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Editor's Comments

With this edition, my term as Editor of *Physics & Society* comes to a close. When I took on the position four years ago, I anticipated learning a lot of physics and coming into contact with a cross-section of some of the most interesting people in our profession. I have not been disappointed. As I look back over editions from these years, the topics our articles and reviews have covered include issues as diverse as nuclear waste and weapons, climate change, sustainable and renewable energy supply, women in the sciences, science policy, medical isotopes, magnetic fields and alternative medicine, nuclear arms treaties, scientific ethics, terrorism, the body-mass index, and the history of FPS, among others. It all amounts to about a quarter-million words (yes, I kept a spreadsheet) that I feel privileged to be associated with. I was honored when the Forum entrusted me with the editorship, and am proud of the results. Of course, such work is not done in isolation: I have benefited from the support and counsel of a succession of editorial board members, all of whom deserve my heartfelt thanks: Maury Goodman, David Harris, Ruth Howes, Barbara Levi, Lee Schroeder, Richard Wiener, and Jonathan Wurtele. There are times when our opinions differed, but the result was always a better Newsletter. Our continuing reviews editor, Art Hobson, could always be depended upon to keep a steady stream of material in the pipeline. At APS headquarters, Leanne Poteet, Sara Conners, and Shelley Yi have been absolutely superb at transforming my quarterly uploads of individual-article documents into the polished, professional *P&S* that we all see on the web; they have been a delight to work with. My very able successors, Andy Zwicker and Laura Hopkins, are already in the editorial loop and ready to hit the ground running. Andy and Laura exemplify the willingness of Forum members to volunteer their time in support of its activities, and I encourage all members to get involved at some level: run for election to the executive committee, offer to organize a meeting session, volunteer to serve on a committee, serve as a reviewer for the Newsletter or on the editorial board, or nominate a colleague for a prize or APS Fellowship. Yes, some of these things are real work, but they are a fulfilling way of being engaged with and giving back to the professional community which has nurtured your career.

Most deserving of praise, however, are our contributors, reviewers, and correspondents, for without them the Newsletter would simply not exist. It has been a pleasure to interact with all of them.

This edition of *P&S* contains a number of items of Forum News: Election of Forum Executive Committee members was completed shortly before this edition went to press; we extend congratulations to incoming Vice-Chair Arian Pregenzer, Secretary-Treasurer Tina Kaarsberg (replacing Benn Tannenbaum), and Members-at-Large Beverly Hartline and Mike Tuts (replacing Lea Santos and Richard Wiener). We record in this edition the statements and biographies of all candidates. Phil Taylor, the Forum's representative to the APS's Panel on Public Affairs, updates us on goings-on at the highest levels

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of our Society. Also, we announce that a group of longtime Forum members, Dave Hafemeister, Pierce Corden, and Pete Zimmerman, are organizing a Short Course on Nuclear Weapon Issues in the 21st Century, tentatively scheduled to be held in Washington in early November of this year.

We have a number of contributions for this edition. Letters from Art Hobson and Gus Caffrey offer some comments on the articles by Rees Kassen (science policy) and Alex DeVolpi (reactor instrumentation) that ran in our January edition. As announced in the January edition, three students received Forum-sponsored awards for poster papers they presented at the Society of Physics Students (SPS) Quadrennial Physics Congress, which took place in November, 2012. Two of these winners, Matt Goszewski and Allen Scheie (both of Grove City College), describe the work the led to their posters: developing a Physics:SPECTRA comic kit, and serving as a Congressional intern, respectively. In view of the recent North Korean nuclear test, our feature article on technical challenges in implementing the Comprehensive Testy-Ban Treaty by Pierce Corden is particularly timely. Reviews for this edition look at volumes addressing the prospects for life without oil, and an introductory-level textbook on climate change.

Once again, I thank you all for your contributions and support over the last four years. I know that Andy and Laura will do a great job, and encourage all readers to deluge them with contributions.

—Cameron Reed

FORUM NEWS

Report from the FPS representative on the Panel on Public Affairs of the APS

Philip L. Taylor

The Panel on Public Affairs convenes three times a year at APS headquarters in Washington DC, with meetings in February, June, and October. Your representative was not able to attend the first two meetings, as the 2011 FPS elections were not held until March 2012, and the results were not known until too late for him to arrange his schedule to attend the June meeting. This problem should not recur for a while, as the term of office is three years, but the issue is worth bearing in mind when future elections are scheduled.

Had I been at the February meeting, I would have learned that "There are two activities that dominate POPA's time: developing APS policy statements and carrying out studies. APS statements fall under five topical areas: Education, Ethics & Values, Human Rights, Internal Policy, and National Policy. POPA's responsibilities re: policy statements include (1) drafting statements on the aforementioned topical areas and (2) reviewing Council-approved statements every five years to determine whether any should be archived. The other major responsibilities of POPA include conducting studies and producing reports. Ideas for studies can originate within POPA or come directly from the APS membership. The studies build on previously adopted APS statements; they don't create new policy positions, but build on existing positions and advance statements that have already been passed. POPA will often team with another organization to conduct a study, if doing so results in a more expert assessment of the topic. As a rule, a POPA member will volunteer to assemble and lead a study committee through exploration of the chosen topic. The timetable for a POPA Short Report Study is eight months. For topics that require additional time, funding, and/or comprehensive research, larger studies can be conducted as an APS Report Study. Such an effort results in a longer report (ex. APS Energy Efficiency Report). POPA is also responsible for drafting letters under the POPA Chair's name, and responding to concerns voiced by the Society's membership."

The topics already under consideration at the October POPA meeting included many of those that have graced the pages of the FPS newsletter. There were reports on existing studies of the issues involved in extending the lifetimes of commercial nuclear reactors; the surprise for me was that lifetimes of as much as 80 years were discussed. The disruptions that could be caused by shortages of certain rare but critical elements were the basis of another report, which included shortages of an element dear to the hearts of many physicists, namely helium. The report provided several recommendations that have been included in legislation in the House and Senate. Unsurprisingly, nuclear weapons were not neglected, and here the emphasis was on the status of tactical weapons.

I felt I was making a nuisance of myself by asking for an unpacking of the prodigious number of acronyms that flew through the air, but was reassured to find I was not alone in wondering what DNDO was, and why ASP and CAARS were a problem. I learned that it is the Domestic Nuclear Detection Office, which was established to help prevent anyone from smuggling radiological materials into the country. The Advanced Spectroscopic Portal Monitor (ASP) and Cargo Advanced Automated Radiography System (CAARS) programs have apparently not been a huge success. This is a topic of a

current POPA study. Not every aspect could be discussed, as some of these were definitely FOUO. What's that? I'm sorry - it must be catching - it's a Federal government designation that means "for official use only", and applies to information that the government keeps just a tiny bit secret.

In summary, my first POPA meeting introduced me to an environment in which a huge wealth of experience in physics, policy, administration, and government was assembled in the form of about twenty POPA members. They hailed from national labs and think tanks, universities and government departments. I look forward to the next meeting.

Philip Taylor
Case Western Reserve University

AIP FYI on Strategic Plan on Nuclear Waste

[In the July 2012 and January 2013 editions of P&S, we ran articles on the President's Blue Ribbon Commission on Nuclear Waste. This recent AIP FYI updates the situation. The original can be found at http://www.aip.org/fyi/2013/016.html - Ed.]

A fourteen-page document released by the Department of Energy on January 11 continues to build on a path forward for the management and disposal of the nation's civilian and defense nuclear waste. This is important reading for anyone concerned about the future of nuclear energy in the United States. "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste" is the Obama Administration's broad-brush response to the findings and recommendations of the Blue Ribbon Commission on America's Nuclear Future (BRC). The Department of Energy (DOE) established the BRC in 2010 following the Administration's decision to terminate further work on the proposed Yucca Mountain nuclear waste repository. The commission issued its draft report in the summer of 2011, and sent its final report to President Barack Obama and DOE Secretary Steven Chu a year ago.

A key hearing in early 2012 by a Senate committee demonstrated considerable support for the commission's findings, calling for a consent-based approach to the location of one or more interim storage facilities and at least one geologic repository managed by a new organization. In September, the Senate Energy and Natural Resources Committee held an upbeat hearing on a bill introduced by its chairman, Senator Jeff Bingaman (D-NM), who has since retired. Bingaman's bill, which died when the last Congress adjourned, would have implemented many of the commission's findings. Another step forward was taken when DOE released its strategy earlier this month. Importantly, the first page of the report explains: "The Administration endorses the key principles that underpin the BRC's recommendations. The BRC's report and recommendations provide a starting point for this Strategy, which translates many of the BRC's principles into an actionable framework within which the Administration and Congress can build a national program for the management and disposal of the nation's used nuclear fuel and high-level radioactive waste. The BRC report and the Strategy build on the body of physical and social science work completed during the prior decades and benefit from the lessons learned not only from our nation's experiences, but also from those of other countries. This Strategy includes a phased, adaptive, and consent-based approach to siting and implementing a comprehensive management and disposal system. At its core, this Strategy endorses a waste management system containing a pilot interim storage facility; a larger, full-scale interim storage facility; and a geologic repository in a timeframe that demonstrates the federal commitment to addressing the nuclear waste issue, builds capability to implement a program to meet that commitment, and prioritizes the acceptance of fuel from shut-down reactors. A consent-based siting process could result in more than one storage facility and/or repository, depending on the outcome of discussions with host communities; the Nuclear Waste Policy Act of 1982 (NWPA) envisaged the need for multiple repositories as a matter of equity between regions of the country. As a starting place, this Strategy is focused on just one of each facility."

