SCIENCE FOR LEAN TIMES

A Speech by Ralph J. Cicerone, President
National Academy of Sciences
Presented at the Academy's 148th Annual Meeting
May 2, 2011

Good morning and welcome to members of the National Academy of Sciences and their guests to the 148th Annual Meeting of the National Academy of Sciences.

The National Academy of Sciences Building

As you know, our NAS building on Constitution Avenue is closed for restoration and renovation. The historic features of the building will be enhanced by this restoration and the updating of its core facilities and utilities will render it more useful. At our annual Business Meeting tomorrow, I will provide an update on progress but I can tell you now that the project is on schedule and we plan to convene the 2012 Annual Meeting in our own historic building. [Figure 1]

Recent Events

NAS members and Foreign Associates who were elected in 2010 were presented on Saturday and they signed our Great Book. They comprise an amazing group of individual scientists and we are pleased to welcome them. A small, representative group of them described their research at a special session on Saturday.

Figure 1 NAS Council visits the NAS Building on April 29, 2011.

Earlier this year the NAS Council selected this year's Public Welfare Medalist, Dr. Ismail Serageldin, who directs the Library of Alexandria. Dr. Serageldin is an international leader in matters intellectual. He is a strong, eloquent and effective proponent for education at all levels, for scientific research and for democracy. Even with the enormous demands on his time due to the events in Egypt of the last several months, Dr. Serageldin is here, and he received our medal yesterday. The names of recipients of our 2011 medals and awards are in your meeting program; please congratulate each of them.

During the past year, another NAS member has begun to work in President Obama's Administration: Harold Varmus as Director of the National Cancer Institute. The NAS and its members appreciate his service to our government and to our nation.

During this year, John Brauman will complete his eighth year as NAS Home Secretary. Susan Wessler will become Home Secretary on July 1. Also, Dr. E. W. (Bill) Colglazier will retire in June after 18 years as Executive Officer of the NAS and of the National Research Council (NRC). Each of them deserves our thanks, and at tomorrow's annual Business Meeting, I will recognize them.

National Research Council Activities

A major part of the mission of the National Academy of Sciences is to respond to federal government requests for analysis and recommendations on all matters of science. These requests originate in Congressional committees, offices of individual representatives and senators, and Executive branch departments and agencies. We also receive requests from private foundations and from state governments. Most of our projects in response to these requests are conducted by the National Research Council, and the NRC is governed by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine. Each year we provide a complete list of all of our reports in our *Annual Report to Congress* (1).

I note several reports published in the past year: *New Worlds, New Horizons*, the latest in a series of decadal surveys of astronomy and astrophysics; *Tsunami Warning and Preparedness* (focused on U.S. state and territorial coastlines). The following titles are very descriptive of the contents: *Nuclear Forensics: A Capability at Risk*; *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*; two Institute of Medicine reports — *Preparing for the Future of HIV/AIDS in Africa* and *Strategies to Reduce Sodium Intake in the United States*; a group of reports on climate change — the *America's Climate Choices* series on climate science, mitigation, adaptation, and informing effective responses, along with an overarching strategy for managing the risks of climate change; *National Security Implications of Climate Change for U.S. Naval Forces*; and *Climate Stabilization Targets*. [Figures 2 and 3]

