Proc. Natl. Acad. Sci. USA
Vol. 94, pp. 1606–1608, March 1997
From the Academy

The U.S. National Academy of Sciences—In service to science and society*

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The National Academy of Sciences of the United States of America (NAS) was established in 1863 by the U.S. Congress. Under the terms of its charter, signed by President Abraham Lincoln,

> The Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

The charter stipulates virtually complete autonomy for the Academy, including freedom to elect its members and establish its own policies and procedures. Independence of the Academy is reinforced by the stipulation that, apart from reimbursement of the actual costs of studies it undertakes on behalf of the government, it receives no government subsidy.

The National Academy of Sciences fulfills two distinct, although not entirely unrelated, functions. It serves as an honorific society, election to which is widely regarded as among the highest honors that can be conferred on an American scientist. The Academy also serves, in accordance with the terms of its charter, as an important and influential advisor to the U.S. government on issues involving science and technology. The former function is one that the NAS shares with many other national academies of science, while the latter is somewhat distinctive, as is the stipulation that the NAS receive no direct subsidy from the government.

Here I shall attempt to describe these two roles.

The National Academy of Sciences as a Membership Organization

The membership of the NAS presently numbers 2158, including 1743 active members, 95 emeritus members, 306 foreign associates representing some 35 countries, and 14 public welfare medalists (individuals recognized for "eminence in the application of science to the public welfare"). Current rules provide for the election of up to 60 new members and 15 new foreign associates each year.

Members of the NAS are distributed among six classes, listed below, representing the major scientific disciplines and, further, among 25 sections, representing sub-disciplines, for example, mathematics, astronomy, physics, chemistry, geology, and geophysics in the case of Class I.

Class I: Physical and Mathematical Sciences (743 members).
Class II: Biological Sciences (603 members).
Class III: Engineering and Applied Sciences (236 members).
Class IV: Medical Sciences (215 members).
Class V: Behavioral and Social Sciences (258 members).
Class VI: Applied Biological and Agricultural Sciences (95 members).

The great majority of NAS members, both active and foreign associates, work in universities or research institutes engaged in basic research. Reflecting one of its important missions and the priorities and interests of its membership, many of the Academy's own activities, in most cases supported by its privately derived resources, are directed at promoting the health of science, improving science education, and enhancing public understanding of science. Among these activities are:

- *Proceedings of the National Academy of Sciences (PNAS)*. The Academy's flagship journal was established in 1915 and continues to be one of the world's leading journals for publication of results of original research, particularly in the biological sciences. Efforts currently are underway to expand its scope to cover the full range of science encompassed by the NAS. Another recent modification provides for nonmembers to submit papers directly to PNAS without requiring sponsorship by a member.
- *NAS Scientific Colloquia*. Under this program the NAS sponsors about six major international colloquia each year dealing with crosscutting forefront scientific themes. The proceedings are published in the *Proceedings of the National Academy of Sciences.* Topics of recent colloquia were: *Genetic Engineering of Viruses and Viral Vectors*; *Symmetries Throughout the Sciences*; *Elliptic Curves and Modular Forms*; *Memory: Recording Experience in Cells and Circuits*; *Developmental Biology of Transcription Control*; *Science, Technology, and the Economy*; *Vision: From Photon to Perception*; and *Quasars and Active Galaxies*.
- *Frontiers of Science Symposia*. This program brings together annually about 100 of the country's leading young scientists to report and discuss important recent developments in diverse branches of science. The success and impact of these distinctive symposia are such that they have served as models for other similar programs, notably the international German–American Frontiers of Science Symposia, cosponsored by the NAS and the German–American Academic Council and the Frontiers of Engineering Symposia, sponsored by the National Academy of Engineering.
- *Public Understanding of Science*. This program is directed at enhancing public understanding of science and of the contributions of science to society. "Beyond Discovery: The Path from Research to Human Benefit," one project in this program, comprises a series of case studies, written by scientists and adapted for broader audiences by science writers, that identify important recent technological and medical advances and trace their origins, notably the roles played by basic research. Examples are studies describing the scientific origins of the ozone depletion phenomenon, the global positioning system, human gene testing, and optical communication.

