Comments from the Editor

This is the second of our proposed semi-annual all-web issues (October, April) in contrast to our semi-annual paper ***and*** *electronic issues (January and July). Unfortunately, the first of our web issues gained far fewer "hits" than was the usual circulation of our past paper issues. Hopefully this drop represents a "learning curve" and we will soon again have the large readership presumably represented by our past regular circulation.*

One way to boost readership is to earn it by raising and dealing seriously and interestingly with issues of concern to the membership of the Forum on Physics and Society , as well as - hopefully - to the rest of the physicist population and society in general. The themes of this issue, science Vs pseudo-science and the prospects of nuclear power, are two such recurrent controversial concerns. Holton, Duncan, and Puechl discuss what science, and education for it, should be. Various aspects of the "practical" use of nuclear energy are considered by Cohen, Sailor, Wolfe, Rosa, Bodansky, and Ahlquist. We hope to continue the exploration of all aspects of these controversies in the next few issues.

Also in this issue is another fiction contribution , this time by one of my undergraduate non-science students, since - on the whole - previous correspondents have reacted favorably to the occasional inclusion of such physics-related stories.

As usual, we welcome comments, criticisms, and suggestions - for publication in this journal or otherwise. Let us hear from you!

ARTICLES

Introduction: The following article is based on a presentation at an invitational Conference on Basic Science in the Service of Public Objectives, November 28-29, 2000, Washington, D.C. It was the third such meeting, the previous two having been held at the offices of the OSTP and at the National Academy of Sciences, respectively. In the November 2000 meeting, the speakers included Mary Good, Lewis Branscomb, David Hamburg, D. Allan Bromley, Richard Klausner (of NCI), Rita Colwell, Shirley Malcom, Jim Duderstadt, Ralph Gomory, Paula Rayman (Radcliffe Institute), Sarah Harringan (OMB), Jack Gibbons, Walter Massey, Rep. Vernon Ehlers, David Guston, Leon Lederman, John Bransford, Rush Holt, Warren Washington, Mildred Dresselhaus, John Holdren, and several others. A full report is to be published.

"What is the Imperative for Basic Science that Serves National Needs?"

Gerald Holton

A major focus of discussion in Washington and in academe is how to strengthen the conduct and support of basic research in science and technology. It is a timely effort: the federal support for basic research has dropped precipitiately during the last decade (to about 0.6% of GNP, back to where it was in 1953), the U.S. population remains, to our shame, dangerously ignorant of the sciences (for example, 70% of the nation's colleges do not require even one hour of science or mathematics for graduation), and the true champions of basic research support in the House and Senate of Congress are still few in number. More ominously, the world has entered a new phase of history, with potential instabilities before us, including global change, energy, literacy and learning, the threats of wars, poverty and the spread of disease--among many possible examples. Many of these are relevant to scientific studies; but all, known or yet unsuspected, will greatly determine the life of our children and generations beyond. Just as our nation's civilization has been shaped in large part by the extraordinary powers of the sciences and technologies, the phase of history which we have entered will surely also be formed by the findings and tools to be developed by scientists and their near colleagues, by how their work is to be encouraged and conducted.

Thus a main point of the vision I wish to sketch is this: The scientific part within our total cultural spectrum can do, and now must do, far more to serve the needs of this nation and humankind, and needs a corresponding expansion in terms of human resources and financial support. True, the sciences as a whole have risen to glorious heights in the twentieth century, despite many shortcomings and persistent obstacles. In addition, economists have found that the social return on the federal investment in science and technology has been between 30% and 60%. In the darkest middle-part of World War II, the sciences and technologies even helped the Allied forces to rescue Western civilization itself. Now, in our battle for a more secure future, the sciences, more mature and numerous, are even more capable of great achievements for the public good.

How? Many of us believe the first step is to widen the common understanding of what the sciences now can do. It is imperative to cut the chains impeding some of today's sciences; to let them help more effectively with the public needs before us. By widening of the common understanding of science's powers, I mean specifically to encourage much more intensively *a style of basic research that locates itself in areas of ignorance of how to meet societal needs*. It is a mode of research that I have thought and written about for some time, using as convenient shorthand the term "Jeffersonian Research." That notion is neither radical nor untried. For example, much of the basic research now supported by the National Institutes of Health is chosen and pursued in this mode, with wide approval in Congress and among the public. The White House report on science in 1994, and Rep. Vernon Ehlers' report of 1998 contain similar proposals. A fascinating attempt to institutionalize this mode across all executive departments and agencies was made under the direction of Frank Press during the Carter administration. In the last decades there were also a few other federal initiatives along that line. But what many of the past attempts have lacked is an explicit verbalization of the overarching rationale and the institutional legitimating of Jeffersonian Research within science policy. This is what I shall consider here. A proper start is to summarize more precisely what characterizes the two current main research styles as commonly perceived, and how a third one I select for greater attention differs from the others.

Newtonian vs. Baconian mode of research

Among the familiar research styles are two modes of basic research, well established and utterly needed to be adequately supported in the total range of efforts. One mode is primarily curiosity-driven basic research, without the expectation of any but perhaps long-term social benefits, apart from the important one of increasing of scientific understanding itself. The other mode is that part of R&D pursued in the reasonable hope that a fairly early harvest would result, for use and practice beyond the originating laboratory. In popular parlance, the difference between the two is ivory tower versus quick payoff, or pure versus mission-oriented, or the craving for omniscience versus that for omnipotence, or, for shorthand use, the Newtonian mode versus the Baconian.

At first glance, those two modes seem antithetical, even antagonistic, and invite choosing one over the other. For example, as to the support of basic research, Senator Harry Reid warned in April 2000 that many people are now beginning "to see science as a luxury that can be reduced or abandoned." On the other hand, federal support for applied science research has been attacked as "corporate welfare"; and similarly, one still hears occasionally Vannevar Bush's remark, made in passing in his grand Report of July 1945, that "there is a perverse law governing research:...applied research invariably drives out pure."

If one looks at these two modes in turn, and arrays historic examples of scientific results in two opposite columns, deep differences seem to persist. In the column on the left, that of curiosity-driven achievements, we would find for example Galileo's telescopic discovery of the moons of Jupiter; Newton's Principia; Faraday's discovery of generating electricity by moving conductors in magnetic fields; Johann Gregor Mendel's report of his experimental results of artificial plant hybridization and Thomas H. Morgan's research on fruit flies; Roentgen's discovery of xrays; Einstein's brief paper of November 1905, ending with the speculation that "The mass of a body is a measure of its energy content," and the vaguely expressed hope that "It is not beyond possibility that this theory may be tested." The story continues in the latest, astonishing reports in journals such as Science and Nature.

The second, right-hand column, presenting mission-oriented or Baconian-mode results, would be equally long. It might start with the casting of a monstrous canon of new design at the command of Sultan Mechmed II in the 14th century, which breached the walls of Byzantium; in our century it would feature the inevitable transistor, antibiotics, the Genome project, or the discovery by Müller and Bednorz of high-temperature superconductivity found in a substance nobody else thought worth investigating.

A closer look at these apparently divergent listings, left and right, reveals that they have four important commonalties. First of all, each has its own charisma. I need only say that the fascination of the public with, say, astronomy on one hand and mechanical and electronic devices on the other are reminders of those ancient, benign enchantments with science and technology that are built into most souls from the beginning.

Second, both modes are part of a whole seamless web or eco-system. Galileo's telescope depended on the practical results of ancient glass-making technology; Newton's calculations required data supplied by map-making expeditions; and so forth. Conversely, Müller and Bednorz's work rested crucially on basic results in thermodynamics, crystallography, quantum mechanics, as well as the applications of low-temperature technology, and of some thermometry first developed in the 19th century. There is much borrowing of ideas and sharing of instruments. Thus, both these research modes are essential for each other's well being.

Third: Basic research done without an explicit mission does of course sometimes result in unforeseen, extraordinarily useful applications, although usually with considerable time delay. Faraday's discoveries were the basis of electric generators and motors built decades later. Mendel's and Morgan's labors eventually became part of the intellectual ancestry of brilliant biotechnology industries. One of Einstein's papers of 1916 was to be the basis for the ubiquitous laser. NMR was morphed and transformed into MRI. The roots of the computer and the Internet can be traced similarly.

The possibility of such eventual, but not foreseeable, spin-offs from basic research has undergirded the public's affection with basic science so far. These were explicit in Vannevar Bush's Report when he wrote to President Roosevelt, without committing to a timetable of achievements: "Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress."

A last, fourth kind of similarity between the Newtonian and Baconian modes of research is both exciting and troublesome. An advance in either one can undermine an old worldview, and help in the ascent of a new one. Galileo's finding of the moons of Jupiter presaged the final acceptance of the Copernican view of the universe, and of our place in it; and similar tectonic shifts began with Darwin's lonely studies of finch beaks. The whole pseudo-scientific alibi for racism had to be abandoned, thanks to the findings of anthropologists and geneticists. In each case where a new worldview and new rights asserted themselves, vigorous resistance had to be overcome, and may, to some degree, exist to this day. It explains why science and technology are now feared or derogated by some parts of academe, and why the public may be quietly troubled by the possibility of another such revolutionary earthquake. Therefore I see part of the imperative for an expanded vision of science policy that it may put the needed respect of the populace and policy makers on a sounder basis.

The Jeffersonian mode of research

The Baconian mode generally applies known science to a known need; the Newtonians pursue science regardless of needs. Both must of course continue to flourish, not least because all modes interact. But research in the Jeffersonian mode, by contrast, places itself on an uncharted area on the map of science, which, if the expedition succeeds, may reasonably soon have a bearing on a persistent national or global problem. It is in a sense a combined mode, and the label I chose for it reflects the fact that Thomas Jefferson himself saw two intertwined goals for science--not only the full understanding of nature, which he treasured, but in addition what he called simply "the freedom and happiness of mankind."

It is not difficult to imagine intentionally targeted basic science research projects where, with less uncertainty and less time delay than from Newtonian research, one can reasonably hope to find a key to alleviate specific, well recognized societal dysfunctions. For example, much remains to be done in cognitive psychology; the biophysics and biochemistry involved in the process of conception; the neurophysiology of hearing and sight; molecular transport across membranes; or the physics of nanodimensional structures, to name a few. The results of such basic work may plausibly be expected, on a reasonable timetable, to give us a better grasp of complex social tasks such as, respectively, childhood education, family planning, improved quality of life for handicapped people, the design of food plants that can use brackish water, and improved communication devices. Other examples with plausible societal significance, many now in progress, could include marine biology resources and related environmental and ecological goals; further research on imaging of the brain; studies situated between understanding behavior and mental illness on the one hand, and neurophysiology on the other; and research on the remaining social and psychological obstacles that still stand in the way of greater participation and diversity, not least in careers in science and technology.

