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EDITOR'S COMMENTS

It's been almost a full year since Wolfgang Panofsky and Edwin Salpeter kicked off our series, in the October 2005 issue of P&S, on science advice & policy formulation in the White House. With this issue we bring you three more articles in the series, all written by men who either have been, or are now, the science advisor to the President of the United States: Jack Gibbons served as science advisor to President Clinton starting in 1993. Neal Lane succeeded Gibbons in the Clinton Administration. John Marburger is currently serving President Bush as Director of the Office of Science and Technology Policy. In their articles in this issue of P&S, Gibbons and Lane both shed light on policy making surrounding many specific issues, and they give us a taste of the "family dynamics" among the advisors and other public servants within the White House. We hope that these articles, as well as those of Panofsky and Salpeter from last year, are viewed as an important contribution to the discussion of science advice to the President.

ARTICLES

Reflections of a Science Advisor: General Considerations, the Superconducting Supercollider (SSC), and the Space Station

John H. Gibbons

In the October 2005 issue of this periodical, Professor Wolfgang Panofsky provided an excellent introduction to a planned series of articles for Physics and Society designed to illuminate the intricate and sometimes obscure relations between science and technology and national policy. The interplay might be described as "war" (or forced marriage) between the two interdependent but disparate worlds of facts (science) and faith (politics). In this article, I offer some general reflections regarding this liaison, including a bit of history. Then, I focus attention on two issues that needed attention right after I joined the Clinton Administration in January 1993: the Superconducting Supercollider (SSC) and the Space Station.

Reflections

Science and technology (S&T) have been part and parcel of the passions of Americans since Benjamin Franklin so brilliantly and uniquely led our birth as both a democracy and an exploratory society. Right from the outset, enlightened public leadership fostered public investment in education, exploration, technology development, and intellectual property protection. The freedom of inquiry provided under the Constitution energized people to unheralded inventiveness.

As a result of many decades of sustained support, forward surges in the 20th century of discovery (knowledge) and invention (technology) dwarfed other factors

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affecting health, conflict resolution, and prosperity. Public support enabled S&T to blossom during World War II and to be the dominant factor in enabling advances in human aspirations. It continues unabated today, but the very success of S&T has led inexorably to the need for new forms of governance and new requirements for science literacy in our people. This need for enhanced science literacy was foreseen in a letter that James Madison wrote to W.T. Barry in 1822. Madison wrote: "A popular government, without popular information, or the means of acquiring it, is but a prologue to a farce or tragedy; or, perhaps both. Knowledge will forever govern ignorance, and a people who mean to be their own governors, must arm themselves with the power which knowledge gives."

Sadly, however, science knowledge seems to be advancing faster than our science literacy, and this situation puts our democratic society at risk: To the extent that our literacy lags behind our science, we become vulnerable to the making of poor decisions. This is particularly the case for those charged with public policy decisions.

In response to the widening gap between the availability of information resources and the ability of citizens and elected officials to effectively utilize them, several actions have been taken during our history to help our citizen governors. Congress chartered the National Academy of Sciences in 1863, during the Lincoln Administration, to give better public access to rapidly accumulating scientific knowledge. It remains a vital private and non-profit asset, providing expert and non-partisan advice on technical issues of government. By the end of World War II it became clear that help which could be directly useful in framing and guiding public policies was needed. It began with William Golden's recommendation to President Truman that a science advisor to the president be appointed. This evolved to a mostly unbroken mechanism (Congress established the Office of Science and Technology Policy [OSTP] within the Executive Office of the President) to assist the Executive Branch, followed later by the establishment of the bi-partisan, bicameral Congressional Office of Technology Assessment (OTA) in the Legislative Branch.

I had the unique opportunity to direct both OTA (1979-1993) and OSTP (1993-1998); some think that this extensive experience should make me "educated" in S&T policy. My response is that (1) "education consists of the progressive discovery of one's ignorance" (Will Durant), and (2) in public policy "...science has the first word on everything and the last word on nothing" (Victor Hugo). The political importance of science derives not simply from science itself but from the implications of that knowledge for national needs (e.g., security, economy, health, environment, and knowledge itself) and social norms (e.g., stem cell discoveries). Most public policy decisions are as complex and convoluted as are the horde of stakeholders. Science, per se, is seldom the dominant factor in making a "science policy" decision. This claim is not meant to diminish the importance of scientific judgment, but rather to highlight the importance of other factors in political decision-making. The President chose to appoint me as "Assistant to the President for Science and Technology" (in addition to my OSTP title) as did President Bush in 1989 for my predecessor Allan Bromley. The visibility bestowed upon me by that title was a clear signal of the commitment of the Clinton-Gore Administration to strong support of science and technology, and to the influence of S&T considerations in the formulation of national policy.

A lesson to be drawn from these reflections is the importance of the science advisory apparatus being effectively engaged in the policy decision-making process. The science advisor's job is primarily that of bringing the content, implications, and political relevance of scientific aspects of public issues to the President in a timely, helpful, and authoritative way. A necessary but not sufficient requirement for the science advisor is to be familiar not only with the subject but also with key individuals and processes in the Administration that must be party to decisions. A close understanding of the priorities and perspectives of the President (and Vice President) was always required of me so that I could comfortably be a surrogate for them in my areas of responsibility without overtaxing my call on their time and attention. Effective communication and cooperation with Executive offices (White House, Cabinet, and sub-Cabinet agencies) is mandatory for the science advisor.

Personalities are very important!

President Clinton, from the outset of his administration, had a close and comfortable relationship with Vice President Gore, and he recognized Gore's broad, in-depth interest and understanding of science and technology. Thus, he naturally depended heavily on Gore in such matters. The bright side of that comment for me is that both championed my work, and I, in turn, enthusiastically supported their priority of using S&T to achieve over-arching goals: strengthening the economy and creating jobs, improving education and health care, enhancing the quality of the environment, harnessing information technology, and maintaining national security. They also fully supported the establishment of councils, panels, and advisors to provide themselves with wisdom on science, similar to the advisory panels successfully utilized at OTA.

Advising on Inherited "Big Science" Programs: The SSC and the Space Station

For "Big Science" projects, one presidential term – or even two – is short. When I came to the White House in January 1993 two large science policy issues were on my plate for immediate attention - the Superconducting Supercollider (SSC) and the Space Station. The inauguration of a new Administration is very near the deadline for the annual federal budget to be submitted to the Congress. Both the SSC and Space Station projects were carrying a lot of political commitments and both were in serious trouble. Within only days of my Senate confirmation, I had to help devise a sensible strategy to brief and advise the President and Vice President on the status, options, and recommended actions for these projects.

(1) The SSC: In the preceding years this accelerator was a very popular project for politicians because it was viewed as a large construction project and also a way to create a massive high-tech complex aimed at extending the frontiers of science.. Almost all states weighed in to be the site of the accelerator, but Texas had just won the contest. The previously widespread political interest quickly reduced to Texas. In addition, in the previous two administrations, the notion of the United States "going it alone" was seen as a point of national pride; therefore not much effort had been spent on recruiting substantial international financial partners. Questions

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now were being raised about construction management and the cost/performance of the superconducting focusing magnets. On top of these issues the new mood in the White House and Congress for more fiscal constraint made the SSC a choice target, especially since few people saw a persuasive connection between this “big science” project and broad public benefits.

The “ball” landed in my court, simultaneously with responsibility to figure out what to do about the Space Station (...more on that below). I was urged by several people, including the previous science advisor, Allan Bromley, to go quickly overseas and seek financial aid for the SSC. In my judgment such a move could have been too little, too late, in the face of a resolute attitude in Congress and genuine concern of the President to reduce expenditures in the face of an inherited \$300 billion-plus deficit that, in those days, was a lot of money! At the same time it became clear that the scientific rationale for SSC was solid and that the magnet problem could be resolved. We decided to mount a modest campaign for the SSC budget but not to fall on our budget sword over it. I testified with passion [See my book *This Gifted Age: Science and Technology at the Millennium*, New York: Springer-Verlag, 1997, pp. 191-195] on the promise of scientific discovery and on the inevitable (but unpredictable) practical benefits that could accrue from the SSC. The effort failed in Congress, primarily because of lack of conviction about the SSC’s importance to the nation and the sharply rising resistance to federal deficits. In retrospect, one positive tradeoff of the retreat from the SSC was increased political support for sustained U.S. participation in international high-energy physics studies centered at CERN.

Lessons learned:

(a) Big Science requires Big Participation!

(b) The fiscal condition of our country bears heavily on “discretionary expenditures,” and

(c) The popularity of political support for science reflects the perceived value to our security, economy, health, and environment.

(2) The Space Station: Long-viewed as the next step in human exploration

beyond the Moon, the Reagan and Bush I Administrations had pushed the U.S. Station as a challenge to the U.S.S.R.’s Cold War Space Station, i.e., as our counter to the notion of U.S.S.R. space dominance. Remember the aerospace industry-sponsored TV ads in the 1980’s depicting a massive, menacing Russian space station hovering over the Free World? By January 1993, roughly \$20 billion had been spent on our design of the Station named “Freedom.” No hardware had been built. The pre-1993 design orbit for our Station had been chosen to exclude access to and from former Soviet Union territory. International participation in the venture was meager. Popularity was on the wane because the Station was seen more and more as a Cold War relic short of great scientific promise. On the other hand, the U.S. already had made a massive psychological and fiscal investment, along with political commitments.

What to do? This challenge to the new Clinton Administration had forced its way to the top of the pile of urgent matters for budgeting resources. We were committed to a strong and enduring space program but also to fiscal restraint. In the form we inherited the program it could not pass the test of scientific rationality. Accordingly, with the encouragement of members of Congress from both sides of the aisle we decided to re-orient the plans for the Station in a massive way: down-size the project, make it a truly international venture, and bring in Russia as a full partner.

Under the new cabinet-level National Science and Technology Council (NSTC), a Station redesign committee was appointed by the President to reduce the size and cost (and improve safety) of the Station. Headed by Chuck Vest, then President of MIT and a member of the President’s Committee of Advisors on Science and Technology (PCAST), the redesign committee comprised key experts from government, industry, and academia. Following their recommendations we worked out a new orbit to allow the Station to be serviced and controlled from launch sites in Russia as well as in the U.S. A decade later in 2003 it became clear that this change enabled the Station to survive the loss of the Shuttle Columbia. Much political and diplomatic as well as technical maneuvering and accommodation went on as the new consortium worked out a *modus-vivendi*. And at least as much energy was consumed in negotiations between the Clinton Administration and Congress. One

key early funding measure was won by a single vote!

As the newly formed project evolved we worked out a cooperative arrangement with Russia to use their existing space station to gain joint operating experience and refine practical aspects such as equipment repair, fire control, emergency management, and environmental controls. Experience gained from the Russian station proved highly valuable; it also unexpectedly engendered a close sense of community and deep trust between the U.S. and Russian participants—on the ground as well as in orbit.

Why was so much of the oversight for this work laid upon OSTP? There was not a lot of science, per se, involved, but a lot of technology. Close communication was required among federal agencies, including NASA, State, Defense, Commerce—a natural role for OSTP to represent the President’s interest.

In summary, we won the struggle to continue support of the Space Station—the largest and most complex peacetime international venture in high technology—and built new bonds with prior antagonists. Just as we had inherited the torch from earlier administrations, we passed the torch to the next Administration.

It could be argued that we’d have been better served if the U.S. Space Station effort had been dropped as an anachronistic Cold War investment. It is instructive to think back to Jim Fletcher’s time when, as NASA Administrator under President Nixon, he virtually abandoned, with very little analysis, development of all new expendable launch systems in favor of the Shuttle (which has been a financial disaster). That decision discloses the historic inordinate emphasis on manned space exploration rather than on robotic and tele-operated space systems. I strongly pushed this latter orientation with very limited success, despite the support formalized for it in 1996 by the President and also by NASA Administrator Dan Goldin.

As later events showed, we would have lost more than gained had we cancelled the Space Station entirely. In retrospect the Space Station decision was beneficial and multifaceted in its effects: it incorporated goals of space engineering of complex systems, advances in international

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cooperation, a mechanism to transform a Cold War relic into an on-going contribution to U.S.-Russia relations, economic continuity in a vital U.S. sector, and technological progress.

I chose these two examples of the SSC and Space Station to illustrate but one facet of the role of Science Advisor. In a succeeding article I will further illustrate the activities with the hope that the reader will gain appreciation of the challenges and psychological rewards of being a science advisor.

