

PHYSICS & SOCIETY

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Editor's Comments

Our three feature articles for this edition of P&S examine issues of both current and historical significance. As this issue was being prepared for publication, Americans were reflecting on the ninth anniversary of 9/11. When physicists think of the role of science in the fight against terrorism, we likely think in terms of developing technological innovations that can help to detect and thwart such threats in advance. Former P&S editor Al Saperstein's article on scaling laws in terrorist attacks reminds us, however, that the analytic tools of physics can also be deployed in attempting to model the dynamics of such horrors, work that may contribute insights to developing policies to minimize their effects.

Readers will be well aware of the British "Climategate" situation of earlier this year. We are pleased to be able to reprint from *Science* an article by Sheila Jasanoff of Harvard University which addresses lessons learned from Climategate and decades of science policy regarding how practicing scientists can work to establish the trust of the many external audiences their work now affects. Openness, transparency, integrity and accountability of the processes, purposes, and products of science are crucial in establishing public and

political credibility. Our third feature article, by Cindy Kelly of the Atomic Heritage Foundation, describes how private individuals can team effectively with government agencies and laboratories to preserve historically scientifically significant sites, specifically, Manhattan Project properties. Her article very nicely complements that by Bob Potter which ran in our January edition on efforts to preserve the Hanford B-Reactor.

I always enjoy reading letters that we receive in response to articles, and in this edition we have one from former Editor Art Hobson, who offers some observations on teaching scientific literacy motivated by Richard Muller's July article on Physics for Future Presidents. Art's efforts as our book reviews editor have again been very fruitful: we offer three reviews, one on the history of nuclear proliferation and two on tips for how scientists can be more effective public communicators. I also draw your attention to an announcement of an upcoming Forum-sponsored workshop on the Physics of Sustainable Energy: Efficiency and Renewables to be held next March at Berkeley.

We welcome readers' contributions and feedback.

—Cameron Reed

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FORUM NEWS

Second Conference on the Physics of Sustainable Energy: Efficiency and Renewables

A popular energy workshop is making a repeat performance. The first go-round was a conference on the physics of sustainable energy held at the University of California, Berkeley in March 2008, and the proceedings were published as #1044 in the AIP Conference Series. (For a review of the proceedings, see *Physics & Society*, July 2009, pg. 22.) In response to the positive enthusiasm about the conference, a second one is being held, again at UC Berkeley, on March 5-6, 2011 under the sponsorship of the APS Forum on Physics and Society, the APS Topical Group on Energy Research and Applications, and the American Association of Physics Teachers. International experts will give the technical background to understand the issues connected with using energy more efficiently and producing it renewably.

The event sold out last time, so we recommend signing up in advance. The cost is \$100 for 24 talks, a 400-page book and 2 lunches. The student rate is \$80. An additional \$35 is being charged to attend the banquet at the Berkeley Faculty Club. The event is being organized by Dave Hafemeister, Barbara Levi, Dan Kammen and Peter Schwartz. Registration is expected to commence in mid-October. For further information, contact Dave Hafemeister at dhafemei@calpoly.edu.

Saturday, March 5, 2011

Energy Policy

CA State Policy,

Dian Grueneich (CA PUC Commissioner, tentative acceptance)

Science and Policy Innovations for a Low-Carbon

Economy, Dan Kammen (UC Berkeley)

Energy in the Developing World, Ashok Gadgil (LBL)

Energy and Water Connection,

Michael Webber (Univ. Texas)

Environmental Effects of Fossil Fuels

NAS Study, Hidden Environmental Costs of Fossil Energy,

Chris Field (Carnegie Inst., Washington)

Studying the Causes of Recent Climate Change,

Benjamin Santer (LLNL)

Non-Carbon Greenhouse Gasses,

Katey Anthony (U. Alaska)

Global Circulation Models, Inez Fung (UC Berkeley)

Carbon Sequestration, Julio Friedmann (LLNL)

Decarbonizing Transportation

Transportation Mode Switching,

Betty Deakin (UC Berkeley)

Electric Cars: Hybrids/PHEV/BEV,

Dan Sperling (Inst. Transportation Studies, UC Davis)

Low Carbon Transportation of People and Products,

Dan Kammen (UC Berkeley)

Banquet Speaker

Energy Efficiency (1970 to 2030):

From Sustainability to Carbon Taxes,

Art Rosenfeld (former CEC Commissioner)

Sunday, March 6, 2011

Enhanced Efficiency Building

Energy Efficient Buildings, David Claridge (Texas A&M)

Energy Simulation Tools for Buildings, Phil Haves (LBL)

Smart Buildings Using Demand Response,

Mary Ann Piette (LBL)

Appliance and Lighting Energy Standards,

Greg Rosenquist (LBL)

Renewable Energy

NAS 2009 Study on Electricity from Renewable Resources,

John Holmes (NAS)

Smart Grid APS/POPA Study, George Crabtree (ANL)

Offshore Wind, Walter Musial (NREL)

Polymer and Thin Film Photovoltaics,

Alan Heeger (UCSB)

Photovoltaic Roof Systems, Kelly Truman (Solyndra)

Photovoltaic Concentrator Systems,

Steve Horne (Sol Focus)

Small Reactors and Nuclear Waste, Bob Budnitz (LBL)

Call for Nominations: Beller and Marshak Endowed Lectureships

The APS Committee on International Scientific Affairs invites APS Divisions, Topical Groups, and Forums to submit nominations for the 2011 APS Beller and Marshak Endowed Lectureships. These Lectureships provide travel funds to support foreign physicists invited to speak during sessions at the annual March and April APS meetings. The Beller Lectureship was endowed by the estate of Esther Hoffman Beller for the purpose of bringing distinguished physicists from abroad as invited speakers at APS meetings. The Marshak Lectureship was endowed by the late Ruth Marshak in honor of her late husband and former APS president, Robert Marshak, and provides travel support for physicists from “developing nations or the Eastern Bloc” invited to speak at APS meetings. Four lectureships are awarded every year, with a \$2,000 maximum for each lectureship. The lectureships support travel for distinguished speakers during sessions at the following APS meetings:

Beller Lectureship: For a distinguished physicist from outside of the United States. Two lectureships for the March Meeting (21-25 March 2011, Dallas, TX), and one lectureship for the April Meeting (30 April – 3 May 2011, Anaheim, CA).

Marshak Lectureship: For a physicist from a developing country or Eastern Europe. One lectureship for either the March or April Meeting. Along with the travel funds, recipients will be honored in the meeting program and/or other printed materials as recipients of the Beller or Marshak Lectureship. **The deadline for nominations by FPS members for the 2011 Lectureships is Monday, 1 November 2010;** Lectureships will be announced in December. You are welcome to nominate those physicists who have been or will be invited as speakers for your sessions to receive this distinction and the accompanying travel funds.

Nominations from FPS members should be sent to Lea Santos, Chair of the Nominating Committee, at lsantos2@yu.edu.

LETTERS

I loved Richard Muller’s discussion of “Physics for Future Presidents” (P&S July 2010), agreeing heartily with his overall message and most of the details. I’ve read his book and found it accurate and well written.

In physics courses for non-scientists we do indeed assume too often that students can’t learn “real physics.” As Muller says, many of these students thirst after the kind of scientific knowledge that is valuable to them, but instead we talk down to them, we hide behind the fog of math, we try to make them into mini-physicists. Math is not the essence of physics; concepts are.

