

PHYSICS & SOCIETY

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

Note from the Editor

In this issue of *Physics and Society* we start with News from the Forum. Our Chair, Arian Pregoner, announces the winners of the 2016 Joseph A. Burton Forum award and the Leo Szilard Lectureship Award. In addition, we also announce our new Fellows chosen under the guidance of the Fellowship Committee led by Allen Sessoms. Finally, we have an announcement of sessions that are sponsored by FPS at both the March and April APS meetings.

After the News section there is a letter to the Editor on climate change. Then, our first article is by Hannah Davinroy, an undergraduate physics major at Princeton University. She worked as an intern at the Federal Energy Regulatory Commission this summer and has written a note on new policies related to geomagnetic disturbances. David Hafemeister, who has had a long and distinguished association with the Forum has written an outstanding history of our activities from our

origin in 1972 until today. For those of you that don't know all of the details, I urge you to read Dave's article. As part of his history, he reviews the origins of this newsletter and I am personally honored to be part of a long line of distinguished Editors that includes Martin Perl (1972-79), John Dowling (1980-86), Art Hobson (1987-1996), Al Saperstein (1997-2009), Jeff Marque (2003-2009) and Cameron Reed (2009-2013). Finally, we end with a book review, Greg Craven's, *What's the Worst That Could Happen? A Rational Response to the Climate Change Debate*.

As always, I am looking for people that would like to publish articles of interest to our readership. Please let me know if you or one of your colleagues would like to submit an article for an upcoming newsletter.

Happy reading!

—Andrew Zwicker
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Message from Chair

It is an honor to chair the Forum on Physics and Society. I encourage all members to become more involved in the activities of the Forum, especially when it comes to nominating candidates for awards and fellowships and for suggesting new topics for FPS sessions at the March and April Meetings. This last year has been a particularly good one, and I'm looking forward to our efforts in 2016. Some highlights include:

NEW FELLOWS

Allen Sessoms, the new FPS Vice Chair, did a phenomenal job chairing the Fellowship Committee, which successfully nominated 4 new fellows:

Douglas Arion

For groundbreaking work towards improving the educational impact of the physics degree by promoting the widespread adoption of entrepreneurship training and mindset within the discipline.

Ashton Carter

For exceptional service to physics and to society through service in the academy and in government.

Roger Hagengruber

For decades-long leadership of nuclear arms control and nonproliferation efforts informed by deep knowledge of the U.S. nuclear weapons program.

Benn Tannenbaum

For outstanding contributions to international peace and security by addressing nuclear arms control, nonproliferation, and terrorism; and for mentoring young scientists and educating students to bring science to bear on societal challenges.

JOSEPH A BURTON FORUM AWARD

Bill Barletta of MIT chaired the Awards Committee, which nominates candidates for the Joseph A Burton Forum Award and the Leo Szilard Lectureship Award. U.S. Secretary of Energy Ernest Moniz has received the 2016 Burton Award "For outstanding contributions in government service to advancing national energy and science policy over two decades and to reducing the threat of nuclear proliferation through key roles in disposition of Russian nuclear materials in the 1990s and negotiation of the nuclear agreement with Iran in 2015."

LEO SZILARD LECTURESHIP AWARD

The 2016 Leo Szilard Lectureship Award, recognizing outstanding accomplishments by physicists in promoting the use of physics for the benefit of society in such areas as the environment, arms control and science policy, was awarded to Joel Primack, University of California, Santa Cruz.

THE MARCH AND APRIL PROGRAMS

The March and April Programs are shaping up with some very exciting sessions on both new and traditional topics. Not everything has been decided yet, but here's a preview of what's on the list to date:

March

- The Iran Nuclear Deal: Physics, Physicists, and the Historic Agreement
- Special Session with Steven Weinberg discussing his new book *To Explain the World: The Discovery of Modern Science*
- The War on Cancer: Physics Enters the Fray
- Physics of Epidemics

April

- Modernizing Nuclear Weapons
- Politicizing Science: Benefits and Costs
- Planetary Systems and Extraterrestrial Life

To the Editor

The climate and energy dilemmas are inextricably linked, but this fact is often ignored. For instance Pope Francis, on his tour of the United States mentioned climate change, but apparently there was no recognition on his part that the fuel we burn is not frivolous; on the contrary, it has allowed for a healthier, longer lived, better educated, more prosperous population, who live in a cleaner environment.

There are in fact, strong moral imperatives on each side of this argument. However this ignorance of the benefits of the use of fossil fuels, this stated or unstated assumption that we can just turn them off without any adverse consequences, has permeated the debate to a very large extent. Turn on your TV almost any day and you will hear many who say we should drastically reduce, or even end our use of fossil fuel virtually immediately. Even physicists are not immune. The APS, in its statement on climate change (1) says we must begin to reduce the emission greenhouse gases ‘starting now’. It speaks about climate effects likely to occur, but there is no word about the benefits of fossil fuel. The AIP has gone one step further and gives a time limit. In its flagship publication *Physics Today* had two articles in its October, 2011 issue arguing that we must turn off carbon input into the atmosphere in about 20 years from 2011, without any thought that this would mean the decent into abject poverty for billions of people(2,3). If anyone should be aware of the importance of energy for civilization, it is physicists!

This Forum has provided a wonderful opportunity to argue these points, and this author has taken advantage of it (4,5). It is worth pointing out another journal, Standard Science Research and Essays also encourages scientific essays,

and is willing to publish essays longer and more provocative than what is usually appropriate for *Physics and Society*. These are published open access and are freely available on line, like *Physics and Society*. I have recently taken advantage of this opportunity and published one such essay (6) on the climate energy dilemma. This discusses not only the science, but also gives an amateur’s view of the theology and human psychology. It is nothing if not provocative, but it makes an argument I believe is long overdue.

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1 http://www.aps.org/policy/statements/07_1.cfm

2 Steven Sherwood, “Science controversies past and present,” *Physics Today* 64(10), 39-44 (October, 2011), http://www.physicstoday.org/resource/1/phtoad/v64/i10/p39_s1

3 Richard C. J. Somerville and Susan Joy Hassol, “Communicating the science of climate change,” *Physics Today* 64(10), 48-53 (October, 2011). http://www.physicstoday.org/resource/1/phtoad/v64/i10/p48_s1

4 Wallace Manheimer, Letter to the Editor, *Physics & Society* 38(3), 3 (July 2009). <http://www.aps.org/units/fps/newsletters/200907/letters.cfm>

5 Wallace Manheimer, *American Physics, Climate Change and Energy, Physics and Society*, 41, 2, April, 2012, <http://www.aps.org/units/fps/newsletters/201204/manheimer.cfm>

6 Wallace Manheimer, *Original sin, prophets, witches, preschool sex abuse, and global warming. Standard Science Research and Essays* 3, (9), 277, 2015 <http://www.standardjournals.org/journals/SSRE/Pdf/2015/september/Manheimer.pdf>

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

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Physics and Society can be found on the web at www.aps.org/units/fps.