If Congress passes legislation allowing this process to move forward, the Administration estimates that a pilot interim storage facility would begin accepting waste by 2021. A high priority would be given to "stranded" waste now being stored at eleven shut-down reactors sites. A larger interim storage facility would accept waste by 2025, allowing "for acceptance of enough used nuclear fuel to reduce expected government liabilities." The Administration predicts this larger facility could hold 20,000+ metric tons heavy metal (MTHM). There are currently 68,000 MTHM of spent fuel in storage at 72 sites, increasing by 2,000 MTHM annually. Under this strategy, operations at a geologic repository would commence by 2048. Changes would also be made to current law involving funding mechanisms and organizational responsibility. The concluding paragraph of the strategy looks ahead to next steps: "This Strategy translates the BRC's report and recommendations into a set of broad steps that will ultimately benefit the entire nation. The Administration will work closely with Congress to develop a path forward that maximizes the likelihood of success. When executed, the new program will provide near-term and long-term solutions for managing

the back-end of the nuclear fuel cycle, thereby resolving a longtime source of conflict in nuclear policy by providing safe, secure, and permanent disposal. Until the necessary new legislation has been enacted, the Administration will pursue components of the Strategy as described above pursuant to current law and in close coordination with Congress. Finally, in executing the program the federal government must work closely with potential host states, tribes, and communities whose engagement will be essential for successfully operating a comprehensive used nuclear fuel and high-level radioactive waste storage, transportation, and disposal system."

Congressional reaction to the strategy has been mixed. The Ranking Member of the Senate Energy and Natural Resources Committee, Lisa Murkowski (R-AK) commented: "It's important that we act quickly to resolve the federal government's outstanding liability issue with interim storage facilities, while continuing to work on a permanent solution. DOE's study is an important and constructive step in developing a viable path forward. Establishing an interim storage facility makes a lot of sense, and the best option is to use a consent-based siting approach. I'm hopeful that Congress and the administration will work together to enact legislation that will advance our nuclear energy strategy." Murkowski will introduce a nuclear waste bill "early in this Congress." Reaction in the House of Representatives was considerably less favorable. House Energy and Commerce Committee Chairman Fred Upton (R-MI) and Environment and the Economy Subcommittee Chairman John Shimkus (R-IL) commented as follows: "We cannot have a serious conversation about solving America's nuclear waste problems without talking about Yucca Mountain. There remains a gaping hole in this implementation plan because President Obama precluded the commission from considering Yucca Mountain in its report. The Blue Ribbon Commission emphasized the need for a long-term storage repository, and Yucca Mountain remains the most viable and thoroughly studied option. "The implementation report proposes making 'demonstrable progress' toward siting a new nuclear repository that can be open by 2048. What the report fails to mention is the fact that we have already made 'demonstrable progress' on Yucca Mountain. Last summer, 326 members of the House, three out of every four elected representatives, voted on a bipartisan basis to continue that progress by increasing funding for the NRC license review. We cannot afford to start over - billions of dollars and decades of work have been invested in Yucca Mountain. If politics are allowed to derail a project set forth in 1983, there is no reason to believe this new effort will be any more successful. We have the responsibility under the law to pursue Yucca Mountain as the nation's long-term nuclear waste solution. It's time to stop wasting time and move forward with the process we started 30 years ago."

The U.S. Court of Appeals for the District of Columbia is now reviewing the legality of the Administration's actions terminating consideration of the proposed Yucca Mountain nuclear waste repository.

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FPS Offers Short Course on Nuclear Arms

The Forum on Physics and Society is sponsoring a short course on Nuclear Weapon Issues in the 21st Century, to be held at George Washington University over November 2/3, 2013. The course is being organized by Pierce Corden, Dave Hafemeister, and Peter Zimmerman, and the subject matter will include strategic nuclear weapons, the Comprehensive Test Ban Treaty, missile defense, nuclear proliferation, and nuclear terrorism. Further details should be available for the July or October edition of P&S.

Candidates for Forum Executive Committee Positions

Editor's note: Voting for positions on the Forum's Executive Committee will be complete by the time this edition of P&S goes to press. We record here candidates' biographies and statements under each open position. Thanks are due the Nominating Committee [Tony Fainberg, Lea Santos, Pierce Corden, Neil Gershenfeld, and Pushpa Bhat (ex-officio)] for developing a strong list of candidates.

VICE CHAIR

(Vote for no more than one candidate)

Arian L. Pregenzer

Background: Arian L. Pregenzer is internationally recognized for her work to enable international technical collaboration to enhance security. She retired from Sandia National Laboratories in Albuquerque, New Mexico in December 2011. At Sandia, she was Senior Scientist in the Global Security Program, where her responsibilities included initiating new programs in arms control and non-proliferation and developing strategies for nuclear security that cut across laboratory missions in nuclear arms control, non-proliferation, and nuclear weapons. Since her retirement, Dr. Pregenzer has continued to be active in these areas. She is a member of National Academies of Science Study Panel on "Improving the Assessment of Proliferation Risk of Nuclear Fuel Cycles," and consults with Lawrence Livermore National Laboratory on opportunities for engagement in the Asia Pacific and for international technical cooperation on nuclear arms reductions. In 2012 Dr. Pregenzer was awarded the Joseph A. Burton Forum Award by the Forum on Physics and Society of the American Physical Society "For her intellectual and managerial leadership in creating centers that allow international technical and policy experts to explore confidence building measures and other arms control regimes." In 2009 – 2010 she was a visiting scholar at the Center for International Security and Cooperation at Stanford University, where she initiated new research in applying the concepts of systems resilience to nuclear non-proliferation. In 1994 she led the establishment of Sandia's Cooperative Monitoring Center (CMC), which promotes dialogue between policy and technology experts. In 2003 she worked with the National Nuclear Security Agency (NNSA) and the Arab Science and Technology Foundation (ASTF) to establish the Iraqi S&T Engagement Program. Arian Pregenzer is a Fellow of the American Physical Society and a member of the Council on Foreign Relations and the International Institute for Strategic Studies. She has Bachelor's degrees in Physics, Mathematics, and Philosophy from the University of New Mexico and a Ph.D. in Theoretical Physics from the University of California at San Diego.

Statement: Physics and other natural sciences play a critical role in addressing society's most pressing problems, such as clean energy, health care, climate change, and nuclear arms control. However, scientists need an understanding of both technical and political aspects of these problems to develop effective solutions. In addition, as public attitudes toward science decline, it is more important than ever that scientists communicate the excitement, nature and value of science to ordinary citizens. The Forum on Physics and Society (FPS) has a long history of facilitating understanding, interaction and communication among scientists, policy experts, and the public and continues to do so today. I have dedicated most of my career to the intersection of science and international security policy: as a technical advisor to negotiators of the Chemical Weapons Convention, as founder of Sandia National Laboratories' Cooperative Monitoring Center, and as initiator of technical cooperation to address common security problems from the Middle East to China. If elected Vice Chair of the Forum on Physics and Society I would be honored to bring my leadership and management experience to the executive committee. It would be a pleasure to work with the other members to assure that FPS continues to have a strong voice into the future.

Richard Wiener

Background: Richard Wiener is a Program Director at Research Corporation for Science Advancement (RCSA), a private foundation that has been funding research by academic scientists for 100 years. He directs RCSA's *Scialog: Solar Energy Conversion* program, which funds highly innovative high risk research and convenes and networks researchers with the goal of accelerating breakthrough science. Wiener completed a Bachelor of Arts degree in philosophy at the University of California, Berkeley and a Ph.D. in physics at the University of Oregon under the direction of London Prize recipient Russell Donnelly. His research previously focused on nonlinear pattern formation, with an emphasis on controlling chaotic patterns in fluid flows. Recently, he has been working on the application of nonlinear dynamical models to the production of energy resources, social group competition, and conference-mediated growth of collaboration networks. From 1995-2006 Wiener was a physics professor at Pacific University in Oregon and Chair of the Division of Natural Sciences from 2004-2006. At Pacific University, he implemented a variety of empirically based active learning curricula, and he has a deep commitment to science education reform. He has been a National Corporation for Atmospheric Research Postdoctoral Fellow in Ocean Modeling at Oregon State University, a Visiting Professor at Lewis & Clark College, and a Visiting Scientist and Visiting Professor in Eberhard Bodenschatz's research group at Cornell University. Wiener

currently holds an appointment as an adjunct Professor of Physics at the University of Arizona and he is a Member-at-Large of the FPS Executive Committee.

Statement: I would be honored to serve as Vice-Chair of the FPS. I am deeply committed to the Forum's mission to address issues related to the interface of physics and society. Physicists are in a unique position to contribute expertise to many challenges facing humankind. The world is facing tremendous challenges with the trajectory of human population heading toward ten billion at midcentury. How will humankind create a peaceful and just global society that allows such a large population to attain a humane standard of living? Physicists are needed to help overcome the challenge of providing the world peaceful security, sustainable energy, and a livable environment, as well as many other challenges. Physicists not only need to contribute to solving these challenges, but we also need to participate in the debate as to how these challenges can and should be overcome. Physicists are not typically policy makers, but policy makers, and the general public, need our input, if there is to be hope of a better future for humankind. FPS provides one means to this end. My goal if elected as Vice-Chair of FPS is to involve more members of APS in physics-related issues that affect society. I will continue promoting a strong newsletter with high quality articles that ignite discussions. I will work hard to continue providing outstanding FPS sponsored sessions at APS meetings. I will encourage and support constructive debate amongst the APS membership on important societal issues.