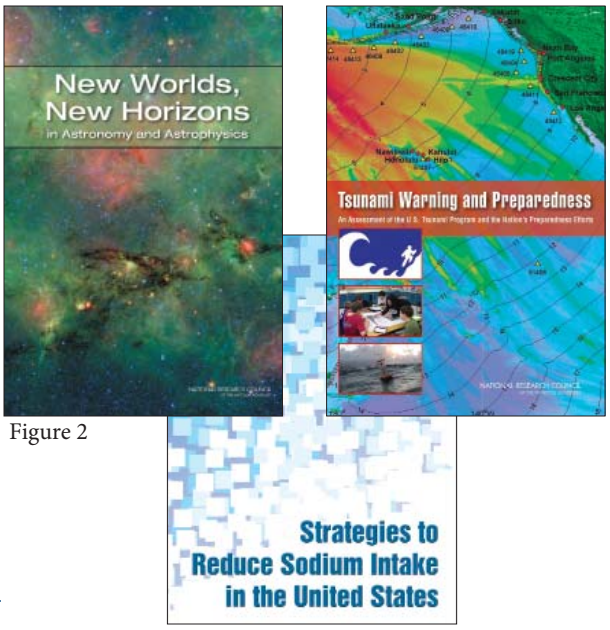

Figure 2

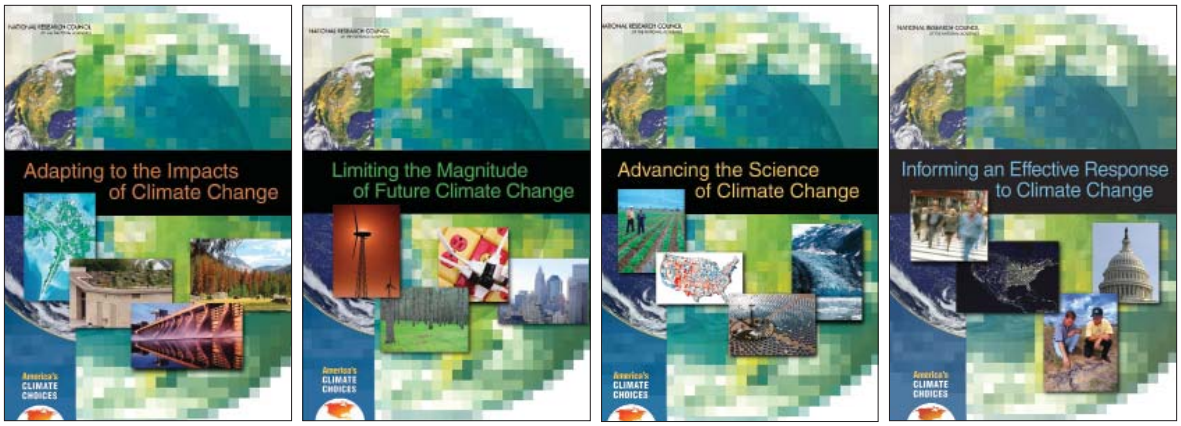

Figure 3

Two 2011 reports on education are *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* and *A Plan for Evaluating the District of Columbia's Public Schools: From Impressions to Evidence*. Other reports that illustrate the range of important topics of our studies are: *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters*; *Review of the Environmental Protection Agency's Draft IRIS Assessment of Formaldehyde*; and *A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay-Delta*. [Figure 4]

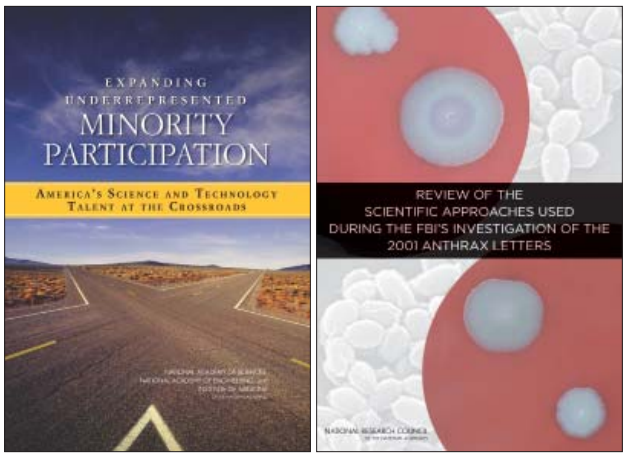

Figure 4

Years after they were published, some of our reports remain at the fore of scientific understanding on vital topics; others are late bloomers, appreciated some years after publication. In the past year, the 2009 report *Strengthening Forensic Science in the United States* continued to have impact and our 2006 report *Safety and Security of Commercial Spent Nuclear Fuel Storage* was in the spotlight again largely because of its focus on the advantages of moving spent nuclear fuel to dry storage from wet storage as soon as possible. [Figure 5]

During the past year, each of these reports and many others have benefited from the efforts of many NAS members, from our colleagues in the National Academy of Engineering and the Institute of Medicine and many other expert study participants. Reviewers of all NRC reports were also instrumental in assuring high quality, as always, as was the diligence of the Report Review Committee.

