

# PHYSICS & SOCIETY

A Publication of The Forum on Physics and Society • A Forum of The American Physical Society

## Message from the FPS Chair

With physicist Ernest Moniz recently sworn in as U.S. Secretary of Energy, succeeding physicist Steve Chu in that role, and with physicist John Holdren continuing to serve as Assistant to the President for Science and Technology, there is no question that physicists are active and influential in policy. The articles in this issue on physicists as science advisors provide more examples of ways physicists are active in policy. Even so, incorporating policy into a physics career can be challenging, particularly for students and early career physicists.

The Forum on Physics and Society (FPS) provides opportunities for APS members to learn about and get involved at the interface of physics and society. Through FPS, physicists can be involved at modest levels, attending policy-related talks at APS meetings, participating in the conferences offered by the Forum, and serving on committees. As an introduction to FPS, or as a refresher, below are some of our activities and some of the ways you can get involved.

*Sessions at annual meetings:* Every year FPS organizes sessions at the March and April meetings. We welcome suggestions for topics and speakers. This past year's sessions included Physicists as Science Advisors, Science in the Next Administration, Hydraulic Fracturing, Low Carbon Electricity, and Low Carbon Transportation. In addition, FPS sponsored sessions at both the March and April meetings on American Science, America's Future; these sessions built on FPS sessions from the previous year, contributing to a national dialogue on the role of science in US competitiveness.

The program committee will start to organize sessions in August. What topics would you like to see covered in this year's FPS sessions? What speakers do you recommend?

*Conferences and Short Courses:* In November FPS will be sponsoring a short course on Nuclear Weapons Issues in the 21st Century, which will be held in Washington DC. Details can be found later in this newsletter and registration is through our web site: <http://www.aps.org/units/fps/meetings/nucwpiissues>

In March FPS will sponsor a conference on the Physics of Sustainable Energy, which will be held in Berkeley California. These short courses, organized by FPS members, provide not only an opportunity to learn about the issues, but also to meet other physicists working on these topics.

*Newsletter:* The FPS newsletter is published four times each year. Although not a peer-reviewed journal, the newsletter includes substantive articles and provides a publication opportunity for physicists working at the interface of physics and society. Submissions are welcomed!

*APS Fellowship:* The FPS Fellowship Committee regularly nominates APS members for Fellowship, recognizing contributions to physics and society. Any APS member can nominate another APS member for fellowship; this can be done through the APS web site. Nominations can be submitted at any time and remain active for two years. APS encourages diversity in the nominations, and both US-based and non-US based APS members are eligible.

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*Forum Awards:* The FPS Awards Committee nominates and selects recipients of the Burton Forum Award and the Szilard Lectureship award. FPS has also awarded three prizes at the Sigma Pi Sigma Quadrennial Congress for outstanding student posters involving issues at the interface of physics and society.

*FPS Committees:* Please feel free to nominate yourself to serve on a committee or to be active in some other way in the Forum. I welcome and encourage your involvement.

—Valerie Thomas ([vthomas@isye.gatech.edu](mailto:vthomas@isye.gatech.edu))

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## Editor's Comments

It is a pleasure to start my term as the Editor of the newsletter with this issue. Since 1973, my predecessors have consistently created the highest quality content and it is an honor to hold myself to their standards. I would like to particularly thank Cameron Reed for the tremendous job he has done the past years and for helping to make my transition so smooth.

When I first joined the Forum Executive Committee in 2001 as Secretary/Treasurer, one of the first significant tasks we had to address was how best to transform the newsletter from print-only versions to fully electronic. The cost of printing and mailing the newsletter four times per year was steadily increasing and it was clear that continuing in this manner was not sustainable. Much of our discussion centered upon how going electronic would affect our readership, both for our membership that preferred to read a paper copy and to the hundreds of libraries and academic departments that left copies of the newsletter in public spaces for anyone to read. This discussion was before the prevalence of electronic delivery that we take for granted today and we went slowly, printing two issues instead of four at “first” before eventually going to fully electronic. The question of readership remains, however, and one of my goals as Editor is to increase the ability for those that are not FPS members to find and read our newsletter. The popularity of social media outlets and other methods of electronic delivery are currently an untapped resource and I would like to explore how best to utilize these to the benefit of the Forum. If you are interested in helping with this, please email me. The more people involved, the better!

Speaking of volunteering, our Editorial Board has an open slot. I would like to express my sincere gratitude to the two current members of the board, Maury Goodman and Richard Wiener, along with my Assistant Editor, Laura Berzak Hopkins, for their assistance in putting this issue together. That included finding authors, reviewing submissions, and offering sound advice. If you are interested in serving on the board, please contact me.

This issue is primarily focused on the FPS-sponsored sessions at the March and April APS meetings. Micah Lowenthal chaired a session titled “Science in the New Administration” and wrote a summary for the newsletter while Pushpa Bhat did the same for the sessions she chaired on “American Science & America’s Future.” In addition, each of the speakers from the session on “Physicists as Science Advisors” was kind enough to contribute an essay on their personal experiences. Finally, M. V. Ramana has written a fascinating article on “The Limited Future of Nuclear Power in India.” As always, our Books Editor Art Hobson has added reviews of books that should be of interest to all.

Our next issue will be published in October and I plan to focus on how physics has contributed to the social sciences. If you would like to contribute to this issue or have a suggestion for an author, please send me an email.

Happy Reading,

—Andrew Zwicker ([azwicker@princeton.edu](mailto:azwicker@princeton.edu))

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## Garwin Biography Announcement

A number of physicists, who have worked for years in the intersection of physics and national security, are gathering support for a biography of Richard Garwin. He is, as most of you know, a major figure of the early atomic age, who is quite amazingly (given the number of intervening years) still very active in providing the government with technical advice and analysis related to defense and defense policy. Dr. Garwin has had an incredibly eclectic career, contributing advances in many areas of physics and applied mathematics, over the course of well over half a century. Many, but not all, of these contributions had important defense and intelligence applications. Beyond a mere list of diverse and major contributions, his career could alternatively and interestingly be interpreted as a paradigm and metaphor for the efforts of leading scientists

— indeed of the scientific community — since World War II to influence government policy in their areas of expertise. For example, Dr. Garwin is famous for, among many other contributions, leading the design of the world’s first thermonuclear device, and later becoming a leading advocate for test ban treaties and stockpile reductions. A prospective author has been identified, and the project is proceeding.

We are investigating crowdfunding options to help launch this effort at an appropriate level. This approach might be ground-breaking, in terms of bringing to fruition a science-related book with potential broad appeal to diverse intellectual communities. Comments, advice, and support are welcome; please send them to Tony Fainberg, [fainberg666@comcast.net](mailto:fainberg666@comcast.net) or [tfainber@ida.org](mailto:tfainber@ida.org).

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# FORUM NEWS

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## FPS Election Results

*Ed. note: Shortly after the April edition of the newsletter was going to press, the results of the Executive Committee election were completed, but we were not able to include this formal announcement.*

Congratulations to the winners of the elections to positions on the Forum on Physics & Society Executive Committee! Each of these new committee members proposed unique ideas toward facilitating the connection between physics and societal issues that will be essential to the continued expansion of the Forum. Arian Pregoner has been elected Vice-Chair and her contributions to the fields of both technology and public policy will bring a modern dynamic to understanding the role physics plays outside of a strictly scientific realm. Tina Kaarsberg, the new Secretary-Treasurer, harbors a strong interest in the interplay between physics and society, particularly energy and the environment, and plans on using her experience in these concentrations to expand the Forum's presence among other scientists, various scientific foundations, and others. Beverly Hartline's long history with FPS

and her independent experience with the melding of physics and society makes her uniquely qualified for aiding the communication between physicists, policy makers, and the public as a member-at-large. Finally, Mike Tuts, as another newly-elected member-at-large, will pursue some of the numerous ideas he possesses about methods by which FPS can reach out to the public to become more accessible in its message showcasing the important role physics has in society. Thanks to all nominees for these executive committee positions and to the nominating committee for designating such strong candidates and we look forward to the contributions the new members will make toward the development of FPS.

*Constance Kaita,  
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## Summary of Sessions on “American Science & America’s Future” at the APS March and April 2013 Meetings:

*Pushpa Bhat*

FPS organized one session each at the March and April meetings on the general topic of “American Science & America’s Future,” following an overwhelmingly positive response for a similar session at the April meeting in 2012. The sessions were organized and moderated by Pushpa Bhat (Fermilab), FPS Chair. The main focus of the session was the latest report by the President’s Council of Advisors on Science & Technology (PCAST), entitled “Transformation & Opportunity: The Future of the U.S. Research Enterprise.” I summarize the two sessions here.

The March meeting session was held on Wednesday, March 20, 2013. The speakers at this session were, Congressmen Bill Foster (IL- 11), Rush Holt (NJ-12) and Randy Hultgren (IL-14), Dr. Maxine Savitz, a PCAST member and Vice-Chair of the National Academy of Engineers, and Prof. Neil Gershenfeld, Director of the Center for Bits and Atoms at MIT. Pushpa Bhat opened the session with some introductory remarks. She showed graphs on the trend of Federal funding over the past several decades for various fields of science and their dependence on major world events. She noted that the federal investment in R&D has decreased steadily and considerably over the past decades, from nearly 2% of the GDP

at its peak in 1963 to ~0.67% now. The investment in R&D by the private sector has grown with the GDP, to keep the overall R&D investment around 2.5% of the GDP. However, the investment of the private sector is primarily in R&D for product improvement and not in basic science research or early applied research. It would make a huge impact on the science enterprise (and therefore technology and economy) if the federal investment went up by at least another 0.5% of the GDP. The PCAST report also calls for maintaining a total R&D investment of 3%.

The central question for the session and for the panel to address was -- how do we strengthen and enhance the Science & Technology enterprise in the United States so that it can successfully compete, prosper, and provide strategic leadership in the 21st century global society?

