Worldwide Science and Technology Advice

to the Highest Levels of Governments

edited by

William T. Golden

Worldwide Science and Technology Advice

to the Highest Levels of Governments

Worldwide Science and Technology Advice

to the Highest Levels of Governments

edited by

William T. Golden

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

First published 1991 by Pergamon Press, Inc.

Published 2021 by Routledge
605 Third Avenue, New York, NY 10017
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

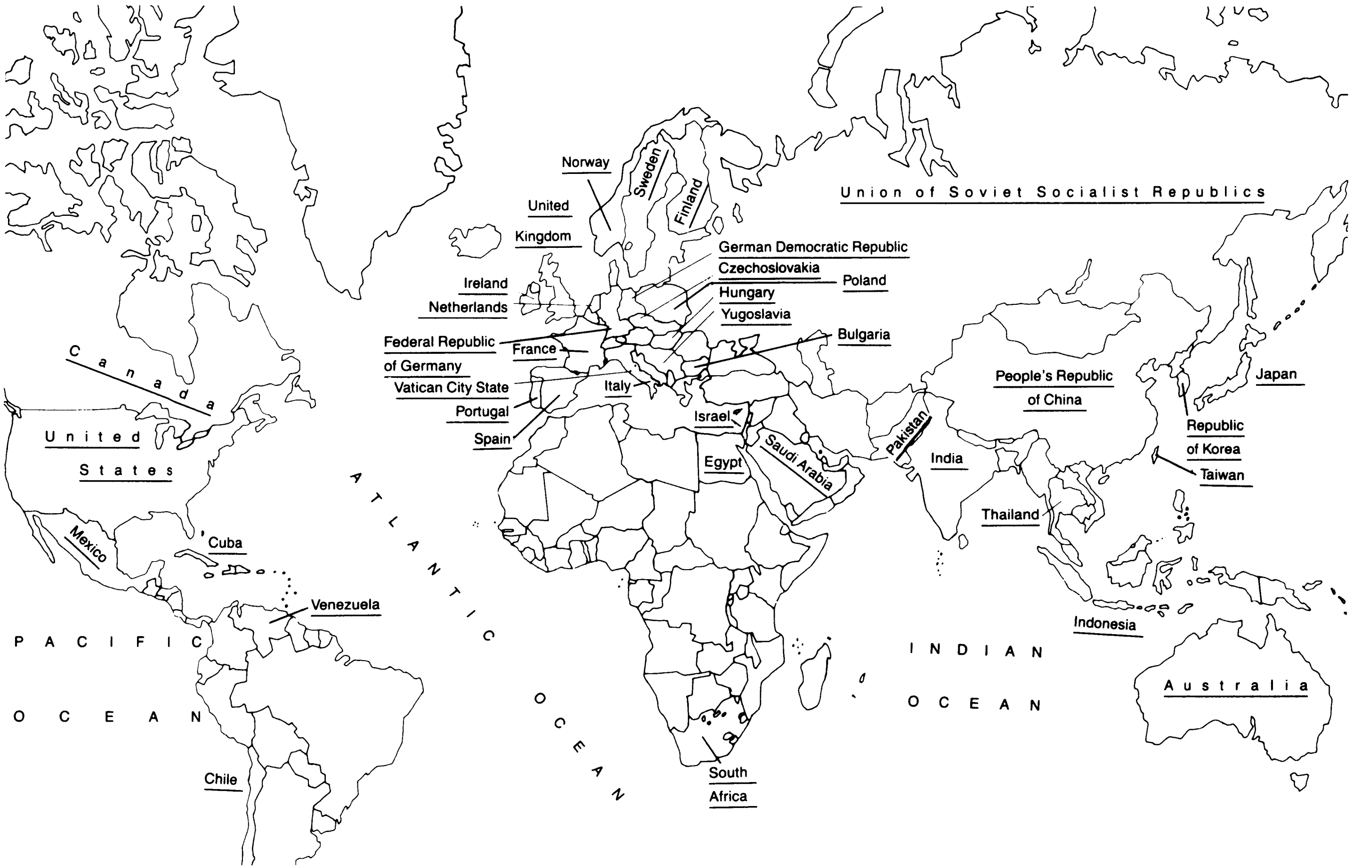
Routledge is an imprint of the Taylor & Francis Group, an informa business

ISBN 13: 978-0-08-040407-3 (pbk)

Library of Congress Cataloging in Publication Data
Worldwide science and technology advice to the highest levels of governments / edited by William T. Golden
p. cm.
Includes index.
ISBN 0-08-040406-5 (hard : alk. paper). -- ISBN 0-08-040407-3 soft : alk. paper)
1. Science and state. 2. Technology and state. I. Golden, William T., 1909-
Q125.W84 1991
338.926--dc20 90-7942
CIP

Dedication

I take the liberty of dedicating this book, on behalf of all its authors, to the future of Homo sapiens, our endangered species, in the hope that our efforts will contribute to the survival and betterment of humankind through the encouragement of education and international cooperation.



Canada
United States
Mexico
Cuba
Venezuela
Chile
PACIFIC OCEAN
ATLANTIC OCEAN
Norway
United Kingdom
Ireland
Netherlands
Federal Republic of Germany
France
Vatican City State
Portugal
Spain
Sweden
Finland
German Democratic Republic
Czechoslovakia
Poland
Hungary
Yugoslavia
Bulgaria
Italy
Israel
Egypt
Saudi Arabia
South Africa
Union of Soviet Socialist Republics
Pakistan
India
People's Republic of China
Thailand
Japan
Republic of Korea
Taiwan
Indonesia
INDIAN OCEAN
Australia

Contents

COUNTRY CHAPTERS

Acknowledgments

My gratitude goes first to the authors of these original essays, colleagues in a truly international project.

Then, I thank the friends who have been encouragers and helpers. Notable among them are Helene L. Kaplan, David A. Hamburg, J. Thomas Ratchford, D. Allan Bromley, Frank Press, the late I. I. Rabi, Helen Rabi, and the late Mack Lipkin.

And I thank the many others who have helped me in special ways. They include William O. Baker, Harry Barnes, David Z. Beckler, Justin Bloom, Sandra Burns, Robert Cutler, Kerstin Eliasson, Antonio Ruiz Galindo, Patricia Garfinkel, William E. Gordon, Allen Hammond, Ralph E. Hansmann, Ryo Hirasawa, Anne Keatley, George A. Keyworth II, Charles V. Kidd, Rustam Lalkaka, Liu Zhao Dong, Jan Oort, Richard F. Pedersen, Gunnar Randers, David Z. Robinson, Maarten Schmidt, Frederick T. Sai, Frederick Seitz, Kalman Szende, Cyrus Vance, Alberto Vollmer, Henry G. Walter, Jr., Jerome B. Wiesner, and Gabriel Fernandez de Valderrama.

This book would not have reached fruition but for the devoted and resourceful participation of my assistant, Christie Van Kehrberg, and of my other staff members, Ellen Rosenblatt and Eugene R. Gorman. My very special gratitude goes to Martha Miller Willett, finest of editorial ancillaries.

