from what we shouldn't be doing, so we can do well what we should do—so we can insure that State and Federal action is law-

ful, and so we can do what only we can do—decide Federal law cases with care, for example, in the fields of civil rights, securities, labor, admiralty, bankruptcy, patents, Federal crimes, Federal taxes, and the like. That is plenty. But that we can do without becoming gods. That we can do and still retain the respect and trust of the people.

For courts have no armies. Their lifeblood is the respect and trust of the people. Raising respect for the courts to belief in their godship enmeshes the courts too deeply and too widely in the people's lives, requires courts to do what they are not equipped to do, and raises expectations unreasonable and foredoomed. Down that road lies the erosion of respect and trust which will in the end destroy the judicial system itself. If, in our thrashings, we cause Justice to break her sword or drop her scales, our children will be a long time mending them.

So this is a cry for help—not to make the judges' job easier—but to make it possible. It is a cry for help—not for judges—but for the people and for justice. It is a cry to rescue the blindfolded lady of justice before she drowns.

But you say to me: "What shall we do?"—and I just happen to have a few suggestions. Anyone can cite the problem. It's solutions we need.

First, Congress should take another look at the 1946 Administrative Procedure Act, now 33 years old, and at the specific enforcement and review procedures tacked onto some of the 47 statutes I mentioned. In so doing, it should provide, as it has for some agency actions, for procedures guaranteeing that all agency actions be taken in the open, based on all applicable data, and supported by articulated reasons, as the District of Columbia Circuit Court of Appeals has described in a number of cases.

Congress need not and should not eliminate judicial review of agency regulations involving the agency's risk/benefit analysis. All it need do, as it has, for example, in International Trade Commission cases, is substitute these few words: "Judicial review shall be limited to questions of law." That would have the benefit of keeping the courts working at what they know and do best, and at what they are trained and equipped for, the law. It would have the benefit of maintaining the ascendancy of the only tamer of science we have, the law. And it would have the benefit of paralleling the distinction that exists between science and law.

Science and law are not enemies. They are man's servants. But there is a profound and pervasive difference. Science embraces all things material. Law, with its legitimizing moral and ethical philosophies, embraces all things spiritual. Hence science and law are all we have as we strive to become what we have never been before. We need both the slide rule and the Golden Rule.

Science and technology alone would produce a society ruled by cold, hard, despotic, physical facts—without mercy, courage, love, reasonableness, honesty, compassion, or justice—the stuff of the law.

Law alone would produce a society of wise men unable to leave their caves.

One of the reasons judges shy from technologically controlled risk/benefit assessment decisions is that they sense, some without knowing quite why, that they are not dealing with the judicial process. And they aren't. The empiric method of the science process is the exact reverse of the dialectic method of the judicial process. The science

process evolves a new physical principle from hypotheses proved by experiments. When properly conducted, the judicial process, on the other hand, applies an existing, generally accepted moral or social value—an ethical principle—to a specific fact situation.

We need a perspective. You heard what happened when the young college girl wrote her mother and father, and said: "Dear Folks: I have been living with a boy, I am pregnant, I have been caught cheating, I flunked math, and I am being expelled. Love, Mary. P.S. I am not living with a boy, I am not pregnant, I haven't been caught cheating, I am not being expelled, but I did flunk math. I just wanted you to have things in perspective." [Laughter.]

Can't you hear the parents? "Wonderful! She only flunked math."

We are in danger of scientizing the law. There are already attempts to make the judicial process merely another scientific exercise. There are attempts to computer-predict appellate decisions, by remote psychoanalysis of the judges. True. The courts are even now confronted with statistics, epidemiological studies, probability exercises, and suggestions that judges and juries be instructed in Boolean algebra and Bayesian analysis. True. But law is not a science. The judicial process cannot become a mechanical, technical, value-free process and remain judicial. The philosophy of the law is jurisprudence, not "juriscience."

But, you say, if we are going to limit judicial review to questions of law, what will we do for folks who want to object, to a risk/benefit analysis conducted by an agency, on technological grounds? My answer is to return to the people's representatives who created the agency, to the Congressional Office of Technology Assessment. I know Congress is swamped, but I am sure there can be found among its 18,000 employees enough budgetary line items to enable the Office to establish a review division, assisted by selected scientific advisers and consultants when necessary. The review division would assess any new evidence, the agency's procedures, and the correctness of the agency's technological conclusions respecting the level of risk involved. That process, I hasten to add, would not in my view constitute even a type of legislative veto. If error were found, most cases would, I expect, be returned to the agency for further work. The Office of Technology Assessment would not control the funds or activities of the agency, but would merely assess the agency's technological conclusions in a particular case.

I have not, of course, mentioned this approach to anyone at the Office of Technology Assessment, or to any other person anywhere. It occurred as I prepared these remarks last night. So it is a typical Washington ploy—a trial balloon. If it has any merit at all, someone may pick it up. If not, wiser heads will prevail and it will die aborning.

If no change is made, and the courts are to continue with cases that cannot be dealt with on the law of nuisance, or tort, or purely legal statutory and constitutional interpretation, we should do a number of things fast:

(A) Establish seminars like this at the Judicial Center for judges to learn about science and scientists, their empiric method, their commendable contributions, and their foibles and failures.

(B) Ask the scientific community to organize peer-selected groups of scientists in various disciplines around the country as volunteers to answer in a report for the record any technological question a judge has trouble with after a trial, or to report that there is no answer.

(C) Start a group of lawyers and technologists working on a set of Federal Rules of Technological Adjudication.

(D) And this may grab some of the scientists in the audience—station an English major, or a former newspaper science writer, at the door of every science laboratory, and require him to translate into English every scientific statement. [Applause.]

Those applauding are the people who have to read them. Every scientific statement or report intended for the public, the Congress, or the courts should be in English.

(E) Similarly, require all grant requests to be in English—it is a good thing I don't have to run for office—following an axiom that if you can't say in English what you want to do, don't do it. Deoxy-ribonucleic acid can be replaced with "the stuff that controls heredity," just as courts are learning to say "it speaks for itself" instead of "*res ipsa loquitur*."

(F) Begin a system of cross-education in our colleges, wherein undergraduate lawyers would take at least some survey courses in a scientific discipline, and undergraduate scientists would learn about law and lawyers and their roles and methods.

Some of those steps may recommend themselves on their own merit, even if Congress doesn't assure the ascendancy of the law by insulating the courts against involvement with assessing technological risks.

In any event, I remain a consummate optimist. I see no conflict in solving our social and our technical problems. We will solve both. Or we will solve neither.

I know that an optimist is the fellow who fell off a 20-story building and, as he went by each floor, kept saying "Well, everything's all right so far." But I know a secret. We've got something going for us no other society has ever had. We call it our Constitution.

Don't panic. I'm not going to give my standard address on the Constitution. I'll just mention what I call the soul of the Constitution of the United States. It lies in the concept that you and I and every human being, regardless of his race, his color, his creed, his appearance, his stature, his status, his money—every human being is the creature of a God. As we had said in our Declaration a little while before, the creature of a "Creator." There may be other bases for freedom, but that's the best one I know. That is the newest, the shiniest, the most revolutionary idea in the history of the world. Yet most of the world's people have never heard of it. Most Americans never think of it. We, its inheritors, still have many of its promises to keep. It is still so new that I am only 58 years old and I have been around one-fourth as long as it has. If we hang onto that brand-new, sparkling idea—one worth living and dying for—we can't lose.

So of course I'm an optimist. Optimism means hope—and hopes are the great medicines. Sure we have problems, but what's new? Solving

problems, and creating new ones, is the stuff of life—the fun of living. As we solve our problems, as we struggle to reconcile our rights, to recognize our responsibilities, and to regulate our risks, our hopes and our dreams are the engines of our progress. And mighty hopes and mighty dreams are the uniforms of heroes.

Men and women are not ants. Their destiny lies in the stars. We'll do all right if in this aerospace age we keep our eyes on the stars, but more importantly on Him Who put them there. We'll do all right if we remember with Barbara Ward Jackson that in every field of endeavor, in all science and all law, man is still "camped on the beachheads." And as Barbara would say, we can't lose if enough men and women will "dream greatly, and dare greatly, and let their work catch up with their dreams."

[Standing ovation.]

Dr. HARRISON. We stand adjourned.

[Whereupon, at 7:55 p.m., the forum was adjourned.]

RISK/BENEFIT ANALYSIS IN THE LEGISLATIVE PROCESS

WEDNESDAY, JULY 25, 1979

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

MORNING SESSION

The subcommittee met, pursuant to notice, in room 2318, Rayburn House Office Building, at 9:10 a.m., Hon. George E. Brown, Jr. presiding.

Mr. BROWN. May we have your attention, please.

I find this an exceptionally good audience, they are disciplined attractive, attentive, there is nothing else going on, they seem to be able to entertain themselves; it is really exceptional, much better than the House of Representatives, and they take their coats off, which we can't do.

I will have to find out from Mr. Mosher how he was able to select such an outstanding group, we may want to rent you to come back again on some occasion.

This morning we are continuing with the second day of these activities, dealing with the problems of risk/benefit assessment, and to set the stage for us today and give us some new perspective on the various efforts being made in the Congress to deal with this subject and some of its aspects, we have Dr. John Gibbons, Director of the Office of Technology Assessment.

I might say that the Office of Technology Assessment is relatively new, it is still somewhat controversial, still somewhat unclear as to what its mandate really is, and as a matter of fact it is not sure of its continued existence at its present level, the same as many things here in Washington.

Dr. Gibbons is, I think, a man who is very well suited to serve as the leader in this kind of an operation. It takes more than scientific capability, which he has in large quantities, but it also takes a certain personality and style. The worst thing in working on the Hill is not the job, but who you have to work with, and he has proven to be good in working with Members of Congress, which is a tough job for anybody. He, of course, follows in the footsteps of two other distinguished directors of that office in its relatively short span, Congressman Emilio Daddario, who authored this legislation and was its first director; and then former Governor Russell Peterson, who served in an outstanding fashion for a little over a year before he was called to greater things in a job which did not involve working for Congressmen, which is of course always an advantage.

Dr. Gibbons has a Ph. D. in physics from Duke University, and worked for many years as a research physicist and program director at Oak Ridge National Laboratory. He also spent some time in Washington with the old Federal Energy Administration, before the Arab oil embargo in 1973, and then for about the last 5 years, before coming to the Office of Technology Assessment—OTA—he served as director of the Energy, Environment and Resources Center at the University of Tennessee.

So I think he has a good combination of background which qualifies him professionally to serve in this function as director of OTA, but as I indicated earlier, in pursuing this kind of a job, there is more required than professional expertise. In the short time I have known Dr. Gibbons personally, I have found he has this qualification in superabundance, and it pleases me to feel he is going to do an outstanding role in this job. I introduce him to you to give us an outstanding keynote address this morning.

Dr. Gibbons.

STATEMENT OF DR. JOHN H. GIBBONS, DIRECTOR, OFFICE OF TECHNOLOGY ASSESSMENT

I was once cautioned by my grandfather that an accolade is a little like chewing tobacco: It is OK if you don't swallow it. I appreciate Congressman Brown's introduction and am delighted to begin the process this morning.

The subject of risk/benefit itself is a little like OTA—it is fuzzy and developing—a notion without strong and accepted methodological basis, essentially an experiment in the Nation's attempts to resolve some complex socio-technical problems.

I was pleased at the way Mr. Brown described the OTA, because it really is an experiment. It is not a well-established institution; it has a lot of things that can be said about its strengths; and also some things that can be said about its weaknesses.

In thinking back about risk/benefit analysis and its use in policy-making and decisionmaking, it strikes me, first of all, that in its most rudimentary form, the notion of trading risks against benefits has been used by the human race and other members of the animal kingdom since time immemorial—that is, weighing the odds between perhaps starving to death and getting killed in obtaining food.

In its more sophisticated form, risk/benefit analysis is one of many techniques and institutions that have emerged over the recent decades to enable us to evaluate in advance the likely consequences of a proposed action or policy or program, and in doing so, to try to avert the worst of the consequences and encourage the best of the consequences of that action. This is a frustrating process, perhaps best summed up by two businessmen on the street corner—with briefcases in hand. One said to the other, "The way I see it, there's a trade off for everything; if you want to have a high standard of living, you settle for a low quality of life!"

Somehow the cartoonist can capture a very complex situation in one sentence. Risk/benefit, cost benefits, net energy analysis, environmental impact analysis, economic analysis: all of these can be reasonably internally consistent methods of thinking about the future, but they

are almost always inaccurate and frequently wrong. Of course, it is often better to be consistent than it is to be correct, however, and these are all methods that have emerged to evaluate actions in assessing options.

Along with the methodologies for analysis, we have developed institutions to deal with risks of modern technology. They include congressional acts such as NEPA, the establishment of EPA at both Federal and State levels, and changes within our courts to resolve conflicts. Changes, for instance, in the FDA's charter have moved it in over a period of two decades from an institution that was grappling with hazards that are already in the marketplace to an institution which tries to prevent hazards from occurring in the marketplace or even entering the marketplace, and some of you, I'm sure, are familiar with author Rigrey who wrote about trying to prevent hazards from occurring. FDA has been charged with not allowing positive things occurring in the marketplace. The new Toxic Act and even the creation of OTA some 8 years ago now is an influence.

These institutions and analysis methods did not emerge in a formal or extensive way until really after the end of World War II when, as a result of the exploding technology in our society, rapid economic and population growth, and growing complexity and interdependence of our society, we woke up to the fact that things were getting out of hand. We realized that we could not comprehend—much less cope with—the increasingly complex and rapid interaction between our scientific and technological advancements on the one hand, and their use by society, on the other hand.

Initially, we marveled at the things technology could accomplish. It was the constant cornucopia, so successful in helping in World War II. But beginning in the late 1950's, we began to focus on some of these inadvertent and adverse consequences of our actions. Perhaps the pioneer of that rise of new consciousness was Rachael Carson's "Silent Spring." This certainly drew our attention to the harmful impacts of the rapidly growing use of long-lived pesticides.

Then there were air pollution episodes, which made us aware of hazards that mistreatment of air and other common goods pose to human health. Then the discovery of the delayed impacts of low-level radiation, and the SST controversy.

Perhaps one of the best ways to describe the intensity of feeling that emerged during that period of time is to read to you a paragraph from a book by Loren Eiseley, called "The Firmament of Time." Eiseley raised in historical perspective the image of impending doom if we kept going the way we were going. He saw mankind moving rapidly toward the age of another but different kind of dark age:

It is with the coming of man that a vast cold seems to open in nature, a vast black whirlpool spinning faster and faster, consuming flesh, stone, minerals, sucking down the light, wringing power from the atom, until the ancient sounds of nature are drowned in something which is no longer nature, something instead which is loose and looking at the world hard, something no longer planned, spewed out of nature, contending in the final giants against its master.

Those are pretty tough words about technology. Robert Heilbroner said it this way:

The coming generation will be the last generation to seize control over technology before technology has irreversibly seized control over it. A generation is not much time, but it is some time.

An economist would describe these notions as a social response to "externalities"—environmental and other costs to society which are not contained in the private market price for goods and services. These concepts were extraordinary in the sense of reflecting concern about adverse impacts of both public and private decisions, actions and events, that spilled over not only on our own lives, but other generations; across distances to other countries, other States and countries, even to the entire planet.

I think the laws and institutions we have created to deal with externalities have proven their worth, though the methods and procedures they must rely on remain in a relatively primitive stage of development even today.

In NEPA, the main purpose was to cause deliberate examination of the environmental impacts of proposed actions, to weigh these impacts, good and bad, and to explicitly and systematically explore alternatives before the action was taken. It is still too early to evaluate in totality the effects of NEPA. A lot of environmental impact analyses have been performed—the latest count is something like 10,000. Recently NEPA was streamlined in its procedures to make sure the essential choices and tradeoffs are focused on early in the process by all the affected and interested parties.

As formal techniques, risk benefit analysis, cost benefit analysis and other similar methods can be extremely useful in helping to find tradeoffs and choices; but they also have very serious limitations of course. There is no scientific or mathematical formula that can adequately measure risk, because the weighing of risk always involves value judgments, which are diverse in our society. It is vital that formulas and numbers not be allowed to obscure the fact that genuine diverse judgments are involved. For example, two almost identical nuclear reactors were proposed to be constructed, essentially across Long Island Sound from each other, one in Connecticut and one in New York (Long Island). One of these reactors went ahead and was completed and is producing power. The other is still in trouble and controversy, not because they are different reactors, but because they are imbedded in different societies with different perceptions of risk.

Therefore, it is difficult to talk about national resolution to problems in a pluralistic society where regional variation of risk perception and acceptability is so great.

Costs and benefits are not distributed evenly or consistently across time or across different segments of our population. For example, the benefits of a technology such as a pesticide are usually clear and immediate to the user. On the other hand the hazards are much more difficult to appreciate. Often there is a long time lag between the exposure to a harmful substance and its ill effects.

The delayed effects, such as leukemia from radiation, lung cancer from smoking, are good examples of the long time delays involved in risk assessments. In the meantime other factors can intervene to cause the results to be obscure, indeterminate or highly uncertain. We are dealing with a complicated system. I've yet to see any problem however complicated, when you look at it in the right way did not become still more complicated.

The benefits of government regulation, for example, banning or limiting a pesticide or even fossil fuels or cutting down on air pollution,

are not clear and immediate, and cannot be easily expressed in dollar terms. On the other hand, the costs of not taking such actions are very clear in the near term, so if we think we have problems in assessing the technologies, per se, you can begin to appreciate the problems that Congress has when you have to take into consideration so much more than we in the world of technology have to deal with.

A risk-free or antiseptic, "safe" world, I claim, is neither possible nor desirable. Innovation inherently involves risk. If we are to avoid all risk, it means we have to stop innovation.

But the Congress and other institutions in our Nation have insisted we have effective and intelligent control over risk, especially risks involuntarily placed upon society. The basic notion of the laws and institutions for controlling and minimizing risk is that people should not be exposed to a risk unwillingly or unwittingly. Thus before a drug is introduced or a chemical is applied, which in turn might adversely affect health, some reasonable steps must be taken to assess and avert health hazards. On the one hand Congress has determined that individual activities such as laetrile, saccharin, and smoking, to a certain extent involve risks that are basically voluntary, and therefore should not be constrained by regulation.

On the other hand, there is a notion of reasonableness or acceptability of risk. If you think about the cancer risk from preservatives in meat and ask what our national policy should be with regard to this, one way to approach it might be that whatever level is acceptable should be small. It would be nice to have the risk small compared to the risk of cancer by cooking the meat in various different modes. If for instance the preservative in the meat causes a cancer risk that is small compared to the variation between charcoal broiling versus boiling the meat, then perhaps that level of preservative becomes an acceptable risk.

Many of our more practicable problems arise in trying to measure and quantify risk when it is very small. In the absence of good data one tends to use a "linear hypothesis" in which risk up at an exposure level where it becomes measurable is used as a basis to make a linear extrapolation to zero.

OTA is another institution that arose from the notion of trying to measure risk and benefit in the case of specific technologies. It was set up by the Congress about 7 years ago to do integrated analyses of technical issues. It is, I believe, a relatively unique institution and should still be considered in many ways an experiment. The charter is to help legislative policymakers anticipate and plan for the consequences of technological changes and to examine the many ways, both expected and unexpected, where technology impacts people's lives. That calls for exploration and analysis of the physical, biological, social and political impacts that can result from the applications of scientific knowledge.

The staff at OTA is relatively small compared to the range and scope of problems that it needs to be able to deal with. It approaches problems on an interdisciplinary rather than a multidisciplinary basis. We don't do "original" research; rather we draw on existing information from a variety of sources and attempt to evaluate the information. We utilize advisory panels comprised of people representing a very broad range of interests, points of view, and technical expertise in

various areas. We use these panels to help define the studies, to critique the results, and make certain the studies are handled in an even-handed as well as accurate manner. The analysis is done mostly by OTA staff, but we utilize some contractors to do specific pieces of work.

In the broadest sense, our job at OTA is to explore issues in ways that can help the Congress anticipate the range of possible actions and what these impacts and implications of the impact might be, the certainties and uncertainties concerning the subject, and what alternative actions might be available to the Congress in dealing with it.

We try to give a full range of options with a corresponding range of cost/benefit type information, and statements concerning the value and limitations of the data. We try to assess risk and benefits both quantitatively and qualitatively, pointing out what can be quantified. Sometimes the most important information is what is not known about the subject rather than what is known. The weights or values assigned to various potential outcomes must come from the Congress. Congress has to make value judgments on behalf of the citizens of the country.

One recent result from OTA includes the use of antibacterial drugs in livestock feeds, where we assessed the contribution of drugs used in animal feeds. Some 40 percent of antibacterials in this country are used in animal feeds. We concluded in that study that the contribution of this process to the growing pool of drug-resistant pathogens in the country is significant but it cannot be precisely measured. We could not assign precise numbers to the risk of illness to humans that are posed by the continued use of antibacterials and chemical additives in animal feeds, nor to the extent that would occur from restricting or banning these drugs. One reason for this uncertainty is that many of the most important drugs are substitutable, therefore if substitutable drugs can be used, then the likely economic impact is very small compared to the potential benefit.

Another study has to do with the use of energy in the residential sector of our economy. That study examined opportunities to substitute technology, capital investment, and labor for energy consumption in providing comfortable habitat. It looked at the status and effects of existing Federal programs, of the different social-economic impacts of these impacts on various segments of our society, and the impact of energy saved through these programs.

A third study is the direct use of coal. We conclude that if it is required for national purposes, coal production and combustion in the United States could be as much as tripled without having to relax present or pending environmental health standards. Those standards would not directly prevent the use of coal; however, they would increase the price of coal, and that effect could cut the relative competitiveness of coal with other fuels and thus dampen the demand for coal.

If we seek to triple the use of coal over the next couple of decades, we run into problems of inadequate transportation systems, of an insufficient coal leasing policy, and public opposition of various sorts from various constituents. All these could serve as constraints to utilization. Carbon dioxide, health effects of coal-related air pollution, the impact on lakes and water bodies of acid rain provide additional constraints.

The last recent study I want to mention to you was one on the effects of nuclear war. We examined the effects that even a very limited nuclear war could have on typical cities in the United States and corresponding cities in the Soviet Union. Among the conclusions were that social and economic conditions would continue to get worse long after the nuclear war ended. The study looked farther ahead than many of the typical studies of the effect of war.

The effects that cannot be calculated are probably at least as important as those in which you can calculate. One problem is that nuclear war involves a risk that we have no adequate basis of experience to make that assessment. The closest relevant past experience we could find for the United States was the Civil War, and of course it can be argued we still are feeling the effects of the Civil War. One of the measures was simply to look at the point at which our entire national capability to handle burn cases is overstressed. This could happen after just a very few nuclear weapons were used.

The jury is still out on how effective or useful OTA is. A recent editorial in the Los Angeles Times noted that one OTA report on solar energy apparently persuaded the Energy Department to shift the focus of its solar research from huge centralized systems to smaller scale projects that could be put in place more quickly. It also cited one report that "Led directly to major changes in oil tanker safety laws"; another that provided a basis for changes in offshore drilling regulations. Most recently James Kirkpatrick did an article on the study of effects of nuclear war. He said he felt like running down the halls of the Senate floor waving the report and saying, "you must read this"—that this study alone fully justified OTA's existence. It is interesting in that report that people in favor of SALT have quoted it, and also people not in favor of SALT have also quoted it.

Not all of our reports are as useful as others. We get discouraged sometimes. I am sometimes reminded of the alchemist who turned to his assistant and said, "Frankly, at this point, I would be satisfied if I could even turn gold into lead." One problem is the inherent difficulty in trying to do fair and authoritative analysis that is technically accurate, while also doing it in a way that is truly useful to the Congress, ways which we don't fudge, ways that do justice to the gaps in our information and knowledge, and to the inherent uncertainties surrounding the impact of the results. It is difficult to get results that really get to the policy alternatives in a meaningful way, and yet still stay away from policy advocacy. We also have time constraint problems. Congress has to deal with real problems in real time, and that frequently means in a very short period of time.

One of my theorems derived from my limited time in Washington is that the more important the decision, the less time you have to make it. A lot of the studies we take on require a year or a year of more of work. It is difficult to tell a Congressman that when he has to vote on that issue next week!

We have sister organizations that also serve the Congress, which are ably equipped, and focused on providing fast turnarounds to information requests by basically scanning the existing literature. This is a special feature of the Congressional Research Service, part of the Library of Congress. We also have colleagues in the Congressional

Budget Office that focus very effectively on economic analysis of issues. Also a wide variety of activities in the General Accounting Office.

Variability of needs is another one of our problems in OTA. Ours is a small organization commanded to assist the Congress in widest areas of technology impacts. We have a problem that reminded me of a yearbook that the Department of Interior or Department of Agriculture put out around 1870. It described all of the vast lands and duties of that department, and it said that the problem was just getting to be more than the 18 employees could handle.

Our lack of well developed methodologies for doing assessment, of a diverse group of technologies related to a variety of possibilities is still notable. Our work on risk analysis which we recently curtailed because of a tight budget situation, is an example of our problem of not having sufficiently well developed tools and methodologies to meet our needs.

I would like to refer you to an editorial in the May 11, 1979, issue of Science, concerning scientific literacy. The editor says that one test of whether or not scientific literacy could help us resolve problems can be derived from the nuclear safety debate. He said instead of going to the general public, let's examine the feelings of people who are reasonably expert, and knowledgeable in the field. He therefore examined organizations comprised of knowledgeable people, yet he found a range of feelings about nuclear safety that was as broad as within the general public.

Therefore, it seems to me that scientific knowledge will undoubtedly help, but will not be a panacea to our problem. The problems contain but transcend technology. One aid to our understanding might be a realization that perfection cannot be expected from technology which is basically a human enterprise.

Another might be that a society as complex as ours has become increasingly nonlinear. Our "separate" activities are increasingly interactive, and notions of freedom will have to change as a fundamental consequence of that fact.

Last of all we need to think back as a nation to an admonition given us by Ralph Waldo Emerson, when he reminded us that:

Nature never gives anything to anyone, everything is sold; it is only in the abstract of ideals that choice comes without consequences.

Thank you very much. [Applause.]

Mr. BROWN. I think that is a very good start for our morning session. I thank Dr. Gibbons for helping us that way.

Now, we are going to proceed this morning with a modified form of a subcommittee hearing, in which we have three distinguished witnesses, and I am going to make some minor changes in the format by which we operate here.

Normally these witnesses would be seated at this table, the distinguished Congressman would be seated up here, and the audience of course, you are in your proper position. I am going to invite the witnesses to sit up here, and if they would come forward at this time I would appreciate it. We are going to have David Okrent, professor of engineering and applied science at the University of California at Los Angeles—one of the finest institutions in the country I might add—Daniel Callahan, director of the Hastings Center; and Paul Slovic, research associate, Decision Research, Inc.

In addition to that, one of the very distinguished members of our Subcommittee on Research and Technology, Dr. Ritter, is also going to lead off with a short statement this morning, and so I am inviting him to be up here also.

Now, for the purpose of controlling this unique situation, my colleague, Don Pease, another distinguished member of the subcommittee, is going to take over for me. He will continue to sit here and serve as the intermediate between the witnesses and the audience.

I would suggest to him that he allow all of the witnesses to present their statements. After that has been completed, that he ask any questions he may have, and then open it up to the audience to ask any questions they may have, so that we may have sort of a dialog here. Of course when that time comes, in order to have an adequate record we would like to ask that anyone who has a question seek recognition and give his name and/or other suitable identification so that the reporter can record that information.

I should introduce my alternate chairman first, Mr. Pease. I indicated he was a distinguished member of this subcommittee, and he is also a distinguished Member of Congress from the State of Ohio, and I think he is filling the seat of our former distinguished Congressman, Congressman Mosher, who I think handpicked him to carry on the tradition that he had set here during a number of years—is that not correct?

Mr. PEASE. More or less.

Mr. BROWN. There is a little difference, they are of different parties.

Now, as I indicated earlier, we are going to start with a statement by our distinguished colleague, Dr. Ritter, who took a special interest in the problems of risk/benefit analysis, and particularly comparative risk benefits analysis, which will become a subspeciality of his by the time it becomes fully professionalized. Because of his keen interest and broad knowledge in this field, in the normal course of events here, I will probably ask him to prepare a report as a basis for further action by the Congress, and that will show him what he gets for having a special expertise in this particular area.

So, Mr. Ritter, would you proceed with your statement?

**STATEMENT OF HON. DON RITTER, A REPRESENTATIVE IN
CONGRESS FROM THE STATE OF PENNSYLVANIA**

Mr. RITTER. Thank you, Chairman Brown.

As you know, this subject has been widely discussed throughout the public media. I can recall some of the news evolution of this subject just this winter and spring. Among others, I recall Richard Wilson's article on risk and the comparisons of risk and technology reviews last winter—last February, I believe. I also recall Dr. Aaron Wildavsky's article on the comparisons of risk in the Scientific American, I think in the early spring. And, in Science Magazine, Dr. Inhaber's report. Part of his report is edited here in the AAA publication. Remember what a hornet's nest that brought out. Yes; some people find comparative risk a very difficult subject to deal with. And yet perhaps precisely because of the emotions generated, it perhaps is even more necessary to get out into the open.

Recently we saw a full editorial page in the Wall Street Journal, with a number of individuals contributing on the comparisons of risk. Also, there was an article on risk analysis benefits in the Sunday Times Magazine on cancer risk. Then there were several editorials, including an important one in the Washington Post. Also, those editorials even hit your local hometown paper and mine. And then we all experienced the Three Mile Island nuclear accident, and the whole subject just closed right up.

In my judgment, this points out the controversy between what is rather a policy and an intellectual consideration, albeit founded in reality; and what events can do, both in the public perception and in the media perception. I think we saw then a curve of rapidly increasing attention to this subject of comparative risks over time precipitously drop at the time of the Three Mile Island incident. I assume that if this symposium or these comparative risk hearings were developed before the Three Mile Island accident—I may be wrong, but I think now we are witnessing a resurgence of interest at all levels in our society on the subject of risk and the comparisons of risk. I would just like to say how delighted I am to be a part of this very constructive forum on an important subject, the analysis of risk.

As a member of the Science Research and Technology Subcommittee, I want to thank the chairman, Congressman George Brown, as well as Senator Adlai Stevenson, and Mr. Mosher working with the AAA in doing an exceptional job, and for giving me this opportunity to testify before you today.

We have not reached the end of 1979 yet, but already it is clear that two events will end up among the headlines of this year. The first is the nuclear accident at Three Mile Island. The second is the summer of the gasoline crunch.

Now I mention Three Mile Island and the gasoline crunch, because in a very real way, they say more about the subject we are here to talk about than many scholarly statements.

Reduced to basics, Three Mile Island and the gas crunch were two sides of the same coin. TMI gave us a peek at the risks of having a particular energy source here in the 20th century. The gas crunch gave us a peek at the risks of not having an energy source. Some may see this as ironic. I see it as an eloquent unspoken plea for taking comparative risk seriously in Government and the public at large.

The average person may ask why he should care about something as academic sounding as "comparative risk." After all, nobody really discussed this in a broad, public manner before. The answer is that individuals have always assessed risks; they just never bothered to measure them in comparative terms.

In primitive society, tribal chiefs believed to have miraculous powers, made such choices for their people. More recently, as modern society developed, risks were balanced on mainly economic grounds. Until we reached the age of the Government decisionmaker who took over much of the risk balancing from his own agency's perspective.

But the simple fact is that now, at the beginning of the 1980's, in the era of TMI, the gas crunch, and energy belt tightening, the old ways of comparing risks won't work any more. They have broken down. Something new is needed, and badly.