Congressman Bill Foster and Rush Holt, addressed the audience in a specially recorded 16 minute long video message for the session. Congressman Holt said, “We are trying to bring some sanity to the budget. The budget that is in front of us today does not take a very long term perspective, does not treat research very well.” He said that rather than investing in infrastructure, education and research, the mentality is one of

austerity. “It is not a happy time, not a good time for anyone who cares about the future.” Congressman Foster said, “Something that both Rush and I are concerned about is the fuzzy thinking that is happening on the Hill with respect to the pro-growth policy. Both parties claim that they have pro-growth agenda. But, it is very important to understand that a lot of things you invest in do not have an immediate return. Things like basic scientific research, things like education, have a return on investment that accrues not in the next election cycle, but in the next decade, or decades hence. So this is the argument that Rush and I are making until we are blue in the face.”

Rep. Holt also emphasized that it is a well-studied and well-known fact that the returns from investment in scientific research are huge, and the applications to societal needs are numerous. He mentioned that, for example, the digital library studies funded by the National Science Foundation resulted in Google. And by cutting down on investments in science research, he said, “we are eating some of our seed corn!”

Finally, Congressmen Foster and Holt called on scientists to consider serving in the public sphere, and stressed its importance. Rep. Foster urged more scientists to run for office, and Rep. Holt appealed that each of us should carve out a bit of our time to work in the public sphere—that if we are not inclined to run for office, we should be engaged as lobbyists or advisers in the policy-making process.

Congressman Randy Hultgren, who represents Illinois’ 14th district, which includes Fermilab, spoke via a conference call from Capitol Hill and addressed the audience at the session. He too emphasized the importance of basic science research, and of the important responsibility of the federal government to support basic science research and education. He talked about his efforts in Congress to push the agenda for investing in science, and about the bipartisan House Science & National Labs Caucus that he formed in December 2012. He said that the new caucus would focus on reinforcing federal investment in scientific research and national laboratories, as well as raise awareness about the role national labs play in long-term economic growth of the country.

After the addresses from Capitol Hill, Dr. Savitz took to the podium and spoke about the PCAST report. She opened her talk by saying that inventiveness and scientific curiosity are part of the American character. “According to a 2009 Pew poll, Americans think that government investments in scientific research pay off in the long run,” she added. She showed a number of graphs indicating that the GDP has grown exponentially in the past century, and that R&D has grown proportionately. She discussed and summarized the specific actions that PCAST has recommended: (1) Total R & D expenditures should be 3 percent of GDP, (2) Congress and the Executive Branch to find mechanisms to increase stability and predictability of Federal research funding and (3) a research and experimentation tax credit be made permanent.

Prof. Neil Gershenfeld of MIT talked about the digital

revolution that could usher in a new era of advanced manufacturing, of “making anything anywhere” with digital fabrication. The FabLab (fabrication laboratory) is a small scale lab or workshop that enables digital fabrication; the first one was created at MIT and now there are about one hundred of them around the world, including some in remote locales in developing countries. This FabLab digital revolution will empower individuals and small local communities to create things relevant to their environments. There is legislation being introduced by Bill Foster to create a national lab which is a network of all the FabLabs in the US.

The talks were followed by a lively discussion with Dr. Savitz and Prof. Gershenfeld with moderator and audience participation.

The panel session at the April meeting on Monday, April 15 in Denver, Co had Prof. Jim Gates (University of Maryland), a member of PCAST, Prof. Bob Zimmer (President of University of Chicago), Prof. Lisa Randall (Harvard University) and Dr. Kate Kirby (Executive Officer of APS), as speakers/panelists.

After opening remarks and introductions by Pushpa Bhat, Jim Gates talked about PCAST, its members, its charge and activities. He outlined the President’s American Innovation strategy, which includes investing in Research & Innovation, STEM Education, strengthening physical infrastructure, clean energy and Advanced Fuel Technology. Prof. Gates said that the report calls for a long-term, well planned investment in science, and providing incentives to industry to support R&D. Prof. Gates said, “The challenges are great and the path forward is murky. We have to recapture the American dream, and the federal government has to be involved.”

Prof. Zimmer, President of the University of Chicago that runs both Argonne National Lab and Fermilab, talked about the partnerships between universities, national labs and the government. He discussed the mission of these three entities – the research universities are driven by scientific discoveries, the national labs driven by providing infrastructure for big research projects and as national user facilities, and the federal government provides support for science at the universities and national labs because science when there is not enough money, then the relationships between the entities could get strained, especially between the universities and national labs. Prof. Zimmer then discussed the case of high energy physics in the U.S. and the role of the community and leadership. He offered advice to the community that it is our responsibility to convince the federal government what we are doing is part of government’s business.

Dr. Kate Kirby talked about the important role APS is playing in getting the message of the science community across to the government, especially to the Congress and to the public, and in fostering our future scientists. The message is that our leadership in science has meant transformational technology, and good high tech jobs. She said that APS has

been conveying the message recently, through events such as “deconstructing the iPad” on Capitol Hill, which clearly demonstrates how research of 20-30 years ago contributes directly to the technology of today. APS has also been instrumental in having the members connect to their congressional representatives. It is also raising its profile in the industrial sector where most of our young scientists go.

Prof. Randall discussed her thoughts about communicating science to the public. She said that despite the mood of pessimism, this is a very good time for science and an exciting era for physics. Prof. Randall said it was heartening to see how the Higgs discovery was received by people around the globe. While it is challenging to identify the economic benefits, she said we could try to justify how we benefit as a country from doing such science. She pointed out that our role in the Higgs

discovery was much bigger than perceived in the U.S.; the head of the CMS collaboration, Joe Incandela is an American, and there are a large number of American scientists involved. Randall also stressed that big projects answer big questions and inspires people. She closed her remarks, by saying, “it is very important for scientists to communicate, to the public and to the government —not everyone needs to do it but at least some have to do it.”

A lively moderated discussion followed with the panel and audience on communications to the public, policy makers and the broader science community on the value of basic science research and value of fundamental discoveries.

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## Science in the New Administration

*Micah Lowenthal*

**O**n March 21, 2013, FPS sponsored a session at the APS March meeting titled “Science in the New Administration.” The panel of speakers consisted of three administration officials, one professor who has led advisory activities for APS, and a member of the staff of the House of Representatives Committee on Science, Space, and Technology. The talks were rich with details and so this summary only gives an overview of the session. Also, the last speaker requested that her remarks remain off the record, so this summary covers the first four talks.

The session was organized because every four years the March APS meeting is situated well to hear about the Administration’s plan for science policy in the coming four years. The speakers noted that this year it is difficult to talk about science policy because of (1) declining budgets, (2) budget uncertainties (with the looming sequester and failures to reach budget compromises), and (3) a general loss of bipartisanship on Capitol Hill coupled with a small but increasing hostility toward science among some members of Congress. An unprecedented problem for Administration officials speaking at a meeting in March was that the lack of a budget compromise meant that the President’s proposed FY14 budget request had not yet been released publicly, so they could not reveal that budget. Still, they were able to give substantive talks.

Gerald (Jerry) Blazey, assistant director for the physical sciences at the White House Office of Science and Technology Policy (OSTP), described President Obama’s support for science in the context of addressing societal problems and science’s role in our culture, where science manifests discovery. He described the role of OSTP in the government science enterprise coordinating interagency planning, includ-

ing the National Science and Technology Council and the President’s Council of Advisors on Science and Technology, as well as managing interagency policy committees.

Blazey also described the science and technology enterprise within the federal government, comprising \$55 billion in sponsored research and development (R&D), roughly half of which is in the Department of Defense and roughly one quarter in the National Institutes of Health. Of particular interest to the APS-FPS audience is OSTP’s focus on climate change, innovation, energy, STEM education, infrastructure, and energy efficiency. Also, there are recent initiatives including the Presidential Innovation Fellows, (bringing in private innovators to work with government on key issues) and the Public Access and Open Data initiatives. There are also international cooperative efforts with China and Russia with science and education and science and technology foci. Blazey reiterated the President’s commitment to science and technology, pointing to the President’s words supporting science and technology in the State of the Union Address.

William (Bill) Brinkman began his talk by announcing that he would be finishing his service as director of the Office of Science in the Department of Energy in a few weeks. The Office of Science funds facilities, center-oriented research (including the Energy Frontier Research Centers), goal-driven research, and curiosity-driven research. He described 2013 as a challenging time for basic science, noting that the sequester would undermine some valuable science programs. He described the principles for prioritization within its mission. Among these were determinations of fields where the United States must be the leader or a collaborator with other countries and terminations of some facilities and research to keep the remaining programs at highly competitive levels. In

these decisions, Brinkman said that he has sought involvement from the relevant scientific communities in thinking about how to prioritize.

Brinkman then listed ten current priorities for facilities, focusing on several areas of scientific progress, including light sources, such as the Advanced Photon Source; scientific user facilities, such as the Leadership Computing Facilities and NERSC; ITER; the Facility for Rare Isotope Beams; and the neutrino program. He emphasized the importance of supporting basic science in the context of growing scientific achievement and ambitious plans in Asia and Europe as U.S. research productivity has held steady. Brinkman closed by discussing climate change and clean energy R&D, explaining that the questions about climate change are not whether it is real, but when and how bad. This has motivated the need for clean energy and investment in new generating capacity (fossil vs. clean) was on a trend to reflect that shift in 2011 (investment in clean energy surpassing investment in fossil energy resources), but hydraulic fracturing changed that.

Robert Jaffe discussed science advice for the U.S. government, in particular the APS Panel on Public Affairs (POPA), on which Jaffe serves as chair elect. Jaffe gave an overview of mechanisms for science advice in Washington, including the now-defunct Office of Technology Assessment, the National Research Council, the Congressional Research Service, and the Governmental Accountability Office, which is working to get more technology assessment capability. He noted that POPA fills a niche in that it conducts broad-based, high-quality, rapid-response studies that have real impact because of POPA's implementation efforts. No other professional societies have POPA-like bodies, but POPA collaborates with other entities, including the AAAS, MRS, and CSIS.