Recent Policy Surrounding Geomagnetic Disturbance and the Bulk Electric System

Hannah Davinroy

As the reliability of the American electric grid and bulk power electric system is bombarded every day with challenges including a shifting resource mix, the integration of new renewable technologies, and severe weather, the contribution of the Sun in considering reliability has only recently taken a spotlight. Solar storms—in particular, those of the magnitude to cause large coronal mass ejections (CME) of upwards of a billion tons of plasma matter—can cause a rapid change of the alignment of the magnet field of Earth over large geographic distances. The geomagnetic disturbances (GMDs) produced by CMEs—when directed towards the Earth—can also cause magnetic disturbances across the surface of the Earth. These shifts in the magnetosphere can manifest disturbances within the high-voltage power grids around the globe. Geomagnetically induced current (GIC) emerges in the bulk electric system (BES) as a highly magnetizing current and a high harmonic current travel along high-voltage transmission lines and grounded transformers.

Though solar storms and CMEs occur with some frequency, the potentially dramatic impacts to the American BES have not historically been realized. The most often cited event is the GMD-caused collapse of the Hydro-Quebec system in March 1989. Leaving almost six million people without power for nine hours, the 1989 incident pales in comparison with the magnitude of storms in 1921—which disabled telegraph service—and with “the Carrington event” of 1859, which researchers predict would have crippled the BES. Because of the infrequency of events, the projection of the incidence, frequency and magnitude of future storms is highly uncertain. However, as research continues, there is a growing consensus that a “Carrington”-scale storm is inevitable, and that collective action is necessary to protect the national electric infrastructure from extensive damaging impacts. Despite the collaborative resources of national laboratories, regulatory agencies, and industry applied over the last decade to researching and addressing the potential for serious, high-impact GMD events, much information surrounding the impact of their subsequent GIC to the grid is still uncertain. The regulatory challenge is to define equipment and protocol standards with incomplete knowledge of how the threat will propagate throughout the BES—either as a loss of reactive power support increasing voltage instability and power system collapse or as physical damage to BES assets, most commonly transformers.

MITIGATION AND MONITORING

Though the surging interest in GMD prevention has really occurred in the last 15 years, the technology to prevent GIC is not new. GIC blockers—both in the form of neutral-blocking capacitors and neutral-blocking resistors—have been around since the Hydro-Quebec event in 1989. While hardware solutions are available, they are not widely used due to disagreement on their effectiveness. The other option involves system reconfiguration and operational procedures. Richard Waggel, Electrical Engineer from the Office of Energy Infrastructure Security at the Federal Energy Regulatory Commission, believes that for the grid to be robustly durable during GMD, there must be a balance between operational improvements and hardware installation. Speaking on this balance, he contends, “A lot of people look at reconfiguring the system, but that in itself isn’t a foolproof method. It might be able to buy you something, but against a large-scale GMD event, that’s unlikely to be enough.” One of the largest arguments against the implementation of any sort of technology is cost effectiveness. “What you have to look at is the cost to society to have power outages similar to the Quebec incident in ’89,” Waggel said, “For the billions of dollars lost in those outages, you might think mitigating is a very slight cost in comparison.”

On the other side of the equation is the equation of monitoring of CMEs by satellites. It takes CMEs between 14hrs and 6 days to reach the surface of the earth. Space weather is monitored very closely by the National Oceanic and Atmospheric Administration as well as NASA. Improved modeling and forecasting have allowed timely distribution to grid operators of information regarding if and when CMEs will impact the earth and their projected magnitude. Waggel praises the importance of monitoring as an instrumental foundation to the overall response strategy, “One thing I’ll say especially about NOAA and space prediction center is they are instrumental in all this, and we wouldn’t be as far along if it weren’t for them.”

PROACTIVE POLICY

Regulatory Jurisdiction over the reliability of the electric grid falls to the Federal Energy Regulatory Commission (FERC). The FERC designated electric reliability organization—the North American Electric Reliability Corporation—submits system-operator voted standards to FERC for approval. In 2013, FERC moved for the first time to

require mandatory standards related to GMD. A directive to NERC issued May 13, 2013, Order 779 comprised two major steps toward GMD mitigation. The first was an interim step requiring development of operational procedures—like grid-level monitoring and communication of solar activity—to provide some safeguards to the grid, within 6 months of Order 779. The second stage required NERC to develop a standard that included a system-wide risk assessment and the implementation of a plan that would protect against a “benchmark” event. Part of NERC’s response was to define a “benchmark” GMD event, which they set as the 1-in-100 year event in their submission of standards to FERC in January 2015.

Commissioner Cheryl LaFleur, appointed to the five-member Commission in 2010, arrived to the Commission at about the same time as GMD policy did. “Ten years ago, this wasn’t on most people’s radar, in industry or in government,¹” she says. Commissioner LaFleur served on the Commission in 2013 when Order 779 was voted on, and she has remained a prominent spokeswoman on the issue. FERC’s first mandatory GMD standard has not been without controversy however. “One reason is that when we attempt to make rules about geomagnetic disturbance we are making requirements about threats that are not fully understood,” explains LaFleur on the issue, “This isn’t simple like directing them to trim trees. Some studies say that GMD would cause high voltage transformers to melt. Others say that the reactive power would cause the system to break apart before transformers were damaged. So we are developing standards while there’s still some unknown information.”

In May 2015, two years after Order 779, FERC issued a Notice of Proposed Rulemaking that proposed to accept some NERC-submitted standards and required revision of others, including the definition of a benchmark event and the timeline for compliance. Comment period for The Notice of Proposed Rulemaking closed in July 2015 and currently is awaiting further action at FERC.

CONTINUING ACTION

In addition to GMD concerns, the growing threat of Electromagnetic Pulse (EMP)—intentional manipulation of the electric grid often associated with the magnetic pulse caused by a high-altitude nuclear explosion—increases the need for recent standards for GMD mitigation. EMP threats cause concern for national security. Though EMP pulses oc-