The problem is not that Government does not consider risk any more. It is that Government does not understand the need to compare public risks in a down-to-Earth way that the average American can relate to and understand.

Until Government learns to do that, the American people will continue to be left out in the cold, with no way to participate in decisions that affect their jobs, their daily lives, their pocketbooks, their children, and their grandchildren.

Dr. Gibbons from OTA discussed the technology assessment that was done on coal. I attended those hearings and listened very carefully. Judging from whether we learned from those hearings, the potential for 150,000 deaths a year at the year 2000, due to a variety of atmospheric pollutants, not to mention the CO₂ cloud, judging from the fact that presently we talk of 18,000 foreshortened lives a year east of the Mississippi River, judging from the transportation risk and the risk that individuals face in actual mining the coal, why, it is clear, we should cut coal off at the kneecaps and go on to something else.

But that precisely is the problem. We can't consider the mining and the burning and the evolution of alternate fuels from coal in a vacuum. Because whatever risks there are involved with that particular energy source, they must be weighed carefully, compared carefully with the risk involved from other energy sources. For instance, from gas mains which blow all over the country, and where we have a highly combustible explosive source of energy right under our streets.

From oil well spills of vast amounts—and I just read this morning that 1.5 million barrels a day are going out in this Gulf of Mexico oil-spill accident. I was very interested in the controversy raised by this particular report. Because this report tried at least to get a grasp on the comparisons of risk of different energy sources. It should have sparked debate, no doubt; but more than debate, it sparked hostility.

In plain English, what I am pleading for today is that Government begin to make the attempt to inform people how much risk there will be if we take or do not take a given action. We do know a great deal; we don't have to define it to 100-percent scientific accuracy. We have to go on the kinds of basic facts and information that we have today. We must tell the people, we must inform them to the best of our knowledge, how a particular risk compares with the risk of the alternatives. We have to tell them how much risk there will be if we take or don't take a given action. We have to compare these risks—as Dr. Wilson began to do, as Dr. Wildavski has begun to do—with the risk that individuals are familiar with every day. And more importantly, with that risk we face by doing nothing at all. Yes; it is the easiest thing in the world for a bunch of bureaucrats and politicians to sit around and do absolutely nothing. The debate often is to consider and develop all the possible things that are wrong with everything. And the end result is, what happens? That nothing happens.

The average American can start influencing Government decisions instead of just reading about them as if they had been sent down from a mountain on stone tablets. And I want to tell you the special interest groups are most often not average Americans.

In all the vast numbers of words that will be written and spoken about risk this week. I think one single word holds the key. Without

that word we might as well hold these hearings on an island somewhere, as if they were just verbal calisthenics. That key word is "comparative." Risk is only meaningful to the American people if it is put into perspective.

I have often thought since coming to Congress that one of the reasons nobody feels in touch with the Government anymore is that our senses are dulled to the standards that make up Washington decision-making. Congress sets an allowable level of 0.1 milligrams of emission X. EPA sets an allowable level of 0.01 milligrams of emission Y. A steel company threatens that unless an emission can be raised from 0.06 to 0.097 milligrams, 10,000 workers will be laid off.

The average American, sitting in his living room, finds all this hard to comprehend. It may as well be happening in Greenland for all he can understand. Little does he know that the fabric on the chair he is sitting on, the paper he is reading, and the cost of the dinner cooking in his kitchen are all tied into this seemingly irrelevant mumbo jumbo. They are all tied in, and this is supposed to be a democracy.

I'll tell you this, I go home every weekend, and I have real confidence in a lot of those people who are sitting out there wondering what is going on here in Washington, why is everything so tied up. These people have an inherent sense, a common sense that sometimes is very much lacking, as we throw the political football back and forth here on Capitol Hill.

That man and his wife have a right to speak about things that affect them. Sure they go to the polls in November, but just to leave it at that is not enough; they deserve more than the right to just pull a lever. The people deserve the right to make informed choices about policy and to make informed choices about the way the Government works. It is my experience again that they have the capacity to choose. They don't understand some of the things like milligrams, et cetera. But what they do have a feeling for is how dangerous it is to ride their bike in traffic. And how dangerous it is to drive their cars, what they put up with in terms of risk, and how dangerous it is to smoke a pack of cigarettes a day. This is understood. And this has got to be in a framework in which we place, to the best of our knowledge and capability, the kinds of assessments we are beginning to come up with on these more technologically complex matters.

The average American does understand risk. And rather than shutting him out from the decisionmaking, while we, the politicians and the bureaucrats, do our thing here, I submit we should start including him. Not just because he can help us arrive at the best choice. But because it is the right and only way we will ever get around the inevitable logjam that is the end result of Government involvement in these complex scientific and technological issues.

That is where comparative risk comes in. If we continue to operate all our nuclear power plants, what exactly is the health risk of its daily production of electricity? Is it as much a risk as getting a yearly X-ray or living in Denver? On the other hand, if we shut those plants down, what risk do we face? How many millions of barrels of oil will suddenly have to be imported? Exactly what will that foreign oil do to the price of oatmeal and iced tea and dresses at the store, keeping your home healthy in winter, getting to work or keeping your job, or new construction?

I am amazed at the ability of this body to talk about diminishing or limiting changes in our life styles while everybody here has a five bedroom home and three cars. You don't hear these living room discussions, these salon parlances, when you go talk with the steel workers or the chemical workers in my district. Nor with the blacks or Puerto Ricans. They are just trying to get up that ladder to get a three-bedroom home. If we listen to the pleas of a given industry and reduce an emission level from 0.01 to 0.1, will that decimal point shift really send workers into the hospital next year or in later years? Or will it do no such thing, and instead put people to work, take men and women off unemployment and put them onto the tax rolls? Does it help give a piece of the American dream to those Americans at the bottom of the ladder?

If we listen to the concern of those who oppose nuclear power, for instance, and block nuclear waste disposal, does the average American realize that, by not acting, we run a risk of accidents such as those connected with waste leakage? Does the average American know the risk we run by not reprocessing spent nuclear fuel, thus adding to our already large waste disposal problem? The average American does not know that information, nor the whole segment of society. I don't want to insult you, but such issues are really the heart of what we are here for. Until now the questions have been asked behind the hidden doors in the maze of Washington bureaus by scientists, lawyers, special interest groups, but not out in the open air where the American people who have the big stakes can hear them.

I will conclude by telling you that, as a member of the technical and academic communities for many years, I have been thinking about comparative risks in America since long before I ever considered running for Congress last year. My message today is that my thinking about comparative risks, and your thinking about them isn't what counts. What counts is having the average American man and woman, and even children, thinking about comparative risks; to educate them one at a time of the danger of this, that and the other thing. To isolate comparative risks from them is to make them frightened. In an effort to bring these ideas into the open, my first legislative act after coming to Congress was to introduce a bill on this subject. This is an updated form, H.R. 4939. It is available here for your information and review. My bill directs the Office of Science and Technology Policy, (OSTP) to lead Government agencies in exploring the ways that comparative risk can become an active field of investigation and public education in American centers of learning.

I mentioned a few of the individuals working in this field. I would like to point out that Bill Lowrance is here with us, and he will be on the panel this afternoon. The bill would address the question of how comparative risk would become part of the overall economic impact of considerations we make, and wend its way into the Government before regulatory decisions are made. This is consistent with NEPA requirements for considering alternatives, from past practice; risk comparison has been drawn from these at best.

I hope this bill will list the needs and allow wise individual choices among the inevitable but finite risk that we face in a technological society. Large risk, of course, calls for continued regulation. I would

like to make comparative risk a household word. Also that we as a nation will be motivated by intelligence, not fear. There is every reason to believe that if we don't do this, the American people will continue to feel embattled and baffled, as at TMI, or during the gas crunch. I would like to bridge that gap between those of us sitting here who have studied this, and to find some way to make their decisions more intelligent. For if these decisions on comparison risk can be moved forward into public comprehension maybe other government decisions can be equally better understood. They are just too important to be outside of the public domain. So let's hope this week's endeavors together with the concerns of so many fine people like yourselves, will turn out to be a wise investment in the 1980's and beyond.

Thank you very much for this opportunity to speak. [Applause.]

Mr. PEASE. Thank you very much, Mr. Ritter. The bells have just rung, and we have to go over to the floor of the House to record our presence, so I will declare a 10 minute recess and you can stand up while we go vote.

[Short recess was taken].

Mr. PEASE. Could we take our seats again and prepare for the rest of the hearings?

The first person on our panel today is Dr. David Okrent, who is professor of engineering and applied science, Department of Chemical, Nuclear, and Thermal Engineering at the University of California. He holds a Ph. D. in physics from Harvard, and worked at the Argonne National Laboratory for 20 years; he is a member of the NRC Advisory committee on reactor safeguards for 15 years. Recently he served as a member of the risk impact panel and as chairman of that panel's emissions resource group for the committee on nuclear and alternative energy systems of the National Academies of Science and Engineering.

I am happy to present to you for his comments, Dr. David Okrent.

**STATEMENT OF DAVID OKRENT, PROFESSOR OF ENGINEERING
AND APPLIED SCIENCE, DEPARTMENT OF CHEMICAL, NUCLEAR
AND THERMAL ENGINEERING, UNIVERSITY OF CALIFORNIA,
LOS ANGELES**

Dr. OKRENT. Thank you, I am pleased to be able to participate this morning.

My own area of professional interest is related to public health and safety, and my comments today will be strongly oriented in that direction. Thinking about the discussion of yesterday, I might note that in 1957 I designed my own passive solar home when I lived in northern Illinois, a house which was very tight and very well insulated. Little did I know then I was exposing myself to indoor air pollution. And for the last 9 years I have lived in Los Angeles where I walk to work and I have insulated my house. Perhaps this background qualifies me as a de facto conservationist. Actually I classify myself more as a skeptic. I am particularly skeptical of those who come advocating any technology as benign, or attacking any technology as too risky, without

presenting a detailed, quantitative risk-evaluation, without making a choice among feasible alternatives, and without placing the risks in some broader societal perspective. I endorse Congressman Ritter's proposal for looking at comparative risks.

I favor a national energy approach which uses all domestic resources, including and, indeed, emphasizing conservation, and using such resources as wisely as we can. I favor diversity in order to better assure resiliency. I support the judicious case of risk-benefit analysis, and strongly advocate the institution of procedures to insure a proper display of assumptions, uncertainties, and so forth, and to assure evaluation and review of any important risk-benefit analysis by a capable, independent group.

Let me differentiate between the terms hazard and risk as I shall use them today.

Three people crossing the Atlantic Ocean in a rowboat each face a hazard of drowning. The maximum societal hazard in this case is 3 deaths. Three hundred people crossing the Atlantic in an ocean liner each face the same hazard of drowning, but the maximum societal hazard is 300 deaths. The risk per crossing to each individual is given by the probability of an accident in which he drowns. The risk to society is given by the size of the societal hazard multiplied by the probability of the hazard. Clearly, the hazard is the same for each individual, but the risk is greater for those individuals in the rowboat than in the ocean liner.

Let me next make some short observations.

1. Society is not risk-free and cannot be.
2. No existing or proposed energy source is risk-free, either to the ecology or to the public health and safety. This includes solar energy. Even conservation carries risks with it. And the concepts of zero growth and soft energy also inherently incorporate risks.
3. Few, if any, technologies or societal endeavors, such as agriculture, are risk-free.
4. There exist very large gaps in society's knowledge of risks, as well as in its knowledge of costs and benefits. Rather few aspects of society have been seriously studied and quantified with regard to their risks and benefits.
5. Risk quantification, albeit imperfectly, and frequently with large uncertainties, is usually possible and is generally desirable. Consideration should be given to requiring risk quantification for societal endeavors.
6. Decisions are likely to be better, on the average, if they are made with the benefit of more nearly complete information.
7. In view of their statistically smaller contribution to societal risk, large accidents may be receiving proportionately too much emphasis compared to other sources of risk, particularly hazardous residues, pollutants, and wastes.
8. The word "safe" as it is currently used in society is too vague, and it is applied in an uneven and inconsistent fashion.
9. Society's resources are limited. Above some level of expenditure, additional programs intended to reduce risks to the health and safety may be counter productive because of adverse economic and political effects.

10. Resources expended unnecessarily in one aspect of society to provide a needed service more expensively are, at least in principle, not available for use in measures which would defer premature deaths or "save lives". Thus, a more expensive source of electricity carries an economic resource risk penalty compared to a cheaper source.

11. Societal efforts currently devoted to risk reduction are not necessarily being expended in the most cost-effective way. Our priorities should be reevaluated.

12. Congress should take the lead in trying to develop a program to develop an equitable, more quantitative, national approach to criteria for acceptable risk and to risk management.

THE NEED FOR INFORMATION ON HAZARDS, RISKS, COSTS AND BENEFITS

There exist very few published assessments of the hazards and risks to the public health and safety for most aspects of our society. And there are still fewer risk assessments which provide a detailed statement of the assumptions made and the uncertainties in the results, and which have had the benefit of a detailed, objective critique and evaluation by an independent body having the necessary capabilities.

For example, it is difficult to find published quantitative estimates of the hazards and risks which arise from the thousands of large dams in the United States. In fact, the safety capabilities of such dams are generally poorly known, particularly with regard to relatively low probability, more serious failure modes. The situation is the same with regard to facilities in which large amounts of hazardous chemicals are stored.

The gaps in our knowledge are equally great with regard to the risk from chronic atmospheric emissions, and from the disposal of liquid and solid wastes from our chemical industries, from agriculture, from coal-fueled electric power stations, et cetera. And, we are all only too aware of the gaps in our knowledge of the effects of residues and additives in our food, and in our knowledge of the occupational environment.

Now, can these information gaps concerning risk, as well as those concerning benefits, be completely removed? Hardly.

Are there likely to be large uncertainties remaining even if a major effort is made to remove these information gaps? Yes!

Can substantial improvement be made, nevertheless, in our current state of knowledge concerning existing or projected risks, and the potential costs of their reduction? The answer is yes.

A FEW EXAMPLES OF HAZARD AND RISK ESTIMATES

In my opinion, the single most interesting and significant accident-risk study available is that released in June 1978, by the health and safety executive of the British Government entitled "Canvey: Summary of an Investigation of Potential Hazards from Operations in the Canvey Island/Thurrock area".

Canvey Island lies in the Thames River and is about 9 miles long and $2\frac{1}{2}$ miles wide. It contains about 33,000 residents and about 7 large industrial complexes, including petroleum, ammonium nitrate, and a liquefied natural gas facility.

The largest risk of death to Canvey residents arising from an accident at one of the industrial facilities was estimated to be about 1.3×10^{-3} —1 in 800—per year for some of the nearest residents. This risk is about five times as large as the average risk of dying in an automobile accident in the United States. The average risk of death arising from an accident at these industrial installations was estimated to be about 5×10^{-4} —1 in 2,000—for all the island's residents. This is about twice the risk in the United States of death from an auto accident.

The chance of 1,500 people being killed in a single accident was given as more than 1 in 1,000 per year. The chance of 18,000 being killed in a single accident was given as 1 in 12,000 per year.

These estimates were stated to probably err on the side of pessimism by a factor of 2 or 3, but probably not by a factor of 10.

The health and safety executive recommended that improvements be made, improvements that should reduce the likelihood of each of the above estimates by a factor of 2 or 3. With these improvements the health and safety executive judged that the risk would be acceptable.

It is my impression, based on discussions with British experts in safety assessment, that they doubt the practicality of obtaining a factor of 10 improvement in the risks estimated for Canvey for the entire British chemical industry.

I have little doubt that in the United States we have many chemical installations imposing hazards and risks not unlike Canvey.

I understand that the British are making it a matter of national law that safety assessment reports be submitted by each industrial facility utilizing or storing more than some threshold quantity of a hazardous chemical. Notification is required if some specified lesser quantity is stored or used. The health and safety executive will have the responsibility for evaluation of the risk assessment and a decision on the acceptability of the risk.

It is also my understanding that Japan is instituting safety design requirements on chemical plants, requirements which become increasingly severe as the magnitude of fatalities that might occur in a serious accident rises.

Should not the United States be developing some systematic approach to these and other societal risks?

I earlier mentioned dams. Limited studies by our group at UCLA of 10 dams in California yielded fatality hazards ranging from 10,000 to 250,000 deaths for catastrophic failure of each of these dams. Historically, large dams have failed, though not necessarily suddenly and in gross fashion, at a rate of about 2×10^{-4} [one in 5,000] per dam per year. However, our crude estimates of failure rate for some of the dams studied were as large as 1 in 100 per year.

During the San Fernando Valley earthquake in 1971, the Van Norman Dam nearly failed catastrophically due to soil liquefaction, a phenomenon only recognized after its construction. Had it been full, the dam would have failed, with the potential for causing 50,000 to 100,000 fatalities.

The State of California has had a dam safety law since the 1971 earthquake. The safety of each State-controlled dam will have to be reviewed and a finding of "safe" must be made.

But the State provides no statement of the risk it is imposing when it makes a finding of "safe." And, of course, the hazard, that is the maximum possible number of fatalities, remains unchanged by a finding of "safe."

Like all States, but perhaps more acutely, California has severe safety questions arising from the possibly catastrophic effect of earthquakes on its cities. It is my understanding that on March 17, 1976, the U.S. Geological Survey advised the staff of Governor Brown of the relatively large likelihood that a major earthquake would cause a catastrophe in Los Angeles killing many tens of thousands, primarily from collapse of seismically substandard buildings and from dam failure. A report prepared for the Federal Disaster Assistance Administration poses an equally foreboding future. To my knowledge, seismically substandard buildings have not been posted as hazardous in Los Angeles nor have emergency instructions been issued on where to run in the event of dam failure. The city of Los Angeles has been grappling with the problem for some years, with no resolution as yet. Seismic retrofit or building condemnation is very costly.

Similarly, I am aware of no systematic assessment in California of risk from large chemical installations. Very stringent siting requirements were imposed by the State on LNG facilities, but other chemical hazards and risks, some of which may be greater, have received only limited safety consideration.

From what little I know about the relative and absolute hazards of risks from dams, from seismically substandard buildings, from chemical storage facilities, and from nuclear reactors, including those at Diablo Canyon, I would be unable to explain rationally to my students the relative safety emphasis, or lack thereof, which has been given to each of the above by the Los Angeles Times, by various public spirited citizens and public interest groups, or by the Governor of California.

LIQUEFIED NATURAL GAS [LNG]

The LNG technology has received increasingly intense safety review in the last few years. One of the relatively few, large proposed U.S. chemical installations for which a serious, detailed risk study has been published was the proposed LNG facility for Los Angeles, Oxnard, or Point Conception, Calif. This study, which was performed under contract for the corporation requesting to build the facility, has been the subject of some considerable controversy. The study did not include a self-critique, wherein assumptions were clearly identified and uncertainties were critically evaluated. While other estimates of risk from these proposed facilities have been issued, and most yield larger risks, there is not available, to my knowledge, a separate complete, detailed, independent study and evaluation, performed by a disinterested group.

Also, to my knowledge, there do not exist quantitative standards or criteria against which to judge the acceptability of the risk at any of the proposed sites.

And no evaluation was made of the incremental risk that may accrue to society because of the choice of a siting approach which is less favorable from an economic point of view.

THE FLOOD AT BIG THOMPSON CANYON

I'd like to explore briefly one other situation involving large accidents. Some may call an earthquake in Los Angeles or the flood at Big Thompson Canyon, Colo., a natural disaster. But, if the fatalities could have largely been prevented by proper design, by foresight and planning, and/or by proper emergency action, I am unwilling to shrug off the event as a natural disaster, seemingly beyond our control and not to be compared with accidents in manmade facilities.

During the evening of July 31, 1976, an intense thunderstorm stalled over a small portion of Big Thompson Canyon, dropping 10 or more inches of rain in a 3-hour period. Because of the steep mountain topography, the rainfall quickly concentrated and formed a virtual wall of water which displaced everything in its path. Of about 4,000 people in the canyon, the toll was 139 people dead and 4 missing. Property damage exceeded \$41 million.

The flood struck an area totally unprepared for such an event. Efforts were made to evacuate but they were not adequately effective. Was this loss of life a natural catastrophe which could not be avoided? I don't think so. It might have been avoided by restrictions on building in the flood plain, a controversial matter. But accepting the de facto use of the flood plain, the loss of life could have been minimized with the benefit of some preanalysis, a reasonably direct method of measuring and continually monitoring rainfall, and a suitable warning system.

I don't recall any congressional investigation of the matter. I understand that the State of Colorado has imposed restrictions on rebuilding in the flood plain in Big Thompson, restrictions which are being fought. But, there are many other similar canyons, all along the front range of the Rockies, including one which opens onto Boulder, Colo. What safety precautions are being taken for these canyons? Is this question being given its proper priority compared to new LNG facilities or to nuclear powerplants?

EXPENDITURES TO "SAVE A LIFE"

When one looks retrospectively at the expenditures made in society to save a statistical life or defer a premature death, one finds a great disparity.

Morlat estimated that in France, \$30,000 was being spent per life saved in road accident prevention and about \$1 million in aviation accident prevention.

Sinclair estimated that in Great Britain the expenditures to "save a life" ranged from \$10,000 for an agricultural worker up to \$20 million for a high-rise apartment dweller.

Comparable conclusions about the same inconsistency in the implicit value of life are easily found in the United States. Let's look briefly at two energy-related risk-benefit judgments.

In the report from the National Academies of Sciences and Engineering entitled "Air Quality and Stationary Source Emission Control," prepared for the Senate Committee on Public Works in March 1975, estimates are made of the health costs of the pollutants from coal-

fired, electric generating plants. A figure of \$30,000 per premature death is used "rather than the value of \$200,000 used in highway safety." The reasoning given for this choice is that "most of the deaths occur among chronically ill, elderly people, and the amount by which their lives are reduced may be only a matter of days or weeks." This "value of life" was then used as the reference value for cost/benefit tradeoffs which tend to evaluate the merits of various approaches on emission control from coal plants, including the timing of such controls.

On the other hand, in its "As Low As Reasonably Achievable" or (ALARA) Criterion, for routine releases of radioactivity from a nuclear powerplant, the Nuclear Regulatory Commission employs \$1,000 per man-rem as the expenditure limit below which improvements should be made. Using estimates from the report of the Committee on Biological Effects of Ionizing Radiation (the BEIR report), \$1,000 per man-rem translates into more than \$5 million per premature death deferred. Furthermore, this death would on the average probably occur beyond the age of 50; hence it would be a life of reduced value according to the philosophy used in appendix 13 of the study "Air Quality and Stationary Source Emission Control."

If one were to search within the several departments of EPA, one would undoubtedly find a large spread in the implicit value of life. And one would find a large spread in the risk levels implicitly accepted.

I have little doubt that the societal risk from the disposal of hazardous liquid and solid wastes is currently substantial. I doubt that the EPA is using the same risk acceptance criteria of value of life in its choice of criteria for disposal of radioactive and nonradioactive wastes. I anticipate that a similarly large discrepancy also exists with regard to regulation of the transportation of hazardous radioactive and non-radioactive materials.

RESOURCE ALLOCATION AND RISK PERCEPTION

1. Resources for the reduction of risk to the public health and safety are not infinite in extent. At some point, a greater improvement in health and safety is to be expected from a more stable and viable economy than from a direct incremental reduction in the accident rate or in pollution effects.

It may be that the Congress should initiate appropriate studies to enable a reasonably accurate evaluation of the proper level of expenditure on risk reduction.

Within such a level of expenditure, if we fail to devote our resources to those risks where the most reduction in absolute terms per dollar is accomplished, we are not optimizing our effectiveness. Of course, one must assure there are no gross inequities in risk, and that no individual is knowingly being exposed to risk significantly greater than some upper limit of acceptability.

2. There also appears to be a limit on the number of different safety-related issues on which the public and the Congress can focus and act at any given time.

Within this context of limits on resources and limits on areas of focused attention, each individual or group making recommendations, or otherwise taking action which affects national priorities, bears some

responsibility for the adverse effects of his actions. Thus, an individual who effects the banning of the use of DDT in some tropical country may inadvertently cause far more deaths than he defers, because of a higher incidence of malaria. Similarly, if coal-burning, electric-generating plants are found to cause far more premature deaths, statistically speaking, than nuclear power plants, in agreement with most published estimates, an individual or an agency which successfully advocates the construction of coal plants instead of nuclear, may be causing unnecessary deaths.

More generally, if Walter Cronkite, the electronic media, the newspapers, or even the publication *Science* itself, should present an unbalanced perspective on some aspects of risk in society, and this caused societal risk-reduction priorities to be set inefficiently and even wrongly, these institutions would, in effect, be contributors to the causing of premature deaths which could have been averted.

I make the above comments only half-facetiously. I believe that those who directly try to influence safety priorities, or who indirectly affect them by the spoken and printed word, have to accept some responsibility for the consequences of their actions.

I question that any of the above-named institutions have provided a sufficiently balanced approach to informing their public on risks in society.

APPROACHES TO RISK-ACCEPTANCE

Lowrance has said "A thing is safe if its risks are judged to be acceptable."

The Van Norman Dam was presumably considered to be "safe" before it nearly failed in 1971. Was it safe?

The Los Angeles Times some years ago editorialized concerning the proposed Auburn Dam, saying, "Let's build it if it's safe." What does the word "safe" mean in the context of an Auburn Dam whose failure was estimated by an experienced engineer to be capable of killing $\frac{3}{4}$ million people. We cannot prove that there is zero probability of its failure. Quite the contrary. If so, what estimated failure frequency would be acceptable? What uncertainty in this estimate is acceptable? Will it be possible to demonstrate that such a safety objective can be reached?

The Nuclear Regulatory Commission had licensed the Three Mile Island 2 reactor prior to the accident. Hence, the NRC had made a finding that "There is reasonable assurance that the activities authorized by this operating license can be conducted without endangering the health and safety of the public". The NRC Commissioners have not quantified their definition of "reasonable assurance." Should they?

It is not easy to develop a workable, defensible set of quantitative risk acceptance criteria which also allow for benefits, societal needs, equity, economics, political, and social effects, and so forth.

Rather few specific proposals have been published, considering the importance of this subject.

In 1977 Chris Whipple and I described a simple quantitative approach to societal risk acceptance and management which incorporated the following principal features:

1. Societal activities are divided into major facilities or technologies, all or part of which are categorized as essential, beneficial, or peripheral.

2. A decreasing level of acceptable risk to the most exposed individual is proposed (say, 2×10^{-4} /year for essential, 10^{-5} /year for beneficial, and 2×10^{-6} /year for peripheral activity).

3. The risk would be assessed at a high confidence level (say, 90 percent), thereby providing an incentive to the gaining of better knowledge.

4. Each risk-producing facility, technology, et cetera, would have to undergo assessment both of risk to the individual and to society. (The risk assessment would be performed under the auspices of the manufacturer, owner, et cetera. It would be independently reviewed and evaluated. The decision on acceptability would be made by a regulatory group. For practical reasons you might have some risk threshold below which no review was required.

5. The cost of the residual risk would have to be internalized, generally via a tax paid to the Federal Government, except for risks which are fully insurable and, like drowning, are readily attributable.

6. The Government would in turn, redistribute the risk tax as national health insurance and/or reduced taxes to the individual.

7. Risk aversion to large events would be built into the internalization of the cost of risk, but with a relatively modest penalty. If some technology or installation poses a very large hazard at some very low probability, and many do, a case by case decision would be required, with considerable emphasis on the essentiality of the venture.

8. An ALARA criterion on risk could be required, although an incentive to reduce risk as well as the uncertainty in knowledge of risk would already have been provided by establishing a suitable level for the risk tax.

The numbers guessed by Okrent and Whipple are probably wrong and the untested approach is probably too complex and yet too simple. However, there has been all too little real discussion of the question "How safe is safe enough?" Comar suggested a "de-minimus" approach in an editorial in *Science* in January 1979. But more typically, symposia are held on risk benefit without even addressing the subject of quantitative risk criteria.

Let me conclude by summarizing as follows:

1. If our priorities in risk reduction are wrong, if we are spending the available resources in a very non-cost-effective way, we are, in effect, killing people whose premature death could be prevented.

2. There is some optimal level of resources which should be spent on risk reduction, beyond which adverse economic and political effects may be over-riding.

3. There is need for the development of a national approach to risk acceptance criteria and risk management, one that the Congress and the Executive Department and the public can support. [Applause.]

Background information and references on most of the topics treated in my oral comments can be found in the following documents: "An Approach to Societal Risk Acceptance Criteria and Risk Management," by Okrent and Whipple (UCLA-ENG-7746, June 1977), and "A General Evaluation Approach to Risk-Benefit for Large Technological Systems and its Application to Nuclear Power," by David Okrent (UCLA-ENG-7777, December 1977).

Mr. PEASE. I thank you very much, Dr. Okrent.

Rather than entertain questions now, we will go right on to the next paper to be presented by Daniel Callahan, who is director of the Hastings Center.

Dr. Callahan.

STATEMENT OF DANIEL CALLAHAN, DIRECTOR, THE HASTINGS CENTER, HASTINGS-ON-HUDSON, N. Y.

Dr. CALLAHAN. Thank you.

I have been asked to talk about the ethical problems of risk-benefit analysis, and I am very pleased to do so. I think the general problem of the use of risk-benefit analysis for public policy decisionmaking has a profound moral concern behind it: the protection and promotion of the public good. Yet, oddly enough, the explicit language of morality is normally missing from the discussions and debate. The more common language is that of science, economics, regulation, public interest, legislation and what-have-you. I certainly would not want to claim that an approach to risk-benefit analysis by way of its ethical themes and problems will provide a way of unifying those different perspectives, much less some miraculously clean way of slicing through all of the uncertainties generated by the very complexity of the issues. I do want to suggest, however, that an explication of some basic philosophical and ethical principles may provide help in uniting what is now a highly contentious and fragmented way of looking at the problems. I cannot pretend to any great originality. I have tried to examine the literature and talk with people. The main feature that comes through to me about the whole thing here is that of considerable uncertainty.

Many individuals express considerable confidence on this or that particular point, but it seems clear no one has found any broad set of principles that together command automatic support. The deeper one gets into the issues, the more uncertainty appears. My own conclusion is that we are dealing with what I will call inherent uncertainty, that is, an uncertainty built into the very nature of the problems. Just as there is not likely to be a single cure for cancer, neither is there likely to be a single solution to the appropriate use of risk-benefit analysis.

Why is there an inherent uncertainty? Two reasons seem to dominate. First, it is extremely difficult to get solid scientific data about many, if not most, risks. In general, the only solid data is that which is the result of a long period of experience, as with the potential hazards of the contraceptive pill, or the dangers of driving automobiles. In the case of many new technologies, there is simply not a sufficiently long history of exposure to those technologies to develop a solid data base. When one attempts to analyze potential future risks, as in the case of recombinant DNA, or the effect of accumulated carbon dioxide on the ozone layer, the data is inevitably soft and speculative.

Second, while it is often difficult enough to get scientific agreement on the validity of available data, it is even more difficult to gain a social consensus on what counts as an "acceptable" risk. Risk is a scientific concept, the statistical probability of the occurrence of certain hazards. The notion of "acceptable risk," as William Lowrence has stressed, is a normative concept. The most obvious public feature

of acceptable risk is that people differ enormously on what they will tolerate, on the extent to which they are willing to gamble, and on the way they perceive the world, sometimes optimistically, sometimes pessimistically. This is hardly surprising; people vary in age, personal history, economic and social circumstances, and in their psychological predispositions. And we ought to know that, as individuals, we can be both inconsistent and vacillating. Many heavy smokers consider motorcycle riding an exceedingly hazardous activity; some of the most ardent rock climbers are those who are exceedingly anxious about the hazards of food additives, and what can make us nervous one day does not bother us the next day.