POPA studies have addressed nuclear energy and disarmament, energy and environmental issues, and homeland security. Although they generally are self-initiated by POPA, recently POPA did a program review in response to a direct request from the Domestic Nuclear Detection Office. A fea-

ture of POPA's studies that is fairly unique is their extensive efforts in implementation, assisting members of Congress in drafting legislation and in one case working with the American Enterprise Institute and the Heritage Foundation to build support for the recommendations, giving political cover for politicians to support action. Upcoming studies include non-strategic nuclear weapons, license extension of nuclear power plants, and possibly the APS statement on climate change. Jaffe noted climate change and nuclear arms control as two major issues, among many others, on which physicists can contribute to the policy debate.

E. William (Bill) Colglazier is the Science and Technology Advisor to the Secretary of State. He runs an office of twelve people within the State Department. Science and technology are important to the State Department because technology can be disruptive but it can also enable leapfrogging in development (consider wireless phones in Africa). Science and technology are also very important to diplomacy: many countries when they meet with U.S. diplomats make science and technology in economic growth and public welfare the first issue they discuss. They want to increase collaboration with U.S. scientists and engineers. Colglazier noted that scientists outside of government are particularly effective for science diplomacy, and he particularly cited the efforts of the National Academy of Sciences, the Civilian Research and Development Foundation, and the American Association for the Advancement of Science for their work with a broad range of countries, including some where the U.S. has difficult relations, such as Iran, North Korea, Cuba, and Burma.

Overall, the session was informative and spirited, and it made connections between the physics community and the policy community in Washington. It is clear that the two communities benefit from each other's work, and more communication between them can only help.

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*Physics and Society* is the non-peer-reviewed quarterly newsletter of the Forum on Physics and Society, a division of the American Physical Society. It presents letters, commentary, book reviews and articles on the relations of physics and the physics community to government and society. It also carries news of the Forum and provides a medium for Forum members to exchange ideas. **Opinions expressed are those of the authors alone and do not necessarily reflect the views of the APS or of the Forum.** Contributed articles (up to 2500 words), letters (500 words), commentary (1000 words), reviews (1000 words) and brief news articles are welcome. Send them to the relevant editor by e-mail (preferred) or regular mail.

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*Physics and Society* can be found on the web at [www.aps.org/units/fps](http://www.aps.org/units/fps).

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# ARTICLES

*Ed. note: At the April meeting, FPS sponsored a session on physicists as science advisors. Our three speakers have graciously agreed to contribute a written version of their remarks for the newsletter.*

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## Science in the White House

*Steve Fetter*

In many countries there are few opportunities for university scientists to serve as government officials. But in the U.S., hundreds of academic scientists take positions in federal agencies or in Congress every year, through Interagency Personnel Act appointments, fellowships, sabbatical leave, or other appointments. These appointments typically last only one or two years, but the benefits are substantial. Government benefits from fresh ideas and knowledge from scientists who are true experts in their field; universities benefit from having faculty with an understanding of how government works; and faculty benefit from having an opportunity to serve the country and apply their knowledge and skills to important policy problems.

I have had the good fortune to take work in government three times: in the Pentagon for two years in the beginning of the Clinton administration; in the State Department a few years later; and, most recently, I worked for over three in the Office of Science and Technology Policy (OSTP) in the White House. Here I will focus on my experiences at OSTP.

The White House is, of course, a special place to work. During the first year I attended several meetings each week in the fabled situation room, working through various policy reviews. I felt privileged every time I walked through the doors into the West Wing.

The White House is a large and complex operation, with many offices that have overlapping portfolios. Few issues are the sole responsibility of a single person or office. When arranging a meeting, it was important to identify all of the people who would have a stake in an issue, to make sure that all views were represented. I worked on a daily basis with the people from the National Security Staff, the Office of Management and Budget, the Domestic Policy Council, that National Economic Council, and the Council on Environmental Quality. On some issues, I worked with the Office of the Vice President, the U.S. Trade Representative, and the Council of Economic Advisers.

Because portfolios overlap, collaboration is essential. And although everyone is collegial, it is also a competitive environment, with people jockeying to get their policy initiatives to the top of the agenda. For that reason it is also an entrepreneurial environment, with people looking for good policy ideas or for problems that should be addressed. Although there was no shortage of frustrations, it was inspiring to see how hard everyone worked, and how everyone worked for public good.

The director of OSTP is John Holdren, who also serves as the President's science advisor. OSTP has four divisions: Science, Technology, Environment and Energy, and National Security and International Affairs. I initially worked mostly in the national security division, and directed the environment and energy division in the final year. In between, I played the role of a utility infielder, handling issues as they arose, such as the U.S. response to the nuclear accident in Fukushima.

OSTP has two basic roles, which might be summarized as "policy for science" and "science for policy." The most important aspect of "policy for science" is setting overall priorities for research and development, and ensuring that those priorities are reflected in the programs and the budgets of all federal agencies, particularly those with large R&D efforts, such as NSF, NIH, DOE, NASA, NOAA, NIST, DOD, DHS, CIA, EPA, USDA, and USGS.

OSTP works closely with the Office of Management and Budget (OMB) on budgets for R&D programs. The OSTP and OMB directors issue a joint memorandum to the heads of all executive departments and agencies on science and technology priorities. The priorities memo for fiscal year 2014 outlined priorities in advanced manufacturing, clean energy, climate change, information technology, nanotechnology, biotechnology, and STEM education.

Agencies use this guidance in preparing their budgets, which are submitted to OMB in early September. OSTP assists OMB in analyzing and reviewing these submissions and suggesting adjustments to R&D programs. OMB returns the adjusted budgets to agencies in late November in the "passback." Agencies appeal some of the adjustments, and negotiations with OMB ensue. There is never enough money to fund all priorities, and tough decisions remain for the president. President Obama understands the value and importance of scientific research, and he has accorded high priority to R&D in these decisions.

Part of OSTP's job is to defend federal R&D expenditures to Congress and the public. Many people do not understand the nature of science and the research enterprise or fully appreciate the value of government-sponsored R&D for society. One member of Congress said, "We're spending over \$60 billion a year for research. What are we getting for that money?" That is a hard question to answer; if one could say with confidence what the benefits of current research

will be, it would not be research. But you can identify the benefits of past research. Studies of the social returns to past R&D consistently show returns of 20-30 percent per year over the last several decades—a rate of return that far exceeds stock markets.

Much—maybe most—research expands human understanding but does not produce tangible economic benefits. But some research produces enormous benefits that cannot be foreseen. When the Office of Naval Research gave Charles Townes small grants in the 1950s to support work in quantum electronics, no one could have foreseen that it would lead to lasers and other devices that would transform dozens of industries. No one imagined that ARPAnet would one day be the foundation for the digital economy, or that the need for particle physicists to share data would lead to the creation of the World Wide Web.

Scientists must get better at explaining the significance of their research, and why it matters. A steady stream of senior scientists came through our office. Most were terrific, but I was surprised that many could not explain in five or ten minutes what they were doing and why it was important and worthy of support. Business schools teach students to give an elevator pitch—how to describe their idea in one minute, well enough so that potential investors want to hear more. They develop 5-minute and 15-minute versions in case the investor wants to hear more. We should train our graduate students to do the same thing, using language that any intelligent person can understand. If you really understand something, you ought to be able to explain succinctly to an assistant secretary or senator what you are doing and why it matters.

The budgetary process is important, but more time is spent on policy or “interagency” processes. Interagency committees are commonly chaired or convened by a White House office—usually by OSTP when the issues concern the conduct of science. This includes coordinating R&D programs across Federal agencies, to ensure that key challenges are being addressed while avoiding unwanted duplication. OSTP convenes dozens of such groups under the auspices of the National Science and Technology Council, on topics ranging from space weather to critical materials. Other “policy for science” issues include improving STEM education; streamlining visa processing for foreign scientists; promoting international scientific cooperation; protecting scientific integrity; and policies to make data and other results of federally-sponsored research widely available. The Obama Administration has made significant progress in all of these areas.

The second main role of OSTP is “science for policy.” OSTP is responsible for ensuring that the President and his senior staff have the best available scientific and technical advice, and that all of the President’s policies are informed

by the best available scientific information and analysis. Science and technology play important roles in many key policy challenges and issues before the Administration, including health care, economic recovery and growth, climate change, clean energy, homeland security and cybersecurity, and nonproliferation. Accordingly, OSTP had a seat at the table on a very wide range of policy issues. One of the things I enjoyed most was the opportunity to work on a wide range of issues: nuclear weapons and arms control policy; ballistic missile defense and landmines; identifying opportunities for scientific and technical collaboration with other countries; climate change, ocean policy, and various EPA regulations; energy research and development; protecting the grid against solar storms; and earth observation satellites. It was incredibly stimulating.

These interagency policy committee (IPC) meetings are often convened at the assistant or deputy assistant secretary level. If agreement by all the key agencies cannot be reached at that level, the issue will be escalated to the “deputies” level for resolution; if agreement cannot be reached at the deputies level, the “principals” or cabinet secretaries will be convened. The deputies or principals also are convened to confirm agreements reached at lower levels on particularly important issues.

Let me close by sharing a few things I learned:

- Personal relationships matter. Be nice to people. You never know who you will be working with or for in the future.
- Information is everything. Do not count on your position or “official channels” to ensure that you are informed. Schmooze; invite people to lunch or coffee. If you are not hearing anything about an issue, it probably means that you are not in the loop.
- Generate ideas. Write them down—preferably in one paragraph, but no more than one page. Prepare an elevator speech. Be persistent. Don’t get discouraged. Wait for an opportunity.
- Do not seek credit. A common quip is that you can get a lot accomplished in Washington if you do not seek credit. This is true but frequently ignored (including by people who cite it).
- If you don’t know something, call an expert. One of the wonderful things about working in the White House is that almost anyone will take your phone call and offer to help. Resist the temptation to rely entirely on your own analysis.