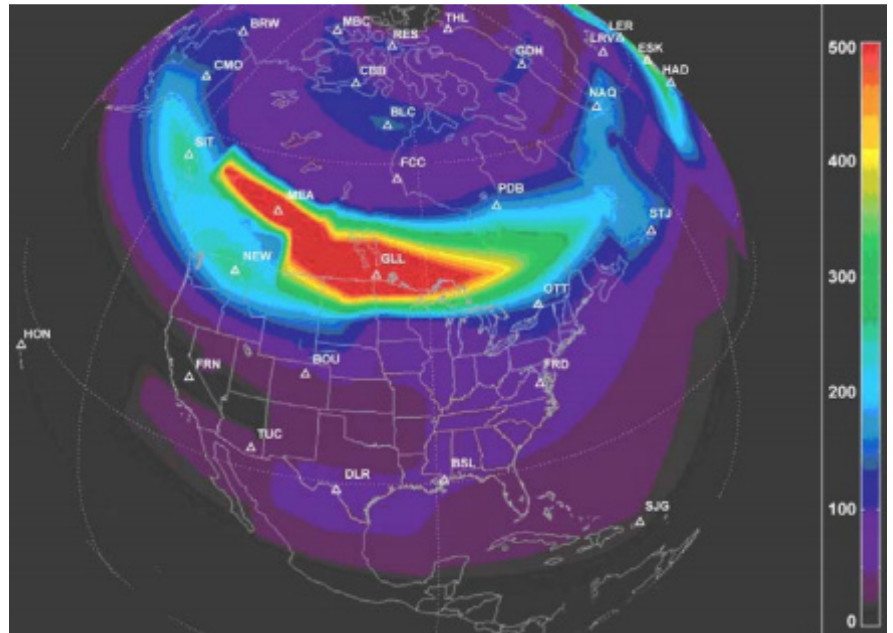


Figure: Model of Geomagnetic Intensity- March 1989 Hydro-Quebec Storm. Source: NERC Reliability Assessment: Effects of Geomagnetic Disturbance on the Bulk Power System 2012, <http://www.nerc.com/files/2012GMD.pdf>

cur within a much shorter time scale, mitigation for GMD can diffuse some impact of the EMP pulses as well. The addition of GMD standards can potentially create a more robust electric grid, addressing several reliability issues.

Even without the mandatory standards that will emerge from Order 779, many in industry have been addressing system vulnerabilities with voluntary measures for years. According to Commissioner LaFleur, “Most scientists agree that it’s a question of when not if one of these large scale events occur. I don’t want to be the one with the report that the levee would break if the hurricane came when it’s our responsibility to get ready.” The policy addressing GMD has become a forefront of the reliability question, and Order 779 is simply the foundation of grid protection. “I believe the long term solution is building the transformers to have more resistance to GMD up front, not retrofitting equipment,” LaFleur says, “A lot of thought is going into how to design the system so that we have more redundancy if something happens and to mitigate against the effects of cascading outages. I think the future of grid protection is in the way we build and design it.”

¹ Personal interview, October 5, 2015

Hannah Davinroy is an undergraduate studying physics at Princeton University. She worked as an intern at the Federal Energy Regulatory Commission this summer.

History of the APS Forum on Physics and Society (1972–2015)¹

David Hafemeister

Physics is a major component of many of society's difficult issues: nuclear arms and their proliferation, energy shortages and energy impacts, climate change and technical innovation. Because physics principles underlie so many of these societal issues and because physics offers a way to quantify some aspects of them, members of the American Physical Society (APS) should be encouraged to understand, analyze and debate them. This is precisely why APS members formed the Forum on Physics and Society (FPS). To those of us who have been involved in FPS affairs for a long time, it seems like only yesterday that we attended the organizing meeting at the 1972 APS San Francisco meeting. Some 44 years later, it's a good time for FPS to look back at its accomplishments and look ahead at the direction of its future activities.

- 342 APS Sessions in 44 years (7.8/year)
- 12 books (3 Forum Studies, 9 AIP Conference Proceedings, 4 booklets)
- Physics and Society published for 42 years, referenced by other journals
- Two Forum Board members became US Congressman [V. Ehlers (R-MI), R. Holt (D-NJ)], others had notable public service careers
- Szilard and Burton Awards recognize positive contribution of physicists in society
- The Forum helped establish the Congressional Science Fellowships

THE EARLY YEARS

The FPS was born in the tumultuous 1960's and 70's. The issues of that era—the Vietnam War, Anti-Ballistic Missile systems, and the energy crisis, along with the start of the environmental movement and the civil/human rights revolution—impelled that generation of physicists to consider their professional responsibilities. Many felt that the APS should have a division or forum in which appropriate science and society issues would be debated by informed participants before the APS membership. An excellent review of the early days of the Forum was published by Barry (“Mike”) Casper in the May 1974 issue of *Physics Today*.

In its 40 years, FPS had too many excellent leaders to mention each by name. But I would like to describe briefly

the four “founding fathers” pictured in Casper’s article: Earl Callen (American University), Martin Perl (SLAC), Mike Casper (Carleton College) and Brian Schwartz (then MIT, now CUNY). Callen was the founding chair of the Forum. Although his particular interest was international human rights of scientists, the major goals of Callen’s term were building membership, developing a reputation within the APS membership for quality and objective management, and establishing effective working relationships with the APS Council.

Martin Perl can only be described as a phenomenon. While acting as the second chair of the Forum in 1973-74, he discovered the tau meson, establishing the third family of leptons. (For this discovery he was awarded the 1995 Nobel Prize in physics, shared with Frederick Reines, who was honored for the discovery of the electron’s anti-neutrino). And in his spare time Perl established and edited the forum’s newsletter, *Physics and Society*, from 1972-79 and mobilized two Penn State Conferences on graduate physics education (1974, 1977). It was my pleasure to work closely with Marty on these conferences, as he was discovering the tau lepton. Mike Casper, the Forum’s third chair, established the two Forum Awards. After that, he actively worked on arms control and became a senior advisor to Senator Paul Wellstone. Schwartz, the ninth chair of the FPS, served brilliantly and creatively in the crucial job of organizing the first Forum panels at APS meetings. While he might have been regarded as a “young Turk” by the APS establishment in the 1970s, he has gone on to be an APS insider, serving as the APS Education Officer and as APS Associate Executive Secretary (1991-94). He was also responsible for much of the planning for the APS centennial activities in 1999.

Sadly, three of the four founding parents of the Forum have passed on. Most recently Marty Perl died on 30 September 2014. The last surviving parent, Brian Schwartz, wrote Marty’s obituary, which appeared in the January 2015 issue of *Physics and Society*. *Physics Today* published Marty’s obituary in the March 2015 issue.

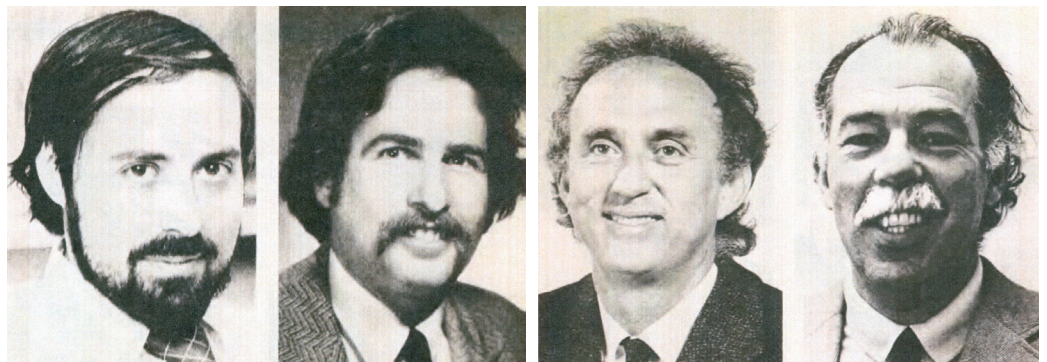


Fig. 1. The Four FPS Founders: Brian Schwartz, Mike Casper, Martin Perl and Earl Callen. [M. Casper, “Physicists and public policy: the “Forum” and the APS,” *Physics Today*, May 1974.]