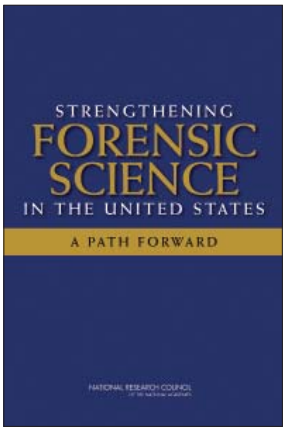

Figure 5

"Golden Age of Science"

In many ways we are living in a golden age of science. We usually do not describe it this way because we are always hoping to make it better — by finding more research funding, by seeking ways to improve opportunities for students from under-represented groups, by trying to remove remaining barriers to full participation of women, for example. We also want to reduce the amount of time and effort required to obtain research grants and for research accounting. And it is getting harder to find good positions for our students and postdoctoral fellows. Nonetheless, compared to past times, recent years have been pretty good for research and the frontiers of science today offer very large opportunities for discovery and development.

The quantity and quality of research being reported in our journals today is very impressive: just look at any issue of *PNAS*, *Science*, *Nature*, or *Cell* or the more focused, high-quality disciplinary journals from scientific societies and commercial publishers. Every week, when I look over *PNAS*, I see new discoveries, quantification of previously unquantified phenomena, new methods of investigation and stunning progress in all fields. In addition, specialized journals are more numerous than ever before and they are filled with research reports. Similarly, popular magazines like *Scientific American*, *Discover* and closer to home, Sigma Xi's magazine, give a sense of today's vibrant research enterprise.

In addition to the progress underway in each discipline of biological, physical and social sciences, exciting and ambitious questions are being framed for future investigations. For example, the 2010 National Research Council report (2) *Research at the Intersection of the Physical and Life Sciences* lays out a stunning set of such questions, and this set could easily be augmented by others from social and behavioral, engineering and medical sciences. Because of previous science, the societal fruits of science have been visible for generations and future harvests are being sown now. Science in the early 21st century is a dynamic venture, active on many fronts and propelled by recent progress.

It has not always been so. For example, in the 16th and 17th centuries, the ideas and research results of Bruno (3) and Galileo (4) on astronomy and Earth's place in the universe were heavily censored and condemned by religious and political authorities. Being a scientist was very difficult then. A scientist's way of thinking took a long time to become accepted. Other obstacles included a lack of scientific instruments and a shortage of colleagues. The struggles of nineteenth century microbiologists in learning about microscopic life and in devising medical treatments also demonstrate how far we have come (5).

Today, the status of science and technology is also elevated by how much we depend on them — in nearly every aspect of agriculture, transportation, communication, medicine, national security, environmental protection, geolocation — throughout society.

U.S. Science

The idea that we have been in a golden age of science is particularly accurate for the United States. In the last 50 years or so, the U.S. became the world leader in most fields of science, as can be seen from the authorship of journal articles, the high fraction of Americans winning major prizes in science, patents granted, amounts of research funding available from U.S. federal agencies and many other indicators. Important institutions of science like the National Science Foundation, NASA, and most of the National Institutes of Health were founded in this period, as was the Howard Hughes Medical Institute.

U.S. government laboratories were created and expanded and our research universities grew in quality and depth. American graduate programs are highly regarded and ranked internationally.

Laboratory equipment and specialized facilities have enabled U.S. research advances. They include X-ray light sources, particle accelerators, supercomputers, regional mass-spectrometer centers, genetic sequence analysis facilities, oceanographic vessels, research aircraft and earth-orbiting satellites. Human resources such as those in NIH's intramural laboratories have fostered entire careers in science and they have attracted visitors from around the world. U.S. scientific resources, governmental and non-governmental, are often deployed to help people and countries elsewhere as with floods, earthquakes, tsunamis and nuclear accidents.