If it is exceedingly difficult then to get solid scientific data, and if it is even more difficult to get any agreement on what counts as acceptable risk, systematic and inherent uncertainty is bound to reign supreme. Moreover, if uncertainty reigns even with very specific issues, for instance, the risks to humans from the ingestion of saccharin, the difficulties are bound to be increased immeasurably when one is dealing with multiple risk benefit factors, those that involve a variety of uncertain risks counterpoised against a variety of uncertain benefits.

Given this state of affairs, what is the most reasonable response? I would propose the old-fashioned virtue of prudence, a virtue that stresses the need for constant calculations, for caution, for making use of historical experience, and above all, a virtue that stresses flexibility and constant reexamination. The most dangerous temptation in the case of problems that generate inherent uncertainty is that of looking for mechanical and rigid decision procedures. They do not exist for the use of risk-benefit analysis and there is no reason to believe they will ever exist.

A second broad point I would like to make is to simply underscore something which is increasingly common in the literature, namely, the great difficulty of separating facts and values. Both from the philosophical and the practical side, it ought to be evident by now that no neat distinction can be made between facts and values. Philosophically, all alleged facts reflect to a considerable extent the perspective of the investigator toward reality. Facts do not simply present themselves to the naked eye; interpretation and analysis is always necessary. Our values and our angle of vision determine, in the first place, what we choose to call a fact. Practically speaking, the numerous and unending debates of scientists concerning facts, whether those facts bearing on the origin of the universe, or those bearing on the relationship of carcinogenicity in animals to that of human beings, indicate that there are rarely single expert solutions even to what appear to be straightforward factual questions. As any number of adversary proceedings have made clear, scientists can and do differ radically on the scientific state of their theories and on what counts as a well established fact. Their disagreement ordinarily stems from subtle and often tacit value differences, which may take the form of different assumptions underlying their hypotheses, a choice of different facts as significant, or a more ordinary bias in the direction of that evidence that will support their social values.

The greatest hazard, I believe, is assuming that, with better science only, one could find a perfect technical solution to the question of risk; that is, some simple procedure that will automatically sort out

and fully establish facts and probabilities. At best, even the most solidly established facts are only rough approximations of truth, something all well-trained scientists know. Naturally, efforts should continue to refine the technical art of risk-benefit analysis; but if it is believed that a better technical analysis will solve any real problems, that appears to be a vain hope, one likely to distract our attention from the deeper and more difficult issues, that of making decisions in the face of both scientific and social uncertainty, and in the face of the common inseparability of facts and values.

A third general point I would like to make is that we must take account of the inevitability of conflict of interest. There is a constant and cynical tendency in our society to assume that people act only in their self-interest, and that all instances of conflict of interest represent the pitting of self-centered choices against each other. No doubt there is some truth in that general attitude, but it is far more important to recognize that, just as individuals see the world differently, so too will different groups in our society. None of us look at the world from the same spot, and it is rarely possible for any of us to totally transcend our personalities, our backgrounds, or the class or group of which we are a part. It is not necessarily mere self-interest that moves legislators to worry about the views of their constituents, or drug companies to develop and promote new products, or women at risk for pregnancy to seek effective contraceptives, or scientists to seek more money for research—those are legitimate and appropriate interests. All ought to share a concern for the public good, but they, like the rest of us, will conceive the public good from different perspectives. There is no single, privileged position that will allow a value-free, interest-free perspective on society. And that may be just as well.

A fourth point I would underscore is the unavoidability of risk, and the only way to avoid risk is to avoid being born in the first place. Risk can be reduced, but it is hard to imagine a risk-free life in a technological society. Nor can we return to an earlier time. We well know that life in nontechnological societies carries a wide range of risks also, primarily direct risks to health as a result of disease. The future will carry risk, and if we want to escape to patterns of life of the past, we would simply get a new set of risks.

The next broad point I would mention is the necessity of an open and clear political process. Judge David L. Bazelon and Dr. Harold P. Green have both reiterated, effectively and persuasively, the need for an open and clear political process in establishing policies concerning a risk and benefits. Of course an open political process is often a confused and tumultuous process—it opens the door to irrationality, to hysteria, and to a manipulation of that process by the clever. Nonetheless, the more tidy alternative, decisions made by small groups of experts, has even greater liabilities, among them the likelihood that the values of experts will differ from those of the general public, the likelihood of private arrangements and consensuses shared only by a few, and the violation of a very central democratic principle—that those who are going to be affected by decisions ought to have a role in the making of those decisions.

The last very broad point I would like to make before moving on to some specific moral principles, is that it seems to me imperative we develop a broad moral bias. Let me explain what I mean.

If it is not possible to perfectly distinguish between facts and values, and if it is also true that our values are likely to color the way we gather and interpret facts, then it is important to be self-perceptive about where our general bias or predisposition lies. Perfect neutrality is not possible, and neither is perfect scientific objectivity. In the past there was, with technology, a strong bias in the direction of gambling, of not worrying fully about the problems of safety and the protection of the public. Now, the pendulum seems to have swung, and the general bias now seems to be that of caution, even at the risk of hindering technological innovation, or of increasing costs. That bias now colors a great number of policy decisions, and it is obviously present in much recent legislation on health and safety. On the whole, it is reasonable bias, given the fact of very rapid technological change and the proliferation of many previously unknown hazards and dangers.

The broad question now is whether that bias has gone too far, and whether some swing back toward a more open, less worrisome and anxious spirit is necessary. My own tendency is to think that the bias of caution is appropriate, and that while there are problems of excessive regulation, and a very high, almost neurotic level of anxiety on many possible hazards, we need to live with that for a time to fully measure the consequences. One way or the other, however, we cannot do without a general bias, and that inevitably means that the burden of proof must lie with one group or another. At the moment, the burden of proof lies with those who would push ahead technologically; society is asking them to prove that the changes and advances they propose will not do harm to the public. Perhaps that burden is excessive, but, again, I think we need to live with that a bit longer before we are in a position to say that the bias ought to swing back toward the older, more care-free standards.

Let me say something about what I take to be the moral principles that ought to be addressed in considering risk-benefit analysis. The first and most important I take to be the principles of justice and equity. All public policy decisions result in a distribution of benefits and burdens. Some will gain from a decision, others will lose. The most important technical shortcoming of risk-benefit analysis is that it has no effective way of determining how risk and benefits will in fact be distributed, and no criteria whatever for determining how they ought to be distributed. Risk-benefit analysis must, therefore, be supplemented by a moral analysis. The first moral question to be asked is this: How ought benefits and risks be distributed? What counts as a fair and equitable distribution? It is a good rule of thumb to assume that no policy based directly on risk-benefit analysis will automatically distribute benefits and burdens fairly. That will happen only as the result of a deliberate additional effort. A very heavy burden of risk on one group, while another group gains most of the benefits, is clearly inequitable. All policies need to be devised with a view toward fairly distributing risks and benefits. A straight utilitarian calculus, the greatest good of the greatest number, is hardly likely to be sufficient. A major drawback of the utilitarian principle is that it allows in principle a very unfair distribution of burdens. Some can, under that principle, be allowed to suffer severely for the benefit of the greater majority, a patently unfair outcome. The principle of justice is a necessary corrective of utilitarianism.

It is of course unlikely that in the real world a perfect distribution of risk and benefits can always be found. I would propose in that case a negative test: Any policy developed out of risk-benefit analysis that clearly maldistributes the burden of risk is wrong because unfair; it ought to be abandoned. Put another way, any policy that works to the direct harm of a small group of people, however great the benefits to a large group, cannot be morally acceptable.

Let me suggest a second moral principle, that of truth telling; and, for the sake of justice, the virtue of truth telling must be paramount. In many cases of risk-benefit analysis, naturally, the whole truth will not be known, and in those cases the uncertainty must readily be admitted. Truth telling is not just the absence of lying. On the contrary, the full truth will be that which provides the richest perspective on reality, however complex or muddy. That perspective may be clear in places, and exceedingly unclear in others, but if that is the full reality, then that reality must be revealed. It should also be borne in mind that the truth must be told to oneself as well as others, and that is sometimes the most difficult task of all, particularly when risk-benefit analysis can go in a direction we favor or one we don't favor; it is easy in those circumstances to get ourselves to not notice it.

A third very broad moral area I would point to is the relationship between individual freedom and governmental paternalism. One of the most difficult moral issues is the extent to which individuals should be left free to make their own decisions, and the extent to which the government should intervene to protect them. Our society has had a strong bias in favor of individual freedom and against paternalism. However, as we well know in the case of environmental and other large-scale hazards, there is very little individual choice possible even for mature and informed adults; and choice is of course considerably diminished in the case of children and other dependents, who are in no position to make a decision of any kind. Moreover, in many circumstances, freedom of choice can be an illusion—a worker might ideally choose not to undertake hazardous employment, but if that is the only employment available, then there is no real choice at all.

There is no simple or general solution to the question of how much freedom individuals ought to have, and when government should step in to protect them—and there is nothing at all in risk-benefit analysis helpful in striking the right balance. Again I would propose a negative test, if a policy does not allow individuals free choice, then the burden of proof ought to be on those who would curtail that choice. A policy that severely restricts choice, particularly in the face of a demand for choice, should be seen as a doubtful one on the face of it. While it will be difficult to quantify, a risk to freedom is a moral burden that, on occasion, can have as great a weight as a burden to life or health.

The final point I would like to make is the importance of devising a very rough set of priorities. Those priorities can be reviewed and revised from time to time, but it is an illusion of rationality to think that all possibilities can or ought to be put on an equal footing from the outset. It is better to realize that we must come to the evidence with some set of values and then work with their implications. I suggest above it is necessary to have some kind of bias, the bias either toward caution or toward risk taking. What would a set of rough priorities look like? Following my own bias toward caution, I would propose

something like the following: That a risk to life is greater than a risk of physical disability, that a risk of disability is greater than a risk to economic benefits, and that a risk to economic benefits is greater than a risk to the personal pleasures and predilection of individuals. To such a list of priorities, one might add certain other considerations. It would not be inconsistent with what I have already said to suggest that, if a group is prepared knowingly and voluntarily to accept a risk to their lives, they might then come up with a different set of priorities; economic losses might, for them, be seen as a greater risk. If they were genuinely in a position to bear the risks they are prepared to accept, and if those risks would be equitably distributed, then one might be prepared to override the ordinary ranking of priorities in their case. The point is not that there ought to be a fixed and rigid set of priorities. On the contrary, there ought only to be a rough working set of priorities together with some general principles that would serve to rationally justify the suspension or overturning of higher priorities in special circumstances.

Finally, I would say the key to all morality is that of bearing moral responsibility. It is obvious, to me at least, that in the case of risk-benefit analysis, scientists have a special responsibility to make the best use they can of scientific methodology, and to present to the public the best risk-benefit evidence and information they are able to amass. And legislators have a special responsibility, as they analyze risk-benefit data, to consider the common good and, in the process, to balance the legitimate interests of different groups in the society. Individual citizens have a special responsibility to be concerned about the welfare of those toward whom they have special obligations, for instance the obligations of parents toward children, which as any parent knows requires almost daily risk-benefit analysis.

Moral responsibility, I think, involves something more than an accountability. It is not enough to be able to point a finger at somebody who made a mistake or did something wrong, nor for some of these individuals to be able to say, "I am prepared to take the blame." Moral responsibility is broader than that of accountability, and I would also suggest that those who are in positions of making decisions and those in positions of making scientific evidence which will help in making the decisions bear a special responsibility.

There is no easy way to discharge that responsibility, but I will take it that is where the final test will lie. How that is done and how seriously and soberly will make a critical difference.

Thank you. [Applause.]

Mr. PEASE. Thank you, Dr. Callahan.

Our final discussion this morning will be from Paul Slovic, research associate at Decision Research, Inc., a branch of Perceptronics Inc., which he and two associates cofounded in 1976. They have coauthored numerous journal articles in the area of human judgment, decision-making, and risk assessment. Dr. Slovic has a Ph. D. from the University of Michigan; before the formation of Decision Research, he spent 12 years on the staff of the Oregon Research Institute.

Dr. Slovic.

[The prepared statement of Dr. Slovic follows:]

Risk Assessment: Technical and Behavioral Issues

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Risk Assessment: Technical and Behavioral Issues

Citizens of modern industrial societies are learning a harsh and discomfoting lesson: the benefits from technology must be paid for not only with money, but with environmental degradation, anxiety, illness, injury and premature loss of life. Through the news media, the American public has experienced a relentless parade of new and exotic hazards. As Rabinowitch (1972) observed:

One day we hear about the danger of mercury, and run to throw out cans of tuna fish from our shelves; the next day the food to shun may be butter, which our grandparents considered the acme of wholesomeness; then we have to scrub the lead paint from our walls. Today, the danger lurks in the phosphates in our favorite detergents; tomorrow the finger points to insecticides, which were hailed a few years ago as saviors of millions from hunger and disease. The threats of death, insanity and--somehow even more fearsome--cancer lurk in all we eat or touch (p. 5).

The daily discovery of new threats and their widespread publicity threatens to create a national neurosis characterized by mistrust of technology and obsessive preoccupation with risk. The urgent need to help society cope with risks has produced a new intellectual discipline, "risk assessment" (Fischhoff, Slovic, & Lichtenstein, 1979; Kates, 1978; Lowrance, 1976; Otway & Pahner, 1976; Rowe, 1977; Slovic, Fischhoff, & Lichtenstein, 1979). Risk assessment has two major components (see Figure 1). An estimation component aims to identify hazards, determine the nature of the possible consequences, and assess the probabilities of

those consequences. The term "risk perception" applies to these processes. The evaluation component attempts to determine which hazards, in what form, society should tolerate. As the left side of Figure 1 indicates, there are a variety of approaches to evaluating hazards, of which risk/benefit is but one. We shall compare and critique these approaches in the course of this testimony.

Performing a risk assessment requires an extraordinary degree of cooperation between technology sponsors, the public, its representatives, and specialists from many fields. Technical issues require the efforts of physicists, biologists, chemists, and engineers. Social issues involve lawyers, political scientists, geographers, sociologists, economists, and psychologists. Specialists in decision making attempt to coordinate this diverse expertise. They ask, in effect: "Given our society's values and all this knowledge, what actions should be recommended?"

However valid such assessments might be, the decisions eventually taken by society will reflect social and political pressures as well as the calm, analytic weighing of costs and benefits. Before acting, participants in those decisions must judge for themselves the possible consequences of a technology, the likelihood that these consequences will occur, their importance, and the combined implications of these various considerations. Whether or not these decision makers will use risk assessments to supplement and guide their intuitions may depend on numerous factors, which we shall discuss below.

Despite an appearance of objectivity, risk assessment is inherently subjective. Rarely will relevant statistical data (e.g., historical

failure rates or precise dose-response curves) be available. When they are, interpretation of such data is still subjective (e.g., Is the situation the same now as it was in the past?). More often, especially with new technologies, the risks must be estimated by applying engineering judgment to blueprints or extrapolating from data on related systems and tests. For the lay person, lacking specialized training and access to data, the decision process will be even more subjective.

This testimony explores some of the intellectual elements in the risk assessment process that are critical to the management of hazards. Its basic premises are that both the public and the experts are necessary participants in the process, that the process is inevitably subjective, and that understanding the limitations of judgmental abilities and proposed decision-making technologies is crucial to effective hazard management.

Risk Estimation: Perceived Risk

People respond to the hazards they perceive. If their perceptions are faulty, efforts at public and environmental protection are likely to be misdirected. For some hazards, extensive statistical data are readily available; for example, the frequency and severity of motor vehicle accidents are well documented. For other familiar activities, such as the use of alcohol and tobacco, the hazardous effects are less readily discernible and their assessment requires complex epidemiological and experimental studies. But in either case, the hard facts go only so far, and then human judgment is needed to interpret the findings and determine their relevance for the future.

Other hazards, such as those associated with recombinant DNA research or nuclear power, are so new that risk assessment must be based on theo-

retical analyses such as fault trees (see Figure 2), rather than on direct experience. While sophisticated, these analyses, too, include a large component of human judgment. Someone, relying on educated intuition, must determine the structure of the problem, the consequences to be considered, and the importance of the various branches of the fault tree. Once the analyses have been performed, they must be communicated to the various people who are actually responsible for dealing with the hazards, including industrialists, environmentalists, regulators, legislators, and voters. If these people do not see, understand, or believe these risk statistics, then distrust, conflict, and ineffective hazard management can result.

Judgmental Biases

When people are asked to evaluate risks, they seldom have statistical evidence on hand. In most cases, they must rely on inferences based on what they remember hearing or observing about the risk in question. Recent psychological research has identified a number of general inferential rules that people seem to use in such situations (Slovic, Fischhoff, & Lichtenstein, 1977; Tversky & Kahneman, 1974). These judgmental rules, known technically as heuristics, are employed to reduce difficult mental tasks to simpler ones. Although valid in some circumstances, in others they can lead to large and persistent biases with serious implications for risk assessment.

Availability. One heuristic that has special relevance for risk perception is known as "availability" (Tversky & Kahneman, 1973). People who use this heuristic judge an event as likely or frequent if instances

of it are easy to imagine or recall. Frequently occurring events are generally easier to imagine and recall than rare events. Thus, availability is often an appropriate cue. However, availability is also affected by numerous factors unrelated to frequency of occurrence. For example, a recent disaster or a vivid film such as "Jaws" can seriously distort risk judgments.

Availability-induced errors are illustrated by several recent studies in which we asked college students and members of the League of Women Voters to judge the frequency of various causes of death, such as smallpox, tornadoes, and heart disease (Lichtenstein et al., 1978). In one study, these people were told the annual death toll for motor vehicle accidents in the United States (50,000); they were then asked to estimate the frequency of forty other causes of death. In another study, participants were given two causes of death and asked to judge which of the two is more frequent. Both studies showed people's judgments to be moderately accurate in a global sense; that is, people usually knew which were the most and least frequent lethal events. However, within this global picture, there was evidence that people made serious misjudgments, many of which seemed to reflect availability bias.

Figure 3 compares the judged number of deaths per year with the actual number according to public health statistics. If the frequency judgments were accurate, they would equal the actual death rates, and all data points would fall on the straight line making a 45 degree angle with the axes of the graph. In fact, the points are scattered about a curved line that sometimes lies above and sometimes below the line of accurate judgment. In general, rare causes of death were overestimated, and common causes of death were underestimated. As a result, while the

actual death toll varied over a range of one million, average frequency judgments varied over a range of only a thousand.

In addition to this general bias, many important specific biases were evident. For example, accidents were judged to cause as many deaths as diseases, whereas diseases actually take about fifteen times as many lives. Homicides were incorrectly judged to be more frequent than diabetes and stomach cancer. Homicides were also judged to be about as frequent as stroke, although the latter actually claims about 11 times as many lives. Frequencies of death from botulism, tornadoes, and pregnancy (including childbirth and abortion) were also greatly overestimated.

Table 1 lists the lethal events whose frequencies were most poorly judged in our studies. In keeping with availability considerations, overestimated items were dramatic and sensational, whereas underestimated items tended to be unspectacular events, which claim one victim at a time and are common in nonfatal form. A study of newspaper reporting of deaths shows much the same biases as those in Table 1 (Combs & Slovic, in press).

In the public arena the availability heuristic may have many effects. For example, the biasing impact of memorability and imaginability may pose a barrier to open, objective discussions of risk. Consider an engineer demonstrating the safety of subterranean nuclear waste disposal by pointing out the improbability of each branch of the fault tree in Figure 2. Rather than reassuring the members of the audience, the pre-

sentation might lead them to think, "I didn't realize there were so many things that could go wrong." The very discussion of any low-probability hazard may increase the judged probability of that hazard, regardless of what the evidence indicates.

In other situations, availability may lull people into complacency. In a recent study (Fischhoff, Slovic, & Lichtenstein, 1978), we presented people with various versions of a fault tree showing the "risks" of starting a car (reproduced in Figure 4). Participants were asked to judge the completeness of the representation that they saw. Their estimate of the proportion of no-starts falling in the category labeled "all other problems" was about the same when looking at the full tree of Figure 4 or at versions in which half of the branches were deleted. Such "pruning" should have dramatically increased the judged likelihood of "all other problems." However, it did not. In keeping with the availability heuristic, what was out of sight was effectively out of mind.

Overconfidence. A particularly pernicious aspect of heuristics is that people are typically very confident about judgments based on them. For example, in a follow-up to the study on causes of death, participants were asked to indicate the odds that they were correct in their judgments about which of two lethal events was more frequent (Fischhoff, Slovic, & Lichtenstein, 1977). Odds of 100:1 or greater were given often (25 percent of the time). However, about one out of every eight answers associated with such extreme confidence was wrong (fewer than 1 in 100 would have been wrong if the odds had been appropriate). About 30 percent of

the judges gave odds greater than 50:1 to the incorrect assertion that homicides are more frequent than suicides. The psychological basis for this unwarranted certainty seems to be that people are insensitive to the tenuousness of the assumptions upon which their judgments are based (in this case, the validity of the availability heuristic). Such overconfidence is dangerous. It indicates that we often do not realize how little we know and how much additional information we need about the various problems and risks we face.

Overconfidence manifests itself in other ways as well. A typical task in estimating failure rates or other uncertain quantities is to set upper and lower bounds so that there is a 98 percent chance that the true values lies between them. Experiments with diverse groups of people making many different kinds of judgments have shown that, rather than 2 percent of true values falling outside the 98 percent confidence bounds, 20 percent to 50 percent do so (Lichtenstein, Fischhoff, & Phillips, 1977). People think that they can estimate such values with much greater precision than is actually the case.

Unfortunately, experts seem as prone to overconfidence as lay people. When the fault tree study described above was repeated with a group of professional automobile mechanics, they, too, were insensitive to how much had been deleted from the tree. Hynes and Vanmarcke (1976) asked seven "internationally known" geotechnical engineers to predict the height of an embankment that would cause a clay foundation to fail and to specify confidence bounds around this estimate that were wide enough to have a 50 percent chance of enclosing the true failure height. None of the bounds specified by these experts actually did enclose the true failure height. The multi-million dollar Reactor Safety Study (the "Rasmussen

Report"), in assessing the probability of a core melt in a nuclear reactor, used a procedure for setting confidence bounds that has been found in experiments to produce a high degree of overconfidence. Related problems led the recent review committee, chaired by H. W. Lewis of the University of California, Santa Barbara, to conclude that the Reactor Safety Study greatly overestimated the precision with which the probability of a core melt had been assessed (U.S. NRC, 1978).

Another case in point is the 1976 collapse of the Teton Dam. The Committee on Government Operations has attributed this disaster to the unwarranted confidence of engineers who were absolutely certain they had solved the many serious problems that arose during construction (U.S. Government, 1976). Indeed, in routine practice, failure probabilities are not even calculated for new dams even though about 1 in 300 fails when the reservoir is first filled. Further anecdotal evidence of overconfidence may be found in many other technical risk assessments. Some common ways in which experts may overlook or misjudge pathways to disaster include:

- Failure to consider the ways in which human errors can affect technological systems. Example: The disastrous fire at the Browns Ferry Nuclear Plant was caused by a technician checking for an air leak with a candle, in violation of standard operating procedures.

- Overconfidence in current scientific knowledge. Example: The failure to recognize the harmful effects of X-rays until societal use had become widespread and largely uncontrolled.

- Insensitivity to how a technological system functions as a whole. Example: Although the respiratory risk of fossil-fueled power plants has been recognized for some time, the related effects of acid rains on ecosystems were largely missed until very recently.

- Failure to anticipate human response to safety measures. Example:

The partial protection offered by dams and levees gives people a false sense of security and promotes development of the flood plain. When a rare flood does exceed the capacity of the dam, the damage may be considerably greater than if the flood plain had been unprotected. Similarly, "better" highways, while decreasing the death toll per vehicle mile, may increase the total number of deaths by increasing the number of miles driven.

Desire for certainty. Every technology is a gamble of sorts and, like other gambles, its attractiveness depends on the probability and size of its possible gains and losses. Both scientific experiments and causal observation show that people have difficulty thinking about and resolving the risk/benefit conflicts even in simple gambles. One way to reduce the anxiety generated by confronting uncertainty is to deny that uncertainty. The denial resulting from this anxiety-reducing search for certainty thus represents an additional source of overconfidence. This type of denial is illustrated by the case of people faced with natural hazards, who often view their world as either perfectly safe or as predictable enough to preclude worry. Thus, some flood victims interviewed by Kates (1962) flatly denied that floods could ever recur in their areas. Some thought (incorrectly) that new dams and reservoirs in the area would contain all potential floods, while others attributed previous floods to freak combinations of circumstances, unlikely to recur. Denial, of course, has its limits. Many people feel that they cannot ignore the risks of nuclear power. For these people, the search for certainty is best satisfied by outlawing the risk.

Scientists and policy makers who point out the gambles involved in societal decisions are often resented for the anxiety they provoke. Borch (1968) noted how annoyed corporate managers get with consultants who give them the probabilities of possible events instead of telling them exactly what will happen. Just before a blue-ribbon panel of scientists reported that they were 95 percent certain that cyclamates do not cause cancer, Food and Drug Administration Commissioner Alexander Schmidt said, "I'm looking for a clear bill of health, not a wishy-washy, iffy answer on cyclamates" (Eugene Register-Guard, 1976). Senator Edmund Muskie has called for "one-armed" scientists who do not respond "on the one hand, the evidence is so, but on the other hand . . ." when asked about the health effects of pollutants (David, 1975).

The search for certainty is legitimate if it is done consciously, if the remaining uncertainties are acknowledged rather than ignored, and if people realize the costs of certainty. If a very high level of certainty is sought, those costs are likely to be high. Eliminating uncertainty may mean eliminating the technology and foregoing its benefits. Often some risk is inevitable. Efforts to eliminate it may only alter its form. We must choose, for example, between the vicissitudes of nature on an unprotected flood plain and the less probably, but potentially more catastrophic, hazards associated with dams and levees.

What Determines Perceived Risk

What accounts for people's extreme aversion to some hazards, their indifference to others, and the discrepancies between these reactions and experts' recommendations? Why, for example, do some communities react vigorously against locating a liquid natural gas terminal in their

vicinity despite the assurances of experts that it is safe? Why do other communities situated on flood plains and earthquake faults or below great dams show little concern for the expert's warnings?

My colleagues Sarah Lichtenstein, Baruch Fischhoff, and I have been engaged in a research program designed to provide answers to these questions. We have asked lay persons and experts to judge the present risks of death from a large set of activities and technologies including nuclear power, motor vehicles, handguns, smoking, pesticides, and skiing. In addition, we asked these people to estimate the fatalities from each activity during the next year under the assumption that next year was an average year. Finally, we asked them to estimate the fatalities assuming the next year was a particularly disastrous one.

This research, summarized in a report by Slovic, Fischhoff, and Lichtenstein (1979), produced several interesting results. We found strong differences in the risk judgments of experts and lay persons (see Table 2). Experts' risk judgments were closely related to annual fatality rates. However, lay persons' risk judgments were only moderately related to these rates. The risk perceptions of lay people, but not of experts, were highly related to the estimated fatalities in a disastrous year, defined as "the worst they could imagine occurring in their lifetime."

Lay people judged nuclear power to have a very high degree of risk, but very few fatalities in an average year. A disastrous year for nuclear power, however, was judged to be far worse than that for any other technology. Further study showed that people's mental images of a nuclear accident include the spectre of hundreds of thousands, even millions of immediate

deaths, accompanied by incalculable and irreversible damage to the environment (Slovic, Lichtenstein, & Fischhoff, in press). These images bear little resemblance to the views of most technical experts. In sum, perceived potential for large-scale catastrophe plays an important role in determining the strong aversion observed to hazards such as nuclear power.

In a further attempt to improve our understanding of perceived risk, we examined the hypothesis that some hazards are feared more than others because the deaths they produce are much "worse" than deaths from other activities. We thought, for example, that deaths from risks imposed involuntarily, from risks not under one's control, or from hazards that are particularly dreaded might be given greater weight in determining people's perceptions of risk.

However, when we asked people to judge the relative "seriousness" to society of a death from each of the thirty activities and technologies, the differences were slight. The most serious forms of death (from nuclear power and handguns) were judged to be only about two to four times worse than the least serious forms of death (from alcoholic beverages and smoking). Furthermore, across all thirty activities, judged seriousness of death was not closely related to perceived risk of death.

Reconciling Divergent Opinions

Our data show that experts and lay people have quite different perceptions about how risky certain technologies are. For some hazardous activities, such as nuclear power, these differences can be best described as "immense." Kasper (in press) has commented at length on the consequences of such great discrepancies between expert and lay judgments of techno-

logical risks. One consequence is that experts, fearing overreaction by the public, feel forced to overstate the precision of their estimates. A more important consequence is the confusion and distrust on the part of a public which believes the risks to be vastly greater than the experts' assessments indicate. The experts, in turn, question the rationality of the public and decry the emotionalism stymying technological progress. Thus, the stage is set for bitter and possibly violent confrontations.

Recognition of these problems has naturally resulted in the belief that the public must be educated about the "real" risks from nuclear power. One public opinion analyst put the matter as follows:

The biggest problem hindering a sophisticated judgment on this question is basic lack of knowledge and facts. Within this current attitudinal milieu, scare stories, confusion, and irrationality often triumph. Only through careful education of facts and knowledge can the people know what the real choices are and can thereafter make the decision wisely (Pokorny, 1977, p. 12).

While we, too, favor educational attempts, we believe they face immense difficulties which must be recognized. This pessimistic stance is based on two key aspects of the problem, one technical and one psychological. The technical problem is that disputed risks are often so improbable that they are not amenable to precise empirical verification. The psychological problem is that people's perceptions are not irrational, but are based on normal ways of thinking which, when applied to the special qualities of certain risks, are likely to thwart attempts to modify beliefs.

Reliance on indicators such as memorability and imaginability, as noted above, is one such mode of thought that leads to strongly held but divergent views. Another psychological problem is demonstrated by the large body of research showing that people's beliefs change slowly and are extraordinarily persistent in the face of contrary evidence (Ross, 1977). Once formed, initial impressions tend to structure the way that subsequent evidence is interpreted. New evidence appears reliable and informative if it is consistent with one's initial belief; contrary evidence is dismissed as unreliable, erroneous, or unrepresentative. Thus, depending on one's predispositions, intense effort to reduce a hazard may be interpreted to mean either that the risks are great or that the technologists are responsive to the public's concerns. Likewise, the incident at Three Mile Island "proved" the likely possibility of a nuclear reactor meltdown to some people, while to others it reinforced their faith in the effectiveness of the multiple safety systems. Like other cognitive biases, unreasonable refusal to listen to contradictory evidence is probably as common among experts as among lay people.

From a statistical standpoint, convincing people that the catastrophe they fear is extremely unlikely is difficult under the best conditions. Any mishap could be seen as proof of high risk, whereas demonstrating safety would require a massive amount of evidence (Green & Bourne, 1972). Nelkin's case history of a nuclear siting controversy (Nelkin, 1974) provides a good example of the inability of technical arguments to change opinions. In that debate, each side capitalized on technical ambiguities in ways that reinforced its own position.

The Fallibility of Judgment

Our examination of risk perception leads us to the following conclusions:

- Cognitive limitations, coupled with the anxieties generated by facing life as a gamble, cause uncertainty to be denied, risks to be distorted, and statements of fact to be believed with unwarranted confidence.

- Perceived risk is influenced (and sometimes biased) by the imaginability and memorability of the hazard. People may, therefore, not have valid perceptions even for familiar risks.

