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Editor's Comments

When I became editor of *P&S* just over a year ago I looked forward to reading contributions on a variety of subjects, and I have not been disappointed. For this edition our Forum News includes a report on the Forum Executive Committee Meeting that was held during the Washington, DC, APS meeting in February, and an informative summary of FPS-sponsored or co-sponsored sessions held during that meeting. Reprints of statements from the American Association of Physicists in Medicine and the AIP respectively address radiation exposure and the appointment of a commission by the Secretary of Energy to advise on issues concerning spent nuclear fuel and nuclear waste. (As this issue of *P&S* was being prepared for publication, an AIP FYI reported on testimony before the Congressional Subcommittee on Health of the House Energy and Commerce Committee on the need for stronger federal regulation of medical radiation diagnostic and treatment procedures.) We also have an exchange of letters on global warming and commentaries on three very different topics: the risks of alternative medicine, the need for an Advanced Research Projects Agency for Commerce, and energy policy. Our feature articles concern tips for communicating science to the media and the issue of federal involvement in isotope production, and our book reviews examine treatments of U.S. science policy in the twenty-first century and a look at the life of Werner Heisenberg and the German nuclear energy program.

As always, we hope you find these articles enjoyable and though-provoking, and welcome your contributions. I especially encourage those of you who have presented papers at Forum-sponsored sessions the APS meeting to write up your talks for the Newsletter.

—Cameron Reed

IN THIS ISSUE

FORUM NEWS

Report on Forum Executive Committee Meeting

Cameron Reed, Editor

The annual meeting of the FPS Executive Committee was held in the Capitol Ballroom of the Marriott Wardman Park Hotel, Washington, DC, 8-10 am, Monday, February 15, 2010. Present were D. Prosnitz (outgoing chair), C. Ferguson (incoming chair), P. Bhat, J. Clark, M, Goodman, D. Harris, L. Santos (by telephone), B. Schwartz, B. Tannenbaum, R. Wiener, and P. Zimmerman. Newsletter Editor C. Reed and Assistant Editor J. Wurtele were also present, as was Editorial Board Chair B. Levi (by telephone).

Discussion opened with Bhat summarizing the Forum budget, which has a balance of about $55,000. Major expenses over the past year included travel ($29,000) and student fellowships ($8,000).

Schwartz summarized Forum-sponsored sessions to be held at the upcoming March meeting in Portland, OR. Zimmerman then summarized POPA deliberations on downsizing of nuclear stockpiles and clarification of the Society's global-warming statement. This was followed by some discussion of the makeup of Forum committees (Fellowships, Awards, Nominating).

Discussion then turned to a draft Travel Policy that Prosnitz had circulated. There are some questions on this issue that require discussion with Society officers.

Discussion was held as to how the Forum might help to best inform its members on the science of climate change, with venues such as workshops and newsletter articles being proposed.

Reed briefly summarized the status of the newsletter before the meeting adjourned at about 9:50 am.

FPS-Hosted Sessions at the APS April Meeting

Charles Ferguson, FPS (cferguson@fas.org), with contributions from Cameron Reed & William Happer

The annual APS "April" meeting was held in Washington, DC, 13-16 February 2010. The Forum on Physics & Society hosted or co-hosted six sessions on a variety of topics including art and physics, secrecy and physics, nonproliferation, physicists inside the "beltway," energy education, and the awarding of the Burton Forum Award. The following paragraphs briefly summarize the papers presented. The complete scientific program of the meeting can be found at http://meetings.aps.org/Meeting/APR10/Content/1786. Unfortunately, due to weather conditions, some speakers were unable to make the meeting. Brief biographies of speakers who are new Forum-sponsored APS Fellows appeared in the January edition of *P&S*.

Session A5: ART AND PHYSICS. This session was chaired by incoming FPS Chair Charles Ferguson. Jim Sanborn led off, speaking on the perspective of an artist inspired by physics. Using digital images and video, he presented thirty years of science-based artwork from 1970s-era museum installations to a series of large format projections on the landscape in the western US and Ireland which emulated the 19th century cartographers hired by the United States Government to map the western landscape. He discussed *Kryptos*, his commissioned work for CIA Headquarters, in which he has embedded a coded message that still has not been fully deciphered after more than 20 years. In the past ten years, he has achieved growing recognition from physicists for his work, *Critical Assembly*, in which he recreates aspects of the Manhattan Project, including facsimiles of the cores of the first nuclear bombs. His current project, an installation titled *Terrestrial Physics*, is a recreation of the particle accelerator used in the experiment that fissioned uranium in 1939 at the Carnegie Institution in Washington DC. This will be shown in June 2010 at the Museum of Contemporary Art in Denver.

Felice Frankel of Harvard University then spoke on "More Than Pretty Pictures: How Translating Science Concepts into Pictures Advances Scientific Thinking." Her talk addressed how the judgment and decision-making required to render science visual can help to clarify thinking. She argued that in a visual presentation of science one must decide on a hierarchy of information: what must be included and what might be left out? Thus, as in writing an article or responding to a question, we must understand and then plan what we want to "say" in a drawing or other forms of representation. Since a visual representation of a scientific concept is a representation and not the thing itself, interpretation or translation is involved. The process tends to transcend linguistic and educational barriers and so attract and communicate to students and teachers of all backgrounds, rendering the images, in essence, as more than "pretty pictures." While her collaborator, George Whitesides of Harvard University, was not able to attend the meeting to speak on "Using Art to Teach Science," Frankel concluded her talk by discussing this research, in which students supplement their learning of science by drawing pictures of concepts. For example, she showed a student's cartoon sketch of bumper cars colliding to try to illustrate Brownian motion. Frankel asked the audience to discuss what is wrong with the picture. One misconception is that the picture did not depict the underlying "sea" of jostling molecules that cause the Brownian "bumper cars" to move the way they do. Frankel's demonstration underscored that "picturing to learn" techniques quickly allow teachers to understand and correct students' misconceptions. Frankel and Whitesides have an archive of more than 3,500 student drawings.

Session B5: SECRECY AND PHYSICS (jointly sponsored with the Forum on the History of Physics and AAPT). This session was chaired by Peter Galison of Harvard University, who also gave the first paper, "Secrecy and Physics." He pointed out that while secrecy in matters of national defense goes back far past antiquity, our modern form of national secrecy owes a huge amount to the large scale, systematic, and technical system of scientific secrecy that began in World War II and came to its current form in the Cold War. He reviewed this trajectory and then discussed some of the paradoxes and conundrums that our secrecy system offers us in the Post-Cold War world.

Steven Aftergood (Federation of American Scientists) then spoke on "Secrecy and Physicists: Intersections of Science and National Security." He began by reminding the audience that physicists have been both proponents and critics of government secrecy: Enrico Fermi wrote in *Physics Today* that "… secrecy was not started by generals … but was started by physicists …", while scientists such as Edward Teller and Frederick Seitz argued that secrecy in science and technology could be reduced by 90% or more. He then reviewed the current landscape of secrecy in science and recent controversies involving publication of nuclear weapons physics, the infrastructure of nuclear research, and prospects for secrecy reform.

William Happer of Princeton University then spoke on "How Much Secrecy?" Happer argued that the need for some secrecy to optimize the well being of societies has been recognized since antiquity, but that it is also clear that too much secrecy is counterproductive and that the right balance depends on how pluses and minuses of secrecy are weighed against other important values. Too much secrecy tends to be a more common problem than too little. The only real quality control of secret programs, review by impartial committees with all the appropriate clearances, is often ineffective because committee members are not fully independent of the program they are reviewing, a situation which leads to a violation of James Madison's precept: "no man is allowed to be a judge in his own cause." He went on to say that misuse of secrecy is not exclusively a disease of governments; it can also be misused by agenda-driven, non-governmental organizations, and that here are many regrettable examples of the misuse of secrecy by the mass media. The credibility of all of science has been seriously harmed by the recent misuse of secrecy by some parts of the climate-change community.

Session D5: NONPROLIFERATION. This session was chaired by Ferguson. Frank von Hippel, the Leo Szilard Lectureship Award winner and a physicist from Princeton University, started off by discussing the work that he and the International Panel on Fissile Materials (IPFM) has been doing in recent years. The IPFM has been raising awareness of the many hundreds of metric tons of highly enriched uranium and plutonium in both the military and civilian sectors. Von Hippel presented many tables of data illustrating the amounts and locations by country. Although President Obama has made securing all vulnerable nuclear material a priority, von Hippel emphasized the numerous challenges remaining in securing and reducing fissile material. For example, the high cost of burning up military plutonium in reactors has stymied reducing this stockpile. Adding to this problem is the ongoing separation of plutonium from civilian spent fuel in France, India, Japan, and Russia. South Korea has expressed interest in pyroprocessing, which some have claimed is a proliferation-resistant form of reprocessing of spent fuel, but von Hippel presented technical arguments for why there remains concern about this activity. The potential for major expansion of nuclear power worldwide may lead to more countries' reprocessing spent fuel to reuse plutonium. Thus, von Hippel urged governments to form better policies now to head off the potential for more proliferation.

The next speaker was Pavel Podvig from Stanford University. He discussed the complexities of the renewed nuclear arms control talks between Russia and the United States. The two countries are trying to conclude a follow-on treaty to the 1991 Strategic Arms Reduction Treaty (START). START expired on December 5, 2009. Podvig explained that festering concerns blocked the negotiating teams from concluding a new treaty before that date. One concern is how to count the number of warheads attributable to each delivery system. For example, the United States has a large upload potential for the

Trident missiles on ballistic missile submarines. The United States is worried that Russia has far more tactical nuclear weapons. But Podvig argued that the disparity is not as big as it may seem because many of Russia's so-called tactical nuclear weapons are dedicated to air defense and naval weapons such as torpedoes, which are unlikely to serve an effective military role. Podvig pointed out that the tactical nuclear weapons issues will have to be dealt with separately from the strategic arms treaty. Two other concerns that he discussed in detail are U.S. missile defense and conventionally armed Trident missiles. In both areas, Russian military planners have expressed fear that these systems could eventually give the United States a advantage. But as long as the U.S. missile defense system is directed at the Iranian and North Korean missile threats and is not capable of shooting down Russian ballistic missiles, and as long as the United States only deploys relatively few conventionally armed Trident missiles, Russia should have reassurance that these U.S. capabilities will not upset the potential for deeper nuclear arms reductions.