On a more deeply personal basis, I think of my grandparents, steerage immigrants little more than a century ago, who found refuge, freedom and opportunity in the United States of America, as did countless others, and I think of my late parents, S. Herbert Golden and Rebecca Harris Golden; my late brother, Barry; my late wife of forty-five years, Sibyl, ever loving and supportive; my cherished and admired daughters, Sibyl Rebecca and Pam; and certain friends. They are my inspiration and my reward.

William T. Golden
New York, March 1990

Worldwide Science and Technology Advice

to the Highest Levels of Governments

Introduction: Science and Technology Advising in a Dynamically Changing World

William T. Golden

Tempora mutantur nos et mutamur in illis.

The only permanent condition is change.

—Heraclitus, c. 500 B.C.

We must, indeed, all hang together or, most assuredly, we shall all hang separately.

—Benjamin Franklin

As this is written, much of the world's political, economic, societal and governmental structure is in flux. Progress in science and technology has been accelerating. Information and advice about relevant issues have become exquisitely important to the highest levels of governments. The times are changing, and we are changing within them. It is a truism, but nonetheless true that science and technology affect increasingly the lives of all of us (and of other living creatures, including animals, plants and microorganisms) and of govern-

---

William T. Golden designed the first Presidential Science Advisory organization for President Truman in 1950. He is Chairman of the American Museum of Natural History and Past Chairman of the New York Academy of Sciences, and is Co-chairman (with Joshua Lederberg) of the Carnegie Commission on Science, Technology, and Government. He has served in the US Navy (World War II), the Atomic Energy Commission, the Department of State, and the Executive Office of the President. He received the Distinguished Public Service Award of the National Science Foundation (1982). Mr. Golden is an officer and trustee of the American Association for the Advancement of Science, the Mount Sinai Hospital and Medical School, and the Carnegie Institution of Washington; and is a member of the National Academy of Public Administration, the American Philosophical Society, and of the American Academy of Arts and Sciences.

ments and, indeed, the conditions and prospects of the earth itself.

These original essays, by distinguished and well-qualified authors, provide brief descriptions, with relevant commentary, of the science and technology advisory organizations to the highest governmental levels of all major countries of the world and a representative selection of smaller ones, a total of more than thirty-five countries. The United States advisory organization is described briefly in this volume and *in extenso* elsewhere.[1] These countries are diverse in many characteristics, including area, geography, population, economic and political systems, language, religion, culture, and stability. All are linked by a growing interdependence.

This collection considers an aspect of modern life that influences its entire fabric and quality: the role of science and technology in governments throughout the world—in the comity of nations, in peace and in war. It aims to be helpful to government officials, to politicians, to political scientists, to the media, and to the concerned public. The improvement of public understanding of science, worldwide, is "a consummation devoutly to be wished."

This volume is the first attempt at such a comprehensive organizational atlas. It aims at moving targets which are actively evolving. As recent and ongoing political events in Europe, Asia, Africa and Latin America demonstrate, the high road from dictatorship to democracy may digress, from time to time, through the bog of chaos.

The initiation of modern science and technology advising organizations in the United States (making a multi-millennial leap from the Serpent as adviser to Adam and Eve),[2] starting with President Truman's action of early 1951 and fortified by President Eisenhower after Sputnik in 1957, was chronicled definitively in 1974 by Detlev Bronk,[3] former President of Rockefeller University and former President of the National Academy of Sciences.

Perhaps evolving from these early US origins and other stimuli, many nations of the world have developed their own organizations and methods for introducing knowledge and ideas of science and technology into their governments' policy formulation and execution for both internal affairs and international relationships. The Truman science advisory emphasis was on national defense issues, spurred by the outbreak of the Korean War in mid-1950; and Eisenhower and the American people were galvanized by the success of the Soviet Sputnik. But over the years, as science and technology have become integral parts of everyday life, the involvements have broadened and deepened to comprise virtually all human concerns, including economic, societal, educational, political, health, population, ecological, space, and cultural issues—as well as matters of armaments, defense, and arms limitations.

THE ESSAYS

The essays which follow, on individual countries, were written in response to my request that each author (a) describe the science and technology advising organization to the highest levels of his or her government; and (b) comment on its effectiveness and how it actually influences policy formulation and action.

The authors, from some thirty-five countries, have done well, each in his or her own style and each independent of the writings of the others. I am grateful to them. They are of diverse political and cultural backgrounds, and are immersed in different cultural and political environments. Many of them occupy or are recent occupants of official positions more or less comparable to that of the Science Adviser to the President of the United States, and some of the authors are presidents of their national academies of sciences. All are well qualified by status, experience and wisdom.

In addition to the articles on individual countries, a number of broad overview articles, also especially written for this volume, are presented to fill *lacunae,* to stimulate thought, and to provide inspiration and guidance for the decades ahead in our interdependent world. Special attention is paid to the prospects for Europe after 1992 (Henry Durand, Vincent J. McBrierty) and to the needs and aspirations of the developing countries (Abdus Salam, Thomas Odhiambo).

D. Allan Bromley, Science Adviser to President Bush, and Frank Press, President of the National Academy of Sciences of the US, have graciously written prefatory essays of wisdom and scope.

An article by Shalheveth Freier is a distillate of the presentations and discussions at a remarkable four-day international Forum on Science and Government held in December 1989 at the Weizmann Institute of Science at Rehovot, Israel, in which some forty-five distinguished scientists, engineers, government officials, political scientists, sociologists, humanists, and journalists from eighteen countries participated. The co-chairmen of this extraordinary conference were Cyrus Vance, former Secretary of State of the United States, and Sir Zelman Cowen, Provost of Oriel College, Oxford, and former Governor-General of Australia.

David Z. Beckler's essay, "A Decision-Maker's Guide to Science Advising," is a practical, how-to-do-it manual by a practitioner of unique experience. It will repay careful study.

A recent novel development in the United States that may inspire creation of counterparts in other countries is the Carnegie Commission on Science, Technology and Government, conceived by David Hamburg, President of the Carnegie Corporation of New York, and organized in 1988. Its activities are described and its membership enumerated by its Executive Director, David Z. Robinson, in his article on the United States.

Another American innovation which may be deemed worthy of attention by other countries is the Congressional Science and Engineering Fellows Program initiated by the American Association for the Advancement of Science in 1973. Described elsewhere,[4] it has brought more than 400 scientists and engineers into federal government service for one-year staff terms. Many have remained in government service; others have returned to industry and universities better informed, as concerned citizens, on the practical workings of the government. The program flourishes, now bringing annually some twenty-five men and women, generally achievers of advanced degrees or at mid-level status in industry, into one-year Congressional staff service through a highly competitive selection process. A small comparable program of Westminster Fellows is now being initiated in England.

Caveat lector. Reader beware. This book is offered as a pioneering effort. The salutary trend toward globalization, encouraged by the acceleration of progress in science and technology and in communications, creates a need for such a compendium. It is hoped that it will encourage international cooperation and stimulate discussion in many countries, each of which can learn from others. From diversity may come progress. As Kipling put it, in a very different context, "There are nine and sixty ways of constructing tribal lays,/ And every single one of them is right."