Table 1. FPS Sessions (1972-2015). The break-out by topic of FPS sessions is displayed in the three time periods and in-total.

	1972-1999	2000-2011	2012-2015	1972-2015
National Security	51 (26%)	24 (22%)	2 (6%)	77 (23%)
Policy Process	36 (18%)	19 (17%)	5 (16%)	59 (20%)
Energy/Environment	40 (20%)	17 (15%)	10 (31%)	67 (18%)
FPS Awards	25 (13%)	13 (11%)	4 (13%)	42 (12%)
Education	20 (10%)	12 (11%)	1 (3%)	33 (10%)
Miscellaneous	16 (8%)	29 (26%)	10 (31%)	55 (16%)
Contributed Papers	9 (5%)	0 (0%)	0 (0%)	9 (3%)
TOTAL (rate)	197 (7.3/y)	111 (8.5/y)	32 (8.0/y)	342 (7.8/y)

The FPS was the first APS forum. Recognizing that the Forum would attract members from across disciplinary lines, the APS waived the additional dues that are traditionally charged to members for joining a division, such as the Division of Biophysics or the Division of Condensed Matter Physics. With the subsequent creation of additional fora, APS instituted a charge for membership in each forum over two per member. The APS gives a certain amount of money to each forum, based on the forum membership, to help defray cost of a newsletter, travel funds to APS meetings for non-APS members, etc. This approach induced APS to create six other forums following the FPS experience: The Forum on History of Physics (FHP, 1980), the Forum on International Physics (FIP, 1985), the Forum on Education (Fed, 1991), the Forum on Industrial and Applied Physics (FIAP, 1995), the Forum on Graduate Student Affairs (FGSA, 2001) and the Forum on Outreach and Engaging the Public (FOEP 2010). Under the leadership of FPS Chair Tony Nero, a council of APS forums was established in order to coordinate and enhance the work of all the forums. This has led to joint sponsorship of invited paper sessions at APS meetings. In addition there are fourteen topical groups, the FPS has worked with the topical groups on Energy, Research and Applications (GERA), Physics Education Research (GPER) and Physics of Climate (GPC).

WINNING RESPECT

In its early days, the Forum was looked upon with suspicion by the APS leadership, which was concerned that the Forum would move issues too far and too fast. Because of this concern the APS council appointed two senior APS members to attend the Forum Executive Committee meetings to make sure that the Forum did not embarrass the APS. Embarrassment never happened.

I recall three examples in which the Forum was very even handed. The first concerns an amendment to the APS Constitution proposed by Robert March, which would have required

the APS to “shun activities which contributed harmfully to the welfare of mankind.” It was very difficult to obtain a speaker against the March amendment at an April 1972 FPS session. The first Forum Chair, Earl Callen, stepped forward and filled that role (in which he believed). His presentation helped to defeat the March amendment. The second example concerns the publication of a very political cartoon by the editor of *Physics and Society*. That editor was warned not to run any more such one-sided cartoons, but he ignored the warning. Although in other respects, that person had been a good and tireless editor, the Forum Executive Committee was forced to adhere to the principle of objectivity and fire him.

A highly publicized controversy occurred with the newsletter in 2008. The editors wanted to promote a debate between those who accepted the scientific findings that human activities were having an impact on climate-change and those who did not. Unfortunately, they chose a highly controversial and outspoken non-scientist, Christopher Monckton, to represent the arguments of the climate deniers. Monckton subsequently presented his *Physics and Society* piece to journalists as a peer-reviewed paper from a “learned journal” and touted it as evidence for APS support of his position. The newsletter tightened its editorial oversight and now adds a disclaimer to every article; “These contributions have not been peer-reviewed. They represent solely the view(s) of the author(s) and not necessarily the view of the APS.”

By now, the FPS has long since won the respect of the APS Council. They no longer appoint representatives to the Forum Executive Committee. The Forum is regarded as a source of manpower and ideas for the APS to utilize in preparing its public positions. Of the 38 chairs of the APS Panel on Public Affairs from 1975 to 2012, six of these have been chairs of the FPS.

As of January 2015, the Forum had 5676 members, 11.02% of the total APS membership of 51,523. The 11.02% FPS membership is exceeded among the forums only by the

History of the Forum continued on page 8

Forum on Industrial and Applied Physics at 13.19%, which is followed in third place by the Forum on International Physics at 7.20%. Among the APS Divisions, FPS is led only by the Division on Condensed Matter Physics (DCMP) at 11.33%, which is followed by the Division of Particles and Fields (DPF) at 6.69%. The vast majority of Forum members are active physics researchers and professors who are already overly committed to their professional careers. These FPS members are not actively publishing on the Forum issues of arms control, energy and environment. However, these members do want the FPS to hold debates, publish a viable Physics and Society newsletter, sponsor occasional studies, offer short courses and give awards. As in any division of the APS, the heavy lifting is carried out by the 1% of the membership who volunteer to be more heavily involved.

FPS SESSIONS

One of the most important activities of the FPS has been to sponsor sessions at APS meetings on topical science-and-society issues. Some FPS sessions have had more than 1,000 attendees. Over the first 27 years up to 1999, the FPS offered 197 sessions for an average of 7.3 +/- 1.7 per year.

Over the next 13 years (2000-2012), FPS offered 111 sessions for an average of 8.5 +/- 1.7 per year, an increase of 16%. Over the next four years (2012-2015), FPS offered 32 sessions for 8/year. The rise in session over time is somewhat remarkable since sessions are now rarely held in Washington, DC, an easy place to find experts on policy-related issues. The March meeting has had an average of 3.0 per year and the April meeting has had an average of 5.8 per year, twice that of the March meetings.

The total number of FPS sessions from 1972 to 2015 is 342, for an average of 7.8 per year. To provide more in-depth background on certain issues, FPS has offered short courses on a number of topics. If one adds the sessions from the two Penn State conferences and seven short courses, the total number of sessions rises to about 375, for an average of 9.4 per year.

Trends

National Security was 23% of all sessions, but it has dropped in the latest time-bin. FPS could do more on nuclear proliferation, terrorism, ISIS and bio-weapons.

Policy Process has had national security aspects. It remains constant at 20%.

Energy/Environment has been relatively constant at 18%.

Awards has been constant at 12%.

Education has been relatively constant at 10%.

Miscellaneous has quadrupled to 31% for an average of 16%. FPS has become more broadly based.

Contributed Sessions have been replaced with Short Courses.