Science in America has enjoyed and is enjoying great prestige and admiration from around the world as is seen in public opinion surveys, in the continuing stream of talented scientists who wish to come here, and in international rankings. An asset of American science that is admired widely overseas is our competitive, merit-based system of allocating research funding. In some other nations, enterprising scientists have fewer opportunities.

Troubling Trends

As you know, there are numerous, clearly visible signs of trouble for science.

First, federal research funding is likely to decrease for the foreseeable future as our government tries to reign in deficit spending. Over the last few years, federal spending has far exceeded revenues and the deficit has been financed by borrowing. Current amounts of governmental borrowing are widely seen as unsustainable and it is very likely that spending will be decreased. While an improving economy is likely to generate larger tax revenues, the revenues will lag growth for some time. So while there are good grounds from which to argue that federal science spending should not be cut, and even with a Presidential Administration that is very supportive of science, fiscal problems are severe enough for us to expect cuts.

One measure of the adequacy of research funding, the success rates of those applying for research grants, has been in decline for years. At NIH, the success of applicants for new grants (6) fell from 27% to approximately 17% over the last decade. Similarly, success rates for NIH renewal grants fell from 52% to 40% from 2001 to 2010. At NSF, success rates were 33% in 2001 and fell to 23% in 2010, after federal stimulus spending (the American Recovery & Reinvestment Act) had raised the 2009 rate to 32% (7). While some people contend that it is growth in the number of scientists who seek grants that is unsustainable, and others might suggest that grant sizes are too large and that more smaller grants would be better, these decreasing success rates are signs of a worsening situation.

Research universities are also experiencing serious financial problems. In approximately mid-2008, investments in endowments plunged in value, threatening operations at private universities and philanthropic giving everywhere. Economic recession has decreased tax revenues to American states and support for public universities. Many investments have recovered most of their 2007–08 value, so private universities are on the mend but state budget deficits have increased and state support per student and state-based research support have been cut substantially, and many public research universities are being hurt. During the past three years, federal research support has enabled research at universities to continue but projected reductions are not good news for private or public universities.

Corporate support for research is always hard to gauge as targeted product development is often mixed with less targeted research. It does seem clear though that some corporate sectors have reduced their research activity, notably pharmaceutical companies. Philanthropic funding of research, long an American asset, is strong. Programs at HHMI, Kavli, Keck, Moore, Packard and Sloan Foundations are notable.

First-rate research laboratories located overseas are becoming much more visible. Significant investments in a number of countries (Singapore, China, Korea, for example) are very impressive and they are attracting not only a new generation of young people (some of whom might have come to the U.S.) but also established researchers from the U.S.

Other trends should be mentioned. Visas for students and researchers who seek to visit the U.S. continue to be difficult to obtain. While some progress had been made in the last several years, there continue to be too many instances of apparently needless delays and denials and of scientific meetings, once anticipated to be held here, going elsewhere. The teaching of evolution in science classrooms continues to be opposed in a small number of places — American schools, school districts and states — each year. The frequency of these intrusions into science education seems not to diminish. More broadly, American goals and achievement levels in K–12 math and science education are not a source of pride, nor is American science literacy. Finally, in what I hope is only a temporary phenomenon, research on climate change has become polarized by political party, an unnecessary, strange and harmful development that impedes scientific progress on this vital issue.

Navigating the Next Few Years (or Preparing for Lean Years)

Attitudes. As we enter a period that is very likely to see significantly reduced budgets for scientific research, we must prepare. We cannot foretell how long these serious problems will persist or whether all fields of science will fare the same, but we can expect fewer and smaller grants, delayed or cancelled projects, and possibly fewer fellowships for graduate students and postdoctoral researchers.

It seems to me that we have enough clarity of purpose that we can decide that we should not just stand by and watch. We know that science and technology are forces that can create beneficial economic growth. We are also inspired by the purely intellectual side of science. So we should be motivated to preserve and improve the scientific enterprise and the conditions for those who conduct it.