I am not saying that this terminology, Jeffersonian research, is the only acceptable one. Of course not. It is merely a convenient shorthand term, analogous to the widely accepted one using the names of Newton and Bacon.

"Basic Research in the Service of Public Objectives," although longer, is one of many equally good terms. But Jefferson himself pointed to the existence of this third mode, when he announced the twin aims for the support of the Lewis and Clark exploration. He wrote that its purpose was "to extend the boundaries of science, and to present to [the citizens of this nation] their knowledge of this vast and fertile country which their [children] are destined to fill...."

Jefferson, who declared himself most happy when engaged in some scientific pursuit, was delighted to receive from the explorers the samples of new fauna and flora, the notes on Indian languages, the geographical maps, and the like. But he also knew that such scientific information would help to prepare America's future on its vast new territory. Out beyond the frontier, there had to be, as Jefferson put it, "room enough for our descendants to the hundredth and thousandth generation." In just this way do I see the need for some portion of our sciences to be dedicated explicitly to the preparation, beyond our own time horizon, of the fortunes of our descendants.

In the Louisiana Purchase and the Lewis and Clark expedition, we see also examples grasped initially by only a few visionaries, to change the opportunities latent in history, as if by a quantum jump. The institutionalization of the Jeffersonian mode of research in all fields, as part of a new mandate for science, parallel to that for National Security, would again take a brave act of political will, expressed not least in enlarging the whole pie of federally-funded support for the entire spectrum of science and technology--just at a time when we may afford it.

In one of the meetings arranged on this topic, Dr. Harold Varmus, then of NIH, noted that it would be important to get active public support through the kind of council-of-citizens group he used at NIH, and also that the delivery of outcomes is now of concern to every sponsoring agency as a result of the Government Performance and Results Act (GPRA). Dr. Rita Colwell reminded us that the National Science Foundation has recently developed increasing constituency support, for example, by forming the NSF Council for Public Research. Other participants thought that the availability of explicitly Jeffersonian research might greatly appeal to potential science researchers now not sufficiently attracted to the other, more visible current modes. As Dr. Walter E. Massey remarked: "I am particularly attracted to the argument that tying research to broad and meaningful national goals may make science more attractive to women and minorities.... I think that showing how scientific research can be related to visible societal goals can be a strong attraction to many students who might otherwise not consider scientific careers."

Finally, there is a need to face the rarely asked question, "In what consists the moral authority for the pursuit of science and technology in the first place?" In my view the answer consists of several interlocking components: the imperative to excellence of the enterprise; internal accountability, which centers on the ethical imperatives in the conduct and use of research; external accountability, including explaining to the lay public and funding authorities what is being achieved and how; identity preservation, including identifying what is science and what is not, where the limits are, and fighting against unjustified external attacks or misrepresentation, as well as internal enemies such as arrogance and scientism. The most important component of the moral authority of science is the last component on such a list, obligation to the larger community, or, in short, coupling science and technology to the wider interests and needs of the country and the world. As Representative George E. Brown once said: “We must have a research system that arches, bends, and devolves with society’s goals...I consider it a moral imperative to enlist science and technology in a campaign for a more productive and humane society.” Representative Brown did not need to evoke Jefferson explicitly, but there was an echo in his words.

I know it will not be easy to make this vision a functioning imperative, alongside, and with the same power as, the existing imperatives for lively curiosity-driven and mission-oriented research. Like the latter two, basic research in the service of urgent public objectives will need administrative help and funding through various administrative agencies, although no single "home," any more than, say, applied research is the captive of only one agency. However, the enlarging of basic research in the nation's interest will need, at least in its early stages, a congenial institution that agrees to serve as champion, teacher, information center, facilitator.

A search for that will not be easy. But this should not dissuade us. Jefferson himself gives us courage. In 1812, a dark period in the nation’s history, he writes to John Adams: "I have given up newspapers in exchange for Tacitus and Thucydides, for Newton and Euclid; and I find myself much the happier." But Jefferson's native optimism prevails all the same, an optimism we can share as we gather allies. He tells John Adams: "I do believe we shall continue to grow, to multiply and prosper, until we exhibit an association, powerful, wise and happy, beyond what has yet been seen by men."

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Leukemias from Military Use of Depleted Uranium

Bernard L. Cohen

There has been a great deal of media publicity recently about leukemias induced by military use of depleted uranium (DU) in Bosnia and Kosovo. DU is used in anti-tank shells because of its high density (1.7 times the density of lead) allows it to penetrate tank armor; the principal alternative, tungsten, is more expensive. The high density and abundant availability of DU leads to other uses where packing a lot of mass into a small volume is advantageous, like counterweights in missiles and in airplanes (including the Boeing 747), in sailboat keels, and as protective armor for tanks. It is especially useful for radiation shielding as its high atomic number makes it much more effective than lead for X-rays and low energy gamma rays.

When a shell tipped with DU penetrates the armor of a tank, it often becomes heated to 500-1000 °F at which uranium ignites and burns, producing a very fine dust which may be inhaled. Inhalation of this dust is the principal source of potential radiation exposure from DU. Maximum exposure would occur immediately after, and close to, the burning, but the dust disperses for possible inhalation at distant locations, it settles on surfaces from which it can later be resuspended leading to additional inhalation, contaminate vegetation later used for food, or migrate down into the ground to be picked up by plant roots to get into food supplies.

There has been extensive publicity about trace amounts of plutonium and other transuranics in the DU. These arise from the fact that the isotope enrichment plants from which the DU was derived were used to enrich uranium in reprocessed spent fuel from the government production reactors at Hanford and Savannah River. The transuranics were chemically removed in the reprocessing, and were further reduced in the conversion of uranium to the hexafluoride gas used in the enrichment process, but tiny traces may have remained. The United Nations Environmental Program (UNEP) reported that four samples of DU from Kosovo contained Plutonium levels between 0.8 and 12.9 Bq/Kg; the latter corresponds to less than one alpha particle emitted from Pu per million alphas from the DU, and a fraction of Pu by mass of about 5 parts per trillion. The health impacts of this slight contamination would add far less than one percent to those of the DU., so I ignore the Pu contamination here.

I begin by explaining how Health Physicists evaluate hazards of this type, and will present the findings of various investigations as reported in the media. UNEP considers the maximum credible quantity of DU inhaled to be 100 mg. Inhalation of 1000 mg of any dust causes death by choking; the highest air pollution levels in cities (15 times the alert level) are 1 mg/m3 which would lead to inhalation of about 20 mg per day. I therefore accept the UNEPs 100 mg of DU inhaled.

Health Physics is heavily concerned with determining radiation exposures from inhaled and ingested radionuclides, and for this purpose acquire data to determine their behavior in the human body. This information is continuously collected and evaluated by task groups of the International Commission for Radiological Protection (ICRP), and I will use their numbers [1]. When the very fine particulates of uranium oxide formed from burning DU are inhaled, 25% of the inhaled deposits in the nose and pharynx, 8% deposits in the trachea and bronchi, and 25% deposits in the pulmonary region. From the pulmonary, 40% goes to the G-I tract within about 1 day, another 40% goes to the G-I tract after an average time of 500 days, 5% goes into the blood stream with a 500 day time constant, and the remaining 15% goes into lymph nodes from which 90% eventually gets into the blood stream after about 1000 days. Of the DU deposited in the nose, pharynx, trachea, and bronchi, 99% rapidly goes into the G-I tract and only 1% gets directly into the blood stream. Of the material that goes into the G-I tract, only 0.2% goes through the intestine walls into the blood stream. Putting these numbers together tells us that about 5 mg of DU get into the blood stream. According to ICRP, 2.3% of this, 0.12 mg, deposits in the bone where it stays for an average of 5000 days.

The next step is to calculate the dose to the bone. For beta or gamma rays, the dose in rem is defined as an energy deposit of 0.01 joules/kg, but alpha particles are taken to be 20 times more biologically effective, so 1 rem is 0.0005 j/kg. As the average mass of the bone is 5 kg, the dose in rem is 0.0025 times the energy deposit. Calculating the energy deposit is straightforward physics: from the half life, DU emits 39 alphas/s-mg; the alpha energy is 4.2 MeV; the residence time is 5000 days; multiplying these and conversion factors, MeV to j, days to seconds, we find that the 0.12 mg deposited gives a dose to the bone of 0.6 rem. From measurements on natural uranium, which is found in all our bodies, the dose to the bone marrow is found to be 15% of the dose to the bone, or about 0.1 rem. The lifetime risk of leukemia from exposure to bone marrow is known from the Japanese A-bomb victims to be 10-4/rem, so our final result is that inhalation of 100 mg of DU would give a lifetime leukemia risk of 0.1 x 10-4 = 10-5, of which only about 10% would be expected after such a short time. Since there were far less than one million NATO soldiers stationed in Bosnia and Kosovo, we would expect less than one case of leukemia by now even if all of them were exposed at our maximum credible level of DU.

Health Physicists have procedures for calculating exposures from clouds of dust as the are blown by the wind, from deposition on the ground and later resuspension, for migrating down into the ground, for pick-up by plant roots and accumulation in food, etc but there is not space to describe them here. UNEP has gone through such analyses, and I will quote their results for maximally exposed individuals [2]:

·*Inhalation:* effective dose including all body organs

< 1 rem, which corresponds to a lifetime cancer risk of <0.001.
None except leukemia would be experienced for at least 10 years.

·*Resuspended inhalation* (assuming all time spent in the most contaminated area)

0.1 rem first year, decreasing rapidly thereafter.