Dr. John H. "Jack" Gibbons, President, Resource Strategies, and Chairman of the Board, Population Action International, is a member of advisory and working committees of The National Academies, the U.S. Department of Energy, and the Massachusetts Institute of Technology, among others. Following White House tenure (1993-1998) he served as the Karl T. Compton Lecturer, MIT; Senior Advisor, U.S. Department of State, and Senior Fellow, National Academy of Engineering. Before he served in the Clinton Administration as Assistant to the President for Science and Technology and Director of the Office of Science and Technology Policy (OSTP), Dr. Gibbons was Director of the U.S. Congressional Office of Technology Assessment (OTA)(1979-1993). During the early 1970's "energy crisis" he initiated and directed the first work on energy conservation and policy for the federal government.

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Personal observations on science advice to the President

Neal Lane

In his article which introduces this series, Wolfgang Panofsky has done an excellent job of reviewing the manner in which science advice has been provided to the President over the years and has outlined some issues or "tensions" that need to be kept in mind as one examines the present system and how to improve it. His list includes: possible conflicts of interest (e.g. discipline bias) on the part of scientific advisors; the question of who "owns" the President's Advisor (the President or Congress); accountability on the part of the Advisor to the President and Congress; access of the Advisor to the President; Science Advisor vs. spokesman for science policy; conflict of scientific advice with preconceived policy. Dr. Panofsky has suggested that the subsequent articles in this series provide detailed examples, with particular emphasis placed on what he calls "science in government", e.g. the application by government of scientific knowledge in developing public policy. There have been a number of well publicized examples in the current G.W. Bush Administration where policy has not followed sound scientific advice. Panofsky argues that what he calls "government in science", e.g. the Federal government's funding and regulation of science, is less controversial, at least less politically charged. An exception, of course, is the current G.W. Bush Administration's policy severely restricting NIH-supported research on embryonic stem cells and banning NIH support for somatic cell nuclear transfer (human cloning).

In this paper, I will limit my comments to the matter of how a Science Advisor gets his or her scientific advice to the President – personal access, in particular – and use a few examples from my own experience in the White House as well as discussions with prior Science Advisors. Since access is often connected with the other "tensions" Panofsky lists, I will comment on those as appropriate.

Fragile Visibility of the Science Advisor in the White House

First a few general observations about working in the White House, some of which, I suspect, have been invariant over time.

The White House is a very busy place. The number of issues being dealt with on any given day is enormous, and the pace is pretty much as depicted in the popular TV show "West Wing." But, the priorities of the President's senior staff, including the Science Advisor, and everyone else in the White House are clear – they are set by the President's agenda. They often include such policy-related areas as national and domestic security, the Nation's economy and employment, natural disasters and other crises, Congressional activity (or inactivity), front-page news, campaign promises and other items high on the President's policy agenda. Whatever the President is doing on any given day is, itself, news. But the White House wants that news to be good news and carefully plans Presidential events, travel and meetings, "message" of the week or month, press communications, interactions with the Congress, and so forth, to maximize the good news for the President and his Administration. An effective White House staff works as a team to provide the President with the advice he needs to make decisions on a range of topics, often with some urgency. The Science Advisor, if he or she expects to be effective, needs to be at the table, as a valuable, reliable and trusted member of the team.

During WWII and early cold-war years, when the immediate value of science and technology required no amplification or explanation, one can understand why the Science Advisor would have more immediate and frequent access to the President. But in recent decades, the

single-focus threat of the Soviet Union faded and, simultaneously, science and technology emerged as fundamental to many areas of societal importance and national need, e.g., energy, health and medicine, environmental protection, economic competitiveness (including Federal R&D funding and regulation as well as tax laws and trade relations). Under such circumstances, more decisions were being made at the agency level, and often the President was only peripherally involved. Certainly, there have been exceptions, e.g. some of former President G.H.W. Bush's initiatives (global change research, information technology, biotechnology) and those of former President Clinton (climate change science and technology, Kyoto negotiations, and the National Nanotechnology Initiative, among others). These involved the Science Advisor, but they also required more consensus building among the President's advisors on economic, domestic, environmental and national security policy, all of whom are perceived as having portfolios that are more "politically" important than that of the Science Advisor.

Access to the President

Let me turn now to the importance of the Science Advisor having personal access to the President. Given the fact that White House science policy is no longer focused on a single issue – nuclear weapons and strategy – but rather relates to a host of other policy issues, hence to the work of most of the President's other advisors, one challenge is simply not to get lost or ignored in the huge array of topics

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of everyday business and the cacophony that surrounds the President. The Science Advisor can be effective only if he or she can be sure that his or her advice – untouched by others – actually gets to the President. The title “Assistant to the President” is very helpful in that regard, since it sends the message that the Science Advisor reports directly to the President.

In addition to the formal title, the White House staff and agency officials also need to know that the President considers science and technology to be important and that the President wants to see his Science Advisor from time to time. But, of course, having access does not mean dropping by. The President’s calendar is a competitive arena with lots of participants; and the President’s scheduler has to determine the relative priorities of competing requests for appointments, speeches, interviews, trips and other demands on the President’s time. The Office of Science and Technology Policy (OSTP) staff are good at identifying possible science and technology events, budget initiatives, policy innovations, and other opportunities for the Science Advisor to get the President’s attention on some important matter of science policy. If this sounds a little like marketing, that perception would not be far off the mark.

In addition to having personal access to the President, it is also important for other senior advisors around the President (the other “Assistants”) to understand something about the Science Advisor’s issues, why they should be important to the President, and the rationale for science-based recommendations.

That requires that the Science Advisor establish a good working relationship with the other Assistants. One way to do that is to offer the services of OSTP to help them with their issues. The President’s advisors serve him best if they work as a team and reach consensus on important

issues. As mentioned above, when the advisors disagree, they need to be able to provide the President with reasoned arguments for their different opinions and recommendations. A balance between collegiality and assertiveness is required.

In my own case, as Assistant to the President for Science and Technology, I was assured direct access at the outset, initially by the Vice President and later by the President himself. I found that I was able to establish very good working relationships with President Clinton, Vice President Gore, and senior White House staff. In large measure this was because my predecessor, Jack Gibbons, who was particularly close to Vice President Gore, had assembled a fine staff, and had produced high quality products and valued advice. Gibbons’ legacy enormously facilitated my ability to function effectively.

It was also fortuitous that President Clinton’s Chief of Staff during the latter part of the Administration, John Podesta, was (and still is) personally interested in science and technology, which he had studied in school. He was particularly helpful in advising me on the workings of the West Wing, which allowed me to move forward with some issues I felt were particularly important (e.g., research budgets).

I should also note here that the late Allan Bromley, who was the first Science Advisor to have the title “Assistant to the President for Science and Technology”, also understood the importance of having a good working relationship with the President’s Chief of Staff. Indeed he worked well with John Sununu and, as a result, was able to establish a very good relationship with former President Bush.

The importance of access also includes the OSTP Associate Directors (Senate confirmed Presidential appointees) and their staff, who assure the effective operations of OSTP in several ways: working with the

agencies and scientific community to get accurate information, e.g, by developing and coordinating interagency programs; advising the Office of Management and Budget staff on science and technology components of the budget; and helping to educate their counterparts in the other policy councils (economic, domestic, national security) and offices of the White House about the science and technology issues and their importance to important policy considerations. Doing all this successfully requires outstanding individuals who have access to the appropriate people in other parts of the White House and agencies. Usually, the Science Advisor briefs the President, but on occasion, while I was serving in the White House, other OSTP staff would be included. I was fortunate to have outstanding staff during the time I served at OSTP, most of whom had been recruited by Jack Gibbons.

In the end, it must be recognized that the President’s agenda is always oversubscribed. Personal access to the President is a privilege that should be used sparingly. In my own case, I requested personal meetings with the President on rare occasions and was always granted those meetings. Most of my direct interactions with President Clinton were to brief him on some upcoming meeting, interview, speech, or other timely matter. On a few occasions, there was time to chat about whatever was on the President’s mind – on one occasion, dark matter and black holes, on another, some geological features in Antarctica – or a policy issue that was pending. Those meetings were as frequent as several in a single week; on other occasions weeks could pass without my seeing the President. I sent the President weekly reports, which he always read, often making marginal comments (which his private Secretary, Betty Curry, would sometimes have to help decipher). On some matters, he would have questions or would request a more complete memorandum on a topic. He seemed to read and digest

A few specific examples from the Clinton Administration

Perhaps the points made in the earlier paragraphs can be best illustrated with a few examples of how particular policy matters were handled during the time I served as President Clinton’s Science Advisor (from the summer of 1998 to mid- January 2001).

President Clinton’s National Nanotechnology Initiative

The first example, the National Nanotechnology Initiative (NNI), is one of “government in science” rather than the other way around. But it illustrates several of the points I have made about personal access to the President, teamwork with other Assistants to the President and Federal agencies, and the importance of identifying and “marketing” an initiative.

The motivation and the rationale for the NNI, with its bold set of “grand challenges”

and the doubling of Federal funding for nanometer-scale science and engineering research, was twofold: to promote a promising, perhaps potentially revolutionary new technology of the future and to increase research funding of the physical sciences and engineering. The history of the NNI has been recounted elsewhere (Neal Lane and Thomas Kalil, in “Issues in Science and Technology,” Summer 2005, p 49-56, National Academies and University of

Texas at Dallas) so I will only briefly summarize it. The NNI was a grass-roots effort, built on years of impressive research leading to new knowledge and tools at the nanometer scale. Before the White House got formally involved, NSF and other agencies convened (in 1996) an interagency working group, which (in 1998) was raised to the Presidential level, under the authority of the National Science and Technology Council, formally chaired by

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the President. That body developed a proposal to the President for the NNI. It was reviewed by the President's Council of Advisors on Science and Technology, which, along with the Science Advisor, recommended the Initiative to the President. My involvement with the NNI, as Science Advisor, was to work closely with several key people and organizations: the technical advisor to the National Economic Council, Tom Kalil, who reported to Gene Sperling, one of the President's key senior advisors; the interagency coordinating group, chaired by NSF's Mike Roco; the Office of Management and Budget; and PCAST, which I co-chaired with John Young (former President and CEO of Hewlett Packard). I briefed the President at several budget meetings (...including one to which I had not been invited!) and formally recommended the NNI to the President along with unprecedented increases in overall research funding, which he included in his budget request for FY2001. While there was much support for the NNI and increased funding for the physical sciences, in general, among White House Advisors, there were also some strong feelings about other budget needs, which resulted in some heated internal debates and some personal scars and bruises.

Nuclear Missile Defense

My second example, nuclear missile defense, is an example of "science (and technology) in government".

Ballistic missile defense has been a politically divisive issue and an area of questionable policy, at least since President Reagan rolled out his "Star Wars" proposal in 1983. The APS, based on a study carried out by the APS Panel on Public Affairs (POPA), took a strong stand, questioning the technical capability of any effort to put in place a shield to protect the U.S. from ballistic missile attacks. In recent years,

the U.S. military has scaled back its efforts, adding the word "Limited." In 1996, DOD's Ballistic Missile Defense Office was tasked to develop a deployable system within three years; and President Clinton, under pressure from a Republican controlled Congress, agreed that he would make a decision by the year 2000 on whether to deploy the system. While the principal White House responsibility for advice on military matters rests with the National Security Council (NSC), OSTP was expected to provide advice on the "technical capability" of such systems; and that occurred during the time I was in the White House. A string of failed tests of system components were highly publicized. Also, APS and many other organizations and individuals criticized the proposals on the grounds that rather straight forward countermeasures could be deployed to further reduce the system's defensive capability. Members of the OSTP staff who were knowledgeable about defense technology and missile defense, in particular, developed briefing material, in cooperation with NSC staff, and arranged meetings with appropriate government officials. On the basis of those briefings and staff recommendations, I sent the President a classified assessment of the technical capability of the proposed system. The memo was shared with the NSC in advance to assure factual accuracy, as well as to avoid surprises, but it was not subject to clearance or editing by NSC staff. I am not aware that there were any substantial differences in the views of OSTP and NSC on the technical assessment. The President, weighing all the advice he received, decided that it was not appropriate to deploy the system at that time. The G.W. Bush Administration has deployed a limited missile defense system, in spite of further failed tests and technical criticism. The arguments appeared to be "get it up and work out the bugs later!" It is not clear whether OSTP had any role in advising President Bush on his decision.