CONCLUSION

Stimulated by these papers, I conclude with a question and a proposal. Where do we go from here? Would an informal, unofficial organization of science and technology advisers to the top levels of governments of the major countries—or of all countries—of the world be useful and viable? Such an organization could be a forum for discussion, for cross-pollination, and for exchange of ideas. It would have influence, but not authority. If it flourishes, it will mutate as conditions change.[5] If it does not prove useful, it will atrophy and disappear.[6] *Primum non nocere.*

The success of the Weizmann Institute conference, with its participants from diverse countries, encourages this idea. Consideration is being given by the Carnegie Commission on Science, Technology and Government and by the American Association for the Advancement of Science to inviting science and technology advisers of the top governmental levels of a few selected countries to a preliminary meeting to explore the merits, impediments and practicalities of establishing such an organization that might later be open to all countries of the world. Its informality and flexibility might confer advantages not available to existing official intergovernmental agencies, such as those of the OECD[7] and the UN.

Such a forum, with its cross-fertilization and peaceful interchange of ideas, would tend to broaden and intensify governmental and public awareness of the role of science and technology in national and international policy formulation and in everyday life. Whether or not such an organization is convened and flourishes, it is hoped that this book—the work of many heads and hands—will enrich the international gene pool of alternatives, and stimulate progress toward the betterment of life throughout the world.

NOTES

1. William T. Golden, ed., *Science Advice to the President* (New York: Pergamon Press, 1980) and *Science and Technology Advice to the President, Congress and Judiciary* (New York: Pergamon Press, 1988).
2. ''Science advising has a long history. According to Genesis, 'In the beginning God created the Heaven and the Earth.' In due course, Adam appeared and then Eve. The Serpent was waiting for them. The Serpent, much maligned disturber of complacency, aroused Eve's curiosity and resistance to authority. Eve's example and persuasion spurred Adam to the quest for knowledge and understanding—which equates with science. Thus Adam and Eve became the first scientists—co-investigators, one might say—thanks to the Serpent who was clearly the first science adviser.''—William T. Golden, ''Science Advice to the President: Past, Present, Future,'' *Proceedings of the American Philosophical Society,* Vol. 130, no. 3 (1986), pp. 325–329.
3. Detlev W. Bronk, ''Science Advice in the White House: The Genesis of the President's Science Advisers and the National Science Foundation,'' *Science,* Vol. 186 (October 11, 1974), pp. 116–121; reprinted in *Science Advice to the President, supra,* pp. 245–256.
4. Michael L. Telson and Albert H. Teich, ''Science Advice to the Congress: The Congressional Science and Engineering Fellows Program,'' *Science and Technology Advice to the President, Congress and Judiciary, supra,* pp. 447–452.
5. ''. . . from so simple a beginning, endless forms most beautiful and most wonderful have been, and are being, evolved.''—Charles Darwin, *The Origin of Species,* concluding paragraph.
6. ''. . . Natural Selection, entailing Divergence of Character and the Extinction of less improved forms.''—Charles Darwin, *op. cit.*
7. Reference is made to the series of informative Reviews of National Science and Technology Policy in individual member countries of the Organization for Economic Cooperation and Development prepared in recent years under OECD auspices.

Foreword: Science Advice in a Global Context

D. Allan Bromley

There is no need to underscore the unique potential of science and technology for improving the human condition. Yet it is easy to forget just how rapidly and dramatically science and technology are transforming the world. Our knowledge of the physical universe and of the chemical and biological basis of life is expanding exponentially. And, in consequence, the importance of this knowledge and the technologies built upon it has risen to the point that science and technology are decisive factors in determining the international competitiveness of national economies, in establishing military advantage, and in a vast array of endeavors that speak to the quality of human life and the health of the planetary environment.

Given this growing importance, it is obvious that governments have a great need to make wise decisions about science and technology. These decisions are of two kinds: what kind of science and technology to support, how much support to give, and how best to provide it—in effect, policy for science and technology; and how best to tap the world's storehouse of scientific knowledge to help solve the myriad problems and challenges that governments and nations face—science and technology for policy. This second task is by far the more challenging aspect of science advice, and yet it is precisely the molding of the best available science and technology information into the policy-making process that holds the greatest hope of mobilizing the potential of science for helping humankind.

What makes the task of policy-making in science and technology so challenging today is its increasingly global context. The world is changing at an astonishing and accelerating pace, politically and in science and technology, so much so that it sometimes seems hard to adjust to, much less to identify and seize the new opportunities that it presents.

Nonetheless, it is clear that the fundamental new economic alignments underway in Western Europe and the even more fundamental political and eco-

---

D. Allan Bromley, physicist and educator, is Assistant to the President of the United States for Science and Technology ("Science Adviser to the President") and is Director of the Office of Science and Technology Policy and Chairman of the President's Council of Advisers on Science and Technology (PCAST). He has been Director of the A. W. Wright Nuclear Structure Laboratory and Henry Ford II Professor at Yale University. Born in Canada in 1926, Dr. Bromley is a former President of the American Association for the Advancement of Science, and has been a member of the White House Science Council (1981–89). He has received many honors and awards and is the author of many publications.

nomic changes taking place in the Soviet Union, in Eastern Europe and, inevitably, in China will reshape our options and our priorities away from defense issues and toward other pressing international and domestic problems, for example.

The nature of the science and technology issues that we face on an international level is changing, too. Global environmental problems, for example, can only be studied and resolved by concerted joint effort on an unprecedented scale. Increasingly, the key issues are science-based or science-related. Let me mention a few examples.

GLOBAL CHANGE

Science and technology are intimately related to the health of the environment, both locally and globally. There is great public concern in many countries about global change, the pollution of the earth's oceans, long-term disposal of hazardous wastes, too much ozone near the earth and too little far above it. People are increasingly making known their demands for clean air and water and for a halt to activities that threaten to degrade natural resources or destroy unique species and the genetic heritage that they represent.

These concerns focus attention on the state of human knowledge of both the sciences and the technologies involved. In the United States, we are expanding our research efforts in global change. But the problem is, indeed, global, and will require an international effort, both to reduce the substantial scientific uncertainties that surround our understanding of global warming and to stabilize or reduce emissions of the greenhouse gases that are changing the composition of the atmosphere. In this regard, the work of the Intergovernmental Panel on Climate Change, under the auspices of the United Nations Environmental Programme and the World Meteorological Organization, is an excellent model that is leading to a consensus set of information on which international policy-making can be based.

Francis Bacon wrote that "We cannot command nature except by obeying her." His meaning was clear: We must observe and understand the world to live within its bounds. If we fail to protect the environment, we will inevitably undermine the very conditions that make a technological civilization possible. Thus science and technology have a very special role—and a very special obligation—in improving our stewardship of Spaceship Earth.