The notion of teaching concepts instead of technicalities to non-scientists has been widespread since at least Paul Hewitt’s first edition of *Conceptual Physics* in 1971. In fact Albert Einstein and Leopold Infeld’s wonderful book for the general public, *The Evolution of Physics: from early concepts to relativity and quanta* (Simon & Schuster, Inc., New York, 1938), takes a purely conceptual approach. But many instructors still insist on an algebraic approach. How many generations of non-scientists will we alienate before we learn? But then, it’s not really important, right? These students—our future attorneys, school teachers, parents, reporters, political scientists, policy experts, legislators, and presidents—are mere non-scientists, right? Yeh, sure.

I’m delighted that potential physics majors at Berkeley

are urged to take Muller’s course before beginning physics. Every physics student should in fact begin their education with an entirely conceptual introduction to a broad spectrum of classical physics and especially modern physics, along with physics-related social topics.

Muller’s “ultimate goal ...to have both elected and electorate be scientifically literate” is absolutely crucial in today’s science-dominated society. Science-and-society topics should be included in every introductory physics course for non-scientists and also for scientists. Industrialized democracy demands a citizenry that’s literate in such topics as energy resources, global warming, nuclear weapons, and technological risk.

I do disagree with Muller’s opinion that it’s hopeless to teach the concept of conservation of energy because “it takes over a year before even math-adept students begin to understand this subtle concept.” Lately it’s become fashionable to try to teach energy without ever defining the term, and I suspect that this lies behind Muller’s pedagogical difficulties. But energy is traditionally defined as “the ability to do work,” and there’s no good reason to avoid this clear, concise, teachable definition. Work is done when a force acts through a distance. The amount done, assuming the force is in the direction of the displacement (other directions can be neglected in a conceptual course), is force times distance. The

amount of work a system can do (relative to some “zero energy state”) is then its energy, be it kinetic, gravitational, elastic, thermal, electromagnetic, radiant, chemical, nuclear, or some other form [1]. For example, a system’s gravitational energy is the amount of work it can perform due to the gravitational forces acting on it. A system’s “energy” is the total amount of work it can do. Energy is the most useful physics concept. Students deserve a clear definition of it and a clear statement of its principles [2].

My other disagreement is Muller’s advice to refrain from explicitly teaching the “scientific method.” The scientific process is the central lesson for non-scientists and, indeed, for scientists. Science is based on evidence and reason, not on charismatic sages, old books, kingly power, religion, emotion, or your daddy’s opinion. Indeed, the American Association for the Advancement of Science’s book Project 2061: Science for All Americans (AAAS, Washington, DC, 1989) devotes its lead chapter to “The Nature of Science,” and emphasizes that this topic is essential for scientific literacy. The perils of

pseudoscientific nonsense and religious fanaticism evident all around us testify to the importance of understanding and using, particularly in matters of public policy, the scientific process: knowledge comes from evidence and reason [3].

Despite my quibbles, Muller has introduced a valuable new approach to teaching scientific literacy.

- [1] Art Hobson, “Energy flow diagrams for teaching physics concepts,” *The Physics Teacher* 42, pp. 113-117 (Feb 2004). Also see Art Hobson, “Energy and work,” *The Physics Teacher* 42, p. 260 (May 2004) and references therein.
- [2] Art Hobson, *Physics: Concepts & Connections* (Pearson/Addison-Wesley, San Francisco, 5th edition 2010), Chapter 6.
- [3] Ref. 2, Chapter 1 “The way of science: experience and reason,” and brief “How Do We Know?” sub-sections in every chapter.

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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.

ARTICLES

Why do Terrorist Attacks Satisfy a Scaling Law?

Alvin M. Saperstein

Abstract: *It has been empirically well verified that the relation between the severity of a terrorist act, as measured by fatalities or casualties produced, and the frequency of these acts, satisfies a decreasing power law – a scaling law. Attempts to explain this law have focused on the behavior and structure of the terrorist cells. This paper points out that the postulates upon which these explanations are based have little empirical validity. However, applying the same derivation to the dynamic organization of both terrorist and the victim populations leads to the same power law without the previous discrepancy between postulate and reality.*

Situations in which the probability, or frequency, of the occurrence of an event is proportional to a power of that event are said to satisfy a “scaling law.” Concisely, if f is the frequency and x the magnitude of the event as measured by the numbers of casualties produced by the event, $f \sim x^{-a}$, where the exponent “ a ” may be either a positive or negative number. It is called a scaling law because if the magnitude of each event is multiplied by a constant number k , the frequency is just multiplied by the constant factor k^{-a} , independent of the

value of x . Situations in which the observed frequencies of possible events satisfy such a scaling law over large ranges of x are very common in the physical and biological sciences [1]. For example, if x represents the population of American cities and f the number of cities having such a population, f satisfies a power law with exponent ~ 2 ; similarly, the frequency with which earthquakes of magnitude x occur roughly satisfies a power law with exponent $\sim 2/3$. Such laws have also been empirically found to accurately describe many situations of interest to the social sciences [2]. Richardson, analyzing many wars, was able to show that the frequency of wars resulting in x fatalities could be accurately expressed as $f \sim x^{-a}$, where a is a positive number [3]. More recently, a number of studies have been made of the frequency of terrorist attacks resulting in x casualties in civil conflicts throughout the world, and they have been found to very accurately satisfy such a scaling law with a value for a in the vicinity of 2.5[4].

When an event is the result of many small independent causes, it is usually expected to satisfy a normal distribution (also referred to as a “Gaussian” or a “bell curve”). In such a distribution, outcomes are closely bunched about the mean value. For example, if one-half of all possible events are ex-

pected to occur in an interval of width 2σ centered upon the mean value $\langle x \rangle$ of the normal distribution, then 0.82 of the events are expected to occur in the interval when its width is doubled, i.e., only 30% more. On the other hand, if the distribution follows a scaling law with positive exponent, and if $\sigma \ll \langle x \rangle$ (not a necessary requirement for either Gaussian or power law distributions), doubling the width of the interval about the mean leads to a doubling of the number of events included (100% more). Thus, scaling laws with positive exponents are said to have “a very heavy tail”. It is expected that if such distributions govern the process, many events will occur very far from the mean.

To illustrate the heavy tail, the distribution of worldwide deaths per terrorist attack since 1968 has been shown to have a mean value of ~ 4 and a standard deviation of ~ 32 [5]. If these deaths were distributed normally, the probability of a terrorist incident resulting in ~ 100 deaths (3 standard deviations) would be 7×10^{-5} – a very unlikely event. Empirically, the heavy tail leads to a thousandfold greater probability that there would be 100 or more deaths, a fact very evident to readers of current newspapers.

Given the apparent universal validity of the power law as an empirical representation of the effects of terrorist acts, it is natural to seek an explanation of the law. Such an explanation would go a long way to satisfy inherent human intellectual curiosity. It might also furnish tools for action – either by the forces of “law and order” to diminish the effects of terrorist acts, or by the terrorist groups seeking to enhance their effectiveness. Several quite different theoretical models leading to scaling laws have been suggested in the references already given, but it is hard to believe that any one model will adequately explain the varied applications of scaling laws. For example, some attribute innovation in cities to the network connections between the various social factions in a city that maintain the cohesiveness of that city [2]. Such a model, however, is very unlikely to be valid for terrorist groups trying to destroy social cohesiveness. Thus, it is not expected that a single type of explanation would serve for all examples of power law distribution.