SECRETARY-TREASURER

(Vote for no more than one candidate)

W. David Kulp

Background: David Kulp is a nuclear security advisor in the Office of the Assistant to the Secretary of Defense for Nuclear, Chemical & Biological Defense Programs. As a 2011-2013 AAAS Science and Technology Fellow, he has focused on issues relating to countering nuclear threats, including cooperative threat reduction, nuclear detection, nuclear forensics, and consequence management. Dr. Kulp has been Chair of the User Executive Committee at TRIUMF, Canada's Laboratory for Particle and Nuclear Physics, an advisor to the IAEA International Network of Nuclear Structure and Decay Data Evaluators and the U. S. Nuclear Data Project, and a Fellow in the Sam Nunn Security Program at Georgia Tech. He earned his PhD in physics at the Georgia Institute of Technology and became research faculty there, where he led experimental teams at universities and national laboratories to elucidate the internal degrees of freedom realized in the atomic nucleus through gamma-ray and particle spectroscopy. His MS in physics is from Emory University, where he studied fractal surface growth. A Trident Scholar and graduate with distinction from the United States Naval Academy, David's undergraduate research employed ion beam analysis in the characterization of archaeological artifacts.

Statement: Physicists tend to develop a sense of social responsibility as their awareness of the impact the field has had on society grows. The APS Forum on Physics and Society is thus the natural meeting place for APS members to explore the impact our field has on society and to discuss how to approach issues that are critical to society. Yet, the Forum could do more: it can act as a conduit to reach out and inform the public about critical issues, and it can help APS members to develop the skills necessary to engage the public and work directly on public policy. Outreach could provide a critical input into public discourse. A 2010 poll conducted by Scientific American and Nature ndicated that scientists were the most trusted group of people for important issues in society, edging out friends and family and enjoying a significant lead over journalists and elected officials. Yet there is reason for concern: the same poll showed that 40% of respondents in the U.S. believed that scientists should talk only about the science and avoid advocacy. Moreover, 26% thought that scientists should pay attention to the wishes of the public, even if they think citizens are mistaken or do not understand the work. Worse yet, a different 2011 poll showed that a majority believes that it is "likely scientists have falsified global warming research." As a Forum officer, I would support not only focused topical sessions at APS meetings on important issues facing society, but also advocate for sessions or workshops to educate members about how to work with the media, to frame issues for policy makers, and to directly engage the public. I would help to expand Forum participation and include more of the APS membership, and support the Chair's initiatives and keep the Forum members informed.

Tina Kaarsberg

Background: Tina Kaarsberg currently leads the Small Business Innovation Research Team and is Interim Chief Operating Officer for 'Tech to Market' within the Energy Department's Office of Energy Efficiency and Renewable Energy (EERE). Prior to this, Dr. Kaarsberg served in a number of technology--specific positions within EERE including Team Leader for lighting standards, Team Leader/SBIR Lead for Recovery Act-ground source heat pumps and building retrofits, and Geothermal (non-EGS) from Fall 2009 to February 2012. From 2005 to 2009, she work in the DOE Policy Office serving as the only non-economist expert on Office of Science and EERE related matters. Dr. Kaarsberg has also held positions with Sandia National Laboratories, Vista Technologies Inc., the American Physical Society and the Northeast-Midwest Institute. She also served on Capitol Hill on the Senate side during the Energy Policy Act of 1992 for Senator Domenici and on the House side for Epact 2005 for Chairman Boehlert. She was awarded a PhD from Stony Brook University in 1988

after conducting her doctoral research at Cornell University from 1984-1988 and a B.A. in Physics with Distinction from Yale University in 1982. After 2 years on the UCLA Physics Department faculty Dr. Kaarsberg began her switch to a policy career beginning in 1990 by working for the American Physical Society's Washington Office and staffing the new PPC and the Panel on Public Affairs (POPA) to which she was later elected. She is active in and has served as an officer in both the American Association for the Advancement of Science and the APS. She was elected a Fellow of the APS in 2005. Dr. Kaarsberg recovers from the Washington scene in a zero-energy home with an organic garden and plays fiddle and sings with the "Bluegrass Bureaucrats."

Statement: I ask for your vote so I may serve as Secretary Treasurer of the Forum on Physics and Society. I do so because the Forum needs an energetic, experienced Secretary/Treasurer to serve it and I believe I have the energy and experience to do so. I had been interested in physics and society—especially energy and the environment-- and a member of the forum for many decades. This avocation and my vocation appeared to blend well when I was elected Chair-Elect of the Forum in 2003. Then, as now, I believed that the events of recent years have strengthened my longtime belief that physicists could be key players in addressing many of the security, economic and environmental problems now facing society. "The Forum on Physics and Society has a long and distinguished record of catalyzing physicist involvement in issues ranging from nuclear weapons policy to global climate change."…… starting as a graduate student, going to November 11th committee meetings at Cornell, and especially since 1990, I have worked in many of these areas. I believe I have the experience (or can recruit others who have the experience) to guide FPS efforts on a wide range of societal challenges." Specifically, as Sec Treasurer I would (a) fund or better fund our Awards and Prizes through outreach to Foundations and others. (b) recruit our distinguished past and current prize winners and awardees for these and other activities, (c) expand the readership of the Forum newsletter and other publications; and (d) increase the number of Forum-sponsored or co-sponsored sessions at APS meetings.

MEMBER-AT-LARGE

(Vote for no more than two candidates)

Beverly Karplus Hartline

Background: Beverly Karplus Hartline is Vice Chancellor for Research and Dean of the Graduate School at Montana Tech (Butte, MT). Previously, she has served as Associate Provost for Research and Graduate Studies at the University of the District of Columbia; as Dean of Mathematics, Natural Sciences and Technology at Delaware State University (Dover, DE), as Special Assistant to the President at Heritage University (Toppenish, WA), and in numerous research and management positions at several Department of Energy National Labs, including Lawrence Berkeley, Jefferson Lab (Newport News, VA), Los Alamos, and Argonne (IL). From 1996 through 1998, she was Assistant Director for Physical Sciences and Engineering at the White House Office of Science and Technology Policy. Earlier, she has been a research news reporter for Science and a research scientist at NASA-Goddard. Her bachelor's degree is in physics & chemistry from Reed College (Portland, OR) and her Ph.D. is in Geophysics from University of Washington (Seattle). She is a Fellow of the APS and of AWIS, and she also holds memberships in AAAS, Sigma Xi, AAPT, and AGU, among others. She served from 2000 to 2011 on IUPAP's Working Group on Women in Physics and as the lead fundraiser for the *Women in Physics* International Conferences, and the lead editor for the Proceedings of the first three conferences, published by AIP and pioneered free on-line access to these Proceedings. For APS, she has served previously on the Physics Policy Committee, Committee on the Status of Women in Physics, and Committee on Minorities; as Vice Chair, Chair Elect, Chair, and Past Chair of the Forum on Education; and as a member of the Task Force on Ethics Education. She has also been a member and chair of the NSF's Committee on Equal Opportunities in Science and Engineering (CEOSE) and the Office of Polar Programs Advisory Committee. She is a member of the Editorial Board for the Journal of Science Education and Technology, and has served on numerous review or advisory committees for NSF, DOE, NIH, USGS, various national laboratories, and university-based programs.

Statement: I have been affiliated with the FPS for many years and engaged independently with various initiatives at the interface between physics and society. Special interests include getting students, parents, the public, and policy makers interested in, excited about, and supportive of physics; clear and effective two-way communication between physicists and policy makers and the public; including and advancing more women and underrepresented minorities in physics to be able to tap into their ideas and energy to advance the field; ethical behavior; and promoting international collaborations, exchanges, and experiences. To date, my direct service to the forum has been limited, and I feel honored to have the opportunity to remedy that deficiency through service as one of the Members-at-Large on the FPS Executive Committee. If elected, I would champion clear and effective communications between and among physicists, policy makers, and the public; work hard on forum initiatives; and seek to engage more of the forum membership in FPS activities.

Gregory Harry

Background: Gregory Harry is currently an assistant professor of physics at American University in Washington DC. He received a BS from the California Institute of Technology

(1990) and a PhD from the University of Maryland in 1999 in experimental gravitational physics. Since then he has worked with the LIGO (Laser Interferometer Gravitational Wave Observatory) collaboration on gravitational wave detection as a postdoc at Syracuse University and a postdoc and research scientist at MIT. As a member of LIGO, he has been involved with the working group on education and outreach, taking responsibility for political outreach activities, in addition to serving as the optics working group chair and cognizant scientist for optical coatings. While at MIT, he also taught a class on Energy, the Environment, and Society at Northeastern University in Boston. He is currently building on that experience to develop a class at American University on physics and society, drawing on the many resources at American in political science and public policy. His research interests involve thermal noise from optical coatings and other materials in precision experiments including gravitational wave detection, detection of stochastic gravitational waves with interferometric gravitational wave detectors. His previous APS service activities include the Nominating Committee for Executive Board of American Physics Society Mid-Atlantic Section (2012), Session Organizer at Joint Spring Meeting of the New England APS and AAPT (2009), and being nominated for Delegate to the Executive Committee of the APS Topical Group in Gravity (2007).

Statement: As member of the Forum and a member of the American University community, I am very interested in how physics discoveries and principles can impact public policy. I am developing a class at American University on the importance of physics to policy. I will use contacts I develop during this experience, both on campus at American and off campus in the wider Washington DC science policy community, to bring to the Executive Committee what physics issues are important to the policy community. I will also use these connections to bring important thoughts, concerns, and decisions from the Forum Executive Committee and the wider physics community to the attention of the outside world. American University students are known for political activism and I am helping to create a student group on physics and public policy. This will be a valuable conduit for new ideas and concerns from student members of the Forum. In addition, I am working on plans for how physicists can better engage with political opinion leaders as part of my role in the LIGO Scientific Collaboration Education and Public Outreach Working Group. I will use my experiences from this project to help inform and advance the mission of the Forum.