PUBLIC HEALTH AND THE QUALITY OF LIFE

Health and an improved quality of life are universal aspirations. In the next half century, the world's population is likely to double. Most of these five billion new humans will be added to the developing nations of the world, and most of them to already crowded urban areas. Just to address the basic needs of adequate health care, food, shelter, and energy for these expanding populations will be an enormous task. Yet the developed nations have a number of reasons, quite beyond very real humanitarian concern, for taking on these serious problems. These include the desire to develop new markets for goods and services and the fact that we live in an era of rising expectations, when global communications bring into stark relief the disparities between rich and poor.

Relieving these disparities by enabling developing nations to improve their economic growth and meet their citizens' basic needs will require a sharing of the basic toolkit for industrial civilization. That means not only the transfer of technology, but also building, in developing nations, both an educational and a science and technology infrastructure. We will need wisdom, generosity, and perhaps new mechanisms to accomplish this task.

The developed nations also share with the rest of the world such serious problems as the growing prevalence of AIDS, drug abuse, and the burgeoning costs of medical care, as well as having to face the health challenges associated with an aging population. Again, as the AIDS epidemic makes all too clear, the context for policy is a global one.

INTERNATIONAL COOPERATION IN RESEARCH

Science has always been a truly international community, with members often having closer relationships with colleagues on the other side of the planet than with those on the other side of the hallway; technology was less so, but it is rapidly catching up. In a world that is increasingly interdependent—economically, militarily, environmentally—it is not surprising that even basic science projects must be considered in an international context. In particular, the time is right for expanded international cooperation on large science projects (megaprojects) whose beneficiaries are, in truth, the entire family of man. The cathedrals of science must increasingly be international—or, at least, multinational—ones.

A number of current world-class projects, such as the superconducting supercollider, the space station, and the human genome project are, in fact, being planned and supported on a multinational scale. Cooperation such as this, even when difficult, needs to become far more common, both to make better use of scarce resources and because cooperation builds human communication links that are valuable far beyond the confines of the science and technology involved. Such links, built through cooperative projects, scientific exchanges, and enlightened self-interest, speak to every nation's direct interest in remaining or becoming technologically competitive in a peaceful and cooperative—rather than a confrontational—world.

Because basic science—and, to a lesser degree, technology—are relatively neutral in a political sense, it is frequently possible to establish communication bridges and cooperation in matters of science and technology that would not be possible in other fields. Once established, however, these bridges can—and usually do—expand to encompass a much wider range of topics. And the person-to-person and institution-to-institution bonds that are forged under such international agreements are lasting ones and are at the heart of international science.

CONCLUDING REMARKS

In conclusion, I should like to pay particular tribute to the editor of this volume, William T. Golden. For more than forty years, Bill Golden has been one of the truly central figures in the establishment of formal channels for authoritative science and technology advice to American Presidents. It was also largely according to his plan—and as a result of his persuasion—that President Truman selected Alan Waterman to be the first Director and initiated the program of the National Science Foundation in 1950. And, in the intervening years, he has been a consistent and effective advocate for a strengthened White House science advising presence—in addition to all his many other leadership activities on behalf of American science.

The collections of papers in the earlier books, *Science Advice to the President* and *Science and Technology Advice to the President, Congress and Judiciary,* that Bill Golden edited in 1980 and 1988, in a very real sense are manuals for my position and provide very perceptive insight into the many dimensions of science and technology advising.

The present volume is a pioneering and unique companion volume in illuminating the broad range of approaches taken around the world to the challenge of providing national leaders with the scientific and technological advice that is essential to participation in an increasingly technological world. Bill Golden again deserves our congratulations and thanks for this important contribution to the growing literature in this field.

Preface: International Cooperation in Science—A New Agenda

Frank Press

In a volume dedicated to comparing differing national approaches to providing science advice to government leaders, it is appropriate to discuss a common issue faced by all governments, one that is a matter of continuing concern for scientists everywhere: that of global cooperation in science. It is an old issue, but one for which the time has arrived for serious consideration at the highest levels of governments. This follows from the changing relations between nations, the unprecedented pace of scientific discovery, and the new strategic roles of science in connection with transnational issues, such as health, hunger, population growth, global environmental change, and economic development.

The issue, then, is not so much whether international cooperation is a good thing. It is moving beyond its acceptance to constructing beneficial arrangements and having these arrangements survive the chronic political and economic frictions that occur—and will re-occur—among nations. The challenge—the art of scientific diplomacy—is to identify the points of intersecting interests, and then construct frameworks for national cooperation pivoting on such interests.

The bare bones of those intersecting interests, of beneficial arrangements, can be quickly stated. One is when nations recognize that they simply do not have sufficient resources to execute a desirable scientific or technological goal, and that international help is needed. That imperative is evident in the programs in space science between East and West. It animates the international role of CERN.[1] And it most certainly is responsible for the transEuropean scientific institutes from EMBO[2] to EUREKA.[3]

A second intersecting interest of nations, making for international cooperation, is that the scientific or technological goal is implicitly international—that it is feckless for one nation to go it alone, even making the dubious assumption that it has sufficient resources. Such recognitions drove the creation of the International Geosphere Biosphere Program, and it is driving the International

---

Frank Press, educator and geophysicist, is serving his second six-year term as President of the National Academy of Sciences, and is a former Science Adviser to the President of the United States (President Carter, 1977–80). He was a member of the President's Science Advisory Committee (PSAC) from 1961 to 1964 and of the National Science Board. Dr. Press has been on the faculties of Columbia University, the California Institute of Technology, and the Massachusetts Institute of Technology. Born in 1924, he has served on many government and scientific boards and has been the recipient of awards and honorary degrees. Dr. Press is a member of the American Philosophical Society and of The Royal Society (UK) and the French Academy of Sciences.

Decade for Natural Disaster Reduction and the Global Change Program, both under the auspices of the United Nations.

A third reason why nations cooperate is that they need concrete expressions of mutual regard that go beyond words. International agreements to cooperate in science and technology serve that need very well. The symbolism that nations can work together in an area as strategic as science is an important message.

SMALL SCIENCE/BIG SCIENCE

Another factor promoting cooperation is the fact that more and more fields of science that nominally have been small science are taking on the semblance of big science. By that I mean they require ever more costly instrumentation, large facilities, and large teams of personnel. That is true of materials science, of a widening list of chemical fields—from laser chemistry to homogenous catalysis, and of many sectors in modern biology, such as sequencing the genome.

This expanded need for resources is amplified by the increasingly transboundary nature of science. Thus, the fact that sciences increasingly depend on each other inevitably requires international collaboration.

I believe firmly that, in this next decade, we will move forward with much enhanced cooperation. International organizations like UNESCO[4] and ICSU[5] will undoubtedly play major roles, as well as regional organizations. We do not lack for things to do. We need cooperation in basic science, in the tools that will enable all nations to make substantial scientific advances in this decade. And we need cooperation to cope with the common problems pressing in upon all nations, such as installing networks of instruments to monitor global change or developing new, safe, non-polluting energy sources.