Concluding the session, Siegfried Hecker, co-director of Stanford's Center for International Security and Cooperation and a 2010 APS Fellow, gave a talk titled "In Search of Plutonium: A Nonproliferation Journey." One of the world's leading experts on plutonium, the most chemically complex element, Hecker led listeners through his life experiences as a metallurgist and former Director of Los Alamos National Laboratory who has made seminal contributions to national and international security. Toward the end of the Cold War, he helped launch the lab-to-lab program that brought together American and Soviet scientists working in their respective countries' nuclear weapons complexes. This program was instrumental in facilitating implementation of improved security of weapons-usable materials. Since Hecker has been with Stanford University, he has reached out to North Korea and India. Having made six visits to North Korea, Hecker has helped to increase outsiders' understanding about North Korea's nuclear weapons program. For example, the North Koreans showed Hecker plutonium that they had made; the message was that North Korea had a nuclear weapons capability. This demonstration occurred prior to North Korea's first nuclear test in October 2006. Hecker's main message was that the scientists with expertise in nuclear issues have a responsibility to correct misconceptions of politicians. Returning to the case of North Korea, he underscored that a risk-based approach should prioritize three goals: no exports of North Korean fissile material or nuclear bombs, no more production of bombs or bomb-usable fissile material, and no improvements to their bombs. He concluded his talk with a display of images from North Korea depicting the human side of that pariah country. His message was clear that we must refrain from vilifying North Korea and focus on improved security for all nations.

Session P5: ENERGY EDUCATION (jointly sponsored with Forum on Education). This session was chaired by Ferguson. Richard Wolfson of Middlebury College and a 2010 APS Fellow, led with a talk on "Energy Education: The Quantitative Voice." A renowned educator with many books and public teaching to his credit, Wolfson captivated the audience with his everyday examples of how to teach students about energy. To illustrate the amount of work needed to light a light bulb, he asked a volunteer to turn a hand crank that could be connected to three types of bulbs: 60-watt incandescent, 100-watt incandescent, and a compact fluorescent rated equivalent to 100-watt incandescent. The volunteer had to exert considerable effort to keep the 100-watt incandescent lit while with relative ease the compact fluorescent could stay lit. Wolfson used this example to talk about the number of "energy servants" a typical American needs during the day. Because such an American demands about 10,000 watts of power, in effect about 100 energy servants would have to turn hand cranks. In comparison, a typical European only uses about half as much. Wolfson concluded his presentation with some back of the envelope energy calculations to show how to lead students through such calculations concerning important energy concepts.

The second and third invited speakers, Alan Meier and Mary Spruill, were not able to attend. To partially fill this gap, Charles Ferguson stepped in to talk about the work he has done in collaboration with Spruill of the National Energy Education Development Project and Frank Settle of Washington and Lee University. They have been partners on the "Nuclear Energy Education in the 21st Century Project." This project has reached out to different audiences: middle school and high school teachers, college professors, policymakers, non-governmental analysts, and nuclear industry officials. The project team has produced curricula (available at www.need.org) and numerous publications. Two forthcoming products are a multimedia guide to nuclear energy (available at www.cfr.org) and a book titled *Nuclear Energy: What Everyone Needs to Know.*

Session H5: PHYSICISTS INSIDE THE BELTWAY (jointly sponsored with AAPT). This session was chaired by Ferguson. The first speaker was Alan Sessoms, whose topic was "Perspective from Academia and Government." He discussed his more than four decades of experience as a physicist who had served in government and in recent years as president of the University of the District of Columbia. In the State Department, he worked on a variety of issues, including assessments of the potential for increased nuclear proliferation and analysis of the ability to detect nuclear tests. A main message was that government needs talented physicists. He concluded by discussing other job opportunities in non-governmental organizations such as think tanks and by describing his efforts to reform the University of the District of Columbia.

Sessoms was followed by Brendan Plapp (2000-2001 APS Congressional Science Fellow, currently with the Department of State), who spoke on "A Decade in DC: The Congressional Science Fellowship and Beyond." Plapp reviewed the APS Congressional Science Fellowship program, arguing that it presents a remarkable opportunity for individuals to make the transition from practicing science to developing public policy. He presented a sampling of his experiences in this career path, including in the legislative and executive branches and in the non-profit sector, along with some perspectives on the similarities and differences between doing physics and doing policy.

Peter Lyons, a consultant, who recently accepted the position of Principal Deputy Assistant Secretary of Energy for Nuclear Energy, who spoke on his "Perspective from Capitol Hill and the Nuclear Regulatory Commission." Lyons talked about how he had become a senior adviser to Senator Pete Domenici of New Mexico and the work he did for the senator on nuclear energy and national security. Having devoted much of his career to the Los Alamos National Laboratory, Lyons brought the skills of a practicing physicist to his government service on Capitol Hill, the Nuclear Regulatory Commission, and the Department of Energy. He encouraged younger scientists to consider work in public policy.

Session X5: BURTON FORUM AWARD. This session was chaired by Ferguson. This year the Joseph A. Burton Award was shared by Pervez Hoodbhoy and A.H. Nayyar, both from Pakistan. Hoodbhoy, the chairman and a professor of the Department of Physics at Quaid e Azam University, traced his awakening to his life's mission of helping to reform Pakistan's educational system to his education at MIT, where he was inspired by Philip Morrison and Victor Weisskopf. Around that time, Carl Sagan's Cosmos television series showed Hoodbhoy the power of television to educate the public about science. Using this model, Hoodbhoy created numerous science education broadcasts for Pakistani television. This activity was only a small part of his educational work. Pakistani students have suffered from a system that emphasizes rote learning and bows to Islamic fundamentalism. Hoodbhoy said that he believes in science as a means to open minds.

Like Hoodbhoy, Nayyar has devoted his life to stopping the nuclear arms race in South Asia. Similarly, he served on the faculty of the Department of Physics at Quaid e Azam University. He is presently working at the Sustainable Development Policy Institute in Islamabad. Nayyar focused his talk on his and others' efforts to inform the public about nuclear issues and on the complexities of halting the arms buildup. Through displaying images and texts, Nayyar demonstrated how the Pakistani government has used propaganda to mythologize the bomb and make it a national symbol of pride. He then discussed how the Pakistan Atomic Energy Commission, which is Pakistan's largest scientific society, has squashed dissenting voices. Analyzing current challenges, he explained that nuclear weapons issues are low on the list of public priorities because of the ongoing war on terrorism, the dismal state of the economy, and political crises. Moreover, the United States and other allies have eased up on pressure for Pakistan and India to pursue nuclear disarmament. Instead, the United States has worried about the threat of terrorists acquiring nuclear weapons, and this concern has caused Islamabad to fear that Washington wants to seize Pakistani nuclear assets. Furthermore, anti-American sentiment is growing in Pakistan. He outlined the tasks ahead: push for nuclear arms restraint; prevent internal breakdown in security; move to resolve the festering bilateral conflicts in South Asia; and press for global nuclear disarmament.

AAPM Statement on Radiation Exposure

[On December 21, 2009, a panel of experts at the American Association of Physicists in Medicine (AAPM) issued a statement calling for an open discussion of the facts about radiation hazards from computed tomography (CT) scanning in light of recent public concerns and news reports about excessive radiation doses. We thank the AAPM for permission to reprint the statement, which can be found at http://www.aapm.org/publicgeneral/CTDoseResponse.asp – Ed.]

AAPM Response in Regards to CT Radiation Dose and its Effects The American Association of Physicists in Medicine (AAPM) is a scientific and professional society comprised of scientists (medical physicists) who establish radiation measurement procedures and perform them on radiation emitting devices, including computed tomography (CT) scanners. There have been a number of CT related issues in the news over the past months pertaining to radiation dose, however there have been several misleading statements made with respect to radiation hazards from CT scanning. The AAPM believes in an open discussion, but one that is based on facts. The goal of this statement is to present these facts.

We should state from the outset that medical physicists are partnering with technologists, radiologists, regulators, manufacturers, administrators and others to strive for CT scans that are medically indicated; and when they are performed that the minimum amount of radiation is used to obtain the diagnostic information for which the CT scan was ordered.

CT Brain Perfusion Overexposures The Food and Drug Administration (FDA) issued an alert in regards to high dose levels used in head CT perfusion studies at a hospital in Southern California (1). Over 200 patients apparently received excess radiation during these time-lapse (repeated) CT studies of the head. Subsequently, similar incidents have been identified at two other hospitals in Southern California and potentially in other locations as well. Early investigations of these incidents revealed a misunderstanding of some of the automated dose selection features on the scanner, and this led to an estimated 8 fold increase in radiation to the patient. This was discovered when a number of the patients experienced some temporary hair loss (epilation) and skin reddening (erythema).

This incident apparently resulted from a lack of adequate training of CT technologists, and perhaps an overreliance on the use of preselected CT protocols. There is no excuse for such radiation overexposures, and improved training as well as machine interface features may need to be improved to prevent future occurrences. News of these incidents has led to a nationwide mobilization of medical physicists, working with hospital administrators, radiologists, and CT technologists to get a better handle on CT protocols at each individual institution. Longer term, the AAPM has responded to this incident by developing a scientific symposium on this topic to be held in late April 2010, which will be led by two medical physicists who have vast experience with developing and managing CT protocols at large institutions. This course will be open to lead CT technologists, radiology managers, radiologists, medical physicists, and all others interested in learning more about CT protocol optimization and management. (www.aapm.org).

Cancer Risks from CT in the United States Two articles were published back-to-back in the Archives of Internal Medicine (2,3) recently, suggesting that increased use of diagnostic CT leads to the cancer deaths of tens of thousands of Americans each year. The fact that large radiation exposures to an individual can cause cancer is not controversial, however the supposition that much smaller radiation exposures (such as with CT) to many individuals can cause substantial increases in cancer incidence is certainly controversial and not universally accepted. Indeed, many of the series of assumptions used in these articles (and their source materials) make use of worst case scenarios and most conservative assumptions. One example of this is in the Smith-Bindman article (2), where the risk of cancer was illustrated in Figure 2 for 20 year old women. The authors acknowledge that this is an extreme example because younger women are the most susceptible group to radiation induced cancers, even though the median age for women undergoing CT scans is well into the 5th decade (3); in fact CT scanning of women in their 20s is relatively uncommon.