Other NAS activities include sponsorship of the Academy's Committee on International Security and Arms Control, whose goals are to help seek ways to reduce the threat of nuclear conflict and to encourage global limitations on destabilizing weapons; also cosponsorship, with the National Academy of Engineering and the Institute of Medicine, of the Committee on Human Rights, which works on behalf of scientists worldwide who are victims of severe repression. This committee also oversees and coordinates the International Human Rights Network of Science Academies.

*Based on a lecture delivered at a Symposium on the Contribution of Academies to the Progress of Modern Science held in Lisbon, Portugal, on November 8–9, 1996 under the auspices of the Academy of Sciences of Lisbon.

Finally, the National Academy of Sciences represents the United States on the International Council of Scientific Unions (ICSU) and the InterAcademy Panel, an informal organization of world science academies.

The National Academy of Sciences as Advisor to the Nation—The Role of the National Research Council

Requests from the U.S. government for the advisory services of the NAS started almost as soon as the institution was founded. The first such requests, during 1863–1864, were for reports on weights, measures, and coinage; magnetic deviations in iron ships; and protecting bottoms of iron ships from corrosion. In fulfillment of the terms of its charter, NAS continued to serve the government as an independent and influential source of advice and, during the first few decades of its existence, issued reports that played a major role in the establishment of the U.S. Geological Survey, a new Naval Observatory, the National Park Service, and the National Park System.

By 1916 it had become apparent that the range of expertise needed for the advice that the NAS was being called upon to provide, especially under wartime conditions, transcended that of its membership (then about 150), which was largely restricted, as it now is, to scientists engaged in basic research. Accordingly, the decision was made to establish the National Research Council (NRC) as the operating arm of the NAS, to conduct studies and provide advisory services under the oversight of the NAS, but with participation of nonmembers from the larger scientific and technical community, including engineers.

In 1964, under the authority of its charter, the National Academy of Sciences established the National Academy of Engineering (NAE) and in 1970, the Institute of Medicine (IOM). These organizations recognize, through election to their memberships, distinguished members of their fields and bring to the tasks of the National Research Council the expertise of their communities. Oversight of the National Research Council now is shared by the NAS, NAE, and IOM. Although the IOM conducts its own studies and the NAE does selected studies, most studies in which the three organizations participate are conducted by their common operating arm, the National Research Council.

The National Research Council is composed of the Commission on Behavioral and Social Sciences and Education; Commission on Engineering and Technical Systems; Commission on Life Sciences; Commission on Geosciences, Environment, and Resources; Commission on Physical Sciences, Mathematics, and Applications; Office of International Affairs; Office of Scientific and Engineering Personnel; Board on Agriculture; Transportation Research Board; Policy Division; and Center for Science, Mathematics, and Engineering Education. Although the Institute of Medicine is not part of the formal structure of the NRC, its studies are conducted under the same guidelines, and with the same approval and review procedures as those of NRC units.

Studies conducted by the NRC and its component organizations and reports issued by these organizations conform to strict guidelines. These govern prior approval of each study, appointment of study committees, conduct of the study and peer review and approval of reports before they are issued.

The size of the NAS/NAE/IOM/NRC complex and the volume of its activity experienced a period of marked growth through about 1990 when they attained their current levels. Presently, the complex employs approximately 1200 persons, about half of whom are professionals, and has an annual program and operating budget of about $200 million. About 80% of the budget is derived from federal government contracts, and the rest comes from the Academies' own endowments and other private sources.

The studies overseen by the NRC and the Academies (the NAS, NAE, and IOM) are conducted by committees of unpaid volunteers, who also are responsible for preparation of the reports. Currently, there are about 600 such committees, with a total membership of about 6000 people, of whom about 20% are NAS, NAE, or IOM members. In recent years the NRC and Academies have issued about 200 reports annually, many of them hundreds of pages in length. These are published and distributed by the Academies' own press, the National Academy Press.