·*Ingestion via contaminated food, water, hands in mouth*

<1 rem/y (Note that it would be easy to detect this and avoid further exposure)

·*Picked up pieces of solid DU carried in pocket for several weeks*

·*No skin burns, no important health problems*

All of the above discussion is based on paper studies; I now turn to experimental studies with measurements. UNEP sent teams of investigators to Bosnia and Kosovo in 1999 and again in 2000. They reported no elevated radiation near destroyed military vehicles or along the roads they traveled. In response to publicity about their soldiers who had served in the Balkans suffering from leukemia and other diseases, Italy, Germany, Portugal, and the Czech Republic each sent teams of investigators and each reported in press releases that they had found no increased levels of radiation in areas where their troops had operated. In a Jan. 24, 2001 press conference, NATO stated that more than a dozen nations tested soldiers or sent teams to Bosnia and Kosovo, and none of them found any indication of increased radioactivity. NATO further stated that they had convened a committee of 50 nations and that committee concluded that there was no evidence for DU causing cancer, and that soldiers who had served in Bosnia and Kosovo were no sicker than soldiers who had not served there. Investigators for the German and Portugese governments each concluded that there was no link between DU and diseases reported by soldiers. An investigation by the United Nations in collaboration with World Health Organization concluded that there is no evidence for DU related medical cases in Kosovo, and that there was no excess of leukemia cases in Kosovo hospitals; it also pointed out that there had been no excess of leukemia among those exposed in the Chernobyl accident where tens of thousands of people had been exposed to far more radiation than anyone got from DU in Kosovo.

Two U.S. studies are relevant to this issue. A group of 50 American soldiers who were hit by friendly fire invoving DU in the Gulf War have been followed for the past 10 years by researchers from University of Maryland. They have DU fragments in their bodies that are still dissolving, and they have high DU levels in their urine. They have had no leukemias or other cancers, and aside from hormonal problems that have no disappeared, they have had no unusual health problems. They have fathered 38 children, all without birth defects.

The other U.S. Study involves following 78,000 workers involved in milling and processing uranium since the 1940s; there has been no excess leukemia among them. The World Health Organization stated that these were exposed, on average, to more than twice as much radiation as the most exposed soldiers in the Balkans.

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How to Think About Proliferation and Nuclear Power

William C. Sailor

Scientists should be concerned with the spread of nuclear weapons and should see the role that technology can play in mitigating the threat. Although it is natural for scientists to want to simplify a problem in such a way that makes it appear tangible and solvable, forming a world model that is too simple can lead to inappropriate, wasteful and even counter-productive solutions. Tensions surrounding nuclear weapons over the decades have produced simplistic problem-models, which has given us some simplistic answers. Nuclear proliferation concerns should rightfully place constraints on the growth of nuclear energy, but there are no quick-fixes for the problem of proliferation. Scientists are unfortunately among the worst offenders in seeking the easy answers through a technological fix.

We begin by describing one model of world nuclear proliferation taken to its most naïve and extreme form. The most important driving force for governmental decision-making is preservation of the state's existence. Nuclear weapons enhance a nation's survivability by deterring aggression. Therefore, any nation, especially one that feels militarily threatened, would seek to acquire nuclear weapons. The bottleneck in the process of acquiring nuclear weapons is acquisition of nuclear technology. Promotion of commercial nuclear technology throughout the world provides the missing ingredient for nations to acquire weapons. The speed at which the weaponization process would occur would therefore increase as nations become wealthier and nuclear technology becomes more widespread. Therefore, banning commercial nuclear power (especially in the developing world) is an important part of the solution to the proliferation problem.

During the 1960's, this model led many physicists and others to predict that there would be twenty or more nuclear weapon states by 1980. The failure of this prediction by the early 1980's led some to a reevaluate this model. The main problem with the original modelis that there is no fundamental imperative for nations to produce nuclear weapons. For most nations, nuclear weapons have no clear utility for enhancing security, either as a component in a military strategy or as a political tool. The nations that have pursued nuclear weapons have done so out of their own naive and myopic worldview.

The correlation of the existent commercial nuclear technology with a nuclear weapon decision is only very slight. Nations who would chose to build weapons will find it easier to build a dedicated weapon-manufacturing infrastructure. A nation must first weigh some huge national security costs and risks if it is to pursue nuclear weapons, and it must come to the conclusion that its security, prestige or bargaining position is enhanced by having the weapons. The actual cost of the weapons is small compared to these considerations. Additionally, the fissionable material in a weapon system is only a small part of the cost, if the entire delivery system is included. The decision to "go nuclear" then is unlikely to be influenced by the cost of only the nuclear component of the system. There would be a weak link between commercial nuclear power and weapons proliferation even if the commercial infrastructure were a good springboard to weapons.

Lastly, if a country decides to build weapons, and it has ratified the Non-Proliferation Treaty (NPT) it would be required to either withdraw from the treaty, which requires giving 90 days notice, or covertly break its safeguards commitments.

Strengthen the Non-proliferation Regime

The NPT is at the center of the international regime to prevent the spread of nuclear weapons; it has been ratified by 187 countries. Discussions of proliferation prevention should focus on this regime. The treaty allows there to be a maximum of five nations admitted as nuclear weapon states. These are the US, USSR (now Russia), China, France and the UK. The 182 countries that have ratified the treaty as non-weapon states agree not to develop or otherwise obtain nuclear weapons. Only India, Pakistan and Israel are not NPT signatories and they are all now weapon states, although Israel has not declared itself as one.[1] (Note: that no nation that has ratified the NPT as a non-weapon state has then proceeded to become a weapon state.)

The continued success of the NPT requires that we work towards strengthening the regime, by providing a variety of incentives for countries to stay within the regime. Security guarantees have provided incentives in the past for countries to join and stay within the NPT. How long this can successfully continue is not known, especially if there is a weakening of the US' influence in world affairs someday. Other measures to keep the regime together should be considered.

In the original NPT bargain, countries that committed as non-weapon states would receive, in return, assistance in developing their civil nuclear power programs. This was an incentive for countries not to defect from the non-proliferation regime, and at the time was a strong non-proliferation argument *for* civil nuclear power. It should be remembered that there was much more optimism about the future of commercial nuclear power when the regime was started; the prospects for nuclear energy were seen as almost limitless. While this incentive was unfortunately not strong enough to entice India and Pakistan to join, it did entice North Korea to join in 1985. Currently, the bargain of the NPT for most countries is thought to be in mutual security and cost avoidance, i.e., by renouncing nuclear weapons, the threat of nuclear attack is reduced without the huge cost of acquiring and maintaining an independent deterrent force. The treaty itself has never been amended.

The treaty has been at risk over the last decade from clandestine activity within two signatory states. One (Iraq) was discovered to have operated clandestine nuclear programs in defiance of its NPT obligations. The other country (North Korea) continues to resist the IAEA's efforts to verify its compliance with its safeguard agreement pursuant to the NPT.

In other ways, too, the treaty appears to be at risk. Egypt, a party to the NPT, has stated that it cannot continue to show restraint on nuclear weapons if Israel does not also become a party to the treaty. Egyptian withdrawal from the NPT would be a terrific blow to the treaty and perhaps would stimulate other nations, such as the Arab nations that have only recently adhered to it, to withdraw also. It has been said that the willingness of the US to ignore Israel's proliferation has undermined the norm the NPT strove to achieve.

Some parties to the treaty have complained about the slow rate of progress in nuclear disarmament as required by Article VI of the treaty. Multilateral negotiations among the nuclear weapon states to further reduce nuclear arsenals remain elusive. Despite this, the 1995 NPT extension enabled the five nuclear powers to maintain their positions as holders of nuclear weapons. This extension was adopted under the condition that the nuclear powers carry out nuclear arms reductions in good faith, based on Article VI of the NPT. For that reason, the enforcement of the Comprehensive Test Ban Treaty (CTBT) lays important groundwork for strengthening the NPT. The US Senate should ratify the treaty as soon as possible.

Safeguards

[1] Cuba also has not ratified the treaty but it belongs to the Treaty of Tlatelolco, which defines Latin America as a Nuclear Weapon-Free Zone.

International safeguards are designed to provide credible assurance that States are complying with their NPT commitments and not diverting declared materials to a nuclear weapons program. The International Atomic Energy Association (IAEA) safeguards system makes diversion of materials from declared commercial facilities to weapons purposes extremely difficult.

Because of the problems with Iraq and North Korea, the safeguards system has started to evolve in new directions. There will be a shift in emphasis to a flexible state-level approach with a greater emphasis on transparency, rather than simply inspecting declared facilities. In other words, inspectors will visit sites that are not part of a state's declarations.

Satellite surveillance stands out as an approach that will increase cost-efficiency of safeguard systems. The US government has assisted private companies many times in space ventures and it should be equally generous with the IAEA. The US intelligence community still has access to technology that would enable the IAEA to better do its job and sharing more of this technology would be in the national interest.

Effective international enforcement of non-proliferation will also probably rely heavily on special inspections. For these to be effective, it is essential that the IAEA be able to send inspectors to a suspect site with a minimum delay. This implies, among other things, permanent visas for some IAEA inspectors so that they may enter the territory of the state with no delay. These inspections stress the resources of the IAEA, and the US and other nations should be more generous in supplying adequate funding to the agency. The investment could pay for itself in terms of national security at a far better rate of return than many portions of the US military budget.

Nuclear Power

No country has successfully started a nuclear weapon program beginning with civil nuclear power facilities. On this basis, one may form the simplistic conclusion that there is no link between nuclear power and proliferation. However, several countries (such as India, Pakistan and Israel) have used civil nuclear programs as a cover story to justify establishment of weapon activities or to buy items on the international market.

As the decades have gone by, the Pressurized Water Reactor (PWR) has become the favorite reactor design for most nations. A variant of the PWR is the Boiling Water Reactor (BWR), a somewhat simplified design which uses fewer layers of isolation for the reactor core. These two basic designs, when lumped together, are called LWRs (for Light Water Reactor). Although Russia, England and France each had their own power reactor designs that evolved out of their weapons programs, these designs have each been abandoned in favor of the PWR. The only other reactor that is considered to be current technology is the Canadian heavy-water reactor design called CANDU.

During LWR or CANDU operation, some of the uranium content is converted to plutonium that is wholly contained within the uranium fuel matrix. Some of this plutonium undergoes fission, which helps stretch the fuel utilization. If the fuel is discarded after its useful life is over, no separated fissionable materials are ever produced.

It was once thought that the continued use of nuclear power would require reprocessing, recycle and a buildup of separated plutonium inventories in order to fuel a generation of plutonium breeder reactors. Governments and some businesses invested in the reprocessing infrastructure in anticipation of large demand growth for nuclear power accompanied by rising uranium prices. Because nuclear demand has not grown as anticipated, the original plan of reprocessing can only be called a mistake. Such mistakes are common in economic affairs, but in the European, Japanese and Russian nuclear reprocessing businesses, these ventures have been shielded from market forces by governmental subsidy.