Papers that try to explain the terrorism scaling law focus on the behavior of the organizations of the terrorists [4, 5, 6]. In their “toy model,” Clauset, Young and Gladitsch focus on the behavior of the terrorist movement, as a single entity, planning and carrying out a single attack [5]. They postulate that the probable severity of such an attack increases with the time spent planning the attack so that the rate of increase of this probability is itself proportional to the probability. From this postulate, it follows that the probable severity increases exponentially with time: $p(t) \sim e^{\kappa t}$, $\kappa > 0$. They also postulate that the protective organs of the society are also planning to

minimize the effects of terrorist actions so that the rate of decrease of probable severity is proportional to the magnitude, x , of the expected severity. Hence, the probable severity is a decreasing exponential in time: $x \sim e^{\lambda t}$, $\lambda < 0$. Combining these two assumptions, we obtain the desired power law: $P(x) \sim x^{-\alpha}$, where $\alpha = 1 - k/\lambda$ [1].

However, it is difficult to reconcile what we know of reality with the general validity of the two postulates. It may very well be that the success of an outlier event, producing casualties in the thousands, like the September 2001 attack on the World Trade Center, required a long interval of planning. But if one looks at events that caused fatalities ranging from one to one hundred, there is scant evidence that the suicide bombing that kills fifty people in a town market place required a much greater planning time than the attack on a military patrol that kills a few non-combatant bystanders. And there is certainly little support for the second postulate. The “authorities” certainly spend more time trying to guard against the multiple few-fatality events expected in a “combat zone” than they do against unexpected outlier events in non-combat zone such as New York City. Given the weakness of its two postulates, the apparent success of the double exponential mode, in deriving a scaling law, must be just fortuitous.

A different organizational model of the severity of terrorist attacks, not depending upon planning time, is based upon the postulate that the severity of damage inflicted in such an attack is proportional to the size of the terrorist “cell” carrying out the attack [4, 6]. This model assumes that the terrorist movement is made up of cells whose size is constantly changing. Small cells come together in random encounters, aggregating into larger cells. Larger cells randomly disintegrate into smaller cells, either because of internal conflicts, satisfaction with a completed “job”, or pressure from police and military forces. The mathematical model is that of a “master equation” in which the rate of change of the number of groups of any given size (the rate of change of the “frequency” of that size) is proportional to a sum of the products, two by two, of the frequencies of all other sized groups (determining the probability of aggregation) and a linear sum over all of the frequencies (giving the probability of disintegration of the cells) [1]. The resultant non-linear, time-dependent, set of differential equations cannot be solved in general. And so another postulate is introduced – that the time variation can be ignored. It is assumed that after some unspecified time, the world of the terrorists, the society upon which they prey, and the military and police forces trying to protect that society, has reached a steady state so that on average, none of the cell-size frequencies are time-dependent. The resultant time-independent master equation can be solved, and, after some reasonable approximations, gives the result that the frequen-

cies of cell size (the number of terrorist cells having a specified number of members) satisfies the power law with the desired exponent equal to $5/2$. Using the postulated proportionality between cell size and severity of damage inflicted by a given cell in any given attack, one obtains the desired empirically observed scaling law, in which the frequency f of an attack producing x casualties is proportional to a negative power of x .

Again, it is difficult to accept the empirical validity of the two postulates. Terrorism is a time-dependent process, starting with the present state of a society and ending, sooner or later, with either the triumph of the terrorists and a major change in the society, or with the defeat of the terrorists and the preservation (in some form) of the status quo [7]. In either final steady state there will be no frequency of terrorist-cell size to satisfy a power law. Either the terrorist cells will all voluntarily disband with the triumph of the terrorists, or they will be quashed by the victory of the status quo forces. Furthermore, there is little to support proportionality between casualty rate in a terrorist attack and the number of terrorists in the cell carrying out the attack. Massive terrorist attacks often result in few casualties among the target population, whereas single “lone wolf” suicide attacks (cell size of unity) have often resulted in many fatalities and injuries. So a model just built upon the cell sizes of the terrorists cannot be very satisfactory.

The difficulty created by the second postulate – that the damage inflicted by a terrorist cell is proportional to the size of that cell – can be removed by considering the role of the victims in determining the severity of a terrorist attack. The members of a civil society, the non-combatants, who are the presumed targets of the terrorist attacks, also are members of groups of varying and fluctuating sizes. There are familiar, friendship “cells”, groups who go to market together, who pray together, work together, play sports together, engage in political or cultural events together. It is easy to presume that the frequency of cell size, for these “civilian” groups, also satisfies a similar master equation having linear and bilinear terms. Again presuming time-independent steady state solutions, the size frequency of these civilian cells should also satisfy a similar power law with the same exponent. One could then postulate a proportionality between size of victim group and the number of casualties inflicted upon that group by a terrorist attack to again derive the observed desired casualty-frequency scaling law.

But there is no more reason to believe in a proportionality relation between victim-cell size and severity of attack than to believe in a proportionality between terrorist-cell size and attack severity. A victim-cell proportionality would imply a tight correlation between the number of casualties inflicted in an attack upon a city and the population of that city. But footnote

9 of the Clauset, Young and Gleditsch paper, shows that there is a very weak association between these two variables [5].

However, the damage inflicted in a terrorist attack is not likely to depend only upon the number of attackers or only upon the number of targets. The damage is more likely proportional to the product of the two numbers [8]. Certainly, the losses inflicted will depend upon the number of those firing (the terrorist cell size). But the terrorists are unlikely to be aiming at specific individual targets; more likely, they are aiming at a general area and the probability of a hit depends upon the number of targets in the area (the number of potential victims in the target group, a group whose size distribution is determined by the same form of master equation governing the terrorist cell size distribution). Thus the number of casualties inflicted is likely to be proportional to the product of the two cell sizes [9, 10]. Since the two cell sizes, terrorist and victim, satisfy the same distribution law, with the same exponent, it follows that their product also satisfies that same frequency distribution with the same exponent.

Thus, bypassing the conceptual difficulties of the steady-state (time independent) hypothesis, we have an “explanation” of the empirical terrorist attack severity- frequency law. One policy implication for minimizing casualties inflicted by terrorists seems immediate: make sure that neither the terrorist cells, nor the potential victim cells, grow to large sizes. (Controlling “victim cell size” in most societies may be very unrealistic.) Have your defense forces strive to their utmost to fragment the terrorist cells and discourage the massing of potential victims in vulnerable areas – such as market places. This suggestion certainly comports with “common sense.” Another suggestion is directed at the steady state hypothesis. Since a time independent situation leads to the observed scaling law, perhaps a policy directed at forcing time dependence will change the severity-frequency relation, hopefully for the better a decrease in casualties. Such a policy implies fast, continuous reactions by the defending forces, never allowing the terrorist cell structure to relax to a steady state. This suggested policy again seems to agree with common sense, whether or not it is commonly put into practice.

It thus appears, so far, that a mathematical derivation of the scaling law, a theoretical understanding of the immediate effects of terrorist victims, does not lead to novel policy suggestions for action. However, a policy for action is more likely to receive public support if it is based upon multiple, different, theoretical and empirical supports – in this case mathematical as well as the usual verbal conceptualizations. (After all, any political candidate usually tries to say as many good things about himself, and as many bad things about his opponent as possible, to convince the public to vote for him – a policy decision.) Science is like a woven cloth; its strengths

increase with the number of differently oriented threads passing through, and supporting, each point [10]. There is much that the public policy-maker can learn from the normative processes of science.