Although responding to requests from the federal government continues to be an important role of the NRC and the Academies, many of their recent reports are the result of studies and other activities undertaken on their own initiative. Even when not requested, such studies often are recognized as being of sufficient public interest and value that the government agrees to fund them. Other reports, based on studies undertaken with private funds, have anticipated government interest and subsequently turned out to have major impacts on public perception and policy, for example, a 1984 report on acid rain deposition and a 1986 report first proposing a national strategy for the prevention and treatment of AIDS in the United States.

The range of themes, encompassed by the Academies' studies, reports, and other activities now extends to virtually all of science, technology, and society. Some of these are:

- *Supporting the Sciences*. A continuing series of studies and reports assessing different scientific disciplines and identifying needs and opportunities. Examples are: *Opportunities in Chemistry* (1985); *The Behavioral Sciences: Achievements and Opportunities* (1988); *Frontiers in Chemical Engineering* (1988); *Opportunities in Biology* (1989); and *Polymer Science and Engineering* (1989).
- *Science Policy Issues*. Reports containing policy recommendations concerning criteria and priorities for the support of science. Examples are: *Science, Technology and the Federal Government: National Goals for a New Era* (1993); *Major Award Decision-Making at the National Science Foundation* (1995); and *Allocating Federal Funds for Science and Technology* (1995).
- *Assessment of Government Research and Technology Programs*. The Academies are constantly being called upon to assess the government's own research and technology programs and facilities. Examples of such reports are: *Assessment of the National Institutes of Science and Technology* (1995); *Research Programs of the U.S. Bureau of Mines* (1995); *Review of the Environmental Protection Agency* (1995); *An Assessment of the National Science Foundation's Science and Technology Centers* (1996); and *Review of the Research Program for a New Generation of Vehicles* (1994, 1996).
- *Science Education*. A landmark study by the National Research Council culminated in a report, *The National Science Education Standards* (1995), that sets national targets for what students should learn in science at levels from kindergarten through grade 12. Follow-up studies are addressing implementation of these standards. Other recent Academy reports address graduate education, including *Research-Doctorate Education Programs in the United States: Continuity and Change* (1995) and *Reshaping the Graduate Education of Scientists and Engineers* (1995).
- *Health, Safety, and Social Issues*. The Institute of Medicine and National Research Council conduct studies and issue reports covering a wide range of issues connected with medicine, health, and social issues. Recent examples (1993–1996) include: *Science and Judgment in Risk Assessment*; *Social Impact of AIDS in the United States*; *Strengthening Training in Geriatrics for Physicians*; *Early Visual Development, Normal and Abnormal*; *Assessing Genetic Risks: Implications for Health and Social Policy*; *Measuring Poverty: A New Approach*; *The Poten-*

tial of Telemedicine; and *Understanding and Preventing Violence*.

● *Natural Resources and Environment*. Some recent reports in this area are: *Alternatives for Ground Water Cleanup*; *The Greening of Industrial Ecosystems*; *In Situ Bioremediation: When Does it Work?*; *Science Priorities for the Human Dimensions of Global Change*; *Assigning Economic Value to National Resources*; *Understanding Marine Biodiversity: A Research Agenda for the Nation*; and *Coal: Energy for the Future*.

● *Space Science*. Recent reports include: *The Future of Aerospace*; *Scientific Opportunities in the Human Exploration of Space*; *Microgravity Research: Opportunities for the 1990s*; *A Strategy for Ground-Based Optical and Infrared Astronomy*.

● *Industry, Commerce, Transportation, and Technology*. A wide range of issues is addressed in recent reports such as: *Commercialization of New Materials for a Global Economy*; *Detection of Explosives for Commercial Aviation Safety*; *Industrial Waste Remediation and Utilization*; *Realizing the Information Future: The Internet and Beyond*; *Cryptography's Role in Securing the Information Society*; *Airports of Tomorrow*; and *Intelligent Vehicle Highway Systems*.