As a result of the mistake, as of 1995, about 185 tonnes of plutonium have been separated for commercial use worldwide, but only about 50 tonnes of this have been recycled. The UK-owned inventory of over 50 tonnes is expected to continue increasing slowly, reaching a level of more than 100 tonnes by 2015. There are no reactors in UK that can burn plutonium. The 175 tonnes of plutonium that are in store for commercial purposes, mostly in France, the UK and Russia are in addition to the worldwide military stocks of comparable size.

Should these stockpiles be of great concern? Most countries that stockpile separated plutonium for commercial purposes are weapon states, and most of these countries are not actively seeking more weapon material. Additionally, if they were, they would not rely on commercial plutonium, which is much less suitable for weapon use because of its higher content of the isotope 240. Japan also stockpiles plutonium under IAEA safeguards but has no weapon program. There is no evidence that Japan has incorporated a nuclear weapon option in the design of its nuclear fuel cycle facilities. It also does not use its commercial plutonium stockpile in the international political realm as a "latent" weapon capability, for instance by threatening to convert to a weapons path. It has also acted as a leader in the community of nations with respect to non-proliferation objectives, for instance by being one of the first countries ratify the Comprehensive Test Ban Treaty (CTBT). It is clear that commercial plutonium stockpiling is not interpreted by Japan as giving it access to nuclear materials for weapon purposes.

There is no immediate reason to be concerned about the existing commercial stockpiles of plutonium, provided that the proper protection measures stay in place. These measures typically involve the "three G's" - guns, guards and gates, connected both in series and in parallel. Of the three G's, the most serious concern is with the guards. A discontented guard force could lead to access of nuclear materials for terrorist organizations or for nations that otherwise could not afford the nuclear infrastructure for weapon material acquisition. Such access has been the concern of international organizations and the US government since the dissolution of the Soviet Union and the economic difficulties that have followed there. The great majority of reported theft incidents have involved materials from weapon facilities, research facilities, or naval fuel facilities and not commercial power facilities, but there are some important lessons for the future of commercial nuclear power from these incidents.

The crisis in nuclear material management in the Former Soviet Union that has resulted from societal and economic disruption is a clear indicator that the world cannot rely solely on institutional measures such as armed-guards to protect fissionable materials. Social disorder tends to arise in every part of the world at one time or another. For example, although Japan and France are two of the most stable countries in the world, some portions of these countries were in utter chaos during this last century. Certain portions of the US were in the state of anarchy during the Civil War, which was less than two centuries ago. It appears (at a glance) that a period of one hundred years without some major economic political or economic disruption is rare for any country.

The commercial fuel cycle certainly should be configured to make theft by terrorists or criminal organizations as difficult as possible. This is independent of any perceived threat of national diversion of fissionable materials to weapons purposes. For this reason alone, discouraging the production of separated weapons-usable fissionable material should be undertaken now on a worldwide basis. These materials should be locked in spent fuel, but there will always be some small risk of theft during transportation or storage of this spent fuel. As an international anti-theft measure, consolidated surface storage of spent fuel at a few internationally sanctioned sites would be better than the present widely dispersed storage at nuclear stations and fuel cycle facilities. It would be better for transparency, accountability, security and control and it should be pursued.

Power Reactor Fuel Cycle Choice

The continued utilization of the LWR without recycle is compatible with a phasing-out of separated weapon-usable materials, and it meets the need for international uniformity in selection of fuel cycle options. For the relative near term (next couple of decades at least) this fuel cycle should be retained for its proliferation resistance and good economics. Further increases in LWR fuel utilization are possible with the so-called Radkowsky fuel cycle (without reprocessing), which employs both uranium and thorium in the fuel.

Some claim that a strategy that relies on the once-through fuel cycle is doomed to produce a uranium shortage in the future and that plutonium recycle is inevitable to avoid escalating fuel costs due to resource depletion. While there is some appeal to the simple logic that all resources are finite and therefore must be conserved, technological changes will occur that in general make the cost of mining and extraction decline. In any case, an upper limit on the cost of uranium would be the cost of extracting it from seawater, which is thought to be ~$100/lb, roughly eight times the current, depressed price. If this nuclear fuel price rise were to happen, the cost of nuclear electricity would increase by no more than 20%. Thus, the economic case for reprocessing, even in this extreme case, would not be compelling.

At some time in the future, if recycling is utilized, fissionable materials must be entrained with intensely radioactive fission products and possibly some neutron-absorbing species. Accumulation of plutonium even under these conditions should be avoided by recycling the plutonium at the same rate it is recovered. From an environmental perspective, these reactors offer the advantage of a greatly reduced need for mining of uranium ore. However, an economically sound start date for this is many decades in the future, if ever. There are also other (potentially less expensive) reactor designs that could be a replacement for the LWR, including the high temperature gas cooled reactor. One proposed design uses a core lifetime equal to the reactor lifetime and so the system can be completely sealed. Nuclear fusion may someday be economical and should not be forgotten.

All these advanced nuclear energy systems will also unfortunately have potential use in the clandestine manufacture of weapon material. This is because nearly all systems envisioned so far either rely on a neutron flux to induce nuclear fission, or produce a neutron flux as a by-product of nuclear fusion. In all cases, safeguards will be required to verify that nuclear weapon materials are not being produced in the flux.

Improvements in safeguards cost-effectiveness and security could be achieved in the future through standardization and integration with nuclear design. Facilities that are non-standard or unique tend to take far more man-hours of inspection time per year per unit of power output than standard designs.

A Nuclear Power Expansion Without Proliferation?

To date, the commercial nuclear industry has played very little, if any, role as a bridge to national entry into the nuclear arms race, nor are there any known cases in which individuals or sub-national groups have stolen materials from nuclear power facilities for use in weapons. However, this does not mean that there is nothing to worry about.

It is important to address the need of developing countries for increased energy supplies. To reduce the reliance of these countries on fossil fuels, it is desirable for the developed world to share nuclear technology with them, under proper safeguards, as stipulated in Article IV of the Non-Proliferation Treaty. Now is the time to cautiously consider the greater use of nuclear energy under the most stringent safeguards standards. Power reactors could be provided (below cost) to recipient nations under a "clean development mechanism" within the UN framework on Climate Change. Other forms of energy production could also be exported under this mechanism, with the choice of technology left to bilateral agreement. However, the recipient would be required to ratify the NPT and accept the most recent IAEA safeguards in order to receive subsidized reactors. A comprehensive set of initial inspections would be required. Fuel cycles which produce weapon-usable material anywhere in process would be disallowed from receiving the financial incentives.

If there is to be growth of nuclear power in the US it could also be focused in ways to prevent nuclear proliferation or theft of nuclear materials in other countries. The US should welcome imports of nuclear power components and systems from manufacturers throughout the world, but constrain the imports so that they originate only in countries that will allow comprehensive IAEA inspections. Peaceful cooperation between nations is a potential benefit that has been recognized since the Atoms for Peace era. These experiences and changes should be integrated into a new program, one that is centered on strengthening the NPT and promoting a comprehensive safeguards regime.

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Nuclear Energy: Will It Save the World?

Bertram Wolfe

Nuclear Energy; The Recent Past:

For the past quarter century there was a surplus of electricity in the US. This occurred because in the late sixties and early seventies electricity use was doubling every ten years. Then in 1973, came the Arab oil boycott that led to an increase in energy costs, and a resulting decrease in energy growth. The orders placed before 1973 resulted in the US electricity surplus.

Before 1973, nuclear energy orders in the US were dramatically growing, with tens of new orders a year. It was projected that nuclear energy would exceed a thousand plants by the end of the century. The environmental movement was favorable to nuclear energy, compared to fossil plants. Indeed, the Sierra Club was a major influence in the acceptance of Pacific Gas & Electric's Diablo Canyon nuclear plant in California.

However, after 1973, the environmental movement became opposed to nuclear energy, as well as to coal, and gas, and oil, and dams, and geothermal plants. Solar and wind power were the only new plants favored. Although solar and wind power cannot meet a major share of energy needs, it didn't matter because of the surplus.

The Present and Future Problems:

Alas, our surplus has now ended, and in California we face uncomfortable energy difficulties that are projected to extend to other parts of the nation. More important is the world growth of energy use, and in the coming decades the projected global warming disasters and the potential international hostilities over limited energy supplies. It may not be remembered that one reason for Japan's entry into WWII was its concern over needed energy.

Fossil fuels, which today provide over 80% of our energy, are heading into a disturbing period. First, the potential disasters from global warming are due primarily to the CO_2 from fossil fuels. In addition, oil and gas supplies are projected to be depleted in this century, and coal in the next. Should we wait until the resulting energy tragedies take place before we try to mitigate them? Why is it that some organizations frighten the public about nuclear energy wastes ten thousand years out, and don't indicate that the real energy problems and potential disasters are approaching in the coming decades.

In the next fifty years the high birthrate in the undeveloped world is expected to cause world population to go from today's six to ten billion people. If, by then, world per person energy use reaches a third of that in the US today, then world energy use will triple. Where will we get the needed energy? If we don't, will there be international fighting over the lack of needed energy? And if the global warming projections are real, how can we prevent them?

Solutions:

Let us hope that an infinite amount of new fossil energy is found, and that global warming is not real. Let us hope that fusion, or cold fusion is developed. Should we count on this? Solar and wind power can help; but the large areas needed and their lack of continuous energy production limit their large-scale economic and environmental viability. There is only one available energy source that can significantly mitigate, or eliminate the potential disasters for our future: Nuclear Energy.

The Start of Peaceful Nuclear Energy:

Peaceful nuclear energy began in this country in 1954 under President Eisenhower who was concerned with the expansion of nuclear weapons development by other nations, "perhaps all nations". Peaceful nuclear power was initiated and agreements were made with other nations that gave them access to our peaceful nuclear technology in return for their agreement to abandon nuclear weapon's development. Despite the recent nuclear bomb tests by India and Pakistan, very few new nations have developed nuclear weapons; and none have been used.

Peaceful nuclear energy began with a key requirement - safety. In the fifties, before computers were generally used, safety requirements were set to assure that even if there were a "double guillotine break" of the main pipes coming from the vessel containing the nuclear reaction, no significant radiation would reach the public. US (and western) reactors were designed with a "containment" building surrounding them so that even with a major accident, the radiation would be contained, and would not reach the public. The only major nuclear power plant accident in the US has been the Three Mile (TMI) core meltdown due to operator misunderstanding of some instrument indications. It may surprise readers to hear this author's conclusion that TMI, in view of the safety backups, could be looked at as a success. A person who stayed at the TMI fence for the entire accident would have received less extra radiation than from taking a two week vacation in Denver, where nature's radiation is higher than at TMI. And guess what? People live longer in high radiation areas like Denver, than they do in low-level areas.