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Testing Time for Climate Science

Sheila Jasanoff

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On 31 March 2010, a British parliamentary committee exonerated Philip D. Jones, director of the Climatic Research Unit (CRU) at the University of East Anglia, of personal wrongdoing in his conduct and management of research. Climate science fared less well. The Science and Technology Committee concluded in its report that the focus on a single individual had been misplaced: “we consider that Professor Jones’s actions were in line with common practice in the climate science community” [1]. Those practices included routine refusals to share raw data and computer codes. The committee judged that this had to change and that all future raw data and methodological work should be publicly disclosed.

In early 2009, few would have predicted that climate science was headed for a public trial or public embarrassment. The Intergovernmental Panel on Climate Change (IPCC), the world’s chief provider of scientific knowledge about the climate, enjoyed a pristine reputation. With nearly two decades of work and four assessment reports to its name, the IPCC seemed to have quelled the doubts of many skeptics. A growing scientific consensus accepted the anthropogenic causes of climate change [2]. Added validation came when

the IPCC shared the 2007 Nobel Peace Prize with former Vice President Al Gore. President Barack Obama earned worldwide commendation when he signaled that America was at last willing to act on the IPCC’s painstakingly assembled knowledge.

The ground shifted dramatically in November 2009 with the event that became known as “climategate” [3]. A hacker entered the CRU’s computer system and disclosed some 1000 private e-mails and 3000 documents. Some showed climate scientists apparently fudging data to exaggerate the effects of warming. Words like “trick” and “hide,” referring to modelers’ techniques of representing data, were seized upon as signs that CRU was purposefully distorting results to support its claims. Other messages suggested that scientists were reluctant to make raw data available to known critics and had tried to keep unfriendly papers from publication in peer-reviewed journals. In the ensuing uproar, the credibility of climate science suffered. A poll conducted in February 2010, found a 30% drop over 1 year in the percentage of British adults who believe climate change is “definitely” real [4].

In a time when global policy increasingly depends on scientific knowledge, the CRU’s plight is not good news for science or society. What can be done to guard against such setbacks and to rebuild public faith in the credibility of climate science? A half-century of scientific advising holds some lessons.

From Integrity to Accountability

Scientific progress has always depended on credibility and trust. To build new knowledge, scientists have to be able to take each other's findings at face value. If every claim needed to be verified before others could act on it, research would grind to a halt. English experimental scientists in the 17th century set out to perfect, not only their methods of inquiry, but also the techniques of communication that would enhance credibility. For example, the adoption of an impersonal writing style increased the appearance of objectivity [5]. As in the law, fact-finding in science also called on witnesses to validate new claims. The sociologist R. K. Merton attributed the rise of peer review, a form of "organized skepticism," to scientists' need for results that could be trusted [6].

In earlier times, it was enough to build trust within a researcher's community of scientific peers. Disciplines were small and methodologically coherent. Research neither drew heavily on public funds nor profoundly affected public decisions. Today, the circle of stakeholders in science has grown incomparably larger. Much public money is invested in science and, as science becomes more enmeshed with policy, significant economic and social consequences hang on getting the science right. Correspondingly, interest in the validity of scientific claims has expanded to substantially wider audiences. It is not only the technical integrity of science that matters today but also its public accountability.

In the United States, an elaborate legal framework for holding policy-relevant science accountable has been in the making since just after World War II. The 1946 Administrative Procedure Act (Public Law 79-404) required federal agencies to consult with the public before enacting new regulations; at minimum, providing notice and an opportunity to comment. A later milestone was the 1969 National Environmental Policy Act (NEPA) (Public Law 91-190), which called for extensive public inputs. Scoping exercises and hearings designed to solicit information from the public and to explain agency findings became recognized elements of the NEPA process. Many environmental and consumer protection laws now mandate public involvement beyond the requirements of notice and comment. Moreover, administrative decisions can be overturned if an agency does not have adequate scientific and technical evidence or has failed to act reasonably on the basis of available knowledge [7]. Under the Federal Advisory Committee Act (FACA) (Public Law 92-463), scientific advisory committees must be fairly balanced and, in the absence of special circumstances, committee meetings and records are presumed to be open to the public.

The rising importance of public accountability is also reflected in growing concern with ethics in science and the

proliferation of ethics oversight bodies. Once limited largely to concern for the welfare of human and animal subjects, today, ethics covers a wide array of issues across many emerging areas of science and technology, including stem cell research, nanotechnology, computer science, and the neurosciences. It is no longer enough to establish what counts as good science; it is equally important to address what science is good for and whom it benefits.

A 1983 and a 1996 report of the National Research Council bookended the turn from integrity to accountability. The first recommended that the largely scientific exercise of risk assessment should be separated as far as possible from the political and value-laden task of risk management [8]. The chief purpose was to protect science against possible biases. The second concluded that risk analysis should be seen as an intertwined analytic-deliberative process, requiring repeated public consultation even in the production and assessment of scientific knowledge [9]. Here, there was recognition that public consultation improves the quality and acceptability of expert judgments.

Science today has to meet a series of public expectations, not only about its products but also about its processes and purposes. The credibility of climate science has to be evaluated in this context of heightened demand for accountability. Accountability can be seen as a three-body problem, with each interacting component posing special problems for climate science.

A Three-Body Problem

The individual scientist or expert. In any professional activity where truth-telling counts—whether in law, accounting, engineering, medicine, or science—practitioners must be held to high standards of honesty and integrity. In science, peer review partly serves this purpose, weeding out dishonesty and misrepresentation along with mistaken or inconclusive results. Of course, the scientific community has experienced many episodes of misconduct, but there is often broad agreement on what constitutes deviant behavior, and publics by and large have reason to trust science's self-correcting practices [10].

Scientific knowledge. This body is organized into disciplines or into well-defined, topically focused areas of inquiry. Reliable bodies of knowledge are built on theories and methods that have wide currency among practitioners. Again, peer review serves a crucial legitimating function by maintaining rigor, coherence, and integrity in the development of a field's research frontiers. Peer review also demarcates work that is considered acceptable from work that is not [11]. In many areas of science, the ongoing work of peer criticism is enough to ensure a field's credibility to the outside world.

Committees that translate scientific findings into policy-relevant forms. This third body is increasingly important in modern democracies and frequently combines knowledge and skills from experts in different fields and contexts—for example, science and engineering, universities and industry, and bench and clinic. Their authority derives in part from individual members' impartiality and sound judgment and in part from the views they collectively represent, as required in the United States by FACA. Scientific advisory committees have dealt with the demand for accountability far longer than scientists who never did the work of translating science for policy. In most Western countries, expert advisers are required to explain their judgments to audiences outside, as well as within, their own research communities [12].

Implications for Climate Science

Standards of individual good behavior are especially difficult to identify and enforce in evolving scientific domains with under-developed histories of accounting to external audiences. Divergent national traditions of openness and confidentiality present additional hurdles for climate scientists, who are involved in international, as well as interdisciplinary, consensus-building [13]. As the UK inquiry on the hacked CRU e-mails revealed, some data relied on by climate scientists had been obtained from national governments under nondisclosure agreements. The parliamentary committee conducted, in effect, a process of post hoc standard-setting when it concluded that the climate science community should have followed more open practices of publication and disclosure.