The four Short Courses since 2000 added the equivalent of 25 sessions on Energy and Environment and 6 sessions on National Security. The end of the Cold War saw National Security arena shift from SS-18s and Star Wars to Terrorism and Proliferation. Miscellaneous sessions rose dramatically from 8% to 31%, implying that FPS is becoming more eclectic as we considered debates over biological evolution, physics and art, physics and entertainment, physics and commerce and more. Contributed Paper sessions dropped to zero, as FPS decided that a diverse collection of ten-minute papers lacked focus

FPS Goals for APS Sessions

The goal of Forum sessions is to present the best arguments on both sides of an issue in a no-holds-barred debate. Unfortunately, this goal is occasionally abused by people who wish to offer views that are unscientific or that confuse the debate. For instance, at the spring 1986 APS meeting in Washington, DC, the Forum held a session on the pros and cons of the Strategic Defense Initiative (SDI). Organizers invited representatives from the Reagan administration and from the Congressional Office of Technology Assessment, along with some university faculty. It never occurred to us to invite Lyndon LaRouche's Fusion Energy Foundation. However, this group felt they should have been invited and they attempted to shut down the session. As Forum Chair at the time, it was my task to go head-to-head and threaten them with police action if they would not be quiet and allow the session to continue. They did quiet down, and the details of lasers in space were quantified and debated. It can be difficult to define when a position should be categorized as "unscientific." Luckily this issue doesn't come up very often.

An example of even-handedness was the March 2007 session in Denver on "Nuclear Weapon Missions in the 21st Century." This session focused on the merits and needs for Reliable Replacement Warhead (RRW) and not its design. The event was timely in that a few days before the session, Lawrence Livermore National Laboratory won the contract to develop the RRW because of its more traditional design which had already been tested, while Los Alamos National Laboratory's more advanced design took second place because it had not been tested, and this would be a problem under the Comprehensive Test Ban Treaty. The panel was balanced between government, universities and non-governmental organizations. It consisted of John Harvey (NNSA Director for Policy and Planning, last minute replacement for NNSA Director Linton Brooks), Lt. General Robert Kehler (Deputy Commander of the Strategic Command), Bruce Tarter (former LLNL Director and chair of AAAS Study on the RRW), Sidney Drell (a member of the Jason group that had studied the RRW issue), and Ivan Oelrich (Vice President of the Federation of American Scientists, who had written a paper "Missions for Nuclear Weapons After the Cold War."). The Bulletin of the American Physical Society contains the lineups for the other sessions, many of which I view as truly historic.

AAPT BOOKLETS

The American Association of Physics Teachers has often shown an interest in FPS sessions and short courses. The AAPT published three FPS sessions as informative booklets for its members:

Nuclear Energy, Nuclear Weapons Proliferation and the Arms Race by Bernard Spinrad, John Holdren, Gene Rochlin and Herbert York, January 1982, 48 pages.

Nuclear Weapons and Nuclear War by Philip Morrison, Hans Bethe and Wolfgang Panofsky, April 1982, 35 pages.

Acid Rain: How Serious and What to Do by Myron Uman, George Hidy, Michael Oppenheimer and Leonard Weiss, April 1985, 47 pages.

PHYSICS AND SOCIETY

P&S is in its 44th year. Martin Perl was founding editor (1972-79, SLAC). He was succeeded in 1980 by the late John Dowling (1980-86, Mansfield State University). Art Hobson (University of Arkansas) was editor from 1987 to 1996. Al Saperstein (Wayne State University) was editor from 1997 to 2003, when Jeff Marque joined him as Co-Editor until 2009. Cameron Reed (Alma College) was editor from 2009 to 2013. Andrew Zwicker (Princeton Plasma Physics Laboratory, current editor). This is a tremendous list of persons with talent and dedication, thank you very much. *P&S* fulfills an extremely important function by informing FPS members of current topics. It is much more than a newsletter. Since there are not many journals that cover the many applied-physics issues, *P&S* provides a useful outlet for physicists who have viable data or theory to publish. There are not many such quality journals in existence. It has long been a goal of the FPS to convert *P&S* from a “quasi-journal” to a full-fledged subscription journal. The display at the Atlanta Centenary showed the evolution of the *P&S* masthead and front-page. With the passage of time the contents of *P&S* have shifted from more general commentary to the more technical aspects of physics and public policy issues.

Thanks to the diligence of former editor, Cameron Reed, the FPS-*P&S* web site has an archive of all the back issues, with the exception of all of Volume 1 (1972) and a few other editions. The site also includes an index, arranged by topic and by author. It is interesting to examine these older issues. The March 1973 issue tells us that the Forum leadership (Mike Casper, Anne Cahn, and Joel Primack) will describe at the upcoming Washington APS meeting the Congressional Fellowship Program, which was to begin in September 1973. This issue tells us that Edward Teller and Sam Goudsmit debated “Science and Secrecy” and that Philip Boeffey and Ralph Nader also debated.

In order to encourage the exchange of ideas among physicists, many of the FPS symposia are published in *P&S*. Examples include: SDI (September 1986), a forum-sponsored study of land-based intercontinental ballistic missiles (July

1988), energy research (July 1989), safeguards on plutonium and highly enriched uranium (July 1990), pseudoscience (July 1990), a forum-sponsored study of energy (October 1991), powerlines and public health (January 1992), climate change (October 1992), environmental physics (July 1993), physics and law (October 1993), risk and nuclear power (July 1994), theater ballistic missiles (October 1994), legacy of radiation from cold war (July 1995), sustainable technologies (October 1995), linear low dose radiation (January 1997), monitoring nuclear materials (July 2006), reflections of presidential science advisors (October 2006, January 2007), what are nuclear weapons for (October 2007, April 2008), nuclear weapons at 65 (January 2012), nuclear power after Fukushima (July 2014), physics and politics (October 2014) and more. Among the talks in these various symposia, one of my favorites is the one by James Randi (October 1989) on “Fooling Some Scientists Some of the Time.” The unplanned juxtaposition of Randi’s talk and the big APS debate on “cold fusion” at the 1989 Baltimore APS meeting was indeed timely. The April 1991 issue of *P&S* contains a nice debate between Peter Zimmerman and Art Hobson on the use of high technology conventional weapons in the Gulf War. *P&S* also reviews recent books and describes recent events in physics and public policy. Over the years *P&S* has published a wide variety of letters on both popular and unpopular topics. Many times an editor (and the editorial board) has disagreed sharply with the contents of some of the letters to the editor, but openness has often dictated their publication as long as the view makes some logical points. As pointed above, *P&S* publishes a disclaimer at the end of each article stating “These contributions have not been peer-reviewed. They represent solely the view(s) of the author(s) and not necessarily the view of the APS.”

FORUM STUDIES

Over the years the FPS sponsored three studies, which were published by AIP Press. The study groups arose after a small group of individuals decided to study selected issues in depth. The individuals contributed their own time, talent and energy. FPS and APS contributed some funds toward helping the authors hold occasional meetings and lent its auspices for publication of the results.