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## Practice and Pitfalls of Science Advising in the Government

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Government leaders require high-quality, objective scientific advice on a daily basis. Science advisors have played critical roles in the development of almost every major policy initiative in the last generation. In many cases, scientists have led agencies in the federal government and executed technically-complex programs. Nonetheless, scientists are often underrepresented or ineffective in policy discussions. Scientific principles or ideas are often misrepresented or oversimplified to meet political objectives. Science professionals should understand the importance of their input into the policy and practice of government at all levels. Further, we must understand that successful engagement requires an understanding of politics and communication skills. Finally, the science advisor must combine a healthy skepticism of the limits of science with a passionate advocacy for the advancement of science across all disciplines.

In this article, I will discuss my personal experience with science advising across multiple levels and branches of government and offer some practical advice to anyone who seeks to do similar work. I bring an unusual perspective, because I served as an elected official in the Maryland House of Delegates for eight years at the same time as I worked at the Johns Hopkins University Applied Physics Laboratory. I had the honor of serving as the American Physical Society's Congressional Science Fellow in the mid-1990's. In the last dozen years or so, I have served in multiple positions in the Federal executive branch, including stints as the Deputy Director of the National Institute of Justice (NIJ, the science agency of the Department of Justice), Deputy Director for Science and Technology of the Combating Terrorism Technology Support Office, and most recently as Command Science Advisor of the US Army Special Operations Command. In each of these circumstances, I represented the scientific community in an organization that was focused on missions outside of the scope of scientific inquiry per se and where I was the outsider. In the legislature, my colleagues referred to me as the "rocket scientist," and although I had worked on spacecraft, I certainly was not an expert in the physics and engineering of rockets. In the Justice Department, my office was the sole province of scientists in the largest law firm in the world. Although the Army sponsors and manages a wide-ranging scientific research program, it is the oldest bureaucracy in American government, predating the Declaration of Independence, and the institution remains very hierarchical and bureaucratic. This makes it difficult for any type of innovator to be effective, including scientists and soldiers who advocate for positive change. In every part of the government, inconvenient truths are everywhere. The scientist is often in the position of undermining established wisdom of every type across the ideological spectrum. In

this sense, science and technology are inherently subversive, especially in the government, which is run by interests, relationships, and politics, not objective data. In the media, scientists are routinely stereotyped as socially inept dweebs; the science advisor must transcend those prejudices to be effective. At NIJ, I helped to develop and manage a major program relating to the use of DNA and forensics. From the inception of the program, it was necessary to transcend the dry language of the polymerase chain reaction. At one point, we met with senior officials to brief the new program. We used props—such as cool-looking micro-capillary electrophoresis chips—to convey the importance of scientific research to improvements in crime laboratory practice. We did not use the term, electrophoresis, but we did mention "lasers" and use Dr. Evil-style air quotes, an Austin Powers reference that was not lost on our audience. Later, when I was fortunate to meet the producers of the CSI television shows, they apologized to me for the unrealistic portrayal of the technologies and resources available to actual crime labs. I demurred, telling them that we welcomed the creative story-telling, which inspired the aspirations of the policing community and caught the imaginations of policy-makers. The NIJ program has been a great success for practice and science. It might never have come about if the talking points had been limited to the textbook chemistry.

If done right, the science advisor will often play the role of the scold. Some people will dislike what the scientist has to say, because it may threaten established ideas or the culture of an organization. Therefore, executive buy-in is essential. Those above the science advisor must tolerate such challenges, even if they are directed against the goals of the senior executive or political appointee. It does no good to be an advisor that always reinforces prevailing orthodoxy. While it can lead to stress, honest, objective advice is cherished by good leaders. In one of my positions, I encountered a company that sold detection equipment that was little more than an empty box. They had nonetheless convinced some key people to buy their product and use it in very sensitive situations. I invited them to demonstrate their technology at my office and we conducted a short field experiment. As expected, the device performed no better than random chance. I told the company representatives that I believed their device was fraudulent and told them that I would follow up on that basis. I did not know that one of the representatives was an old friend of my supervisor, who called me into his office soon afterward to tell me that my actions were unsatisfactory. I stood my ground, explained the science behind my thinking, and apologized for not previously alerting my supervisor. Fortunately, he was a decent man and solid leader. He backed me up after reviewing

the information and even gave me top-notch performance reviews soon afterward. Just as importantly, he understood that he could trust me to tell him the truth based on sound science, whether he liked it or not.

Similarly, the scientist must understand that scientific truth is not absolute. First, there are many considerations in policy decisions, and science is only one of them. Also, science is inherently limited in the scope of its knowledge. For example, we understand the spectral absorbance of carbon dioxide and the implications for atmospheric warming, but the implications of specific climate change policies are much less certain. To be effective, especially in the long term, the scientist must abandon self-righteousness and ideology. The scientific community has done a poor job in this regard in recent years and has unnecessarily alienated policy-makers, especially among conservatives. Interdisciplinary collaboration is important in this regard. With respect to policy development, the hard sciences can benefit from a close relationship with social science, especially those who work in economics and evaluation research. Scientific evidence must encompass the human and social impact of policy and practice, not just the cold numbers of physical science. Again, such a synthesis must be pursued with an appreciation for the limits of current understanding, which must in turn be honestly conveyed to policy-makers and government officials. Scientific progress can often be slow, but it is relentless. Similarly, a rigorous, inter-disciplinary approach to science advising may be frustrating at times but will reap inevitable rewards in the long run.

Unfortunately, despite its importance in modern society, science is still poorly understood by the public and their representatives. Many think the new model of iPhone is “science.” Science doesn’t have a constituency, but technology does. Every government official wants to use technology to make their agency more effective, and every member of Congress wants the next high-tech startup in their backyard. In this environment, the science advisor must be an advocate for science for its own sake. Salutory examples abound. The smartphone wouldn’t exist if weren’t for solid state physics, band theory, and the development of the transistor. Washington debates policies relating to medicine and drugs that wouldn’t exist without modern chemistry and biology. Chemistry has succeeded because it sought fundamental understanding through experiment and classification, as exemplified in the periodic table or crystallography. Basic science will not thrive unless gov-

ernment leaders understand and support the importance of the continuing quest for better fundamental understanding across all the scientific disciplines. Scientists—whether in government or not—must advocate for basic science. This is the one area where it would be appropriate for the science advisor to be a traditional advocate; in this case, self-interest is in the public interest.

All scientific professionals play the role of science advisor, in some cases only to friends and family. It can seem to be an impossible challenge for those who wish to do more. There are many ways to be effective through writing letters or blogs or volunteering in local settings. I got my start in local politics while I was still in graduate school. My thesis advisor questioned my activity in voter registration as outside employment, but I was happy to inform him that it was volunteer work. The American Physical Society and other scientific associations offer fellowships and committees that provide opportunities for public policy engagement. The most common form of science advising is also one of the least recognized—that of the program manager or technical expert in science agencies or, as I have done, in organizations that need science and technology expertise. Many government agencies seek people like scientists, who possess graduate degrees and relevant expertise. Public service can be a very rewarding way to use one’s scientific background. At some point, if you choose that path, you will be forced to leave the laboratory behind. That was difficult for me, because I enjoyed the practice of science a great deal. Also, I have found it very difficult to stay on top of developments in my field as I once did. In government, the science advisor must have enormous breadth of knowledge, which prevents one from delving too far into the details of most issues. The best science advisors are natural generalists who are curious about other people’s work even when it doesn’t directly relate to their own research. I have discovered a new appreciation for the synthesis of ideas and, as outlined above, interdisciplinary research.

It is of the utmost importance for scientists to become involved in government and policy. Science advisors can make a positive contribution and a real difference in the problems faced by society. I encourage scientists of every political persuasion to engage in policy debates and the important work of public service.

*John S. Morgan  
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## Reflections on Science Advice

Valerie M. Thomas

### Overview

Being a science advisor is often viewed as prestigious, even glamorous. It is an honor to serve as an advisor to policy-makers, decision-makers, and the public. At the highest levels, science advisory roles are positions of leadership, with recognition of scientific achievement and discernment. Science advisors, particularly at the high levels, may meet and work with state and national leaders, their advice and comments may be reported in news media, and they may contribute to policy development. Science advisors can be influential; they have been called the fifth branch of government (Jasanoff 1998).

In fact, being a science advisor may not be glamorous at all. Yet it is an important service. In my reflections here on science advice, I will emphasize two points. The first is that there are many science advisory opportunities, and interested scientists and engineers can find opportunities to participate. Modest mid-level advisory committees and positions may not be glamorous, but scientists and engineers in these roles can provide valuable service, strengthening the scientific and technical basis of policy and regulation. Mid-level science advisory activities can also provide policy-makers and the public with direct contact with scientists and engineers, creating direct, often open-meeting examples of how scientists work and the contributions of scientists and engineers to society. Serving in these roles can be time consuming, but can be deeply satisfying.

The second point is that being a science advisor is a position of responsibility; there is potential for errors of commission and omission. Many of the issues that science advisors address are, in the big picture, technical or minor. But every once in a while there are big, difficult, controversial issues. Identifying these problems quickly and addressing them appropriately is a substantial challenge, key not only to the successful resolution of the technical issue at hand, but also to the public trust in scientists and engineers. Science advice goes far beyond explaining known science and engineering to decision-makers and the public; science advisors have their greatest potential to be influential at precisely those points at which the science and the policy decisions are controversial, uncertain, or complex.

I have had a number of opportunities to serve in advisory roles, at a modest level. After completing my PhD in high energy physics at Cornell University, I changed my research emphasis to nuclear arms control, and I was fortunate to receive a post-doctoral position in the Department of Engineering and Public Policy at Carnegie Mellon University. Later I moved to Princeton University's Center for Energy and Environmental Studies, where I continued to work on nuclear arms control, and over time took up environmental and energy topics. My current position is at the Georgia Institute of Technology,

where I hold a joint appointment in the School of Industrial and Systems Engineering and in the School of Public Policy. This background in physics and broad policy-related research experience opened up opportunities to serve on the Science Advisory Board of the US Environmental Protection Agency, and also as a Congressional Science Fellow in the US Congress.