These are two among many examples

that illustrate how at least one of President Clinton's Science Advisors advised the President. Other advisory issues included: stem cell research and human cloning; a string of failed NASA Mars missions; a string of failed expendable launch vehicles (rocket) mishaps; food safety and environmental (lead, mercury, arsenic) regulations; the international space station; U.S. participation in the Large Hadron Collider accelerator construction and experiments; human genome project; gene patenting, energy R&D and tax incentives to promote energy efficiency; genetically modified foods and crops and related trade negotiations, Kyoto follow-up negotiations; international S&T agreements; science and security at DOE weapons laboratories; disposal of nuclear waste; science and engineering education and workforce issues; and others.

My conclusion, at least my experience, is that the Science Advisor remains a key advisor to the President. But, perhaps, unlike the early cold-war days, the Science Advisor has to compete for attention with other players whose agendas are often of more immediate political importance.

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Prior to returning to Rice University in January 2001, Dr. Lane served in the Clinton Administration as Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy, and before that as Director of the National Science Foundation.

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"Science and Policy"

John Marburger

A talk given at the D. Allan Bromley Memorial Symposium in New Haven, Connecticut, December 8, 2005

My interactions with Allan Bromley were limited to a few brief periods, but they were close encounters and I was grateful for his friendship and advice. The first time I met Allan was during my term as chairman of Universities Research Association. URA had the Department of Energy contract to build and operate the Superconducting Super Collider in Texas starting in 1989, the year Allan became President George H. W. Bush's science advisor. Congress voted to terminate the project in 1993, the year Allan left Washington to return to Yale. You could say that the SSC survived as long as Allan

was there to defend it, but of course the history of that project is complicated, with many contending forces. My experience with the SSC actually began about a decade earlier when the proton collider ISABELLE at Brookhaven Lab was in balance. Its fate was sealed when the heavy weak interaction vector bosons were discovered in 1983 at CERN, and the particle physics community realized that President Reagan would support the construction of a much larger next generation machine. While the collider was still in play, Stony Brook colleagues had urged me to help make the case for

Brookhaven, and I used Congressman Bill Carney's conservative credentials to arrange a visit with Reagan's budget director David Stockman in 1981. But it was too late. The subsequent phoenix-like emergence of the Relativistic Heavy Ion Collider from the abandoned ISABELLE infrastructure probably owes something to the regional strength in nuclear physics to which Allan Bromley, of course, was a significant contributor.

Bromley always seemed to be at gatherings

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where physics and politics converged, and I saw him off and on at events in Washington during the next seven years. When the news broke that President George W. Bush had nominated me as his science advisor, Allan was among the first to contact me and offer his advice and assistance. He traveled across Long Island Sound to join me for a long lunch at a restaurant near Brookhaven National Laboratory, and afterwards we continued our conversation by phone. Looking back on those conversations, I realize that some of the most useful things he told me were anecdotes (which he very much enjoyed telling) about his experiences. He appreciated that each administration is a world unto itself, but that people are people and politics is politics, and his anecdotes illuminated a corner of the Washington scene with which I had no experience at all. As it turned out, Bromley and I were drawn to different aspects of the science advisory role (with respect to style in public affairs, I am a minimalist, he was a maximalist), and when I finally arrived on the scene that role had been altered further, if only temporarily, by the terrorist attacks of September 11, 2001. But we thought alike on substantive issues, and maintained contact until his untimely and unexpected death, and exchanged views on a wide variety of topics.

My title, *Science and Policy*, encompasses two distinct areas to which Allan was passionately devoted, and today I would like to reflect on these concepts and their mutual relationship from my own perspective. Before the White House personnel office called to suggest that I should be a candidate for this position, my interest in science policy was very narrow and wholly selfish. I wanted tools for physics, and more generally for the science programs I was trying to build, first at the University of Southern California, then at Stony Brook, and finally at Brookhaven. I was an advocate for my institutions, and I worked for their success, not for the success of science overall, or of the larger purposes it serves. So in the summer of 2001, at the age of sixty, I began to think seriously about policy for the first time. Allan Bromley's example was an important guide.

Bromley had set forth his admirably structured views of the aims and operation of the office of the science advisor in Yale's Silliman lectures of 1993, given while his memory was still fresh and his notes intact.¹ (One had the impression that Allan's notes were always intact.) Supplements appeared later in books edited by William Golden,² the guru of science advice to U.S. presidents, and by the Technology and Policy Program at MIT in the proceedings of a symposium celebrating the 25th anniversary of the legislation that established the current version of the Office of Science and Technology Policy.³ These books were

useful to a policy neophyte, and they served me well as I contemplated my task in late 2001. At the time three issues – you might call them “meta-issues” impressed me as important for our science policy today.

The first thing that struck me, as I looked back over the history of the U.S. government involvement with science, was how reactive the pattern of support was to more or less random external events. The mother of all such events was World War II, which came serendipitously on the heels of the discovery of nuclear fission, and brought science forcibly into contact with national affairs. It created an opportunity for Vannevar Bush, Bill Golden, and others to insert science permanently into the federal establishment, at least within the Executive branch, and it set the stage for science policy through the cold war and into the period when Bromley served the first President Bush.

As the nation's discretionary budget grew during this period, the science budget initially increased exponentially after Sputnik to a peak during the Apollo program, and then settled down to a relatively predictable pattern. Non-defense science funding held to a nearly constant fraction of the domestic discretionary budget, the share of the total rising and falling slightly about a slowly rising mean in a pattern roughly coincident with the solar sunspot cycle. Big science projects have come and gone, each with its own story, while the NIH budget ascended monotonically to its present dominance. Today NIH consumes nearly half the non-military federal research budget. NASA consumes about fifteen percent. NSF, DOE, and DOD basic science share nearly all the rest. I have struggled to identify a rational basis for this distribution of funds, and failed. Many observers, including the President's Council of Advisors on Science and Technology⁴ and a recent panel sponsored by the National Academy of Sciences,⁵ point to an imbalance in federal research support to the physical sciences as compared with the life sciences. And indeed there are many more imbalances than this one, depending on what you mean by “balance”.

The potential irrationality of federal funding patterns was apparent early on the leading edge of the huge increase in science budgets in the early 1960's. Alvin Weinberg, in a 1961 *Science* magazine article that should be better known,⁶ said “...it is presumptuous for me to urge that we study biology on earth rather than biology in space, or physics in the nuclear binding-energy region, with its clear practical applications and its strong bearing on the rest of science, rather than physics in the Bev region, with its absence of practical applications and its very slight bearing on the rest of science. What I am urging is that these choices have become matters of high national policy. We cannot allow our over-all science strategy, when it involves such large sums, to be settled by

default, or to be pre-empted by the group with the most skillful publicity department. We should have extensive debate on these over-all questions of scientific choice; we should make a choice, explain it, and then have the courage to stick to a course arrived at rationally.”

Such a debate has never occurred in the science community, although Frank Press (who had served as President Carter's science advisor) tried to get one started in 1988 when he divided science programs into three priority categories and “named names” of projects that should be in each, urging scientists to take responsibility for setting priorities. It was not a popular proposal. Quotes from the subsequent media coverage make interesting reading. Here's Al Trivelpiece, then Executive Director of the American Association for the Advancement of Science: “Nobody asks farmers whether they want price supports for wheat rather than for cotton. Why should scientists be treated any differently and be required to choose from among several worthy projects? I think the issue for scientists should be the quality of the research.” And a congressional staffer: “I hope we can forget his words and move on.” And an official of the American Association of Medical Colleges: “It's a question of strategy. Why should we assume that there's a fixed pot of dollars? I prefer the idea that support for science is not fixed, at least not until we get to a level that represents a reasonable proportion of our GNP.” Whatever you may think of the wisdom of Frank's statement, it was a call for rationality in the midst of a very irrational battle for federal funds. Part of that battle ended in 1993 when Congress voted the International Space Station up and the SSC down. Neither was at the top of Frank's list. Science advisors do not have the luxury of ignoring the need for prioritization. In a time of tight budgets it can be the most important issue in science policy.

The second “meta-issue” that seemed significant to me in 2001 was the interplay between basic and applied science and technology. During most of history, technology got on without science. We should keep in mind that nearly the whole of the industrial revolution occurred while scientists still thought heat was a material fluid. That changed toward the end of the nineteenth century, and the relationship between science and technology has been changing ever since.

Much of value has been written about the relationship between basic and applied science. Congressman Vern Ehlers emphasized the value of “targeted basic research” in his important 1998 report⁷ sketching a new post-cold war science policy. Gerald Holton spoke of “Jeffersonian science” in a 2000 conference on Science for Society whose proceedings⁸

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Lewis Branscomb sent me in the summer of 2001 as I was meditating on these things. Princeton's Woodrow Wilson School dean Donald Stokes wrote an entire book titled "Pasteur's Quadrant – Basic Science and Technological Innovation"⁹ where Vannevar Bush's "linear model" of the continuum of basic to applied research to technology was replaced by a two dimensional space. Probably more than two dimensions are needed here. The evolving complexity of this relationship was an important theme of an excellent and influential report¹⁰ produced in 1995 by a National Research Council Committee chaired by Frank Press that I want to dwell upon for a moment. This report introduced the new category of "Federal Science and Technology," or FS&T, into the science policy lexicon. The Office of Management and Budget decided to adopt such a category for the first time in the President's FY2002 budget proposal to Congress. The authors of the NRC report stated that "The committee's definition of FS&T deliberately blurs any distinction between basic and applied science or between science and technology. A complex relationship has evolved between basic and applied science and technology. In most instances, the linear sequential view of innovation is simplistic and misleading. Basic and applied science and technology are treated here as one inter-related enterprise, as they are conducted in the science and engineering schools of our universities and in federal laboratories."

This report is one of the more important science policy documents of the past decade, and it needs to be taken even more seriously than it has been. It bears on the significance of "development" (the "D" in R&D), and of industrial research, which are being given far too little credit in today's advocacy briefs for increasing federal support for science. As Alvin Weinberg realized already in 1961, it would be possible for us to double or triple funding for the overall basic research category and still not address the need for substantial investment in the kind of basic research that most effectively addresses societal needs. I had the impression, talking with Allan Bromley, that he understood better than most the complex processes that lead to innovation or economic competitiveness.

The third "meta-issue" in science policy that caught my eye four years ago is just how weak the tools of science policy really are. I made this point earlier this year in my address to the AAAS Science Policy Forum in April¹¹, and in a subsequent editorial in Science magazine.¹² In contrast with tax policy, where economic policymakers have a substantial body of ongoing scholarship to guide them, science policymakers have very few resources that help make choices among policy options. We have more data than we have models for interpreting it, and the data

definitions are weak and not keeping pace with the changing practice and content of science. I think the situation is most serious in resolving questions about science and engineering workforce policy. What are the implications of globalization of technical work, rates of graduation in engineering and science programs in other countries, and the impact of information technology on research, design, and manufacturing? Empirical and theoretical bases for policy suggestions in this area are surprisingly weak. Some of these concerns surfaced in a recent NRC study I cited in my AAAS talk¹³, and OSTP strongly supports the recommendations in that report.

In reading over the key policy documents of the past decade in preparation for this talk, I came across a statement by former House Science Chairman George Brown bound with Vern Ehlers' 1998 report⁷ as a "Supplemental View." Brown declined to sign onto the report "because it does not sufficiently probe the depth of the problems facing our scientific enterprise. Any new policy should adhere to three principles which require more study. First, it should reflect our understanding of the process of creativity and innovation. Second, it should articulate the public's interest in supporting science – the goals and values the public should expect of the scientific enterprise. Finally, a new science policy should point towards decision-making tools for better investment choices." These three principles align well with the three "meta-issues" that seemed important to me in 2001.

I will conclude with a few remarks on concluding remarks that Bromley made in "The President's Scientists," the book¹ based on his 1993 Silliman Lectures. "I was asked toward the end of my stay in Washington," he wrote, "what my biggest surprises had been. The answer was surprisingly obvious. First, the people with whom I had the privilege of working, both in the Administration and in the Congress, were much more able, dedicated, and hardworking than I expected. Second, it took longer to make anything happen than I could have believed possible!"

"There are some truly fundamental problems that require attention in Washington," he continued, "Perhaps the most important is the balkanization of Congress. We have too many committees and subcommittees, and there is no rational distribution of responsibility among them. What is needed is a complete restructuring of the way Congress does its business ..."