Civil Defense: A Choice of Disasters, edited by John Dowling and Evans Harrell, 1986, 248 pages

The Future of Land-Based Strategic Missiles, edited by Barbara Levi, Mark Sakitt and Art Hobson, 1989, 310 pages.

The Energy Sourcebook: A Guide to Technology, Resources and Policy, edited by Ruth Howes and Anthony Fainberg, 1991, 550 pages.

Each of these studies contains the caveat: “This volume was prepared by a study group of the Forum on Physics and Society of the American Physical Society. The American Physical Society has neither reviewed nor approved this

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study.” This disclaimer is only fair since the APS Council did not take an active role in the development of these studies. Time has eclipsed the large-scale plans for civil defense structures and the evacuation of cities. Land-based missiles will not be confined to single warheads, but there has been reasonable (although slow) progress on strategic arms control. The energy issue may have been forgotten in the press in the 1990’s, but FPS members knew it would return in the 21st century, which it has. Hopefully, many physicists will blow the dust from the Howes-Fainberg energy volume and use their timeless principles to help solve today’s problems. These studies have held up over the years and remain good references today.

PHYSICS JOBS

The first “job crisis” for young PhD’s took place in the early 1970s. The Forum responded by organizing two conferences at Penn State University (August 19–23, 1974 and August 1–3, 1977). Martin Perl and Roland Good were the driving forces behind these conferences, which examined the data and possible responses by the physics academic community. Of course, there was no easy solution then, or now, to the vulnerability of young PhDs and post-docs in a tight job market, but the conference developed a number of partial solutions. The results of the first conference on “Technology Change in Physics Graduate Education” were published in the 64-page, February-1975 issue of *Physics and Society* and it still remains the newsletter’s largest single edition. The results of the second conference on “Changing Career Opportunities for Physicists” was edited by Martin Perl and published in the AIP Conference Series (*Physics Careers, Employment and Education*, AIPCP 39, 1978, 340 pages). These studies were a precursor to the later studies by the APS Committee on Careers and Professional Development and the Young Scientists Network.

CONGRESSIONAL SCIENCE FELLOWS

In 1973, APS chose its first two APS Science Congressional Fellows in an AAAS program with different societies (IEEE, OSA, etc.) when Ben Cooper and Richard Werthamer were selected. Cooper served a long and distinguished career on the Senate Energy Committee, rising to the position of the staff director under Democratic Senator Bennett Johnston (and as a FPS chair). Dick Werthamer served his congressional year with Republican Congressman Charles Mosher of Ohio and later served as Executive Secretary of the APS. Since then, some 150 physicists have served as Science Congressional Fellows, either as APS or AIP Fellows or as fellows from other scientific organizations. Many Fellows have remained active in the FPS leadership. Forum members Mike Casper, Richard Scribner and Joel Primack played distinct and significant roles in the creation of the APS Congressional fellowship program which former FPS chair Scribner directed for many years at AAAS.

FPS also started 3 years of summer internships in collaboration with the Society of Physics Students.

<http://www.spsnational.org/programs/awards/fellowships.htm>

PHYSICS EDUCATION

Over the years, the Forum organized 33 sessions on education issues. Former FPS chairs Ruth Howes and Ken Ford took an active role in organizing the Forum on Education in 1991. The Forum on Physics and Society maintains an active interest in physics education issues, but is now in a supportive role with the Forum on Education and the APS Committee on Education.

SHORT COURSES

In order to study physics and society issues more deeply, the Forum organized a series of nine short courses between 1982 and 2014 (33 years), which lasted for 2 to 3 days. The participants heard some 20 hours of lectures from 24 assorted experts; later they received copies of the 500-page AIP Conference Proceedings. The \$100 fee also covers two box-lunches and four cups of coffee. For an additional \$35, the participants can come to the banquet hall. The short courses are at bargain prices with essentially no FPS outlay because the speakers generously agree to attend *pro-bono*, without charging for their time, travel or hotels and institutions have generously provided a free venue. The short-courses and proceedings must be highly professional to attract this caliber of speakers. The Forum offered four short courses on arms race matters (1982 at APS San Francisco, 1983 at APS Baltimore, 1988 and 2014 at George Washington University), four on energy (1985 at Office of Technology Assessment, and 2008, 2011 and 2014 at University of California at Berkeley) and one on climate change (1991 at Georgetown University) The four short courses held in the 21st century attracted an average of 150 to 200 attendees each. Eight of them were published in the AIP Conference Proceedings Series (AIPCP):

Short Course on the Arms Race, edited by D. Hafemeister and D. Schroerer, El Coral Press, San Luis Obispo, CA (1982), 179 pages

Physics Technology and the Nuclear Arms Race, edited by D. Hafemeister and D. Schroerer, AIPCP 104 (1983), 380 pages.

Energy Sources: Conservation and Renewables, edited by D. Hafemeister, H. Kelly and B.G. Levi, AIPCP 135 (1985), 676 pages.

Nuclear Arms Technologies in the 1990s, edited by D. Schroerer and D. Hafemeister, AIPCP 178 (1988), 480 pages.

Global Warming: Physics and Facts, edited by B.G. Levi, D. Hafemeister and R. Scribner, AIPCP 247 (1992), 326 pages.

Physics of Sustainable Energy: Using Energy Efficiently and Producing It Renewably, edited by D. Hafemeister, B.G. Levi, M. Levine and P. Schwartz, AIPCP 1044 (2008), 447 pages.

Physics of Sustainable Energy II: Using Energy Efficiently and Producing It Renewably II, edited by D. Hafemeister, D. Kammen, B.G. Levi and P. Schwartz, AIPCP 1401 (2011), 495 pages.

Nuclear Weapon Issues in the 21st Century, edited by P. Corden, D. Hafemeister, P. Zimmerman, AIPCP 1596 (2014), 265 pages.

Physics of Sustainable Energy III: Using Energy Efficiently and Producing It Renewably II, edited by R. Knapp, D. Kammen and B.G. Levi, AIPCP 1652 (2015).

APS (FORUM) AWARDS

The FPS presents nominees to the APS Council for two APS awards, the Joseph A. Burton Forum Award and the Leo Szilard Lectureship, for significant work on physics and society issues. The Burton-Forum Award “recognizes outstanding contributions to the public understanding or resolution of issues involving the interface of physics and society.” The Szilard Lectureship “recognizes outstanding accomplishments by physicists in promoting the use of physics for the benefit of society in such areas as environment, arms control and science policy.”