The sciences represented by IPCC Working Group I do not share common principles for such basic tasks as visualizing data, interpreting anomalies, representing uncertainty, data-sharing, or public disclosure. That such disparate communities have come to agree on the causes, size, and scope of the climate problem, through iterative rounds of assessment, may be taken as strong evidence of reliability. At the same time, the very fact that judgment has been integrated across many fields leaves climate science vulnerable to charges of groupthink and inappropriate concealment of uncertainties.

Though intergovernmental in name, the IPCC is subject to none of the legal or political requirements that constrain, but also legitimate, national expert committees. The IPCC has invented its own procedures, including extensive and sophisticated peer review. These methods are good enough to satisfy many scientists, but they rest on traditions of scientific, rather than public, accountability. Yet the IPCC performs a mix of functions—part scientific assessment, part policy advice, and part diplomacy—that demand external, as well as internal, accountability.

These problems suggest that it will not be enough for climate scientists to be still more scrupulous and transparent toward their peers. Adding more new forms of expertise may increase the credibility of the field, but it will not fully address the third component of accountability, which involves relations between science and its publics [14].

Creating accountability practices that work at a supra-national level will be neither straightforward nor easy. Administrative procedures mostly operate within nation states, and there is no higher court where science can account for itself to the world. However, the IPCC has demonstrated that it can learn and change in its methods of representing science to scientists. That ingenuity should now be directed toward building relationships of trust and respect with the global citizens whose future climate science has undertaken to predict and reshape.

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Preserving the Manhattan Project

Cynthia C. Kelly

This year is the 65th anniversary of the dropping of atomic bombs on Japan and the end of World War II. While most people know about the atomic bombs, few people know what the Manhattan Project was or where it took place. The majority of the 125,000 Manhattan Project workers did not know about the bomb until the day the first one was dropped on August 6, 1945, and for decades thereafter much of the work of the Project remained shrouded in secrecy. Production facilities and laboratories were located “behind the fence,” where only those with the proper security clearances were allowed. By the early 1990s, hundreds of Manhattan Project properties were slated to be destroyed as part of a nationwide cleanup of former nuclear weapons facilities. Few members of the public were aware that almost all that remained of this important chapter of history would soon be lost.

This article tells the story of efforts to preserve a few of the most important Manhattan Project properties. These efforts represent collaborative work between federal agencies including the Department of Energy and the National Park Service, State and local governments and historical societies, and other organizations. My six years with the Department of Energy alerted me to the dangers posed to the Manhattan Project properties and prompted me to found the Atomic Heritage Foundation (AHF) in 2002 to help preserve them.

The story begins in 1997, when the last remaining buildings at Los Alamos National Laboratory (LANL) where the work of the Manhattan Project had taken place were slated for demolition. The original technical buildings around Ashley Pond had been torn down more than thirty years earlier. Now the rest were on the “D&D” or “demolition and destruction” list. About fifty original Manhattan Project properties were scattered behind the security fence in remote parts of the Laboratory. Isolated in space and time, few people even knew these buildings existed. While the Laboratory was required to keep the memory of historic properties by prescribed documents and photographs, preservation was not considered an option.

Most of the Manhattan Project properties were built to last only for the duration of the war and had been abandoned in mid-1950s. Among them was a cluster of humble wooden buildings called the V Site on a mesa that is surprisingly bucolic. Ponderosa pines tower above the structures and occasional herds of mule deer trot across the surrounding meadows. By the mid-1990s, nature had begun its own process of demolition. The roofs leaked and earthen mounds built as protection from possible explosions had broken through portions of the interior wall and dirt covered the floor. The high-bay doors that

once swung open for the “Gadget,” the world’s first atomic device tested on July 16, 1945, were badly weathered.

In its report to New Mexico’s environmental authorities on the V Site buildings, the Laboratory cited contamination with asbestos shingles and possible residues of high explosive materials. Apparently, the fact that the Laboratory determined that the buildings were contaminated was reason enough for State authorities to allow their demolition as part of the cleanup program. Working for the Department of Energy’s environmental management program in Washington, DC at the time, I learned about their impending demolition. Alarmed that these properties might be lost, I called the Advisory Council on Historic Preservation (ACHP), a small Federal agency that advises the President and Congress and is the arbitrator of important preservation issues. John Fowler, the Council’s long-standing executive director, was immediately interested in the plight of the Manhattan Project properties. Since the Council was planning to meet in Santa Fe in early November 1998, Fowler proposed that the Council members spend a day at Los Alamos.

When the Council members toured the V Site properties on November 5, they were struck by the contrast between the simplicity of the structures and the complexity of what had taken place inside them. Designing the world’s first atomic bomb was the most ambitious scientific and engineering undertaking in the twentieth century, yet the buildings put up hastily in the summer of 1944 more closely resembled a common garage or work shed. Bruce Judd, an architect whose parents had worked on the Manhattan Project at Los Alamos, commented that the V Site properties were “monumental in their lack of monumentality.” Who could believe that the world’s first atomic bomb was designed and assembled in such an unimpressive structure? The birthplace of the atomic bomb was humble, like the garage in Palo Alto, CA where Bill Hewlett and David Packard invented one of the world’s first personal computers in 1938.

Another Council member present was Carol Shull, the Keeper of the National Register of Historic Places for the National Park Service. In her judgment, the V Site properties not only qualified as a National Historic Landmark, of which there are fewer than 2,500, but also as a World Heritage Site. Today the United Nations has designated 890 World Heritage Sites such as the Acropolis in Athens, Machu Pichu, the “Lost City of the Incas,” in Peru, and the ancient city of Petra in Jordan. Somewhat chastened, LANL management agreed to remove all of the V Site buildings from the demolition list.



Los Alamos V-site before and after restoration. PHOTOS COURTESY CINDY KELLY.

However, funds for restoration would have to come from some other source.

Fortunately, Congress had set aside \$30 million under the new Save America's Treasures program to commemorate the millennium by preserving significant Federal properties that were in danger of being lost. Under the guidance of Secretary Bill Richardson, the Department of Energy competed for the new Save America's Treasures grants. The Department submitted seven applications, of which two were funded: \$700,000 for the Los Alamos Manhattan Project properties and \$320,000 for the Experimental Breeder Reactor-I in Idaho, the first test reactor built by the Atomic Energy Commission in 1951.

At Christmas time in 1999, the Save America's Treasures winners were honored at the White House. A little wooden replica of the V Site carved by a laboratory employee decorated a mantle in the green room. To raise the required matching funds for the Save America's Treasures grants, I left the Federal government and soon founded the Atomic Heritage Foundation. I soon learned how hard it was to raise funds for properties that were owned by the federal government and not easily accessible to the public. Many prospective donors believed that the government should pay for the restoration of its own properties. Because National Park Service officials wanted this first Save America's Treasures program to succeed, they took a liberal approach in considering what qualified as an in-kind donation. Eventually we were able to get credit for over \$450,000 in in-kind donations.