If we accept the claim that 29,000 cancers were caused by CT in 2007 among the 70 million people in the U.S. receiving about 13.8 mSv from one CT session as reported in the Berrington de Gonzalez article (3), then it follows that 21,000 cancers are likely to be induced from background radiation levels of 3.1 mSv to the other 230 million Americans who have not had CT. The average background level of 3.1 mSv per year is 22% (3.1/13.8) of the average effective dose from CT.

Predicting cancer deaths from radiation is not the same as assessing deaths from other causes such as automobile accidents or gun shots – in these latter cases the victims can be counted without much ambiguity in the cause of death. Because radiation induced cancers are exactly the same clinically as normally occurring cancers, there is no way to know who died from a radiation induced cancer and who died from a naturally occurring cancer. This issue is compounded by the fact that the number of predicted radiation induced cancers is tiny compared to the very large cancer incidence rate in humans (~25-30%), making the impact of radiation on cancer rate very hard to measure.

Observations and Recommendations in Regards to CT Examinations Most of the 70 million CT scans performed each year in the U.S. are medically indicated, resulting in more accurate diagnostic assessment of patient health, which in turn results in more appropriate treatment and better health outcomes. Many CT scans, however, are ordered without sufficient medical justification and the most efficacious way to reduce CT radiation levels to the U.S. population is to substantially reduce unnecessary CT scans. Patients and their referring physicians should discuss the risks of a CT scan, as well as the risks of not having a CT scan (i.e. potentially compromising an accurate diagnosis). A radiologist should be consulted if there remains any ambiguity as to whether or not a CT scan should be performed. By confirming the presence or absence of disease or injury, an appropriately-ordered CT examination is of tremendous benefit to the individual patient, and far outweighs the radiation risks in the vast majority of cases.

Providers of CT scanning services – hospitals, clinics, and radiologists – have in general made good progress in reducing the dose levels of CT scanning, however the patient should ask the CT technologist if all appropriate measures for dose reduction for a particular CT study have been used – and if an adequate answer is not obtained from the technologist, they should insist on talking to the radiologist prior to the scan. Patients and referring physicians should inquire if their CT facility is accredited by the American College of Radiology – if so, this is an excellent way of assuring that the CT facility is practicing state of the art, low dose CT.

For a patient undergoing a specific CT scan, the factors which need to be considered for reducing dose include (1) the scanned area should be limited to the region of the body where the suspicion exists, (2) the CT technique factors should be adjusted according to the size of the patient's body – newer scanners can adjust radiation output automatically, which is useful, and (3) repeated CT scans should be avoided whenever possible, and certainly if the scans are only being repeated because the physician does not have access to the images from a recent CT scan.

The patients who experienced hair loss and skin reddening from head CT perfusion studies are in general gravely ill, many are comatose, and a large fraction will die from their head injury or stroke. Indeed, the procedure itself is one way of assessing brain death. The CT perfusion study gives practitioners essential guidance as to the need for or success of interventional procedures such as angioplasty or surgery. By comparison, patients with cancer routinely lose all of their hair when treated with some forms of chemotherapy, but this is presumed to be an acceptable consequence of the treatment. While there is no excuse for unnecessarily high radiation levels in CT perfusion, hair loss and skin reddening can and will occur even with appropriate levels of radiation when the procedure is repeated or is combined with other x-ray examinations such as interventional angiography.

Summary CT scans are a very important tool for diagnosis and assessment of response to treatment in the practice of medicine. The detailed assessment of anatomy and function that CT imaging provides does require the use of x-rays, which do result in some small, but not zero, risk to patients. Medical Physicists are working with technologists, radiologists, regulators, and manufacturers to assure that CT is practiced uniformly across the U.S. in a low dose manner.

(1) FDA Safety Investigation of CT Brain Perfusion Scans: Update 12/8/2009, accessed 16 Dec 2009.

(2) Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer, R Smith-Bindman, J Lipson, R Marcus, et al., Arch. Intern. Med. 169(22); 2078-2086 (2009).

(3) Projected cancer risks from computed tomographic scans performed in the United States in 2007, A Berrington de Gonzalez, M Mahesh, K-P Kim, et al., Arch. Intern. Med. 169(22); 2071-2077 (2009).

AIP FYI on Nuclear Waste

We reprint here, slightly edited, an article from the American Institute of Physics FYI news service regarding the issue of nuclear waste management. The original can be found at http://www.aip.org/fyi/2010/012.html. Another FYI on the same issue can be found on page 5 of our April 2009 issue.

Energy Secretary Steven Chu announced today (January 29, 2010) the appointment of a 15-member Blue Ribbon Commission that will, according to a statement, *"provide advice and make recommendations on issues including alternatives for the storage, processing, and disposal of civilian and defense spent nuclear fuel and nuclear waste."* The commission will be co-chaired by former Representative Lee Hamilton and Brent Scowcroft. An interim report is due in 18 months, and a final report within 24 months. The appointment of this commission is the latest step in a decades-long search for a lasting solution to the nation's management of nuclear waste. In the early days of the Administration of President Obama, Secretary Chu told Congress that the Yucca Mountain repository "is definitely off the table," declaring "I think we can do a better job." In announcing the commission, Secretary Chu stated that *"The Administration is committed to promoting nuclear power in the United States and developing a safe, long-term solution for the management of used nuclear fuel and nuclear waste. The work of the Blue Ribbon Commission will be invaluable to this process."*

This announcement and remarks made in President Obama's State of the Union Address further solidify the Administration's position on nuclear energy. Last year, senators and representatives asked Chu in the early months of the Administration about its commitment to nuclear energy. During his Address, President Obama spoke of "building a new generation of safe, clean nuclear power plants in this country." Chu was quoted in today's release as saying "Nuclear energy provides clean, safe, reliable power and has an important role to play as we build a low-carbon future." Carol Browner, Assistant to the President for Energy and Climate Change, stated that "As the world moves to tackle climate change and diversify our national energy portfolio, nuclear energy will play a vital role." The co-chairs' positions are also clear, with Hamilton saying, "Finding an acceptable long-term solution to our used nuclear fuel and nuclear waste storage needs is vital to the economic, environmental and security interests of the United States," and Scowcroft, who said, "As the United States responds to climate change and moves forward with a long overdue expansion of nuclear energy, we also need to work together to find a responsible, long-term strategy to deal with the leftover fuel and nuclear waste."

Other members of the Blue Ribbon Commission are:

Mark Ayers, President, Building and Construction Trades Department, AFL-CIO; Vicky Bailey, Former Commissioner, Federal Energy Regulatory Commission and Former Department of Energy Assistant Secretary for Policy and International Affairs; Albert Carnesale, Chancellor Emeritus & Professor, UCLA; Pete V. Domenici, Senior Fellow, Bipartisan Policy Center and former U.S. Senator (R-NM); Susan Eisenhower, President, Eisenhower Group; Chuck Hagel, Former U.S. Senator (R-NE); Jonathan Lash, President, World Resources Institute; Allison Macfarlane, Associate Professor of Environmental Science and Policy, George Mason University; Dick Meserve, Former Chairman, Nuclear Regulatory Commission; Ernie Moniz, Professor of Physics and Cecil & Ida Green Distinguished Professor, Massachusetts Institute of Technology; Per Peterson, Professor and Chair, Department of Nuclear Engineering, University of California–Berkeley; John Rowe, Chairman and Chief Executive Officer, Exelon; Corporation; Phil Sharp, President, Resources for the Future

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These contributions have not been peer-refereed. They represent solely the view(s) of the author(s) and not necessarily the views of APS.

LETTERS

In their response to my comments published in the January 2010 edition of *Physics & Society*, David Hafemeister & Peter Schwartz repeat some of the statements I commented upon, and refer to other sources to fill the gaps in their original tutorial. In summary, I insist that their simplified treatment, or for that matter the results of General Circulation Models, do not give convincing arguments for anthropogenic carbon dioxide being an essential factor behind the climate changes that have occurred over the last 100 years. The GCM's at best, offer a fit to sea level data, but the parameter values required for this agreement results in poor agreement with independent measurement at higher altitudes [1-4]. I add some further comments:

1. The authors claim that "The large natural fluxes of CO_2 are approximately balanced. The increase in CO_2 emissions from humans raises the CO_2 atmospheric concentration." This is claimed although the natural fluxes of CO_2 are more than 10 times larger than the anthropogenic contribution. No comment is made to the fact that they are coupled and dependent on the concentration in the atmosphere, that is, that the fluxes depend on the atmospheric CO_2 content such that if is higher, more is consumed both in photosynthesis (see below) and absorption by sea-water. IPCC has acknowledged this effect in their concern for CO_2 "sinks" which have systematically caused the measured CO_2 content to stay below their predictions. It is, for example, well-known, and even utilized as a source of fertilization, that that the photosynthetic process is more efficient and consumes more CO_2 if the atmospheric content of CO_2 is increased well beyond the present level. A further bonus is that plants that grow in an CO_2-enriched atmosphere have a lower density of stomata cells and therefore consume less water [5]. This may be a reason for the present shrinking of deserts [6]. It is also the background reason behind the use of stomata cell density as a proxy for atmospheric CO_2-content in past atmospheres [5].
2. My second remark was that Hafemeister & Schwartz's equations only treated radiative transport, leaving out important contributions from convection and phase change. The authors agree that these missing contributions exist, but mention that they have been considered in other treatments. This naturally raises the question of why their "radiation only" treatment gives the correct total result.

It is hard to avoid the impression that their use of atmospheric emissivity as an adjustable parameter, just after eq. 17 in their tutorial, "By adjusting e_a to 0.76, we obtain the 'correct' surface temperature, T_s = 287 K", is the reason for such a coincidence. I mentioned in my comment that the adiabatic model - without adjustable parameter – also gives the right end result. Yet, it is not correct.