### Availability of advisory opportunities

As mentioned above, after I finished my PhD thesis, I decided to transition to policy-related research. I thought it would be fairly easy: the US Office of Technology Assessment (OTA) offered a number of post-doctoral policy fellowships, as did the American Physical Society (APS), the American Institute of Physics, and the American Association for the Advancement of Science. My policy experience consisted of having read quite a bit about it and having helped to organize university seminars and symposia on the topic; with so many openings for scientists I thought I was a shoo-in.

The transition was harder than I had expected. The responses to my applications for congressional and OTA fellowships were uniformly something like this: "*Thank you for your interest. We received many excellent applications and we regret that we will not be offering you a position.*"

Although my applications for congressional fellowships were not successful, post-doctoral science policy positions at universities were also available. I was delighted to be offered a post-doctoral position in the Department of Engineering and Public Policy at Carnegie Mellon University. This was a leading group from whom I learned a great deal; this position provided the start for career at the interface of science, technology, and policy.

Years later I again applied for a congressional science fellowship and was fortunate to be offered the APS Congressional Science Fellowship for 2004-05. I had an excellent experience working in the legislative office of Representative Rush Holt, one of the few scientists in the U.S. Congress. During that year I worked on science and technology topics, including the Energy Policy Act of 2005, technology assessment for the U.S. Congress, and federal support for research and development.

Since then I have occasionally served on the APS congressional fellow selection committee. Interviewing the candidates has driven home to me how competitive these fellowships are. The scientists applying for congressional fellowships, while often having only recently finished their PhDs, have strong research records and outstanding letters of recommendation. They are articulate, thoughtful and mature. In retrospect, it is no wonder that it took me some years, and more than one try, to be selected as a congressional science fellow.

I offer my experience to underscore that there are many opportunities to be involved in policy and science advice, and that nevertheless the process may not be completely easy or quick. All doors do not open at once; rejection is likely and probably healthy. Learn more and keep trying. Develop expertise, communicate, and think beyond committees.

**Communicate.** In addition to publishing papers, speaking at scientific and technical conferences and organizing sessions, consider reaching beyond the boundaries of your discipline. Write, at least occasionally, for an audience beyond your research peers. Also, consider striking up a conversation with people in government whose work is similar to yours. This could be as simple as an email or phone call.

**Think Beyond Committees.** Do not be dazzled by the prospect of serving on a government committee. Committee work is often boring, and generally involves reviewing or synthesizing other people's research. Recognize that your own original research and peer-reviewed publications can be influential, and may be of greater value to society than any committee service. Find your way to contribute and serve.

### **Responsibilities and challenges of advisory positions**

The most challenging of my experiences in science advice was my service on the US EPA Science Advisory Board's (SAB's) review of the dioxin reassessment in 2000-2001 (SAB 2001). The assessment of the risks of dioxin has been and remains controversial; SAB had previously provided reports on dioxin in 1987, 1992, and 1995. When I was invited to serve on the 2000 dioxin reassessment review committee, I had already been participating in SAB reviews for several years. I was familiar with the procedures of the SAB.

This assignment turned out to be different. As always, SAB advisory committee meetings are open to the public. Generally only a couple of people show up. This time, the committee met in a large hotel room, and there was a full audience. As the committee began its discussions, I noticed that when some members of the committee spoke, members of the audience raised signs. I wondered what was going on: some committee members seemed to have large numbers of supporters in the audience, others just a few. Finally I realized what was going on: an environmental advocacy organization, the Center for Health, Environment, and Justice, had researched the sources of funding of each of the committee members; for each company linked to dioxin emissions, they made a sign. So for each committee member who had received funding from a dioxin-producing company, a sign with the name of that company would go up each time he spoke. (I had no external funding for my dioxin work, and so was not a target.) It was a clever and theatrical protest, underscoring the environmental group's claim that some committee members had conflicts of interest.

After the face-to-face meeting there was a period of several weeks while we wrote up our review document, through

numerous emails and drafting and committee reviews. During that time, I was invited by an industry-funded organization to speak at a small conference on dioxin; due to the short preparation time, they said, they offered me a sizable honorarium. I must admit that I considered saying yes. But after reflection, it seemed that there was no other real interpretation than I would be paid by dioxin interests in the middle of a potentially influential dioxin review. I declined the invitation.

A week or so later I discussed this with the SAB staff director; he said not only was it mandatory that I refuse the invitation, but also that industry groups should not have been issuing such an invitation. I believe a reprimand or warning was issued to one or more stakeholder groups. So, another lesson learned: have an open and active line of communication with the staff supporting the advisory committee; they can be helpful, and they need to know what is going on. And, of course, don't take money from stakeholders.

The most challenging part of this episode, however, was not the theatrical environmental protests or the monetary offers from industry, but the work of constructing the review itself. There were scientists on the ad hoc review committee who had strong views, wrote copiously, and were able to devote a great deal of time to the review process. Scientists who serve on committees of the EPA's Science Advisory Board are federal employees - called special government employees or SGEs - during their hours of work, and they are paid for these hours. Nevertheless, as an employee of Princeton University at the time, I was limited in the amount of time I could spend on outside activities (about two days per month); moreover I had ongoing research work that was not easy to completely put aside. As the draft report started to be put together, I found many statements throughout what grew into a large review document that needed attention. The time commitment escalated; some committee members were inserting sentences here and there throughout the document on an ongoing basis; when we would catch a problem and fix (e.g. delete) it in one part of the document, something very similar to the deleted text would appear elsewhere in the document. It became almost a competition; it was a time consuming and stressful process.

In any review, each committee member must understand from the outset that he or she bears responsibility. However, going in to this review process I was not fully prepared for the degree of involvement that was needed; I have not experienced this kind of aggressive "review capture" behavior before or since. I spoke up repeatedly, fully reviewed the document, and worked to ensure that the document did not misrepresent my views or those of other committee members. After I questioned statements in the draft about what "most" of the committee agreed on, SAB even organized a public conference call in which committee members voted on statements in the text, to ensure that committee views were not misrepresented. In the end, however, the process of reviewing numerous complex scientific questions with a difficult committee did not result in

a smooth and nuanced document. At the end of our process, I was not fully confident that the draft review document developed by the ad hoc review committee was ready for release.

Fortunately, the SAB has a two-tier review structure: the top level chartered SAB board reviews the draft reports developed by ad hoc SAB committees to determine whether they are appropriate to finalize and to send to the EPA Administrator as an SAB report. In the case of the dioxin reassessment review, the chartered SAB substantially revised our document before issuing it in final form (SAB 2001).

There was fall-out from the 2000-2001 dioxin review process. There were staff changes at the SAB. And the procedures for vetting of SAB panelists and committee members were substantially revised. There is now a public nomination process of experts when a new ad hoc panel is formed for a review; there is opportunity for public comment on candidate experts; there is a new requirement for a Confidential Financial Disclosure that allows EPA's SAB Staff Office to review information for conflict of interest and appearance of lack of impartiality; and there is publication of a determination memo explaining the panel formation process for each review.

I have served on many SAB panels, reviews, and committees. With this one exception, all have been conducted with the highest scientific standards and with collegiality, and have attracted little outside interest. The 2000-2001 dioxin review was unique; it was the kind of situation that most scientists will probably never experience in their careers; it is not representative of the SAB. However, I have discussed it here to show that this can happen; somewhere something like this will happen again. Scientists need to be vigilant and active; scientists need to be ready to work hard against pressure to ensure that their advisory work is a credit to science and provides sound information to decision-makers.

Serving as an advisory committee member is a public trust. Experts who serve as Special Government Employees are subject to federal ethics regulations. Committee members also participate in a public process governed by the Federal Advisory Committee Act, where deliberations happen in a fishbowl. Public scrutiny and public comment are part of that system and scientists who give generously of their time must have a thick skin.

A few years ago, the discovery of errors in an assessment by the Intergovernmental Panel on Climate Change (IPCC) became a subject of intense media coverage. That episode called into question all of the work of the IPCC, which aims to provide policy makers and the public with understanding of climate change (Biello 2010). The circumstances of the errors in the IPCC documents were quite different from the dioxin story I described above. Yet here again, it is clear in retrospect that a broader and more careful review by more of the participating scientists, and a stronger internal vetting process, could have avoided a great deal of confusion and bad publicity for the IPCC.

## Resources

A number of scientists have written up their experience and reflections on scientists in the policy arena. von Hippel (1991) has written on policy challenges from nuclear arms control to energy, and the role of the citizen scientist. Kammen (1996) provides reflection and advice as well as a list of resources for scientists interested in getting involved in policy. Cozzens (2001) focuses on science and technology professionals – those that work full time on these issues - and provides a useful set of references on science and technology policy. Morgan and Peha (2003) have written about science and technology advice for congress. Acton (2008) traces his path from physics to international security policy. Most recently, Scheie (2012) writes of his experience as an undergraduate summer intern in the U.S. House of Representatives Committee on Science, Space and Technology.

These and numerous other examples show that participating in science and technology policy can be a normal part of the careers of many scientists and engineers. With sufficient determination, scientists and engineers can find opportunities to serve as advisors. However, even modest committee work carries responsibility. The job is not to rubber-stamp but to bring disciplined scientific thinking to the task, especially when there is external or peer-pressure.

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# The Limited Future of Nuclear Power in India

M. V. Ramana

## Introduction

For nuclear energy to substantially contribute to reducing greenhouse gas emissions, it would have to expand significantly over the next few decades. Much of this expansion would have to occur in industrializing or developing countries that have fast growing electricity requirements and relatively low levels, or a complete absence, of nuclear generation capacity. For a variety of reasons, some of these countries are still contemplating constructing nuclear reactors despite the accidents at Fukushima (Ramana 2013).

India offers a case study for understanding the challenges facing expansion of nuclear power in developing countries. It is “ahead of the curve” when compared to most developing countries. Thanks to decades of sustained government support for the nuclear program, the Department of Atomic Energy (DAE) has developed expertise and facilities that cover the entire nuclear fuel chain, starting with uranium mining and milling to reprocessing of spent nuclear fuel, and vitrifying and storing the wastes produced. India has also developed nuclear weapons under the aegis of the same program.