Nuclear Radiation:

The public has not been well educated about nuclear radiation. For example, few know that nature's normal background radiation is over 30 times higher than the radiation at the fence of a nuclear reactor. Radiation studies tend to indicate that exposure to less than 100 times nature's radiation poses no harm to an individual; indeed the low-level radiation seems to add to human health. (Does this address why people seem to live longer in Denver?)

About half our radiation exposure comes from radon, a radioactive gas coming from natural materials in the ground. Prof. Bernard Cohen of the University of Pittsburgh did a US study of the effects of radon, and found that people in areas with the highest radon areas had less cancer than those in the low-level areas.

A recent study by the United Nations Scientific Committee on the Effects of Nuclear Radiation concludes that the number of deaths from the Chernobyl accident was about 50. They did not bring out that there were some tens of thousands of additional deaths in Europe. These deaths were due to abortions by women who were frightened of the effects of radiation moving over Europe from Chernobyl, the radiation in Europe was much less than nature's radiation. Clearly, European deaths were not due to Chernobyl, but to irrational nuclear radiation fears spread to the public? What is our present radiation education in the US?

The point of the above discussion is that no one in the public has been harmed by nuclear energy in the US and the West. (Chernobyl type reactors would not have been allowed here, and Russia is now adopting our safety standards.)

In a similar vein, nuclear wastes, which frighten the public, have harmed no one There are two basic types of nuclear wastes; low-level and high-level wastes. High-level wastes are the used fuel elements that powered the reactor. Low-level wastes are those from irradiated materials in the reactor. In addition, low-level wastes are from some 50,000 yearly medical uses of radiation that save lives, and from industrial uses of radiation that permits production of equipment that would otherwise be difficult or impossible to produce. Consider that your Teflon coated frying pan, to which eggs don't stick, is irradiated so that the Teflon joins to the metallic base of the pan, and stays, even after frying.

Low-level radiation dies away in a few hundred years, whereas the high-level fuel elements maintain their radiation toxicity for thousands of years. Low-level radiation has been disposed of in underground "repositories" and has harmed no one. The government has now required that the low-level repositories be commercially, not federal government, supplied. California's Ward Valley Repository was planned as the first of these commercial repositories. It was studied over several years by a number of state and federal organizations that concluded that it would be safe. Before transferring the federal Ward Valley land to California for the repository, Secretary of the Interior Babbitt insisted that the prestigious National Academy of Sciences (NAS) perform a final study. After some 15 months NAS in 1995 concluded that Ward Valley was safe, and Sec. Babbitt stated that he would shortly transfer the land. Politics entered, and the land has still not been transferred.

Similarly, the high-level (fuel) waste repository at Yucca Mountain in Nevada has been delayed by anti-nuclear activists. After the Congress selected the site in 1987 it took over five years for the state of Nevada to give a permit just for site exploration. Nevada originally favored the site; but the anti's took over and it was only after threats of federal legislation that Nevada agreed to site work. The Department of Energy contractors have just completed an overall review that is positive. Next year the NRC will review the results and hopefully by the end of the decade the site will start receiving and placing the waste fuel underground.

One should understand that for the past four decades used nuclear fuel and lowlevel wastes, have been carefully maintained and have harmed no one. And despitethe arguments against shipping wastes, one should understand that they are shippedso safely that no one has been significantly radiated by shipments in the past decades. Indeed, one might be interested in learning that the spent fuel is shipped in such strong containers that, in a test, a locomotive going 50 MPH hit the container broadside and did not rupture the container.

In summary, nuclear wastes are a problem, but the problem is soluble and 40 years of experience indicates so. One may note that the wastes from a coal plant, which contains radioactive materials, and chemically dangerous materials, is a hundred thousand times larger in volume than the waste from the same size nuclear plant. And, of course a main problem with fossil fuels is the waste emitted to the atmosphere, and the potential dangerous chemicals in the solid waste.

U.S. Nuclear Plants Today:

One may note that the 103 nuclear plants in the US are in the 80 to 90% efficiencyoperating range, and supply about 20% of US electricity. The operating plants havehad, or are having their 40 year licenses extended for another 20 years. They are now the least expensive operating electricity producers.

However, after the Arab oil crisis of 1973, the licensing for a new plant became so burdensome from government (Nuclear Regulatory Commission) bureaucratic requirements, and from anti-nuclear court cases, that it has delayed construction 10 to 20 years and as a result caused billions of dollars of extra costs. On the other hand abroad, with need, and more efficient licensing systems, US manufacturers build US plants economically in 4 years.

The NRC has recognized its inefficient licensing system and has developed a newstandardized licensing system intended to be as efficient as systems abroad. This new system has been put into place and Combustion Engineering, GE, and Westinghousedesigned plants have each received a new standardized license. But the new licensing system has not been demonstrated; and despite its intent, who knows how the courts will handle an anti nuclear suit intended to delay construction? Thus, for a billion dollar construction project, will an organization risk the money before a demonstration takes place? We need a government program to financially protect the builders of the first couple of new plants to demonstrate that the new system works.

With the new higher price of gas and the added costs of coal plants to reduce unhealthy particle emissions and their CO_2, nuclear plants built in four years (as they are abroad) will be the most economic new electricity source, and will protect the environment. If we can soon revive the building of new plants here, we can maintain our world leadership and aid the future welfare of our nation and the world.

Future Benefits, and Problems:

f we revive nuclear energy here, and aid in expanding its use around the world we may save the world from environmental disasters and international hostilities. But as a result we may find a shortage of uranium to fuel our present type reactors. The solution is to develop the fast breeder reactor for future use. By converting unfissionable U238 to fissionable plutonium, the fast reactor can provide 100 times more energy from a pound of uranium than can our present plants, and thus can provide energy to the world for thousands of years. Indeed, with the use of uranium from seawater it could provide world energy indefinitely. Some 15 fast reactors have operated here and around the world, but they haven't been developed as an economic power reactor, although they surely can be. Indeed, in Russia today, we have the BN350 (two reactor) plant that is supplying electricity.

The fast reactor fuel cycle has been studied and can be developed to prevent the diversion of the plutonium to weapons. Further, this type of fuel cycle produces wastes (like the low-level wastes) that decay in a few hundred years, rather than the thousands of years of potentially dangerous radioactivity from spent fuel from our present type reactors. Our present used fuel would be the source of the initial plutonium to fuel the start of the fast reactors, and thus would not be left to decay over thousands of years.

We have learned that it takes a decade, or several, to develop and optimize a new reactor plant, so that new fast reactor development should be starting soon.

Conclusions:

The world is growing, is using up the available fossil fuels that are contaminating the globe. The only available solution is a major worldwide expansion of nuclear power. In this country we should be efficiently building new nuclear plants; and we should be an international leader in providing needed, safe, non-proliferation prone, nuclear power for the world. The future of our nation, and the world may depend on our ability to build plants here as efficiently as we did before the Arab Oil Boycott, and as we have done abroad. In addition, as noted, we should be developing the fast reactor to be economic, and proliferation resistant, and provide the needed energy for the distant future.

The present energy problems in California were projected a few years ago, with no ameliorating actions. Should we wait for future national and world energy disasters before reviving new nuclear energy in the US?

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Public Acceptance of Nuclear Power: Déjà vu All over Again?

Eugene A. Rosa

Introduction

Recent developments make prospects for the renewal of nuclear energy look more promising now than at any point in the past several decades. The growing scientific consensus is that global climate change is an established reality due to human activities (anthropogenic in the language of climate research). This, combined with the accumulating evidence of health effects due to gaseous and particulate emissions from the burning of fossil fuels, appears to make the nuclear option not only the most effective means for addressing the growing worldwide demand for electricity, but also an environmental bonus.

This potential has attracted considerable recent interest. *Nuclear News* devoted its November 2000 issue to the topic, the Electric Power Research Institute heralded "nuclear's new lease on life" [i], a June 2000 workshop on the topic was held at Stanford University [ii] ,and *Science* magazine published a pre-workshop article by the core Stanford group [iii]. The Stanford group performed this optimistic thought experiment: they projected the worldwide generation of nuclear energy to 3300 GW-year/year in 2050 from the 259 GW-year/year in 1997. The projection was based upon the assumption of reaching 50% of France's current per capita production. It amounts to a compounded growth rate of 5% per year, an apparently modest rate of increase. However, it represents more than a tenfold increase over the period, and calls for the building of approximately 60 nuclear power plants *per year*.

The central question is whether such a remarkable rate of growth is feasible—especially in view of the verity that, with the exception of painfully few countries like France, nuclear power is deadlocked everywhere. Not a single nuclear reactor has been ordered in the United States since 1978, Germany is actively considering a phase out of nuclear power, as is Sweden, and Japan is rethinking its grand design for nuclear power because of the September 1999 accident in Tokai, mura, Ibaraki Prefecture.

To properly address the nuclear feasibility question, we must first recognize a distinct asymmetry between two sides of nuclear power: the scientific/technical side and the institutional side (including public acceptance). The first side of nuclear power has enjoyed considerable progress, including the potential of a new generation of safer reactors. This progress, in part, fuels the renewed enthusiasm for nuclear power.