In all our elaborations of the problems and possibilities of scientific cooperation, we mustn't forget that the simplest, that of scientists of different countries being given opportunities to talk and work together—may be the most powerful of all. It would be a historic error if concern over national economic or military security prevents scientists from being scientists, with all that that implies for free and easy communication.

President John F. Kennedy said it well in an address to the members of the US National Academy of Sciences when they gathered for their centennial celebration:

> Recent scientific advances have not only made international cooperation desirable, but they have made it essential. The ocean, the atmosphere, outer space belong not only to one nation or ideology, but to all mankind, and as science carries out its tasks ahead, it must enlist all its own disciplines, all nations prepared for the scientific quest, and all men capable of sympathizing with the scientific impulse.

The world had been torn by wars on virtually every continent in recent decades. We raised our children amidst the foreboding of a nuclear holocaust.

Concern about food grips the majority of the world's population. We have witnessed recent decades of economic and political turmoil. A constant that remains is the dedication of scientists to understanding the universe, the world, and humankind.

We do not face the question of cooperating in science; rather, in the shadow of the dangerous forces about us and the opportunities for doing good, we must cooperate.

NOTES

1. The Conseil Européen de Recherche Nucléaire (European Council for Nuclear Research).
2. The European Molecular Biology Organization.
3. EUREKA is an organization concerned with competitiveness and productivity in European industry.
4. The United Nations Educational, Scientific and Cultural Organization.
5. The International Council of Scientific Unions.

OVERVIEWS

Report on the International Forum on Science and Government

Shalheveth Freier

A forum of forty-seven senior scientists, engineers, political leaders and journalists from eighteen countries[1] met at the Weizmann Institute of Science in Rehovot, Israel, from December 9 to 13, 1989.[2] Co-chairmen for the forum were Cyrus Vance, former Secretary of State of the United States, and Sir Zelman Cowen, Provost of Oriel College, Oxford University, and former Governor-General of Australia. The forum was organized by the author as Director of the Science and Government Forum of the Weizmann Institute. (A list of participants can be found in the Appendix.)

The group met in order to reappraise the role and structure of science and technology (S&T) advice to the highest level of government and to suggest improvements in the interaction of S&T and governments on the strength of their varied experience.

The forum agreed that a reappraisal was called for in view of the changing issues on the science and technology agenda and the resulting new challenges. Improvements were suggested in three areas. First, the institutional means and functions at the disposal of government are of crucial importance in generating the climate in which science and technology and government can consummate their mutual responsibilities and endeavors. Second is the manner of facing up to the ever-growing international interdependence brought about by advances in science and technology. Third is the role of education and the media and the need for publicly available information and open debate as essential for the enlightened appraisal of S&T issues.

There was agreement on most of the proposals made, and this included the character and functions of science and technology advice to governments. There were, however, differences of opinion and experience on the appropriate institutional arrangements, which resulted naturally from the different types of governments. Among these, the most prevalent were the presidential system, in which the president and the legislature derive their powers separately from the

---

Shalheveth Freier was Director of the International Forum on Science and Government at the Weizmann Institute. Born in Germany in 1920, he has been Director of the Arms Development Authority, Deputy Director of the Weizmann Institute, Head of the Israeli Atomic Energy Commission, and Chairman of the Presidential Council for Science Policy. Dr. Freier established the first electronic music studio in Israel, wrote the British part of the official history of the war of independence, and is a member of the Pugwash Council, the Academic Committee of the Jerusalem Academy of Music, and the Committee for Youth Activities in the Sciences.

electorate, and the parliamentary system, in which the government's authority derives from parliamentary support.

It was manifest also that the size of the country matters. Institutional arrangements are more critical in the bigger countries than they are in smaller ones, in which communication is easier.

But, most importantly, there is the difference between the industrialized countries, which have succeeded the most in integrating science and technology into their social and economic well-being, and the majority of countries where this is not yet the case for widely dissimilar reasons.

The forum registered these differences. It saw merit in this mutual exposure, and felt that all stood to benefit from studying the diverse experiences which had accumulated.

THE NEED FOR REAPPRAISAL: CHANGING ISSUES

In previous decades, the science and technology agendas of the industrialized countries gave prominence to military, nuclear, and—in varying degrees—space research and development.

Of late, place of priority is being claimed by science and technology issues relating to the following:

- Global environmental threats, such as greenhouse warming, ozone depletion, and the destruction of genetic diversity;
- Biomedical topics, such as the prevention and cure of AIDS, the development of new drugs, the sequencing of the human genome, and biotechnology and its implications, in general;
- Sustainable economic development, including sustainable energy supplies and agricultural systems;
- Improved manufacturing technologies, less demanding of energy and materials and sensitive to the environment; and
- The appropriate association of countries which differ in their attainments in S&T or its beneficial applications, or both.

It is in the character of these emerging areas that they are more international and interconnected, and cut across many traditional disciplines. They involve and affect more members of society, and are less tolerant of delays in diagnosis and response. The ten-year delay between the first warning of the pollution of the environment and the official recognition of these hazards, as requiring concerted action, shows how damaging such delays can be.

SPECIAL CHALLENGES ARISING FROM THE NEW AREAS OF PROMINENCE

The new areas of prominence demand a departure from traditional attitudes, as follows:

- More thought needs to be given to the anticipation of hazards and their prevention than to remedies alone. This is not easy in an environment which rallies to the cure of an actual affliction more readily than to the prevention of one which is perceived. The former has high visibility, and the latter has none.
- Governments need to embark on long-term policies for the benefits of which they will not be credited during their terms of office. Such policies will require broad parliamentary and public support in order to be credibly sustained.
- Timeliness is of the essence in making decisions, and decisions will have to be made also on the bases of uncertain premises, especially when potential hazards need to be forestalled.
- Forethought and anticipatory studies and assessments will be increasingly important in order to meet the requirements of timeliness in decisions.
- Science and technology should become as intelligible to the citizen as are, nowadays, economic or societal situations also to the non-initiated. This is essential for enlightened public debate in matters which, as was said, affect everybody.
- More of the formerly hidden agendas, meaning those that are at the back of one's mind, will need to be spelled out and discussed nationally and internationally. It will not be sufficient for societies to adapt or react to the applications of sciences or to the advances of technology, but they will have to try to grapple with the social and ethical problems so raised. The uses to which biotechnology should or should not be put illustrates the new type of dilemma.
- Concerted and harmonized international thinking and action on the issues under discussion is not a matter of volition, but of necessity. There was a stark reminder of our interdependence in the observation that most of the oxygen on which our lives depend is produced in the less-developed, debtor nations than elsewhere.
- The emerging areas of science and technology endeavor, some of which are set out above, do not supplant the traditional ones, except in prominence. In assessing budgetary requirements, account needs to be taken of this circumstance and not only of the urgings of the practitioners.
- Without science, it was said, there is no application. Even in the most advanced countries, there are ambivalent attitudes with respect to basic science, which is the origin of most insights. There needs to be clear government support for its pursuit. The solution to many of the problems under discussion depends on the ingenuity of the basic scientific endeavor, which often begot them in the first instance.
- All these challenges also commend the international discussion of institutional arrangements for science and technology administration and ad-

vice. These need to measure up to their tasks, and the forum brought into relief how much countries could learn from one another.