Yet, the currently installed nuclear capacity is 4.78 GW (gigawatts),<sup>1</sup> a mere 2.14% of the total electricity generation capacity. There are twenty operating reactors with plans to build several more. Even if the reactors under construction come online, the nuclear share is unlikely to exceed 5% of the generation capacity over the next decade or more. Can this change in the longer term? There are several reasons why nuclear energy will not be a significant part of the answer to India’s electricity demands even in the long term (Ramana 2012).

Before examining those reasons, however, it may be useful to briefly describe the current electricity and energy scenario in the country, as well as projections for the future. India has a total installed electricity generation capacity of 224 GW. Together, these generated 876.4 TWh of electrical energy in 2011-12, with an average growth rate of 5.3% over the last decade (CEA 2012). Given the roughly 1.2 billion population living in India, at a per capita level, the electricity generated turns out to be only about 730 kWh/y; the corresponding figure for the United States in 2012 was about 13,400 kWh/y. About 70% of the electricity generated in India was from coal or lignite, and another 10% was from natural gas. The OECD’s International Energy Agency projects that if current policies continue to be followed, India would generate about 2600 TWh by 2035 (IEA 2012, 180). According to the IEA, this projected growth is driven by rising population and per-capita incomes.

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<sup>1</sup> That is the maximum level of power that can be generated when all the reactors are operating. In 2011-12, efficiency of operations as measured by the load factor was on average about 77% (CEA 2012, 11).

## Explaining Poor Performance

To start with, the small share of nuclear power in India’s electricity portfolio is not due to a lack of funding. Practically all governments, regardless of which political party is in power, have favored nuclear energy and the DAE’s budgets have always been high. The only period when the DAE did not get all it asked for was the early 1990s, a period marked by cutbacks on government spending as part of economic liberalization. But this trend was reversed with the 1998 nuclear weapons tests: since then the DAE’s budget has increased from Rs. 19.96 billion (US\$ 470 million) in 1997-98 to Rs. 98.33 billion (US\$ 1787 million) in 2013-14.<sup>2</sup> In comparison, the Ministry of New and Renewable Energy was allotted Rs. 15.33 billion (US\$ 279 million) in 2013-14. The Ministry is in charge of developing solar, wind, small hydro, and biomass based power, which together constitute around 28 GW of generating capacity as of April 2013.

The other element that is not lacking is aspiration. Like nuclear agencies elsewhere, the DAE has a long history of making ambitious projections, none of which have been fulfilled (Ramana 2012). In the early 1970s, for example, the DAE predicted that by 2000, there would be 43 GW of nuclear capacity. Actually installed capacity was 2.7 GW in 2000.

One cause of this failure was India’s 1974 nuclear weapon test and not signing the Nuclear Non Proliferation Treaty (NPT). Despite Indian diplomatic effort at trying to make the 1974 test to be a peaceful nuclear explosion, few outside the country bought into that charade. Following the 1974 test, the United States and other countries formed the Nuclear Suppliers Group (NSG) with the aim of preventing exports for commercial and peaceful purposes from being used to make nuclear weapons and India was not allowed to import nuclear reactors or materials from other countries till 2008.

In September 2008, the Nuclear Suppliers Group created a special exception for India that allowed it to import nuclear reactors and materials despite not having signed the NPT. The waiver came about in large part due to pressure from the United States, France, and Russia. For France and Russia, the main motivation was the expectation that they could sell nuclear reactors to India and revive their moribund nuclear sectors. In the case of the United States, which led the process of advocacy for the waiver, there were commercial interests, primarily related to nuclear and military technologies, as well as geopolitical motivations (Ramana 2012, 279–292). Following the NSG waiver, estimates for nuclear power in the country have gone up. The current long-term target is for

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<sup>2</sup> The conversion rate between the Rupee and the U.S. Dollar has varied over the years; during the period being discussed, the rate was approximately Rs. 42 per dollar while the current rate is roughly Rs. 55 to the dollar.

470 GW by mid-century. Because of India's rapidly growing demand for electricity, even that roughly hundred-fold increase would leave nuclear power at about 35% of the total projected electrical capacity of the country.

There are multiple reasons for why even this target is very likely to be missed. The first is simply that nuclear power is a complex and difficult technology and it is not easy to develop it very rapidly. This is particularly so in the case of post-colonial developing countries like India because there is pressure not just to generate electricity but simultaneously to indigenously develop the requisite technologies, materials, and equipment, partly for solid developmental reasons (creating jobs, stimulating technical education), partly to avoid dependence on whims of Western countries, and partly for the prestige and glamour associated with nuclear power.

If one looks at the history of nuclear power projects in India, practically each reactor took longer to build, cost more than projected, and performed worse than had been envisaged when plans were made. There were problems that had not been envisioned when the site was selected, leading to delays in construction and reduced efficiency in operations. All of this is despite the fact that most operating reactors are of the same type—pressurized heavy water reactors based on the Canadian CANDU design—and thus India has benefited both from standardization and experience elsewhere. The DAE's projections of rapid growth implicitly assume that all previous problems have been solved and no new problems will ever emerge. Such assumptions have been repeatedly shown to be untenable, not just in India but elsewhere.

In the future, however, construction and operation might fare worse because India plans to import a new reactor type: light water reactors.<sup>3</sup> Light water reactors constitute the most common reactor type deployed around the world; of the 434 reactors currently operating, 354 are of this type (IAEA 2013).<sup>4</sup> Current plans in India envision importing at least four new kinds of light water reactors: the VVER from Russia, the EPR from France, the ESBWR and the AP1000 from the United States of America. Apart from the fact that these are incredibly expensive compared to domestic Indian designs and would make nuclear electricity uncompetitive (Raju and Ramana 2013), a further problem is that Indian safety regulators have no experience with these designs. The primary reasons for the purchase, therefore, seem to have to do with international diplomacy.<sup>5</sup>

The second major reactor type that figures prominently in Indian nuclear planning is the fast breeder reactor— and

<sup>3</sup> *There are two boiling water reactors that were commissioned in 1969, but they have had numerous problems and by 2006, they had undergone over 500 modifications (Mittal, Ramamurty, and Bhattacharjee 2006).*

<sup>4</sup> *The reasons for this dominance have to do as much with history and politics as with technical features. Technically, both light water reactors and heavy water reactors have advantages and disadvantages.*

<sup>5</sup> *A former secretary of the DAE candidly explained: "America, Russia and France were the countries that we made mediators in the efforts to lift sanctions, and hence, for the nurturing of their business interests, we made deals with them for nuclear projects" (Kakodkar 2011).*

DAE projections involve constructing literally hundreds of them over the next few decades (Grover and Chandra 2006). Fast breeder reactors are thus termed because they are based on energetic (fast) neutrons and because they produce (breed) more fissile material than they consume. These are important to India because in the early years of the nuclear program, its leaders adopted a three-stage plan for nuclear power that was aimed at utilizing the country's limited reserves of relatively good quality uranium ore to pave the way for exploiting the much larger resources of thorium. The first phase was to construct and operate heavy-water reactors fueled by natural uranium and then separate plutonium out of the spent fuel. In the second stage, the accumulated plutonium stockpile is used in the nuclear cores of fast breeder reactors. These nuclear cores could be surrounded by a blanket of uranium, to produce more plutonium; if the blanket were to use thorium, it would produce uranium-233. In order to ensure that there was adequate plutonium to fuel these second-stage breeder

### *Note on Thorium*

There is a lot of discussion in the literature on the Indian nuclear program about thorium-based breeders. However, even in the DAE's plans, these become significant only after 2052 (Grover and Chandra 2006). This is primarily because of difficulties in dealing with the highly radioactive contaminant uranium-232 that is produced along with uranium-233, the fissile material produced from fertile thorium. Even if such reactors are constructed they will likely have the same features that make plutonium-based breeders uneconomical: the need for reprocessing and the requirement for extensive safety precautions in fabricating fuel with uranium-233 if it is contaminated even at very low levels with uranium-232.

reactors, a sufficiently large fleet of such breeder reactors with uranium blankets would have to be commissioned before thorium blankets were introduced. The third stage involves breeder reactors using uranium-233 in their cores and thorium in their blankets.

The essential principle behind the breeder reactor had been recognized by physicists as early as 1943 and the first concepts were developed by Leo Szilard who was responding to concerns shared by his colleagues, who were engaged in developing the first nuclear bomb, that uranium would be scarce. In the early decades of nuclear power, many countries pursued breeder programs, but practically all of them have given up on breeder reactors as unsafe and uneconomical (IPFM 2010). India's experience with breeders so far has been with one small pilot-scale fast breeder reactor, whose operating history has been checkered (Ramana 2009). Further, a significant fraction of the domestic research and development effort has been spent on breeder reactors and it

is likely that India would have much more installed nuclear capacity if they had simply focused on improving their PHWRs.<sup>6</sup>

In addition, the DAE's projections have simply not accounted properly for the future availability of plutonium, because it has not included in its calculations the lag period between the time a certain amount of plutonium is committed to a breeder reactor and when it reappears along with additional plutonium for refuelling the same reactor, thus contributing to the start-up fuel for a new breeder reactor (Ramana and Suchitra 2009). These problems with the projected growth rates are not a matter of differences in assumptions but plain impossibilities. Sociologically this elementary error appears to be a result of the absence of open, peer-review mechanisms.

Another problem with nuclear power for India, and industrializing countries in general, is that they need not just any kind of energy but electricity that is cheap and affordable. Nuclear power is in that sense badly suited to many of these because it is expensive. This has been amply borne out in the Indian case, where coal based thermal power has been much cheaper than nuclear electricity. Future reactors, both imported light water reactors as well as fast breeder reactors, promise to be much more expensive, which will make electricity generated in these unaffordable to the weaker sections of society. Expectations that the nuclear industry will learn from past experience and lower the construction costs have also been belied repeatedly. Nuclear reactor costs have risen steadily in many countries, and this has been best documented in cases of the United States and France (Kooimey and Hultman 2007; Grubler 2010). In 1958, during the early years of nuclear power in the country, the British economist I.M.D. Little observed: "electricity is in short supply in India. It is likely to go on being in short supply if one uses twice as much capital as is needed to get more". That prognosis has proven to be prescient.