Congress did implement a minor reconfiguration of its appropriations subcommittees this year, and it is too early to say whether it will help science. But reorganizing Congress is not going to be the solution to problems of irrationality in our federally supported science and technology programs. I think many of the irrationalities

we see in our national behavior are a direct result of the complexity and chaos of events to which the Administration and Congress must respond. That first surprising discovery Allan made, that the people in government are able, dedicated, and hardworking, should give us hope that with better tools for understanding the chaos of events and for mapping out effective plans, our government – even in its present form – can do a better job of focusing its resources. Who better than the science community itself to provide these tools?

Allan Bromley's willingness to dedicate much of his life to the improvement of science policy formation will make it easier for others to follow his example. I am very pleased to be able to contribute to this symposium in his memory.

1. The 1993 Silliman lectures are expanded in "The President's Scientists – Reminiscences of a White House Science Advisor" D. Allan Bromley, Yale University Press, New Haven 1994

2. "Science Advice to the President" 2nd Edition, enlarged, William T. Golden, Ed. AAAS Press, 1993.

3. "White House Office of Science and Technology Policy – 25th Anniversary Symposium" Proceedings, Massachusetts Institute of Technology, 2001.

4. "Assessing the U.S. R&D Investment" Report of the President's Council of Advisors on Science and Technology, Office of Science and Technology Policy 2002.

5. "Rising Above the Gathering Storm" National Academies of Science, Report of the Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academies Press, Washington, D.C. 2005

6. "Impact of Large Scale Science on the United States" Alvin M. Weinberg, Science Vol 134, p 161 (1961)

7. "Unlocking Our Future: Toward a New National Science Policy" Committee Print 105-B, Committee on Science, U.S. House of Representatives, 105th Congress, September 1998

8. "Science for Society" Report on the November 2000 Conference on Basic Research in the Service of Public Objectives, Lewis Branscomb, Gerald Holton, Gerhard Sonnert, (Publication sponsored by The David and Lucille Packard Foundation and the Alfred P. Sloan Foundation, 2000)

9. "Pasteur's Quadrant", Donald E. Stokes, Brookings Institution Press, Washington, D.C. 1997

10. "Allocating Federal Funds for Science and Technology" Report on the Committee on Criteria for Federal Support of Research and Development, Frank Press, Chairman.

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Nuclear Energy in France :Public Perception (2006)

Michel Lung and Berol Robinson

In this essay, we shall try to analyze the development of the public's perception of nuclear energy from the beginning until today (April 2006). We will follow the fluctuations of public opinion as they reflect national and international events, public policy as well as known and hidden influences. Therefore we shall take a historical path.

1. The beginnings – 1945 to 1960

At the end of the war, everything had to be rebuilt. The Marshall Plan helped us do that. Influenced by a few scientists who had contributed to nuclear physics before the war and during the war in the USA and Canada, General de Gaulle founded the "Commissariat à l'Énergie Atomique" (CEA) in 1945. ZOE, the first experimental pile, went critical in 1948. It was a great boost for the public reputation of French science and engineering, and it led us to entertain great hopes for the future. "Atomic energy", as we called it then, seemed to have fair sailing. Every country wanted its reactor, even tiny Luxembourg. In 1956, the first nuclear electricity in France was widely acclaimed. The first gas-cooled graphite-moderated reactors with natural uranium fuel produced weapons-grade plutonium, which was separated in the reprocessing plants at Marcoule (1958) and at La Hague (1960). De Gaulle wanted a nuclear defense and his successors, whether Socialist or Communist, were of the same opinion. The first bomb was tested in 1960.

But that plutonium was also to be used in breeder reactors because it was already clear to our leaders that we ought not be satisfied with the one part in 140 (0.7%) represented by the fissionable isotope U-235, but rather that we should extract all the nuclear energy from natural uranium. Rapsodie, the first

fast neutron reactor, was built at Cadarache under the direction of Georges Vendryes and went critical in 1967.

In that pioneer period we were already concerned about the proper way to handle highly radioactive long-lived nuclear waste. With the cooperation of the glass industry, the CEA perfected the Piver method of vitrification (1969), later transformed into the continuous AVM process. Starting as early as 1954, first at Saclay and then at Cherbourg, the CEA trained a corps of engineers specialized in the design and safe operation of nuclear reactors.

In brief, it was a euphoric time and the public and the media enthusiastically greeted the success of our engineers, led by the graduates of our Ecole Polytechnique. Even our mineral waters advertised their slight radioactivity as a desirable quality.

We must not forget President Eisenhower and his Atoms for Peace initiative (1954) which led to the organization of the well known Geneva conferences on civilian applications of nuclear energy (1955, 1958, etc.), the creation of the International Atomic Energy Agency (IAEA) at Vienna (1957), and the spread of swimming pool research reactors for universities The Euratom Treaty, parallel to the Treaty of Rome founding the Common Market of six European countries, was also signed in 1957.

2. Continuity – 1960 to 1970

Strengthened by popular approval, the government of France continued to invest in nuclear energy, following the examples set by the USA, Canada, its neighbors in Europe, especially the United Kingdom and Germany, and by the Soviet Union. Their resolve was further strengthened by the scarcity of domestic coal and oil resources and by the fact that dams had already been built on most of the potential hydroelectric sites. The CEA opened uranium mines in France and invested in uranium mining abroad. The state-owned electricity monopoly, Electricité de France (EdF), was urged to invest in the new power.

After the success of Admiral Rickover with nuclear submarines, the pressurized water reactor (PWR) at Shippingport PA and General Electric's boiling water reactor, and in view of the satisfactory performance of the small

Franco-Belgian power plant at Chooz (1967), essentially a Westinghouse PWR, a "committee of wise men" meeting upon the initiative of Marcel Boiteux, Director General of EdF and a leading figure in the nuclear program, decided to abandon the line of gas-cooled graphite-moderated light water reactors in favor of the Westinghouse PWR (1969). This decision also took into account the fact that enriched uranium was already available from the plant at Pierrelatte, and that more would eventually come from Tricastin. It was decided then to focus on the PWR, which was bit by bit "Frenchified" by the builder Framatome, initially a joint venture of the Westinghouse and the Belgian group Empain-Schneider, later CEA and Empain-Schneider.

Public opinion followed these developments with interest and passion. However, atmospheric weapons testing, mainly American and Soviet, led to medical concerns about radioactive fallout, especially radio-strontium; and the tests went underground starting about 1966. Furthermore, prominent people began to worry about the proliferation of nuclear weapons, with talk and rumors from Israel, Pakistan, India and Argentina.

The May 1961 Oslo Conference against the Proliferation of Nuclear Weapons gave Nikita Khrushchev the occasion to adopt a pacifist position, and high level clubs like Pugwash (founded in 1957) began to ask questions. In brief a certain pacifist movement was born which surreptitiously began to shake the blind faith in this new form of energy, in France as elsewhere. Among great voices, that of Linus Pauling (Nobel Peace Prize 1962) had a strong impact on the public opinion.

3. The period from 1970 to 1981

This period was a turning point in France and probably in the whole Western world. Civilian nuclear energy was keeping its promises; one had confidence in it. The oil shocks of 1973 and later, the lack of domestic fossil fuel reserves in France, a rapidly expanding economy and a highly centralized and technocratic government under President Pompidou led to a forced march to build nuclear plants in order to free the country of its dependence on foreign sources of energy which might compromise its economic growth. EdF and Framatome began an "assembly line" of PWR reactors, to the point of starting four a year, first 900 MW, then 1300 MW. It was a major financial and industrial effort, but the country was proud it. EdF was able to site reactors with no great difficulty, profit-sharing grants

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National Academy Press, Washington, D.C. 1995

11. Keynote Address, John Marburger, 2005 AAAS Science and Technology Policy Forum, Washington, D.C., April 21, 2005 (Available at www.ostp.gov)

12. "Wanted: Better Benchmarks" John Marburger, Science Vol 308 p 1087 (2005)

13. "Measuring Research and Development Expenditures in the U.S. Economy" Lawrence D. Brown, Thomas J. Plewes, Marisa A. Gerstein, Eds., National Academies Press, Washington, D.C. (2005)

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to nearby towns helped, new installations brought well paying jobs, the government supported it all, and the Communist Party, powerful in France and in control of the CGT labor union, approved of the investments.

The first reactor went on grid in 1977; it was a 900 MW PWR at Fessenheim in Alsace, on the Rhine. It was followed by over fifty more in the space of twenty years. The fast neutron reactor Phenix had gone on grid in 1973 and was running very well; the next step would be Superphenix. Reprocessing and enrichment, too, were going well. "Everything was for the best in the best of all worlds". The French public was satisfied and nuclear energy was welcomed.

But a dark cloud loomed on the horizon about 1970 with the founding of Greenpeace and a number of concerns which had begun to appear a few years earlier in certain circles. Pacifism began to invade the West and people began to draw a parallel between civilian nuclear power and nuclear weapons and the victims of Hiroshima and Nagasaki. Pacifist movements and the distrust of all technocracy became fashionable. The student movements of 1968, especially widespread in France, had a lot to do with this state of affairs; and we see the effects among the French media and especially among the French governing class to this very day.

The 1972 fire in the Windscale reprocessing plant (UK) had strong repercussions, although there had been hardly a murmur 15 years before when a plutonium production reactor on the same site suffered a dangerous and disabling fire with extensive radioactive pollution. In 1976 President Ford deferred the opening of the Barnwell (SC) commercial reprocessing plant, citing the risk of proliferation. The next year his successor, Jimmy Carter, ended all work on reprocessing by permanently abandoning Barnwell; and he tried to convince the British, the French and the Japanese to do the same, to no avail. But the measure was widely acclaimed in pacifist and socialist circles, as well as by Greenpeace, WWF and others, including the Aga Khan at Geneva. The Green movement grew fat, supported by the leftist movements ("Besser Rot als tot" [Better Red than dead] as they said in Germany). It was at the height of the Cold War with tactical nuclear weapons installed in Europe, nuclear-armed bombers crashing with local contamination. All this contributed to public concern. It was at this time, for example, that International Physicians for the Prevention of Nuclear War (IPPNW,) was founded (1980). Environmental concerns were growing, and in the 1980s the Norwegian Gro Brundtland launched her famous notion of "sustainable development", following the ideas of the Club of Rome.

The French managed to resist these sentiments pretty well, perhaps on account of the military component in the national nuclear industry. At the request of President Carter, whom he met on a Concorde visit to Martinique, President Giscard d'Estang, himself a Polytechnician, stopped all French aid to Pakistan, but refused to halt reprocessing in France. At the same time he launched the construction of Superphenix (December 1976), a liquid-sodium cooled breeder reactor of 1200 MW, declaring that "with this new type of reactor and domestic uranium resources, the country possessed as much energy as Kuwait with all its oil." Although correct, it was a regrettable statement; for it led more than one oil-rich country to reflect upon its implications for its own relations with France. The result was not long in appearing: in July 1976 tens of thousands of demonstrators from all over Europe were mobilized on the site of the future Superphenix, by then an international project including Italy, Germany and Benelux. And the following July there were over 100 000 demonstrators; one person died and several were injured, one seriously.

In 1979 the Three Mile Island (PA) accident cost its owner dearly, but no one was injured or even much irradiated, thanks to the confinement structure of the PWR, like those built in France. But what a racket! A catastrophe! The "China Syndrome" and all (the film with Jane Fonda and Jack Lemmon had just appeared!). One is reluctant to believe that all this public reaction was spontaneously generated. (Look for the "master mind" directing traffic. Your suggestions are welcome.)

In France, public opinion favorable to nuclear power received a blow. On the political scene, the Socialist Party led by Mitterrand sought to replace the liberal government of Giscard [N.B. in France "liberal" means "market economy."]. In their program, besides the alliance with the Communists and the Greens, the nuclear question appeared in the form of a vow to stop the nuclear power program and especially reprocessing (without which nuclear is not viable for the long term).

4. The Socialist period – 1981 to 1986 – a period of "resistance".

The presidential elections of 1981 brought the Socialists to power under President Mitterrand, and everything nuclear in France began to shake in its boots. But the Communists and the CGT (Communist-dominated trade union) would not agree to stopping the on-going program or to interrupt construction in progress. Mitterrand, as a concession to his party members, immediately cancelled the plans for a power station at Plogoff on the coast of Brittany, which had been the subject of demonstrations for years, but he continued to

support nuclear power as he had years before as minister in diverse functions during the IV Republic (1945-58). The nuclear industry had had a near miss. But public convictions were shaken by the sight of the government's hesitations and its inability to keep the new ministers in line on the question of nuclear energy. The ideas of the Greens took center stage and their simplistic point of view pleased the media. "Scientific matters are not a dogma, one had better beware."