In addition to formal studies that culminate in consensus reports with recommendations, the Academies and NRC also sponsor a variety of workshops and roundtables and, because of their distinctive expertise and resources, serve as administrators of certain activities, notably fellowship programs, for other organizations, both government and private.

International Activities

The National Academy of Sciences has engaged in international activities from its earliest days. In 1866, three years after its founding, the U.S. Secretary of State, on behalf of the Minister of Nicaragua, asked the Academy to undertake a study of means to improve the navigability of the San Juan River and its port, a study that resulted in a report completed the same year.

In recent years, the scope and importance of the Academies' international activities, many involving collaborative interactions with other academies of science, have increased greatly, as has the scope and importance of the NRC Office Of International Affairs that oversees many of these activities.

Reference already has been made to the NAS Committee on International Security and Arms Control, to the Committee on Human Rights, and to the role of the NAS in the International Council of Scientific Unions. Other international activities of the Academies include regular dialogues with science academies of other countries, for example, the Royal Society of London and the academies of science of China, Russia, and Mexico. Increasingly, efforts are being made to identify joint projects with these and other academies and to help them to play more active roles as science and technology advisors to their governments. Such collaborative activities include:

● A joint project with the Mexican Academies of Science and Engineering that resulted in a bilingual report, *Mexico City's Water Supply: Improving the Outlook for Sustainability* (1994). Another joint project entitled "U.S./Mexico Collaboration for Ocean Science Research" has been initiated. The NRC also is assisting the Mexican Academy in a review of Mexican university graduate programs.

● Several U.S.–German studies cosponsored with the German-American Academic Council (GAAC) with which the NAS is affiliated. These include an NAS-cosponsored study on *U.S.–German Cooperation in Eliminating Weapons Plutonium*; an NRC-cosponsored study on *International Friction and Cooperation in High-Technology Development, Competition, and Trade*; and an NAE-cosponsored study on *Technology Transfer Systems in the United States and Germany*. The NAS also cosponsors with the GAAC a German–American Frontiers of Science Symposium series, modeled on NAS' own successful program.

● Activities of the Interacademy Panel (IAP), on which the NAS serves as U.S. representative. An outgrowth of the successful 1993 Population Summit of the World's Scientific Academies in New Delhi, the IAP was formed in 1995 to act as a forum through which the world's academies of science can help address the scientific aspects of important issues of international and regional concern. Currently, the IAP is planning a *Conference on Sustainability Transition* for the year 2000.

● Other international activities include a joint project with the science academies of India and China on the interaction of population growth and land-use changes and a joint study with the scientific academies and councils of the Middle East on sustainable water resources for the Middle East region. The NRC also provides scientific and administrative input for the U.S. government into the Radiation Effects Research Foundation (RERF), a U.S./Japan binational research organization that is conducting follow-up studies of the health effects of the Hiroshima and Nagasaki atomic bomb explosions on the survivors and their children.

Summarizing Comments

During the 133 years since its founding, the National Academy of Sciences has undergone substantial growth and profound change in response to the changing character and demands of science and society. Throughout, it has remained remarkably faithful to its original mission of providing the government and nation with independent expert advice on a wide range of science and technology issues. At the same time, this mission has expanded to keep up with the explosive growth and importance of science and technology and with the increasingly pervasive impact of science and technology on society—an impact that now extends to education, health, commerce, social welfare, the environment, transportation, and virtually every other aspect of human welfare. To reinforce its ability to respond to this expanded mission the NAS has created the National Academy of Engineering, the Institute of Medicine, and the National Research Council. The Academies and NRC also have expanded the scope of their international activities and intensified their interactions with other scientific academies to reflect the increasing internationalization and global impact of science and technology.

November 1, 1996