Michael Tuts

Background: Michael Tuts is an experimental particle physicist and Professor of Physics at Columbia University. He received his B.S. in Physics and in Mathematics from M.I.T in 1974, and his Ph.D. in Physics from SUNY Stony Brook in 1979. After a postdoc at Stony Brook, he joined the faculty of Columbia in 1983. His research career has taken him to numerous accelerators: starting with E-321 at the internal target area at Fermilab and the Nevis Cyclotron as a student; then as a postdoc and junior faculty member he helped build the CUSB experiment at the Cornell Electron Storage Ring (CESR) and the D0 experiment at the Fermilab Tevatron; currently he is a member of the ATLAS experiment at the Large Hadron Collider (LHC) at CERN. Besides his particle physics research, he has also been the co-spokesperson of CUSB, the Run IIa Upgrade Manager for D0, and currently the US ATLAS Operations Program Manager. During his tenure at Columbia, he has also served as the Director of Nevis Laboratories.

Tuts is a Fellow of the APS, and has served as Secretary/Treasurer of the APS Division of Particles and Fields (DPF). He has also served on the Fermilab Users Executive Committee, and he is currently on the US LHC Users Executive Committee. Most recently he was asked to blog (occasionally) on the Huffington Post, although he has not yet learned how to tweet.

Statement: There has never been a more important time to engage the public and policy makers in a discussion of the role of science in society. The challenges are enormous, but this past year in particle physics has also shown us that so are the opportunities. The fiscal pressures on our field are daunting, but as the turn on of the LHC and the discovery of what is likely the Higgs Boson have demonstrated, the thirst of the public to better understand science is unquenchable. One of the roles of FPS is to exploit that thirst in various forms. On the public front, the opportunities for outreach need to be further developed and supported. The FPS can play a role in that area, together with the Forum on Outreach and Engaging the Public (FOEP). Public lectures are an excellent way to acquaint the public with the ideas and results from cutting edge research and offer an opportunity to engage the public, from young to old, in the excitement of physics research and its importance to society. It offers an opportunity to remind the public that the fruits of basic research are that they drive the technology of tomorrow. Perhaps the FPS can facilitate or sponsor such activities. In addition it might be able to facilitate placing physicists before the media (press, television, etc). One advantage of the FPS is that its membership cuts across all APS fields offering a unique opportunity to build a strong and broadly scoped plan.

In dealing with policy makers, the FPS has had a role in showcasing the benefits of physics to society. This is a very important activity. I would be interested in understanding how these activities could be coordinated with other divisions and organizations, such as users groups, that visit Congress to educate policy makers. A coordinated effort could leverage precious resources. My personal view of congressional visits (having participated as a member of user group visits) is that they are very effective – so again the FPS has an important

role to play in this area. It would be useful to brainstorm on ways that this communication could be made even more effective – for example perhaps a FPS newsletter that would be of interest to policy makers could be distributed to them, and let them know that physicists occupy many essential roles in society. Once again the broad membership in the FPS would be important in developing such a newsletter. If elected, I would be interested in pursuing some of the above ideas.

Andrew Zentner

Background: Andrew Zentner is an associate professor in the Department of Physics andAstronomy at the University of Pittsburgh, where he has been a member of the faculty since 2007. Andrew is also a member of the executive committee of the Pittsburgh Particle physics, Astrophysics, and Cosmology Center at the University of Pittsburgh. Prior to joining the faculty of the University of Pittsburgh, Andrew earned a B.S. in electrical engineering from The Cooper Union for the Advancement of Science and Art in New York City in 1998 and a Ph. D. in physics from The Ohio State University in 2003. Andrew conducted postdoctoral research in theoretical cosmology at the University of Chicago where he was a fellow of the Kavli Institute for Cosmological Physics (2003-2006) and a National Science Foundation Fellow (2006-2007). His primary research interests are theoretical cosmology, interpreted broadly to include early universe physics, the evolution of structure and the formation of galaxies, and the quests to identify the dark matter and dark energy that dominate the energy budget of the Universe. He has published over 50 refereed journal articles on these subjects. Andrew maintains an active interest in education and outreach and organizes an Education and Outreach partnership between the University of Pittsburgh and the Carnegie Science Center. One of his current education projects is to develop a general education program for non-science majors at the University of Pittsburgh aimed at improving upon the appreciation of physics as a field of discovery and the importance of physics as a basis for understanding energy, climate, and technological issues that affect society.

Statement: To FPS members, it is evident that physics bears ever more directly on societal issues. This pertinence stems from the specific knowledge and expertise of physicists as well as the general methods of quantitative science. An active community of physicists enriches our culture and lays the foundation for technological and economic progress. As a highly-trained component of society, it is the obligation of physicists to communicate scientific perspectives on societal issues. The FPS can help physicists better meet their obligation in a number of ways. The FPS can expand upon its already successful programs, including the popular APS sessions and in particular by providing for further Forum Studies. Expansion may require growing membership and seeking novel sources to support such activities. Renewed effort must be placed in "grassroots" efforts to invigorate physicists to participate in societal debates and public education. The FPS has the second highest membership among APS Fora, yet roughly 88% of APS members are not FPS members. The Forum should reach out to professional colleagues to encourage physicists to participate in service, education, and outreach. Young physicists often feel that such activity is impossible because service is not valued highly as a consideration for promotion and career advancement (or is thought not to be valued highly). Successful, high-profile education and outreach programs can change this perception.Meanwhile, it is also incumbent upon the FPS to emphasize the value of service to society and change these perceptions in order to broaden participation by active physicists. This revaluation should be an FPS priority. As a practical matter, society decides the effective value of input from physicists and if physicists do not actively engage in societal decision making, this input will be undervalued. The FPS must strive to encourage and empower, with specific advice and tools, its membership to be active in their communities, participating in local debates and education activities. Local activity of this nature will exhibit the power of the scientific approach, better equip the general public with the tools to address issues, some of which are fundamentally quantitative and exemplify part of the value of supporting an active community of physicists as an important piece of modern society. I hope to serve the FPS in order to help cultivate stronger relationships among physicists as well as between physicists and the general public for the benefit of both societies and our profession.

LETTERS

I enjoyed Alex DeVolpi's article on reactor safety in the January 2013 issue of Physics and Society. However, the Idaho National Laboratory was named incorrectly in the capsule biography at the bottom of his paper. From about 1978 through 1994, the facility was known as Idaho National Engineering Laboratory. It was briefly known as Idaho National Engineering and Environmental Laboratory, and in 2005, it received its present name.

From about 1950 until 2005, Argonne National Laboratory had a way station at my lab, known as Argonne National Laboratory West. I expect that most of Alex's interactions in Idaho were conducted at Argonne West. The Argonne folks built two breeder reactors in Idaho, and one remains: Experimental Breeder Reactor 1 (EBR 1), the first reactor in the world to generate electricity from nuclear power. EBR 1 is now a national historical site, open to the public. Please visit if you are touring the West one summer - Idaho Falls is just 90 miles from Yellowstone Park.

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I couldn't agree more with Rees Kassen's article "Who speaks for science? Experience from Canada" (Jan. 2013, p. 15). It is scientists themselves who are primarily responsible for the failure of elected officials to pay attention to policy-relevant scientific results. We need better ways for scientists to engage with elected officials, and scientists need to head up the effort to establish such engagement. This kind of effort is central to the mission of our Forum on Physics and Society.

But there is another needed ingredient. Science education of the general public is an even bigger part of the picture, although here the effort required is broader and the payback is years in the future, as each new generation becomes more scientifically literate. Nearly all of Canada's Members of Parliament got whatever scientific knowledge and enthusiasm (or lack of such) they have from Canada's schools. The same goes for most of their parents, for the journalists who report the news to MPs and others, and for the Canadian citizens who elect parliament - citizens whose opinions ultimately determine Canadian public policy. Do Canadian scientists participate significantly in the effort to provide science education to the public? Do American scientists?

In the United States, one huge stumbling block to greater science literacy is the gap between research and teaching in our research universities. There is substantial evidence that the scientific literacy courses taken by non-science students at American colleges are surprisingly effective in raising our nation's level of scientific literacy.[1] Most other nations don't teach such "general education" science courses, and their scientific literacy levels are measurably poorer for it. Yet there is essentially zero encouragement for physics faculty at U.S. research universities to develop or teach such courses, and in fact the inducements are negative because serious involvement in such teaching can detract from the all-consuming and institutionally-demanded effort to obtain grants, PhD students, and research prestige. [2]

Scientists need to be more fully involved in science education. One of the many reasons is that the issues our Forum is interested in, issues such as energy, environment, nuclear weapons dangers, pseudoscience, and the scientific process, can be included within K-16 science courses. In fact, the scientific process--i.e. rational evidence-based thinking--should be the bottom line in all introductory science teaching. The poor public policy decisions that result from our failure to adequately teach such topics are all around us.

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ARTICLES

The Comprehensive Nuclear-Test-Ban Treaty: Technical Issues for the United States

Pierce S. Corden

Introduction

On September 24, 1996, the United States, having taken the lead in initiating the negotiation of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) in the Geneva Conference on Disarmament, was the first country to sign it. The CTBT is the culmination of over four decades of proposals, initiatives, intensive research and capacity development in test-detection technologies, and the contributions of partial test bans: a treaty outlawing all nuclear explosive testing of nuclear weapons. The U.S. saw the Treaty as imposing a substantial constraint on the nuclear weapon programs of potential adversaries while not damaging its own deterrent capabilities, and as an important component of its strategy of leadership in pursuing arms control, nonproliferation and global stability.