3. Hafemeister & Schwartz repeat the mistake of considering only solar variations at the top of the atmosphere. The more relevant factor is the variation of solar intensity at the surface of earth, which is strongly modulated by low clouds. It is well-known that only a few percent change in this cloud cover is enough to change local and global average temperatures more than the increase of 0.6 – 0.8 C that we have observed over the past 100 years. IPCC admits poor basic knowledge about cloud formation mechanisms, and the formation of clouds occurs on a spatial scale that is smaller than cell size of the numerical models.
4. Finally, I am disappointed that Hafemeister & Schwartz have no comments to the four references [1-4] that give measured results challenging the high climate sensitivity values used in the numerical models. After their statement "It is our belief that 'theory leads experiment' on climate change," such comments should be of interest to the visitors of *Physics & Society*.

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These contributions have not been peer-refereed. They represent solely the view(s) of the author(s) and not necessarily the views of APS.

1. *R. W. Spencer et al., "Cloud and radiation budget changes associated with tropical intraseasonal oscillations." Geophys. Res. Lett. 34, L15707, (2007)*

   doi:10.1029/2007GL029698.
2. *David H. Douglass et al., "A comparison of tropical temperature trends with model predictions." Int. J. Climatol. 28, 1693–1701, (2008)*
3. *R. S. Lindzen et al., "On the determination of climate feedbacks from ERBE data," Geophys. Res. Lett. 36, L16705, (2009). doi:10.1029/2009GL03962.*
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5. *L. Kouwenberg, et al. "Atmospheric CO2 fluctuations during the last millenium reconstructed by stomatal frequency analysis of Tsuga heterophylla needles." Geology 33:1, 33 (2005).*
6. *Eklund L. and Olsson L. "Vegetation index trends for the African Sahel 1982-1999" Geophysical Res. Lett. 30:10.1029/2002GL016772 (2003)*

David Hafemeister replies:

We thank Professor Ribbing for his continued interest in our work. As we pointed out in our January 2010 response, our three-page paper contained some simple climate models, which were obtained from my text Physics of Societal Issues (Springer 2007). Let us take a moment to consider an even simpler model. In the building sciences we know that there will be a heat flow (dQ/dt) when there is a temperature difference between surfaces (ΔT) over an area (A) with thermal resistance (R), $dQ/dt = (A/R)\,\Delta T$.

The necessary temperature difference needed to expel the internal heat power through the thermal resistance in the steady state is $\Delta T = (R/A)\,dQ/dt$.

Note that an increase in R from increased carbon dioxide and other gases (absorption and re-radiation, convection) requires an increased surface temperature to force the heat power through the atmosphere to space. This is the basic cause of the warming: more thermal resistance requires a greater temperature difference to dispatch a given heat source in the steady state. To this, one must add positive feedbacks (more water vapor, less ice to reflect, methane release, IR absorption in clouds), which are larger than the negative feedbacks (reflecting clouds). Aerosols and volcanic dust lower surface temperatures, but these particles leave the atmosphere after a few years.

My simple models have been successful for non-climate physicists to understand the basic physics, but they clearly are not sufficient to determine policy, compared to the work of the professional atmospheric and climate scientists [1]. The IPCC global circulation model calculations agree with the time dependent temperature data over the past century ONLY if CO_2 absorption is taken into account [2]. The blue curves (natural forcing due to solar activity and volcanoes) remain relatively constant in temperature over the century. On the other hand, the red curves (both natural and anthropogenic forcing) separate from the blue curves in 1955, with an increased temperature of about 0.7°C in 2000.

Some climate skeptics say the Earth is cooling: But many skeptics plot temperature starting in 1997, where they should begin the plot 50 to 100 years earlier. The IPCC stated in 2007 that "eleven of the past 12 years (1995 to 2006 – the exception being 1996 – rank among the 12 warmest years on record since 1850." In the last few decades we have seen the area of the Artic Icecap reduced 7.5%/decade (from 8.5 Mkm^2 in 1979 to 6.5 Mkm^2 in 2009), the rapid rise in the melting of Greenland, twelve fewer days of frozen lakes, and a doubling of the ocean level rise rate. Our Alaska and your Lappland have increased in temperature by 1-2°C. It is unclear how skeptics can say the Earth's climate is cooling.

Other climate skeptics say the Earth is warming but argue that, rather than the warming being due to carbon dioxide, it is caused by a sun that is emitting more ultraviolet photons or increasing the flux of galactic cosmic rays that make clouds. This has been refuted by a variety of authors [3]. The main argument is that the 11-year solar cycle has been quite constant, not showing a trend over the past 30 years. The amount of extra ultra-violet photons and cosmic rays has been minimal; the sun did not cause significant warming of the Earth at the end of the 20th century.

Some climate skeptics say that CO_2 additions are irrelevant because its effect is saturated by the exponential absorption from a collimated beam of infrared photons. But this is not true for the atmosphere. Each micro-layer absorbs IR photons and re-radiates new IR photons, both up and down. As one goes higher in the atmosphere it is cooler, thus reradiating fewer IR photons upwards. It is this physics that produces considerable forcing from carbon dioxide; it is logarithmic in concentration and it is not a negative exponential with concentration. For today's increase of 2 ppm/year for a decade, the thermal forcing increases linearly with time. For a doubling of CO_2, the forcing is not doubled but increased by a factor of 1.69. Temperature increases (direct and feedbacks) are approximately proportional to the additional thermal forcing.

Some climate skeptics ignore the fact that carbon dioxide is now at 390 ppm, which is over 100 ppm above the pre-industrial revolution level of 280 ppm, and rising 2 ppm/year. This level will double somewhere in the next century, it is already the highest level in the past 650,000 years, which has always been less than 280 ppm. Carbon dioxide cycles in and out of the atmosphere over past ice age cycles, but at lower levels and a much slower rate. At the same time methane is now at 1800 ppb, compared to its pre-industrial value of about 600 ppb. It is the rate of change of carbon dioxide and methane that is worrisome since they are exploding the natural norms.

Ribbing holds out the hope that increased photosynthesis from raised CO_2 levels will help (with water), but not in all ecosystems, and the additional sequestering of carbon is far, far smaller than global emissions of 30 billion tons of CO_2 per year (now) to 50 billion tons in 2050. I wish there was an easy fix, but it will be difficult.

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These contributions have not been peer-refereed. They represent solely the view(s) of the author(s) and not necessarily the views of APS.

[1] *G. Schmidt, "The Physics of Climate Modeling," Physics Today 60, 72-73 (January 2007)*

[2] *Climate Change 2007: The Physical Science Basis (IPCC, Geneva, 2007), Fig. Summary-4.*

[3] *J. Lean, G. Rottman, J. Harder and G. Kopp, Solar Physics 230, 27 (2005). J. Lean, "Living with a variable Sun," Physics Today 58, 32-38 (June 2005), P. Duffy, B. Santer, and T. Wigley, "Solar variability does not explain late-20th century warming," Physics Today 62, 48-49 (January 2009).*

ARTICLES

Communicating Science to the Media

Kathryn Grim

Media interviews can be unfamiliar territory for scientists used to the discourse of the seminar room and laboratory. Unprepared interviewees can be caught off-guard by unexpected questions, which can potentially lead to inappropriate responses. For example, in May 2009, Comedy Central's The Daily Show ran a feature on the Large Hadron Collider. The satirical news program poked fun at the mainstream media for playing up fears that the LHC could create a black hole and destroy the Earth by feigning to approach their story biased in favor of this point of view. At one point an interviewer repeatedly tried to bait CERN physicist John Ellis with the mumbled question: "Evilgeniussayswhat?" Ellis mostly kept his cool, possibly in part because the CERN Press Office had warned him ahead of time about the comedic nature of the television program. While it is impossible to anticipate everything a reporter will ask you, it is possible to prepare for interviews with print, television or radio journalists. In this article I will provide a general overview of how the media works, what makes news and why, what reporters look for, and how to prepare for interactions with reporters in ways that will help get across your key message, avoid jargon, and provide good sound bites just in case The Daily Show ever comes knocking on your door.

A reporter wants to write or produce a piece that will interest readers, viewers or listeners. The seven qualities that make a story interesting are its impact, immediacy, proximity, prominence, novelty, conflict and emotion [1]. Audiences are interested in a story with impact, one that speaks about something that has an effect on them or their pocketbooks. A story is more newsworthy if it has immediacy—if it just happened or is about to happen. Reporters often search for stories with proximity because events that occur close to home matter more to readers. Audience members also care about stories involving people with prominence: celebrities or other well-known public figures. Articles can draw readers in with novelty: man bites dog. Finally, audience members are interested in stories with conflict and those that elicit an emotional response. If you can highlight one or more of these qualities in the story you'd like to tell the public, reporters will be happier to pick it up and their audiences will be more interested.

The first and most important way to prepare for an interview is to develop your key message. This should be one or two sentences that answer the questions: What is the main point of your story and why is it important? You should prepare to give more details to flesh out your story, but be sure to begin the interview by expressing your main point. It may be what you hope to discover. It may be that your experiment is the largest of its kind. It may be that you are using a novel method to make your discovery. No matter what your main point is, be sure to explain why people should care. What is your goal? What are you trying to do? How will this affect others?

Your key message should fit nicely into a sound bite. A sound bite could be a direct quotation in a printed story or a clip played on the radio or television. Reporters use direct quotations rather than paraphrasing your words when your words are specific, vivid, descriptive, or show your personality [1]. So if you speak only in bland phrases full of jargon, you make it hard for a reporter to find a way to make your subject look interesting. Prepare a few sound bites before an interview. Make sure they are one or two short sentences long, easy to remember and take ten seconds or less to say.

When preparing for an interview, you should be ready to answer seven basic questions about your research: Who is involved? What is it? When does it take place? Where does it take place? Why are you doing it? How are you doing it? Why should we care? Beyond these, there are other possibilities to prepare for: Is this research dangerous? What could go wrong? How much does it cost? Why wouldn't the money be better spent on finding a cure for cancer? These questions should not bother you. In fact, you should welcome them. A reporter's job is to ask the questions that his or her audience members would want to ask. Taxpayers want to know how their dollars are being spent. A reader who has a family member with a debilitating disease wants to know if our country's great scientific minds are wasting their time when they're studying something else. These people and their concerns matter. The better you can explain to them what you're doing and how it will benefit them, the better chance you have of gaining support for your research. The key is to be understandable and positive.