At the Laboratory, John Isaacson and Ellen McGehee directed award-winning restoration work at the V Site. In 2006, the Atomic Heritage Foundation joined LANL and many other partners to celebrate the Site's restoration. On May 1, 2007, the State of New Mexico provided a Heritage Preservation Award "for the exemplary restoration of the V Site of the Manhattan Project, which successfully challenged

the boundaries of preservation." On October 23, 2008, the National Trust for Historic Preservation also recognized the project with an award. Today, V Site is a touchstone for the Laboratory, a place where new employees and important visiting dignitaries are brought to learn about the Laboratory's history. While three of the buildings were destroyed by the Cerro Grande fire in 2000, the remaining two give the Manhattan Project a tangible reality. Through them, we are connected to the "galaxy of luminaries" recruited by J. Robert Oppenheimer to build the world's first atomic bombs. When we stand within its walls, we can imagine Oppenheimer and his colleagues inspecting the "Gadget" as it hung from the metal hook above our heads.

Inspired by the restoration of the V Site, in 2000 the Department of Energy listed eight properties as Signature Facilities of the Manhattan Project. The list included the V Site and Gun Site at Los Alamos, the X-10 Graphite Reactor, Beta-3 Calutrons and K-25 Gaseous Diffusion Plant at Oak Ridge, and the B Reactor and T Plant at Hanford. This was a major step forward but did not guarantee the preservation of these facilities. Thanks to the work of the B-Reactor Museum Association, however, that facility was subsequently declared a National Historic Landmark in 2008 (P&S, January 2010).

Having been to Los Alamos, the Advisory Council convened a special task force to go to Oak Ridge and Hanford. In February 2001, the Council's report urged the preservation of the Signature Facilities at those sites as well as properties in the communities. In March 2003, President George W. Bush reinforced the importance of preservation with Executive Order #13287, "Preserve America," charging Federal officials to "actively advance the protection of their historic Federal properties." Preservation was gaining traction, and in 2003, Congress followed up these reports by requiring the Department of Energy to develop a plan for preserving Manhattan Project history and directed that the Atomic Heritage



Los Alamos "Gun site," currently under restoration. It is expected to be ready for visitors in about two years. PHOTO COURTESY CINDY KELLY

Foundation be tasked with preparing the plan. The AHF began by convening a series of public meetings at Oak Ridge, Los Alamos, NM, and Richland, WA to develop recommendations.

The Foundation submitted its report to the Department of Energy on August 3, 2004. The report was also published as part of the Atomic Heritage Foundation's volume *Remembering the Manhattan Project* (World Scientific, 2004). The report's most important recommendation was to create a Manhattan Project National Historic Park at the three major Manhattan Project sites. Other recommendations urged that oral histories be taken of the surviving Manhattan Project veterans and that first-of-a-kind equipment and artifacts be preserved. The plan also listed properties that were essential to tell the story of the Manhattan Project at each of the major sites.

In September 2004, Congress passed the Manhattan Project National Historical Park Study Act [PL 108-340] that authorized the National Park Service to study whether to create a Manhattan Project National Historical Park. In December 2009, the National Park Service recommended a Manhattan Project National Historic Park at Los Alamos, NM but not at Oak Ridge, Hanford or Dayton, Ohio, which were all part of the study. (Dayton was included because that is where the polonium-beryllium "initiators" for the bombs were made.) The draft report argued that it was not feasible for the National Park Service to maintain or ensure the safety of the public or employees in radioactively contaminated facilities such as B Reactor or the uranium enrichment plants at Oak Ridge. Even the V Site along with other Manhattan Project properties owned by the Los Alamos laboratory was excluded.

In response, Congressmen, State and local government officials and the public deluged the National Park Service with letters in favor of including Oak Ridge and Hanford as units of

the National Historical Park. Tennessee Senators Alexander and Corker wrote that "It would be impossible to tell the full story of the Manhattan Project without including all of the sites which made the project a success." At the same time, the Department of Energy clarified its commitment to maintain its Manhattan Project properties in perpetuity. In a letter dated May 13, 2010, Assistant Secretary for Environmental Management Ines Triay proposed a "strong and permanent partnership" with the National Park Service. As the nation's storyteller, the National Park Service could interpret the history and educate the public, while the Department of Energy would ensure visitor and employee safety.

This fall, the National Park Service is expected to submit its recommendations to Congress for a park with units at Los Alamos, Oak Ridge and Hanford. Over time, a number of affiliated areas could be created at the University of Chicago, University of California at Berkeley, Wendover Air Force Base in Utah, the Trinity Site at Alamogordo, NM, and sites in Dayton and on Tinian Island. With the likely designation of a Manhattan Project National Historical Park, the Atomic Heritage Foundation is planning to develop a national traveling exhibition on the Manhattan Project and its legacy. With oral histories, audiences will be able to hear first-hand accounts from Manhattan Project participants. The exhibition will address the Manhattan Project, Cold War and the continuing challenges of dealing with nuclear weapons today. In addition, a website will offer a "virtual tour" and a variety of programming and educational resources.

In the meantime, the AHF is continuing its work to preserve key Manhattan Project properties. A top priority is to ensure that at least a portion of the half-mile long K-25 plant in Oak Ridge is preserved. For the past few years, the Department of Energy has maintained that preserving a portion of the plant would be too dangerous and expensive. More than one-third of plant has already been razed. In May 2010, the Tennessee Trust for Historic Preservation named the K-25 plant as one of the state's ten most endangered historic sites. However, with increasing prospects for a Manhattan Project National Historic Park, the Department is taking a "second look" at the K-25 plant. An expert evaluation underway may prove that a piece can be cost-effectively and safely preserved for future generations. A second preservation priority is the Gun Site (TA-8-1) at Los Alamos, where Manhattan Project

scientists and engineers developed and tested the uranium-based weapon design and assembled the Hiroshima Little Boy bomb. In FY 2010 Congress provided \$500,000, and Clay and Dorothy Perkins of San Diego have pledged \$250,000 for restoration of the bunker-like buildings, a 45-foot periscope tower, and a Naval cannon and their housings.

For more information about the history and preservation plans for Los Alamos, please see our recent Guide to the Manhattan Project Sites in New Mexico (www.atomicheritage.org). Given the reception for this publication, we hope to publish similar guides to Project sites in Tennessee and Washington in the near future. In addition to the guidebooks, our anthology, *The Manhattan Project: The Birth of the Atomic Bomb in the Words of Its Creators, Eyewitnesses, and Historians* (Black Dog & Leventhal Press, 2007), traces the history with numerous historical documents and lively first-hand accounts of Manhattan Project history.

Over the past decade, the Foundation has been fortunate to work in partnership with Federal, State and local governments, historical societies, academia, and corporate and non-profit organizations to preserve this remarkable past. With the prospective Manhattan Project National Historical Park, our vision of having some tangible remains from the Manhattan Project for future generations may become a reality. When future generations look back on the 20th century, few events will rival the harnessing of nuclear energy as a turning point in world history. Having some of the authentic properties where the Manhattan Project scientists and engineers achieved this is essential. As Richard Rhodes has said, “When we lose parts of our physical past, we lose parts of our common social past as well.”

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REVIEWS

Nuclear Express: A Political History of the Bomb and its Proliferation

by Thomas C. Reed and Danny B. Stillman, (Zenith Press, Minneapolis, 2008), 400 pp., \$30. ISBN 978-0760335024.