These challenges place additional burdens on the role of S&T in policy and policy in S&T, on education for S&T, and on the role of the media in enlightening the public on the critical issues with which it is confronted. They necessitate science and technology advice to governments that is more comprehensive in scope, more directly involved in all major policy decisions, and of more immediate access to the decision-making body than ever before.

These themes will now be addressed.

SCIENCE AND TECHNOLOGY EDUCATION

More attention needs to be given to all aspects of science and technology education, improving the teaching of S&T in schools and colleges, offering more and better worker training in S&T skills, increasing the S&T literacy of other citizens beyond the regular school years, and providing better training of scientists and engineers in the nontechnical aspects of the science/technology/society interaction, which includes economics, politics, the social sciences, and moral value judgments.

Practical proposals made included a greater emphasis on mathematics, the potential and limitations of organizing and processing information, and the natural sciences. Curricula and textbooks in these subjects should not only be written by educators, but should—at all levels—be jointly prepared by teams of educators and practicing scientists.

On the mutual exposure of scientists and engineers with governments and legislatures, an infusion of scientists and engineers into both was considered of paramount importance in view of their minimal representation in both, except where their professional expertise is required. Indeed, it was suggested that more scientists and engineers be trained than are required for teaching and professional work.

The scientific and technological backgrounds of scientists and engineers were considered assets, no matter what positions they occupy. The practice of fellowships, of inviting young scientists and engineers to spend time in government service was recommended for adoption.

Students and citizens should be taught *the nature of science* and not only its findings. They should be told that science progresses not smoothly, but in fits and starts, with errors and corrections, controversies and paradigm changes. They should also learn that science and technology are not cure-alls for society's ills and that the potential of S&T for good or ill depends on how well or how foolishly society uses them (wherein ethics as well as education and competence play roles).

There is an *international* dimension to S&T education. More emphasis is needed in all aspects of education on comparisons and contrasts in characteristics of societies, natures of problems, and approaches to solutions. Increased international mobility of students and mid-career professionals through fellowships and exchange programs would be highly desirable. It is the universal nature of science and technology that commends exchanges in these areas, which also hold promise for eventual cooperation.

Communication skills should be taught to S&T students and polished by practice and further training during their professional lives. Making S&T relevant and intelligible to the public, to decision-makers, and to legislators is important. Scientists and engineers who take the time to do this well should be rewarded and not derided by their peers as is often the case. Academies of science and other professional societies could help by honoring good performance in this sphere.

The role of the media is as crucial in presenting science and technology issues as it is on any other matter. The primary responsibility of the media is to their audiences, not to government, the scientific community, or any other constituency. To engage and retain these audiences, the media must present information in ways that make it interesting and understandable, and clear positions are expected on issues which are, in fact, attended by a large degree of uncertainty. This is especially true in science and technology reporting which dwells on scientific findings rather than on the nature of the scientific endeavor or its societal implications.

Since society is less familiar with S&T issues than with others, the public, administrators and legislators seek clear guidance from the media in these areas. These circumstances and the time pressures inherent in media work necessitate close collaboration between scientists and journalists to make complex material simple and entertaining without making it *too* simple or wrong.

The media require ready access to scientists and engineers. Without such access, they cannot fulfill the aim of responsible and accurate coverage that scientists and journalists alike prefer. This aim can be facilitated by the increased use of referral services that link journalists with willing scientists and engineers (such as, in the US, the Scientists' Institute for Public Information—SIPI), fellowships for journalists in S&T-oriented organizations, and scientist-journalist workshops and minicourses on particular topics. It was emphasized that referral services or expert panels could help the media especially in separating agreed facts from differing surmises or biases. Such practice would set in train discriminating reporting and public discussion of science and technology issues.

ADMINISTRATION OF S&T BY GOVERNMENT AND S&T ADVICE

The various systems of government represented at the forum differed in the way science and technology are administered by them and the way science advice is obtained.

They all, however, have a head of government (President or Prime Minister), who makes the ultimate decisions or associates his or her authority with decisions made by the Cabinet. They all assure themselves of the functions and services of a chief adviser for science and technology (described below), whether such a position exists or not. They all have legislatures to which they are either answerable or by which they can be challenged. All use the services of independent professional panels for science and technology advice.

Some have ministers for science; some have not. Some have chief scientists in the various ministries (or Assistant to the President, as in the case of the US), who are or need to be coordinated, while, in the West German instance, the Minister for Science and Research attends to the research needs of his colleagues. Some have ministerial councils for science and technology, chaired by the Prime Minister, to which, in some instances, scientists, civil servants, and industrialists are co-opted.

All countries have coordinating committees—some highly effective, and some less so—in order to ensure an overall perspective. While the relative merits of these various systems will not be discussed here, two practices deserve mention, decoupled from any particular paradigm.

In West Germany, the head of state convenes periodically a National Council for Science (Wissenschaftsrat) on which all sectors of society are represented and for which an agenda is prepared on topics on which an exchange of views among the different competences and interests may set the course for major policy decisions. This council is supported by a permanent secretariat, and it has no permanent membership. This institution is deemed to be eminently useful.

In The Netherlands, it is mandatory that government react officially to reports and recommendations submitted by the Scientific Council for Government Policy within three months, whereupon Parliament discusses both report and reaction and invites the views of independent professionals before taking a stand. This appears to be a good example of the interaction of government, Parliament, and independent advice, and is so seen by the Dutch.

In the following comments, only that part of the discussion will be reviewed which pertains to the head of government, the legislature, and the chief adviser for science and technology.

POLICY AT THE TOP

Despite the differences in systems of government, it was agreed that the head of the government (President or Prime Minister) should have—and should be seen to have—a policy for science and technology, either on his or her behalf or on that of his or her government. (It was welcomed that only two genders were eligible for these offices, and no "it" could stand for election!) It was recommended that a policy for S&T statement be included in the yearly presentation of his or her overall program. This is a practice in many countries, but it should be universal. A statement constitutes a commitment.

In most systems, the need was felt for a chief adviser on science and technology (CAST), who should be appointed by the head of government and supported by an advisory committee. It is the functions of the CAST, rather than the appellation which matter, and these will be detailed later. Irrespective of institutional differences, it was felt that the highest decision-maker or body should be assisted by the functions of a CAST.

The head of government should be placed in the situation of having to decide, and should be presented—where appropriate—with more than one policy option for a given problem.

He should ensure that his judgment benefits from public debate, and not depend only upon the advocacy of his appointees. In particular, he should insist that studies be solicited and unsolicited ones be considered from professional institutions or committees competent in the problem posed.

Open debate for the benefit of the decision-maker is especially necessary if the head of government is unfamiliar with science and technology issues. He may then be inclined to abdicate judgment to a trusted individual or permit the civil service alone to control the science and technology advice he receives.