Part of being understandable is avoiding jargon, that is, words that make sense to a physicist but sound like gibberish to the rest of the public. There are two ways to deal with jargon. Either use it and explain it with a definition or an analogy or don't use it at all. To find examples of jargon explained, try reading the "Explain it in 60 Seconds" features from Symmetry magazine [2]. Here is how the magazine explained matter-antimatter annihilation: "[D]ig a hole, and make a hill with the earth you've excavated…antimatter will annihilate its matter counterpart in a burst of energy, just like the hill will fill the hole, leaving neither."

To avoid using jargon, think of another way to say what you'd like to say. To avoid having to explain what a nanometer is while describing the diameter of atom, describe how many atoms fit on a pinhead or compare the size of an atom to the diameter of a human hair. Stay positive. Do not repeat a negative idea, even to deny it. If a reporter asks you, for example, if your experiment is going to cause a black hole, it is better to say, "The experiment is perfectly safe" than "The experiment will not cause a black hole." Someone watching you say the latter on the news is going to wonder why you need to talk about the possibility of black holes at all. Most reporters would not use such a quote for the sole purpose of making you look suspicious. However, a good reporter cannot take the statement, "The experiment will not cause a black hole" to mean "The experiment is perfectly safe." You may say there will be no black hole, but perhaps your experiment will cause a huge ball of fire instead. Put things in a positive light; don't expect the reporter to do it for you. Before the interview, think of difficult questions you might face, and come up with positive answers.

You should also think of questions you would like to ask the reporter. What ground will you cover in the interview? What kind of message is the reporter looking for? How will the story be used? With what other material? Who else will be interviewed for this piece? If the piece is for radio or television, ask if the interview will be live or recorded. How long will the interview last? Where and how will it take place? If you are cold-called and asked to do a phone interview, tell the reporter that you are busy and set up a good time to call back. This will give you time to prepare. But realize that reporters are usually working on tight deadlines, so if you make them wait too long, they will have to find someone else to interview. Talking on the phone can feel comfortable and informal, perhaps too much so. To avoid saying something you will regret, imagine that someone whose opinion you care about is standing behind you as you talk.

Conversely, a live interview can make you nervous. If so, try to think of it as a social chat. If you are preparing for a television or radio interview, arrive early. If the interview is pre-recorded, feel free to ask to try to explain something again if you do not think you did well on your first try. During a radio interview, talking with your hands can make you sound more natural. In preparing for a television interview, check your appearance. Dress quietly, without bold patterns or dangly earrings. Wear summer-weight clothing, as studio lights are hot. Avoid wearing tinted lenses. If someone at the studio offers to change your clothes or makeup, trust him or her. During the interview, sit forward rather than leaning back, which will make you seem disengaged from the conversation. Do not cross or splay your legs. Look at the interviewer, not the camera, and use normal body language. If you are unsure where to look, ask.

During any interview, state the most important information first and give the background second. Keep your responses brief but long enough to give the reporter quotes to use. Stick to your key messages, repeating if necessary. Mention the subject you're discussing by name – rather than saying "it" or "this" – several times during the interview to create better sound bites, ones that need less or no introduction.

Do not overestimate a reporter's knowledge of your subject. Give background and set the record straight if the reporter seems to be asking a question based on incorrect information. Be sure to identify whether something is a fact or your opinion. Do not overstate your results; give the reporter enough background to explain if your results are conclusive or if further studies are required. If you do not understand a question, ask for clarification rather than risking a confusing answer. If you do not know the answer, tell the reporter you will get back to him or her; inventing something off the top of your head will come back to bite you! Just as you shouldn't make things up, you should also correct reporters when they are wrong. They will appreciate it. They do not want to look bad any more than you do, and mistakes in their stories reflect badly on them. But make sure to set the reporter straight without being argumentative. Realize that the reporter is the one who's producing the story. Don't make yourself look bad with combative quotes. If you are on a live program, realize that the audience is loyal to the reporter. If you try to make him or her look bad, it will wind up reflecting poorly on you. Instead, be enthusiastic about your research. Let people know what interests you. Your excitement could be infectious and will give you better quotes.

After the interview, be sure the reporter knows how to spell your name and your correct title or position. Don't expect to review the piece before publication, although you can offer to fact-check. The reporter may or may not take you up on the offer. Ask for a copy of the final product or to know when the piece will air. Ask for feedback so that you can be better prepared for your next interview. Thank the reporter for his or her time and interest. With any luck, you will be able to establish a professional relationship, and the reporter will use you as a source in the future.

Interviewing is a skill like any other; in order to improve, you need to practice. Explain your key messages to non-physicists. Ask non-physicists to interview you. Practice with a member of the public relations staff from your institution before being interviewed on the record. Watch, read or listen to reports on unfamiliar topics. Think about what interests you and what you remember. Try to listen to yourself that way. Finally, discuss upcoming interviews with your university or institution's public affairs office. They can offer advice, answer questions and serve as an excellent test audience.

[1] Harrower, Tim. Inside Reporting: A Practical Guide to the Craft of Journalism. New York: McGraw-Hill, 2007.

[2] http://www.symmetrymagazine.org/cms/?pid=1000253

Kathryn Grim is with the Office of Communication at Fermi National Accelerator Laboratory. This material was based on a presentation from the CERN Press Office, and was presented at the Division of Particles and Fields meeting held at Wayne State University, Detroit, MI, July 27-31, 2009. kgrim@fnal.gov

Isotopes for the Nation's Future

Donald F. Geesaman and Ani Aprahamian

Introduction In the October 2009 edition of Physics & Society, Tom Ruth described some of the history of how the current medical isotope crisis came to be. In addition to medical applications, stable and radioactive isotopes are essential tools in a wide variety of technological, engineering, environmental, and materials-sciences enterprises. The value of US isotope shipments is approximately \$3 billion annually [1]. Recent news headlines have focused on the impact of isotope shortages on medicine, homeland security, and basic science. These include the shortage of molybdenum-99 (Mo-99), the most commonly used medical isotope, and helium-3 (He-3), an isotope critical for both national security and low temperature research [New York Times, 23 July and 22 November 2009]. On November 18, 2009, the House of Representatives overwhelmingly passed HR 3267, the Medical Isotope Bill, encouraging the production of Mo-99 in the United States. None is being produced in the US at this writing. This article reviews the current and proposed federal involvement in isotope production.

DOE Isotope Development and Production for Research and Applications Program Federal involvement with isotope production began with the Atoms for Peace initiative of President Eisenhower. While today private producers are the main suppliers in the isotope markets, they have benefited from and continue to be significantly affected by DOE involvement.

In 2009, management of the isotope program within DOE was transferred from the Office of Nuclear Energy to the Office of Nuclear Physics of the Office of Science, at which time the program was renamed the Isotope Development and Production for Research and Applications Program (IDPRA, or simply Isotope Program). Today, the DOE Isotope Program focuses on isotopes where it has unique capabilities, research isotopes where the demand is limited and often sporadic, and research and development of isotope production techniques.

The mission of the IDPRA is threefold:

- Produce and sell radioactive and stable isotopes that are in short supply, associated byproducts, surplus materials and related isotope services.
- Maintain the infrastructure required to supply products and related services.
- Conduct R&D on new and improved isotope production and processing techniques.

The IDPRA is a relatively small federal program funded by appropriations (FY08 $14.8M) and sales (FY08 $17.1M). It has stewardship responsibilities for two facilities whose primary missions are isotope production. The Brookhaven Linac Isotope Producer, a 200 MeV proton linear accelerator and associated radiological work areas (hot-cells) at Brookhaven National Laboratory, was built in 1972 to utilize beams from what is now part of the Relativistic Heavy Ion Collider. The Isotope Production Facility and associated hot-cells at Los Alamos National Laboratory were completed in 2004 and utilize beams from the Los Alamos Neutron Science Center LANSCE accelerator complex. Oak Ridge National Laboratory hosts the Isotope Business Office, which coordinates all isotope sales, including those made elsewhere and the stockpile of stable isotopes that were previously produced at the now-mothballed Calutrons, the National Isotope Data Center, and materials processing facilities and hot-cells. The Isotope Program also supports a suite of laboratory and university facilities for isotope production, such as the ORNL High Flux Isotope Reactor, which is stewarded by Basic Energy Sciences. These additional production facilities are funded for primary missions apart from isotope production. This allows significant cost efficiencies in the isotope production enterprise while simultaneously presenting challenges in scheduling needed isotope production around other constraints which are not under the control of IDPRA operations. IDPRA also acts as a sales broker for He-3 harvested at Savannah River during the maintenance of nuclear weapons. Other facilities and resources within the DOE complex have been applied to isotope production in the past and will likely continue to be utilized in the future when specialized capabilities are needed. These include the Advanced Test Reactor at Idaho National Laboratory and hot cells and various stockpiles of irradiated targets stored at several national laboratories. IDPRA does not have responsibility for certain critical isotopes, including weapons materials such as tritium, enriched uranium, and plutonium. For example, the responsibility related to the production of Mo-99 has been assigned to DOE/NNSA. This is mainly because the most common production method of Mo-99 in reactors uses highly enriched U-235, and is thus a proliferation concern.

Legislation in the 1990's substantially modified the operation of the Isotope Program, and imposed the requirement for full cost recovery for isotope sales. Since 2003, research isotopes have been priced based on production cost while commercial isotopes continued to be sold at full cost. Over the past two decades, these requirements have lead to a sizable down-sizing of the isotope program due to foreign competition and increased reliance on foreign suppliers. For example, the Y-12/ORNL Calutron stable-isotope separation capability was shut down in 1998 leaving no significant US production capability for a large number of stable isotopes. Reduced missions in aspects of national security have also led to reliance on foreign supplies. Numerous expert panels and advisory committee reports over the past decade have pointed out the risk of relying solely on limited foreign suppliers [2,3]. It is not an exaggeration to say that research and clinical studies of essential mineral nutrient metabolism in humans, as well as a broad array of environmental and ecological studies, would come to a complete halt if the supply of these isotopes were curtailed.