Nuclear Express, by Thomas Reed, longtime Livermore employee and a former Secretary of the Air Force, and Danny Stillman, former head of intelligence for Los Alamos, was conceived as a polemic from the beginning. There is nothing intrinsically wrong with polemic; it is a venerable literary genre known, at least, from the ancient Egyptians. The narrative is on a single track. Its main premise, succinctly (also, accurately and approvingly) enunciated by a New York Times reviewer is that only the United States possesses scientific and technical talent [1]. Hence, all other nations must have acquired nuclear weapons by pilfering American nuclear “secrets,” either by cajoling (England and France), or espionage (USSR and China).

Such nativism by itself does not necessarily devalue the written word. The still-classic book *Military History of the Western World* was penned by J. F. C. Fuller, a well-known Nazi sympathizer, and abounds in references to “brutes” and “asiatics” in connection with ethnic groups the author considers “inferior.” So, I took up Nuclear Express desiring to avoid as much of the authors’ polemics as I could.

But I already stumbled on p. 4: “China stands astride this world like a young Colossus, a nation clearly supportive of nuclear proliferation... China collected its technology one graduate student at a time” But China, being a great beneficiary of its own acquisition of nuclear technology, is highly unlikely to share it with others. Similar attribution of irrational but nefarious motives to the international actors disliked by the authors pursues the reader throughout this book. One does not need to wait long for an explanation to follow: “Overlying all this history is radical Islam’s desire to destroy Western ways.” I am not sure what in particular is meant by “Western ways.” Is Albania (a NATO member), or Singapore “Western” [2].

The book abounds in stories of discovered (mostly real) and undiscovered (mostly imaginary) Soviet spies. Not being satisfied with a tale about a mysterious highly placed Soviet spy who, in the view of the authors, was an American-born son of European immigrants who was educated abroad and recruited through his contacts in leftist organizations, the authors recycle the Ted Hall saga (p. 30). Ted Hall was a 19 year old high-school graduate posted as a soldier to Los Alamos in 1944. He left Los Alamos after the war to resume his study at the University of Chicago. Supposedly he was a major Soviet agent [3]. Then there is Perseus, a mythical code name of an undiscovered superagent and another favorite of the conspiracy buffs. And the chapter titled “The Cold War

Ended, but Mysteries Linger On” has all the quality of the Roswell or Nevada Area 51 stories.

A habitual weakness of conspiracy theories is poor chronology. “Khariton was put in full charge of the Soviet thermonuclear program at Arzamas-16 (p. 35).” But he was already technical head of the Arzamas-16 facility, supervising all research including thermonuclear studies. A chapter is titled “July 1979: Saddam Hussein takes full power in Iraq,” although he came to power in a 1968 coup.

The chronological mismatch is prominent in the following two storylines. First is the alleged Soviet transfer of nuclear weapons technology to the Chinese. In fact, on meeting Mao, Stalin sternly rebuffed his solicitations. Whoever Stalin was, he was not naive. Yet, Sino-Soviet relations had many facets apart from nuclear weapons and they remained strong, souring only after the 20th Party Congress and Khrushchev’s denunciation of Stalin (1956). Reed and Stillman pinpoint the visit of three high-ranking Soviet nuclear officials and the precise date (18 June 1958) of the “transfer” of the atomic bomb to the Chinese [4]. But then, according to their assertions, the Soviet-Chinese relations were already in deep decline.

An important feature of Reed and Stillman’s thinking is their belief that nuclear technology is contained in a single “secret” which can be verbalized. In reality, even the US, not to speak of the post-WWII USSR and especially China, needed to create from scratch entire new industries to design and produce nuclear weapons. Besides defective chronology, this story is improbable because the Chinese fission bomb used highly enriched uranium, while the Soviets used plutonium.

Second is the alleged stealing by the Soviets of the principle of the H-bomb. The authors attribute their conjecture to slips of tongue by the deceased L. P. Feoktistov, who cannot vouch for himself [5]. Supplementary “proof” is that Sakharov never publicly appropriated this idea. Indeed, the first workable Soviet proposal was issued on 14 January 1954 by Ya. B. Zel’dovich, mentioning V. A. Davidenko as an author and undersigned by A. D. Sakharov. In contrast to Teller, Sakharov was ethical enough not to arrogate to himself critical ideas of his colleagues and subordinates when he submitted them to superiors.

If the Zel’dovich report served only as the conduit for the information obtained by espionage then the question arises: When could this act of espionage have taken place? Klaus Fuchs was apprehended in early 1950, before the concept of radiation compression of the secondary had fully congealed in the US [6,7]. If the report was founded on messages of an as-yet-undiscovered Soviet agent, then why did the USSR continue to waste precious resources for nearly four years after the Teller-Ulam report? The fateful meeting, which terminated exploration of a design similar to Teller’s original “Super”,

happened only in 1954. Moreover, the adoption of radiation compression followed, rather than preceded, this meeting [8].

Let’s be clear: The US nuclear weapons complex in the mid-50s employed more people than the automobile industry and nobody can claim that among these were no spies. However, unlike the Soviet fission bomb there is no shred of evidence that espionage was a serious factor.

This opus magnum is not without its hilarity. Reed and Stillman obviously subscribe to the conspiracy theory that Stalin was murdered by Beria using “the rat poison” [9]. But let them inquire of their doctors what the words “coumadin clinic” really mean. I would abstain from mentioning this sad episode but it is central to the authors’ worldview.

Nuclear Express is so riddled with factual errors, cherry-picked evidence, and unedited 1950s and 1980s agitprop that even the chapters about Pakistan and North Korea where I cannot form an educated opinion seem suspicious. If there is a conclusion I can derive, it is that scientific and technological progress cannot be restricted to any nation, and the quest for long-term military superiority is elusive. But this conclusion is rather trivial.

References and Notes

1. *Reviewed by W. J. Broad, NY Times, Dec. 8, 2008.*
2. *I remind those who respond with a resounding “yes” that, according to the American press, Iran was considered thoroughly westernized in the 1970’s and Pakistan in the 1980’s.*
3. *Hall may have met a Soviet agent in New York once or twice, was interviewed by the FBI, but never was charged with anything (www.fbi.gov/libref/historic/history/foxpaper.htm).*
4. *E. A. Negin, N. G. Maslov and V. Yu. Gavrilov, according to Stillman and Reed.*
5. *L. P. Feoktistov (1928-2002), Soviet Russian nuclear weapons designer, first deputy head of Chelyabinsk-70, the Soviet counterpart to Livermore.*
6. *J. Carson Mark, A Short Account of Theoretical Work on Thermonuclear Weapons, 1946-1950. Los Alamos Preprint LA 5647-MS (declassified).*
7. *C. R. Loeber, Building the Bombs: A History of the Nuclear Weapons Complex, Sandia, Albuquerque, 2002.*
8. *Yu. B. Khariton, V. B. Adamskii, Yu. N. Smirnov, Physics-Uspечи, 39(2), pp. 185-190, 1996.*
9. *As if the death of Stalin—heavily drinking, heavily smoking man with a sedentary lifestyle, who survived smallpox in his youth and suffered a series of strokes—at 74 is of any surprise.*

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Am I Making Myself Clear?: A Scientist's Guide to Talking to the Public

Cornelia Dean (Harvard University Press, 2009) ISBN 978-0-674-03635, 288 pages, \$19.95

Yes, you are coming through loud and clear! And the message is that scientists must accept more responsibility for explaining their work to the public. Cornelia Dean, the bearer of the message, is a science writer and former editor of the New York Times and teaches seminars on the communication of science at Harvard University.