Too often in times of change (improving or declining), people extrapolate solely from current trends to guide their choices. We must take into account both leading and lagging indicators of distances from our goals. Our attitudes in these times must also recognize that science is heavily dependent on government.

Actions

Conduct of Science. The pursuit of scientific research is one of the most inspiring of all human activities. It has been so historically and it should be now. Setting examples of the highest standards of openness and honesty will minimize the risks of exaggerated or false claims that can set back science in the public's eye. More positively, high-minded behavior in science attracts bright people who are interested in science and discovery. All of us should avoid

conflicts of interest and biases due to personal interests. In matters like these, NAS members have more influence than most others.

If the next several years do bring a worsening climate for research, we will need new ideas for means to support science and scientists. Convening discussions at your home institutions could bring out such ideas. In these discussions, we would do well to remember that science continues at an impressive pace in America, even though trends are negative. Scientific discovery is more exciting than ever and the potential benefits of science are enormous and more people need to know it.

One of the first courses for scientists is to undertake the kinds of things that we do normally to help colleagues to get started in research or to get through funding gaps. Traditional behavior like sharing equipment, lab space and projects, helpful actions, should now be done more widely. We should set a tone of cooperation and of extra resourcefulness, important in research.

A topic that needs some serious consideration is whether our traditional model of producing Ph.D.s to enter research and to obtain individual federal research grants is sustainable or if it is ideal for science and for careers of scientists. There are many variables at play, including the interest and ability of new Ph.D.'s to work on topics well outside the scopes of their dissertation research, career opportunities, societal needs, federal and private support and institutional factors but the warning signs of decreasing success rates at NIH and NSF and longer times spent in postdoctoral positions must be recognized.

In our interactions with students, we should redouble our efforts to prepare them for potential careers. Ph.D. and other research projects could be made broader and extend toward contemporary applications (such as health, environment, energy, agriculture). We should support students for their long-term careers, while they also do more focused research in our laboratories. We should learn from them what their career interests are rather than assuming that we know. To place students, the full range of potential careers — in industrial research and development, in government labs and non-profit organizations, in universities and other research institutions — should be considered.

In confronting each of the challenges and uncertainties of the next few years, individual scientists have major roles but they will not be alone. The institutions of science have capabilities for, and they will have to become involved in, finding solutions. The National Academy of Sciences has been and will continue to be a leading institution that serves this role.

Institutions as Resources

Questions and Opportunities Will Arise

Many of the problems that face science now and similarly universities and government agencies are financial and the actions that are needed to address them are largely those of governments and of business development. Growth in individual employment and incomes is needed along with controlling governmental spending. As our government and various interest groups seek effective paths forward, we and other institutions of science should conduct our own analyses and offer productive advice.

For example, we should be prepared to answer questions like: What does the country gain from research expenditures? How much research money is enough? What should priorities be for large projects and various fields of science? Can we afford to be leaders in science? Questions like

these also arose in the early 1990's when the Cold War had ended and our federal budgets were in deficit. The NAS, NAE and IOM prepared four reports (under the Committee on Science, Engineering and Public Policy, COSEPUP). These reports (8–11) described national goals for science, from applications in economic development and toward societal goals, to science as a measure of international leadership and as a cultural value. It was recommended that "the United States should be among the world leaders in all major areas of science" (8) for several reasons, including being able to recognize major advances elsewhere and to be able to capitalize on them.

These reports (8–11) also outlined how to assess the quality, impact and standing of research in different fields and nations. In today's climate, these same reports provide a starting point for answering questions like: What early gains have been achieved by the 1997–2004 doubling of the NIH budget? What could be gained by doubling NSF's budget or federal support of energy research? What is to be lost if research funding is reduced?

In approaching these issues and in furnishing evaluations of the value of scientific research, the NAS, working with NAE and IOM and through the NRC, can serve the country well. Other scientific societies and institutions will be able to contribute as well, both nationally and locally, with policy analysis and advice.