Then there was the unfortunate affair of the Rainbow Warrior in 1985. It was a small sailboat, used by Greenpeace to protest French weapons testing in the Pacific; and it was torpedoed by a French secret service commando in Auckland harbor (NZ), killing one man and injuring several others. That episode contributed to a weakening of the image of the "authorities" in nuclear matters.

Thus public opinion began to waver around 50% for or against "le nucléaire". In spite of it all, but more discretely than before, newly built reactors were put on the grid. The two new reprocessing plants at La Hague, each one able to treat 800 tons a year, were built normally under the direction of COGEMA, created by the CEA in 1977. Superphenix went into operation in 1986 after having been subjected to a rocket attack in 1982 (rockets supplied courtesy of the international terrorist Carlos). Greenpeace went from demonstration to demonstration at reactor sites. Greenpeace-France spoke man-to-man with the minister of the environment. Its "bêtes noires" were carefully and strategically targeted: the reprocessing plant at La Hague, the Superphenix reactor, the transport of radioactive material; if any were stopped the nuclear industry would be strangled.

It was at this moment that the slogans appeared which are well known to the "nuclear lobby": "we don't know what to do with nuclear waste, there are no solutions, we will leave it to future generations", etc. These slogans hit a bull's eye in the press and media, and the public fell for it. We have seen that the farther the public is from a nuclear plant, the easier it is to make an impression on them; people who live nearby, familiar with the industry, have more confidence in it.

5. The thunder clap of Chernobyl – 26 April 1986

It would take volumes to recount the exaggerations in the press and television of this "soviet" accident and the political and media fallout. The Central Service for Protection against Ionizing Radiation (SCPRI), an agency of the Ministry of Health, was among the first, after Sweden, to detect the radioactive cloud thanks to monitors installed on international air liners

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and a centralized automatic network of monitors covering all of France. Professor Pierre Pellerin, director of SCPRI, following the measurements closely over the long May 1 weekend (Labor Day in Europe), observed that the radioactive “cloud” had indeed reached France, but judged that the radioactivity was not strong enough to imperil the public health. In some of the neighboring countries, the conclusions were different, coming close to panic. The French media, supported by the “anti-nuclears”, seized upon the question to say that Pellerin had lied, that he obeyed the “nuclear lobby” to protect the industry, that he was responsible for hundreds of thyroid cancers. (A steady increase in the occurrence of thyroid cancers dates from 1975, ten years before Chernobyl, and it is observed even in places like Canada, never touched by Chernobyl fallout.) Law suits were pressed and Pellerin won them all; but even so, on this twentieth anniversary of the accident, the media are still persuaded that the government lied to the French, and it’s a veritable witch hunt against the nuclear lobby, the “nucleocrats”, with many films, lectures by visitors from Ukraine and Belarus, regions which obviously suffered directly from the catastrophe. The movement in France is so intense that one has become suspicious: Why? And especially whose money is paying for the propaganda?

When they are shown pictures of deformed babies, the well-meaning public has doubts: Are they hiding something from us? Suppose our reactors exploded like Chernobyl? Is it true that the storage pools at La Hague have the equivalent of hundreds of Chernobyls? The IAEA estimates that Chernobyl will have caused at most 4000 cancers: but maybe Greenpeace is right with 100,000, or even 6 million? And now comes our French Nobel laureate Georges Charpak and his American friend Richard Garwin who recently published a book in French entitled “De Tchernobyl en Tchernobyls”. This appears to be a translation of their successful “Megawatts and Megatons”. When asked about the title, Garwin replied “One is not in complete control of one’s publisher”. So much for today’s hard sell anti-nuclear publicity campaign. What’s next?

In any event, Chernobyl has turned out to be an extraordinary lever, and it has been powerfully exploited against nuclear energy, at least in Western Europe, and especially in France.

6. The period from 1986 to 2002: decline and distrust

It will help to say a few words about the structure of the French government. The president used to be elected for a term of seven years, reduced to five years starting 2002. The Chamber of Deputies, now called

the National Assembly, is elected for five years, but the president may dissolve it and call new elections. The president selects the prime minister from the majority in the Chamber, and the ministers who constitute the Government must be approved by the Chamber. The Socialist Mitterrand was president from 1981 until 1995 (7 + 7) and was succeeded by the liberal Chirac whose term ends in 2007 (7 + 5) (liberal means market-economy oriented). During this period, the government alternated between Socialist-Communist-Green coalitions and liberal majorities in the Chamber. From 1981 to 1986 the regime was Socialist. From 1986 to 1988 the socialist President Mitterrand had to live with a liberal majority in the Chamber. From 1988 to 1993 the regime was Socialist again. From 1993 to 1995 the government was again liberal. In 1995 the new President Chirac had a liberal majority, but from 1997 he had to live with a Socialist government. Finally, in 2002, Chirac was re-elected with a liberal majority, which is still in office.

In 1986, the reactor program was well under way, and it was completed despite the alternation of governments, largely due to the presence in all governments of some perceptive ministers. With a certain amount of beating around the bush, the four big PWRs (1450 MW) were completed, two at Chooz and two at Civaux; the last one went on grid at the end of 1999.

But one could feel a certain growing distrust in French public opinion, stoked by anti-nuclear attitudes of the media, fed by Greenpeace, the Greens, WWF and other organizations, branching out in neighboring countries, at the headquarters of the European Community in Brussels, and especially in the European Parliament. Some anti-nuclear organisms appeared, such as WISE, Sortir du Nucléaire (“Let’s get out of nuclear power”) which claims to coordinate the operations of 700 anti-nuclear associations, CRIIRAD (an “independent commission” on information about radiation) and others. The Ministry of the Environment and ADEME, its agency for energy conservation, became hot beds of the anti-nuclear movement. During the years of Socialist government, the Greens managed to place their friends in various organs of the administration and most are still in place. Greenpeace mounted some incredible demonstrations to protest the La Hague reprocessing plant, and to impede the transport of spent fuel domestically and from Japan and Germany and the return of the waste to those countries. But public opinion did not completely follow; the program ran out of steam and demonstrations were in the end abandoned, not without leading one participant to die on a railroad track in France. Already in 1977, the residence of Marcel Boiteux, president of EdF, had been blown up with a plastic bomb; but the culmination was the horrible murder in 1986 of Georges Besse by Action Directe,

a French terrorist organization. President of Eurodif and COGEMA, he had built the uranium enrichment plant at Tricastin and imparted a remarkable impetus to our nuclear industry; his perception and human qualities were appreciated by all.

In 1991, Mitterrand’s Socialist Prime Minister Rocard wanted to find an underground site for highly radioactive long lived waste, but a unanimous popular protest, inflamed by the Greens, led him to put off all decisions for 15 years. Well, here we are, in 2006, and nothing is less uncertain, although the present government favors a reasonable solution for an underground repository, with deposits being reversible for a certain period of years.

During these years we have seen Italy renounce its nuclear program; activities frozen in Germany, Belgium, and Spain; and the entry into the European Community of some violently anti-nuclear countries – Austria, Denmark and Ireland. So the European Commission has become very discrete about nuclear energy, in spite of the efforts of the remarkable Commissioner Loyola de Palacio.

In 1995, Jacques Chirac became president of France and wanted to show his mettle through a series of weapons tests in the Pacific, before the test center at Mururoa would be permanently closed. This gratuitous decision was not appreciated in world at large and was received in various ways in France. It certainly did not strengthen the public image of civilian nuclear energy, while the Greens and Greenpeace were only too happy to take advantage of the occasion to connect nuclear power with the bomb. On the other hand, the Navy’s arrest of the Greenpeace commando at Mururoa was rather well received.

But in 1997 the Green Minister of the Environment, Dominique Voynet, (1997 – 2001) struck a devastating blow at the French nuclear program. She demanded that her Socialist Prime Minister Jospin agree to the permanent and definitive closure of the Superphenix, without consulting France’s European partners, Italy, Germany and Benelux. She monitored the operation herself to be sure that the reactor would never run again. All efforts to save the machine were in vain, although it had functioned well after a difficult start up period. This act cost the French taxpayers the tidy sum of 15 billion Euros (US\$18B) and set the country back fifty years. (Dominique Voynet now represents the Green Party in the French Senate.)

This period of uncertainty, after Chernobyl and Dominique Voynet, was very unfortunate for the public image of nuclear energy. Henceforth it would not be “honorable” to defend it; a journalist would call you the devil’s advocate, or a “nuclearist”

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even worse a “nucleocrat”. Leaders in the government would hardly mention nuclear energy at all, as if the industry were taboo.

But a few voices were raised against this ostracism. In particular, AEPN (l'Association des Ecologistes Pour le Nucléaire) founded in 1996, which has thousands of supporters, which is spreading world wide and which works in coordination with similar organizations abroad (EFN, Environmentalists For Nuclear Energy). Other organizations, mostly of retired engineers, are equally active in informing the public. The SFEN (Société Française d'Energie Nucléaire), the SFR (Société Française de Radioprotection), the Academy of Science and the Academy of Medicine are playing an increasingly active role. They are well known in scientific circles, but it is a struggle to get their voice heard by the media who are still distrustful.

7. From 2002 until now

We now have a “liberal” government in France, a “right wing” government, under President Chirac and his Prime Ministers Raffarin, then de Villepin. We speak more and more these days of the likely consequences of an enhanced greenhouse effect (Kyoto 1997, Johannesburg 2002), of the end of oil and gas in this century and the associated price increase. Yet when Roselyne Bachelot, the new Minister of the Environment, thoughtlessly suggested that nuclear energy might make up for a shortage of oil, she was rebuked by her prime minister for having said an unseemly word. The rule is “conservation and renewable energies”, especially to build wind turbines, following our neighbor Germany, the world champion. The new Minister of Industry, Nicole Fontaine, supported Mme Bachelot, and she was similarly called to order by Raffarin. But she managed to organize a series of public debates on energy around the country. They were well received by an informed public, and led up to the National Debate on Nuclear Energy ending late 2005, dealing with nuclear waste and the proposal to build an EPR – European Pressurized Reactor (a Generation III reactor) to begin to replace the aging reactors of the 1970's. Although not widely followed, the Debate had the virtue of making the media speak of energy problems and to help extract nuclear power in France from its (self-imposed) ghetto.

The USA with President Bush's recent announcement, and Finland starting construction of an EPR, its fifth reactor, have given a push. China and India have announced nuclear ambitions; in view of their enormous needs it seems inevitable. Japan, South Korea and Russia are moving forward. The USA had initiated and supported the Generation IV International Forum. Government people are beginning to

talk nuclear in France and President Chirac approves. About 70 % of the public are aware of France's advantageous position; but the public, the students, the ordinary medical doctors, are very little informed. Many people still believe that a few wind turbines can replace a central power station. The teaching profession is invaded by the Left and the Greens, and most teachers refuse to offer objective information about energy. And every year in April the media serve up afresh the story of Chernobyl with ever more cancers and deaths (up to six million!). This year, on the twentieth anniversary, they are presenting a veritable festival of films and “documents”. In public debates, the unfortunate “nuclearists” have to face crowds of anti-nukes who generally know very little but who are firmly convinced that simplistic arguments will move the audience, repeating incessantly their claims that the government as well as the IAEA and WHO are lying to protect a “nuclear lobby”. Except for the Minister of Research, the government has been silent.

Quite recently however (April 21, 2006) three ministers who supervise nuclear activities in France, the Ministers of Industry, Environment and Public Health, have declared in a press release that thyroid cancers in France cannot today be attributed to the fallout of the “Chernobyl cloud”. But the press didn't pay much attention to it. AREVA and EdF are similarly silent, as is the Parliament. Their reluctance to speak may be due to the fact that a group of thyroid sufferers are now suing the government for not having taken measures to protect them from the disease, a disease which specialists say cannot have been caused by Chernobyl's fallout. The law suit is advancing, and the anti-nukes are taking full advantage of it.

The recently organized international antinuclear demonstration in Normandy, at the site proposed for the EPR, recalls to mind those mounted against Superphenix thirty years ago. But things are different now and it seems that these demonstrations will not be taken as seriously as they were in the past, especially with current alarming talk about running out of oil and the price of gas at the pump.

We should also note with satisfaction that the Socialist Party, now in opposition, has prudently declared that if they were elected next year (May 2007), they would not phase out nuclear energy in France, only rearrange it somewhat. UDF, the centrist party, followed suit.