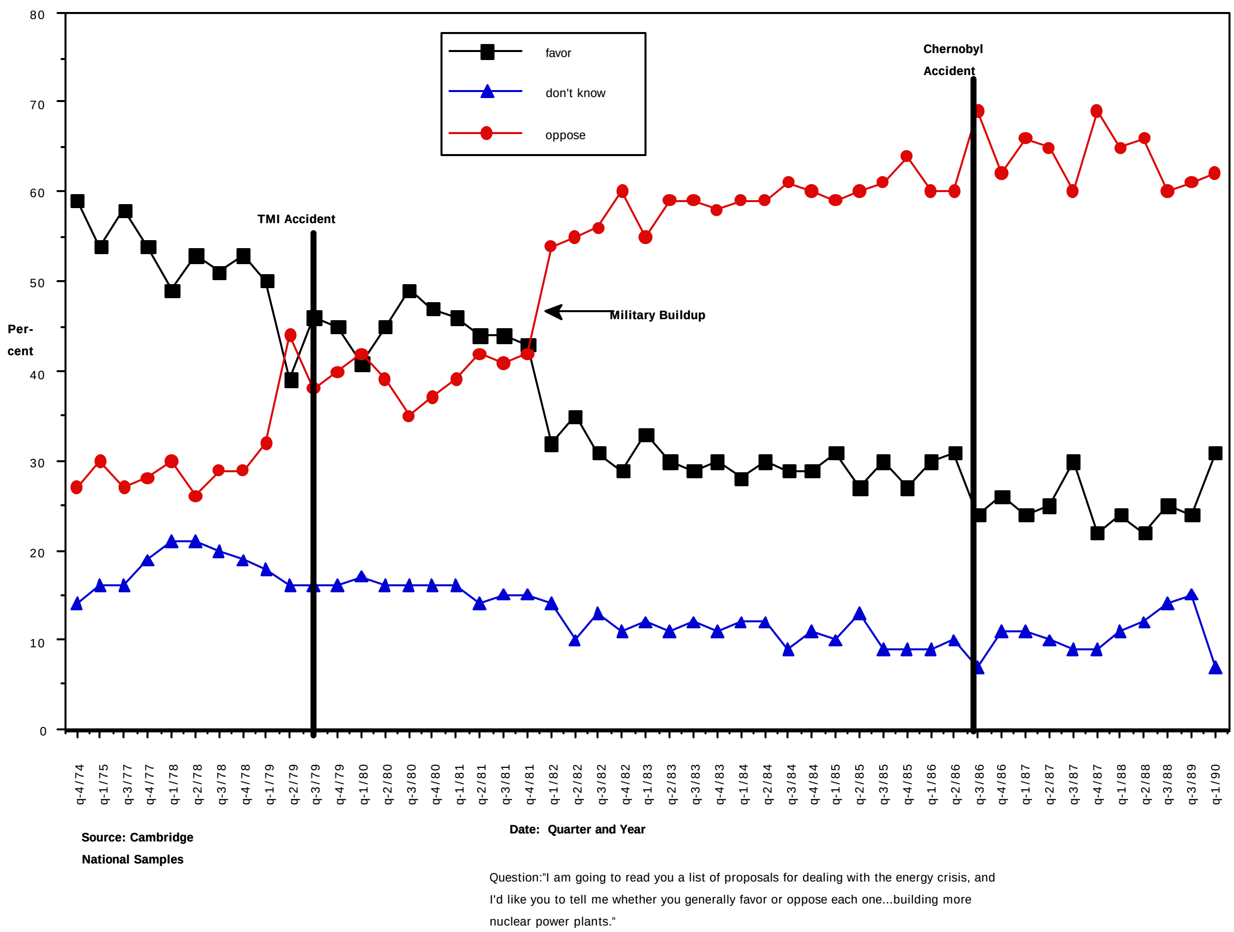
In contrast, the public acceptance side of nuclear power has barely attracted any attention at all. Decades ago, there were clear signs that all was not right with nuclear power. Indeed, at the very height of enthusiasm for nuclear power in this country, a shifting public mood suggested that more sobering times were approaching. For example, even before the last nuclear reactor was ordered in the U.S., Alvin Weinberg, doyen of America's nuclear development, reflected on the changes in nuclear's fortunes: "The public perception and acceptance of nuclear energy appears to be the question we missed rather badly in the very early days. This issue has emerged as the most critical question concerning the future of nuclear energy"[iv].

So, presumably a key lesson learned from early mistakes was that public acceptance was crucial to nuclear success. Was this lesson learned? If it was, it has all but been forgotten by the promoters of nuclear's renewal and, as noted above, this deciding issue has been eclipsed by a focus on the scientific and technical features of nuclear power. I support my argument with selected time-series of public opinion data.

What has been the historical mood of the public on this technology?

To address this question we can examine the longest running time series [v] asking about nuclear power in general.

Figure 1. Public Attitudes Toward Building Nuclear Power Plants in the United States



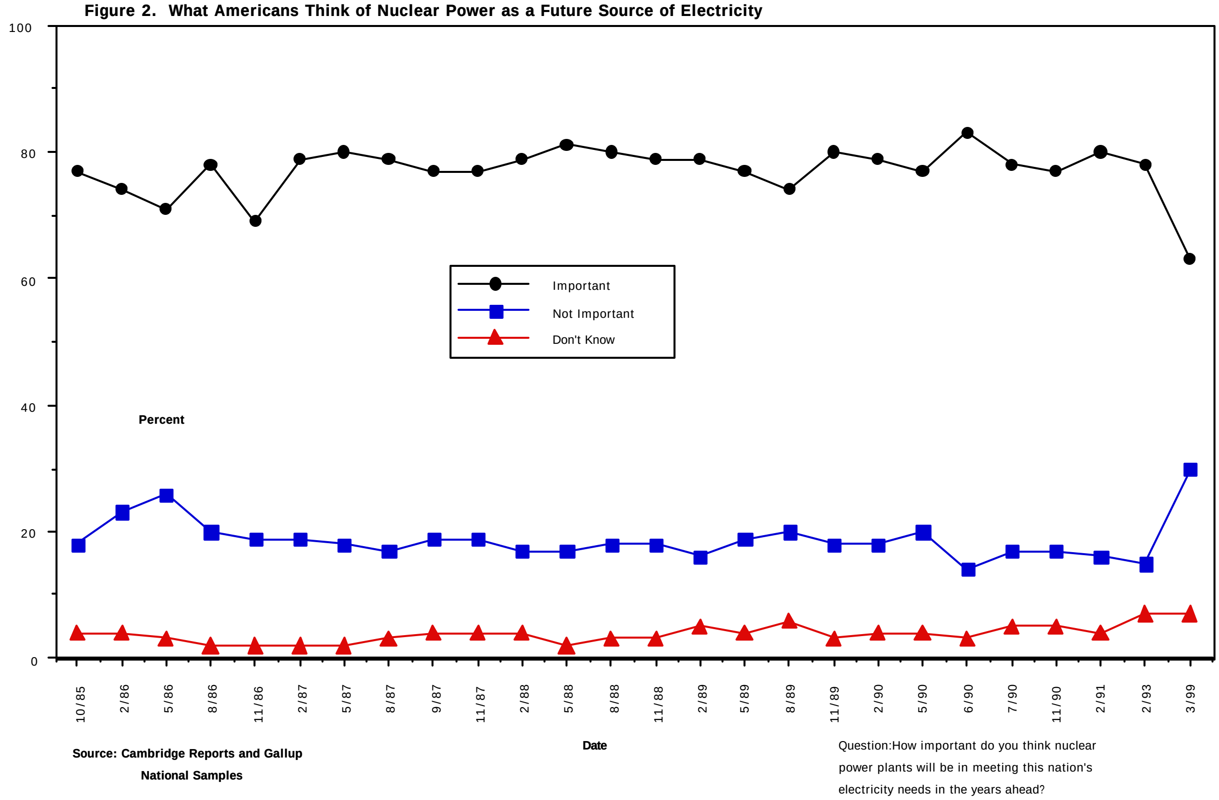
Briefly, a vast majority of the public supported nuclear power prior to the Three Mile Island (TMI) accident, but became ambivalent after the accident. That ambivalence disappeared with the Chernobyl accident that crystallized opposition by a vast majority of the public—a position, according to available empirical evidence, that has remained virtually unchanged since. For example, a March 1999 national poll showed that when asked about building more nuclear power plants in the U.S., 60% opposed, 26% favored, and 14% were undecided.

One important point to note is that the TMI accident had a significant impact in dampening public enthusiasm for nuclear power. And TMI remains deeply embedded in the public conscience as evidenced, for example, by unstructured solicitations about the technology in studies by psychologists. This is at sharp odds with proponents of nuclear power who, like Bertram Wolfe, argue "TMI should be looked at as a success"[vi].

What do Americans think about nuclear power as a future source of electricity?

A comparable time series is available to address this question.

Figure 2. What Americans Think of Nuclear Power as a Future Source of Electricity

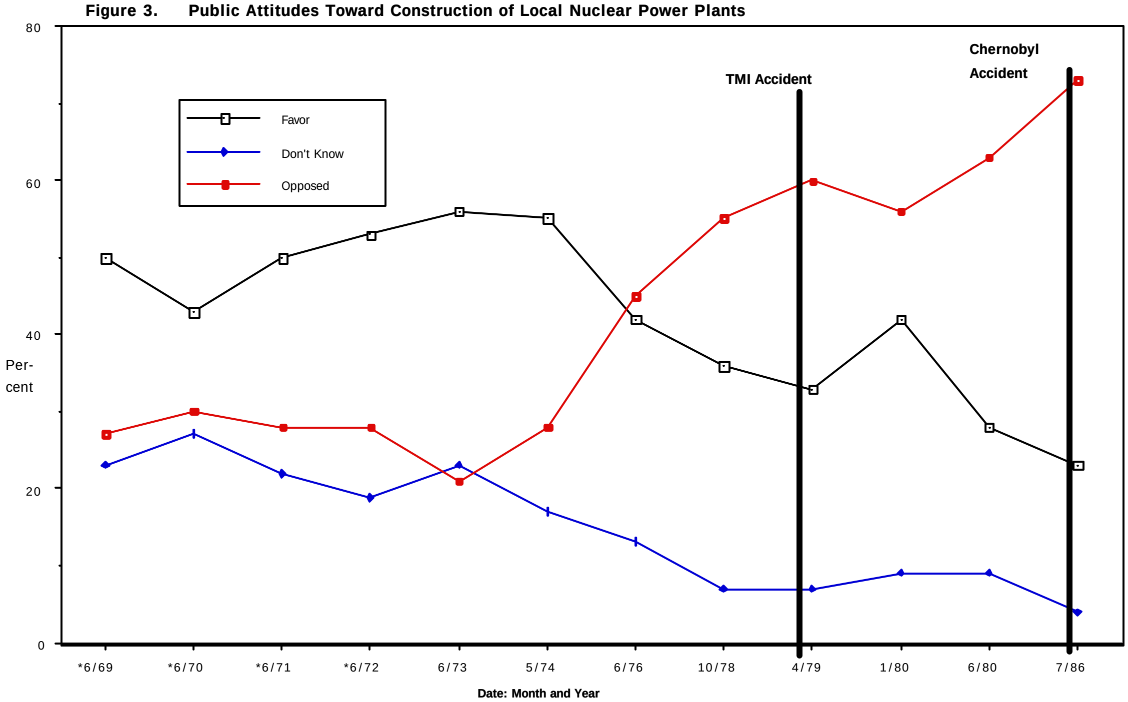


The evident pattern here is that the vast majorities of Americans consistently believe that nuclear power will be a very important source of electricity in the future. Proponents have seized upon this finding as support for the view that it is only a radical fringe of Americans who oppose nuclear power, whereas the overwhelming majority of the citizenry favors the technology. For example, Gene Preston concludes: "One encouraging sign is that public attitudes are shifting. A poll conducted in the United States in February 2000 [no reference provided] shows more than 60 percent support for nuclear power…and in Canada an earlier poll revealed that 77% of respondents thought the use of nuclear energy to generate electricity would increase over the next 50 years…"[vii]

This interpretation of public attitude may be correct, but logical problems face this interpretation. First, the data asking about the building of nuclear power plants now has an anchored time perspective, the present—which is also the time of likely experience for many people. In contrast, the data asking about building plants in the future has no fixed anchor point, since—by definition—the future is just that, an unspecified time later, not now. Second, in virtually every survey where the underpinnings of general attitudes toward nuclear are explored, people continue to express great concerns about the safety of nuclear power and about high-level nuclear wastes. An acceptable solution to the disposal of high-level wastes still eludes the nation.