Finally, there has been significant opposition to every new nuclear reactor that has been planned since the 1980s, most dramatically illustrated by the intense protests over the Koodankulam reactors (Kaur 2012). In addition to concerns about safety or radioactive waste, opposition to nuclear facilities also stems from their impact on lives and livelihoods. Nuclear reactors, for example, require cooling water and land and these compete with the needs of farmers, while discharges of hot water and radioactive effluents into the sea affect fish workers. This source of opposition will likely intensify over the decades as land and other natural resources become subject to tremendous competition.

<sup>6</sup> Even the weak justification offered by limited uranium reserves in the country ceases to be valid after the 2008 waiver by the Nuclear Suppliers Group because now India is in a position to import uranium from the international market, and it has been doing so at a steadily increasing rate.

## Conclusion

With a population that is projected to eclipse China's by mid-century, and a rapidly increasing demand for electricity, India has difficult choices to make regarding its energy future. But, despite much media hype and continued government patronage, nuclear power is unlikely to contribute significantly to electricity generation in India for several decades. This history and prognosis offers important lessons in thinking about the future of nuclear power globally, especially in countries that are preparing to embark on constructing nuclear reactors.

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# REVIEWS

## **An Indispensable Truth: How Fusion Power Can Save the Planet**

*Francis F. Chen, Springer, 2011, 433 pages, ISBN 978-1-4419-7819-6, \$50 hardcover*

This book was written to convince us that large controlled fusion based electrical power plants are not only possible but are indispensable. Part I reviews the evidence for global warming, the use and lifetime of fossil fuels as our primary source of power, what Chen calls “backbone power,” a variety of renewable power sources, and nuclear fission reactors. It continues with technical descriptions of some of the newer devices, such as very tall windmills and quantum dot solar cells. Chen concludes that none of these power sources are feasible as a long term source of backbone power and that we must develop and use controlled fusion.

Part II is about fusion power starting with the fundamental physics of nuclear fusion and going on to describe how a hot, dense deuterium-tritium plasma might be coerced or coaxed into becoming a contained, stable source of fusion energy. Chen concludes with a discussion of what a practical controlled fusion based power plant might look like. Throughout, the author strives to present all this material in a non-mathematical format and at a level that a well-educated non-scientist can understand. To this end the book contains many drawings and figures to explain the complex interactions between plasmas and magnetic fields that exist inside fusion devices like stellarators and tokamaks. I suspect that those readers who have no familiarity with the basic physics of electric and magnetic fields will struggle a bit with this material but in principle it should be accessible to them.

Although the real strength of this book is in the second part, and the author suggests that some readers might wish to skip the 170 pages that comprise Part I, this section contains a wealth of information about climate change and energy sources that will be of interest to many readers. I would only caution that in his zeal to convince us of the need to pursue research on fusion power, Chen sometimes includes sweeping generalizations and negative conclusions about the long term use of any power source except fusion along with some off the cuff remarks that are sometimes inaccurate and distracting. With regard to renewable energy sources Chen focuses too much on the negative aspects of each source and tends to conclude that since they all have limitations none of them is useful as a reliable source of backbone power. He chooses to ignore the possibility of combining these sources into a comprehensive power producing and utilization scheme which would include sources of more reliable power such as natural gas or nuclear fission along with increased energy conservation. However, in some cases Chen’s own careful and objective descriptions of power sources such as solar

cells provide good arguments to contradict his own negative conclusions.

Part II, Chapters 4 -11, deals primarily with the physics of magnetically contained, hot, dense plasmas, and here the book offers an excellent opportunity for the non-expert to understand what has been achieved so far and what is still left to be done if controlled nuclear fusion is to become an important source of energy in the future. Chapters 4 and 5 cover the basic nuclear and plasma physics of controlled fusion. The nuclear physics of fission and fusion processes is described, including what is needed to induce fission and fusion reactions and the amount of energy released from these reactions. Chen describes what a plasma is and how magnetic fields can be used to confine the energetic components of a plasma. The basic concept of a toroidal magnetic bottle is introduced along with an explanation as to why a simple toroidal coil will not produce a magnetic field configuration that can stably contain a plasma. The stellarator configuration is introduced along with a discussion of the temperature, confinement time and density parameters for a plasma that must be achieved to realize controlled fusion. The last part of this chapter introduces the problem of plasma instabilities.

Chapters 6 and 7 focus on the most advanced magnetic confinement configuration, the Tokamak, and describes in great detail with many excellent figures the behavior of a plasma in a Tokamak along with ways to heat a plasma to temperatures sufficient to produce a self sustaining fusion reaction, i.e. ignition. These chapters describe much of what is understood and not understood about plasmas confined in a Tokamak that approaches the conditions required for ignition, particularly the unexpected stabilities and instabilities, not all which are currently understood theoretically.

Chapter 8 reviews the impressive progress that has been achieved towards producing a confined plasma with the parameters required for a sustained, useful, controlled fusion reaction. Yet Chen also points out that there are several important characteristics of plasma behavior such as disruptions that may pose serious problems. The chapter concludes with a description of the International Thermonuclear Experimental Reactor (ITER) tokamak project which was (as of the writing of this book) scheduled to start operation with a deuterium-tritium plasma in 2020. Chen makes it clear that this is definitely an experimental project with no guarantee that it will demonstrate that a fusion reactor can really be built but he believes that the amount of progress made to date bodes well for the future. Assuming that ITER achieves ignition, Chapter 9 describes the considerable engineering challenges that lie ahead in building an economically useful fusion reactor. Chapter 10 entitled “Fusion Concepts for the Future” briefly describes other possible ways to make a fusion reactor including inertial confinement.

Although Chen is an unabashed advocate for an all out effort to try to develop a fusion reactor, he presents what appears to this non-expert to be a valuable, mostly balanced, and mostly objective assessment of this issue. He states, “There are problems in the technology of fusion so serious that we do not know if they can be solved. But the payoff is so great that we have to try.”

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## The Pseudoscience Wars: Immanuel Velikovsky and the Birth of the Modern Fringe

Michael D. Gordin, (University of Chicago Press, Chicago, 2012), x + 291 pp., \$29, ISBN 978-0-226-30442-7.

Immanuel Velikovsky was not the first to seek astronomical explanations for cataclysms on Earth when he published *Worlds in Collision* in 1950. Isaac Newton’s successor as Lucasian Professor of Mathematics at Cambridge University, William Whiston, posited a comet as the cause of the flood that sent Noah to his ark. But Princeton history professor Michael Gordin sees the publication of *Worlds in Collision* as the onset of Cold War pseudoscience, which is the topic of this book. Moreover, Velikovsky’s own massive documentation of his work—65 linear feet of material now cataloged by Princeton University and available to researchers—enabled Gordin to be especially thorough in treating his subject (65 of the book’s pages are endnotes).

For those wondering how someone with a background in psychoanalysis like Velikovsky could come to develop a set of astronomical explanations for cataclysms in Earth’s recorded history, and a revision of that history that would move the dates of some events 600 years forward from their presently-established dates, Gordin informs us that *Worlds in Collision* began as a rebuttal to Freud’s *Moses and Monotheism*. Yet the only historians who challenged Velikovsky’s reconstruction of history were historians of science, and they did so on scientific grounds, as did the community of scientists, whose protests were directed more to publisher Macmillan, lest Macmillan’s publication of *Worlds in Collision* be interpreted as making the book to appear to be a legitimate work of science.

Velikovsky is best known to the scientific community for his skirmishes with it and his desire to be accepted by it. Gordin argues that Velikovsky also sought vindication for his historical reconstruction as well, by suggesting that Velikovsky was “motivated by a quest to rewrite the history of the ancient Near East so as to reconcile discordances that had some bearing on the history of the Jews” (p. 73), and by writing that “Velikovsky thought his major contribution was in *history*, not astrophysics” (p. 126). But in the end Velikovsky was never accepted by the scientific or historical communities. In the quest for scientific acceptance, Harry

Hess, Albert Einstein, Lloyd Motz, Valentine Bargmann, and William Plummer granted Velikovsky the courtesy of a hearing but not the satisfaction of recognizing his ideas as valid. And radiocarbon dating made Velikovsky’s reconstruction of ancient history untenable.

Velikovsky nevertheless *did* sell a lot of books, and many readers became enthusiastic supporters, many of them college students. Groups devoted to Velikovsky’s ideas were formed, and similarly-devoted periodicals were published, and the last of Gordin’s six chapters describes these in detail. That some joined the movement in support of Velikovsky for the purpose of furthering their own ideas while others sought to push beyond what Velikovsky had done put Velikovsky in a position of wanting to be both in control of the movement and disassociated from it. Only the British *Chronology and Catastrophism Review* continues to publish today.

Gordin spends a great deal of his Introduction describing the difficulties of demarcating pseudoscience from science, especially because “Pseudosciences are the products of actions and categorizations made by scientists” (p. 15). Though he finds himself in disagreement with the demarcation criteria of Karl Popper, Irving Langmuir, and Philip Kitcher, he does agree with Martin Gardner that “pseudoscience is a fuzzy word that refers to a vague portion of a continuum on which there are no sharp boundaries” (p. 12). In his Conclusion, subtitled “Pseudoscience in Our Time,” he notes two points along that continuum in addition to the “pseudoscience” exemplified by Velikovsky. The first is studies of science by humanists and social scientists in the “science wars” of the 1990s. The second is denials of mainstream science, such as those described by Naomi Oreskes and Erik Conway in *Merchants of Doubt* in the cases of tobacco smoke (both primary and secondhand), acid rain, ozone depletion, and climate change. Because of their questioning of the premises of mainstream science, humanistic “science studies” are regarded by the scientific community as a greater threat than Velikovskian pseudoscience. “Denialists” are established scientists who, though they may have been co-opted by industry, see themselves as legitimate, and even more legitimate than the scientists they are denying. Denialists see themselves as less threatening to mainstream science as compared with Velikovskian pseudoscience or humanistic studies. One issue which Gordin does not place along this continuum is creationism and “Intelligent Design.” Although the deniers described by Oreskes and Conway are vociferously opposed to creationism, Gordin’s only reference to creationism is to Velikovsky’s interaction with it in his penultimate chapter. Because I feel that denial of climate change and “Intelligent Design” are the two most serious present threats to mainstream science, I would have appreciated a comprehensive consideration of these issues in any discussion of “Pseudoscience in Our Time.”