- There were some striking discrepancies between expert and lay judgment. Our experts' risk perceptions corresponded closely to statistical frequencies of death, while lay people's risk perceptions were based only in part upon frequencies of death. Lay people appear particularly sensitive to catastrophic potential which they sometimes perceive to be vastly greater than indicated by experts' estimates.

- Disagreements about risk should not be expected to evaporate in the presence of "evidence." Definitive evidence, particularly about rare hazards, is difficult to obtain. Weaker information is likely to be interpreted in a way that reinforces existing beliefs.

The significance of these results hinges upon one's acceptance of our assumption that subjective judgments are central to the hazard management process. Our conclusions mean little if one can assume that there are analytical tools that can be used to assess most risks in a mechanical fashion and that all decision makers have perfect information and the know-how to use it properly. These results gain in importance to the extent that one believes, as we do, that expertise involves a large

component of judgment, that the facts are not all in (or obtainable) regarding many important hazards, that people are often poorly informed or misinformed, and that they respond not just to numbers but also to qualitative aspects of hazards.

Whatever the role judgment plays in the risk estimation process, its products should be treated with caution. Research not only demonstrates that judgment is fallible, but it shows that the degree of fallibility is often surprisingly great and that faulty beliefs may be held with great confidence.

Since it can be shown that even well-informed lay people have difficulty judging risks accurately, it is tempting to conclude that the public should be removed from the hazard-management process. The political ramifications of such a transfer of power to a technical elite are obvious. Indeed, it seems doubtful that such a massive disenfranchisement is feasible in any democratic society.

Furthermore, this transfer of decision making would seem to be misguided. For one thing, we have no assurance that experts' judgments are immune to biases once they are forced to go beyond their precise knowledge and rely upon their judgment. Although judgmental biases have most often been demonstrated with lay people, there is evidence that the cognitive functioning of experts is basically like that of everyone else.

In addition, in many if not most cases effective hazard management requires the cooperation of a large body of lay people. These people must agree to do without some things and accept substitutes for others; they must vote sensibly on ballot measures and for legislators who will serve them as surrogate hazard managers; they must obey safety rules and use the legal system responsibly. Even if the experts are much better

judges of risk than lay people, giving experts an exclusive franchise on hazard management would involve substituting short-term efficiency for long-term effort needed to create an informed citizenry (Fischhoff, in press-c).

Risk Evaluation: Acceptable Risk

Once a hazard is identified and its risks estimated, the question of acceptability becomes preeminent. This question, well known in its generic form "How safe is safe enough?", takes on such specific guises as "Do we need better containment shells around our nuclear power plants?", "Is the carcinogenic risk of saccharin sufficiently low to allow its use?", "Should schools with asbestos ceilings be closed?", etc.

Lack of adequate answers to such questions has bedeviled hazard management and has led to a search for clear, implementable rules which will indicate whether or not a given hazardous activity is sufficiently safe (Fischhoff, Slovic, & Lichtenstein, 1979). Risk/benefit analysis, a form of cost/benefit analysis in which the major costs include risks to life, limb or property, is the major approach, and we shall examine it extensively in this section. However, to place risk/benefit analysis in perspective, it is useful to consider some of its major competitors such as revealed preferences, expressed preferences, and natural standards. All of these approaches have their pros and cons, their uses and limitations.

Revealed Preferences

One well-known approach to determining acceptable risks is the method of revealed preferences advocated by Chauncy Starr (1969). This approach is based on the assumption that, by trial and error, society has arrived

at an "essentially optimum" balance between the risks and benefits associated with any activity. As a result, it is assumed that economic risk and benefit data from recent years will reveal patterns of acceptable risk-benefit tradeoffs. Acceptable risk for a new technology is defined as that level of safety associated with ongoing activities having similar benefit to society. Starr argued the potential usefulness of revealed preferences by examining the relationship between risk and benefit across a number of common activities.

From this analysis, Starr derived what might be called "laws of acceptable risk":

The acceptability of risk is roughly proportional to the third power (cube) of the benefits.

The public seems willing to accept risks from voluntary activities (e.g., skiing) roughly a thousand times greater than it would tolerate from involuntary activities (e.g., food preservatives) providing the same level of benefit.

The acceptable level of risk is inversely related to the number of persons exposed to that risk.

Although based upon an intuitively compelling logic, the method of revealed preferences has several drawbacks. It assumes that past behavior is a valid predictor of present preferences, perhaps a dubious assumption in a world where values can change quite rapidly. It is politically conservative in that it enshrines current economic and social arrangements. It ignores distributional questions (who assumes what risks and who gets what benefits?). It may underweigh risks to which the market responds sluggishly, such as those involving a long time lag between exposure and consequences (as in the case of carcinogens). It

makes strong (and not always supported) assumptions about the rationality of people's decision making in the marketplace and about the freedom of choice that the marketplace provides. Consider the automobile, for example. Unless the public really knows what safety is possible from a design standpoint, and unless the industry provides the public with a set of alternatives from which to choose, market behavior may not indicate what a reflective individual would decide after thoughtful and intensive inquiry.

A revealed preference approach assumes not only that people have full information, but also that they can use that information optimally, an assumption which seems quite doubtful in the light of much research on the psychology of decision making. Finally, from a technical standpoint, it is no simple matter to develop the measures of risks and benefits needed for the implementation of this approach.

Expressed Preferences

Revealed preference analyses must infer public values indirectly, using procedures that may be both theoretically and politically untenable. The expressed preference approach tries to circumvent this problem by asking people directly what levels of safety they deem acceptable (see Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978).

The appeal of this approach is obvious. It elicits current preferences; thus it is responsive to changing values. It also allows for widespread citizen involvement in decision making, and thus should be politically acceptable. It allows consideration of all aspects of risks and benefits, including those not readily converted into dollars and body counts. Some ways of obtaining expressed preferences are through refer-

enda, opinion surveys, detailed questioning of selected groups of citizens, interviewing "public interest advocates," and hearings.

One frequent criticism of the expressed preferences approach is that safety issues are too complicated for ordinary citizens to understand. However, the results just cited suggest that, in some situations at least, motivated lay people can produce orderly, interpretable responses to complex questions.

A related criticism is that, when it comes to new and complex issues, people do not have well-articulated preferences. In some fundamental sense their values may be incoherent--not though through (Fischhoff, Slovic, & Lichtenstein, in press). In thinking about acceptable risks, people may be unfamiliar with the terms in which the issues are formulated (social discount rates, miniscule probabilities, mega-deaths). They may have contradictory values (a strong aversion to catastrophic losses of life and a realization that they are not more moved by a plane crash with 500 fatalities than one with 300. They may occupy different roles in life (parents, workers, children) which produce clear-cut but inconsistent values. They may vacillate between incompatible, but strongly held, positions (freedom of speech is inviolate, but it should be denied to authoritarian movements). They may not even know how to begin thinking about some issues (how to compare the opportunity to dye one's hair with a vague, minute increase in the probability of cancer twenty years from now). Their views may change over time (say, as the hour of decision or the consequence itself draws near), and they may not know which view should form the basis of a decision.

In such situations, where people do not know what they want, the values they express may be highly unstable. Subtle changes in how is-

sues are presented, how questions are phrased, and how responses are elicited can have marked effects on their expressed preferences. The particular question posed may evoke a central concern or peripheral one; it may help clarify the respondent's opinion or irreversibly shape it; it may even create an opinion where none existed before.

Three features of these shifting judgments are important. First, people are typically unaware of the extent of such shifts in their perspective. Second, they often have no guidelines as to which perspective is the appropriate one. Finally, even when there are guidelines, people may not want to give up their own inconsistency, creating an impasse.

Natural Standards

A shared flaw of approaches to acceptable risk is that all of them are subject to the existing limitations of society and its citizens. It might be desirable to have a standard of safety independent of a particular society, especially for risks whose effects are collective, cumulative, or irreversible. One such alternative is to look to "biological wisdom" to insure the physical well-being of the species. Rather than examining (recent) historical time for guidelines, one might look to geological time, assuming that the optimal level of exposure to pollutants is that characteristic of the conditions in which the species evolved.

Specific proposals derived from this approach might set allowable levels of chemical wastes according to the levels found in archeological remains (Ericson, Shiranata, & Patterson, in press). These standards would not constitute outright bans, as some level of radiation-induced mutation is apparently good for the species and traces of many chemicals

are needed for survival. Since exposure has varied from epoch to epoch and from place to place, one could establish ranges of tolerable exposure.

Natural standards have a variety of attractive features. They avoid problems of converting risks into a common monetary unit (like dollars per life lost). They present issues in a way that is probably quite compatible with people's natural thought processes. Among other things, this approach can avoid any direct numerical reference to very small probabilities, for which people have little or no intuitive feeling. Use of natural standards should produce consistent practices when managing the same emission appearing in different sources of hazards.

As a guide to policy, natural standards are flawed by the fact that our natural exposure to many hazards had not diminished. Thus, whatever new exposure is allowed is an addition to what we are already subjected to by nature and thereby constitutes excess "unnatural" exposure (although conceivably within the range of toleration).

A second problem is that most hazards increase some exposures and reduce others. Trading off different exposures brings one back to the realm of cost-benefit analysis.

Another problem arises when one considers completely new substances for which there is no historical tolerance (saccharin, for example). In such cases, a policy based on natural standards would tolerate none of the substance at all, unless it involved no risk. The Delaney Amendment, which outlaws the addition of any known carcinogen to food, is consistent with this approach.

The technical difficulties of performing this type of analysis are formidable. Indeed, while there may be some hope of assessing natural

exposure to chemicals and radiation that leave traces in bone or rock, appraising the natural incidence of accidents and infectious disease is probably impossible. Furthermore, should such an analysis be completed, it would quickly become apparent that the ecology of hazard in which humans live has changed drastically over the eons--mostly for the better, as in the case of the reduced incidence of infectious disease. The biological wisdom (or importance) of restoring one component of the mix to its prehistoric values would demand careful examination.

In addition to whatever difficulties there may be with their internal logic and implementation, natural standards are likely to fail as a sole guide to policy because they ignore the benefits that accompany hazards and the costs of complying with the standards.

Cost/Risk/Benefit

This brings us to risk/benefit analysis, which we shall discuss in its more general forms, cost/benefit analysis and decision analysis. Our comments apply equally well to each of these forms. Cost/benefit analysis attempts to indicate whether the expected benefits from a proposed activity outweigh its expected costs. The first steps in calculating the expected cost of a project are: to enumerate all the adverse consequences that might result from its implementation; to assess the probability of each such consequence; and to estimate the cost or loss to society whenever the consequence occurs. Next, the expected cost of each possible consequence is calculated by multiplying the cost of the consequences by the probability that it will be incurred. The expected cost of the entire project is computed by summing the expected losses associated with the various possible consequences. An analogous pro-

cedure produces an estimate of the expected benefits (Fischhoff, 1977). The most general form of cost-benefit analysis is decision analysis, in which the role of uncertainty, the subjective nature of costs and benefits, and the existence of alternative actions are made explicit (Brown, Kahr, & Peterson, 1974; Howard, Matheson, & Miller, 1976).

These procedures, and decision analysis in particular, are based on appealing premises and are supported by sophisticated methodology. Furthermore, they permit considerable flexibility; analyses are readily revised to incorporate new options and new information. An important advantage of these methods for decision making in the public sphere is that they are easily scrutinized. Each quantitative input or qualitative assumption is available for all to see and evaluate, as are the explicit computational rules that combine them.

However, decision analysis and its variants have a number of potentially serious limitations, perhaps the most important of which is their unrealistic assumptions about the availability of the data needed to complete the analysis. Performing a full-dress analysis assumes, among other things, that all possible events and all significant consequences can be enumerated in advance; that meaningful probability, cost, and benefit values can be obtained and assigned to them; and that the often disparate costs and benefits can somehow be made comparable to one another.

Unfortunately, it is sometimes impossible to accomplish some of these tasks, while in the case of others, the results are hardly to be trusted (Fischhoff, in press-a). Despite the enormous scientific progress of the last decade or two, we still do not know all or even most of the possible physical, biological, and social consequences of any large-scale

energy project. As noted earlier, even when we know what the consequences are, we often do not, or cannot, know their likelihood. Even if all the consequences could be enumerated and their likelihood assessed, placing a value on them poses further difficulties. Inferring values on the basis of observed societal actions runs into the pitfalls of the revealed preferences approach. Asking people directly about their values runs into the problem that people often have poorly articulated opinions that are strongly influenced by the methods in which they are assessed.

Risk/benefit analysts attempt to accommodate the uncertainties inherent in the assessment of probabilities and consequence values through the judicious use of sensitivity analysis. The calculations of expected costs and benefits are repeated using alternative values of each troublesome probability, cost, or benefit. If each reanalysis produces the same relative preponderance of expected costs or benefits, then it is argued that these particular differences do not matter.

Unfortunately, however, there are no firm guidelines regarding which of the data might be in error or what range of possible values ought to be tested. A further problem with sensitivity analysis is that it typically tells us little about how the uncertainty from different sources of error is compounded or about what happens when different data are subject to a common bias. The untested assumption is that errors in different inputs will cancel one another, rather than compound in some pernicious way (Fischhoff, in press-b).

In the end, determining the quality of an analysis is a matter of judgment. Someone must use intuition to determine which inputs are of doubtful validity and which alternative values should be incorporated in sensitivity analyses. Essentially, that someone must decide how

good his or her own best judgment is. Unfortunately, an extensive body of research suggests that people tend to overestimate the quality of such judgments (Slovic, Fischhoff, & Lichtenstein, 1979).

Multiple Hazards

Our discussion so far has focused on the acceptable risk associated with individual hazards. What additional problems are created by considering many hazards at once? There are some 60,000 chemicals and 50,000 consumer products in common use in the United States. If even a small fraction of these presented the legal and technical complexities engendered by saccharin or flammable sleepwear (not to mention nuclear power), it would take legions of analysts, lawyers, toxicologists, and regulators to handle the situation. If hazards are dealt with one at a time, many must be neglected. The instinctive response to this problem is to deal with problems in order of importance. Unfortunately, the information needed to establish priorities is not available; the collection of such data might itself swamp the system.

Even if legions of hazard managers were available, the wisdom of tackling problems one at a time is questionable. Responsible management must ask not only which dangers are the worst, but which are the most amenable to treatment. A safety measure that is reasonable in a cost/benefit sense may not seem reasonable in a cost-effectiveness sense. That is, if our safety dollars are limited, finding that the benefits of a particular safety measure outweigh its costs does not preclude the possibility that even greater benefits could be reaped with a like expenditure elsewhere. The hazard-by-hazard approach may cause misallocation of resources across activities (for instance, giving greater pro-

tection to nuclear plant operators than to coal miners) or even within activities (protecting crop dusters but not those in the fields below) (Berman, 1978).

The cumulative danger from a problem that appears in many guises may be hidden from a society that tackles hazards one by one. The current cancer crisis seems to reflect an abrupt realization of the cumulative impact of a risk distributed in relatively small doses over a very large number of sources. The nuclear industry has only recently been alerted to the possibility that temporary workers who receive their legal limit of radiation exposure in one facility may move on unnoticed to another and another (Federal Register, 1978).

Proponents of new products or systems can often argue persuasively that the stringent risk standards imposed upon them by the public constitute irrational resistance to progress. After all, many currently tolerated products have much greater risks with appreciably less benefit. The public may, however, be responding to its overall risk burden, a problem outside these proponents' purview. From that perspective, one of the obvious ways to reduce a currently intolerable risk level is to forbid even relatively safe new hazards unless they reduce our dependence on more harmful existing hazards.

Facing Political Realities

Methods that do not capture the critical facts about a hazard will not pass muster before the scientific community. Approaches that fail to represent the political realities of a situation will be rejected by those interests that are underrepresented. No one method for determining acceptable risk can serve the needs of all the environmentalists, indus-

trialists, regulators, lawyers, and politicians involved with a particular hazard. These people appropriately view each specific decision as an arena in which broader political struggles are waged.

In theory, any of the approaches described here should find some support among public interest advocates and some resistance among technology proponents, since all of them make the decision process more open and explicit than it was in the dark ages of hazard management when matters were decided behind closed doors. However, the enchantment of the public wanes some when closed doors are replaced by opaque analyses that effectively transfer power to the minute technical elite who perform them (McGinty & Atherly, 1977). In such cases, public interest advocates may resist formal analysis, believing that avoiding disenfranchisement is more important than determining acceptable levels of risk.

Such beliefs may underlie much of the concern over the use of risk/benefit analysis to regulate toxic substances and other hazards.

For other members of the public, the openness itself is a sham, since each of these approaches makes the political-ideological assumption that society is sufficiently cohesive and common-goaled that problems can be resolved by reason and without confrontation. Sitting down to discuss a risk/benefit analysis would, in this view, itself constitute the surrender of important principles. Cooperation may even be seen as a scheme to submerge the opposition in paper work and abrogate its right to fight the outcome of an analysis not to its liking (Fairfax, 1978). Such suspicions are most easily justified when the workings of the decision-making process are poorly understood. It is not hard to imagine the observers of a risk/benefit analysis accepting its premises but balking at its conclusions when the results of the analysis are complex or counter-

intuitive. At the extreme, this would mean that people will only believe analyses confirming their prior opinions.

Proponents of a technology would probably prefer to have the determination of risk acceptability left to their own corporate consciences. Barring that (or the equivalent captive regulatory system), proponents may find it easier to live with adversity than with uncertainty. As a result, one would expect industry increasingly to advocate routinized approaches with rigorous deadlines for making decisions. From this perspective, the zenith of the influence of the Toxic Substances Control Act may have been reached immediately after its enactment. At that moment, industry practice could respond only by making all products as safe as possible, not knowing which substances would actually be dealt with nor how stringently. Cynically speaking, the sooner and more precisely the rules are laid down, the more efficacious the search for loopholes can be.

One could draw similar caricatures of the hidden agendas of other (would-be) participants in hazard management. The point of such an assessment is not to argue that reasonable management is impossible, but that all approaches must be seen in their political contexts. Such a broadened perspective may help us to understand the motives of the various participants and the legitimacy that should be assigned to their maneuvers.

In so doing, a crucial issue will be deciding whether society should have higher goals than maximizing the safety of particular technologies. Such goals might include developing an informed citizenry and preserving democratic institutions. In this case, the process could be more important than the product, and it would be important for society to provide the resources needed to make meaningful public participation possible (Casper, 1976). Such participation would require new tools for communicating with

the public--both for presenting technical issues to lay people and for eliciting their values. It might also require new social and legal forms, such as hiring representative citizens to participate in the analytic process, thereby enabling them to acquire the expertise needed by the governed to give their informed consent to whatever decision is eventually reached. Such a procedure might be considered a science court with a lay jury. It would consider any or all of the analytic techniques described here as possible inputs to its proceedings. It might also place the logic of jurisprudence above the logic of analysis, acknowledging that there is no single way to determine what risks are acceptable.

The forums in which safety issues are currently argued were not designed to deal with such problems. Piehler et al. (1974) have, in fact, argued that the legal system could hardly have been designed more poorly for airing and clarifying the technical considerations which arise in product liability suits. Much public opinion about hazards derives from the testimony of experts. Often this testimony is offered in rancorous debates between experts trying to cast doubt on the probity of their opponents (Mazur, 1973). In addition to creating negative attitudes toward scientists, such spectacles tend to destroy public confidence in the possibility of ever understanding or satisfactorily resolving these issues.

Natural disagreements in areas of incomplete knowledge are aggravated by the tendency for bad evidence to drive out good evidence. A two-handed scientist ("on the one hand . . . while on the other . . .") may be tested by a two-fisted debater intent on acquiring converts.

Muddling Through Intelligently

No single approach to acceptable risk is fully adequate. To exploit the contributions each of these methods can make, careful consideration

must be given to the social and political world in which they are used, and to the natural world in which we all live. Our social world is characterized by its lack of orderliness. Since hazards are not the only consideration in hazard-management decisions, the best we can hope for is some intelligent muddling through. Recognizing this, we should develop and apply the various approaches to hazard management not as inviolate ends in themselves but as servants to that process. The openness of formal analyses must be assured in order to avoid suspicion and rejection of whatever conclusions are finally reached. When the available numbers are not trustworthy, we should content ourselves with qualitative structuring of problems. When good numbers are available, but the issues are unfamiliar, great care must be taken in designing suitable presentations. When we do not know what goals we want to reach, value issues should be framed in a variety of ways and their implications carefully explored.

A distinctive characteristic of our natural world is that it typically is not and cannot be known to the desired degree of precision. We must not only acknowledge this uncertainty, but also devote more of our efforts to determining its extent. The most critical input to many hazard management decisions may be how good our best guess is. The real alternatives may be: "If we don't understand it, we shouldn't mess with it" and "If we don't experiment, we'll never know what it means" (Goodwin, 1978).

Uncertainty about facts and uncertainty about values both imply that determining the acceptability of a hazard must be an iterative process, partly because, as time goes on, we learn more about how a hazard behaves and how much we like or dislike its consequences. In

other words, it takes experience which acknowledges the experimental nature of life to teach us what the facts are and what we really want.

Iteration is essential to any well-done risk analysis. A measure of the success of any analysis is its ability to inform (as well as to reflect) our beliefs and values. Once the analysis is completed, we may then be ready to start over again, incorporating our new and better understandings. In this light, many of the non-political critiques generated by the Reactor Safety Study (the "Rasmussen Report"; USNRC, 1975) reflect its success in deepening the respondents' perspectives. As an aid to policy, the study's main weakness was in attempting to close the books prematurely, and thereby failing to take adequate account of these criticisms.

While a good analysis should be insightful, it need not be conclusive. At times, it may not be possible to reach any analytic conclusion, for example, when inter- and intra-personal disagreements are too great to be compromised. If people do not know what they want, or if a topic is so politicized that no solution will ever be acceptable, analysis should perhaps best be treated as a process for deepening knowledge and clarifying positions. Performing the sort of calculations that lead to a specific recommendation would, in such cases, only create an illusion of analyzability.

A Combined Approach

The disciplinary training of scientists shows them how to get the right answers to a set of specially defined problems. The problems raised by hazard management are too broad to be solved by any one discipline. No one knows how to get the right answer. All we can do is

avoid making the particular mistakes to which each of us is attuned. The more scientific and lay perspectives applied to a problem, the better chance we have of not getting it wrong.

Just as no single discipline has all the answers, no one of the approaches discussed above provides a sufficient basis for determining what levels of safety are acceptable. In attempting to solve the problems inherent in the other methods, each approach engenders problems of its own.

Are better approaches likely to come along? Probably not, for it seems as though all attempts to rule on the safety of particular hazards share common conceptual and operational difficulties whose source lies in the very attempt to reduce the problem to manageable size. What we can hope for is to understand the various approaches well enough to be able to use them in combination so that they complement one another's strengths rather than compound each other's weaknesses.

References

- Berman, D. M. How cheap is a life? International Journal of Health Sciences, 1978, 8, 79-99.
- Borch, K. The economics of uncertainty. Princeton, N. J.: Princeton University Press, 1980.
- Brown, R. V., Kahr, A. S. & Peterson, C. Decision analysis for the manager. New York: Holt, Rinehart & Winston, 1974.
- Casper, B. N. Technology policy and democracy. Science, 1976, 194, 29-35.
- Combs, B. & Slovic, P. Causes of death: Biased newspaper coverage and biased judgments. Journalism Quarterly, in press.
- David, E. E. One-armed scientists? Science, 1975, 189, 891.
- Ericson, J., Shirahata, H. & Patterson, C. Skeletal concentrations of lead in ancient Peruvians. New England Journal of Medicine, in press.
- Eugene Register Guard. Doubts linger on cyclamate risks. January 14, 1976.
- Fairfax, S. K. A disaster in the environmental movement. Science, 1978, 199, 743-748.
- Federal Register, February 6, 1978, pp. 1865-1868.
- Fischhoff, B. Cost-benefit analysis and the art of motorcycle maintenance. Policy Sciences, 1977, 8, 177-202.
- Fischhoff, B. Behavioral aspects of cost-benefit analysis. In G. Goodman (Ed.), Impacts and risks of energy strategies: Their analysis and role in management. London: Academic Press, in press.
- Fischhoff, B. Clinical decision analysis. Operations Research, in press.
- Fischhoff, B. Informed consent in societal risk-benefit decisions. Technological Forecasting and Social Change, in press.

- Fischhoff, B., Slovic, P. & Lichtenstein, S. Knowing with certainty: The appropriateness of extreme confidence. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 552-564.
- Fischhoff, B., Slovic, P. & Lichtenstein, S. Fault trees: Sensitivity of estimated failure probabilities to problem representation. Journal of Experimental Psychology: Human Perception and Performance, 1978, 4, 330-344.
- Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S. & Combs, B. How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 1978, 8, 127-152.
- Fischhoff, B., Slovic, P. & Lichtenstein, S. Weighing the risks. Environment, 1979, 21(4), 17-20, 32-38.
- Fischhoff, B., Slovic, P. & Lichtenstein, S. Knowing what you want: Measuring labile values. In T. Wallsten (Ed.), Cognitive processes in choice and decision behavior. Hillsdale, N. J.: Erlbaum, in press.
- Goodwin, R. Uncertainty as an excuse for cheating our children: The case of nuclear wastes. Policy Sciences, 1978, 10, 25-43.
- Green, A. E. & Bourne, A. J. Reliability technology. New York: Wiley Interscience, 1972.
- Howard, R. A., Matheson, J. E. & Miller, K. L. Readings in decision analysis. Menlo Park, California: Stanford Research Institute, 1976.
- Hynes, M. & Vanmarcke, E. Reliability of embankment performance predictions. Proceedings of the ASCE Engineering Mechanics Division Specialty Conference. Waterloo, Ontario, University of Waterloo Press, 1976.

- Kasper, R. G. Perceived risk: Implications for policy. In G. Goodman (Ed.), Impacts and risks of energy strategies: Their analysis and role in management. London: Academic Press, in press.
- Kates, R. W. Hazard and choice perception in flood plain management. Research Paper 78, Department of Geography, University of Chicago, Chicago, 1962.
- Kates, R. W. Risk assessment of environmental hazard. New York: Wiley, 1978.
- Lichtenstein, S., Fischhoff, B. & Phillips, L. D. Calibration of probabilities: The state of the art. In H. Jungermann & G. de Zeeuw (Eds.), Decision making and change in human affairs. Amsterdam: D. Reidel, 1977.
- Lichtenstein, S., Slovic, P., Fischhoff, B., Layman, M. & Combs, B. Judged frequency of lethal events. Journal of Experimental Psychology: Human Learning and Memory, 1978, 4, 551-578.
- Lowrance, W. W. Of acceptable risk. Los Altos, Ca.: Wm. Kaufmann, 1976.
- Mazur, A. Disputes between experts. Minerva, 1973, 11, 243-262.
- McGinty, L. & Atherly, G. Acceptability versus democracy. New Scientist, 1977, 74, 323-325.
- McGrath, P. E. Radioactive waste management: Potentials and hazards from a risk point of view. Report EURFNR-1204 (KFK 1992), Karlsruhe, Germany: U.S.-EURATOM Fast Reactor Exchange Program, June 1974.
- Nelkin, D. The role of experts on a nuclear siting controversy. Bulletin of the Atomic Scientists, 1974, 30, 29-36.
- Otway, H. J. & Pahner, P. D. Risk assessment. Futures, 1976, 8, 122-134.
- Piehler, H. R., Twerski, A. D., Weinstein, A. & Donaher, W. A. Product liability and the technical expert. Science, 1974, 186, 1089-1093.
- Pokorny, G. Energy development: Attitudes and beliefs at the regional/national levels. Cambridge, Ma.: Cambridge Reports, 1977.

- Rabinowitch, E. Living dangerously in the age of science. Bulletin of the Atomic Scientists, 1972, 28(1), 5-8.
- Ross, L. The intuitive psychologist and his shortcomings: Distortions in the attribution process. In L. Berkowitz (Ed.), Advances in Experimental Social Psychology. New York: Academic Press, 1977.
- Rowe, W. D. An anatomy of risk. New York: Wiley, 1977.
- Slovic, P. & Fischhoff, B. How safe is safe enough: Determinants of perceived and acceptable risk. In L. Gould and C. A. Walker (Eds.), Too hot to handle: Public policy issues in nuclear waste management, Yale University Press, in press.
- Slovic, P., Fischhoff, B. & Lichtenstein, S. Behavioral decision theory. Annual Review of Psychology, 1977, 28. 1-39.
- Slovic, P., Fischhoff, B. & Lichtenstein, S. Rating the risks. Environment, 1979, 21(3), 14-20, 36-39.
- Slovic, P., Lichtenstein, S. & Fischhoff, B. Images of disaster: Perception and acceptance of risks from nuclear power. In G. Goodman (Ed.), Impacts and risks of energy strategies: Their analysis and role in management. London: Academic Press, in press.
- Starr, C. Social benefit versus technological risk. Science, 1969, 165, 1232-1238.
- Tversky, A. & Kahneman, D. Availability: A heuristic for judging frequency and probability. Cognitive Psychology, 1973, 4, 207-232.
- Tversky, A. & Kahneman, D. Judgment under uncertainty: Heuristics and biases. Science, 1974, 185, 1124-1131.
- U.S. Nuclear Regulator Commission. Reactor safety study: An assessment of accident risks in U.S. commercial nuclear power plants. WASH 1400 (NUREG-75/014), Washington, D. C., October 1975.
- U. S. Nuclear Regulatory Commission. Risk assessment review group report to the U.S. Nuclear Regulatory Commission. NUREG/CR-0400, Sept. 1978.
- U. S. Government. Teton dam disaster. Committee on Government operations, Washington, D. C. 1976.

SOCIAL POLITICAL INSTITUTIONAL MILIEU

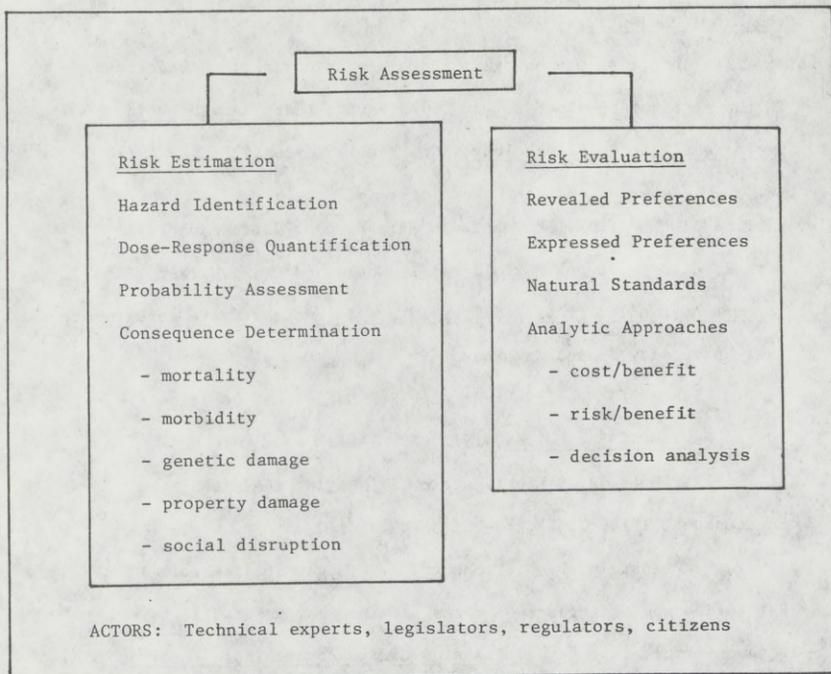


Figure 1. Components of risk assessment.