However, in October 1999, when the Treaty was taken up by the U.S. Senate for its advice and consent to ratification, after a hurried set of hearings by the Senate Armed Services and Foreign Relations Committees and three days of floor debate, the Senate rejected the Treaty. Concerns voiced during the proceedings focused on whether U.S. nuclear weapons can be confidently maintained without nuclear explosive testing, on whether the Treaty is effectively verifiable, on the impact of cheating that escaped detection, and on the Treaty's value for U.S. national security as an arms control and nonproliferation measure.

In response to this stinging defeat, the Clinton administration undertook an extensive review of the Treaty to consider further the concerns voiced in the Senate. Retired Chairman of the Joint Chiefs of Staff General John Shalikashvili was asked to chair the overall effort [1]. He in turn asked the National Academy of Sciences to review technical issues related to the CTBT. The Academy's study, carried out under the auspices of the National Research Council, was released in 2002 [2].

The administration of President George W. Bush did not seek Senate reconsideration of the Treaty. However, in 2009 the Obama administration stated its intention to do so, and asked the National Academy of Sciences to review and update the technical issues dealt with in the 2002 report. In response to this request, on March 30, 2012, the National Research Council (the operating arm of the Academy) released the report of the Committee established to carry out the review and update: "The Comprehensive Nuclear Test Ban Treaty: Technical Issues for the United States." [3]

The third nuclear test carried out by the Democratic People's Republic of Korea (DPRK) on February 13, 2013, and the overwhelmingly negative reaction to the test as a threat to U.S. national security and to regional and global security and stability, attest to the continuing relevance of the Treaty's objective of halting nuclear weapon testing universally.

In this article, I will briefly review the history of nuclear testing and the CTBT and the assessments made in the new report in the context of achieving the security objectives of ratification and entry into force of the Treaty.

Background

The first nuclear weapon test explosion, code-named Trinity, took place at Alamogordo, NM, on July 16, 1945. Since then, eight states have carried out over two thousand nuclear tests, with yields ranging from a fraction of a kiloton to some 50 megatons. These tests have supported the development and deployment of a wide variety of types and great numbers of nuclear weapons. The USSR stopped testing in 1990, and the United States, after conducting over 1000 tests (about fifty percent of the global total), stopped in 1992. Since 1998, when Pakistan and India tested (India tested first in 1974), only the DPRK has tested: in 2006, in 2009, and now again in 2013. At present, the DPRK appears to be the only country intent on testing further. The near-complete set of moratoriums is a consequence of welcome movement toward less reliance on nuclear weapons after the Cold War, and a general if incomplete commitment to halting the further proliferation of nuclear weapons capabilities, both qualitative and quantitative.

The first proposal to halt nuclear testing, with a view to capping advances in nuclear weapons technology, was made in 1954 by Indian Prime Minister Jawaharlal Nehru. By 1958, international interest in test cessation led to adoption of a moratorium, and a Conference of Experts, convened in Geneva, Switzerland, outlined the components of a verification system for a complete, or comprehensive, test ban treaty. These included monitoring for radioactivity, and a network of seismometers in the territories of parties to the agreement. Further investigations pointed to greater difficulty in monitoring underground nuclear tests using seismic instruments than the Experts had expected. In particular, a cheating scenario, first described in 1959, which involved testing a bomb in a large cavity to "decouple" or reduce the size of seismic signals, became a concern.

In its CTBT proposal tabled in 1962, the U.S. insisted that seismic stations would be required on the territory of the USSR, as well as on-site inspections of suspicious seismic events, in order to ensure effective verification of the underground environment [4]. The negotiations failed, but in 1963 the Limited Test Ban Treaty (LTBT), negotiated among

the United States, the United Kingdom, and the USSR, was achieved; this banned all tests save those underground. LTBT monitoring and verification are by National Technical Means (NTM). The LTBT, although opened to all states, was essentially an East-West agreement; France and China have never ratified it. [As described in *Comprehensive Nuclear Test Ban Treaty, Message from the President of the United States, Treaty Doc. 105-28, U.S. Government Printing Office, Washington, 1997*, the term "national technical means" of verification includes such means as nationally owned and operated seismic sensors. It also includes ground stations, ships, aircraft and reconnaissance satellites that use sensors of types other than those in the International Monitoring System. In particular, in the CTBT, national technical means can be used as a basis for requesting an on-site inspection.]

By the time the CTBT was negotiated at the Geneva Conference on Disarmament from 1993-6, nearly four decades of research and development in seismic instrumentation and other nuclear test detection technologies had not only greatly increased the capabilities of National Technical Means, they had also laid the groundwork for the new Treaty's verification regime. For the U.S., monitoring and verification continue to be provided for principally by NTM. But monitoring and verification capabilities now include an international network of seismic, radionuclide, hydroacoustic and infrasound sensors; and provision for on-site inspection of events that remain ambiguous to remote sensing. There are now sensors installed at 280 of the 321 sites in eighty-nine states of the CTBT's International Monitoring System, aiming at global coverage [5]. Other states can of course also deploy their own NTM as they see best to focus on areas of particular interest.

However, as noted above, effective verification was not the only issue to be addressed in seeking Senate agreement to U.S. ratification of the CTBT. The range of issues included ensuring confidently that, without nuclear tests, United States nuclear weapons would not suffer degradation, with a consequent risk to the effectiveness of the weapons and to their role underpinning U.S. deterrent strategy. Such issues are obviously not dealt with directly by the Treaty, but it is understandable that U.S. policymakers would consider that they must be addressed. In 1995, the U.S. set in place a Stockpile Stewardship Program to ensure confidence in weapon performance. The Program formalized existing activities for ensuring confidence, which had in fact been employed during the period when nuclear testing was taking place, and added new resources to the effort, including much more powerful computers enabling better simulation of weapon performance, and new experimental facilities greatly expanding weapons-related experiments not involving nuclear explosions.

The aggregate monitoring and verification capabilities, and those of the Stockpile Stewardship Program, provide the backdrop for the NRC Committee's report.

The NRC Committee

The Committee assembled to carry out the new 2012 study was an eminent one, including scientists and national security experts with backgrounds in monitoring technologies and nuclear weapons science and technology, and nuclear weapons operation. A Subcommittee dealing specifically with seismic monitoring issues was also established [6]. The Committee was asked to focus on four areas: maintaining safety and confidence in U.S. nuclear weapon reliability in the absence of nuclear tests; monitoring capabilities – detection, location and identification of nuclear explosions; resource commitments to sustain nuclear weapons and both U.S. and international monitoring systems; and potential technical advances from cheating or unconstrained testing by others. These areas largely overlap the scope of the 2002 study.

Although the report is described as a review and an update of the 2002 study, in its updating it goes substantially beyond a simple chronological account of the decade since the first report: in its analyses and conclusions it adds to, and departs significantly from, the 2002 report.

Overall Technical Assessment

The Committee reached the following judgments regarding the above four areas of focus (somewhat paraphrased):

- With commitment and adequate resources the U.S. has the technical capability to ensure without testing that its nuclear weapons are safe, secure, and effective for the foreseeable future;
- U.S. technical monitoring capabilities have improved significantly during the past decade, but some operational capabilities are at risk;
- U.S. global NTM are superior to those of the international networks, but the latter are important as a complement to NTM, and a basis for international policy action when NTM should remain classified;
- There is the possibility of cheating, but the U.S. response to new nuclear weapons would not require U.S. testing whether or not the CTBT were in force;
- The most plausible technically motivated circumstance pointing to U.S. test resumption would be a determination that nuclear weapons of types not previously tested were required in response to "adversarial nuclear activities." The Treaty provides for withdrawal to deal with this situation; and
- The U.S. can guard against technical surprise in any case if it sustains the relevant technical resources, which include scientific and other expertise.

In summarizing its conclusions, the 2012 Committee reports that "concerns about maintaining the capabilities to sustain U.S. national security into the future...are *not* the result of

intrinsic technical limitations and are *not* limited by a possible future under the CTBT." However, the Committee was sufficiently concerned about what it learned in its review of financial and policy support for these capabilities that it says that a decision to provide the requisite support is required "whether or not the United States ratifies the CTBT." It believes that risks to the U.S. Stockpile Stewardship Program to maintain nuclear weapons capabilities are limited, such that "the CTBT would not prevent the United States from responding effectively if military and political decisions required development of previously tested weapon types not now present in the stockpile." Were new types required, the U.S. has the option to withdraw from the CTBT. The U.S. can deal with threats from secret cheating on the test ban by others "as effectively under the CTBT as it could without the CTBT." Were an adversary to seek to develop a new type of strategic weapon, the U.S. would observe the required testing, and if U.S. technical capabilities are sustained the U.S. "will retain effective protection against technical surprises" regardless of CTBT ratification.

These are remarkable statements. The Committee concludes, in effect, that a decision to seek Senate consent to ratification can comfortably be taken on technical grounds. Other factors will then be of greater salience, such as how ratification will impact on U.S. objectives to reduce nuclear weapon numbers, cap the qualitative weapon capabilities of others, preserve and strengthen the Non-Proliferation Treaty and broader nonproliferation regime, and best engage in dealing with the current problematic cases of the DPRK and Iran.

Confidence in Reliability; Effective Verification and the Impact of Cheating

Before turning in more detail to these additional factors for ratification, it is of interest to consider further some of the specific matters dealt with in the Committee's report.

Maintaining Confidence in Reliability

The Committee states that, with regard to U.S. nuclear weapons, U.S. technical knowledge and capabilities for stockpile maintenance have significantly advanced since 2002. And lifetime extension programs for warheads and bombs can be carried out effectively without nuclear explosive tests. The Committee cites the accumulated experience since 2002 in assessing that maintenance can be assured with continued supporting resources of personnel, facilities, and funding.