Challenges to the Isotope Program and Proposals for Future Priorities There are a number of challenges facing the isotope program. The need for research isotopes comes from many federal agencies. Promising research opportunities vary from year to year. To be responsive, the program must maintain broad and expensive capabilities, which require highly trained teams of experts that cannot be easily replaced. These capabilities often have significant environment, health and safety implications. Once in operation, the facilities may not be continuously in use due to fluctuating demand. In taking advantage of the capital investments of other parts of the DOE program, the isotope production utilization is subject to the changing mission priorities of those programs, leading to operating schedules or even facility closure decisions beyond the isotope program's control. Many radioisotopes must be used within hours or days of production and treatment regimes require stable long-term availability, but the program currently has no accelerator facility available for the continuous production of isotopes [3]. If a new medical application appears promising, large increases in production are required to support later-stage trials. If a commercial supplier enters the market, they may petition the government to withdraw from a competitive market. If an application fails to perform, the demand may collapse completely. Another aspect is volatility in the market place. For example, if a major customer withdraws from the market the cost for DOE to produce a given quantity of an isotope, and therefore the cost DOE is required to charge other users can increase dramatically on very short notice. At the same time, foreign suppliers, in many cases subsidized by their governments or capitalizing on previous government stocks, can often artificially determine the price that can be charged. This situation greatly increases the risk for a commercial entity to enter the market, placing a greater dependency on the federal program. When foreign governments subsidize research isotopes for their own researchers, U.S. researchers can be put at a significant disadvantage.

Over the past year, the Department of Energy has made significant efforts to address some of the issues of the program. Funding in 2009 and 2010 was increased relative to 2008 levels and included funds for research and development and increased production of research isotopes. American Recovery and Reinvestment Act (ARRA) funds in the amount of $14.7M were allocated to enhance isotope production capabilities to better meet the needs of the nation for isotopes in short supply and to improve America's competitiveness by investing in isotope production research at universities and laboratories. A workshop was held in 2008 to bring together the varied stakeholders in the isotopes enterprise [4] to identify compelling opportunities with radioactive and stable isotopes and future isotope needs. Interagency working groups have been set up to improve coordination and planning, for example, by defining the future isotope needs of the National Institutes of Health and addressing the projected shortfall in the supply of He-3.

The Nuclear Science Advisory Committee (NSAC) is the advisory committee chartered to provide advice to the DOE Office of Nuclear Physics. In August 2008, in anticipation of the transfer of the Isotope Program to the Office of Nuclear Physics, NSAC was charged to identify the most compelling research opportunities with isotopes and to develop a long-range plan for the IDPRA program. NSAC formed a panel of experts, the NSAC Isotopes Subcommittee (NSACI), to carry out these tasks (The authors are co-chairs of this subcommittee). NSACI membership included physicians, pharmacists, research scientists, forensic experts and representatives of the isotope production industry. The full subcommittee membership, charges, and agendas for meetings can be found on the web [5]. Links to the charges and the two resulting reports, "Compelling Research Opportunities with Isotopes" and "Isotopes for the Nation's Future: a long range plan" can be found there and at the NSAC web site [6]. The final report of the NSACI subcommittee presenting the long-range strategic plan was endorsed by NSAC on November 5, 2009, and transmitted to the DOE. Recommendations presented in the report are summarized below. Those in the first category are listed in order of priority. The second category addresses the issue of the dwindling population of skilled workers in areas related to isotope production and applications, a widely documented concern. Within the broad need, this recommendation is focused on the needs of the IDPRA program itself. Its relative priority is comparable to that for a sustained R&D program, with which it is closely linked. The third category addresses future needs. Due to the intense activity underway and active investigations of commercial alternatives led by the NNSA Global Threat Reduction Initiative, NSACI did not make specific recommendations on Mo-99, but did go on record that it was a major concern that must be addressed expeditiously.

(I) The Present Program

I.1: *Maintain a continuous dialogue with all interested federal agencies and commercial isotope customers to forecast and match realistic isotope demand and achievable production capabilities.*

I.2: *Coordinate production capabilities and supporting research to facilitate networking among existing DOE, commercial, and academic facilities.*

I.3: *Support a sustained research program in the base budget to enhance the capabilities of the isotope program in the production and supply of isotopes generated from reactors, accelerators, and separators.*

I.4: *Devise processes for the isotope program to better communicate with users, researchers, customers, students, and the public and to seek advice from experts:*

I.5: *Encourage the use of isotopes for research through reliable availability at affordable prices.*

I.6: *Increase the robustness and agility of isotope transportation both nationally and internationally.*

(II) Highly Trained Workforce for the Future Invest in workforce development in a multipronged approach, reaching out to students, post-doctoral fellows, and faculty through professional training, curriculum development, and meeting/workshop participation.

(III) Major Investments in Production Capability The present program, while highly flexible and responsive to the needs of the nation, lacks two major capacities that limit its ability to fulfill its mission. First, it presently has no working facilities for the separation of a broad range of stable and long-lived isotopes. Each year it is depleting its unique stockpile of isotopes to the point where some are no longer available. Second, many radioactive isotopes are short-lived and cannot be stockpiled. The current program relies on accelerators and reactors whose primary missions are not isotope production; thus, it is not in a position to provide continuous access to many of the isotopes.

III.1: Construct and operate an electromagnetic isotope separator facility for stable and long-lived radioactive isotopes.

It is recommended that such a facility include several separators for a raw feedstock throughput of about 300-600 milliAmpere (10-20 mg/hr multiplied by the atomic weight and isotopic abundance of the isotope). This capacity will allow yearly sales stocks to be replaced and provide some capability for additional production of high-priority isotopes.

III.2: Construct and operate a variable-energy, high-current, multi-particle accelerator and supporting facilities that have the primary mission of isotope production.

The most cost-effective option to ensure continuous access to many of the radioactive isotopes required is for the program to operate a dedicated accelerator facility. Given the uncertainties in future demand, this facility should be capable of producing the broadest range of interesting isotopes. Based on the research and medical opportunities considered by the subcommittee, a 30-40 MeV maximum energy, variable energy, high-current, multi-particle cyclotron seems to be the best choice on which to base such a facility.

The subcommittee gives somewhat higher overall priority to the electromagnetic isotope separator as there is no U.S. replacement. However, a solution in this area is not needed as urgently as the new accelerator capability. Therefore, in the subcommittee's optimum budget scenario that includes both, the construction of the new accelerator starts a year earlier.

The report discusses the implications of these recommendations in both an optimal budget scenario and a constant-level-of-effort-budget relative to the 2009 President's request of \$19.9M. Given the recent investments in the isotope program, constant-effort funding will allow the program to move forward from a more solid base for a few years. Once ARRA funding disappears, sustained constant-effort funding, while it does represent a needed increase from 2004-2008 levels, will place the infrastructure needs for research isotopes at risk in the long term and will not allow the program to address either of the two major missing capacities. The subcommittee does not consider this to be a wise course for the future. The subcommittee recommended an increased optimum budget that also includes new capital funds to realize the needed new capacities.

We hope the readers of *Physics and Society* will take the time to examine to the full reports of the NSACI and we welcome their input. The Office of Nuclear Physics has already begun to implement many of these recommendations within the existing IDPRA budget. The Subcommittee understands that all plans are a snapshot in time that must react to changing circumstances and looks forward to continuing to provide advice to DOE to help meet the nation's needs for isotopes.

[1] *"Stable and Radioactive Isotopes", United States International Trade Commission Industry and Trade Summary, Office of Industries Publication ITS-01, June 2009.*

[2] *M. J. Rivard et al., Appl. Rad. Isotopes 63, 157 (2005)*

[3] *"Advancing Nuclear Medicine Through Innovation", National Research Council Committee on State of the Science of Nuclear Medicine (2007).*

[4] *"Workshop on the Nation's Needs for Isotopes: Present and Future", J. Norenberg, P. Staples, R. Atcher, R. Tribble, J. Faught and L. Riedinger, http://www.sc.doe.gov/np/program/isotope.html (2008)*

[5] *http://www.phy.anl.gov/mep/NSACI*

[6] *http://www.sc.doe.gov/np/nsac/nsac.html*

Ani Aprahamian and Donald Geesaman are the co-chairs of the NSAC Isotope Subcommittee. Prof. Aprahamian is a Professor of Physics at the University of Notre Dame. Dr. Geesaman is a Distinguished Argonne Fellow at Argonne National Laboratory.

They would like to thank all the members of the NSAC Isotopes Subcommittee for their commitment and dedication to defining the future of the IDPRA program and also the many members of the community for their efforts to provide advise and information to the Subcommittee.

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COMMENTARY

Magnetic Fields, Health Care, Alternative Medicine and Physics

Eugenie Mielczarek

In 1996 the American Physical Society, responding to a request from the National Research Council, was asked to examine the potential health hazards of power lines. One of the concerns was that electromagnetic background fields of 2 milligauss might cause cancer. Monitors of outdoor exposure for children to wear were marketed to parents. "Some city regulations sought to constrain B fields to less than 2 milligauss". The report, which was a comprehensive study of the alleged dangers, included both molecular and epidemiologic studies and found that no adverse health effects could be attributed to these low fields. One of the conclusions emphasized that biophysical calculations rule out carcinogenic effects because thermal noise fields are larger than the background fields from power lines [1, 2]. That political agenda, concerned with fear of carcinogenic mechanisms arising from low level magnetic fields, lost credibility. However, about 10 years later claims for health effects from mattress pads equipped with small magnets were marketed and a study of this was funded by National Institute for Complementary and Alternative medicine and claims for their benefits were published in alternative medicine journals. About the same time, small 300 gauss magnets, began to appear on the shelves of drug stores. In 2007 a lawsuit brought by the National Council Against Health Fraud against advertisers of these products was successfully settled. I was one of the persons who agreed to appear as an expert witness if needed. The Federal Trade Commission also threatened to prosecute purveyors who claimed healthful benefits for these products. Amazingly, in the last few years the health and medical and nursing communities in their integrated medicine outreach are now incorporating and marketing the unsubstantiated claims that healing fields of 2 milligauss are emitted from the hands of practitioners (3). This belief in distance healing, Therapeutic Touch, Reiki, and Qiqong cobble the language of physics with the language of physiology, misleading the patient. For example, in Therapeutic Touch the protocol requires that a therapist moves his or her hands over the patient's "energy field," allegedly "tuning" a purported "aura" of biomagnetic energy that extends above the patient's body. This is thought to somehow help heal the patient. Although this is less than one percent of the strength of Earth's magnetic field, corresponds to billions of times less energy than the energy your eye receives when viewing even the brightest star in the night sky, and is *billions* of times smaller than that needed to affect biochemistry, the web sites of prominent clinics nevertheless market the claims [4.5]. This belief has been published in the peer reviewed medical literature [6]. Silence on this issue by physicists is a serious compromise of the scientific endeavors of physicists relating to medicine and biology.