Third, the "Not in My Backyard" phenomenon is not only pervasive, but also even more pronounced for nuclear facilities. A third time series affirms this conclusion.

Figure 3. Public Attitudes Toward Construction of Local Nuclear Power Plants



*Month survey conducted not reported in original sources. Mid-year dates were assumed.

Source: Variety of surveys summarized in Melber et al. (1977), Rankin et al. (1984), and Nealey (1990).
National Samples

What is evident from these data is that Americans are strongly opposed to the siting of a nuclear power plant in their community. Even more noteworthy is the fact that this majority opposition emerged even before the TMI accident. In view of this pattern, where would 60 nuclear plants (the Stanford group projection) be sited each year?

Might not the American public be more favorably inclined toward nuclear power if they weighed its environmental benefits against its risks? Over a decade ago, when global warming was not the media event it is now, Gallup Surveys asked (in 1990 and 1991) (i) whether respondents believed that using nuclear energy would cut greenhouse gas emissions and air pollution, or (ii) would they favor using nuclear energy if it would cut greenhouse gases and air pollution? Both questions were answered in the affirmative: by majorities to the first question and vast majorities to the second. However, recent poll data indicated a considerable change in public mood. A national sample of Americans was asked in March 1999 whether it would favor nuclear power as a means "for dealing with the pollution that causes climate change." Fourteen percent strongly favored, 28% favored, 23% somewhat opposed, 32% strongly opposed, and 3% did not respond. Given this tradeoff, a majority (55%) versus (42%) still opposes the use of nuclear energy.

Conclusion

How can we interpret these data, especially what seems to be an apparent contradiction in public views (no nuclear now, but we expect it to be important in the future)? I interpret the data to reflect one of the nation's most basic values: pragmatism. Past accidents, misrepresentations by the nuclear industry (safe operations, cheap electricity, wastes pose no insurmountable problems), and a growing mistrust of many institutions, especially institutions associated with nuclear power, such as the DOE, have made the public apprehensive about the technology. And all signs indicate that this apprehension runs deep. On the other hand, Americans support the idea of leaving the nuclear option open, perhaps as a trump card against future energy shortages or as the only demonstrated energy alternative for dealing with global warming. In summary, while the public may support this technology in the future; there is little basis to say that the future is now. Under these circumstances, it seems unwise to exaggerate nuclear's potential in the coming century, especially to the neglect of alternatives for addressing the issues of pollution and global warming.

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COMMENTARY

The Perceived Conflict between Science and Meaning

Recent actions by the Kansas Board of Education (KBOE) have focused attention on the nationwide struggle over the presentation of evolution in biology classrooms (see Melott [1] for an excellent discussion). This attention provides an opportunity to improve our ability to communicate physics to the public, by making us aware of an issue underlying many conflicts between the scientific community and other segments of society.

At the root of many such conflicts is the association often made between science and a view of the world which is devoid of human meaning. Scientific explanations are commonly identified with a description of the world which lacks human meaning or purpose. In contrast, creationists and proponents of various beliefs presented in opposition to science make a very direct appeal to the desire for human meaning. They offer a view of the world in which our actions are significant in a fundamental way, and they present this perspective as being in contrast to the scientific view. This perception is a real barrier to accepting scientific ideas when, as Viktor Frankl expressed it, "Man's search for meaning is the primary motivation in his life..."[2] Most people will give up almost anything else before they will give up a sense that their lives and actions are meaningful.

This communication gap is apparent in the differing focus of editorial letters by the two sides following the KBOE decision. The scientific perspective focuses (understandably) almost entirely on questions of consistency with the overwhelming body of scientific evidence. But on the religious side (or even simply from the perspective of the average non-scientist), the central issue is not consistency with scientific evidence. At issue instead are the implications for human meaning and morality which get automatically and perhaps unconsciously linked with the terms “creation” and “evolution.” From this perspective, the (assumed) moral/spiritual implications of one or the other set of beliefs form the primary focus in the debate. The scientific merits of either belief merely tag along for the ride (just as, for most scientists, consistency with scientific evidence is primary and any possible moral implications are carried along without direct consideration). Editorials from this perspective praise the KBOE decision to remove evolution from the standards with many variations of “we are not an accident,” “humans are not the same as animals,” and “in order to act responsibly, we need a belief system (based on creation, presumably) which holds us responsible for our actions.”If we allow it to remain a battle between “meaning” and “non-meaining” and don’t actively challenge the entrenched identification of science with meaninglessness, many will continue to resist our arguments, no matter how overwhelming the evidence we offer.

An analogy may help illustrate the concrete impact of shifting our approach slightly. Imagine communicating (by radio) with someone lost in the desert, near death from dehydration. She has focused her attention on an oasis in the distance, which we know to be a mirage. We’re trying to convince her that she will find no water by heading to the oasis (mirage). In arguing our case, we’ll have a much better chance if we recognize that the oasis represents a great deal more than just a source of water; it also represents her last hope. While we may be arguing on the basis of the scientific evidence for believing it’s a mirage versus believing it’s an oasis, for her the debate is also a battle between maintaining hope and giving up hope. If she gets the impression that we don’t even care that she is thirsty, if we don’t acknowledge her thirst as a reasonable feeling to experience, then she is very unlikely to listen to us at all. She’ll conclude that we have no understanding of her situation and thus that we have nothing relevant to say to her. On the other hand, if we communicate a clear sympathy for her predicament, pointing out that there’s hope of finding water elsewhere if she doesn’t chase the mirage, we’ll have a much better chance to persuade her. We allow the possibility for her to accept our evidence without also giving up the hope which is crucial to her.

A more general expression of this unease about science is found in thewriting of such popular anti-science proponents as Bryan Appleyard, who points out with some degree of truth that “On the maps provided by science we find everything except ourselves,”[3] that “Science, quietly and inexplicitly, is talking us into abandoning ourselves, our true selves,”[4] and draws the disturbing conclusion, “...we must resist, and the time to do so is now.”[5] By appreciating this perspective many people bring to their interaction with science, we’ll be better able to get them to listen to the evidence we wish to present, not just on the creation/evolution debate, but on a variety of topics such as astrology, UFOs, ESP, etc. Sensitivity in this regard can go a long way toward opening ears which otherwise might remain closed to the words of scientists. If in our zeal for “debunking” incorrect beliefs we give the impression that scientists view the needs behind these beliefs as evidence of a lazy desire to be comforted and consoled, then I fear we will only further alienate those we wish to persuade.

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[1] Melott, Adrian. “What Happened to Science Education: Kansas and Beyond,” Physics and Society, vol. 29, no. 2, April 2000, pp. 6-9.

[2] Frankl, Viktor E. Man’s Search for Meaning. Washington Square Press, New York, 1984, p. 121.

[3] Appleyard, Bryan. Understanding the Present. Doubleday, New York, 1992, p. 14.

[4] Ibid., p. xvi.

[5] Ibid., p. xiv.

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Religious Education Harms Science/Math Education

Since Sputnik, there have been on-and-off periods of intense concern over the fact that our children consistently score low on science and math tests relative to students in other countries; Congress has held hearings, science organizations say we need better curricula, educators say we need more and better paid teachers, etc. etc. My thoughts on this subject were jogged in March 2000 by the announcement that Freeman Dyson had been awarded the Templeton "science and religion" Prize; a prize that, in my estimation, is awarded to agnostics who seem to be sort of ambivalent or, perhaps, confused. Specifically, this has led me to the following line of questioning and reasoning: Where are the child-development psychologists hiding when a discussion centers around possible reasons for our children's generally poor test results in mathematics and physics? I'm sure that they know that if a child, soon after birth, is told that there are absolute truths that cannot be questioned, and this is impressed on him or her day-after-day and especially on Sundays by someone whom he or she has been taught to revere, then, after years of such tutelage, it will be almost impossible for that child to develop into a curious, no-holds-barred questioning student and adult; in short, the primary characteristics necessary for the understanding and appreciation of science will have been sabotaged and forever stifled by dogmatism. I suggest that there should be broad in-depth discussion along these lines. Such might lead to a better understanding of the problem, and thereby point to a reasoned and reasonable solution.

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FICTION

Our publication of "physics fiction" in the October, 2000 issue of this journal brought only one negative comment and a number of positive ones. Thus we try another, this from one of my undergraduate students in an intodoctory course for non-science students on twentieth-century physics ("Physics for Poets"). Again, comments are welcome.

Boxed In

Kelly Bennett

Erwin had found the key to immortality. Waves. Possibility waves would give him eternal life. And to think that all it took was an introductory course in quantum physics to reveal it to him. All his life he had described things differently. When he was a child, his mother had gotten him glasses because he said "fuzzy" whenever she asked him what things looked like. Now he knew, he was just seeing things quantumly. With his new understanding, he began to see more clearly. To be exact, he saw the waves collapsing all around him. All the possibilities of events coalesced into one definite actuality. The collapses flashed all around him, frightening him more every moment.

His drive home from school was agonizing. The flashes of definiteness blinded him. Flying up his driveway, he nearly hit his garage door as it was opening to let him in. He threw it in park and shut off the key. Erwin struggled with the strangling seat belt and the heavy car door before freeing himself to run for his house.