Table 1

Bias in Judged Frequency of Death

Most Overestimated	Most Underestimated
All accidents	Smallpox vaccination
Motor vehicle accidents	Diabetes
Pregnancy, childbirth, and abortion	Stomach cancer
Tornadoes	Lightning
Flood	Stroke
Botulism	Tuberculosis
All cancer	Asthma
Fire and flames	Emphysema
Venomous bite or sting	
Homicide	

Source: Lichtenstein, et al., 1978.

Table 2
 Ordering of Perceived Risk
 for 30 Activities and Technologies^a

	Group 1 LOWV	Group 2 College Students	Group 3 Active Club Members	Group 4 Experts
Nuclear power	1	1	8	20
Motor vehicles	2	5	3	1
Handguns	3	2	1	4
Smoking	4	3	4	2
Motorcycles	5	6	2	6
Alcoholic beverages	6	7	5	3
General (private) aviation	7	15	11	12
Police work	8	8	7	17
Pesticides	9	4	15	8
Surgery	10	11	9	5
Fire fighting	11	10	6	18
Large construction	12	14	13	13
Hunting	13	18	10	23
Spray cans	14	13	23	26
Mountain climbing	15	22	12	29
Bicycles	16	24	14	15
Commercial aviation	17	16	18	16
Electric power	18	19	19	9
Swimming	19	30	17	10
Contraceptives	20	9	22	11
Skiing	21	25	16	30
X rays	22	17	24	7
High school & college football	23	26	21	27
Railroads	24	23	20	19
Food preservatives	25	12	28	14
Food coloring	26	20	30	21
Power mowers	27	28	25	28
Prescription antibiotics	28	21	26	24
Home appliances	29	27	27	22
Vaccinations	30	29	29	25

^a The ordering is based on the geometric mean risk ratings within each group. Rank 1 represents the most risky activity or technology.

Source: Slovic, Fischhoff & Lichtenstein, 1979.

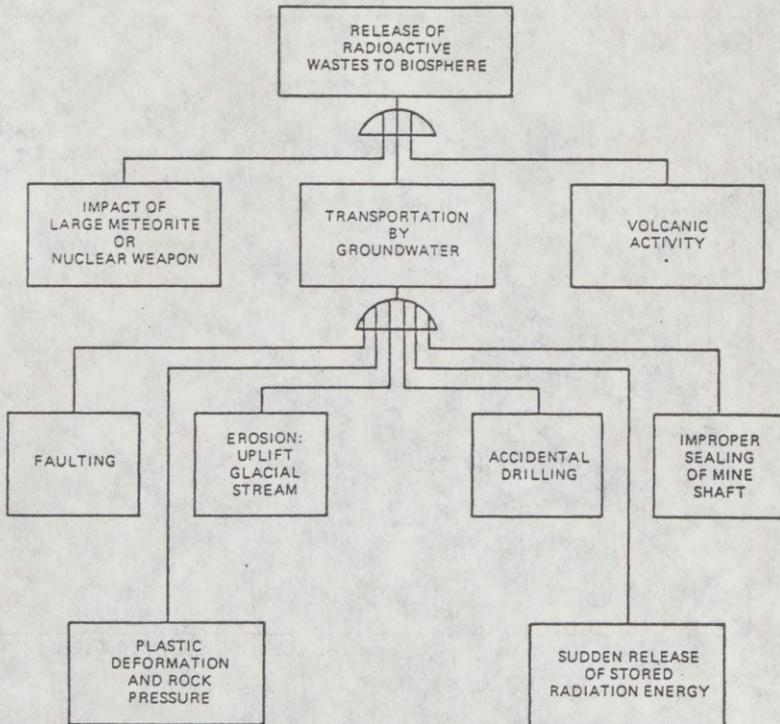


Figure 2. Fault tree indicating the possible ways that radioactivity could be released from wastes deposited in bedded salt (after closure of the repository). (From McGrath, 1974)

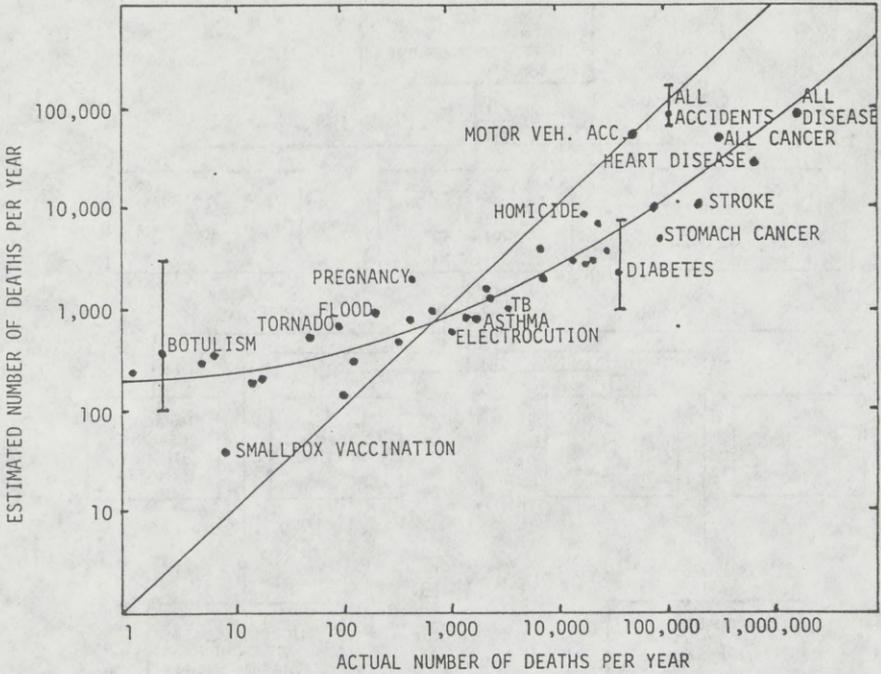


Figure 3. Relationship between judged frequency and the actual number of deaths per year for 41 causes of death. If judged and actual frequencies were equal, the data would fall on the straight line. The points, and the curved line fitted to them, represent the averaged responses of a large number of lay people. While people were approximately accurate, their judgments were systematically distorted. As described in the text, both the compression of the scale and the scatter of the results indicate this. To give an idea of the degree of agreement among subjects, vertical bars are drawn to depict the 25th and 75th percentile of individual judgment for botulism, diabetes and all accidents. Fifty percent of all judgments fall between these limits. The range of responses for the other 37 causes of death was similar. This figure is taken from Lichtenstein et al., 1978.

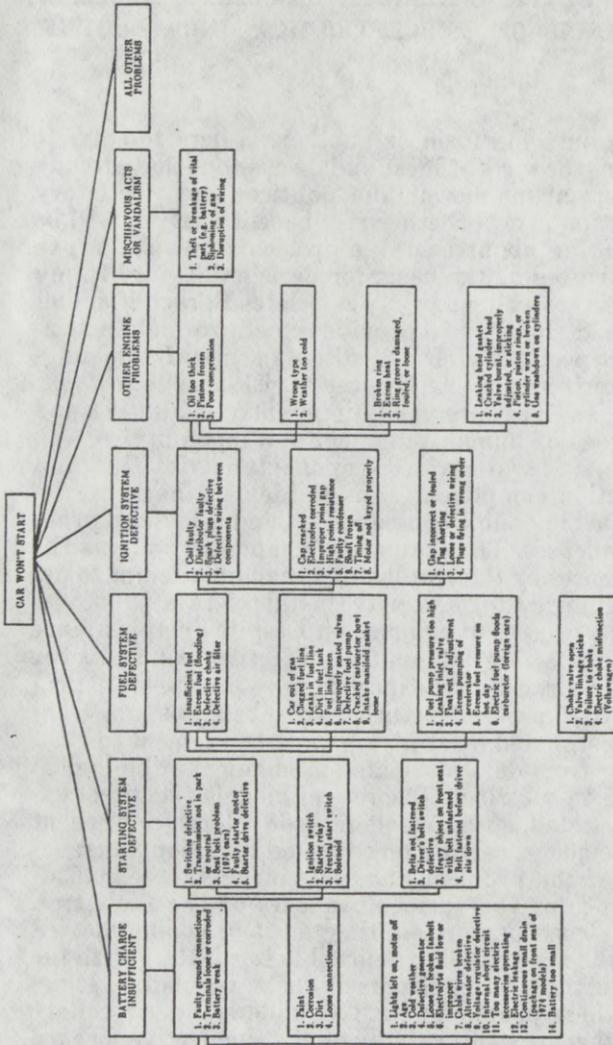


Figure 4. Fault tree indicating the ways in which a car might fail to start. It was used by the authors to study whether people are sensitive to the completeness of this type of presentation. Omission of large sections of the diagram was found to have little effect on the judged degree of completeness. In effect, what was out of sight was out of mind. Professional automobile mechanics did not do appreciably better on the test than did lay people. This diagram is from Fischhoff, Slovic, and Lichtenstein, 1978.

STATEMENT OF PAUL SLOVIC, RESEARCH ASSOCIATE, DECISION RESEARCH, A BRANCH OF PERCEPTRONICS, INC., EUGENE, OREG.

Dr. SLOVIC. Thank you.

Risk-benefit analysis, in some form or another, is here to stay. It formalizes and quantifies the sorts of ideas and discussions that already take place in a less formal manner in the political and regulatory process. What is a question is not whether risk-benefit analysis will be used as an aid to thinking about complex problems but, rather, to what extent it can be trusted as the basis for decisionmaking. In my testimony today, which is co-outlined by my associates Baruch Fishhoff and Sarah Lichtenstein, I shall try to provide some information relevant to this question. Specifically, I will discuss some of the judgmental problems that confront the effective use of risk-benefit analysis. I shall argue that the analytic process is inherently subjective and constrained by limitations of human judgment and ingenuity.

Risk-benefit analysis has two major components: estimation and evaluation. The estimation component aims to identify hazards, determine the nature of their possible consequences, and assess the probabilities of those consequences. The evaluation component weights the values of these consequences by their probabilities in an attempt to determine which hazards, in what form, society should tolerate.

Let us look first at the process of estimation. Despite an appearance of objectivity, risk estimates are inherently subjective. As a number of speakers have noted, we can rarely expect to have precise statistical data to go by. Most often, especially with new substances and technologies, risks must be estimated by applying expert judgment to blueprints, or extrapolating from data on related mechanical or biological systems. We are forced to substitute theoretical models for direct experience. While sophisticated, such models include a large component of human judgment. Someone, relying on educated intuition, must determine the structure of the problem, the consequences to be considered, and the importance of the various branches of the fault tree. Once the analyses have been performed, they must be communicated to the various people who are actually responsible for dealing with the hazards, including industrialists, environmentalists, regulators, legislators, and voters. If these people do not see, understand, or believe these risk estimates, then distrust, conflict, and ineffective hazard management are likely to result.

Unfortunately, there is a great deal of research which shows that estimating risk is an extremely difficult intellectual task for experts and lay persons. Dr. Bingham touched on this yesterday. For now I am going to simply summarize some of the conclusions from this work.

First, perceived risk is influenced by the imaginability and memorability of the hazard. Thus, for example, a recent disaster or vivid films such as "Jaws" and "The China Syndrome" can seriously distort risk judgments. Likewise, the frequency of death from dramatic, sensational causes such as homicide, which get heavy media coverage, are overestimated by most people. Less spectacular killers, such as diabetes, emphysema, or asthma, get little media publicity, and tend to be seriously underestimated. Lay persons do not, therefore, have

accurate perceptions, even for familiar risks, whose frequencies are well established.

Second, the fact that people use memorability and imaginability as the basis for risk judgments poses a barrier to open objective discussions of risk. Consider an engineer, for example, demonstrating the safety of a nuclear reactor by pointing out the ways an accident could happen. Rather than reassuring the members of the audience, such a presentation would lead them to think: "I didn't realize there are that many things that could go wrong." In other words, the very discussion of any low-probability hazard is likely to increase the judgment or probability of that hazard, regardless of what the evidence indicates.

Third, people are typically overconfident in the validity of their risk estimates. For example, a common task in estimating failure rates or other uncertain quantities is to ask the judge to set upper and lower bounds such that there is a 98-percent chance that the true value lies between them. The true value should fall outside those boundaries 2 percent of the time. Studies with diverse groups of experts and lay people making many different kinds of judgments—where the true value is known to the persons conducting the studies—have shown that true values fall outside the 98-percent confidence bounds 20 to 50 percent of the time rather than 2 percent of the time. Thus people think that they can specify such uncertain quantities with much greater precision than is actually the case.

Another illustration of overconfidence comes from the 1976 collapse of the Teton Dam. The Committee on Government Operations has attributed this disaster to the unwarranted confidence of engineers who were absolutely certain they had solved the many serious problems that arose during construction. Indeed, in routine practice, failure probabilities are not even calculated for new dams even though about one in 300 fails when the reservoir is first filled.

Further anecdotal evidence of overconfidence may be found in many other technical risk assessments. Some common ways in which experts may overlook or misjudge pathways to disaster include:

One: Failure to consider the ways in which human errors can affect technological systems. After Three Mile Island, I won't go into detail in illustrating this point.

Two: Overconfidence in current scientific knowledge, like the failure to recognize the harmful effects of X-rays until societal use had become widespread and largely uncontrolled.

Three: An insensitivity to how a technological system functions as a whole. For example, though the respiratory risk of fossil-fueled powerplants has been recognized for some time, the related effects of acid rains on ecosystems were largely missed until very recently.

Four: Failure to anticipate human response to safety measures. For example, the partial protection offered by dams and levees gives people a false sense of security and promotes development of the flood plain. When a rare flood does exceed the capacity of the dam, the damage may be considerably greater than if the flood plain had been left unprotected.

The fourth general problem of estimation is a direct result of these various peculiarities of human thinking. For rare, new and dramatic hazards, such as nuclear power or recombinant DNA research, there

is often an immense gap between what the public believes and what experts believe. For example, we have found that people's mental images of the consequences of a core meltdown include the specter of hundreds of thousands, even millions, of immediate deaths. Such images bear little resemblance to the views of industry officials—and most technical experts—who expect redundant safety and containment systems to prevent almost all reactor accidents and limit the damage of those that do occur.

Recognition of such "perception gaps" has naturally resulted in a call to educate the public about the "real" risks from nuclear power and other technologies. One public opinion analyst put the matter as follows:

The biggest problem * * * is lack of knowledge and facts. Within this current attitudinal milieu, scare stories, confusion, and irrationality often triumph. Only through careful education of facts and knowledge can the people know what the real choices are. * * *

While I too favor educational attempts, I believe they face major difficulties which must be recognized. This pessimistic stance is based on two key aspects of the problem, one technical and one psychological. The technical problem is that the disputed risks are often so improbable that they are not amenable to precise empirical verification. Even the experts may disagree on what the facts are. The psychological problem is that people's perceptions are not irrational, but are based on normal ways of thinking which are likely to thwart attempts to modify beliefs about risk.

For example, a large body of research demonstrates that people's beliefs change slowly and are extraordinarily persistent in the face of contrary evidence. Their initial impressions tend to structure the way that they interpret subsequent evidence. New evidence appears reliable and informative to them if it is consistent with their initial beliefs. Contrary evidence is dismissed as unreliable, erroneous, or unrepresentative. Thus the incident at Three Mile Island "proved" the possibility of a core meltdown to some people, while to others it reinforced their faith in the effectiveness of the multiple safety systems. Like other cognitive biases, refusal to listen to contradictory evidence is probably as common among experts as among lay people.

In sum, risk estimates should be viewed with skepticism. Research not only demonstrates that judgment is fallible, but it shows that the degree of fallibility is often surprisingly great and that faulty estimates may be put forth with great confidence.

Since it can be shown that even well-informed lay people have difficulty judging risks accurately, it is tempting to conclude that the public should be removed from the risk assessment process. Such action would seem to be misguided. For one thing, we have no assurance that experts' judgments are immune to biases once they are forced to go beyond their precise knowledge and rely upon their judgment.

In addition, effective hazard management requires the cooperation of a large body of lay people. These people must agree to do without some products or activities and accept substitutes for others; they must vote sensibly on ballot measures and for legislators who will serve them as surrogate hazard managers; they must obey safety rules and use the legal system responsibly. Even if the experts are much better

judges of risk than lay people, giving experts an exclusive franchise on hazard management would involve substituting short-term efficiency for the long-term effort needed to create an informed citizenry.

Next, I would like to turn to the evaluation component of risk-benefit analysis. Even if all the important consequences of a decision could be enumerated and their probabilities could be enumerated with precision, placing a value on these consequences poses further difficulties.

There are two major ways to quantify social values and both of them have problems. The first method, that of revealed preferences, assumes that, by trial and error, society has arrived at a nearly optimal balance between the risks and benefits associated with an activity. Therefore one may analyze currently accepted risks to discover society's values. This method has several drawbacks. First it makes strong and not always supported assumptions about the rationality of people's decisions and about the freedom of choice available in the market place. Second, a revealed preference approach assumes not only that people have full information, but also that they can use that information optimally, an assumption which seems quite doubtful in the light of much research on the psychology of decisionmaking. Finally, from a technical standpoint, it is no simple matter to develop the measures of risks and benefits needed for the implementation of this approach.

A second approach toward determining societal values, called expressed preference, asks people directly about their tradeoffs between risks and benefits. The problem with this approach is that when it comes to new and complex issues, people may not have well-articulated preferences. In some fundamental sense their values may be incoherent—not thought through. In thinking about acceptable risks, people may be unfamiliar with the terms in which the issues are formulated (such as social discount rates, miniscule probabilities, megadeaths). They may have contradictory values, such as a strong aversion to catastrophic losses of life and a realization that they are not more moved by a plane crash with 500 fatalities than one with 300. They may occupy different roles in life (such as being both a motorist and bicyclist), which produce clearcut but inconsistent values. They may vacillate between incompatible, but strongly held positions, such as freedom of speech is inviolate, but it should be denied to authoritarian movements. They may not even know how to begin comparing the benefits of hair dyes with a vague, minute increase in the probability of cancer 20 years from now. Their views may change over time, as the hour of decision or the consequence itself draws near, and they may not know which view should form the basis for decision.

In such situations, where people do not know what they want, the value they express may be highly unstable. Subtle changes in how issues are presented, how questions are phrased, and how responses are elicited, can have marked effects on their expressed preferences. The particular question posed may help clarify the respondent's opinion or may irreversibly shape it; it may even create an opinion where none existed before.

Risk-benefit analysts attempt to deal with the difficulties inherent in the assessment of probabilities and values by using a technique called sensitivity analysis. The calculations of expected costs and bene-

fits are repeated using alternative values of each troublesome probability, cost, or benefit. If each reanalysis produces the same relative preponderance of expected costs or benefits, then it is argued that these particular differences do not matter.

Unfortunately, however, there are no firm guidelines regarding which of the data might be in error or what range of possible values ought to be tested. A further problem with sensitivity analysis is that it typically tells us little about how the uncertainty from different sources of error is compounded or about what happens when different data are subject to a common bias. The untested assumption is that errors in different inputs will cancel one another, rather than compound in some pernicious way.

Uncertainty about facts and uncertainty about values both imply that determining the acceptability of a hazard must be an iterative process, partly because, as time goes on, we learn more about how a hazard behaves and how much we like or dislike its consequences. In other words, it takes experience which acknowledges the experimental nature of life to teach us what the facts are and what we really want.

As a result, interaction is essential to any well-done risk analysis. A measure of the success of any analysis is its ability to inform our beliefs and values as well as to reflect them. Once the analysis is completed, we may then be ready to start over again, incorporating our new and better understandings. In this light, many of the criticisms generated by the reactor safety study, otherwise known as the Rasmussen report, reflect its success in deepening the critics' perspectives. As an aid to policy, the study's main weakness was in attempting to close the books prematurely, and thereby failing to take adequate account of these criticisms.

In conclusion, it seems obvious that risk-benefit analysis provides no magic formula. As a guide to decision-making in the face of uncertainty, it is, itself, an uncertain guide. Although a carefully done analysis can serve to organize and stimulate our thinking, at its present stage of development we should not put too much faith in its bottom line.

Thank you. [Applause.]

MR. PEASE. Thank you, Dr. Slovic, and much thanks to our entire panel.

Those obnoxious bells you have been hearing tell us that there is a possibility of a vote coming up on the floor, it has not yet arrived. But I think we will go ahead with the questions from myself and Congressman Ritter. We would also like to allow some time for questions or comments from those of you in the audience.

Since we don't have much time before lunch, let me put myself and Congressman Ritter under what we in Congress know as the 5-minute rule, which means you can say anything you want as long as you can say it within 5 minutes.

I found the testimony this morning extremely interesting, and there seems to be a general agreement that risk assessment is here to stay. There also seems to be general agreement that quantifying risk is a very, very difficult proposition. As a member of Congress, I am especially interested in risk decisions, which have to be made in Congress. Risk decisions have to be made in Congress by members of Congress

who basically do not have scientific background, and have very little time to analyze anything, and who are responsible to their constituents who have often only a slight knowledge of any situation.

It seems to me that, increasingly, the really difficult decisions on risk will either fall into the bailiwick of Congress naturally, or will be brought to Congress as the court of last resort as it were by constituents who are concerned. So I would like to focus if I can, and get some comment from the panel members on the decisionmaking process in the Congress.

It seems to me the difficulty of quantifying risk compounds the problems as far as Congress is concerned.

Let me ask our panel members to comment if they would on the degree to which they believe Congress should make decisions in the risk area, based on the testimony of experts, as opposed to the perceptions of their constituents.

Dr. SLOVIC. I will try that as a starter.

I think my remarks imply that both sources should be used. It may be that the public is on to something that might slip through the cracks of the models that the experts use. The public may be sensitive to the possibility of errors in expert judgment, and therefore I think it is important to take public opinion into consideration. I also think it is particularly important to solicit diverse groups, and to make a determined effort to get opposing views aired.

Mr. PEASE. Anyone else?

Dr. CALLAHAN. I think it is very important to realize that people's psychological fears are a part of the real world. Expert testimony may indicate this a very low level of risk, but clear, at the same time, the public could feel highly insecure about the matter. In that case, I could see the decision going to the public, rather than reflecting the actual scientific state of affairs. Policy has to account for what people feel as well as what scientists think is true.

Mr. PEASE. Dr. Callahan, I am happy to hear you say that; that is what Congress should do, because I can assure you that is what Congress will do. I am somewhat distressed as a member of Congress by the number of my colleagues who say essentially on any controversial issue "don't convince me, convince my constituents, and don't expect me to get out in front on a controversial issue," which means on an issue that involves psychological fear, as you mentioned; either you have to educate the entire public, or you have to yield on that point.

That brings to mind what I would call the catastrophe factor in risk analysis, and I wonder if the panel members could comment at all on that, to what degree the catastrophe factor ought to be worked into risk analysis? For example, a nuclear powerplant might be one. There may be a very low probability of accident, but if there is one, it will be a honey, and I think people's fears are built up, more on the potential than on the odds.

I guess another factor associated with that which I would like to have you comment on, is the exploitability factor. There are some risks, I guess maybe dams would be one, where people don't seem to be that excited about the possibilities. But nuclear power is another one, another kind of issue where there is a great deal of concern, and a very, very strong and vocal opposition group. So, if anything goes

wrong, you can count on that accident being exploited by the opposition group. Or in the case of a DC-10 accident, there is nowhere near the vocal opposition group for that.

Should those sort of things be taken into account by decision-makers?

Dr. OKRENT. With regard to your first question, I guess I would say, listen to the experts and, in fact, press them to give you more than a simple comment, press them to discuss uncertainties and to discuss alternatives to what they are recommending. Listen also to your public, to your constituents, but then make up your own mind. Do what you think is right, which may differ from what your constituents think.

With regard to catastrophies, I think looking at history shows that the Congress has responded more to catastrophe in coal mines, than to the accidents in which one or two miners are killed at a time, although the latter accidents probably totaled to a larger number. And the press certainly does respond primarily to catastrophies. I question that this is the way to go about setting our priorities. I think that far more people are killed in small accidents, from polluted air, and so forth, than by large accidents, and I think you should look very hard at whether the overall societal response is appropriate.

We have many things in society that have the potential for large accidents. If we are going to really rule out technologies which pose a large hazard, we would just shut down all those dams. And that is just one example; I can find many more if you wish.

Mr. PEASE. Thank you.

Dr. SLOVIC. I would like to comment further on the catastrophe issue. That is the single most critical element in the conflicts people have over risk assessment, and the differences that experts have among themselves, and in particular the differences of opinion between experts and lay persons. We find that, with regard to nuclear power, the fears of most people are not based on the belief that radiation, which causes cancer, is a worse way to die. For example, they are not afraid of medical X-ray. Rather they have the feeling a nuclear accident will lead to a catastrophe of a magnitude unprecedented in human experience and it will be uncontrollable in its extent.

Wherever we find extreme differences between the reaction of the public and the opinions of experts, there seems to be this catastrophic element involved. This is especially problematic, because this is the very kind of risk that is so difficult for the technical experts to determine, because it is so rare and data are lacking, and this leaves us open to all the judgmental problems I discussed earlier.

Mr. PEASE. Thank you very much.

I will now recognize Mr. Ritter for 5 minutes.

Mr. RITTER. We have heard about the uncertainty and the measurement in the analysis of the risk. But it occurs to me those bold enough to get into this area are in reasonable agreement. If you take a common set of procedures and you look at the different alternatives in an integrated sense rather than one procedure through one alternative, you can come out with some reasonably good comparative assessments. I really think we should move forward in that direction.

We talked about the exploitability factor and the existence of very, very strong remote opposition. I guess I am new enough to Congress to think that we are here not just to follow those who are screaming, but to listen to those vastly larger numbers of individuals back home who don't scream.

And as a matter of fact, we have privileges, we have the thing called the frank, which allows us to help people understand things that perhaps they don't understand as fully as they would like to and as they want to. Also, if they were better informed I think we would find them not screaming, but responding in responsible ways. They may respond in opposition or in a positive way, but I think we have that responsibility to go beyond the special interest screamers.

I really said quite a bit more in my testimony, and I would like to let the people in this audience have a chance to get their ideas in.

Thank you.

MR. PEASE. We do now have a vote on the floor of the House. Mr. Ritter and I are going to have to leave, but we would like perhaps 15 minutes to give a chance to you in the audience to ask questions or make comments.

I am pleased and privileged to turn the Chair over to my predecessor in Congress, a very distinguished member of this committee for a long time, the Honorable Charles Mosher.

MR. MOSHER. A rare experience for a minority member to preside.

Well, I invite questions from the audience to our panelists. Who has the first question?

I see a hand—a gentleman from Case Western, and a former staff member of this committee.

YACOV HAIMES. Thank you, and I would like to respond to the question the chairman just raised earlier. As far as the role of scientific information to congressional decisions, I believe that we need both the quantitative and qualitative aspects, and I would like to read the testimony from several years ago given to this committee with regard to information and intelligence, which I feel germane to a discussion here.

MR. MOSHER. Are you going to ask the persons of the panel to comment?

MR. HAIMES. Yes.

The testimony was by Edward Shearer, and I am quoting, it says:

In talking about the information needs and resources of the Congress, it is important to distinguish between two kinds of data which I would like to label information and intelligence. Information is in a sense raw data, it is a benefit, cheap, easy to acquire, sometimes hard to avoid. It is before committees such as this, and I hope I can avoid it in a sense, they are all too willing to provide it in a great quantity. Intelligence by which I mean the process data, has been evaluated and given meaning is more difficult to acquire and more important to have. Likewise, scarce commodity, intelligence has value, it confirms statutes and power, sheds careers, molds minds.

Et cetera, and he continues.

It seems to me the scientific community does have a role and essentially a commitment to process this information to Congress and their staffers, so that they can make the decisions and the proper tradeoffs. The state of the art in quantification, I think, is in itself that way,

though there are many interesting books and articles, and I would hope those testimonies here would enhance the development of such methodologies so that we can make the proper tradeoff and the different type of risks.

One of these I can think of expanding and attempting is the concept of optimality, where we can get one objective, one attribute only at the expense of the others, and it is nice to see what the tradeoffs are and quantify them so that Congressmen can make decisions based on more scientific basis.

Thank you.

Mr. MOSHER. Do any of the members of the panel wish to comment on that?

Other questions?

Ms. HADDEN. I am Susan Hadden from the L. B. J. School at the University of Texas.

It strikes me that Dr. Slovic and his colleagues suggest that we may be trying to protect people from risks they don't want to be protected from even if they are wrong, and I think saccharin is a case in point. Dr. Slovic said if people assumed a risk voluntarily, then it is less risky, and I think saccharin suggests that while they may be quite wrong, since they are assuming the risk voluntarily, they are willing to accept it, and Congress has responded by allowing them to continue to accept that risk, and I think that where all these uncertainties arise, perhaps we, Congress, should agree that people can decide to accept risk, even if they are not assessing them correctly as the experts know them to be assessed, and I want Dr. Slovic to comment on that.

Dr. SLOVIC. I am not sure I would agree with that interpretation of our work. Our work has been progressing and we think we have learned something about the voluntary and involuntary nature of hazards, and how this characteristic of voluntariness influences perceptions. It seems to us now that, typically, when someone is accepting a risk voluntarily, they know the risk fairly well, the risks are common and familiar. People seem to shy away from involuntary risks because they are less well known and people fear the risks might be quite large.

It seems to me with something like saccharin, people cannot be expected to appreciate the risk involved. Scientists are debating these issues and it is not likely that the average person at this point will have a good understanding of that debate. I think in that case one has to be careful about letting people go their own way and not attempting to inform them—

Ms. HADDEN. But once having informed them, they still might be willing to accept the risk. Saccharin may not be fair as a case, but I think that my own local newspapers and even the minor press did give reasonable coverage to the kinds of questions that people were raising about the risks involved in saccharin, and yet the benefits were assessed by some of the users to be higher.

I think that I feel that Congress has more of an obligation where the risk is really assumed to be involuntary, or where, as Mr. Callahan said, the risks are being spread inequitably, and the benefits accruing to people not acquiring the risk. When we are faced with so much uncertainty, we have to allow people to express their preferences to some extent.

Dr. SLOVIC. I don't disagree with that. I think we will have to consider carefully how we inform people. It is easy to say we should inform people, and I agree with that, but how to convey this information about risk where there is disagreement among experts is really sort of an unsettled question.

Mr. MOSHER. We will go for another 5 minutes.

Dr. LOWRANCE. I'm Bill Lowrance from Stanford.

I have a question for Dr. Okrent; I understood you, David, to say you hope the Congress would take steps to develop criteria about acceptability of different risks, and I wonder if you would say more about that, because though it is a general notion I approve of, I am not sure how Congress can do that, other than in its spot decisions in single hazard issues.

Dr. OKRENT. It is intuitively more clear to me that the Congress should initiate a program that gets to this goal than exactly how the goals are accomplished. In view of the very many things we have heard from Dr. Slovic and Dr. Callahan and everyone else here, it is not a simple path to follow. But, I don't support the continuing procedure of ad hoc decisions, for the reasons I tried to illustrate in my talk. It leads to gross inequities in expenditures to reduce risks, and in the risks being imposed on people involuntarily, frequently when they don't even know the risks are there. In fact, in many cases society itself does not know, since the calculation has not been done for many risks.

I am convinced that this needs to be done, and that with reasonable effort one could develop a program for the Congress to initiate. I am not going to predict how long it will take.

Mr. MOSHER. Dan Koretz, with the Budget Office.

Mr. KORETZ. I have several comments for Dr. Okrent, and I would like to hear your answer to any or all of them. It seems to me that your stance on comparative risk analysis was too easy, and that in fact it is not that easy when looking at, say, environmental hazards, to compare the risk involved in different substances, that there are so many potatoes in a sack.