Conclusion

Am I trying to tell you that this is the swan song of the anti-nuclear movement in France? I feel that the anti-nukes are more and more running into the wall of physical and economic reality; and that the public is, in spite of all, beginning to have a feeling for energy problems, if only in their wallet. Italy,

Germany, Spain and the UK are weighing the possibility of returning to nuclear energy. Mr Putin's natural gas will cost more, while China and India are competing for oil. In the West, France is still the pioneer and leader in nuclear energy, and it's not by chance that France is the principal target of the anti-nuclear movement.

The parliamentary debate on the future of long-lived nuclear waste will take place at the end of 2006. We can therefore expect continued activity all year long. With the election of a president scheduled for May 2007, it would be surprising if any firm decisions were taken before then. But we are moving forward, if only slowly, toward more objective information on the major problem worrying the public: What to do with nuclear waste?

In summary, the weight of reality will gradually be felt in France and those in favor of nuclear energy will be able to speak out more freely, in spite of the powerful anti-nuclear propaganda, for one must call it that. We may expect the French public, especially the older citizens and the youth, to massively come around to the cause of nuclear energy, which has faithfully provided 80% of their electricity in a most satisfactory way. Objections will still be raised on the basis of proliferation and terrorism, but nowadays the French people know how to distinguish between accepted technical risks, inherent in any activity, which must be minimized as much as possible, and political risks, which are left to the government leaders to tackle.

As often occurs in Old Europe, the signal will come from America. Their attitude is more straightforward than ours. It will also come from the new countries of Eastern Europe, which have brought the European Community to its current strength of 25, and from countries which hope to join soon. For them nuclear energy is the key to their economic growth and well being.

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COMMENTARY

Creating an Effective Message on Intelligent Design

T. Jeremy Gunn and David G. Cooper

Courtroom Victory

Scientists, teachers, and civil libertarians scored a major victory last December when Federal District Court Judge John E. Jones III ruled that the school board of Dover, Pennsylvania, crossed the constitutional line by promoting “intelligent design” (ID) in public schools. (http://www.pamd.uscourts.gov/kitzmiller/kitzmiller_342.pdf) The American Civil Liberties Union, in close cooperation with Americans United for the Separation of Church and State, the Philadelphia law firm of Pepper Hamilton LLP, and the National Center for Science Education, laid out the facts in such telling detail that there could be no doubt about either the motivations or the methods of proponents of ID, an idea that has failed to gain the support of any legitimate scientific organization in the United States.

ID asserts that some aspects of biological life are so complex that they could not possibly have arisen through natural biological mechanisms (such as natural selection and random variation), and that these complex biological systems required the intervention of an “intelligent designer.” For most objective observers, including Judge Jones, “intelligent design” is little more than a dressed-up version of “creationism” and the “intelligent designer” is simply a euphemism for “God.”

The case, *Kitzmiller v. Dover Area School District* (400 F. Supp. 2d 707 (M.D. Pa. 2005)), was the first full-scale test of intelligent design in court. The litigators shrewdly undertook a comprehensive investigation of the facts underlying the controversial idea and then laid them out before Judge Jones. The Judge’s 139-page opinion exhaustively analyzed and dismissed the wide range of arguments proponents of ID have conjured, and the decision is so comprehensive that we may

expect that any conscientious school board or legislator will think more than twice before trying to promote ID in the same fashion as Dover.

If any local school board or state legislator might be thinking of promoting ID, the opinion lays out in detail everything that is wrong with such an action. In addition, the voters of Dover, having been given a chance to think over the issue, subsequently threw out the board that foolishly promoted ID and even elected a new board that included several Kitzmiller plaintiffs. (The newly elected Board reversed the ID policy, accepted Judge Jones’s ruling, and stated that it will not appeal.) These legal and electoral victories offer a powerful warning to those who might have considered adding it to the curriculum.

Court of Public Opinion

Our legal strategy showed significantly greater intelligence and design than did the latest incarnation of creationism. But perhaps the most important question is what will happen next.

Those who wish to insert their personal religious views into the public school science curriculum are not necessarily going to be dissuaded by the evidence, a well-reasoned judicial opinion, or even a sobering electoral defeat. The losing ID lawyers from the Thomas More Society are already looking for another unfortunate school board that will be willing to follow its lead over a cliff.

While the ACLU does not have a department of prophecy, we nevertheless can predict with some assurance that this will not be the final effort to promote creationism in the classroom. Our best guess is, however, that creationism’s proponents will cast yet another obscuring veil over their real agenda (promoting religion in public

schools) and that the next wave will more shrewdly say nothing at all about God, creationism, or intelligent design. It will focus on “the problems of evolution” and the “gaps in Darwin’s theory” and that “evolution is only a theory.”

So how do we respond to this?

It is not sufficient for us to be complacent in our self-assurance that the facts are on our side and that we can rest on our litigators’ laurels. Public opinion polls fairly consistently show that the majority of our fellow citizens believe that some form of creationism should be taught in public schools, despite the Supreme Court’s rulings to the contrary. [1] With the majority of the public on the other side, we can continue to expect wave after wave of this until our position can be formulated in a more persuasive way. We need to be wise enough to understand that litigation by itself, no matter how effective, should not be the only tool in our box.

For biology teachers, it is crucial to teach evolution effectively and work to confront the misconceptions students often have about evolution which may undermine their willingness to accept it.[2] For all science teachers, and for scientists speaking to non-scientist audiences, it is essential to instill a basic understanding of what a scientific theory is and what differentiates science from religion.[3]

But in order to be more effective and persuasive to the public, we should all formulate our arguments while bearing in mind two different but interrelated aspects of American popular opinion about religion.

First, a high percentage of Americans consider themselves to be very religious, and public opinion polls repeatedly show that Americans identify themselves with religion more than the citizens of any other developed country in the world.

This is a social fact that we ignore at our peril. Similarly, when Americans are given the stark choice between “religion” or “science,” they are likely to choose religion. Thus scientists and civil libertarians actually help proponents of creationism when they, like the creationists, suggest that this is a battle between science and religion.

Second, although an impressive percentage of Americans will choose religion over science, they do not want the government to be in the business of choosing one religious doctrine over another. So if they see the choice as religion versus science, religion wins. But when the choice is government preferring one religion over another, then they have second thoughts.

The importance of these two aspects of American opinion cannot be overemphasized for creating a convincing message to a public that thinks it wants creationism to be taught in schools. The message is simple: “creationism (and its relatives) are disputed religious opinions that divide people of faith, and the government has no business choosing one religion over another.”

Thus we need to show the fact that creationism and ID and “anti-evolutionism” are controversial religious beliefs that divide people of faith. The Catholic Church supports the teaching of evolution in schools and does not accept ID as a correct formulation. [4] Many of America’s leading biological scientists are very religious and they see no conflict between their faith and their religion. Thousands of members of the clergy are opposed to teaching ID, as is shown by the Clergy Letter Project (http://www.uwosh.edu/colleges/cols/clergy_project.htm). The fact that so many people of faith do not accept ID shows just how controversial it is and the government has no business

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promoting the religious beliefs of some at the expense of others.

Indeed, the genius of the American founders was to recognize that both religion and government prosper best when religious issues are not made the subject of legislative controversy. Keeping the government away from taking sides in religious controversies is good for religion, good for civil discourse, and eminently more fair for all people – whatever their beliefs.

[1] See, e.g., CBS News, Poll: Creationism Trumps Evolution, Nov. 22, 2004,

<http://www.cbsnews.com/stories/2004/11/22/opinion/polls/main657083.shtml>

[2] See Brian J. Alters & Craig E. Nelson, Teaching Evolution in Higher Education, *Evolution* 56(10), 1891 (2002)

[3] For a description of one physicist's efforts to reach out to skeptical members of the public about issues relating to science and religion, see Murray Peshkin, Addressing the Public About Science

and Religion, *PHYSICS TODAY*, July 2006, at 46.

[4] See Eugenie C. Scott, Creationists and the Pope's Statement,

http://www.ncseweb.org/resources/articles/1480_creationists_and_the_pope39_12_22_2003.asp; Pope John Paul II, Message to Pontifical Academy of Sciences, Oct. 22, 1996,

http://www.ncseweb.org/resources/articles/8712_message_from_the_pope_1996_1_3_2001.asp;

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LETTERS

Response to Norsen: The Enigma Remains!

Ordinarily, this journal is not a proper venue for a discussion of the fundamentals of quantum mechanics. But the issue here is how the teaching of quantum mechanics can counter the use of quantum mechanics to provide support for pseudoscience. In the April edition of this journal we argued that by not properly dealing with the human implications of quantum mechanics, we leave that field to the purveyors of pseudoscience. We cited the movie "What the Bleep?" as an example. We noted that while a biology student is able to effectively refute Intelligent Design's challenge to evolution, a physics student, with a typically limited understanding of the quantum enigma, is not similarly prepared to refute quantum nonsense. We can provide that preparation by briefly confronting those human implications when we teach quantum mechanics.

Travis Norsen takes issue with this. He maintains that if the Copenhagen interpretation of quantum mechanics, which he calls "just as unscientific as Intelligent

Design," is replaced by the Bohm interpretation, the problem we are concerned with disappears. The Bohm interpretation, according to Norsen: "...avoids completely the unscientific baggage and subjectivist implications of the Copenhagen approach... In short, it has none of the subjectivist-epistemological 'human implications' which Kuttner and Rosenblum urged on us, in the previous issue of this journal, to explore with our students."

We believe the usual presentation of quantum mechanics based on the Copenhagen interpretation is just fine for all practical purposes, as long as Copenhagen is recognized as one of several current interpretations of quantum mechanics. While each interpretation of quantum mechanics recognizes human implications, each shows how the physics discipline need not deal with them. Students should, however, understand that if we explore beyond practical purposes, quantum mechanics presents us with an unresolved mystery. Understanding the nature of that mystery, students will know the limits to what can legitimately be implied from it.

But according to Norsen, there is no mystery to explore. The Bohm interpretation tells us that that instead of particle or wave (yielding the wave/particle paradox) we have particle and wave. "And that's that. The paradox is resolved: there are two entities, a wave and a particle," says Norsen. Not quite so fast. The Bohm interpretation also requires a third entity, a "quantum potential" yielding a quantum force guiding particles to obey the Schrödinger equation. The quantum potential is otherwise completely undetectable. This potential provides the required instantaneous connection of a particle with all other particles with which it has ever interacted, in principle, with everything-including the conscious observer. (Is this well-established interaction mysterious? Einstein called it "spooky.")

The Bohm interpretation thus does not avoid the subjectivist implications of quantum mechanics. In fact, the mysterious implications of quantum mechanics can never be resolved by any mere interpretation of the quantum theory. The

Re: "Monitoring Nuclear Weapons and Nuclear Explosive Materials"

Physics and Society, Vol. 35, No. 3. (14 July 2006)

Regarding the subject article by Steve Fetter and Ben Rusek, and thus too the associated 2005 CISAC-National Academy report, several technical means are described that would make it seem that multiple tools are in-hand to reliably and securely monitor, as part of some cooperative arms reduction agreement, nuclear weapons, dismantled components and other sensitive nuclear explosive materials. This is not quite the case, yet. While there are numerous technical approaches that would seem to have merit, implementation is very problematic, to the point of being prohibitive. It is these implementation problems that need the real attention.

There is probably no more worthy goal for physicists and other technical specialists working on nonproliferation and arms reduction problems than that of developing viable nuclear arms reduction monitoring techniques. And there is a concomitant high degree of responsibility for policymakers to support research and development of these technical means, and to educate themselves on their efficacy and security.

That said, we are not served well if we are led to believe that the technical means to solve some of the most important nuclear arms reduction monitoring and inspection issues are readily available and waiting for responsible policy makers and security specialists to use them. Examining two of the areas mentioned in the article elucidates some of the more difficult problems: use of nuclear weapons radiation signatures, and use of tags and seals.

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enigma arises directly from the (quantum) theory-neutral experiment, which is logically prior to the quantum theory.

The Bohm interpretation is sometimes discussed as eliminating the involvement of the observer. It is usually not clear in such discussion whether this elimination of the observer is supposedly true in principle or merely for all practical purposes. In the former case, the complete determinism of the Bohm interpretation would deny the observer's free will. David Bohm himself considered the elimination of the observer to be only for all practical purposes. He has written: "...the intuition that consciousness and quantum theory are in some sense related seems to be a good one..."

John Bell is sometimes quoted, and is by Norsen, as implying the Bohm interpretation resolves the wave-particle paradox. Actually, Bell's opinion (which we share!) is that Bohm is one of the "roads open ... towards a precise theory..." but that theory has not yet been achieved. In one of the last papers he wrote Bell speculates that we might find "... an unmovable finger obstinately pointing outside the subject, to the mind of the observer..."