Many of you know that our *Rising Above the Gathering Storm* report of five years ago led to the federal America Competes Act and to increased federal support for scientific research and for science students. An updated version of that report (12) is influencing the current debate. As with the original report, the ability to communicate the contents of a report is critical. The project's leader, NAS Public Welfare Medalist (and NAE member), Norman Augustine, has been creative and effective. For example he has made it clear that economic growth depends on science and technology with a story based on his experience as CEO of Lockheed-Martin. He has noted that often a new aircraft design would have to be changed so as to reduce the aircraft's weight and that there was no time when removing an engine from the aircraft was the right strategy. Science education is the engine that keeps the scientific enterprise aloft; to jettison support for science and science education jeopardizes the intellectual and economic life of the nation.

More traditional roles of institutions will remain valuable, like recognizing excellence with prizes for achievement and awarding scholarship funds to students. Each such event not only delivers tangible rewards, it also represents an opportunity to publicize why science students and scientific excellence are valuable.

Engaging with the Public

The institutions of science (scientific societies, universities, museums, libraries, clubs…) have standing in their communities, not only with their members but also with civic leaders, businesses and elected officials. These institutions are very important interfaces with the public; they help to make the case for scientific research and for education, they help to remind the public about the specific achievements and benefits of science and they can help to identify issues of growing public interest and concern. In some cases, memberships are large enough to be able to influence Congress, not just in Washington but also in home Congressional districts. In these days of increasing competition for public attention and support, and of fragmentation in the world of communication, institutions of science with their many networks are ever more important in communicating with the public.

For example, some of our institutional channels for communication present good matches with interested people; thus, our Marian Koshland Science Museum is serving as a high-quality, growing resource.

Extra work on behalf of science, more effort than ever before, is needed from individuals and from our institutions. I am very confident that we are up to the task because we care so much, for the reasons that I have summarized today and for other value added by science. Recall what physicist Robert Wilson said in response to a Congressional question about a new high-energy physics instrument:

"Dr. Wilson, what is this machine going to do for national defense?" He (Wilson) tried to wiggle out of the question, but the questioner bored in on him, and finally, in desperation, Wilson said, "It's not going to do anything for the defense of the country, but it will make the country more worth defending." (13)

REFERENCES

1. Electronic links to the full list of National Research Council and NAS reports are provided at our NAS Web site and occasionally in our Members' Update issues.

2. *Research at the Intersection of the Physical and Life Sciences*, Committee on Research at the Intersection of the Physical and Life Sciences, National Research Council, 2010.

3. *Giordano Bruno: Philosopher/Heretic*, Ingrid D. Rowland. Farrar, Straus and Giroux, New York. 335 pp. 2008.

4. *Galileo*, J. L. Heilbron. Oxford University Press, New York. 508 pp. 2010.

5. *How to Win the Nobel Prize: An Unexpected Life in Science*, J. Michael Bishop. Harvard University Press, Cambridge, MA. 271 pp. 2003.

6. NIH grant data are at: http://report.nih.gov/success_rates/index.aspx.

7. NSF grant data are at http://www.nsf.gov/nsb/publications/2010//nsb1027.pdf (updated through 2010 by NSF letter to Cicerone).

8. *Science, Technology, and the Federal Government: National Goals for a New Era*, Committee on Science, Engineering and Public Policy, NAS, NAE and IOM, 1993.

9. *Evaluating Federal Research Programs: Research and the Government Performance and Results Act*, Committee on Science, Engineering and Public Policy, NAS, NAE and IOM, 1999.

10. *Experiments in International Benchmarking of U.S. Research Fields*, Committee on Science, Engineering and Public Policy, NAS, NAE and IOM, 2000.

11. *Implementing the Government Performance and Results Act for Research: A Status Report*, Committee on Science, Engineering and Public Policy, NAS, NAE and IOM, 2001.

12. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, By Members of the 2005 *Rising Above the Gathering Storm* Committee, Prepared for the Presidents of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2010.

13. *Global Science: The Universe and Batavia*, speech by Leon Lederman delivered at Thirteenth Annual Fermilab Industrial Affiliates Meeting and Industry Briefing, Fermi National Accelerator Laboratory, Batavia, Illinois, September 9–10, 1993.