I will give two or three reasons for that. The first is that it is hard to apply a single metric, you referred to dollars per death saved, but many hazards can't be measured in terms of deaths. For example, there has been over 6 years' worth of work coming out of Harvard Medical School on very substantial hazards of lead. Death is not among them—the problem is in children, reduced intelligence.

Second is that in comparing, for example, the risk of death from dams and the like, nuclear powerplants, this is a more specific example than the first, you left out the key point, a death that occurs from a flood occurs once, but genes don't heal. I was talking to a marine ecologist who told me his estimates that the damage to the Hudson can't be measured in generations, that the time involved in repairing that would exceed the span of human history to date.

The third point relates to the last question, there is not a safety valve and there can't be, because the funds for safety improvements come from different sources, and I find it hard to see how reducing McDonnell Douglas for a fourth level will have much bearing on whether Ford will stop making Pintos and stop producing cars like those built in Sweden.

Do you have an answer to any of those three?

Dr. OKRENT. I agree with you that the analysis is not easy. If anything, I tried to indicate that not enough risk analysis has been done. And if you were to see me when I serve in another capacity, you would see that I don't believe most of the risk analyses that have been presented to me. Nevertheless, I think not to try to do such studies and not to try to critique them is a mistake. Basically, I am in favor of society having more information on which to proceed when it makes its decision; that was one of the points I tried to make earlier.

I myself did not say one should use dollars per life saved in decision-making. What I read to you was something taken from a study performed for one of the Senate Committees wherein a figure of \$30,000 per life was used in trying to decide whether scrubbers and so forth should be put on coalburning electric generating plants. I was trying to show that, in contrast, another branch of the Government, the Nuclear Regulatory Commission, was using \$5 to \$10 million per life in trying to decide on requirements to reduce routine, low-level releases of radioactivity.

Now if you tell me the Government does not have a safety budget, I will tell you that the Government is requiring the country to spend money to reduce risk in not necessarily the most cost-effective way, after allowing for equity, after allowing for psychological risks, and so forth. It is not doing it in a way that is cost effective. And to put it bluntly, if you don't do it in a way that is cost effective, you are killing people, because you are not deferring the most premature deaths you can per dollar spent.

With regard to permanence, I absolutely agree with you. There are many effects in the environment that are permanent. There are many long-life chemicals, and you gave an example. Some, like mercury, are more permanent in their potential to produce adverse effects than a large release of radioactivity from a nuclear powerplant accident.

I agree with you that there are genetic effects to be considered. But genetic effects can arise from many different sources. If you are going to look at genetic effects and say we should do something about them, my argument is let's try to do it in a comprehensive way. Let's look at all the sources and see how much we know and how much we don't know. Let's find out which are the important contributors and what are the things we can do in a most cost-effective way to reduce genetic effects. But let's not single out only one aspect of the problem, ignoring others which may be much more important.

I think I have indirectly touched on your three questions.

Mr. BROWN. I regret I must arbitrarily cut this off at this point.

Let me make a couple of announcements before we close.

Lunch will be served in a different room from where you were eating yesterday. Today lunch will be served in B-369. It is a smaller room, and it will be a buffet style lunch, with no speaker.

We will return to this room at around 1:30 or so, and I warn you that you may hear a debate this afternoon. Two Congressmen, both articulate, have very different positions on the whole question of environmental matters, and it should be a very interesting session. It will be chaired by the chairman of this committee, Don Fuqua.

The hearing is adjourned until 1:30.

SYMPOSIUM

DON FUQUA, CHAIRMAN, COMMITTEE ON SCIENCE AND TECHNOLOGY,
PRESIDING

Mr. FUQUA. Let's be in order.

I want to welcome everyone to the symposium on risk/benefit tradeoffs and energy policy. The question of risk and benefits which most directly have affected Americans up until recently were mainly in the fields of food, health and drugs.

But today, the issue which we are all faced with, beginning with the President and including every citizen, is the issue of energy. We are all now aware that this is a field in which questions of risk are very prominent. Concerned citizens have expressed themselves, sometimes in highly vocal terms, about what they believe to be the high or low levels of risk and benefits associated with the different energy technologies. This question risk/benefit tradeoffs in energy policy is an important national question.

It's also important for this joint forum. Some of your speakers have focused in various ways on risk/benefit as it relates to energy analysis. This afternoon, we are very privileged to have two speakers who will discuss specifically risk and benefit tradeoffs in energy policy.

Both are Members of the House and members of the Science and Technology Committee, which has the jurisdiction of energy research and development, and both have come to be recognized as experts in every aspect of energy research and development.

They have some things in common and some things not in common. On my right, Congressman Richard Ottinger of New York, chairman of the Subcommittee on Energy Development and Applications of this committee, native New Yorker, graduate of Harvard Law School and being a Democrat that's about as far as he and Jack Wydler agree.

Jack Wydler on my left—and it's not philosophical—is the ranking minority member of the Committee on Science and Technology. Likewise native New Yorker, graduate of Harvard Law School, Republican. That's about as far as they agree. I don't know what they did to them at Harvard, but they took different routes when they left.

They are both people of great knowledge in the field of energy and have very strong opinions. Someone suggested to me today that I could introduce them as similar to faceoff on the popular program "60 Minutes," one being James J. Kilpatrick and another being Shana Alexander, but Dick didn't look like Shana. [Laughter.]

Mr. FUQUA. But, I think you will find it very interesting, the comments that they have to say. We will begin with Congressman Ottinger. He will be followed by Congressman Wydler. Then, we will have some discussion maybe by themselves with each other and maybe some from the audience.

Dick?

STATEMENT OF HON. RICHARD L. OTTINGER, CHAIRMAN, SUB-
COMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Mr. OTTINGER. Thank you very much, Mr. Chairman.

I want to thank Mr. Mosher and the Association for giving us this opportunity. The subject of risks/benefit tradeoffs in energy policy is

certainly very timely. In the Commerce Committee, where I sit on the Energy and Power Subcommittee as the ranking Democrat, we are currently considering proposals made by the President that would permit him to waive any laws, such as those dealing with the environment, public health, safety, labor, or civil rights, that he wanted to in order to expedite a project that he considers to serve a high priority national energy need.

The long gas lines we have been experiencing have caused some of us to jump to conclusions about solutions to this particular energy crisis to a point where we seem willing to disregard the potential economic, health and safety risks or tradeoffs associated with the solutions. The mood in the House has reflected this irrational haste and unless it is reversed, we will see, I think, some very catastrophic decisions made in an attempt to solve our energy problems.

I believe we do have agreement between Mr. Wydler and myself and virtually everybody on the committee that there is a national energy crisis. It's real. The degree of reliance on imported fuels at the present time presents an unacceptable national security risk and an unacceptable economic risk to the country. Therefore, we have to address these problems with dispatch. How we go about it in terms of the relationship of risks and benefits I suspect we will differ very substantially on.

In approaching the subject of risks and benefits, we must address some of the most difficult problems that one could have. For instance, how do you weigh the value of the human life? Many of the energy technologies we are pursuing present very real threats to human life in varying degrees.

In doing risk/benefit analysis on a cost basis, what monetary value do you assign to human life? I think that is very difficult to determine. It's largely for this reason that within the consumer movement, people like Ralph Nader say that when substantial numbers of human lives are at risk, the costs become immeasurable. They ought to be protected virtually regardless of cost. One has to recognize that in doing that, risks may be incurred from alternatives that are also real risks to human life and safety.

You have to weigh the benefits of, for instance, nuclear energy, which has a very small probability of a very huge catastrophe, with the risks of, say, coal technology that is going to kill a certain number of coal miners, and indirectly kill a certain number of people through the air pollution it causes. Compared to nuclear energy, coal technologies have a much more identifiable risk of a much lesser potential in terms of the number of people who might be affected.

A third consideration that has to be made is between voluntary and involuntary risks. We may decide, and indeed Congress has decided, to tolerate a good many voluntary risks like smoking. For example, since cigarettes represent a voluntary risk, their sale is permitted, while actions which present involuntary risks, like the placement of carcinogens in the food supply, have, to date at any rate, been strictly regulated under the Delaney amendment, which deals with risk.

As you can see, conducting a risk/benefit analysis is very, very difficult. We are frequently comparing things where the choices are difficult and painful and involve risks regardless of which direction is taken. The criteria that I think we have settled on in Congress and which is I think, subject to serious challenge today, is that when an

involuntary risk that affects substantial numbers of people exists, we have chosen to legislate with respect to elimination of that risk.

We have the Clean Air Act, the Clean Water Act, the occupational safety and health legislation, the pure food and drug laws. The Congress has decided that where there is involuntary risk that does affect substantial numbers of people, we are going to legislate strictly with respect to that risk. In situations which involve individual choices and voluntary risks rather than involuntary risks, we generally apply less stringent rules, such as the use of warnings on cigarette packages.

With respect to the energy picture, I acknowledge the risks of not acting today. But, I do think that there are a series of choices which can be made that minimize the risks that are involved in resolving those problems.

I think they are not being addressed with any near amount of urgency which they should be. I understand that there is a Harvard Business School study backing up an extensive study by the Council on Environmental Quality that indicates that we can achieve through conservation, and primarily through increasing the efficiencies of energy use, up to a 40-percent decrease in our present energy consumption.

If we were really able to achieve that goal, were able to get the laws through Congress to be able, either through mandatory measures or incentives, to insulate all the houses in America, to go to more fuel efficient automobiles, to use coal for generation in every factory that uses steam, have most of them which produce industrial heat also produce electricity by cogeneration, and every electric plant use its waste heat for either industrial or residential heating purposes, then we could substantially solve the present import problem.

Indeed, that 40 percent is roughly the equivalent of our present dependence on imports. We have a lack of resolve both in the administration and the Congress to be able to propose and pass programs that will meet that challenge.

I think that both parties are very much at fault for not having pursued this conservation option more vigorously because I am convinced that it is by far, in terms of financial, health, and environmental risks—the most preferable way to go.

Next, I think that we ought to assign a second priority to renewable energy resources. There are some potential risks involved in producing these resources, such as in producing the solar heating panels and the photovoltaics.

The risks to human life and health, the amount of capital involved, and the economic consequences of pursuing renewable energy resources are far less than those associated with the synthetic fuels technologies which are receiving top priority at the present time, and are less than those associated with the nuclear option and virtually any of the other energy options except the conservation option.

I think the only way we are really going to see massive application of the solar technologies, as well as options like insulation, is to get the utilities involved. For instance, we should have at least a very aggressive, if not mandatory, program which involves having utilities make energy audits of all buildings that they serve, and have them actually install equipment and include the costs in their rate base.

Recent studies by the environmental defense fund have indicated that in virtually every instance, it's going to cost the utility less, it's going to cost the customers less, and it's going to be better for the stockholders to have an investment made in conservation and solar efforts rather than in new plants, be they nuclear, coal, or whatever.

Conservation and solar are options that I think we are going to be pursuing. On the other hand, I think that we ought to be going very cautiously, very slowly, with respect to the nuclear option and the coal options which still seem to present tremendous capital problems.

Now I would like to discuss the energy program that the President has just proposed. He proposed an \$88 billion fund to be put at the discretion of somebody totally independent of the executive or the Congress and to be spent on providing synthetic fuels, primarily gas or liquids from coal or from oil shale.

The kind of considerations that the President's proposal poses to us first of all are feasibility problems. He's talking about 2½ million barrels a day equivalent by the year 1990. I think that's a goal that is probably impossible to achieve. In terms of the economic risk, \$88 billion is a huge amount. Moreover, I think that the Research Applied to National Needs (RANN) studies recently completed show that, at least on the basis of past experience, that cost figure is likely to be a great deal higher by the time synfuel plants actually get on line.

In reality, then, we are talking about at least \$100 billion worth of capital that is going to be diverted from all kinds of needs within our society to produce these synthetic fuels, at an estimated cost today of around \$35 a barrel. My suspicion is that that cost is going to go up since there has already been a huge escalation in cost in these synthetics.

Just a few years ago, it was thought that synthetic fuels were going to be economical at \$7 a barrel. They are going to end up at \$45 or \$50 a barrel. Thus, I fear that a commitment to synthetic fuels is going to pose tremendous risks to our society in terms of our being able to meet the other capital needs of the country such as for housing, for keeping our cities livable, and for providing energy in much more benign ways.

Third, you talk about oil shale. We were just in Colorado visiting the plants of Occidental and Union Oil. I don't mean to single them out; we just happened to visit those plants. Out there, one gets a sense of the enormity of what they are going to undertake. Shale oil technology is not much further ahead now than it was 20 years ago. You're talking about a water intensive technology that's going to take mountains apart in an area that's very water short.

All the areas being talked about for development of oil shale resources are going to affect the Colorado River. The Colorado River supports a good deal of the agriculture in the country. It already has salinity problems to the point that desalination plants may have to be put on the river at tremendous expense. The leaching of spent shale is going to add to that salinity problem. There are also problems with respect to clean air in an area that depends very heavily for its economy on tourism. In addition, there are direct carcinogenic risks from the processing of the shale oil.

Another potential problem is the tremendous impact on communities that now have 700 or 800 people and may grow to a size of 10,000 or more people. In the final analysis, however, the scarcity of water may

be the most severe problem, and we may find ourselves in a position where we have to choose between the food that the Colorado River produces and the fuel which it might produce from the shale oil.

Those risks can't be swept under the table if you have alternatives that are more promising, which I think we do. They ought to be pursued. I don't think we ought to foreclose them.

I supported research, development, and demonstration projects for all these technologies. I think that we are going to have to have some nuclear energy to fill the gap and keep a proper balance until we have enough conservation measures and other energy technologies in place.

We can't leave society in a situation where it faces economic constriction because we failed to meet the energy needs of the society. I'm not an advocate of "no growth." However, I think we can provide for growth better with conservation and renewables than we can through coal and nuclear.

Those are the kinds of considerations that we have to make. So, I only question the resolve of the country to do the things that appear to be needed to resolve our energy problems in a sound and sensible way. I'm very fearful at the present time that Members of Congress will want to show people that they are prepared to do something, and will sweep away the considerations of truly significant risks to our health and our safety in order to be able to achieve a very speculative gain from synthetic fuels, from exploiting our coal resources too rapidly, and from undertaking the risks of breeder reactors, to which I'm sure Mr. Wydler will address himself.

There is no question in my mind that we can resolve those problems in an environmentally acceptable way. That is the path we should take.

Thank you.

Mr. FUQUA. Thank you, Dick Ottinger. [Applause]

Now, Jack Wydler.

**STATEMENT OF HON. JOHN W. WYDLER, RANKING MINORITY
MEMBER, COMMITTEE ON SCIENCE AND TECHNOLOGY**

Mr. WYDLER. Thanks, Mr. Chairman. I thank Charlie Mosher for inviting me to this meeting today and I am honored to be one of your participants.

Dick, I never knew you went to Harvard Law School. I am glad I came to the symposium today. I found out something else about you that we have in common.

I have a short statement that I would like to make and then we can get into the give and take. As you will see there are some quite significant differences between Mr. Ottinger and myself, although there are a great many similarities as well. What I would like to do here today is address several different aspects of risk benefit analysis as they play a role in energy policy here in the Congress.

In the area of risk assessment, you are probably most familiar with how this tool is used to devise an energy strategy which then must be implemented. With respect to that topic, I would like to direct your attention particularly to the question of indirect risk. Accounting for this type of risk can change one's view of the risk benefit balance for

energy technology. Today I would also like to raise the issue of how we should attempt to minimize risk and thus increase the benefit while decreasing the risk ratio in technology development. Finally, I would like to talk about the risk attendant upon an improper governmental role in determining economic incentives for emerging technology and briefly discuss the real risks of a specific commercialized technology; nuclear energy.

I believe that it might be useful to look at these first three aspects in a sequential way as though one would proceed from energy policy planning into major technology development and finally into commercialization. Actually, of course, in real life the determination of energy policy and the implementation of such planning in the form of significant technology development can proceed in parallel.

I might add that the energy policy of the present Administration has shifted tremendously from one implemented primarily through regulatory incentives and disincentives to a more supply oriented program in recent weeks. I was personally glad to see that shift in emphasis. But some of us in the Congress I am sure had a very strange feeling as we watched the President on TV say that he was calling on us to implement a major new synthetic fuels program for the country when the House had passed such a bill about 10 days before he made his speech. It gives you a little bit of an eerie feeling.

The first thing I would like to talk about is the indirect risk of energy technology. I believe one of the most provocative standards of comparative risk of energy technology was performed within the past 2 years by Dr. Inhaber, a Canadian scientist. The detailed results of this study are no doubt going to remain in dispute for many years to come and more refined comparisons will be done. However, the approach that energy technology must be compared by inclusion of indirect risks is now generally accepted by many scientists and engineers. What they are saying is we must look at technologies from a cradle to the grave, that is include risks due to coal mining and disposal, not just coal burning. Dr. Inhaber looks at the relative risks on both an occupational basis and from the point of view of risk to the general populace for a variety of important energy technologies.

Curiously enough to some of my colleagues, nuclear energy on that basis, is clearly less risky than certain solar technologies because of their great demand for electrical power to produce critical materials. The catch, of course, is that if this Nation intends to push the coal option for electricity and slow nuclear option dramatically it can only serve to increase the public health risk from additional coal burning.

It is interesting to note the results which Inhaber obtained for natural gas. He concluded that natural gas was the most benign energy technology, on a risk per BTU generated basis. Yet the National Energy Act, the one we passed last year, as originally conceived begged the question. It held that since we did not have any gas left so we should not provide incentives to look for any. Interestingly enough, recent subcommittee hearings have raised a question about the enhancement of risk of exposure to radiation from radon gas. Such exposure is increased by improved home insulation. This is apparently much more serious than the radiation from operating nuclear

power plants. I believe that the Inhaber report was extremely valuable in getting people to think in a comprehensive way about the real risks of energy technologies. It brought home the point that one cannot simply assume that the so-called soft technologies are the lowest risk options.

Of course, we have all got to realize in the Congress and outside of it that a riskless society is unachievable and we do a disservice to the country by saying that any energy option is risk-free.

The next subject I wish to discuss is the risk of failure in technology development. I believe that the question of minimizing the risk of failure which is naturally inherent in research and technology is not one that is often discussed. Agencies such as the National Aeronautics and Space Administration have traditionally managed research and development programs from the latter stage of applied research through large technology demonstration projects in a systematic manner. This systematic approach contributed to their outstanding track record of success. It seems to me that it behooves this committee which embodies the congressional corporate memory for research and development, to insist that high quality management and proven management systems be applied to Department of Energy programs. We have wrestled with this problem for over 2 years since the latter day of the Energy Research and Development Administration. Today I think we can safely say that the nuclear programs in the departments are the most carefully managed and the most rigorous management tools are applied.

We must recognize now that ambitious goals cannot be met for the Department of Energy's nuclear programs because the administration's nuclear policy, whatever it is, is ambivalent at best. Fossil energy programs are currently being subjected to similar scrutiny but in major areas such as design efforts for large demonstration projects, the R. & D. activities are still not managed up to the standards the committee has set.

Unfortunately in the solar area, the very mention of applying the achievement of technical milestones as criteria for continued program funding has been viewed as almost heretical by the solar advocates. In the recent hearings on the administration's solar domestic policy review I raised this issue of accountability. A staff analysis which I requested revealed that there was no traceable evidence of progress for many development activities to solar technology. In other cases there was at least a demonstrable lack of progress as evidenced by slippage of major program milestones. Many of my colleagues who also are advocates of solar funding in the Congress do not seem comfortable about applying this very reasonable set of standards to their programs. Yet DOE is requesting roughly \$650 million in technology development and applications and solar devices benefit from another roughly \$200 million in tax credit incentives.

This mention of tax credits in the National Energy Act brings me to the third aspect of risk benefits that I wanted to discuss; that is, the risk attendant to choosing economic incentives to commercialize emerging technologies. It is interesting to note that the sales of solar hot water heating units decreased significantly during the period between the President's April 1977 energy policy speech and the passage of the

NEA a year and a half later. I know that personally because a company in my district explained it to me. They said their company was doing fine until the President mentioned the fact that he might give some tax credits to solar units. After that, from that point on, their sales practically ended. As a result, a number of good companies simply went out of business waiting for Federal promises rather than the market to take over.

I think this teaches us something about tailoring economic incentives to the readiness of technology as it is perceived by the marketplace. In view of this experience I am not convinced that the catalog of solar incentives discussed by the administration to implement their new solar initiative are well thought out. These incentives must be arrived at on a technologically specific basis, to lower the risk while assuring the benefit of commercialization.

Yet there have been no criteria developed to do this in a consistent manner. Our committee is becoming more and more interested in the commercialization arena. We feel we have a significant role to play in this activity because of our intimate knowledge of and unique perspective on technology developments. There have been some differences of jurisdiction, options between us and other committees, but I believe your message has gotten across loud and clear by now.

Finally, I want to talk a bit about perceived risk, I would finally like to mention an area of risk where the benefits cannot simply be compared in terms of cost to give a meaningful ratio because there is a major gulf between public perception and technological reality.

One topic that raises the question of perceived risk is that of nuclear powerplant safety. In the Department of Energy bill scheduled for floor, tomorrow, I will offer an amendment to increase the nuclear safety R. & D. budget of the Department. This increased funding is for development of safety systems which promise enhanced reliability via an improved risk assessment technique which incorporates human error factors into risk analysis and risk accident data. In this manner we can make systems and component factors meaningful in terms of assessment of their relative importance in the ultimate licensing process.

I believe that we learned an important lesson from the Three Mile Island incident. Meaningful risk analysis should have focused on the more probable accidents rather than the known catastrophic possibilities. Rasmussen's report stressed the need for this emphasis in the early seventies. Concentration on probable accident scenario such as began with the seemingly harmless turbine trip at Three Mile Island is very much in order. I believe we can build on that accident to build a strong safety program and make the chance of repetition of such an incident impossible.

Perhaps some day the media will report this reality of very low risk and abandon their irresponsible doomsday messages. There is a common thread that runs through all these approaches to risk, whether it is to be a technical development, planning on the basis of promise, or even tailoring commercialization schemes to the technology. The common element is that we learn to lessen risk from doing and even from mistakes. However, this should not be an excuse for funding in the absence of progress because we simply expect to wish technologies

into being. Neither should we fear the greatest risk from other technologies with which we deal because they are inherently complex. I suggest you look at risk-benefit aspects of energy policy in the broadest sense. We in the Congress must do so or we cannot make the many complicated tradoffs required to responsibly modify or approve the budgets submitted to you.

I thank you. [Applause.]

Mr. FURQA. Thank you, Jack. We have a recorded vote going and we must leave. Congressman Ottinger will be back shortly. I think in order to give some evaluation of the two discussions, I am informed that we have two highly qualified experts that are ready to help us out and make some comments.

Maybe while we are gone they can give some insight to what you just listened to. Prof. Robert Morgan of the Department of Technology and Human Affairs at Washington University in St. Louis, would you raise your right hand?

And Dr. William Lowrance, Program on Human Biology at Stanford University at Palo Alto, Calif.

Dr. LOWRANCE. We had not understood that our role was to react to these presentations. Perhaps someone of the organizers could clarify that. I thought we were shifting to a different area.

STAFF. It is true they were not informed of this role. The two Congressmen will be right back. Why not just jump into this and start a discussion until these people get back?

Mr. FURQA. We should be back in approximately 10 minutes. Probably Dick will be back before that time.

Mr. MOSHER. We also have two or three staff people here.

Bill, why don't you just off the top of your head have an informal discussion until these people get back?

Dr. LOWRANCE. That is not a role I prefer to play. The staffers may want to make some comments. I will make one remark about the Inhaber report just to get the discussion going.

I personally don't endorse the idea of going ahead and saying things like the Inhaber report is a good report. It is going to be argued about in detail and so on. I think the Inhaber report—and I have met the author talking about it in the draft stage and after it came out. I really think he is trying to do something worthwhile in examining all of the risks of nuclear power, solar, geothermal, and so on. But I don't think he did the job.

It concerns me when people say, well, it is just some details that need clearing up. I think there are some fundamental problems in doing that assessment. I am waiting for such things as the National Academy of Sciences so-called CONAES report under Harvey Brooks to come out. It is in the third or fourth final draft or something like that now.

They with several hundred people have tried to do it. What they find is the further you look, the more problems you run into. You don't know how risks project into the future. It is hard to know where to stop analysis. Solar has lots of risks. One thing the newspapers picked up about that report which was interesting was that, oh, yes, solar energy does have its risks because you have to have glass, you have to have copper, people have to climb up on roofs and install them.

But beyond that simple point of assessment philosophy, let's say, I don't think he went far enough at all. I was concerned to hear at least one of the members referring to that report as being a good thing. Others may wish to make comments on the Inhaber report.

Mr. MOSHER. I am going to try another ploy. We have here in the audience a former Member of the Congress who is vitally interested in this—Ken Hechler. Ken, how about improvising some comments?

Mr. HECHLER. I pass.

Mr. MOSHER. Here is Dick. We were just improvising until you got back.

Mr. OTTINGER. All right.

Mr. MOSHER. I think at this point it would be fair for some members of our group to begin asking questions of Congressman Ottinger.

Dr. RADLOFF. I have a two-part question. Discussions have ranged from a case-by-case analysis of risks and benefits, to considerations of catastrophic risk, but I don't think that any time during these 2 days we have considered the ultimate hazard, the risk to our species and to life on the planet. I see those risks as very real.

This hazard does not have to come about directly through the choices we make. It is even inherent in the way in which we make those choices. To illustrate, if we choose to rely on energy sources that are controversial that production gets delayed indefinitely, that process could result in our preferring a dictatorship over a representative democracy or opting for a military solution in order to get the oil that we need.

And so, I think that one of the things that Congress should be asking the scientific community in the choices we make, how can we make sure that we have considered the ultimate risk and all the ramifications of our choices?

The second question is closely related to the first. I think the most significant action that Congress took with regard to energy this year was to fail to give itself a pay raise. I would like to analyze briefly what I think some possible results of that action might be.

We now have double-digit inflation. If we have 2 more years of it and no pay raise, Congress will have had a 50-percent reduction in pay in the span of 4 years. To my colleagues who live in the shelter of the ivory tower and the bureaucracy, I should say that I think that we have on Capitol Hill very dedicated and capable Representatives, especially considering the dizzying social whirl that distracts them and the pressures they face from all the groups clamoring for their attention.

I think they behave a lot better than anyone could expect them to and they are better Representatives than we deserve.

Nevertheless, when you give someone a 50-percent pay cut over about a 4-year period, you have got to expect that it will have a significant impact. It is remotely possible that we will get as congressmen a group of ascetics who sleep on mattresses in their offices and leave the wife and children, or the husband and children as the case may be, at home and tend devotedly to public business.

But it is also possible that our representatives will decide to supplement their incomes in order to maintain their standard of living. In supplementing his income, a congressman might have a choice between giving a lecture to group A at honorarium X or to group B at

honorarium 10X. If he chooses to give the lecture for honorarium 10X, the sponsor has not bought the Congressman's vote, but he may have purchased the Congressman's time and his ear.

It seems to me that that is a very serious problem. I would like to ask Congressman Ottinger whether there is anything a private citizen can do legally to make sure that can keep the integrity of his Congressman intact in the face of those kinds of pressures.

To review, the first question was, considering ultimate risks what can scientists do to assist in their assessment?

Mr. OTTINGER. With respect to the pay raise, I have always supported a pay raise in trying to get Congress at least abreast of the cost-of-living increases. Indeed, if we had done that many years ago, we would have obviated a lot of our present problems.

Congress is showing tremendous timidity with respect to adequately compensating itself from fear of retribution from constituents. The pressures you talk about are very real.

The pressures are enormous particularly as various groups focus on single issues. I voted for tuition tax credits last year for a number of reasons that were important. A substantial part of my constituency was very much concerned about the issue. The teacher's union made that a litmus test issue and was successful in denying me AFL-CIO endorsement for several months until we could work out an arrangement on that one issue.

Members of Congress still have to raise substantial amounts of campaign money. We are dependent on organized groups of this kind in business and labor in order to be able to run our campaign.

I think that is idiotic. Campaigning is public business. The tragedy is that the Congress turned down the limited public financing we had for campaigns. Campaigns ought to be paid out of the public purse. It would make a real difference in our ability to act freely. Some people are willing to act in the face of that and some people are not.

For example, the teachers are against me again because I voted for the Department of Education. I should not have to live under that threat. No member of Congress should. I think this is one of the issues that has to be weighed in making these risk-benefit equations.

Risk-benefit analyses appear in a whole host of energy-related issues, such as proliferation of nuclear weapons, having to safeguard nuclear wastes, exposure to high levels of radiation for 100,000 years or more, and transportation of nuclear waste.

You ask, should society take those risks even though nuclear energy has some of the benefits Mr. Wydler described? Similarly, coal does pose the ultimate risk, according to a large part of the scientific community. Many scientists feel that through combustion of coal, which injects large quantities of carbon dioxide into the atmosphere, significant changes in global climate may occur.

I think that certainly those considerations ought to be given weight. There is a real danger today. You talk about preserving our democratic society. As I view it, the threat of doing away with our basic democratic safeguards in the name of expediency in producing energy is here today.

The bill that the President sent up literally permits the President, on the recommendation of a board that he appoints, to bypass the entire legislative process and to waive any law, civil rights law, health

safety law, labor law, that he feels gets in his way of a particular energy project.

I think that this power to waive existing laws is something we should not have. The committees considering this proposal are now trying to limit that power by providing a one-House veto but that is not the same as having hearings. The President's bill would establish a system bypassing the democratic process in the name of energy expediency. But it also points out that if we are in error, we don't do the things that we need to do to see to it that our society can continue to run, our people can continue to have jobs, that is going to create that.

If I and the people who made the studies are wrong about what we can achieve through conservation and renewable resources, and we end up with large numbers of factories having to close down, then we really do face the threat that we will have dictatorial powers given to the Executive.

These problems cannot be ignored, either.

Dr. RADLOFF. You are in a crucible. Can we help you?

Mr. OTTINGER. These are essentially political decisions and they ought to be made in the political framework and they ought to be made with deliberation. What can you scientists do? I think that you have played a very critical role in making your voices heard, individually and as a society with respect to these problems. You are in a unique situation. You probably have more knowledge about these questions than the average citizen, although perhaps not with respect to the moral side of the problem.

For instance, we were just treated by my friend Mike McCormack, a very strong advocate of the synthetic fuels program. He passed around to every Member of Congress a survey that had just been conducted with respect to the public's attitude toward synthetic fuel. Among the questions that were asked was "Would you like to see the Government pursue a program that substitutes synthetic fuels for gasoline?" The answers to that question were overwhelmingly "Yes." This is an issue on which it seems to me that the scientific community could really make its voice heard.

We had a briefing the other day from one of the top executives of Gulf Oil. We asked him if the President's goal of 2½ million barrels a day of synthetic fuels is realistic. He said that it is wild. The most we can expect to produce is maybe 30,000 or 40,000 barrels a day in test facilities by 1985 if the technologies prove out at that level; maybe we could get as much as half a million barrels a day by 1990. But he even thought that was very improbable. He said the cost of synthetic fuels is nonsensical, even when compared to importing more gas and more oil. They said we can bring in lots more gas and oil at a fraction of the cost of synthetic fuels.

He agreed that conservation was the No. 1 priority. Conservation could save oil at a cost of oil equivalent to about \$3 to \$5 a barrel.

In summary, I think that those ultimate risks do have to be faced and do have to be weighed. There is a great danger of seeing these risks all swept aside in the rush to achieve a solution to a very real, immediate energy problem, a solution that won't even address that problem.

Mr. FUQUA. Jack, do you want to comment?