In all systems of government, it was thought only natural that the legislature have not only a committee for science and technology, composed of its own members, but also enjoy an independent analytical capability on S&T matters. The Office of Technology Assessment of the US Congress was mentioned as a successful example. The point was made that the increased capacity of the legislature to ask pertinent questions needs to be paralleled by a commensurate ability on the part of government to stand up to scrutiny, *i.e.*, to have sufficiently qualified people in government. An analytical service for the legislature has the advantage that its credibility rests on the presentation of established facts, which cannot be disputed from the floor.

THE NEED FOR A CHIEF ADVISER

In most countries, it was felt, there is a need for a chief adviser on science and technology (CAST), reporting to the head of the government and supported by an advisory committee. The CAST and his committee should consist of individuals of high stature and credibility with their peers, who represent diverse expertise (including life sciences, as well as physical sciences and technology; social sciences, as well as natural scientists; and generalists, as well as disciplinary specialists). Members of the committee should be engaged part-time, and be able to return to their parent institutions at the conclusion of their appointments. The committee should include a mix of ages, and should undergo a mandatory staggered rotation of its members.

The CAST must have the confidence of and excellent access to the head of government, should be privy to all major policy issues before the government (including those which have no evident S&T component), and should have the resources to form special expert panels beyond the regular advisory committee as required.

For the CAST's effectiveness, his office should be adjacent to the offices of the head of government and his immediate staff, for nothing substitutes for physical proximity and awareness. The CAST should co-opt for his deliberations government officials germane to the issue being discussed. Mutual recognition and appreciation are necessary.

The functions of the CAST should include assisting the head of the government in the formulation of questions to be addressed; advising on science and technology policies funded by the public purse; informing the head or the government about needs, opportunities or hazards which require decisions and present policy options; monitoring the implementation of any major science and technology policy decisions, and intervening when necessary; initiating or advising on standards and regulatory procedures; and, finally, having on his agenda the appraisal of contingencies which might arise in the future and require study, but no immediate policy decision. The forum discussed whether science for policy and policy for science should be addressed by different advisory bodies. It concluded that the CAST should deal with both.

The CAST should bring his authority to bear on the stimulation of open debate and the education of the public and the media, as set out in detail previously.

The CAST and his advisory committee must have no institutional axe to grind. This is why the CAST was invested, in the forum discussions, with far-reaching responsibilities in addition to those mentioned here.

Where no CAST exists, it was still felt that this was a generic term for the kind of function and service which should be at the disposal of a head of government and answerable to him.

The question of confidentiality was examined. The relations between the CAST and the head of government require that the CAST enjoy and respect the confidence of the head of government. These relations may, of course, be strained if the CAST's advice is not accepted for reasons extraneous to S&T logic or, worse, if policies are engaged which run counter to the CAST's professional conscience or impair his credibility with his peers.

In such circumstances, the CAST can, of course, resign in protest or he can acquiesce. On defense issues, which cannot be adequately addressed in public debate, there are no apparent alternatives. On nonclassified issues, on which information is available and if professional bodies, the legislature, and the public join the debate, it is not principally with the CAST that the head of government need argue. It was agreed that the CAST should not be statutorily compelled to give evidence and air views which could undo his relationship of confidence with the head of government.

INTERNATIONAL COOPERATION

International cooperation does not come naturally, except in basic research. Competition which seeks superiority on the market or in defense is not disposed to share. The need for international cooperation has long been professed as desirable, but sharing of knowledge was practiced in the past mainly by allies in times of war or perceived threat of war. In more recent times, there have been transfers of knowledge across national boundaries and the joint generation of knowledge by way of transnational corporations and national associations in economic blocs, of which the European Common Market is an outstanding example. These associations, of course, have also come about in order to compete successfully.

It would seem, however, that we might be on the threshhold of change. The hazards and scarcities which were reviewed in the beginning of this essay and which have been recognized as global in character—such as those pertaining to the environment, disease, and the finiteness of resources—are threats which compel genuine international cooperation in science and technology. This is, of course, partly acknowledged, but it has not penetrated into public and governmental consciousness as the powerful inducement for a change in attitude that it is.

It was suggested, therefore, that meetings of heads of governments take stock, visibly and prominently, on their agendas, of existing common hazards which can be forestalled.

It was further recommended that periodic meetings of the chairmen of advisory boards on science and technology to heads of government be instituted. In these meetings, common hazards—actual or potential—would be identified, necessary national or concerted action would be discussed, and the agenda would be set for the meetings of the heads of government. It was recognized that, even by itself, the very institution of regular meetings of chief advisers on science and technology would create a new and vital constituency, attuned to the needs of the times.

International cooperation in science and technology between the countries which have been more successful in raising their living standards by the successful application of S&T and those which have been less fortunate—and the reference here is mainly to the countries of Eastern Europe—was touched upon.

In the area of S&T, there did not seem to be impediments to cooperation. On the contrary, motivations for pooling knowledge abound. The formation of competitive blocs favors this accretion of knowledge and markets.

Much thought was given to the ways in which international cooperation could benefit countries which have scientific and engineering bases that are too small to successfully exploit the potentials of their countries and combat its afflictions. These countries again can be divided into those in which the political leadership accepts the importance of S&T and those in which S&T does not figure as a priority item on the national agenda at all.

In the former case, beneficial changes were foreseen. The genuine need to face up together to the new hazards could serve as a powerful incentive to also put international money into education, training, and the establishment of indigenous research capabilities.

It was further suggested that the scientific communities in these countries pull together, as they have already done in some instances, and establish viable regional research centers, which would equally attract international support and interest in the knowledge created there.

Finally, it was thought that the proposed meetings of heads of government and chief advisers on science and technology would bring into prominent focus the need to support S&T in the less-favored countries and integrate them into the joint effort.

The forum was, of course, aware of the beneficial activities of the specialized agencies of the United Nations and other international organizations, but realized that these are not enough. There was no dearth of proposals on bilateral exchanges, fellowships and associations. These have been and are being equally beneficial. But they, too, do not do justice to the scope of the problems.

TWO UNRESOLVED ISSUES

Two proposals were discussed for which there was not much support. They are mentioned because they were made in answer to problems which were acknowledged to be valid. The Challenger disaster and the delay in taking up environmental hazards at the government level prompted the first proposal. It was felt that there should be a statutory repository to whom the Challenger engineers could have appealed against the launch, rather than appealing to their superiors alone. With respect to the delayed response to environmental hazards, it was proposed that the same statutory body should challenge governments on science and technology of which they were not taking timely cognizance.

The second proposal tried to address the vast amount of pertinent information at the disposal of the decision-maker, which could not simply be disregarded. It was suggested that a special position be created, attached to the head of government, which would be able to provide information to him in a concise fashion.

This was deemed especially important in view of the technical ability for presenting the decision-maker with the possible influence that any major decision in one realm might have on others.

Anyone who would so serve the decision-maker would occupy a position of undoubted influence. The proposal was rejected by some and relegated by others to the CAST, but the problem of providing information to the head of government and giving him also the benefit of contemporary technology in this area was acknowledged as one which needed to be solved.