Discussion of the human implications of quantum mechanics increases today as interpretations proliferate. It is unfortunate that the subject also is increasingly fodder for the promoters of pseudoscience. In such presentations even many physics students can have trouble telling where the real quantum weirdness ends and the quantum nonsense begins. It is our responsibility in teaching physics to deal openly with the mystery physics has encountered, which has been called our "skeleton in the closet." This can be done in a single lecture or two, even in a "physics for poets" course. In fact, that level might be where we would get the most bang for the buck. We have been able to present it at that level in courses and in a book.

F. Kuttner and B. Rosenblum, "Social Responsibility and the Teaching of Quantum Mechanics," Forum on Physics and Society of the American Physical Society, Vol. 35 No. 2, April 2006

2 T. Norsen, "Intelligent Design in the Physics Classroom?," Forum on Physics and Society of the American Physical Society, Vol. 35 No. 3, July 2006

B. Rosenblum and F. Kuttner, "The Observer in the Quantum Experiment," Foundations of Physics, Vol. 32 No. 8, August 2002

S. Goldstein, "Quantum Mechanics Without Observers-Part Two," Physics Today 51(4), 38-42 (1998)

D. Bohm and B. J. Hiley, The Undivided Universe, Routledge, London, 1993, p. 381

J. Bell, "Against 'Measurement,'" Physics World, August 1990, pp. 33 - 40

B. Rosenblum and F. Kuttner, Quantum Enigma: Physics Encounters Consciousness, forthcoming from Oxford University Press, August 2006

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Radiation Signatures: In a cooperative monitoring and inspection environment, radiation signatures are useful for validating declarations by the inspected party about the nature of the nuclear item being examined. This is particularly true for the fundamental task of counting warheads, for example. (Accurately verifying the numbers of warheads will become much more important in the future if the weapons states agree to further substantial reductions, and in fact may only do so if secure and effective technical means of accounting exist.) Warheads and components are often in secure containers, or their form is not particularly sight-sensitive nor unique. Radiation signatures can be useful to verify not only that an item has the basic form of a nuclear weapon, but also something about its uniqueness, and if dismantled, something identifiable about the dismantled parts.

There are two basic approaches to employing radiation signatures: template matching and fundamental attribute measurement. The article describes template matching as viable. Problems with template matching include the fact that one first has to verify the master is as declared, and the associated gamma-spectrum template contains a copious amount of weapon design information and is thus very sensitive. The TRIS system described in the article was developed for US safeguard, security, and other unilateral activities. It may not be appropriate for an arms reduction regime that requires high levels of assurance. It is probably not the right tool for cooperatively validating the reference item signature, and it is very problematic to discuss measurement system design and efficacy with a partner state when both parties are under a mandate to protect their weapons design information. Currently it is impossible, within existing legal constraints, to share weapons signatures, particularly the differences that would have to be accounted for in order to make the measurement system reliable. How is that accomplished without fear of revealing weapons design information?

The much better approach is the use of fundamental, unclassified nuclear weapons and nuclear explosive material (NEM) attributes. Some attributes can be discussed quite openly in significant detail, and the associated radiation signals generally

are not as sensitive. Examples of such attributes include presence of Pu239 or U235, threshold NEM mass, Pu240/Pu239 mass ratio maximum value, lack of fissile material in oxide form, NEM configuration not consistent with powder or rubble pieces, and Americium content (age). US and Russian governmental technical specialists have been cooperatively working for more than a decade to develop, certify, and demonstrate systems based on the attribute approach.

But even using an attribute approach, a gamma radiation spectrum is recorded. If it is from a weapon, a weapon component, or (in the case of Russia) raw NEM, this spectrum is classified sensitive information. Special information protection (information barrier) techniques will most likely need to be incorporated into the design and assembly of the measurement system. But also, the measurement system will need to be owned and operated by the host country. Authentication of the measurement system results thus becomes the critical issue. How does the inspecting party verify that the complicated inspection system, owned and operated by the inspected party (because once it is used for the first time it will henceforth be a classified data acquisition system) yields valid and trustworthy results? It is this issue that must be demonstrably solved before a radiation signature system is available to monitor nuclear warheads and their associated components and materials cooperatively. The good news is that the United States and the Russian Federation are making good cooperative progress on this problem, but we are not there yet.

Tags and Seals: It is true that there are a wide variety of tags and seals that can be in principle applied to such items as launchers, warhead containers, and storage rooms, and that some can even be interrogated remotely. But there are only a very, very select few of these types of devices that can be trusted, because of their very high degree of tamper resistance, to be worth much in a nuclear arms reduction environment. Yes, the use of most any tag or seal typically brings with it the right of inspection, and therefore an inspecting party occasional on-site presence. This right should not be under-valued. But to believe that there is a wide variety of tags and

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seals that could be used to uniquely identify, and therefore accurately count, launchers, warheads or their containers is wrong because most are too-easily counterfeited, or too easy to remove and replace without detection. The use of any such technology in a cooperative environment will require that all the features of the tag or seal be known -- making it that much more vulnerable to tampering. There are only two passive methods that have passed muster in the US technical community and were once accepted by the US Government for use on strategic items in an arms reduction environment (investigated for the original START agreement): a tag made of a uv-cured slurry containing micaceous hematite that produced a highly unique and acceptably invulnerable light pattern that could be recorded, and a tag based on the unique intrinsic sub-surface ultrasonic reflection pattern of the interrogated item, similar to technology used in medical and NDT applications. It is the new generation of active (electrically powered) tags and seals that offer the greatest resistance to tampering using embedded cryptographic keys and other tamper sensors. However, they have a huge fundamental problem: there are no long-lived batteries or other miniature power sources for these devices. Thus, they have to be maintained too frequently (2-3 years), offering an excuse for frequent access and change-out that run counter to the whole purpose of tags or seals.

While CISAC, including the authors of the published article, and the National Academy of Science are to be truly lauded for their effort to comprehensively assess the (cooperative) monitoring of nuclear weapons and nuclear-explosive materials, the problems are not as easily solved as portrayed. In several critical areas, in contrast to what has been suggested, the problems have not yet been solved and the technologies do not yet meet the inherent standards required.

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1988-2003 --Member/Chairman, Information Barrier Working Group, US DOE

1997-1998 --Chairman, Nuclear Warhead Radiation Signatures Peer Review Group, US DOE

1991-1993 --Chairman, Tagging Laboratory Advisory Group, US DOE

1990-1992 --Executive Secretary, President's Warhead Dismantlement and Fissile Material Control Advisory Group (Robinson Committee)

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NEWS

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- Finally, students involved in projects applying physics to social issues will communicate their excitement to fellow students and faculty members in their institutions and nationally, thus raising the awareness of the entire physics community.

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Orbach Sees Promising Future for Science at the Department of Energy

"Both the Senate and the House have expressed their confidence in you, the scientific community," Under Secretary for Science Ray Orbach told the Basic Energy Sciences Advisory Committee on August 3. Orbach made a number of important points during his 45-minute presentation about the FY 2007 appropriations outlook, his new position, how basic and applied research programs at the Department will improve their communications and coordination in the future, and ITER.

Orbach was very pleased with how the House and Senate appropriations committees have fully funded the 14.1% requested increase for the Office of Science (see <http://www.aip.org/fyi/2006/088.html>.) Of particular note was how the committees added additional money for congressionally-earmarked projects above the President's request, something that Orbach had not seen in the last five budget cycles. These recommended increases demonstrate the confidence and commitment that Congress has in the Office of Science, he said, adding that the consequences of a doubling of the Office's budget over ten years would be "phenomenal."

When the Congress will finish work on the FY 2007 funding bill is uncertain, with it looking "increasingly likely," Orbach told the committee, that the legislation will not be finished until after the November election, at least a full month into the new budget year. "We don't know" what the

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NEWS (continued)

consequences of that delay would be on DOE's science programs, he added. If stop-gap funding continued at the current level it "would really hurt the new initiatives" the department wants to start.

The Energy Policy Act, now one year old, established the position of Under Secretary for Science. For the remainder of this Administration, Orbach will "dual hat" this position and that of the Director of the Office of Science (Orbach explained that future Energy Secretaries will have to decide how to staff these positions.) On July 3, Energy Secretary Samuel Bodman sent Orbach a memorandum stating: "the primary responsibility of the Under Secretary for Science is to advance the science portfolio at the Department of Energy and to strengthen the contributions of science to all of the Department's activities in collaboration with the Under Secretary and the Under Secretary for Nuclear Security." In addition, the memo stated, "to work collaboratively with the Under Secretary and Under Secretary for Nuclear Security to review all applied research programs in the Department to better coordinate these programs with the Department's basic research programs. . . ."

This memo, Orbach explained, gives him the mandate to work with the Department's applied research programs. It is his goal to develop better communications between basic and applied research programs at the Department, while maintaining the integrity of the Office of Science. He quickly added that he does not want to "fuzz" the boundaries between Office of Science programs and applied research programs. Reaction within the Department to increasing communications has been "very positive," he said.

Orbach gave a number of examples of what he envisions. The National Ignition Facility is scheduled to come on line in 2010. Operation of this facility will provide unanticipated "surprises," and Orbach wants basic research scientists to be involved. He said it is not clear where stockpile stewardship ends and science begins when the NIF achieves ignition. Other examples of areas requiring collaboration and coordination between basic and applied research programs are advanced nuclear energy systems, alternative energy, hydrogen, materials, high-performance computing, and carbon sequestration. "We can learn a lot" at the interface, he told the committee.

In response to a question, Orbach said the department is still in the process of responding to the Senate Appropriations Committee report language calling for the establishment of a new Office of High Energy Density Physics (see <http://www.aip.org/fyi/2006/088.html>.) He explained

that the federal government has not dealt effectively with research in this area, adding that a task force report on the opportunities in this field is due in December.

Regarding ITER, Orbach said the agreement has now been sent to Congress for its review. He anticipated there will be a formal signing of the document in mid to late November of this year.

FYI

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Is Congress Getting the S&T Analysis It Needs?

"We do not suffer from a lack of information here on Capitol Hill, but from a lack of ability to glean the knowledge and to gauge the validity, credibility, and usefulness of the large amounts of information and advice received on a daily basis."

- Rep. Rush Holt

On July 25, the House Science Committee heard from Rep. Rush Holt (D-NJ) and four other witnesses that Congress lacks an effective mechanism for sorting through the vast amounts of scientific and technical information that it receives on many issues, and identifying various policy options and their ramifications. They discussed the sources of S&T policy analysis currently available to Congress, as well as the benefits and shortcomings of the Office of Technology Assessment (OTA), a congressional support office that conducted such analyses from 1972 until 1995, when its funding was terminated as a budget-cutting measure.

The purpose of the OTA, Holt said, was to "inform the policy debate with assiduous and objective analysis of the policy consequences of alternative courses of action" and consider "the various outcomes given particular policy choices," without making any recommendations. When OTA was eliminated, Members of Congress believed "technical assessment could come . . . through committee hearings, CRS reports, experts in our district, think tanks, and the National Academy of Sciences," he said. "In the ten years . . . [since the OTA was eliminated] we have not gotten what we need in order to do the people's work." Holt has been active in trying to resurrect some version of the technology assessment office. However, witnesses and Members alike acknowledged that negative perceptions of OTA's timeliness and responsiveness would

make reviving it a difficult task. Science Committee Chairman Sherwood Boehlert (R-NY), who had supported OTA, remarked, "I think we need to get beyond the debate about reviving it". He also pointed out that in many cases the problem was not that Congress lacked sound analyses, but that it did not have the political will to make the appropriate policy decisions. "You can lead a horse to water but you can't make it drink," he said.

"Much of the information we receive comes from advocates selling their point of view," said Ranking Minority Member Bart Gordon (D-TN), adding that Congress could certainly use an in-house entity to help "in sorting through the conflicting expert opinions." Of the other sources of policy analysis available to Congress, Jon Peha of Carnegie Mellon University noted that broad, comprehensive assessment of S&T topics was beyond the traditional purview of the Congressional Research Service (CRS), the Government Accountability Office (GAO), and the Congressional Budget Office (CBO). Peter Blair of the National Academy of Sciences explained that while Congress relies heavily on the National Academies and the associated National Research Council (NRC) for their reports on S&T issues, the NRC generally uses a time-consuming process to form a committee of expert volunteers who review the issue and present consensus recommendations. This process, Blair said, "is less well equipped to elaborate on the broader context of an issue" and analyze "the policy consequences of alternative courses of action, especially those that may involve value judgments and trade-offs." He suggested that the NRC might be able to expand its role to take on that type of analysis. Blair and others also had positive comments about a pilot program of technology assessment by GAO, but warned that such a program would have to compete for resources with GAO's more traditional role.