Mr. WYDLER. I think you were talking about the synthetic fuels situation. I personally like much better what the House is proposing than what the President is proposing. I know there is always a danger in assessing somebody else's programs to be against everything that is being proposed. There are some people that do that. One ends up with nothing if he is not careful because we talk ourselves out of each and every program and we have no programs at all when we finish the analysis. But I think the greatest danger in the synthetic fuels program as proposed by the President was not the technology development aspects. I think these are sensible today, and should be undertaken. Rather the President a few years ago raised the cry of dangers from a worldwide plutonium economy. I have a little feeling that he might be proposing a synthetic fuels economy in its place. I don't see any need at this point in our history to set forth a program to develop 2 million gallons of synthetic fuels a day. I say so because I am afraid we don't know what it would cost.

What will the final product cost? If it turned out to be much more expensive than oil which is very likely, it seems to me, we will find ourselves with a tremendous commercial undertaking that we have to use, because we have committed ourselves to \$88 billion of Federal spending. And we will find we are forcing our consumers to pay more for their gasoline than anybody else in the world is paying.

That would put us at a tremendous disadvantage worldwide. So my thought is that the House proposal, which is essentially a proposal to demonstrate the technical aspects of synthetic fuels, is the sensible way to go. Then about 1985, as Dick Ottinger says, when we have some production, we will have some better basis on which to make crucial judgments. We can decide at that point whether the OPEC situation is such and the international situation is such that it makes sense now to go for a million barrels a day or two million barrels a day, whatever the case may be. I think that would be a much sounder approach to doing what the President wants to do. It gives us some alternative to buying OPEC oil without committing ourselves to some massive program at this point. The President's program is dramatic, and politically it may make some sense but from a point of view of planning and trying to set forth a sound program, I think it is not sound. It is overblown.

Mr. FUQUA. Any other questions?

Mr. WYDLER. I heard that when I wasn't here somebody said Congressmen should get more money. There is no hope of that happening. The worst part of that from our point of view is the fact we have to vote on our own pay raises.

Mr. FUQUA. That is a risk-benefit. [Laughter.]

Dr. HERMAN. My question is in a more generalized vein. It has to do with a political reality in the risk-benefit analysis scenario. From a devil's advocate standpoint let me take an extreme position to clarify my posture. There are a lot of policies we could pursue where the investments and the risks have to occur now but the benefits may not come for 20, 30, or 40 years. My question has to do with the political problem which that poses when your constituents today have to make that investment, have to assume the risk and even though you are fully convinced that the Nation should pursue that goal, the benefits will not be realized for several generations.

How do you address a situation like that?

Mr. FUQUA. Are you speaking about basic research?

Dr. HERMAN. Yes; let me give one example in the area of the energy agency. The ultimate potential of using the fusion process, for example. There are lots of things like that. Going back in history, Notre Dame Cathedral was built over a 200 year period. We don't have the political structure right now that can force that kind of investment where the pay-off won't come for 200 years.

But there are policies like that that the Nation should pursue which could be political dynamite today but that should be done for the ultimate benefit for the next generations. How do you cope with those situations?

Mr. FUQUA. Jack, do you want to start off?

Mr. WYDLER. I will tell you, I sometimes think that the scientific community does not appreciate what the Members of the Congress do for them sometimes. I mean that most seriously. I remember an experience I had. We traveled to Europe to the European Space Agency. I don't know if you were on that trip with us, Don. I think that was 2 years ago. Anyway, we got into a discussion and the people in the European Space Agency were complaining about the budgets. They complained about the fact we did not give them enough money. I said if you really think about it, we are all that stands between you and a zero budget because if I took a vote in my district, put it to a referendum vote in my district, the space budget would be zeroed out. If you thought about it, you would realize that. People would vote fairly heavily I would guess toward giving no money. The only reason you get some actually is because you have enough Members of Congress and the Senate and the House and members of the Administration—I want to give them full credit, too—to stand up and say this is necessary, important, it has a meaning for our country. You may not see it immediately but it is there, it is real and it is part of a process of living and developing.

Who is willing to go back and take the heat of a public meeting when some fellow stands up and says you just voted to waste another \$4 billion on that crazy business of shooting rockets off in the air?

I don't need it. I don't want it. Why are you wasting my money on that kind of a venture? It is the Members of the Congress. I try to tell the scientists what I think is the truth, which is all that stands between them and nothing is the Congress. Although it may not give them everything they want I think sometimes they don't deserve everything they ask for.

Mr. FUQUA. Dick, do you want to comment?

Mr. OTTINGER. I have not noticed a great deal of difficulty in supporting the long-term energy options, at any rate. Maybe you have other examples in mind. We support a very sizable fusion program which I support and perhaps too much.

There must be at least eight or nine different fusion reactors throughout the country that we are supporting. A good deal of that research is being duplicated. In fact, I am somewhat critical of the Department of Energy for not at some point betting on the most promising horses, rather than spreading their options so widely.

At any rate, the committee and the Congress as a whole has supported the fusion program. Similarly, they support photovoltaics

which is also long-term. But I don't see those programs as posing a tremendous present risk for a future benefit, which is really what you are talking about.

The risk is of money that may or may not pay off. Similarly, we support basic scientific research, as Jack Wydler noted. Maybe our support isn't always fully recognized. I don't think it is popular but we have continued to provide it.

I would like to turn the question around, though, Jack, and ask about the willingness of Congress to accept present benefits for future risks.

I am very concerned about the cavalier acceptance of nuclear energy because its protagonists say that nobody has been killed yet. I don't think that attitude is right. Certainly not many people have been killed in the nuclear program, yet we are taking a risk and jeopardizing our future by risking a massive catastrophe resulting from a possible meltdown, and jeopardizing society as a whole through nuclear proliferation.

They argue that since the rest of the world is going nuclear, why shouldn't we jump on board? I think we should, as the President tried to do, lead the world into some restraint. The reverse of your point is of more concern to me.

We are prepared to sail ahead in the utilization of coal and disregard the CO₂ problem. That worries me even more.

Mr. FUQUA. I might add a postscript that we fund projects in basic research not knowing what the ultimate good or bad may be. The National Science Foundation budget is approximately \$1 billion. That is basic research primarily. That is money that you don't really see light at the end of the tunnel but you know it is going to be there and good is going to come from it.

We have had research in recombinant DNA. There was concern expressed. I think the Congress responded and then we received more facts and then decided the legislation was not necessary at this time.

The same points that both Dick and Jack have indicated are very clear. We are also dependent on the confidence that we have in the scientific community that we are being advised properly in our science policy, that the decisions that we make do have some ultimate benefit with hopefully minimal risk. But sometimes we don't always answer those questions maybe as forcefully as we should.

Dr. HERMAN. I was well aware of those programs. My question was whether those programs cause you all a political problem. Apparently not. Apparently your constituents accept a posture that certain things we do will not have an immediate benefit or payoff but should be done nevertheless.

That was the gist of my question.

Mr. FUQUA. I think yes, in most cases that it should, and you have to move ahead. We can't stand still as a country or as a nation. As a matter of fact, former Speaker McCormack was one of the few people that was involved in the Manhattan project. He said had that not succeeded, probably a lot of them would have been in jail for squandering public money.

So you run that risk also in programs of that type.

Dr. CODDINGTON. I think that we have all gotten used to the fact that it is the very essence of basic research to take risks. But what has been

of more recent origin has been the extreme uncertainty dependent upon any further development of the findings of basic research largely as a result not so much of regulation, as such, but of the uncertainty of regulation.

Bob Sharpey has expressed it saying that he does not want to bet his company on what may be next year's form of regulation. We simply don't know. It seems that the laws of the edge of innovation, there has been so much in public print, need to be addressed from a variety of perspectives. One of these perspectives must be getting a grip on the uncertainty of future regulation and perhaps to provide some kind of grandfathering remedy so as to at least distribute the risk of future, perhaps highly necessary, social regulation as it develops beyond that of the single firm or perhaps segment of an industry that undertakes those risks and proceeds to innovate on the basis of nescience and nontechnology.

Right now we have been waiting with the meter running at Harvard, just to bring it home a little bit, for the word from Research Triangle on what the NO_x criteria document is going to look like and what the proposed standard on nitrogen oxides will look like.

It was promised last summer and due perhaps this summer and if not this summer, for sure next summer. Let's think of what the people in the business community must think about when they are asked, if they may be asked, to get involved in some commercializing synthetic fuel projects and invest millions of dollars of moneys some of which was theirs and some of it the Government's I presume, to get a massive program underway. It might—and then—it might happen next year—a Presidential election takes place. A different President comes in than the one we have and he says I think the synthetic fuel program is terrible.

It is a waste of money. It is an awful idea. Let's stop it. And these people are caught in the middle of a project with a substantial portion of their business assets tied up in one way or another in the project. But you can say say—that is not farfetched because that is exactly the situation that utility companies in our country found themselves in with a breeder reactor.

They went into a partnership agreement with the Government to build a project and when the administration changed the new President came in and said I don't like that project. His point was proliferation argument, whatever it was. He decided he didn't want to go ahead with that project. It was brought to halt as a result. That has to have an effect on the thinking of the next businessman whose turn it is to take another venturesome walk down the garden lane with the Government as its partner.

It is a very unreliable partner and I think it is a situation that present risks, business risks that most businessmen don't want to take.

I think it will be hard to get people into the synthetic fuel business.

Mr. FUQUA. Richard?

Mr. OTTINGER. I agree but I am not sure I know what the solution is. For example, consider a very real situation that I am very much concerned about, diesel cars. Diesels look good. They have great promise with respect to more efficient utilization of fuel.

Developers of the diesel cars could do a great deal more if they knew what the emission standards were going to be. John Dingell, one

of the founders of our National Environmental Policy Act, who also represents Detroit, says this delay is nonsense. We have got to go full speed ahead. We have not got sufficient knowledge yet. Should we in fact devote a period of years to developing diesel cars and then find out later that we have a problem with emissions that we have to stop, or should we take the time first, which is what we are doing, to try to ascertain the answers before we give the go-ahead to the diesel program?

These are not at all simple problems. In situations where you have a degree of risk that is considerable, I think we probably ought to stop and take the time to explore the problems before committing ourselves.

Mr. FUQUA. We have time for one more question.

Dr. CLARK. I would just like to ask: Is there any feeling in this country at all for doing what the European countries did a long, long time ago, and that is to nationalize the power industry? Let me point out that you don't necessarily have to be a big time spender in order to run one. So, this is a matter of the Government and the public at large taking over this whole problem of the risks that are involved in making mistakes in a very huge enterprise for the public good.

Mr. OTTINGER. I think Jack and I probably agree on this. I think that what works in other countries might well not work in this country. In our experience, publicly run enterprises have not been satisfactory because of a whole host of institutional problems that are built into our society in terms of benefits. Government has a hard time operating enterprises efficiently. Indeed, it has a hard time operating government efficiently. I would at least be reluctant to have the Government take over.

I think we do better by trying to devise a better way of regulation with respect to utility companies to give them more of the right kind of incentives, such as, for instance, an incentive to invest in conservation instead of investing in new coal or nuclear plants, than we would by trying to nationalize them.

I would be very reluctant to say that about some emergency that seemed to present no other alternative.

Mr. FUQUA. Jack?

Mr. WYDLER. I just don't see how you help yourself.

I have never been impressed with much in the way of government management of any consumer oriented product which is basically what you are talking about here. I am sure that if we ran our rate structures and our power processing through the political machinery, it would come out a lot less efficient for the consumer than what we have today.

So I don't see anything to be gained by nationalizing utilities and turning them over to the Government. I think the whole trend in the world is away from that. I think most places in the world are considering going in the other direction. Not in the direction of nationalization of industry, but in the other direction. I don't think it would solve a darn problem that we face. I think it would make the problems we have worse.

Mr. FUQUA. Last question.

FROM THE FLOOR. I would like to ask the Congressmen then if they take that path, are they sure that they can obtain the information necessary from all the private industries involved in energy to make the proper regulations or provide the proper legislation?

In other words, are you satisfied today that you know what caused the most recent gasoline shortage or the other energy shortages that we anticipate?

Mr. WYDLER. I don't know where you can get the information. I have heard it suggested that somehow the Government is going to have their own information on these things. I don't know how you could possibly do that. It does not seem to me—I can't conceive of the mechanism. Would we have a government inspector at every gasoline tank in the United States measuring the fluid in it? How would we have our own facts and figures on something of that nature? The Government has to depend on businessmen, as they do in every other area, to send information which they compile. Then Government gives you the national statistics, whether it is homes, vacuum cleaners, whatever business it may be.

They depend on the industry to give them the facts because they have them. If we try to set up a national inventory system of gas and oil. I imagine you would be in a billion-dollar Department of Measurements very quickly. I just can't conceive of the numbers of people you would need to be stationed all around the country measuring each and every tank full of oil to know how much is really in there so you would not have to rely on industry's figures.

Mr. OTTINGER. From my standpoint, we don't have enough information, enough reliable information. I do think there are things we can do to gain more reliable information by way of making companies open their books, especially companies that affect the security of the United States and the oil companies. We can station people at the importing points and indeed I think the United States could and should do the importing.

We can station somebody at the refineries to know what is actually happening at that juncture. I think we need that in order to be able to make decisions. There is a real problem because the interests of the oil companies are not always the same as the interests of the United States.

Mr. FUQUA. Thank you very much, Jack Wydler, Richard Ottinger, for your contributions here today and thank you for your questions.

We appreciate it very much.

I am asked to announce that we will have a break for approximately 10 minutes and the final panel will begin here in this room at 3 o'clock.

SUMMARY PANEL

GEORGE E. BROWN, CHAIRMAN, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY, PRESIDING

Mr. BROWN. May we ask that the audience gradually assume the audience position?

Mr. RITTER. Is that a new yoga position, the audience position? [Laughter.]

Mr. BROWN. We welcome the return of even those straying out in the hall if they will come back in. This is the concluding or summary panel of the symposium and obviously, it is the best part of the whole proceeding. It is an ambitious undertaking trying to provide a summary of this 2-day event.

I think that's clear because we have heard such a wide range of ideas and viewpoints that producing a summary is a highly demanding task. However, we have an excellent panel who, whether they attempt to summarize or merely to express what they have distilled from this epic event, in either case, it will be extremely worthwhile.

All of them are persons who have long been involved in matters of risk/benefit analysis and have written extensively about it. But before proceeding to the panel, I want to thank all of those who have worked so hard on this forum, particularly our distinguished former colleague, Charlie Mosher, who has to get most of the credit for the work involved in setting this up and persuading many Members of the Congress to devote some of their very scarce if not valuable time to participation in the panel.

We also want to thank all of the speakers from industry and the universities who have added to the intellectual content of the forum.

As I said earlier, I am particularly thankful to this audience, all of you, because you have really been quite an outstanding audience in terms of your faithfulness and the level of your participation and contribution.

Our panel this afternoon includes the following: William Lowrance, visiting associate professor, Program in Human Biology, Stanford University; Dr. Robert P. Morgan, professor of technology and human affairs, Washington University, St. Louis; our distinguished colleague, Representative Don Ritter of Pennsylvania; and John Stewart, staff counsel for the Senate Committee on Science, Technology and Space.

I'm a very permissive chairman and I have no qualms whatsoever about any changes in the schedule. But, if there are no other preferences, the panelists can proceed with brief presentations in the order in which I introduced them.

Therefore, I will start with William Lowrance, and ask him to lead off with our panelists' comments this afternoon.

STATEMENT OF WILLIAM LOWRANCE, VISITING ASSOCIATE PROFESSOR, PROGRAM IN HUMAN BIOLOGY, STANFORD UNIVERSITY, CALIFORNIA

Dr. LOWRANCE. Thank you, Mr. Chairman.

The members of the panel pointed at each other and the fingers ended up pointing to me to distill what has been said. I'm not sure I'm going to distill, so much as reflect it back into the flask. We've been through a lot of issues.

I want to make some special remarks of my own. Again and again, in the threshing around of the past 2 days, we have heard a couple of central themes. The first is, of course, that there can be no risk of absolute zero. No speaker has failed to mention it, one way or another; so this audience knows and understands that.

The question, then, is where to go. We have seen dramatic changes in regulation and in the way society manages itself as, for instance, with proposals for reform of the Food and Drug Administration from Congressman Martin and others in finding some way out of the impasse in which we find ourselves.

The Delaney amendment says that no material can be added to food if it has been tested and found to cause cancer in laboratory animals or humans. There are many fuzzy words in that amendment. We have to seek more specific guidelines. We are trying now to find some way out of this tendency toward absolute approaches and move toward more relative approaches.

The second theme I've heard running through these days is a very clear recognition that all of these issues have elements of "subjectivity" as well as elements of what might be called "objectivity." People use those terms without defining them. I shall not, either, try to define them. It's like justice, a word you cannot define very well. We have heard from Paul Slovic and others that those who pursue a trade which labels itself as being objective have to remember that these notions are simply a matter of consensus at the time. It can change at any time.

That calls for a certain humility and in some cases increasing recognition of differing views depending on whether they arise from objective measurement—counting of bodies in the street, or estimates of the real magnitude of hazard—as compared to subjectively perceived hazard.

We know that we as humans are not very good at sizing up risks off the tops of our heads. Ask people: "How many people a year do you think get hurt skiing, or in landslides?" People are simply not able to come up with numbers that resemble the statistics from more objective data banks.

So, the two themes, then, that stem from that are themes of uncertainty, uncertainty in scientific facts and uncertainty in social facts or preferences. Again, that has come up again and again.

The issue that results is one of comparison. How do we compare things? If again and again we find ourselves in a box because we have given too much attention to one hazard and not enough attention to another, how do we compare them?

There is some talk of methods, but I think the speakers in general in the discussion have indicated there doesn't seem to be any one general method. In fact, several speakers such as Dan Callahan said they didn't expect a single method to emerge, and it probably wouldn't be a good thing to seek a single general method of risk/benefit analysis.

Several times, people have said that it's fine to try to minimize risk, but at the same time we shouldn't stifle innovation. But we don't know where to go beyond that. I enjoyed hearing the comments. Richard Stafer gave us some notions why we are safer as a country, that has accompanied at least our becoming richer.

He didn't help me personally know how to translate that into policy decisions or analyses. He did present the theme, though, of being careful of technological timidity and not failing to take some interesting chances.

One of the comments yesterday was interesting. Nick Ashford spoke up in response to a couple of speakers and pointed out that he believes the hazards are changing in character and complexity. I believe that, too, very strongly. It's easy, too easy, to say that we have always had earthquakes, flood, fire and so on. But Nick Ashford described examples of the character of hazards changing, mentioning such things as the scale of hazard.

At lunch today, a couple of us were talking about the scale of the security hazard of our dependence on Middle Eastern oil. It's imaginable that a very localized event could tie up one of the straits in the Middle East and change the entire world energy picture even faster than the 1974 embargo did.

Then at lunch, Eula Bingham made some interesting points about relative risks. I'm sorry she isn't here. But, I will share with you a question that I think this audience can contribute to over time. I have visited a number of manufacturing firms in the last few years and among other things have asked questions about the protection of women, as women increasingly enter the physical labor force in such places. I have seen quite a few women at age 18, 19, or 20 who have at that point not done as much physical work as men of their age. Men have been digging ditches and playing football and so on. The women are trying to get jobs in the most hazardous parts of the plants because, of course, those pay the highest. Women are working in very high temperatures, very polluted environments, swinging sledge hammers, lifting heavy castings onto conveyer belts, and so on. I believe that's a trend through the country, and it is a kind of hazard we really don't know how to do much about. I've heard spokespeople from OSHA say again and again, "We will not discriminate between men and women in the workplace." My response to that is that we ought to discriminate as finely as possible among different kinds of people in the workplace.

There are small people and there are large people, younger and older, and so on. I really think it's a profound question, how to protect women's backs and so on. Then there is the classic question of reproductive hazard. People are quick to say, well, pregnant women should be protected by legislation. They should not have to lift as many pounds when they are pregnant. Then people back up and say yes, since women are very sensitive in general to radiation and so on, they should be protected. I would urge attention to this as well. I don't know where to take this argument. I think there are a lot of special categories. Society hasn't gotten around to thinking about them. Maybe one way or the other, we can address that question to Dr. Bingham.

This morning, Dave Okrent quite rightly quoted a line from a book I wrote and said he found the concept of "safety" as being too vague. I quite agree. I learned a lot from writing that book. Like anybody who writes a book, I wanted to rewrite it the moment I saw the first hard copy. I really don't find the word "safe" very useful, either David, and I want to acknowledge that.

David made a lot of good points. One of the things he left me puzzled by, was when he said that he would like to see the Congress and other such bodies try to deal with the notion of "acceptability" or "reasonableness."

Some recent legislations call for "reasonable protection" of this or that. There is, to my mind, insufficient guidance in the record to indicate what the Congress means. The Conservation Foundation held a meeting this year, and the entire meeting of 2 or 3 days was devoted to those words "unreasonable" and "unacceptable" in the Toxic Substances Control Act. David urged the development of criteria of acceptability and perhaps we might add reasonableness. I'm not sure how to do that. He said he wasn't sure, either.

One thing I think we always have to do with any hazard is ask, "What is this particular issue really about for the society?" They are not all about the same things.

It seems to me that the fight over laetrile has been about the fundamental right of someone who is terminally ill of cancer, and knows it, to take whatever curative measures they deem reasonable. As it was dealt with by the FDA and the Supreme Court, the issue was defined more legalistically and narrowly, but for society, that's what that issue was about.

Saccharin is about personal freedom. Smoking is also about freedom, but society is recognizing that that issue has certain externalities; what other people do can affect others.

Three Mile Island, it seems to me, was about many, many things. But one thing I was struck by was the question of reliability: reliability of expertise, of plans, and of the ability of society's leadership to do something about the emergency. I'm not sure it was about the absolute hazard of the reactor. I think people will rather quickly forget lots of things about it, but one impression a lot of people were left with, I believe, is that "the system" fell apart. It's remarkable to read some of the discussions the Nuclear Regulatory Commission and others had during this crisis. I believe it was reliability of social management, if I can use that very broad term, that people were concerned about. The DC-10 problem was more one of reliability of maintenance and some other things.

With nuclear waste, the issue is about social scale, temporal scale, and the right of one generation to make choices for future generations.

The upcoming Supreme Court decision on regulation of benzene will be crucial because it will examine the legitimacy of cost/benefit analyses in regulation and the strictness with which cost/benefit analyses can and should be applied in a formal way to regulatory decisionmaking. I urge you to watch that one. It's a very, very interesting landmark case coming up in October.

Skylab was an exotic issue. Reporters called me for weeks before that hardware came down and asked me just how bad I thought it was. When I gave them a rather blasé answer and said, "I don't know, nobody knows where it's going to land; yes, it could cause damage, but it might not cause any," there was usually a puzzled silence. They asked why I wasn't more upset about it. I said, well, there is not much anybody can say about it.

DNA, the recombinant DNA question, began as an exotic question. There really wasn't much precedent for that kind of problem in which the research itself was part of the problem. I laud this committee for pursuing that DNA issue and developing a very fine record, even before any legislation was contemplated. I think that's the kind of inquiry that needs to be undertaken more often. The issue began as very exotic and eventually died back because it was realized that many areas of recombinant DNA research were not very hazardous. We were able to find some categories of experiments that were really worth worrying about and could begin to take some precautions.

Current dispute about the pap smear is not about the hazards of the pap smear, but whether the test is efficacious in detecting uterine cancer and what kind of guidance it provides women who undergo routine examination.

The last thing I will mention is the question of whether the Amish should be urged or required to vaccinate their children against polio. That is about protection of the commons, the larger society, the children of the larger society in particular, even though this might be at the expense of the Amish, to whom vaccination is offensive.

I think taking an approach of asking what is the essence of an issue is important. We've got to focus on things quicker, recognizing them for what they really are about for society.

Again and again in these meetings, people have mentioned priorities along with comparisons. We really don't know how to compare things and we know even less well how to set priorities in a "rational way."

If I ask myself what issue in 10 years is likely to be as large as the energy issue is now, I have a few candidates. I will mention one: water. I think one day the water crisis will be on the cover of Time magazine the way the energy crisis is now. But, I don't know—I haven't done any deep studies on that. Goodness knows many organizations have investigated water. There are many books written about water. It's hard to make it into a crisis until everything really starts drying up. Californians and New Yorkers and others have had brief periods of drought. But we haven't really experienced it fully yet. I don't know how to urge the Congress to make such an issue into something serious before it gets to be a real social problem.

The last point I would make is a little bit of social philosophizing, the sort of thing that isn't done in these halls often enough. I have realized in a rather painful way in the last few months that three of the foundations of our society are really being tested by some crucial issues.

One is that we are a federation of States. I think federalism is now being put to the test. I was struck vividly by something John Deutsch, of the Department of Energy, said one time as he was starting into some comments on waste disposal. He said, as a scientist coming into the Energy Department, trying to sort things out, somewhat as an amateur, he could recognize only one firm scientific fact about the entire nuclear waste problem: whatever nuclear waste depository is built eventually will have to be located in some congressional district. He and others have used terms such as "constructive federalism". The stuff has got to go somewhere; even if we were to close down both our military and civilian plants right now, we still would have waste to get rid of. That is therefore a test of whether we are a federation and what this implies. Such things as Project Sanguine, or Seafarer, the array of underground wires that would let us communicate with our submarines, is another example. People say wait a minute; we need to have some communications before we fire our missiles. But no State has been willing to accept that antenna.

Again, yes, locally it probably has some hazards we just don't know of. But the antenna has to go somewhere. That's the test of federalism I would point to.

The second is a crisis of small "r" republicanism. The experts in this room have all found themselves confronting the issue of expertise and how those who have a special knowledge should use that knowledge in the larger society. We see it, for instance, when the Department of Health, Education, and Welfare uses our tax dollars to convince us

to stop smoking. That, to my way of thinking, is an exercise of a republic in which a certain minority—HEW is still a minority in the country—is urging us to stop smoking.

The third aspect of Government that's being pressed is democracy. In a meeting such as this we say we need to stay in touch with people, gauge the will of the people in assuming risks. Most of us are willing to say that if the public has a special fear of radiation or genetic experiments, the public should be allowed to maintain that fear. Those of us who are privileged to work in laboratories should pay some heed to that. But we constantly have trouble figuring out what it really means to be a democracy and to take the public's view into account. If one looks at such mechanism as referenda, one fears that they are quite flawed mechanisms.

So, the three aspects of federalism, republicanism, and democracy are being pressed hard by very technological issues.

Mr. BROWN. Now, I would like to introduce our next witness, Robert P. Morgan, chairman of the Department of Technology and Human Affairs, University of Washington.

STATEMENT OF ROBERT P. MORGAN, CHAIRMAN, DEPARTMENT OF TECHNOLOGY AND HUMAN AFFAIRS, WASHINGTON UNIVERSITY, ST. LOUIS, MO.

Dr. MORGAN. What I would like to do briefly is rather than try to summarize my perspective of what went on here, to focus on something that may seem a little bit tangential. But again, I won't be the only one.

What I'd like to talk about is the role of the university. One of the objectives of the symposium was to try to see how scientists, engineers, university people might communicate better with people on the Hill in the area of risk/benefit analysis and their role in the risk/benefit analysis.

My thinking is not very far along on this. Risk/benefit analysis has not been one of the things that I've focused on heavily over the last couple of years. It seems to me the university's role is traditionally thought of as encompassing three functions, teaching, research, and service.

Teaching involves essentially two groups of students. One I would describe as being concerned with science and technology policy at a professional level. The other much broader, larger group are students who comprise the student body at large. Both of these groups are important. The larger group of students includes social and natural scientists, engineers, journalists, business majors, liberal art students, lawyers, and doctors to name some. Their exposure to science and technology issues in general and to risk/benefit analysis in particular may vary from what they read in newspapers and magazines on one hand to formal courses offered by a variety of departments on the other hand.

These courses may be peripheral to their major interests and taken in part because they are interested in something or interested in the topic or maybe they have to satisfy some distributional requirement outside the major. But, the fact is that they do take these courses. They

can be taken in a variety of departments. Bill Lowrance tells me that his book on safety and risk is used in some 260 courses around the country now in a variety of departments, chemistry, biology, political science, to name a few.

For this larger group, the university can serve, if it's doing its job, to educate citizens who can better understand and articulate the issues, students who can look behind the headlines and beyond the limited understanding offered by the media.

The media is not always all that bad. There was a program on this morning at 6:30 on gasohol. They had Nicholas Wade from Science and somebody from the Alcohol Research Institute. It was quite informative.

In any event, understanding of some of these issues really requires insights into the uses and limitations of data and the impact of values upon outcomes, things we talked about here. Being able to articulate these issues means being able to communicate about science and about science policy matters in English, as Judge Markey pointed out.

I think this role of the university, while not directly feeding into congressional policy decisions, is an important one in that the students go out and become a part of society in various ways, in various capacities. There is a smaller group of students who wind up spending a substantial amount of their professional time on science and technology matters and on risk/benefit analyses. They work for Government agencies, both promotional agencies and regulatory agencies, to use Professor Green's terms. They are congressional staffers, on congressional committees and agencies. They work for industries—small and large industries. Sometimes, they learn on the job, coming with no particular training or exposure in science and technology policy. In other cases, they come from a small number of varied degree and nondegree training programs in science, engineering, and public policy or technology and human affairs or public policy. These programs, one of which I'm involved in, start from the premise that science and technology policy analysis, of which risk/benefit analysis is one aspect—one methodological tool—is a serious activity worthy of more than being a hobby or an avocation. And that concerted education will bring benefits to the individuals involved and to the society at large. I don't claim these programs are the only ones that will make contributions. I don't believe they have a monopoly on wisdom and I'm aware of the problem of undue influence of a scientific elite in a democracy.

My experience has been there are students who want this kind of education and there are employers who want to hire these students. The marketplace seems to have made some of them into a viable proposition. That could change, but right now, some of the fledgling programs are doing reasonably well.

It seems to me that we as educators in the universities, and I think there are a fair amount of university people here, have an important responsibility in that we are graduating students who are assuming significant positions in Government and industry, that can influence policy and directions for the United States. What we teach and how we do it is important. Curriculums are not yet cast in concrete in this area; nor will they necessarily ever be. My own personal feeling is that we need a mix of methods and of issue- or problem-oriented education.

We need the qualitative and quantitative. We need to introduce issues of politics, ethics, and values. I think most important, we need to expose students to a variety of points of view as was described yesterday morning, the "on the other hand" kind of education. For students in science and public policy courses to have heard the kind of exchanges going on here I think would have been of particular value. When I say universities here, I don't just mean universities. I mean colleges and junior colleges and the whole spectrum of institutions.

The role of universities in policy research has been somewhat limited up until now. By research, I mean the generation of new knowledge or new methods or insights by a variety of techniques. Research in many universities, including my own, means primarily sponsored research. The sponsors are Government, both mission-oriented agencies and industry. The Congress tends to do its own studies. I'm sorry we didn't get a chance this morning to ask some questions of Jack Gibbons because I think OTA provides a significant interface between universities and congressional decisionmaking which needs additional attention and examination.

I think the fact that Dr. Schneiderman pointed out—that risk/benefit analysis is immature—is significant. I think the point he makes is true. Maybe universities can help it to mature. Dr. Slovic pointed out some of the difficulties as well.

It seems to me it's an area that's worthy of attention. There are a number of issues. Is the research useful? Is the research sufficiently independent, or are the sponsors simply getting the answers they want and knew they would get in the first place? Is the support for the research adequate? My own feeling is that with maybe one or two exceptions, there are not enough programs or sources of support for independent policy research which might yield some new insights and some answers to some of our issues and problems.

I'd like to see more support and a little more risk taking on the part of Government, and supporting university research even if it leads to some short-term answers that may not be liked. In the long term, they may turn out to be beneficial.