A brief summary of the forum's reasoned recommendations on the above and other themes will be published, and will be sent to governments, legislatures, academies of sciences, industries, and the media. Edited proceedings will be published subsequently, as will an instructional package on compact disc in CD-ROM format.

NOTES

1. The countries participating in the forum were Argentina, Australia, Brazil, Canada, France, the Federal Republic of Germany, Israel, Italy, Japan, Kenya, Mexico, The Netherlands, Portugal, Spain, Sweden, the United Kingdom, the United States, and the USSR.
2. The forum was co-sponsored by the International Federation of Institutes for Advanced Study (IFIAS).

Appendix

LIST OF FORUM PARTICIPANTS

Willem Albeda, Chairman, Scientific Council for Government Policy, The Hague, The Netherlands

Moshe Arens, Minister of Foreign Affairs, Israel

Hanan Bar-On, Vice President, Weizmann Institute of Science

David Z. Beckler, Associate Director, Carnegie Commission on Science, Technology and Government, New York

Sir Hermann Bondi, Master, Churchill College, Cambridge

João M.G. Caraça, Director, Science Department, Calouste Gulbenkian Foundation, Lisbon, Portugal

Ashton B. Carter, Associate Director, Center for Science and International Affairs, J.F. Kennedy School of Government, Harvard University

Sir Zelman Cowen, Provost, Oriel College, Oxford; former Governor-General of Australia

James W. Curlin, Office of Technology Assessment, US Congress

John M. Deutch, Provost, Massachusetts Institute of Technology

Israel Dostrovsky, former President, Weizmann Institute of Science

Aryeh Dvoretzky, former President, Israel Academy of Sciences; former President, Weizmann Institute of Science

Kerstin Eliasson, Chairman, Committee on Science & Technology Policy, Organization for Economic Cooperation & Development (OECD), Paris, and Adviser, Scientific Affairs, Prime Minister's Office, Stockholm

Yehuda Elkana, Director, Van Leer Institute, Jerusalem; Director, Institute for the History & Philosophy of Science & Ideas, Tel-Aviv University

Michael Feldman, Head, Department of Cell Biology, Weizmann Institute of Science

Shalheveth Freier, Director, Forum on Science and Government, Weizmann Institute of Science

Virginia Gamba-Stonehouse, Visiting Professor, Department of War Studies, King's College, London; former Director, Buenos Aires Institute for Strategic Studies

Richard L. Garwin, IBM Research Division

William T. Golden, Chairman, American Museum of Natural History; Past Chairman, New York Academy of Sciences; Co-chairman, Carnegie Commission on Science, Technology and Government

Peter Grose, Executive Editor, Foreign Affairs, Council on Foreign Relations, New York

Victor Halberstadt, Leyden University, Leyden, President, International Institute of Public Finance

H.H. Haunschild, former Secretary of State for Research & Technology, Federal Republic of Germany

John P. Holdren, University of California, Berkeley; Chairman, Executive Committee, Pugwash Conferences on Science and World Affairs

Barry Jones, Minister Assisting the Prime Minister for Science & Technology; Minister for Science, Customs and Small Business, Australia

Ephraim Katzir, former President, State of Israel; Institute Professor, Weizmann Institute of Science

Alex Keynan, Special Adviser to the President, Hebrew University, Jerusalem

Giuseppe Lanzavecchia, Scientific Adviser to the Chairman, National Commission for Nuclear & Alternative Energy Sources (ENEA), Rome

Federico Mayor, Director-General, UNESCO, Paris

Charles J. McMillan, Faculty of Administrative Studies, York University, Toronto

J. Fraser Mustard, President, Canadian Institute for Advanced Research

H. Moyses Nussenzveig, Pontificia Universidade Catolica, Rio de Janeiro, Brazil

Thomas R. Odhiambo, President, African Academy of Sciences, Nairobi; Chairman, Kenya National Academy of Sciences; Director, International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya

Michio Okamoto, Senior Member, Council for Science & Technology, Prime Minister's Office; former President, Kyoto University, Japan

Juriy A. Osipyan, Vice President, USSR Academy of Sciences, Moscow

David Owen, MP, Leader of the Social Democratic Party; former Foreign Secretary, United Kingdom

Baruch Raz, Director, Interdisciplinary Center for Technological Analysis & Forecasting, Tel-Aviv University, Israel

Francis Rosenstiel, Director of Political Affairs, Council of Europe, Strasbourg, France

Avram Schweitzer, Senior Editor, *H'Aretz,* Tel-Aviv, Israel

Michael Sela, Deputy Chairman, Board of Governors; former President, Weizmann Institute of Science
Guillermo Soberón, Executive President, Fundación Mexicana para la Salud; former Minister of Health, and Rector, University of Mexico, Mexico City
Gerald M. Steinberg, Political Science Department, Bar-Ilan University, Israel
Victor L. Urquidi, Member, National Science Advisory Council; Research Professor Emeritus and former President, El Colegio de Mexico
Cyrus R. Vance, former Secretary of State, United States of America
John Vereker, Deputy Secretary, Department of Education and Science, United Kingdom
Susan Watts, Technology Correspondent, *The New Scientist,* London
Ezer Weizman, Minister of Science & Technology, Israel
Andrew Wiseman, Media Consultant, London

A Decision-Maker's Guide to Science Advising

David Z. Beckler

In all countries, there are significant rewards to the government policy-making processes in reaching outside government for the best available scientific and technical advice. The increasing complexity of science and technology-related policy issues is such that, in many situations, there is no sound alternative to seeking outside advice. Scientists and engineers outside government, if mobilized and properly utilized, can bring a range of competence and experience to governmental decision-making that constitutes an enormous source of strength.

This essay is concerned with the interaction between part-time science and technology advisers and government decision-makers. It suggests a set of principles to guide this interaction that reflects the experience of the United States with the science and technology advisory process from the vantage points of both the decision-maker and the science and technology adviser. This experience may be applicable to other governments, although its relevance may vary in different political, organizational and decision-making contexts.

THE DECISION-MAKING ENVIRONMENT

Outside science and technology advisers should be aware of the decision-making environment in which they are advising, insofar as it affects the nature and receptiveness of science and technology advice. In this context, it is instructive to view the performance of the President's Science Advisory Committee prior to President Nixon's decision to terminate the White House science and technology advisory mechanism in 1972.

Although the decision reflected strains between the White House staff and the academic community engendered by the Viet Nam conflict, there were underlying factors that affected the committee's effectiveness during its entire lifetime, with periods of strengths and weaknesses. (See Beckler, D., "The Precarious Life of Science in the White House," *Daedalus*, Summer 1974.) They included:

David Z. Beckler was Executive Officer of the President's Science Advisory Committee and assistant to six Science Advisers to the President from 1957–1972. He served as Special Assistant to the President of the National Academy of Sciences of the US from 1973–1976. From 1976–1983, Mr. Beckler was Director for Science, Technology and Industry at the Organization for Economic Cooperation and Development in Paris. He is currently Associate Director of the Carnegie Commission on Science, Technology, and Government.