The first 6 chapters describe the general scene including the “landscape of journalism” and its relation to the scientist and research. Thereafter the book provides detailed advice to scientists on how to treat the various forms of journalism he/she may encounter. She believes that the general public does not understand science. On the other hand, there is a great need for an informed public, who can decide public social policies on reasonable and rational grounds. Americans do respect science; consequently, people with a political point frequently will cloak their arguments in the rhetoric of science by twisting the facts. Sad to say, several of the federal government's organizations such as the Office of Technology Assessment have been eliminated. These are just the very organizations that people and public officials might once have turned to for impartial expert advice.

The newspapers, a traditional source of news, have increasing competition from the internet and the proliferation of cable television. Many newspapers seek to cut costs by reducing or eliminating scientific articles and shifting science reporters to other tasks for which they are not trained. Who will rescue newspapers and journalists from this predicament? Dean's answer rings clear—*The Researchers!* But this will require a change in the mindset of most researchers, who tend to spend their time on nothing but their research. If they let their voices be heard beyond the bounds of scholarly publication, they could inject a lot of rationality into our public debates.

Dean's goal is to discuss the barriers to public understanding of science and technology by describing the journalistic landscape in which public discussion of these issues take place, and identifying the many ways in which researchers can fruitfully participate in this discourse. Prime requirements are that the scientist should know their audience and that he/she should *prepare, prepare, prepare*. She knows the public is largely ignorant of technical facts, and, worse still, of how science works, which leads to incorrect reasoning and false conclusions. But even if the public received an ideal level of understanding, they would still need someone to report the findings and explain what they mean. Who will do this?—*The Journalists!* And so Chapter 3 is titled The Landscape of Journalism.

To produce the journalism needed to maintain a democratic society, several newspapers are trying new paradigms, mostly using the internet, publishing online for example. Blogs are multiplying at a great rate, but unless these have high editing standards, blogs may end up cluttered with rumors and conspiracy theories which ordinary readers may find difficult to differentiate from reliable content. Furthermore, young people are far less interested in news than older people and the gap is growing. On top of this there is a poor match between what researchers do and what the reporter thinks of as news. To survive, newspapers frequently cut their budgets for reporting. Science coverage is often an early victim. Journalists cultivate an instinct for what people are going to want to know about, and Dean gives a list of attributes that tend to make an item “newsworthy.” It must be remembered that space, time and reader's attention are limited, especially in television and radio where news accounts must be immediately clear on first hearing. This is quite difficult for developments in science and engineering. With a shrinkage of science reporting staff, reporters—who normally don't report on science—suddenly find themselves parachuted into technical issues. Many more of the journalist's problems are discussed.

Researchers perennially complain about journalistic incompetence resulting in his/her embarrassment when they find their interview is wildly hyped in print. Dean gives a list of things that irk researchers followed by a list of how journalists view researchers. These are well worth consulting. Scientists also complain that they find themselves pitted in the media against some contrarian or crank who ostensibly provides proper balance to an argument. Journalists believe, falsely, that this leads to *journalistic objectivity*. But, journalists have real problems in distinguishing a good source from a specious one, and will frequently in effect turn the decision over to the reader, who may be as confused as the journalist. The desired objectivity then disappears. To Dean this is the most intractable problem in the coverage of science and engineering. She believes scientists and engineers can help solve it.

Chapter 6 is titled The Scientist as a Source. Ideally the researcher wants to convey the facts in a way that allows no misinterpretation. This is difficult to do, but Dean has many ways to improve the odds of success. The first of these is adequate preparation on both sides. The scientist must go into an interview with something to say, remembering that a fact is not a message or a point of view. So he or she should take time to figure out the message and think about how to convey it. Whether the researcher likes sound bites or not, the journalist is looking for terse, telling quotes that an ordinary person will understand, and for better or for worse there will be sound bites. It's better that they are the scientist's rather than the journalist's, which may be less accurate and cogent.

Hereafter there is a series of chapters on a multitude of more specialized subjects which I will not attempt to review individually. Examples are Public relations, Press conferences, Telling stories on line, radio and television, Writing about Science and technology, Editorial and Op-Ed pages, Writing books and several other venues.

Suffice it to say that this book emphasizes the practical, political, and policy reasons why scientists should engage in the public life of the nation. It fills a gap by providing useful advice and information on a wide range of methods scientist can use to inform the public. It also gives scientists some understanding of the inner workings of the public institutions that publish news in all its forms. I recommend it.

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Don't Be Such a Scientist: Talking Substance In an Age of Style

Randy Olson, Island Press, Washington, DC, 2009, ISBN: 978-159726-563-8, 207 pages, \$19.95

The basic message of this fairly short book is that scientists, and even some prestigious non-scientists such as Al Gore (on global warming), endeavoring to convey important scientific ideas needed by the public, fail either partially or completely. Starting with this premise the author advances corrections to his postulated problem.

The work is structured largely as an autobiography of the author, first as a Harvard PhD in marine biology and then as a tenured professor at the University of New Hampshire who at age 38 is beginning a new professional life at as a Hollywood film maker. There is little question as to which aspect of his life he views as more decisive. One of the appendices lists 14 films written and directed by Olson during 1990-2008, most of which have titles related to marine science. Several of these films have won awards and a good deal of TV or internet exposure. Olson's published scientific papers are not listed, though this omission does not appear in his judgment to be relevant to the book's central thesis.

Olson's formula for reaching a mass audience is mostly summarized in an italicized paragraph in the first chapter, a

chapter titled Don't Be So Cerebral: "When it comes to connecting with the entire audience, you have four bodily organs that are important: your head, your heart, your gut, and your sex organs. The object is to move the process down out of your head, into your heart with sincerity, into your gut with humor and, ideally, if you're sexy enough, into your lower organs with sex appeal." He expands this hypothesis in sometimes surprising detail, occasionally pushing the envelope too hard with an arguable infelicity. "All I have to say is 'penis' and you're either physically smiling or internally smiling. Why is this? Well, let's ask Bill Clinton — remember him? He's the man who obliterated his entire historical legacy thanks to this region." Frankly, this reviewer's reaction is not to smile but to say: "C'mon!"

Is this book worth anyone's attention, whether he or she be a scientist or an intelligent layman concerned with contemporary ideas? Though not persuaded by the author's arguments, this reviewer feels the book deserves reading. It does raise a serious question, but without providing a suitable answer. Today, when a sizeable number (maybe a majority) of citizens, including hyper-religious constituents and others, has actually induced a growing group of state legislatures to challenge Darwinian evolution or the clear validity of the hazards of global warming, it is apparent that scientific communication has not been successful despite the existing abundance of it. However, the cure must be more fundamental than Olson's criticism of excessive cerebral effort, or lack of clarity, or lack of style by the collective scientific community.

The United States, though still the world's leader in the physical and biological sciences, is finding that our students are falling behind other nations in mathematical and scientific achievement. Something does need to change. The book is illuminating and fun to read. Olson's former wife's admonition "Please ... don't be such a scientist," which led to his title, does have merit. There is much of ancillary interest in the book's content. And Olson has done a reasonable job of alerting us to a consequential problem. So the book is worth reading. But the solution or solutions are more complex than he proposes. Perhaps his proposals can stimulate some of his readers to find more meaningful approaches.

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