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## Confronting the Bomb: Pakistani and Indian Scientists Speak Out,

*Edited by Pervez Hoodbhoy, Oxford U. Press, (Karachi, Pakistan), 2013, \$40.00, 392 pages, ISBN 978-0-19-906833-3*

Though the principal thrust of this important book is the combustible situation between India and Pakistan, the themes addressed can be extrapolated to the general problems of conflict between any potential nuclear adversaries. The chief contributor is the Pakistani physicist Pervez Hoodbhoy who received his PhD in nuclear physics from MIT. Hoodbhoy authored the Introduction and seven chapters, and co-authored two others. John Polanyi, winner of the 1986 Nobel Prize in Chemistry, gives historical and philosophical perspectives. Polanyi writes: "Nuclear weapons are a plague on the earth, differing from earlier plagues in that they are visited on us not by God but by man."

Among the familiar names associated with the genesis of nuclear bombs, Polanyi gives ironic "credit" to Hitler's deputy, Rudolph Hess, who after deserting Germany and parachuting into England in 1941 may have reported the threatening meaning of the discovery of uranium fission by German scientists. The subsequent observations of Leo Szilard, Enrico Fermi, Edward Teller, and the famous Albert Einstein letter to President Roosevelt, were decisive in leading to American nuclear weapons.

Hoodbhoy and Zia Mian give in Chapter 15 an analysis titled "America, Global Domination, Global Disarmament." Mian, a physicist, directs the Project on Peace and Security in South Asia at Princeton University's Program on Science and Global Security. They estimate there are in excess of 25,000 nuclear weapons in the world today of which 20,000 are held by the U.S. and Russia with the other seven countries (Great Britain, France, China, India, Pakistan, Israel, North Korea) each having up to several hundred but striving for more. There has been almost universal agreement since the atomic bombing of Hiroshima and Nagasaki that the world was in danger from weapons. Over 400,000 people have signed on to the International Global Zero Declaration for a verifiable agreement to completely eliminate nuclear weapons from the planet. Apparently the former president of the Soviet Union, Mikail Gorbachev, and the late president of the United States, Ronald Reagan, actually made efforts toward this objective during their meeting in October, 1986 but only limited success has been achieved. Other nations have tried to obtain these weapons despite the Nuclear Nonproliferation Treaty (NPT) signed by most nations. Non-signers include India and Pakistan. Agreeing to the NPT did not assure that Iran would abide by its terms.

However, there also has been reluctance to use these weapons. The U.S. did not use them in Vietnam and accepted 58,000 American deaths and several hundred thousand combat casualties in a futile and lost war. The Soviet Union lost its own war in Afghanistan and also opted not

to use nuclear weapons. That country's disintegration into independent entities was not prevented despite its nuclear stockpile. Potential uses were the reported U.S. readiness to use nuclear weapons in the event of a Soviet invasion of Western Europe during the Cold War, and the 1962 Cuban missile crisis, generally acknowledged to be the closest the U.S. came to nuclear war with the Soviets.

During the 1973 Yom Kippur war when Israel was attacked and came close to defeat by Egypt and Syria, Defense Minister Moshe Dayan reportedly received permission from Prime Minister Golda Meir to use its never-acknowledged atomic arsenal. The Arab thrust was finally thwarted by conventional military means. India began developing nuclear weapons in 1971 with its first explosion in 1974, saying it was for "peaceful" purposes. Pakistan's first bomb followed later in 1990 with the cooperation of China which had tested its bomb in 1964. In 1998, India conducted five nuclear weapons tests, followed 17 days later by Pakistan detonating five of its own.

There have been three consequential wars between India and Pakistan centered on the disputed Kashmir area populated by a Muslim majority but awarded by the United Nations to India. Among the more serious other incidents are the attack by Islamic jihadists on the Indian parliament in 2001 and the Mumbai massacre in 2008 which killed 164. A nuclear war between India and Pakistan is not inevitable but is becoming more likely. In their conventional wars, India has prevailed more or less decisively because it has a larger and better educated population and a stronger industrial and technical base.

In an all-out engagement where overwhelming defeat was envisaged, Pakistan might use its nuclear arsenal. India would retaliate in kind. In anticipation of Pakistan's use of its nuclear weapons, India may preemptively attack Pakistan's launch sites prior to a conventional military invasion. An estimate of immediate nuclear casualties in an all-out war is 2.9 million deaths with 1.45 million severely injured. This does not include the unknown effects of radiation sickness and genetic damage to subsequent generations.

Many issues discussed are of direct U. S. concern. Iran's obvious effort, despite their denial, to develop a bomb is reviewed. Hoodbhoy writes, at the conclusion of the chapter titled "Iran, Saudi Arabia, Pakistan and the 'Islamic bomb'": "However unwelcome Iran's bomb (and the "Sunni bomb" that could someday come from Saudi Arabia), it is far better to live with potential dangers than to knowingly create a holocaust through military action. Tel Aviv and Washington must never even contemplate an attack; to do so would set the world on fire." However, it appears from President Obama's and Israeli Prime Minister Benjamin Netanyahu's statements that military action may be imminent.

The book states "Albert Einstein, whose mass-energy

*continued on page 21*

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# Short Course on Nuclear Weapon Issues in the 21st Century

*Sponsored by the American Physical Society's Forum on Physics & Society*

November 2–3, 2013 (Saturday/Sunday)

Room 213, 1957 E Street, NW

The George Washington University, Elliott School of International Affairs, Washington, DC

A popular technical workshop is making a repeat performance. The first two conferences on physics and nuclear weapon issues were published in American Institute of Physics Conference Proceedings #104 and #178. International experts will give the technical background to understand the issues. We recommend signing up early, as it probably will sell out. The cost is \$100 for 24 talks, a 400-page book, 2 lunches, plus \$30 for the banquet (first 70). The event is organized by Pierce Corden (AAAS), David Hafemeister (CalPoly) and Peter Zimmerman (Kings College, emeritus). Information/registration at [www.aps.org/units/fps/meetings/nucwpiissues/](http://www.aps.org/units/fps/meetings/nucwpiissues/) or by check, APS Meetings Dept., American Physical Society, 1 Physics Ellipse, College Park, MD, 20740-3844. Contact [dhafemei@calpoly.edu](mailto:dhafemei@calpoly.edu) (805-544-5096) for more details.

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## Saturday, November 2, 8:30 am

### Keynote Address: Nuclear Arms Control Issues

*Rose Gottemoeller, Under Secretary of State*

### I. Nuclear Weapons and Arms Control

Monitoring the START Treaties

*Linton Brooks, START I Chief Negotiator*

Monitoring Nuclear Weapons

*Dick Garwin, IBM Fellow*

Modernizing the U.S. Nuclear Arsenal

*Hans Kristensen, Federation of American Scientists*

Future Nuclear Weapons Policies

*James Acton, Carnegie Endowment for Int'l Peace*

### II. Comprehensive Nuclear–Test Ban Treaty

Seismic Monitoring: 2012 NAS Report and Recent Explosions, Earthquakes, Meteorites

*Paul Richards, Columbia*

Radioxenon Monitoring and the NAS Report

*Ted Bowyer, PNNL*

CTBT On-site Inspections

*Jay Zucca, LLNL*

Stockpile Stewardship and the NAS Report

*Marvin Adams, Texas A&M*

### III. Ballistic Missile Defense

NAS Study on Ballistic Missile Defense

*Dean Wilkening, LLNL*

Science, Technology and Politics of BMD

*Philip Coyle, CACNP*

### Saturday Evening Banquet: Intersection of CTBT with NPT and FMCT

*Tom Graham, former ACDA General Counsel*

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## Sunday November 3, 8:30 am

### IV. Nuclear Proliferation: Evolution of the Non-Proliferation Regime

*Arian Pregenzer, Sandia*

North Korean Nuclear Program, Negotiations and the Role of Science

*Robert Gallucci, MacArthur Foundation*

Iran's Nuclear Program and Negotiations

*David Albright, ISIS*

India and Pakistan's Nuclear Programs

*Zia Mian, Princeton*

Monitoring Centrifuges and Blend-Down

*Larry Satkowiak, ORNL*

Laser and Centrifuge Enrichment

*Francis Slakey, APS/Georgetown University*

Monitoring the FMCT

*Frank Von Hippel, Princeton*

Nuclear Forensics

*Jay Davis, Hertz Foundation*

### V. Mass Casualty Terrorism

Science and Technology for Homeland Security

*Daniel Gerstein, Deputy Under Secretary Homeland Security*

Risks and Responses to Mass Terrorism

*Peter Zimmerman, Kings College, emeritus*

Terrorism and Nuclear Detection

*Warren Stern, BNL*

Scanning of Vehicles for Nuclear Materials

*Jonathan Katz, Washington University*

### Conference Review and the Future

*Pierce Corden, AAAS*

equivalence formula lies at the very foundation of the bomb, became convinced that danger lurked around the corner.” Einstein wrote in 1948: “Let us hope that the abolition of the existing international anarchy will not need to be bought by a self-inflicted world catastrophe the dimensions of which none of us can possibly imagine. The time is terribly short. We must act now if we are to act at all.” *Confronting the Bomb* makes it clear that the time has become even shorter.

Hoodbyoz expresses the opinion that “It is unlikely that this will be a popular book.” This reviewer hopes Hoodbyoz turns out to be wrong. This scholarly study warrants the widest readership.

*Leonard R. Solon, Ph.D.*  
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