1. *David Hafemeister, "Resource Letter BELFEF-1: Biological effects of low-frequency electromagnetic fields," American Journal of Physics 64(8), 974-981 (1996).*
2. *Robert K. Adair, "Constraints on biological effects of weak extremely-low-frequency electromagnetic fields," Physical Review A43(2), 1039-1048 (1991).*
3. *A report detailing the current claims, authored by myself and Derek Araujo, was issued by the Center for Inquiry, on September 28, 2009: http://www.centerforinquiry.net/uploads/attachments/A_Fracture_in_our_Health_Care_Paying_for_Non-Evidence_Based_Medicine.pdf*
4. *"Healing Touch is performed by registered nurses who recognize, manipulate and balance the electromagnetic fields surrounding the human body, thereby promoting healing and the well-being of body, mind and spirit." Scripps Institute website: http://www.scripps.org/services/integrative-medicine/services__treatments-and-therapies*
5. *Affiliated with Harvard Medical Center is Brigham and Women's Hospital Osher Center. Two upcoming course offerings feature Reiki: "During this class you will receive a reiki level one attunement. This attunement enables you to become a channel for this universal healing energy which will be with you for your lifetime. From this point on you will be a reiki practitioner. With level one reiki you will be able to do healing on yourself, friends, family and pets." See http://hms.harvard.edu/hms/home.asp; see also http://www.brighamandwomens.org/medicine/oshercenter/.*
6. *Jhaveri, A., Walsh, S.J., Wang, Y., McCarthy, M., and Gronowicz, G. "Therapeutic touch affects DNA synthesis and mineralization of human osteoblasts in culture." J. Orthop. Res.* ***26****(11), 1541-1546 (2008).*

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Lost in Translation: Jobs (Hint: We need an ARPA for Commerce)

Tom Katsouleas

The U.S. economy today is more consumer-driven and less investment-driven than at any point in its history. The Obama administration has an opportunity to turn this around by bridging a gap in federal support for research commercialization.

Ever since the divestiture of AT&T in 1984, there has been a steady decline in industrial basic research in the U.S. The role that industrial research at AT&T Bell Labs and others played in innovation and economic stimulus has not been replaced, and as a result, we're missing a link in the innovation supply chain. The standard corporate sector response to downturns has become to slash expenses rather than invest in basic R&D for long-term revenue generation.

The U.S. basic research investment strategy has a big hole in it. Federal funding stops too soon and industrial investment begins too late, creating in between a 'valley of death' for new innovations. Valuable research is not getting translated into the products, services and companies that are sources of new jobs.

As a result, many inventions languish in a lab rather than fuel our economy. As an example, it took 50 years for the discovery of nuclear magnetic resonance to come to market as the first commercial MRI machine, a key contributor to human health and the health sector of the economy. We can no longer afford to allow promising latent innovations to languish.

In my own field of particle accelerator research, the U.S. has led the invention of promising new technologies using lasers and plasmas that can miniaturize the size and cost of these sometimes behemoth devices by several factors of ten. But more work is needed to translate this invention into a product that could, for example, revolutionize cancer therapy with particle beams. Both Japan and the European Union have development projects to do just that. I believe the U.S. could do it better, but there is no U.S. agency charged with funding the significant translational research needed to advance these devices to the point that private companies could pick them up.

I recently had the opportunity to ask Robert Calderbank, former head of research at AT&T Bell Labs in its heyday and now a Professor of Electrical Engineering at Princeton, about the secret to Bell Labs' remarkable success. According to Calderbank, the difference between Bell's approach and university research is simply explained. Bell identified commercial needs up front and then matched them to their capabilities. They came up with a winning technology solution only 3 out of 10 times, but when they did, the result was commercialization nearly 100% of the time.

By contrast, university research funded by the National Science Foundation, for example, seeks proposals from faculty organized along the lines of advancing a discipline such as biological sciences or chemical engineering rather than an application. The success rate is similar to that at Bell Labs and has unquestioned long term value to society, but only a small fraction of successful projects lead to near-term commercialization.

Fortunately, there is something we can do about it. We can fill the void left by Bell Labs by funding the translation of research and education already taking place at universities. Imagine harnessing the real power inherent in 300 research universities and more than 30,000 graduating PhDs in engineering and the sciences each year.

Universities already do mission-driven basic research, but for the Department of Defense. DOD's Defense Advanced Research Projects Agency support of basic research proposals from university investigators has led to solutions ranging from detecting improvised explosive devices (IEDs) in Iraq to fighting at the speed of light with laser weapons and predicting the onset of flu epidemics in sailors days before an anticipated deployment. Energy Secretary Steve Chu and the Department of Energy have taken a page from the defense department's DARPA program to create ARPA-e, where the 'e' is for energy.

What we need now is an ARPA-c where the 'c' is for commerce. Such an agency would identify priorities for mission-driven basic research in areas of critical need for the economy. On a limited scale, the relatively recent NIST Technology Innovation Program is a good start toward this concept.

So how might this work if you are a university physics professor? Would we all start companies? Not at all. You might respond to an RFP from ARPA-c just as you might now respond to one from the Air Force Office of Scientific Research for basic research on high power microwaves, except it might now be for basic research on beam propagation and control in tissue (for the cancer application above) or nano-manufacturing control at large scale. Would it change the culture of university research? We can hope so and hope not. Research universities need to provide a rich intellectual environment that accepts and nurtures all types of inquiry, including both traditional research that is not mission-driven and the type here that is. What about national laboratories; isn't this more aligned with their culture? National laboratories do have a long and successful tradition of mission-driven research, but generally not the commerce mission here. Moreover, anecdotal evidence from program managers suggests that universities are a better deal for the taxpayer. The scale of investment to bring to fruition a paradigm-changing technology tends to be five to one between national labs and universities.

We need innovation to create new jobs now and if we don't pursue them, other nations beginning to make the right investments will. We don't have the luxury any more of waiting 50 years for a discovery to become a paradigm-shifting new economy. The world won't wait with us.

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Grow Up and Emulate China on Energy

Robert Ehrlich

President Obama has recently requested funding for two new nuclear reactors – the first to be built in 30 years in the U.S. This follows his State of the Union speech in which he expressed support for new safe nuclear plants, clean coal, and off-shore drilling for oil and gas. All three proposals have considerable merit, and complement rather than undermine progress towards more renewable energy and a sustainable future.

The burning of coal, if it is to be truly clean, must be coupled with carbon sequestration. This is likely to be a major technical and economic challenge. However, if it can be done at reasonable cost in a manner that assures a relatively permanent sequestration, then coal can make a significant contribution to a clean energy mix. Most observers agree that no one solution will solve our energy dilemma, and that it will be a considerable time before we are able to wean ourselves from coal, which accounts for nearly two thirds of our electricity generation.

President Obama's support for new, safer nuclear plants may be the largest source of disappointment among anti-nuclear activists. However, the public opposition to building new nuclear plants has steadily faded since Chernobyl. In 1975, 60% of the public opposed them, while only 35% oppose them now. Moreover, the technical improvements envisioned in the new generation of nuclear plants solve most of the problems of the earlier "second" generation of plants. Reactors with a fuel cycle based on a thorium rather than uranium appear to be particularly promising in terms of ore abundance, lack of need for enrichment, proliferation prevention, breeding properties, solution to the waste problem, and protection against catastrophic accidents. Who is pursuing thorium reactors? The main action is in India and China. India plans to increase its nuclear power (mainly thorium) by 2050 to 25% of its total energy production, while China plans to build dozens of nuclear reactors in the coming years, and it hosted a major thorium conference in 2009.

Off-shore drilling is likely to prove nearly as controversial in some quarters as the other two proposals. However, the US transportation sector currently relies almost entirely on oil, and it is dangerous and fiscally ruinous for the US to have an increasing reliance on oil imports. The possibility of shifting entirely to electric vehicles will depend largely on further improvements in batteries at an economical cost, and consumer acceptance of a limited vehicle range. The best hope for moving away from oil may eventually be biofuels, but in the interim, relying more on domestic oil sources (along with energy conservation and hybrids) seems like a sound policy. Energy independence, and renewable energy in particular, have great support among the US public, who favor it for reasons that go well beyond preventing climate change: Fully 85% favor federal incentives to promote renewable energy, while many believe that the media is exaggerating the effects of climate change.

President Obama has gone on record in support of greatly expanding U.S. efforts in researching and deploying more renewable energy, an area in which we have been significantly behind a number of nations. In particular, the Chinese have not only set emission reduction targets by 2020 almost three times as stringent as ours but have been backing up their rhetoric with real actions. As reported in the January 31, 2010 New York Times *"China vaulted past competitors in Denmark, Germany, Spain and the United States last year to become the world's largest maker of wind turbines, and is poised to expand even further this year. China has also leapfrogged the West in the last two years to emerge as the world's largest manufacturer of solar panels. And the country is pushing equally hard to build nuclear reactors and the most efficient types of coal power plants."*

President Obama's declared policies are now strikingly similar to those of the Chinese, with two important exceptions. He has not renounced binding limits on CO_2 emissions, whether congressionally mandated or internationally agreed upon. But the idea of going full steam ahead on renewable energy, trying to develop really clean coal and pursuing new safe nuclear plants may actually promote the goal of reducing CO_2 emissions far better than arbitrarily chosen binding limits, whether nationally or internationally set.

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REVIEWS

Beyond Sputnik: U.S. Science Policy in the 21st Century

By Homer A. Neal, Tobin L. Smith, and Jennifer B. McCormick The University of Michigan Press, 2008, 386 pages, cloth $70, paper $30. ISBN-13: 978-0-472-03306-5.