Of particular interest is the report's assessment, which goes beyond that of the 2002 report, that because of progress in the Stockpile Stewardship Program, beyond the baseline concept of warhead "refurbishment," "re-use or replacement of nuclear components can be considered as options for improving safety and security of the warheads." The 2002 approach stressed maintaining design discipline in considering modifications to the nuclear explosive package. The 2012 assessment acknowledges an increased interest in weapon safety and security after the 9/11 terrorist attacks, which might lead to a consideration of changes in the nuclear explosive package. But while expanding the envelope of options, this flexibility is constrained to considering "design changes" "within the range of U.S. tested designs." This means essentially interpolating between designs, not extrapolating beyond them. (Re-use refers to combining previously test-proven components from different nuclear explosive packages; replacement refers to introducing a modified component.)

This assessment is far from a blanket endorsement of implementing reuse or replacement options. It points to the critical importance of ensuring that what might be termed 'ground truth' in fielded weapons is maintained between previously manufactured warheads in series production and new series production. The element of expert judgment to arrive at a net assessment of confidence in the reliability of the nuclear explosive package of a nuclear warhead cannot be set aside. The question is how much of a departure from previously serially produced weapons can be accepted with the same level of assurance from expert judgment. The Committee's view has taken into account the greatly increased capabilities to carry out detailed simulations of the nuclear weapon explosion made possible by the very large increases in computational capabilities of peta-scale computers and improved models based on better understanding of physical phenomena provided by experiments in the Stockpile Stewardship Program. These capabilities were not yet proven in 2002.

The Committee has also noted the more widespread use of the methodology of Quantification of Margins and Uncertainties (QMU) in evaluating warhead performance and retaining confidence in the warhead's reliability. However, the Committee recommends a systematic stockpile surveillance program that is "statistically based where possible."

The Committee also recommends a number of specific steps to retain confidence, such as continuing "experiments linked with analysis," and ensuring appropriate weapon production facilities. With continuing support for the science and technology base, including personnel, the Committee judges U.S. nuclear weapons can be appropriately maintained without testing.

Effective Verification and the Impact of Cheating

With respect to monitoring, the Committee notes the substantial advances in capabilities, including the use of regional seismic data, and more sensitive radionuclide monitoring. Monitoring is much better than was foreseen in 2002, resulting in lower explosive yield detection levels at a given detection probability.

The Committee has helpfully presented its analyses for detection with different degrees of probability. For example, station networks are evaluated at 90% or 10% probability

for three-station detection. This introduces important clarity into the typical discussion of a "threshold" for explosive yield detection, with the implication that below the threshold there is zero probability of detection. The verifying party naturally looks for high detection probability at low yield, but the potential cheater must take into account that the risk of detection has not disappeared, even at low probability, and must in addition factor in the risk of being caught by multiple systems, or surveillance for which a probability cannot be estimated. Thus the cheater can never have an absolute assurance of success.

The contribution of on-site inspections to effective verification evidently did not figure prominently in the Committee's assessment. On-site inspections will require an in-force Treaty, and the framework for the assessment is in terms of whether or not the Treaty is in force. Verification will be even more effective under an in-force Treaty.

The Committee urges both upgrading national technical means for seismic monitoring, and sustaining the international system. In particular, NTM that rely on satellite platforms should be upgraded. There should be further research and development in radionuclide monitoring.

With so many advances in monitoring technologies and capabilities since 1958, it might be imagined that there would be little disagreement with the judgment that effective verification of the CTBT can be assured. But over time assessments of what constitutes effective verification have moved further and further toward requiring capabilities at lower and lower seismic signal magnitude. This is evidently linked to assessments of cheating that consider lower and lower yield explosions as posing a greater potential threat in their contribution to an adversary's nuclear weapons [7].

The report therefore discusses so-called "hydronuclear" tests at some length. Such tests are described as tests in which the nuclear yield is less than that of the triggering high explosive yield. (Other ways to characterize such tests have included restricting them to nuclear explosions with a nuclear yield less than about four pounds high explosive equivalent; or including sub-critical events [8].) It considers the utility of hydronuclear testing as limited for the U.S., and although concluding that such testing could provide "some benefit" to Russia, says that this would be unlikely to lead to a Russian capability "to develop new strategic capabilities outside of its nuclear-explosion test experience."

With regard to cheating scenarios, the Committee extends the analysis begun in the 2002 report. It concludes that monitoring advances make cheating by testing under cover of conventional mine explosions now a less credible scenario. It also concludes that with the use of regional monitoring and general advances in monitoring, a cheater, even utilizing a cavity, would be constrained to testing below one kiloton "to ensure no more than a 10 percent probability of detection for IMS [the CTBT's International Monitoring System] and open monitoring networks." Because this conclusion does not depend on NTM, it is likely that the detection probability at one kiloton is better than 10 percent.

The Committee discusses extensively the cheating scenario of testing in a cavity. This scenario, as noted above first discussed in 1959, has had very long legs. The Committee notes that if the scenario remains of concern, U.S. should:

- "Apply modern computational and experimental methods to understand the decoupling process in various geologies;
- "Identify areas such as geologic salt domes advantageous for decoupling and consider the need for additional monitoring;" and
- "Identify indicators that a county is using – or may be planning to use – decoupling as an evasion strategy."

In evaluating advances in nuclear weapons technology that potential adversaries might seek, the Committee judged that many of these might be pursued regardless of the in-force status of the CTBT, and that the U.S. can counter them without resuming testing. Technological advances such as modern two-stage weapons by states other than Russia and China are precluded without multiple tests, which should be detectable. For Russia and China, deploying "new types of strategic nuclear weapons that fall outside the design range of their nuclear-explosion test experience" would be unlikely in the absence of "several multi-kiloton tests to build confidence in their performance," which tests should be detectable.

Conclusions: The Larger National Security Perspective

The NRC Committee's report makes a persuasive technical case for continuing the existing moratoriums, and, other things being equal, for ratification of the CTBT. The "other things being equal" qualifier reflects the fact that the Committee does not make an overall policy judgment for seeking Senate advice and consent to ratification. Its assessments and recommendations are presented as valid whether or not the CTBT is in force. The larger national security framework, including broad security policy factors, can accordingly be considered from this point of departure.

The eight states whose ratifications are necessary for entry into force – the U.S., China, India, Pakistan, Egypt, Iran, Israel and the DPRK – include four that are observing moratoriums (U.S., China, India, Pakistan), three not known to test (Egypt, Iran, Israel, of which Egypt and Iran are non-nuclear-weapon states party to the Non-Proliferation Treaty), and one (the DPRK) that pursues testing activity. There appears to be essentially no prospect that the U.S. will resume testing, absent a major change in the international balance among the U.S., Russia and China. At the same time, the U.S. actively seeks to preclude further testing by the DPRK, testing

that together with its launching of a satellite and its missile capabilities poses a serious problem for nonproliferation and global stability. It would also be a serious blow to the global nonproliferation regime were Iran to acquire nuclear weapons, and an even worse blow were it to begin testing them. A resumption of testing by China could lead to new nuclear weapon capabilities and an upgrading of its nuclear arsenal. Further Indian and Pakistani testing would be a serious negative development for regional and global security.

None of these prospects is attractive to U.S national security in terms of nonproliferation, achieving further weapon reductions, and global stability. In every case, ratification of the CTBT would strengthen the U.S. hand in dealing with the other states whose ratifications are required for entry into force of the Treaty, and put it on the high ground in securing those ratifications. Every step that moves the Treaty closer to entry into force strengthens the stability of the moratoriums, and enables increasing pressure to be brought to bear on the remaining non-ratifying states. Every step increases the stability of the global non-proliferation regime. U.S. ratification would give political support to the objectives of nuclear weapon reductions and the cessation of fissile material production for weapons. In particular, U.S. ratification prior to the Review Conference for the Non-Proliferation Treaty scheduled for 2015 would greatly strengthen its hand at that conference.

If the administration decides to proceed actively in a dialogue with Senators to seek Senate approval of the Treaty, the NRC Committee report provides a sound technical basis for making the case that the national security benefits of ratification greatly outweigh potential risks. It is possible to overcome the doubts about the nonproliferation value of CTBT ratification voiced in 1999, and complete the persuasive case for Senate action. A positive result of the benefit-risk calculus was nearly adopted in the early 1960s. In signing the CTBT, 183 states have endorsed the benefit side. The Treaty addresses the threats of both "horizontal" proliferation, making acquiring a primitive nuclear weapon capability a minimalist prospect, and "vertical" proliferation, cutting off technical avenues to greater capabilities. It is key to reversing them both.

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[4] International Negotiations on Ending Nuclear Weapon Tests: September 1961-September 1962, U.S. Government Printing Office: United States Arms Control and Disarmament Agency, Publication 9, released October 1962.

[5] The status of stations installed and certified or under testing in the International Monitoring System is as follows:

45 of 50 primary seismic stations;

113 of 120 auxiliary seismic stations;

45 of 60 infrasound stations;

11 of 11 hydroacoustic stations; and

66 of 80 radionuclide stations.

[http://www.ctbto.org/map/-ims]

See also S. Biegalski, "International Monitoring System of the Comprehensive Test-Ban Treaty," Physics & Society **39***(1) 9-12 (2010).*

[6] The Committee included Ellen Williams, then at the University of Maryland, Chair; Marvin Adams, Texas A&M; Linton Brooks, former Administrator of the National Nuclear Security Administration; Ted Bowyer, PNNL; Donald Cobb, LANL (ret.); Richard Garwin, IBM (emeritus); Raymond Jeanloz, Univ. of Cal. Berkeley; Adm. Richard Mies, USN (ret.), and Bruce Tartar, Director Emeritus of LLNL. The Subcommittee included Lynn Sykes, Columbia, Chair; Hans Hartse, LANL; Paul Richards, Columbia; Gregory van der Vink, Terrametrics; and William Walter, LLNL.