The Awards were first offered by the FPS (and not the entire APS) in 1974, but became awards of the full APS in 1985. David Inglis received the first Szilard Award. It has been received by a wide variety of hard-working physicists. Key APS members on arms control received it, including Hans Bethe, Sid Drell, Dick Garwin, Pief Panofsky and Frank von Hippel, as well as Soviet arms control supporters; Andrei Sakharov, Roald Sagdeev and Evgany Velikhov. Ralph Lapp earned the first Burton Forum Award. A wide variety of persons received it, including James Randi, Ash Carter, John Holdren, and four Brazilian and Argentine physicists who promoted the arms control agreement between their two countries. Initially a modest honorarium of \$250 was given, along with a handsomely scripted scroll. The honorarium became even more modest in 1985 when the Szilard Award had to be shared among the seven dominant authors of the papers on the “Nuclear Winter” calculations. The embarrassingly small stipend led the FPS Executive Board to conclude that it was better to offer no honorarium rather than an amount that would (in this case) only buy one good dinner. In desperation, the FPS then moved from monetary awards to symbolic art, plus a travel stipend to receive the award. Two California artists created statues whose bases are engraved with the names of the awardees. The winners kept the statues for one year after which they passed them to the next year’s winners. The statue accompanying the Szilard Award, which was created by David Smith, is a dolphin, the symbol of Szilard’s novella, *The Voice of the Dolphins*. The Burton Forum Award statue is an abstract spherical model of the Earth created by Crissa Hewitt. After many years of transcontinental shipping, the awards now reside in my backyard as a statue (Burton-Forum) and in my home-office (Szilard). The library at the University



Fig. 2. FPS Award Statues. (left) The Joseph Burton–Forum Award for Public Understanding and Resolution of Science and Society Issues. (right) The Leo Szilard Lectureship Award for Physics in the Public Interest.

of California at San Diego established a center to digitize and store the writings of Szilard. William Lanouette, Szilard’s biographer, *Genius in the Shadows*, is assisting in these matters. We have offered the Szilard Award dolphin to the Szilard center, if they will locate it in a dignified manner.

In 1986, the two FPS Awards were promoted to awards of the entire APS, but this promotion in status came with pressure to create permanent endowments for the awards. In 1997, the Forum Award was endowed with \$70,000 from the Apker Award Endowment, creating an annual honorarium of \$3000, plus travel expenses to the April meeting. The Forum Award was renamed the Joseph A. Burton Forum Award in honor of Joe Burton, beloved former APS Treasurer and long-time FPS supporter. In 1998, the Szilard Award received an endowment of \$70,000 from the MacArthur Foundation, the Energy Foundation, the Packard Foundation, the FPS and a number of individual donors. In order to create a climate for graduate students to consider careers in physics and society, the award was changed to a lectureship, and its name was changed accordingly to the Leo Szilard Lectureship Award. Starting in 1999, the recipient has received a \$1000 honorarium and travel money to present talks at an APS meeting and at universities or research laboratories.

POPA/FORUM DIFFERENCES

There often is confusion on the roles of the two APS entities that deal with physics and society issues. The Panel on Public Affairs (POPA) was established in 1974 under the leadership of APS Chair Pief Panofsky, two years after the Forum was established. The major distinction is that POPA is an APS committee whose members are elected by the APS Council and whose role is to advise the APS council, whereas the FPS (and other forums) is a membership orga-

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nization, whose executive board is elected by the FPS members and whose roles include publishing a newsletter and sponsoring invited sessions at APS meetings. As a membership unit, the FPS is responsible to the FPS membership and not the Council, much as the Division of Condensed Matter Physics is responsible to the condensed matter physicists. These distinctions become blurred in the sense that all divisions and fora are responsible to the Council if the actions of the APS units run counter to the goals of the APS. POPA has sponsored studies of certain issues, after receiving outside grants to pay the expenses of experts. POPA also prepares reports by POPA members, and gives advice to the Council on a wide variety of issues. The advice from POPA generates about 3 APS resolutions and 5-10 letters per year for use by the APS leadership. On the other hand, the Forum organizes sessions to raise technical issues in a public arena without concluding policy recommendations, publishes a quasi-journal *Physics and Society*, carries out Forum studies, offers short courses, and organizes the presentation of two APS Awards each year.

POPA submits proposals for APS studies to the Council for its consideration. If the Council supports the proposal, POPA assists the APS Executive Director and the Council in selecting the study participants and obtaining funds. Arguably, the most famous APS study was the 1987 Directed Energy Weapons Study. The Forum also carries out studies, with modest budgets of about \$5,000, as compared to APS reports with budgets of about \$600,000 or more. POPA has helped organize about a dozen APS studies and the Forum has produced 3 studies. In recent years, POPA found it more difficult to obtain funding for the more lengthy studies, with the result that POPA has undertaken many POPA “reports” written by POPA members on possible health effects from the EM fields of powerlines, helium conservation, energy policy, Patriot defense performance, economic growth, the hydrogen initiative, Moon-Mars program, national missile defense, nuclear power and proliferation resistance, interim storage of nuclear spent fuel, electricity storage, nuclear forensics, readiness of U.S. nuclear weapons, nuclear weapons in the 21st century, technical steps to support nuclear weapons drawdown, integrating renewable electricity on the grid, energy critical elements, reductions under New START, Homeland Security radiation detection, and license renewals for nuclear reactors.

FORUM PROBLEMS AND FUTURE

There has been an interesting trend in the make-up of the Forum leadership over the years. The early Forum leaders were essentially all from academia, but this is not true today. In 2015, the Chair, the past-Chair, the Chair-Elect, the Secretary-Treasurer, the Councilor and *Physics and Society* Editor hail from a variety of locations: two national laboratories, one university, one federal agency, one non-governmental orga-



Fig. 3. Three congressmen with PhDs in physics. (L to R) Vern Ehlers (9 terms, R-MI) and Rush Holt (8 terms, D-NJ) were former FPS board members. They were joined in Congress by Bill Foster (4 terms, D-IL).

nization (Nat. Acad. of Sciences). This is a wonderful overall mixture of Forum leadership since each one adds a different perspective. At any rate, it is very important for the Forum to continue to present the issues and show young PhD students that there are career paths other than the academic route.

Our task has been complicated by the shift of the April APS meeting from Washington, DC to other cities around the country. It is far, far easier and cheaper to organize a critical physics and society session in Washington than it is in the cities beyond the beltway. It is amazing that the Forum sessions have continued to be so vibrant away from the city that affects physics and society the most—that is Washington, DC. It is imperative that the Forum keeps the candle of professional responsibility well lit. We cannot slip backwards to the old days when APS meetings had no sessions on physics and society issues. The FPS continues to be a way for physicists in all fields of endeavor to keep easily abreast of the technical aspects of problems facing society.

At the personal level, the Forum’s members have been a great source of friendship, knowledge and inspiration to me and the other members. I believe that science and technology are the driving forces of history, beyond that of nationalism, economic theories and great men/women. If this is true, it behooves us to do our homework with even-handed debates.