This book is intended to be a textbook for an undergraduate or graduate course on science policy. One of the authors, Homer A. Neal, started teaching a class on national science policy in 1999 and was disappointed to find that there were no books that in his view "outlined the basic elements of national science policy." This book certainly fulfills this basic goal and then some. It is a comprehensive review of the basic enterprise of science, primarily in the U.S., since the end of World War II. The book has 20 chapters divided into four sections: 1) overview of U.S. science policy, 2) federal partners in the conduct of science, 3) science policy issues in the post-sputnik era, and 4) science policy in an era of increased globalization. Each of these sections goes well beyond the immediate scope of its title and there are extensive notes and references provided at the end of each chapter. Consequently, this book is a veritable treasure trove of information and certainly would be a valuable resource for a course on science policy. It is also an interesting read for anyone with an interest in science policy in the United States.

Scientists and students of science policy should find the first section the most interesting since it covers the history of the federal government's involvement in funding and managing science research and development (R&D) as well as the myriad agencies, panels and committees that have existed and currently exist for this purpose. In this section are statistics regarding the federal budget, including the amounts allocated for R&D and the roles of the executive and legislative branches in initiating, funding, implementing, and reviewing the effectiveness of science R&D projects. Detailed descriptions are given of the various offices, committees, agencies, and advisory groups involved in science policy, including a discussion of the central role played by the Office of Management and Budget in determining how much money is given to agencies such as NSF that fund science. In addition the authors outline the complex legislative process in establishing the budgets for these agencies.

The second section describes the roles played by universities, federal laboratories, and the states in funding, administering, and implementing R&D. The degree to which these different organizations cooperate and compete with each other is discussed, along with information about the types of R&D they do and the history of how their R&D efforts developed and how funding was provided. Specific organizations are discussed to illustrate some of the general points made. The chapter on industry is particularly interesting, especially for those of us who have worked in either universities or government labs and are unfamiliar with what goes on in industrial labs. The authors note that industry in general has concentrated more recently on applied R&D and less on basic research, with the exception of small startup companies, who rely more on basic research because they are involved in developing radically new products. There is also a discussion about who really pays for university research, with the implication that major research universities don't always recover their full research costs from indirect costs in grants and that student tuition supports some of the research.

The third section deals with large science programs and large problems faced by the scientific community. There is an interesting chapter on science for national defense, which describes the enormous scope, diversity and impact of R&D carried out by the Department of Defense (DoD) and for DoD by national labs and by universities. There is a discussion of conflicts that arise in academia with scientists doing R&D for DoD, along with examples of what seem like unusual projects for DoD to fund, such as a large breast cancer research program. Another chapter in this section deals with large science projects with examples from physics, space science and biology. Except for the discussion on the human genome project most of the examples given are of failures of large projects like the superconducting supercollider. The authors believe that large science projects are often a bad way to train graduate students but they also point out the need for stable long term funding for such projects. Other chapters in this section review scientific infrastructure, science ethics and education for science professionals. The chapter on education reviews whether we actually need to train more people in science and also endorses professional MS degrees in science-based majors.

The fourth section reviews science policy now and in the future. There are chapters on the science, technology, engineering and mathematics (STEM) workforce and the question of whether we really need more STEM professionals; the impact of globalization on science policy and the increased competition with other countries for science professionals; the impact of science on homeland security and conversely the impact of homeland security initiatives on scientific progress due to security concerns about STEM individuals; and the dissemination of certain scientific research. The remaining two chapters give the authors' thoughts about what the future brings in terms of important scientific questions and what science policy should be like.

Clearly this book covers a broad range of topics and does an excellent job of "narrowing the chasm that divides policymakers and scientists, by educating policymakers about science and improving scientists' understanding of how policies are formed and implemented." However, it suffers from an almost exclusive focus on physics and biology, particularly when giving specific examples to illustrate more general points. There is also an understandable bias in favor of the importance and virtues of science. For example, in the last section the authors write: "A strong and vibrant science and engineering workforce is vital to America's economic stability well as our quality of life, public health and national security." And the authors go on to say that: "Obviously the federal government has a vested interest in ensuring the adequate supply of such (science) professionals." While throughout the text the authors present many arguments in support of these statements they pay very little regard to those who might disagree with them. Consequently, while this book would clearly be an excellent textbook for a course on science policy one might wish to augment it with material that presents cogent arguments about the harm that scientific progress has done and might do to society and why there should be a reduced federal role in the scientific enterprise.

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Beyond Uncertainty: Heisenberg, Quantum Physics, and the Bomb

David C. Cassidy (Bellevue Literary Press, New York, 2009), 480 pp., $27.00 ISBN: 978-1-934137-13-0

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Most of our readers are aware of Germany as a fountainhead of science in the 19th and early 20th centuries. We associate science with the pinnacle of humanistic endeavors, and thus have looked to Germany as a pillar of humanism. And yet, 20th century Germany gave us Nazism, with all its bestial ties. How do we account for such a dichotomy?

David Cassidy explores this conundrum in his biography of Werner Heisenberg, born into the German professorial class, defender of the prerogatives of German academia, major contributor to the physics of fluids and elementary particles, and a founder of quantum mechanics. Offered many opportunities to join the flood of liberal academics fleeing Hitler's pre-war Nazi Germany, Heisenberg chose to remain, becoming head of the German government's wartime nuclear weapon applied research program and simultaneously studying abstract non-linear field theory.

This book interested me because it offers insight into the rise of modern physics as well as the rise of the extreme form of nationalism called "Nazism." This masterful combination of biography, history, and popular science speaks importantly to current difficulties in the relationship between science and society and the question of the obligation of the scientist to the world outside of his "ivory tower."

The book begins with an incisive sketch of post-Bismarkian Germany, a quasi-feudal, class-bound society in which the children of the "non-respectable" productive classes--farmers, artisans, merchants--are pushed into the "respectable" professional class. This class, very conscious of its privileges and prerogatives and dedicated to preserving them, demonstrated very little apparent concern for extending privilege to the rest of society. Growing up in the decades immediately following the unification of Germany, Heisenberg's circle of family, friends, fellow students, and colleagues were intensely committed to strengthening and preserving the German state, although there is little evidence of concern for the well-being of the individual German outside of their privileged circle. Werner's father's father was a successful master-locksmith, descendant of a long line of similar tradesmen, who became an official "Burger" of a small German city which brought him far more status than he held as a craftsman. His mother's father was a Gymnasium (academic high school) teacher and educational administrator, but he never achieved his long-sought status of university professor. Heisenberg's father reached the desired status of professor of classical languages at the University of Munich. Werner's long-term goal was to succeed his teacher, Arnold Sommerfeld, in the Chair of Physics at the University of Munich, a goal encouraged by his professional colleagues but never reached because of the dissatisfaction of the local Nazi party apparatus with his political "purity."

A defining event in Werner's late teenage years, during his last years of Gymnasium, seems to have been the attempted post-World-War-I Communist revolution in Munich. As a member of the militaristic and nationalistic student body at his elite high school, young Heisenberg participated in the right-wing counter-revolution. Werner then met the German workingman—at the opposite end of his gun. It was during this time that he became a leader of a German equivalent of the Boy Scouts (an organization too nationalistic to be an affiliate of the actual internationally oriented Boy Scout movement), a pre-occupation with youth that he kept for most of his life.

The book then describes Heisenberg's student and research career, working with Sommerfeld (in Munich), Born (in Göttingen) and Bohr (in Copenhagen), interacting with and sometimes competing with Schrödinger and most of the other great figures of physics in the 1920s and 1930s. We follow his development of matrix mechanics, the uncertainty principle, the quantum mechanics formalism, and the Copenhagen interpretation. We learn about his struggles with the increasing politicization of the German University and his receipt of the Nobel Prize for Physics. The actual physics content is qualitatively sketched--there are no formulas or experimental descriptions; the book's intended audience is not "scientists as scientists." The onset of World War II finds Heisenberg ensconced as the youngest German Professor of Physics at the University of Leipzig, where he built up a formidable research group in theoretical physics (in spite of the Nazi distaste for theoretical physics which they referred to as "Jewish science") after turning down several offers to leave Germany for an American professorship. Except for responses to direct attacks upon himself or his science (responses in which he often "saved himself" at the expense of other considerations), Heisenberg spent these years immersed in the closed circles of his international scientific colleagues, his music (he was an excellent pianist, giving many private recitals), his youth group and its hiking activities, and his rapidly growing family. He married late, after his Nobel prize, to a much younger wife, and soon had six children with whom to be concerned.

Heisenberg's wartime activities are the source of much controversy. Did he help or hinder the Nazi drive for nuclear weapons? Did he try, successfully or otherwise, to save fellow scientists and scholars from Nazi persecutions such as the military draft? Why did he visit his old teacher and friend, Niels Bohr, in Nazi-occupied Copenhagen? Was it to spy on Allied nuclear activities, to boast of German nuclear activities, or to signal some sort of nuclear truce with the Allies that would include the mutual cessation of weapons research? The book does a commendable job of presenting the evidence for both sides of each controversy. The book is well referenced, with 45 pages of notes. Cassidy points out the evident weaknesses of the arguments, the passage of time and memory, and the paucity of written documentation, and then allows readers to reach their own conclusions.

Controversy does not end with the end of World War II and the devastation of his beloved Germany. Heisenberg's self-appointed task, largely successful, is to be a major factor in the rebuilding of German science to its pre-war eminence. As such, he cannot afford to be tainted with the suspicion of moral or professional lapses during the war. Hence, colleagues and friends, such as Carl Friederich von Weizächer, circulate the word that German's failure to create a nuclear weapon during the war was due to the ethical reluctance of German physicists to provide Hitler with such weapons, rather than to any scientific or organizational failures on their part. Again, the author presents the available evidence, including the famous Farm Hall tapes. These secretly recorded British intelligence tapes were the result of eavesdropping on the technical (and personal) conversations of the captured German physics elite while they were comfortably captive in an English estate. They document the German physicists' surprised reaction to the success of the Allied nuclear weapons program when it became evident by the destruction of Hiroshima and Nagasaki. Once again, the author lets the readers make up their own minds.

The book is interesting, well written, and amply documented. Everyone who wishes to function productively in our modern science-based society should be aware of its contents. My wife and I disagree as to whether the average American college undergraduate can productively read it. I hope to use it in a freshman/sophomore honors course for non-science students; my wife thinks I'm crazy. I urge Forum readers to read it and make up their own minds about the many questions raised in this excellent discussion of science, society, and the role of the individual scientist.

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These contributions have not been peer-refereed. They represent solely the view(s) of the author(s) and not necessarily the views of APS.

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