[7]"Effective" verification recognizes that a judgment of sufficiency in verification capabilities is involved with respect to risk from undiscovered cheating. Effective verification would uncover cheating that posed a significant military threat that could not be dealt with in a timely way.

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My Summer as a Congressional Intern

Allen Scheie

During the summer of 2012, I worked as an intern for the U.S. House of Representatives Committee on Science, Space, and Technology. I went into the internship thinking that it would be a unique way to use my knowledge of science, but it turned out to be far more than that. After this experience, my perspective on science's relationship to society has changed dramatically.

Currently, I am a junior at Grove City College (Pennsylvania) pursuing a double major in physics and philosophy. Physics has always fascinated me, and on top of tutoring physics and helping with our local SPS chapter, I have spent a summer internship and three semesters researching nanotechnology. But I also have strong interests in public policy and communication, cultivated through my experiences as assistant captain of the Grove City College debate team, as a content editor for my school's journal of law and public policy, and as a contributing writer for the school magazine (when I can find the time). So when I set out to find an internship for the summer after my sophomore year, I wanted to find something which balanced my interests in physics, policy, and communication. I was thrilled to discover the SPS Mather Public Policy Internship.

The Mather Public Policy Internship is a program supported by Dr. John Mather (2006 Nobel Laureate in Physics for his work with the Cosmic Background Explorer Satellite), the American Institute of Physics, and the Society of Physics Students. This internship sponsors two undergraduate Physics majors to intern for the U.S. Congress every summer. The purpose of the internship is to get physics students involved in public policy, thereby developing future scientists who understand policy as well as future politicians who understand science. The two 2012 interns were myself and Jonathan Morris from the University of Minnesota. The APS staff helped place me with the House Committee on Science, Space, and Technology ("The Science Committee," for short) which is made up of thirty-nine members of congress and their staffs. The Science Committee is responsible for directing our national science policy and overseeing a number of federal research agencies, including the National Science Foundation, NASA, and NIST, in addition to parts of the EPA and Department of Energy. At first I was given small tasks such as preparing materials and testimonials for committee hearings, taking photographs at hearings, building a few databases for the committee, and assisting with administrative tasks (a.k.a. making copies, answering the phone, and making coffee). As the summer progressed and as the staff grew more confident in my abilities, I was commissioned to do real policy research and report-writing for the committee on topics such as NASA technology benefits, hazardous chemical injection wells, open access scientific publishing, and space-flight policy.

In addition to the work for the committee, some of the most memorable parts of the internship were what happened outside the staff office. Highly renowned and influential people visited the Capitol almost every day, and all it usually took to meet them was the initiative to start a conversation. As a result, I was able to personally meet two Nobel-laureate scientists, give a formal tour of the Capitol building, sit down at lunch with executives from major spaceflight corporations, have an article, "A Crisis of Perception," reviewed and published by the editors of Physics Today, and attend a briefing by lead scientists on NASA's Curiosity Rover project [1]. The internship provided invaluable opportunities for networking, and I would encourage any physics student with interests in public policy to consider applying for it.

I learned a number of valuable lessons from this experience. First, I got to experience how public policy works up close, and not all of it was as I expected. For instance, I was surprised at how much work is handled by the congressional staffers instead of the members of Congress themselves. Congressmen rarely have time to write their own statements and questions, much less prepare bills for the floor or press-releases for the public. On a more disheartening note, I also observed members of congress on both sides of the aisle who seemed more interested in toeing their party's line than addressing the issues at hand.

Perhaps most important, I came to understand why it is vital to have politicians who understand science, and scientists who understand policy. Most of the problems our country faces have technical aspects, and scientists frequently have valuable information to contribute; politicians must understand when scientific analysis is applicable. Furthermore, as the federal government is one of the largest funders of basic research, scientists need to be able to explain and defend their projects to Congress and funding agencies. Moreover, it is critical for politicians to understand the value of doing science in the first place. The prominent mentality among congressmen seemed to be that science was good because it stimulated the economy and helped society. While many scientific discoveries do help the economy, basic research like astrophysics and particle physics are difficult (if not impossible) to defend under such a mindset. Sooner or later, someone is going to figure out that decades of cosmology research has done very little to help the economy. The future of science depends upon it being funded for the right reasons, and this requires better communication between the scientists and the legislators.

While the Mather Internship was an incredible experience, it took a lot of hard work to reach this position and to succeed while in D.C. To other students who are looking for similar opportunities, here is some advice based on my experiences.

First, take any new opportunity that sounds interesting.

I began to participate in competitive debate when a friend recommended it to me, and it has led to a host of opportunities (including the Mather Internship) that I would never have previously considered. Don't box yourself into your specialty of study—there is a plethora of fascinating things out there that you have never tried. Second, work hard on the little things. That is how you will get noticed, and that is how you will get better at what you do. Third, I highly recommend getting to know the people who have gone before you. They nearly always have advice on how to succeed, including tips on how to avoid the mistakes they made. This goes not only for internships, but college classes, job applications, and graduate school searches.

The Mather internship inspired me to think deeply about how science—particularly physics—relates to society. I plan to pursue graduate degrees in Physics. However, I hope to stay involved in the discussions concerning science in society. I am not sure where this will take me in the long run, but for now I hope to continue writing articles about science, policy, and the public. These issues are critically important for our future, and they most certainly deserve more attention.

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[1] Allen Scheie, "A Crisis of Perception," Physics Today (August 13, 2012), http://www.physicstoday.org/daily_edition/points_of_view/a_crisis_of_perception

PhysicsQuest: Bringing Super Powers to Life

Matthew Goszewski

I am a senior-level Physics/General Science/Secondary Education Major at Grove City College (Pennsylvania) and plan to become a high school physics teacher. During the summer of 2012, I had the opportunity to work on the PhysicsQuest:SPECTRA comic book sponsored by the American Physical Society. SPETRCA is targeted at middle-school science classes with the intent of providing a medium to present physics in an exciting and engaging way to students. The heroine is a middle-school teenage girl, Spectra, who finds that she can turn herself into a laser. Through her many adventures she saves her friends and school from disaster due to Miss Alignment, General Relativity, and Maxwell's Demon. The comic book is part of a kit which includes an instruction guide and materials needed to perform experiments that are featured in the story; the most notable of these were diffraction grating experiments which relate to when Spectra first discovers her super power. The PhysicsQuest:SPECTRA comic kits are available for free from APS through an online form (register at http://www.physicscentral.com/experiment/physicsquest/index.cfm). Downloadable versions of the comics are also available on the Physics Central web site (www.physicscentral.com). This year's theme and experiments focus on fluid dynamics; my job was to create extension activities to supplement the fluid dynamics featured in the comic book.

Being a student who had previously only worked on experiments that had been "debugged" in advance, the task of creating demonstrations was a new experience. It was very enjoyable to be a part of the process of researching, testing, refining, and explaining experiments. The most interesting part of my research came when I was looking for experiments to demonstrate Bernoulli's Principle. While working on experiments to describe the physics of lift and flight I discovered a "new" debate which involved the Coanda effect (where a fluid jet tends to be attracted to a nearby surface) and Bernoulli's Principle. Some researchers are questioning the traditional Bernoulli's Principle explanation of flight dynamics, and are turning to rely more on the Coanda effect as capturing better scientific understanding.

Among the many lessons I learned while developing these experiments, two stand out most prominently. The first is that experiments always look great on paper, but require a lot of refinements when they are being developed and performed. The second is that there is nothing that can stop you from creating an effective and exciting experiment. A requirement for these experiments is that they can be completed with supplies that you can find around you every day, such as coffee straws, Frisbees, sand piles, hand soap, and food coloring. There is an amazing amount of physics surrounding us at all times; if you are creative and have some perseverance, there is no end to the simple experiments that can be developed.

My internship with the APS provided me with more than just experience with developing demonstrations; I also experienced a sense of the enormity of the science world. I had the opportunity to meet many prominent scientists, and attend a variety of social events and conferences hosted by the society. A large part of the internship experience is making connections and exploring the vast world of science around us. When looking for internships or research opportunities, choose a program that both fits your interests and expands your horizons; be sure to look into any programs that have a national or global scale. As an undergraduate, it is a once-in-a-lifetime opportunity to be able to meet and make connections with scientists within an educational setting.

I would like to thank Becky Thompson, who was my supervisor for the PhysicsQuest:SPECTRA comic, as well as Kendra Redmond, who set up my internship opportunity with the American Physical Society through the Society of Physics Students. I would also like to thank the voters at the SPS 2012 Quadrennial Congress for selecting my work for second place in physics outreach.

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REVIEWS

Life Without Oil: why we must shift to a new energy future

By Steve Hallett with John Wright, Prometheus Books, Amherst, NY, 2011, 435 pages, ISBN 978-1-61614-401-2, $26 hardback

Hallett and Wright's "Life Without Oil" discusses how future declines in oil production may impact the global economy and affect civilization. Hallett, a professor of Botany and plant pathology at Purdue University, and Wright, a journalist who specializes in environmental and energy issues, open with a brief history of civilization and how environmental issues (e.g. overexploiting natural resources and overpopulation) helped lead to the collapse of many Native American and European societies. They then suggest that the world is currently near peak oil production (using "Hubbert's peak" for U.S. conventional oil as an example), with little hope of extracting more oil from current reservoirs, few new reservoir discoveries, and extensive environmental damage in developing unconventional resources.