A number of our members have moved on from forum activities to larger roles. Examples include two former Executive Board members. (1) Vern Ehlers was a former Physics Department Chair from Calvin College and consultant to Congressman Jerry Ford. He served as a Republican Congressman for nine terms from Michigan (1993-2011). Rush Holt, former Assistant Director of the Princeton Plasma Physics Laboratory, served eight terms as a Democratic Congressman from New Jersey (1999-2015). Holt is now the Chief Executive Officer of the American Association for the Advancement of Science. They were joined in 2008 by Bill Foster, particle physicist from the Fermi National Laboratory, who served from 2008-2011 as a Democrat from Illinois and was re-elected in a new district in 2013. Foster filled the chair of the

former House Speaker, Dennis Hastert. At one point these former FPS members filled 3 of the 435 seats (0.7%) in the House of Representatives.

I like to think that the Forum's examination of the critical aspects of science and society issues not only helped send them on their way, but also shaped their approach to some of the issues that they deal with today. Many other Forum members have had active roles in public service. I believe that the individuals that I have known the best would say that the FPS had a big impact on improving their competence in

the area of physics and public policy, helping them to serve. After all, none of us were trained in this generalized area; we had to learn from each other.

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¹ *Bull. At. Phys. Soc.* 60(4), 233-234 (2015), invited paper in Forum on History of Physics session on APS and Public Engagement in Historical Perspective. An earlier, short version is in the April 2012 issue of *Physics and Society* 41 (April 2012).

REVIEWS

What's the Worst That Could Happen? A Rational Response to the Climate Change Debate

By Greg Craven (Penguin, New York, 2009) 264 pp. \$14.95.
ISBN 978-0-399-53501-7.

I asked to review this book because I was curious to see what a fellow high school physics and chemistry teacher had to offer on the subject of climate change, which has captured my interest and concern ever since I worked with NSTA in the summer of 1979 to develop a curriculum about it. I was not disappointed. I was greeted by eleven engagingly written chapters presenting no "graphs and footnotes to convince you which side is right" but rather "a set of thinking tools so you can reach *your own* conclusion." (p. 4)

Craven's approach follows from his philosophy that "the real question about dangerous global warming is not, Is it true? But, Is it worth doing anything about, just in case it's true?" (p. 11) To him the issue of climate change is one of security for the future threatened by climate destabilization. Thus, he chooses to think of it in terms of risk management, and he spends his first chapter (numbered zero and titled "Should I bother to read this book?") making sure that his readers are "on board" with him. The key, he points out in that introductory chapter, is a decision grid, with two columns – A ("significant action now") and B ("little to no action now") – and two rows – whether global warming is false or true. We aren't sure about the rows, he says, though we can estimate their probabilities, but we do have control of the columns.

Before reading Chapter 1, Craven's readers are asked to write what they would have to see for their opinion about global warming to be changed. (If you can't answer this, he says, your mind can't be changed so there's no point in reading the book.) This and the next four chapters are devoted to developing a "tool kit" (spelled out on pages 104-105) to facilitate completing the decision grid in the last half of the book. Among the tools are the realization that there cannot be

a complete consensus about something scientific, though it can be well accepted or established, and strategies for avoiding "confirmation bias" (looking for supportive but not opposing evidence – it "tricks you into being wrong *with confidence*" (p. 65)). To guard against confirmation bias in filling out our decision grid, we also need to develop a "credibility spectrum" – a chart for each side of the issue, with spaces along a line from "most credible" to "least credible" for information from various types of sources.

In Chapter 6 Craven presents the information he has gathered from the "warmers," his name for those who believe the climate is warming and in taking action to oppose it. In Chapter 7 he does the same for the "skeptics." But because he feels that "the shrill urgency of the warmers . . . in Chapter 6 defies common sense (p. 149)," Craven also devotes Chapter 8 to exploring their arguments. Here he points out that "It's not the temperature rise that gets you but what it causes." (p. 157) More than climate *change*, warmers are concerned about climate *destabilization*, characterized by rising sea levels and attendant increased storm surges, increased range of pests and disease-spreading insects and agricultural losses and illness, changing rainfall patterns, more frequent and extreme weather events, collapse of the "conveyor belt" that keeps Northern Europe warm, and changing relationships among species.

Craven likens the global atmosphere to financial markets: both, he says, are complex dynamical systems, with many connected elements and feedback loops, which can lead to erratic behavior—i.e., destabilization. Financial markets represent experiments with our economic system, the atmosphere an experiment with our planet. Among the factors affecting feedback loops are phytoplankton, trees, the Earth's albedo, methane hydrates, the aforementioned "conveyor," ice sheets, and peat. Climate destabilization would be characterized by a "tipping point," marking a change beyond which there could be no return. Craven notes the difficulty identifying tipping

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points due to 1) omission of positive feedback loops in climate models (because we don't understand them sufficiently) and 2) the abruptness of climate change in the past, evidence for which has been found only since the 1990s and which is the focus of the National Research Council report, *Abrupt Climate Change*, issued in 2002. Before that, a 20oF temperature difference over a period of 10,000 years was believed to have occurred at a roughly constant rate over the entire time, but it is now known to have occurred in a 100-year period during those 10,000 years.

Craven uses the imagery of *Abrupt Climate Change*, which depicts the transition of a mechanical system from one equilibrium state to another, to represent two climate states—glacial and interglacial—between which the Earth has flipped over the past three million years, with changes between these climate states occurring over short periods of 100 years. The transition between equilibrium states is expressed as two energy wells separated by a hill. The rapidity of climate change in the past causes Craven to wonder how much human action has gone to push our present climate system up a “hill” on the other side of which is another climate system from which we can't return and whether stabilizing our climate at an elevated average global temperature by controlling carbon emissions at present values could put us at greater risk. It also leaves him with the feeling that the IPCC model predictions are rendered even more conservative, because they don't predict such rapid climate change in the past.

When, in Chapter 9, Craven assembles his credibility spectra for taking and not taking action on climate change, he finds that the spectrum for not taking action is sparse for the most credible types of sources—statements from professional

societies and statements from organizations that contradict their normal bias. This, coupled with the strong statements for taking action from three different communities—science, business, and national security—leads him to consider that global warming is far more probably true than false, and he chooses column A on his decision grid. Chapter 10 invites readers to complete their own decision grids.

James Hansen, characterized as an accepted global warming bellweather, is cited as saying that avoiding a climate tipping point requires ending coal combustion by 2030. According to Craven, “that means we need to be on a very different track by 2015” (p. 216), unless we can bring about cultural change at the rate we geared up for World War II. Craven concedes that, unlike Hitler and Hirohito, carbon dioxide emissions are an enemy without a face to motivate us, but he feels that today's milieu of digital communications could allow a “viral spread of the meme that we should change the question in the global warming debate from, Is it true? to, Why risk it?” (p. 222) Thus he passes the torch to achieve this to his readers. But it is now 2015, and the carbon dioxide concentration in the atmosphere is up to 400 parts per million from the 388 when Craven wrote his book. We have burned less coal, but only because we have replaced it with “fracked” natural gas, and we have increased production of another fossil fuel, oil, from tar sands and oil shale. Although more than a million saw Craven's YouTube video (“The Most Terrifying Video You'll Ever See”) in less than a year, are we any more culturally mobilized to oppose climate change?

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