A third area is public service. This is another important area which people have talked about—the need to reach out and to provide information for the public at large about science and about science technology policy issues.

Here, I think there are institutional roles for universities and there is certainly a role for university personnel—professors. There are public lectures and outreach programs. The science information movement which was instrumental in helping to alert people to the risks of nuclear fallout was based to a large extent in universities. There are a variety of methods. Senator Tsongas mentioned he meets with scientists on Sunday morning. I think it's an important step.

The question of better relationships between science and politics is an interesting one. It's one I haven't really given much thought to. I'm not convinced that the current situation is all that bad. Scientists may have as much influence and access as is desirable. It's not immediately obvious that they should have more.

I think it's good that some scientists and engineers are getting elected to the Congress, particularly from your point of view, if it

turns out that the scientists and engineers see eye to eye with you on political and various kinds of issues. That may be or may not be the case.

This particular kind of forum, a hearing with witnesses, is a tremendous source of information and a tremendous source of exchange. In the universities, we don't get enough of that information. You've got a lot here that would be useful to us as well. Unless we are really up on things—we write a textbook or something—the problem is that in 2 or 3 months, what we write is obsolete.

I've tried to give you some of the perceptions from my point of view of where the university fits in and what its role might be. It's pretty much of an academic point of view. It's sort of within the traditional constraints of the university. I'd be interested in hearing from the congressional side which I think is coming up.

Mr. BROWN. How true. Thank you very much, Bob.

Our next panelist this afternoon is our distinguished colleague, Representative Ron Ritter of Pennsylvania who we are very happy to have as a member of this panel and I'm happy to have as a member of the Subcommittee on Science, Research and Technology.

We are happy for the contribution he is able to make in that forum.

Mr. RITTER. I'm delighted to be on this subcommittee because I think Mr. Brown has really done an excellent job in trying to get at the heart of those issues in science and technology that this country faces and that we really have to get working on and get answers to.

I have experience over the past 6 months to draw on. I would like to commend the subcommittee chairman for being one of the most dedicated individuals as subcommittee chairman as well as forward thinking that I have come across.

Mr. BROWN. That's why he's such a good subcommittee member, of course. [Laughter.]

Mr. RITTER. I don't mince too many words, George. It's true.

I'd also like to thank Charlie Mosher again for putting this together. The summary that I'd like to speak to—I might just start off with what Bob Morgan has just addressed—is the kind of individuals who could be thinking about these risk problems and raising these issues and seeing the other sides to the story.

I think that's important. I'm willing to really go ahead and see if we can bring along in the educational system some of these kinds of individuals. But, I do have a concern that we can develop a whole *cadre*—and I think we have part of that *cadre* here in Washington already—who can explicate six sides of the issue and who can see both sides of the story, but who are not willing or even capable by their background and training to go ahead, make a decision and then implement the decision. Everywhere that decision has negative aspects to it, but somehow on the whole the decision was positive.

In other words, talking about risk, the individuals who make decisions or who provide the framework within which decisions are made, have to be able to take risks. There is not going to be this 100 percent positive side to any of these questions. And to the extent that the educational system will provide for us the kind of individuals who can be firm enough to decide, this is the way to go. Enough of this tempor-

izing. Let's move ahead and let's move ahead as quickly as possible because that's what the country needs.

That's what the Government needs. At some point, we put our "on the other hands" and our differences of opinion behind us. We arrive at a reasonable consensus and we go forward like gangbusters. That's what I think we need more of.

Dr. Wildavsky talked about economic well being and its relationship to safety as being the foremost driving force in the provision of safety. He talked about how mechanization of agriculture did more to benefit nutrition, reasonable and healthy nutrition, than did the FDA. He was making a good point.

Mass education massively contributed to the safety of all workers in all fields and a wide variety of products in the marketplace provided redundancy. So, if you accept or even lean toward that idea that the basic driving force for the achievement of safety is economic advancement, you then come up against a question of the moving up on the economic ladder.

As you know, many of the less privileged in this society have far more risky environments. If you then say that moving up the economic ladder is important to achieve a level of well being and safety in the society, then you come up against the potential contradiction that regulation or massive regulation of the economy to minimize risks can turn off the very goose that laid the golden egg of safety.

I think that's a very, very important point. Chairman Brown is very interested in the innovation cycle and the productivity cycle and we do know of so many potentially valuable technologies. Somebody talked about it this morning. People are not quite willing to get involved because of the potential of getting sued or getting regulated or whatever.

The risk of doing something is greater economically and for the future well being of somebody making a commitment or an investment, is too great. So, you know, we are providing a very high risk for innovation and a very high risk for commitment to new products.

Nowhere is this truer than in the area of biomechanics. There we have scads of people sitting in our best universities, staying in those universities because if you want to get into that field industrially, you have such an enormous framework of legal and regulatory roadblocks that if you've got a good Government grant and you can go skiing on the weekends, why not just take advantage of that and forget about this innovation which would lead to an increase in productivity and new features of our economy?

Keeping that in mind and thinking again about education, I come up with a response to this whole thing and with the complexities of the subject that we are talking about, you almost want to do more in education rather than regulation. To regulate seems to go after the one value at a time. It's difficult to do these comparisons.

I think we have to do a great deal more. I think that if we begin to look at some of these competing or alternative technologies in an integrated sense, even if our methodology is not great, at least we use the same methodologies to compare them all.

Implications for research were mentioned. I kind of like that idea of spending a little more time on what has made us safe rather than what may not be the 0.001 percent of safety that we want to achieve.

Then they were talking about time. They talked about the fifties and being a "gee whiz" generation.

Ed Diamond was talking about that, and the seventies being a generation about science—generation of skepticism. That flows somewhat from the sixties which were kind of a flatout "Government involvement" and "social involvement" in the evolution of our scientific and technological establishment.

If you believe in the fact that the only thing that is really constant is change, we will probably see some kind of different perspective in the eighties. It may be that some of the vast skepticism that we see today will kind of run itself out. Just like the certain energies that you saw in the sixties, they kind of burn themselves out.

The "gee whiz" aspect of the fifties is that I guess people got bored. There are just so many times you could say "gee whiz." So, I look forward to real progress in this area in the eighties. I think maybe the eighties can return to a decade of optimism. We understand that we are not in possession of everything that we could possibly want.

But, we also understand that we are in possession of certain things which perhaps are better to get on with doing and using and evolving rather than saying no, or negating. So, I look forward to some real possibilities coming out of this discussion. I would hope that those of you with a strong interest and an interest in the kind of legislation that I have proposed could personally be in touch with me if you have comments or discussions to help make my job easier and help make me a better Representative, not just in my district, but of all of you and of the American people.

Thanks.

Mr. BROWN. Thank you very much.

Our last panelist is John Stewart, staff counsel for the Senate Subcommittee on Science, Technology, and Space with which we've had a very close and cooperative working relationship. There are differences between subcommittees in the Congress and particularly between the two different house of Congress. It's novel.

STATEMENT OF JOHN STEWART, STAFF DIRECTOR, SENATE SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

Mr. STEWART. Thank you, Mr. Chairman.

I might say that the reason for the cooperation is because there are two good chairmen involved. I realize that there are bigger issues and there are limits. When I was asked to be the last of the 18 speakers, I wasn't sure whether that was an honor or whether it was because the organizers concluded that if I heard all the other speakers, I might have something useful to say. I haven't decided that.

What I have decided is that whatever it is, it better be short. I will try. The one thing that has struck me in listening to the 17 speakers who preceded me was the tendency, not in all instances but generally, to avoid talking about the subject of the conference, which is "Risk/Benefit Analysis in the Legislative Process," and instead to focus quite understandably on how they deal with risks and benefits in their respective jobs or occupations.

So, if I am asked to summarize anything about the Congress, I can't because there hasn't been much said about the Congress.

Therefore, I thought what I might do is to talk a little bit about the Congress, as a "political scientist," I hasten to add, and not as a member of the congressional staff and certainly not as one who is attempting to reflect the views of the subcommittee and the committee for which I work.

I detected a certain note of disdain in Professor Greenhouse's reference to political scientists. I often share those feelings when I attempt to fathom in the "American Political Science Review" some of the work now being done by political scientists. As my former professor will recall, I have approached this assignment in a somewhat more traditional, value-oriented way, one that recognizes there are limits to imposing highly empirical methods of analysis on political life.

I'm interested in questions such as how political institutions function. How do these institutions relate to broader social and economic realities? As Harold Lasswell of Yale once asked: "Who gets what, when, and how?"

What is the nature of the Congress today that attempts to use risk/benefit analysis and how does this nature in turn affect the use of such data?

Finally, what's the nature of the political system in which the Congress functions? These are questions we haven't touched on. In a sense they are things that most people have been talking about. When you go back and read the title of the conference, it seems to me these might be useful questions to ponder briefly before we wind up and steal away in our respective directions.

Congress is an institution extremely susceptible to change and the last 10 years that I have been on Capitol Hill off and on—20 years, as a matter of fact—have been a period of sweeping change in both the House and the Senate.

There has been a very strong trend toward enhancing and strengthening the power of individual Members of Congress at the expense of institutional and party leaders in Congress. By institutional leaders, I mean committee chairmen. And party leaders obviously would be the Speaker and the majority and minority leaders of the respective Houses.

This has always been true, but it's more true today than ever before. The power of the Congress is decentralized. It now rests with the majority on the committee. Ten or fifteen years ago, I think most people would say, the power rested with the chairman.

Chairmen are still powerful. They have a major role in deciding what happens. But it's also true that a majority of the committee, if it is determined, can usually get its way. It is also true that this majority on the committee shifts from issue to issue. Rarely do you have all Democrats lined up and rarely do you have all Republicans. Certainly not when it comes to issues of science and technology.

It's very hard to discern any partisan differences at all when it comes to many issues that fall into the science and technology arena. In addition to this strong decentralization of power, we find Congress as an institution over the past 10 years has dramatically expanded and strengthened its own sense of independence.

This has been an era of congressional assertiveness, compared to a period when Arthur Schlesinger, for example, wrote about the Imperial Presidency and many people worried about the growing domi-

nance of the executive and what that would mean to the future of our country.

We have two Houses of Congress that are open. They are accessible and they are uniquely qualified to experiment with things. Congress is one of the great experimenters of our national life. You will find that both the House and the Senate Members are coming up with all sorts of ideas, some good, some maybe not so good.

People come in, they take positions, and there is a process of germination that goes on continually on Capitol Hill. So in that sense, it is very different from the executive branch.

We have a strong and assertive institution. However, individual powers and prerogatives tend to dominate. Order is not a decisive consideration in the life of the Congress. It is more so on the House side than on the Senate side, but order does not rank at the top of things that matter here on Capitol Hill.

The good news is that such a distribution of power and responsibility permits a very broad range of groups and interests to express their views. We have talked about that. It's true. People can walk in off the street. They can be organized or not so organized.

They can get a hearing and, more often than not, they will have an impact. But, the bad news in all of this is that it is very difficult to reach agreement on broad governing strategies such as Dr. Aaron Wildavsky proposed yesterday.

It's difficult to subsume the work of Congress in any one governing ideology. Committee chairmen can't do it. Party leaders find it difficult. And, it is quite clear that Presidents these days have their problems as well.

These clashing interests are precisely what the founders had in mind. I haven't read it in a while, but I have the distinct recollection that this was discussed with some eloquence by Hamilton in the Federalist Papers, No. 10. He points out that the sensitive republic is the key to liberty.

We have a sensitive republic where all points of view can be heard. The irony of all this is decisions made by Congress have in some people's view placed barriers in our system of economics. In a political environment that favored regulatory initiatives just about every group came to Congress for protection.

The cumulative result of this risk-by-risk approach has perhaps yielded more than anybody thought it would when the process started in the midsixties. Yet one gets a sense that the political environment is changing and the pendulum beginning to swing in the other direction.

I think these things do go in waves. We now have a lot of interest and activity in regulatory reform. There was distinct backing away from legislation to regulate the conduct of recombinant DNA research after thorough hearings conducted by this committee and by the subcommittee for which I work.

There is in effect, and it has been extended by the House, a moratorium on the banning of saccharin. There was a growing inclination in Congress to restrict the regulatory powers of executive agencies through some form of legislative veto. Perhaps over time, there will be a greater reliance on indirect methods of regulation, as

Congressman Ritter suggested just before I began speaking and Dr. Wildvasky advocated yesterday.

But in either circumstance—the highly activist regulatory mode of the recent past and the perhaps somewhat less activist posture toward which Congress is headed—risk analysis is only one point in a much more complex situation.

I think it is fair to observe that in the context of this institution where political power is not centralized and where individual members have a great deal of freedom and prerogative, more often than not risk/benefit analyses are used to defend positions that are determined by less empirical factors.

We forget that Congress is and, goodness knows should be, a political institution. Risk/benefit decisions all involve tradeoffs. Some interests are advanced. Other interests are retarded. In a political arena that is as decentralized as the Congress, these decisions can never be settled strictly on the basis of reported scientific analyses.

Each side to a particular issue will assemble its own set of facts. Given the imperfect state of the science, as pointed out by speaker after speaker, this strategy is feasible and unavoidable.

If we are not happy with the present arrangement, we have to ask some very different questions. Do we want more centralized, that is to say party, control of legislative decisions? We've had it in the past. There have been binding caucuses in the House and in the Senate.

We don't have them today, but we have had them in the past. It wouldn't be anything new. Do we want to cut back the degree of congressional assertiveness vis-a-vis the Executive? Some people are beginning to advocate this. The President is now too weak to lead the country.

I think that's a question that can be legitimately discussed. Do we want to reduce the degree of individual initiative that is involved in running for public office and, instead, enhance the role of party?

One way to increase discipline is having some control over who is nominated to run. As long as individual Members carry the whole load themselves, they are going to come to the Congress and act in interests which they feel reflect their own sense of what ought to happen and the concerns of their constituency.

These are the factors that over time reduce the centralization of legislative decisionmaking. It now renders more risk/benefit analyses of marginal importance. I myself think the system works pretty well the way it is. We do get these swings from time to time. I think that we may be also beginning to swing back toward the somewhat more centralized decisionmaking that prevailed in the past.

It is nevertheless essential that, as we think about the use of the very valuable tools represented by good risk/benefit analyses, we understand that they are going to be used in this peculiar kind of institution. Peculiar not in the sense that it is strange, but that it is unique.

There isn't a legislative body on the face of the Earth that has the power of Congress. In my own view, I think it has been a major factor in preserving the freedom we have in this country, preserving the freedom initiative and the ability to move forward.

I think all of these things reflect the constant activity and turmoil and pushing and hauling that is the essence of what happens up here on the Hill.

That took 12 minutes and 42 seconds, which I think at this time of day is about all you were ready for. Maybe that was even 2 minutes too long. I thank you for your patience and attention.

Mr. BROWN. Thank you. [Applause.]

We are going to now allow the audience to use the rest of the time in whatever way they feel is most useful to them. Obviously, we welcome your comments or questions to any member of the panel. If you have a short 1-minute speech, why, we might even tolerate that.

So, at this point, let me recognize the first hand.

Dr. SALZINGER. I am Kurt Salzinger, National Science Foundation. I was fascinated by the 2-day forum and particularly, I was pleased to hear all the references to behavior and behavioral effects, albeit though they were in such phrases as lifestyle and we have to get people to conserve more and so on.

I think that it may be useful for the Congress to begin to think about behavioral impact statements as it is about economic impact statements. There is a science of behavior and I think that the Congress has been interested in influencing people and it would be useful to them to do this in a more effective fashion.

The example of the warning on the cigarette box is, I think, an example if one can use it, that I have used in my psychology classes with students to show how you can take a particular stimulus and make it ineffective. You start by having a cigarette ad with something very desirable there.

Then, you put a minor warning down. You say this could possibly maybe be harmful to you, somebody says. You then make the warning stronger and stronger over time, preparing it until the stimulus gets you to indulge in the behavior anyway and then, you are surprised that people continue to smoke.

I think also that when we talk about the fact that we must give people more information to get them to conserve more, that's not an up-to-date notion, if I may use that phrase, or to be more direct, it's a naive notion to think that one can educate people to stop smoking rather than educate people to stop driving or that one can educate people to conserve in ways that would be more useful.

There was an opportunity when there were gas lines and when in fact the Government could have in a number of ways made public transportation more desirable for those people who had to give up driving, but who, instead, encountered overcrowded, overheated buses, that passed them by as they waited at their bus stops.

Here was a great opportunity that was clearly missed. I think that when we talk about regulation is bad and that seems to be the latest wisdom everywhere, we are again talking about an ineffective way of influencing behavior. Rather than saying that, gee, isn't it terrible we have made this law and still people pollute, still you get rivers that are polluted, what you are forgetting about is that the manufacturer is in fact in a conflict situation where making more money means polluting more.

It shouldn't be terribly surprising if in fact it turns out that pollution wins under those circumstances. So, there is a need I think of more

application of behavioral know-how and more research in behavioral problems.

Let me just wind up with one thing which is the risk/benefit of such things as Golden Fleece Awards because I think there, too, are behavioral contingencies.

Here, the effect is quite clear. I think it makes the program directors quite cautious, possibly overly cautious. If you are trying to take a risk on a proposal which may sound, gee, this isn't exactly right, but it sounds like it could really pay off, you're going to be very hesitant because you don't want to be the one that's managing a grant that's received the Golden Fleece Award.

Mr. BROWN. Thank you.

Dr. OKRENT. David Okrent, UCLA. A few comments and one question. They mostly go to Dr. Lowrance. He mentioned that he thought the Three Mile Island behavior of those with the highest responsibility represented a different thing than the DC-10 accident. It seems to me I could readily visualize a society in which we had instant communication between the pilot and the group of administrators instead of the single FAA Administrator and his subordinates where exactly the same series of questions came out. What's wrong? Why can't I keep this level? Where did the engine go? Why did it go there? Did we inspect it right?

It's only a question, in my opinion, of dragged-out sequence that's different. That's just an observation. You indicated correctly that I didn't volunteer a method by which one could look at quantitative risk criteria but in fact, I have little doubt that either you or I could suggest to the OTA or the NSF or the National Academy how they could initiate the first studies that could lead to one or more proposals.

I think we should leave that clear for the record.

Dr. LOWRANCE. Absolutely.

Dr. OKRENT. You made a comment about the Inhaber Study and suggested that the CONAES study might provide some answers.

Dr. LOWRANCE. What I meant to say is that I looked forward to seeing the CONAES study because it was an even broader attempt to do somewhat the same thing. I really don't know how the CONAES study is likely to come out.

Dr. OKRENT. I'm a member of the risk impact panel for the CONAES study. We were inhibited, I would say, from trying to do what Inhaber did, in effect. We certainly were inhibited in trying to do comparative risk studies between energy systems and other aspects of society.

I do not look for the answer to this thing from the CONAES study. I think it will be incomplete in this regard.

I did mention something called the risk tax in this possible way to accept risk management. There was an acceptable level of risk to the individual. And then the suggestion was, you cover the residual risk by a risk tax.

I would be interested in your response to this combination of a way to manage risk and to get at risk acceptance.

Dr. LOWRANCE. I have read your paper on that, David, but I've never known quite what we would do with the tax you collect. Even if somehow you could agree on the level of risk and how much that was

worth to us and you could levy a tax on some behavior that had externalities, I don't know what you would do with the tax in offsetting that risk or addressing cost and so on.

It's been a matter of mechanics. In general, I like the idea, but I'm not sure that it would be workable and I'm not sure that it would reduce risk any. It would be a way of passing around the burden of society the way effluent taxes do with river pollution in Europe, for instance.

I have looked at the Rhine tax situation and it seems to me that there countries are paying a tax, the money which goes to downstream countries to clean up the Rhine when it gets there. I'm not sure that the rates have been set high enough to act as a real disincentive to the upstream countries to stop polluting.

You may know more than I do about use of taxes, but that one is similar. Do you want to say something more about it?

Dr. OKRENT. No. I think the setting of levels is subject to what you are trying to measure. One could make it real cost, more than real cost to provide an incentive to reduce the risk or less than real cost because you wanted to get economic growth.

It's not impossible to do. You have to decide what it is you're trying to achieve.

Dr. LOWRANCE. We do that with such things as Black Lung benefits. You and I pay our taxes and our tax money goes to offset the black lung problems of 110,000 or so Americans who suffer from it, or their survivors.

I suppose that's where such mechanisms are being used currently. I'm glad we do that one, but it makes me feel that it's too little too late somehow. I just don't know. I don't have a good response.

I have been asked to serve as Chair for a few moments while a vote is being taken.

Dr. PEYSER. I'm sorry the congressional Members aren't here because I wanted to do some linkage between other committees I'm working with. I'm Minna Post Peyser and I have submitted to the Senate subcommittee a proposal that they look at the 1987 bicentennial of our Constitution, as they are planning their hearings, as a way of opening up the whole question of science and technology and the development of a constitutional system along the lines of the crisis that Professor Lowrance recommended, that Dr. Morgan points out.

It's also an educational crisis of how quickly you tool up the public to be able to participate in the decisionmaking. As Mr. Stewart points out, the resiliency of the public to have informed interplay with the Congress.

There is no way this lag can be met in our current institutional capabilities. Some inventive way through the constitutional observance might link the work of this committee particularly with the focus on information and communication, science and technology being so paramount for the future of education.

The cassettes, who is to develop them, how much the community controls, what happens to the first amendment and the system of freedom of expression as a counter to the market forces that will no longer be regulated? I think the whole society has to address these questions and that this committee ought to explore a joint kind of hearing with the

Senate Judiciary Committee to see how the hearing might frame an observance that would serve all the interests in the society, the science, the technology, and the public.

Dr. LOWRANCE. I find that an interesting suggestion. You, no doubt, will pursue that with the members when they return, or later.

Are there any staff members or others who would want to comment on that suggestion? My own suggestion would be to try to confine it to a few specific issues and try it as an experiment and see what can be learned from it.

One thing I've wanted to do with my classes by way of education is get some video tapes of these congressional sessions and show them what really goes on back there in Washington. It's a very long way from California in lots of ways. I haven't yet found out how to do that. But I'm going to work with public television to see how I can do that.

I hope you'll pursue your suggestion with the Members.

Other questions?

Mr. MOORE. William Moore of the World Futures Society. I'm addressing this as a question to the absent Congressman, Congressman Ritter, and also to the behavioral scientist here because it has to do with human behavior.

It has been said by one of our leading futurists that the mood of people living today will have a profound effect upon the future of mankind. If we are divisive, hateful, jealous, fearful, we will have the kind of future that we deserve.

If, on the other hand, we are optimistic, courageous and confident in man's ability to do good to his fellowman, we will have the possibility of paradise on this Earth. And I'm thinking of Congressman Ritter's bill and his thought that we should expose the public to all of the possible risks and dangers that the various programs and innovations would bring up.

And, I'm wondering what this would do to the mood of people. As he said himself, I believe, they will get afraid. They will be fearful. Is it more important that the people participate in making these decisions or is it more important that their mood should be appropriate in that any bill or law or policy be such that would tend to encourage an optimistic, confident view of the future? Would you have any comments to make on that approach?

Dr. SALZINGER. I think the important thing is to have something to be happy about. I find it a little difficult to speak about happiness per se. But, it seems to me that if you are trying to get people to do something, that you have to use some means of influence that will in fact make them happy in doing it. I think it does happen, certainly for part of the population.

I think it's a matter of using the latest behavioral techniques. But happiness per se is, I think, something that comes from that rather than introducing it.

Dr. LOWRANCE. That might be a good note of optimism to close on. I feel as though we are in one of those symphonies in which the pieces slowly disappear into the wings. With Mr. Mosher's approval, I will declare us adjourned and play a double role of thanking you for the Congress and thanking them for inviting us.

I hope we can all continue at some later time.

[Whereupon, at 4:26 p.m., the subcommittee was adjourned.]

APPENDIX

CONGRESS/SCIENCE FORUM, WASHINGTON, D.C., JULY 24 AND 25, 1979

GENERAL THEME—RISK/BENEFIT ANALYSIS: ITS ROLE IN CONGRESSIONAL SCIENCE
AND TECHNOLOGY POLICY DECISIONS

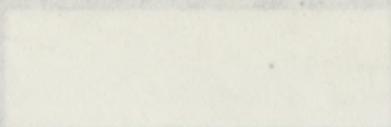
Attendees

Walter A. Albers, Jr., General Motors Research Laboratories	Edward J. Burger, Georgetown University Medical Center
Henry L. Alder, University of California at Davis	Raymond Bye, Jr., National Science Foundation
Thomas H. Althuis, House Committee on Science and Technology	John C. Calhoun, Texas A & M University
Robert C. Anderson, University of Georgia	Geraldine M. Carr, Congressional Research Service
V. Elving Anderson, University of Minnesota	Mark Cavitt, University of Tennessee
Diana Baldwin, American Psychological Association	Rosemary Chalk, American Association for the Advancement of Science
Paul Ballonoff, Independent Consulting Services	Walter Chavin, Wayne State University
Rebecca Barclay, Environmental Protection Agency	Frank P. Chemery, U.S. General Accounting Office
J. Robert Barlow, Cornell University	Don Christiansen, IEEE Spectrum
Paula T. Beall, Office of Naval Research	Louis F. Cimino, American Anthropological Association
Charles Beer, Department of Agriculture	Robert Civiak, Congressional Research Service
Edwin L. Behrens, Procter & Gamble Manufacturing Co.	Mary E. Clark, San Diego State University
William Beranek, Jr., Holcomb Research Institute, Butler University	Parker L. Coddington, Harvard University
Joseph W. Berg, Jr., National Academy of Sciences	Anne Cohn, Office of Congressman Albert Gore
Susan E. Berkow, National Nutrition Consortium	James V. Connor, New York University
Carl M. Berntsen, Society of American Foresters	Paula H. Cooper, Rockwell International
Jim Beyreis, National Bureau of Standards	Richard G. Cunningham, Pennsylvania State University
Curt Biren, Office of Congressman Albert Gore	Richard L. P. Custer, National Bureau of Standards
J. F. Blackburn, Department of State	Manfred J. Czesla, National Science Foundation
Betty B. Blouin, American Dietetic Association	William P. Darby, Washington University
Ray Bouchard, Ministry of State for Science and Technology, Canada	Carolyn Davis, University of Michigan
Peter B. Boyce, American Astronomical Society	Bowen C. Dees, The Franklin Institute
Carole Brill, National Nutrition Consortium	R. D. Deshpande, Embassy of India
Molly C. Broad, Syracuse University	Ronald D. Dobbin, National Institute for Occupational Safety and Health
Mark T. Buchanan, Experiment Station Committee on Organization and Policy	Pamela Ebert-Flattau, National Research Council
	Lynn Edward Elfner, Ohio Academy of Science

- John H. Elliott, Jr., Regulatory Council
 Walter J. Ellis, Federation of American Societies for Experimental Biology
 Lester Ettlinger, MITRE Corporation
 Michael Farmer, Exxon Research and Engineering Co.
 Andrew D. Farrell, IIT Research Institute
 Lloyd C. Faulkner, University of Missouri
 Richard E. Faust, Hoffman-La Roche Incorporated
 Robert J. Fawcett, BF Goodrich Company
 Bob Fensterheim, Office of Technology Assessment
 John Ficke, Environmental Protection Agency
 Steven Flajser, Senate Subcommittee on Science, Technology and Space
 Pat Gerry, Environmental Protection Agency
 Richard C. Fortuna, Office of Congressman John Dingell
 Terry Fortunato, Energy Today
 Raymond F. Fraley, Nuclear Regulatory Commission
 Louis D. Friedman, Senate Committee on Commerce, Science and Transportation
 Harold M. Fullmer, University of Alabama-Birmingham
 Carl Gerber, Office of S. T. Policy
 Thomas Getchell, Wayne State University
 Robert P. Glaze, University of Alabama—Birmingham
 William T. Golden, AAAS Board
 Steven L. Goldman, Lehigh University
 Michael Gough, Office of Technology Assessment
 Robert Z. Gussin, McNeil Laboratories
 Susan G. Hadden, University of Texas—Austin
 N. E. Hager, Jr., Armstrong Cork Company
 Yacov Y. Haimes, Case Western Reserve University
 Loren Hall, Environmental Protection Agency
 Philip D. Harriman, National Science Foundation
 Anna J. Harrison, AAAS Board; Mount Holyoke College
 Martha T. Hatcher, Gainesville Junior College
 Raymond A. Hautala, U.S. General Accounting Office
 Susan B. Hazen, Environmental Protection Agency
 David Heebink, University of Michigan
 Daniel H. Herman, National Aeronautics and Space Administration
 F. Eugene Hester, U.S. Fish and Wildlife Service
 John Holmfeld, House Subcommittee on Science, Research and Technology
 Horace E. Homesley, Jr., Department of Defense
 L. John Hoover, Argonne National Laboratory
 Frank L. Huband, National Science Foundation
 Bartel C. Jensen, Utah State University
 Russell H. Johnsen, Florida State University
 Brian J. Johnson, National Science Foundation
 John C. Johnson, Pennsylvania State University
 Willis H. Johnson, Wabash College
 Paul Jolly, Association of American Medical Colleges
 Raymond F. Jones, Henry Ford Hospital
 Pamela Kacser, Department of Energy
 John W. Kalas, State University of New York
 Gertrude Kasbekar, National Science Foundation
 David Katz, Department of Defense
 J. C. Kellett, Jr., Department of Energy
 Thomas F. Kellogg, Mississippi State University
 Matthew J. Kerper, U.S. Air Force
 Wallace E. Kirkpatrick, BMD Advanced Technology Center
 Leslie W. Koepplin, Rutgers University
 Daniel Koretz, Congressional Budget Office.
 Milan J. Krasnican, Consultant
 Robert A. Krueger, BF Goodrich Chemical Group
 J. A. Kuhlman, International Studies Association
 Jim Lafferty, Paluszek & Leslie, Associates
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 Helmut Lange, Embassy of the German Democratic Republic
 Patricia Laughlin, University of Pittsburgh
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 Stephen, Merrill, Senate Subcommittee on Science, Technology and Space
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 Minna Post Peyser, M.P. Peyser and Associates
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 Allen J. Sinisgalli, Princeton University
 Robert G. Smerko, American Chemical Society
 Clayton O. Smith, University of Wisconsin—Madison
 Brendan Somerville, National Association of Manufacturers
 Howard E. Sorrows, National Bureau of Standards

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| Ronald A. Stanley, Environmental Protection Agency | Robert D. Watkins, American Society for Microbiology |
| Janet A. Steel, Environmental Protection Agency | Elliot H. Weinberg, Office of Naval Research |
| William Leroy Stewart, National Science Foundation | William Wells, House Subcommittee on Science, Research and Technology |
| Norton D. Strommen, National Oceanic and Atmospheric Administration | William H. Westendorf, Monsanto Company |
| Ralph H. Sullivan, Environmental Protection Agency | Elbert Bernard White, University of Virginia |
| Michael Thompson, Institute for Policy and Management Research | Haven Whiteside, Environmental Protection Agency |
| Janett Trubatch, National Science Foundation | Guenther O. Wilhelm, Exxon Research and Engineering Co. |
| William R. Turner, Florida State University | James M. Williams, Los Alamos Scientific Laboratory |
| Paul E. Tyler, Department of Defense | Ellery B. Woodworth, Johns Hopkins University |
| A. G. Unklesbay, American Geological Institute | William E. Wollam, Southwest Research Institute |
| F. J. Van Antwerpen, American Institute of Chemical Engineers | Henry H. Work, American Psychiatric Association |
| Jeffery T. Wack, Yale University; National Center for Health Care Technology | Christopher Wright, Carnegie Institution of Washington |
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