Hallett and Wright dismiss a number of other energy sources as replacements to our declining oil resources. Natural gas is considered difficult to store and transport, with its own peak production issue arising shortly; however, it is not clear if the authors included new natural gas inventories available due to widespread "fracking" techniques (sideways drilling and fracturing of rock to allow natural gas to escape). Likewise, coal is dismissed due to its large greenhouse gas emissions and inability to provide transportation fuels. Currently, renewables are insufficiently developed and far too inefficient; they are dismissed with the conclusion that "we are not even close to being able to replace oil with sufficient renewable energy to support a diverse, thriving society of seven billion over the next century." However, Hallett and Wright suggest that nuclear power may provide an eventual solution, though it requires extensive scaling. Specifically, they highlight issues associated with public perception, waste disposal, and cost. When uranium mining, purification, processing, and disposal are properly taken into account, the authors suggest that nuclear energy is "… by far the most expensive source of electricity that we have." They also note that the reservoir of high-grade uranium ore is poorly characterized and that a similar production maximum problem may eventually be realized with nuclear energy as well.

The book then transitions to a discussion of climate change, its effects on agriculture, and the problems associated with assigning the environment to a common ownership. In regards to climate change, Hallett and Wright focus on the more extreme issues of runaway positive feedbacks, changes in the ocean circulation patterns, extreme weather events, and sea level rise. Notably, they present a compelling case for how changes in weather patterns (e.g. decreased rainfall and increased evapotranspiration in the semiarid tropics) may make many areas unsuitable for agriculture, eventually resulting in local food shortages. One unique aspect of this book is its presentation of the Coase theorem, which states that assigning ownership of a common good (e.g. the atmosphere) to a single party and allowing for subsequent bargaining is favorable over common ownership where no one takes responsibility.

The book's central thesis is that there will be an impending disruption in world oil supplies that will lead to an extended recession with higher food prices and oil wars. Hallett and Wright predict that, in general, wealthier regions (e.g. United States, Europe, Canada, Russia) will withstand this recession, whereas economically-disadvantaged areas (e.g. China, India) will fare poorly. They see "… the past few decades as the most disastrous in the history of humankind," where, "a serious energy crisis can no longer be averted by a switch to alternative energy." Thus, they conclude that "We can no longer afford to focus our energies on trying to save the world as it is," and, therefore, we must "…switch our focus to prepare for a more distant future." This future involves subsidies and taxes to reduce carbon dioxide emissions, a transition to a nuclear/hydrogen economy, extended use of sustainable agriculture, and population control. The critical message is that people must stress sustainability over growth and work to conserve instead of consume.

I will conclude this review with my own personal view. Unfortunately, "Life Without Oil" is a difficult read that vacillates between history, philosophy, and science. Hallett and Wright try to present a vast amount of information with little quantitative data, touching only briefly on each subject. They then draw excessively pessimistic conclusions with a predicted scenario that seems to this reviewer to be fairly untenable. Many of the source materials are excellent, however, and I would recommend reading them instead.

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Introduction to Modern Climate Change

Andrew E. Dessler, Cambridge University Press, 2011, xiii+238 pp., graphs and illustrations, ISBN 978-0-521-17315-5, paperback: $50

Many scientists and educators with broad backgrounds in physics and chemistry find themselves at a loss when friends and students ask them to comment on the latest news regarding global warming. How many of us hasn't wished for a primer that covers the basics, and which we would feel comfortable recommending to others? Andrew Dessler's book is just the

ticket. An accomplished climate scientist at Texas A&M University, Dessler has prepared his *Introduction to Modern Climate Change* as a text for one-semester, algebra-level general education science class. Its 14 chapters are about equally divided between coverage of the underlying science (the first seven chapters) and associated economic and policy issues (the last seven). The writing is clear, has a nice balance of formal and informal prose, and includes occasional elements of dry humor to lighten discussions of otherwise very serious issues.

Chapter 1 opens with preliminaries such as definitions of weather, climate, and climate change, along with the caution that an expert on weather is not necessarily also an expert on climate. This chapter also presents something unusual for a college-level text: a section titled "Why you should believe this textbook". Dessler argues that his readers should trust in the consensus opinion of professional climate scientists, particularly as reflected in the massive IPCC reports. In contrast, many climate-change skeptics are not experts in the field; rather, they often operate by casting largely unsubstantiated doubt on the science or positing that there exists a widespread conspiracy on the part of climate scientists, a notion Dessler demolishes as ridiculous.

Chapter 2 presents evidence for historical and current episodes of climate change, mostly as reflected through temperature-anomaly records. Over its history, Earth has certainly been warmer and cooler than it is at present, but it is the *rate* of recent warming that seems unprecedented: about 0.74°C over the 20th century. Chapter 3 covers electromagnetic and blackbody radiation, the Stefan-Boltzmann and Wien laws, and conservation of energy; this part will be a quick read for physicists and serves as a lead-in to Chapter 4, where readers encounter the idea of a climate model. The solar constant and Earth's energy budget and average albedo are introduced, concepts which set the stage for consideration of a one-layer "greenhouse atmosphere" model, which is refined to a two-layer and finally an n-layer model.

In Chapter 5, chemistry comes to the fore. Dessler describes the composition of Earth's atmosphere, the properties of greenhouse gases, and statistics on the carbon content of the atmosphere and the rate at which it is changing due to fossil-fuel burning. Prior to the Industrial Revolution, the atmospheric abundance of CO_2 had been largely within the range of about 260-280 parts per million (ppm), but has since risen to 390 ppm and is increasing at about 2 ppm per year. Chapter 6 examines climate forcing, feedback mechanisms, and climate sensitivity. Factors here include greenhouse gases, aerosols (anthropogenic and volcanic), soot, albedo changes due to ice melts and land use patterns, and permafrost melting. The IPCC's best estimate is for about 3°C of warming above pre-industrial levels if the CO_2 abundance should rise to 560 ppm. Chapter 7 gets to the issue of why the climate has been changing over the past few decades: is it due to external or natural variations, human activities, or a combination of both? After examining factors such as continental drift, the solar cycle, variations in Earth's orbit, the El Nino Southern Oscillation, and carbon-cycle timescales, Dessler comes firmly to the conclusion that anthropogenic greenhouse-gas emissions are responsible for most of the rapid late-20th-century warming.

Chapter 8 shifts the discussion to economic and policy issues. Trends in factors that control emissions are examined (population, affluence, energy and carbon intensities), as are various IPCC model projections of how these factors might evolve over the balance of this century; Dessler emphasizes that these are *not* intended to be predictions. Warming scenarios for the 21st century run from 1.8 to 3.6°C on top of the 0.7°C that has occurred during the 20th century; we are already committed to an additional warming of at least about 0.4°C over the next several decades, even if emissions were stabilized to year-2000 levels. Chapter 9 examines anticipated impacts of this warming. These will vary by latitude and location (especially within continents and along coastlines), but could involve permafrost melts, increased wet and dry spells, flooding and erosion, ocean acidification and rise, less-efficient photosynthesis, loss of alpine systems, extinction of temperature-sensitive species, and decreased fresh-water supplies. Dessler's tone is not alarmist or frantic, just sober and to the point.

Chapter 10 gets to the cost-benefit economics of dealing with climate change, with an emphasis on how the present value of a future cost can be computed given an interest rate. Do we spend money today to mitigate effects predicted for decades hence, or leave those costs and effects to our descendants? Much depends on the choice of an assumed interest rate, a matter of hot debate among economists. Chapter 11 turns to the fundamentals of climate policy. Dessler divides policy considerations into three categories: adaptation, mitigation, and geoengineering. Adaptation will have to be part of our response to warming, but depending on adaptation as the only approach has a moral dimension: it abandons the poorest of the world to face the impacts of a situation that they did not create. Given time lags in the climate system, mitigation (reducing emissions) will become effective only during the latter half of the 21st century; Dessler reviews strategies for reducing emissions via various carbon-safe energy sources. Geoengineering is appealing, but potentially risky. Chapter 12 moves to mitigation policies, and examines carbon taxes and cap-and-trade scenarios. The United States has yet to develop a comprehensive mitigation policy.

Chapter 13 offers a history of climate change and policies, from Joseph Fourier on up to the Kyoto Accord and the limbo of the December 2009 Copenhagen meeting. Dessler traces the "strategy of doubt" employed by skeptics from its origins in the tobacco industry through the issues of ozone depletion, acid rain, and CFCs. The increasing certainty of the anthropogenicity of warming as indicated in a succession of

IPCC reports, however, should convince any sensible reader that no reasonable doubts can be maintained.

The book closes with Chapter 14, which addresses the prospects for long-term policies. We face making decisions knowing that there are uncertainties in how much warming could occur, how much of it could be avoided, and what the cost could be. Dessler advocates for action now: If climate change turns out to be not as serious as anticipated, mitigation efforts could be scaled back in the future; also, switching to clean energy sources will lead to reductions in energy imports and air pollution. But if we do nothing to reduce emissions and worst-case scenarios come to pass, we doom our planet to irreversible, possibly catastrophic damage. Dessler offers a suite of strategies he feels necessary to achieve a middle-of-the road target of holding warming to 2°C above pre-industrial levels: put a price on emissions, reduce coal burning, implement improved efficiency standards, fund research and development of new technologies, prepare to adapt, and be ready to amend policies as necessary.

I learned a lot from this book and will be keeping it at hand. Each chapter contains a list of references as well as qualitative and quantitative questions, although no answers are provided for the latter. I was surprised that the infamous IPCC "hockey stick" was not mentioned, although one of Dessler's graphs derives from it; anybody trolling the web is bound to come across this controversy. In the end, Dessler is optimistic that human creativity can solve the coupled problems of energy and climate. Left unstated, however, is the question of whether or not we have the will, foresight, and leadership to do so.

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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 view of APS.

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