"Do adequate resources exist for Congress to address these issues? From our perspective, the answer is no," declared Al Teich of the American Association for the Advancement of Science (AAAS). "Information is abundant, but objective, timely, policy-relevant analyses, which is what Congress really needs, are in short supply." Teich and Catherine Hunt of the American Chemical Society described efforts by scientific societies to inform Congress, including briefings, testimony, letters, reports, and other interactions.

Boehlert and other members of the committee praised the AAAS for its Science and Technology Policy Fellowships as a valuable source of S&T advice for Congress. Through this program, many scientific

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societies sponsor scientists and engineers to spend a year in Washington, providing expertise to the federal government (see <http://www.aip.org/fyi/2006/104.html> for details on such Fellowships, including two run by the American Institute of Physics). Speaking "on behalf of the entire committee, both sides," Boehlert called the Fellowships "a wonderful program, warmly embraced by all." While some former Fellows stay on Capitol Hill to aid Congress as permanent staffers, he noted, others return to the scientific community with a better appreciation for how the political process works. That is "good for science," Boehlert said, "because I find that in most instances . . . scientists are not effective at lobbying for their interests."

Rep. Dana Rohrabacher (R-CA) criticized the OTA for being a slow, inefficient, added layer of bureaucracy. He instead advocated the use of outside consultants, and having "people on both

sides of a scientific issue debating it here in front of us." Teich responded that the many competing sources of information are "part of the problem." Boehlert and Gordon defended the OTA's record, saying that it never received sufficient resources to respond promptly to all the requests it received. Citing a list of OTA reports, Holt said they were so timely and relevant that many are still useful today.

Gordon asked the pros and cons of resurrecting OTA; all agreed that any new technology assessment organization should learn the lessons of OTA and react more nimbly, interact more regularly with congressional staff, provide more interim results, and collaborate with other congressional support agencies and outside experts. Rep. Al Green (D-TX) questioned how such an entity could avoid becoming a victim of a "shoot the messenger" reaction if it produced analyses that one party or other did not like. Holt stated that it must

be "scrupulously nonpartisan," and Peha recommended that it receive funding for more than one year at a time and have careful oversight of how topics for analysis were chosen, to ensure that both the majority and minority "feel their issues are represented."

After OTA's demise "we have made due, not particularly well, but not particularly badly either" said Rep. Vern Ehlers (R-MI) in closing. He concurred with the value of an organization like OTA, and wished Holt luck in reviving it, but warned that it would be hard work "to make it come about."

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REVIEWS

National Science Foundation Facility Plan, September 2005

Available at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05058

As a fairly general report, the National Science Foundation Facility Plan does not contain any revolutionary piece of information – nor should it, since that is not its primary purpose. However, this sixty-odd page report presents an accurate overview of some of the trends in the development of the material basis of the sciences, namely, the technological platforms upon which major research projects will be conducted in the years to come. Dealing with phenomena that occur on a vast range of temporal and spatial scales, the research equipment showcased in the NSF Facility Plan is a testament to the diversity of science's interests and areas of application. But perhaps more importantly, it is evidence of the magnitude of NSF-funded scientific endeavors and of the growing integration of different strands of knowledge in elaborate large-scale interdisciplinary projects.

The NSF Facility Plan consists of three sections, the first being an introduction to the financial nature of the Foundation's operations (in essence, a brief description of the Major Research Equipment and Facilities Construction account, the MREFC). The second section presents a fairly general description of some of the scientific questions that have been identified in projects dealing with different scales of nature, from the subatomic to the cosmological. Most of the challenges mentioned in this section are

well-known within the scientific community. They include such things as the need to understand the manner in which biological systems assemble themselves; the processes through which new material structures and nanoscale devices can be manufactured efficiently; the properties of new states of matter; the behavior of the Sun and other celestial bodies; the fundamental nature of physical forces and of the elements and structure of the universe, just to mention a few. Of particular interest, however, the report opens with a reference to the areas of science studying mesoscale phenomena, including complex social, economic and environmental processes that require "researchers to view holistically different kinds of interrelated phenomena that have never been regarded as systems" (p. 8). In this sense, the NSF Facility Plan mirrors a relatively recent premise of science, that is, the search for an interdisciplinary understanding of planetary processes and their relation with human societies.

The third section of the report summarizes some of the current and projected facilities financed by the NSF. With an estimated expenditure of nearly 1.5 billion dollars for the 2004-2010 period, the thirteen MREFC projects include research in the following three areas:

(1) Astronomy and astrophysics, including the Atacama Large Millimeter Array which will produce "the world's most sensitive, highest-resolution, millimeter wavelength telescope" (p. 20), the IceCube Neutrino Observatory, the world's "first high-energy neutrino observatory" (p. 24) located under the ice of the South Pole, and the Advanced

Laser Interferometer Gravitational Wave Observatory, that might allow researchers to detect for the first time gravitational waves.

(2) Earth and environmental sciences, including EarthScope, the High-performance Instrumented Airborne Platform for Environmental Research, the National Ecological Observatory Network, the Network for Earthquake Engineering Simulation, the Scientific Ocean Drilling Vessel, the South Pole Station, the Ocean Observatories Initiative, and the Alaska Region Research Vessel, altogether part of the quest for a better understanding of the dynamic nature of our planet.

(3) Supercomputing, including the development of Terascale Computing Systems, a project that funded the construction of the Extensible Terascale Facility, aimed to increase the simulation and analysis capabilities of a growing community of researchers who rely on state-of-the-art computation either for research or education purposes.

Perhaps symptomatic of the bloated budgets that have characterized high-energy particle physics over the last two decades, the report mentions the cancellation in August 2005 of the Rare Symmetry Violating Processes project which sought to explain the predominance of matter over antimatter as well as the physical differences between the electron and the muon. Other projects that are still in the exploratory phase (such as the Coherent X-Ray Light Source, the Interferometric Synthetic Aperture

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Radar, and the Petascale Earth System Collaboratory) are also mentioned in the final part of the report.

Some of the overarching themes that permeate the report merit attention since they confirm some of the current trends in large-scale research projects. International collaboration is a recurring characteristic in several of the projects mentioned in the NSF Facility Plan. Based in Chile's northern region, the Atacama Large Millimeter Array serves as a good example of how the convergence of researchers, knowledge, technologies and funds from different countries leads to the materialization of an ambitious project that would otherwise be difficult to attain. The IceCube Neutrino Observatory is likewise the product of international collaboration, since it involves the participation of American, Belgian, German and Swedish institutions. The National Ecological Observatory Network also considers international participation through the counsel of Argentinean, Canadian and Mexican organizations.

Education and outreach are also stressed in the report, in particular as significant outputs of the equipments and facilities. The Atacama Large Millimeter Array, for instance, is planned to be used by nearly 300 students annually, thereby playing a "central role in the education and training of U.S. astronomy and engineering students" (p. 20). In this sense, the equipments and facilities envisioned by the NSF will not only provide existing scientists with the capability to undertake revolutionary research but will also allow a new generation of researchers to become familiarized with the tools of the trade. In this way, the projects developed under the NSF's auspices are defining and securing the road for the science of the future.

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Military Nanotechnology: Potential applications and preventive arms control

Jürgen Altmann, Contemporary Security Studies, 2006, \$105, 229 pages, ISBN 0-415-37102-3

Nanoscience, the study of interactions and dynamics at the scale of a few to a hundred nanometers, is hardly a new field. Materials scientists, chemists, and biochemists can lay claim to having helped uncover the workings of nature at these small scales. On the other hand, nanotechnology—the effort to apply this knowledge to produce useful products—is a field that has exploded in recent years. The American National Nanotechnology Initiative (nanoscience is

meant to be included in the initiative, but with somewhat less prominence) will fund well over \$1 billion in research this year, split among 23 agencies. One of a short list of items that have been supported with equal enthusiasm by Presidents Clinton and Bush, the National Nanotechnology Initiative (NNI) has grown rapidly over the past decade.

The NNI represents an agreement among scientists, policymakers, and the technology-based industries that have lobbied for it. In exchange for the money disbursed, which is on the scale of the math and physical sciences budget of the National Science Foundation or the high energy physics budget of the Department of Energy, nanotechnology researchers have promised to deliver a product.

Computers are at the center of this promise. With Moore's Law quickly edging towards physical limitations, faster computers will soon require new technologies at small scales. Coupled with speculative ideas of self-assembly and massive parallelism, many suspect that nanotechnology will dominate a new economy; governments are scrambling to ensure that they are included in that economy.

However, the nanoscientists' promise has a darker side. This year one-third of American nanotechnology research was funded by the Department of Defense; nanocomputers may be closely followed by nano-weapons.

These military applications attract Jurgend Altmann's attention in "Military Nanotechnology: Potential applications and preventive arms control." Altmann, a physicist by training, is an arms control expert, and this book is part of the German joint projects on preventive arms control, an effort to guide policy makers to consider the future proliferation implications of decisions they make today. Altmann gives a history of nanotechnology and a detailed overview of funding trends, proceeding to exhaustively list and describe potential military applications. His dry style and attention to detail make this a reference book for policy-makers, but not a pleasure read.

Altmann refers to specific goals of military groups such as DARPA, but he considers any physically possible technology. Computers for simulating nuclear weapons tests and codebreaking seem unimaginative next to clothing that provides camouflage in any surroundings, delivers medication to injured body parts, and stiffens to brace broken bones or increase a soldier's strength. Wilder ideas include armies of tiny self-replicating robots that can destroy equipment or fly undetected into a building for surveillance.

Ethical or legal concerns raised by these

devices are largely ignored; Altmann is interested only in arms control implications. He challenges governments that are paying dearly to develop these new technologies to weigh the benefits against the dangers of proliferation. Altmann believes that the best way to prevent the proliferation of weapons is to avoid developing them in the first place. He offers specific criteria for determining which technologies should be allowed and which should not. A technology worth developing should not endanger existing arms control agreements or humanitarian laws; it should promote stability, and not arms races; and it should protect people, the environment, and society. Altmann judges the list of technologies he has compiled by these criteria. For example, non-metal weapons are likely to be more useful to terrorists than to soldiers; he advocates that no such weapons be developed.

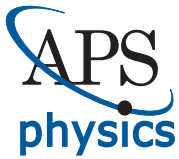
Some cases are more ambiguous; small, self-sufficient sensors could help arms control through verification. However, Altmann worries that undetectably small sensors would be destabilizing—such sensors could improve targeting so that a counter attack becomes impossible, and the incentive for preemptive attacks or hair-trigger responses would consequently grow. He also acknowledges that already existing technology must be permitted to remain in use for his prescription to be practical. From these concerns, Altmann arrives at a carefully worded ban of self-sufficient sensors below a certain size, leaving the way open for verification tools and existing devices.

Speculative systems that integrate small machinery within a human body for the purpose of improving memory, reaction time, endurance, or even controlling moods are discussed, but Altmann shies away from tackling questions that quickly become ethical ones. He advocates a moratorium on such systems until civilian society can reach a consensus on what is appropriate.

For each type of military nanotechnology, Altmann finds possible realizations that could break his rules of stability and protection, and he suggests a strategy for outlawing the worst implementations. He carefully avoids interference with helpful devices or products already in use, as such interference would make his proposals difficult to accept. To these recommendations he helpfully adds suggestions for verification of compliance, rounding out a complete arms control paradigm for nanotechnologies yet to be invented.

Many would argue that it is impossible to develop the good technologies without the bad, and that chance will determine

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the products of the nanotechnology initiative rather than design. But physicists have entered into a dangerous bargain in selling nanoscience as a product-driven endeavor. When research is so tightly linked to technological results, researchers accept a greater obligation to consider the real-world consequences of their work. One cannot justify research with promises of positive technologies, and then refuse to take responsibility for negative technologies resulting from the same science. There is a price to be paid for the generous NNI budget: ensuring that the work is driven by products that society wants to have.

Altmann's attempt to identify worthwhile nanoresearch within the military is a clear framework by which to judge the impact of technology before it has arrived, and to better steer our efforts towards positive outcomes. As such, it offers a good starting point for informing a necessary discussion on the goals of nanotechnology.

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