Jamming the key into the lock and turning it furiously, Erwin burst into the house. He slammed the door shut behind him and leaned against it for a moment while he panted. With his eyes shut, he couldn't see the actualities pop into existence. After a moment of dark peace, he opened his eyes slowly. The waves were back, they were more full here in his small home. He turned around to look at the door. Right at the window, he saw his possibilities shrink into points of concreteness. He jumped back in horror. *Gotta free the waves.* Locking the door and then bounding down the stairs, Erwin began.

He ran to the corner of the dank basement where he had put everything he needed to start. Boards, nails, a hammer, glue, and tape were stacked haphazardly on an old weight bench. He grabbed some boards under one thin arm and the hammer, nails and glue with the other. Slowed down by the extra weight but not any less adamant, Erwin trudged up the stairs to the landing where the offending window was. He stared at it in horror, afraid to touch it. He shook his head to clear the fear and picked up the boards. He nailed them over the small window in the door, effectively covering the portal to the outside. Breathing heavy, he watched with satisfaction and relief as the waves passed through the wood and kept undulating through space far into the house. *I knew it would work.*

Erwin walked into his living room only to stumble backwards out of it. There were three windows in this all too bright room. There was hardly a wave present in there. He flew up and down the stairs five times to bring all of his materials onto the safe landing. With planks and hammer, Erwin bravely walked into the living room. He nailed the wood over the bay window he had paid so much for two years ago and the two small windows on the wall next to it. There were cracks of light between the boards, so he ran beads of glue all along them until they were sealed. Satisfaction flowed through him as the imprisoned waves flowed out into his living room, filling it with possibility.

Erwin sat down on the couch in his pulsing room and sighed. He watched possibility live all around him. Everything was attainable here, nothing could decide the reality that would exist. He looked all around him and realized that he was sitting on a couch of actuality. It barely pulsed. All of the furniture seemed solid. He hoisted himself off the couch and cowered against the wall. Then reason took over and he began tugging on the arm of the couch, pulling it toward the stairs. He pushed it through the kitchen, scratching the cabinets and tearing upholstery off of the couch. Panting and sweating, Erwin finally managed to kick the couch down the stairs. The rest of the living room furniture soon followed. Exhausted, he looked down the stairs and saw no pulsing waves, only solid darkness. A shiver passed through him and he pulled the sliding door to seal the basement off.

Back in his empty living room, Erwin sat on the carpet and basked in floor to ceiling waves. He felt more alive than ever. All the possibilities still existed, he couldn't die if they all remained. He laid back on the floor and looked around, thinking of what to do for the rest of eternity. The television caught his eye. *I wonder what's on.* Erwin got up to turn it on but thought better of it. It wasn't completely solid, but if it were turned on, it could be disaster. News from the outside would seep into his protected home. He paused there a moment and then wrapped his arms around the set and walked away from where it had been sitting. The cord was still plugged in. Erwin kept walking until the cord flew out of the socket, trailing him like a tail. He opened the basement door awkwardly with one hand and let the TV tumble down the steps. Standing there smiling and trying to catch his breath, Erwin thought of the other things that might endanger his immortality. *The radio!* Music and talk radio would have the same devastating result as the television. He gathered all the radios from the house and threw them like Frisbees into the void.

Weary but pleased, he sat back down on the floor of his empty room. He watched the dazzling waves spell eternity for him. It was hard work but if he could live forever, it would be worth it. A content smile had just appeared on his lips when the unthinkable happened; the phone rang. Erwin's heart nearly stopped. He gasped aloud. Paralyzed, he stared in the direction of the phone, seconds erasing the oscillating pattern. Then he snapped out of his inaction from more intense fear. *The answering machine!* If the answering machine picked up, he would hear who was on the other end; destroying millions of possibilities. He ran to the kitchen where the phone sat on the countertop and yanked on the cord attaching it to the wall. It popped free of the socket. His breathing heavy, Erwin stared at the white princess phone that had almost ruined everything and then chucked it and the answering machine into the basement.

It had been a close call with the phone, but all seemed safe again. Erwin silently wondered what time it was, and was immediately shocked. Time was an outside force, too. He whipped his watch off his wrist and gave it to the greedy cellar. Thinking about the watch, he winced. It had been a gift from his brother for going back to school.

He was finding it increasingly difficult to relax, even with his new life. He was antsy and nervous. *Maybe I just need to eat something.* He glided over to the fridge and opened it. Solid food stood there in the fridge, taunting him. Bologna and cheese stood there, only bought yesterday, in preparation for this day. Milk and orange juice were throbbing a bit, but not enough to justify keeping them. Angry for the first time today, he slammed the door shut and laid his head against the cold front. Fighting to rationalize it, he thought *I will be immortal even if I don't eat, if I do everything right.* Not trusting himself, Erwin grabbed the tape and wrapped it around the fridge until the roll ran out.

He stood and looked at his life giving waves and cheered up a little. He sat on the counter, zoned out and tired. He ran his hands over his face and realized he needed a shave. *How long has it been?* Licking his lips, he found them cracked and split. *A glass of water shouldn't hurt me.* He turned on the tap and recoiled when the liquid seemed more solid than the food in the fridge had. He pushed the handle down hard.

The sink has to go. With fear and adrenaline running high, Erwin began pulling the cabinetry from around the sink with the claw hammer. He smashed and clawed at it until only the stainless steel sink was left bare. He wrapped his arms around the sink and pulled until the joints on the pipes snapped. He fell to the floor with the sink on his chest. Then he heard it. The water gushing from the broken pipes. A puddle was headed toward him. He crawled backwards with the sink still on him and aimed for the stairs. The puddle expanded like molten lava, a solid flow of actuality. He threw the sink down the steps ahead of him and then ran down them to find the water main. When he turned on the light, he saw the solid, real basement in full color. Closing his eyes, he climbed over his broken belongings to the pipes at the end of the basement. He tripped and stumbled over his couch and television, but finally reached his destination. Opening his eyes a crack, Erwin saw the shut off valve and began turning it. His hands red from effort, he stopped when it refused to budge any more.

He once more navigated the furniture graveyard blindly and made it up the stairs to see that the pipes weren't gushing water anymore. The puddle of water throbbed a little, but he just stepped over it and made his way back into the safety of his living room. He panted as he lay on the carpet with his eyes closed. *Now I'm safe.* He slept and dreamt.

All around him waves flowed. Water waves, music, and light. Erwin swam in them and exulted in their beauty. Coming up from the wavy water, he saw a dark mass on the horizon.

Erwin woke with a start as his cat walked on his chest. She was solid and heavy on him. The poor cat had no idea of her master's plans. He picked her up from off his chest, touching her as little as possible and brought her to the stairs. *Why couldn't she be outside?* He looked at her green eyes and quivering whiskers, and then closed his eyes. Without looking, Erwin pitched his cat down the stairs and shut the door. Tears stung his eyes as he shuffled back to his spot in the living room. They fell freely when he sat down. *I'm sorry Boots.* Now he really was alone. It couldn't be helped though. She would understand; she would have done it, too.

Tears dried on his face, Erwin thought that he had finally done it. Finally eliminated all wave collapses from around him. It would be worth it, to live forever. There couldn't be anything else here that could collapse his immortality. As he thought this, he saw several gaps in the pulsing waves. The heat vents were exposing him to the outside. Electrical outlets peered at him like unblinking eyes. He jumped to retrieve the tape. There on the floor near the refrigerator lay the empty cardboard roll.

The glue caught his eye. The bottle was half full; enough to do the outlets in the house. Erwin went through the house squirting Elmer's glue into electrical sockets. As the glue filled the evil eyes, the waves increased. The living room was filled with a fog of them. Erwin could hardly move through them.

The heat vents were next. Erwin took what planks he had left and nailed them over the vents. As he was doing this he could feel the heat come out; he worked more desperately to keep it from leaking in. Finished, he took his place on the floor once more. He looked at the mist surrounding him and smiled. Perhaps it was because he was tired or that he really had achieved it, but he felt peace. *Now I can enjoy my immortality*. He let thoughts drift and dwell in his mind. He contemplated the meaning of all this science that had allowed him to achieve what everyone sought. Religion gave people hope for the afterlife, but quantum physics had given Erwin what all religions could only guess about and hope for. *What an achievement…that I can share with no one.* After his thoughts had carried him for a while, a new frightening one came into his malnourished mind. *What if my thoughts collapse the waves?* With horror, he looked around his ravaged and empty house and thought about the implications of his realization. He couldn't destroy his mind that way. Frustration made him beat the floor around him with his fists. The mist was thick around him and his fists so loud that he didn't hear the banging on the door.

When the sound did finally reach his ear, he couldn't be sure of how to act. If he drew attention to himself, then whoever was on the other side of the door would know he was inside. This experiment was still too precious to obliterate by getting up to see who was banging on his door. He decided to wait it out on the floor. Each pound on the door seemed to cause his beloved waves to fuse into sizeless points. Fear quickened his heart and breath. Now the person was calling inside.

"Erwin! Are you in there?" the voice yelled. It was filled with panic. Erwin put his shaky fingers in his ears. The voice pushed through in muffled tones.

"Erwin!"

He saw the door shaking in its frame, ready to fly open at any second. Erwin could not close his eyes. Something inside him was keeping them open, to see, to observe.

A new noise pervaded the house. The clicking of metal on metal. The lock was being picked. *Soon it will all be over. Soon the door will open, destroying them all.* A louder click resounded even through Erwin's sweating fingers. His eyes opened wide with horror.

The door swung open wildly. The fog of waves was reduced to a shower of sparkling points. The wind of reality swept over Erwin, stealing his breath. He slumped over just as his mother's eyes passed over his body, realizing it was dead. She stood in shock, taking in the frantic destruction of her son's home. Behind her, a police officer stood with his gun in hand. Out of the corner of her eye, Erwin's mother saw something move. She turned toward it, and saw Boots walk out the gaping front door and meow.

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FORUM AFFAIRS

The Story Behind the Annual FPS Membership Statistics

Every year in late January, the American Physical Society (APS) holds its Units Convocation at the Physics Ellipse. This is an opportunity to meet and learn from dedicated people during Units' "show and tell" and a live exercise in the "the Unity of Physics". The Units' leadership (typically the Chair and Vice-Chair) is invited to attend this informational get-together. Last year, Peter Zimmerman and I attended, while this year, Laurie Fathe, the incoming Vice-Chair and myself (as outgoing Chair) represented the Forum on Physics and Society (FPS). This is a brief overview of newsworthy items from the recent Convocation, with a special focus on FPS membership statistics and trends.

This year for the first time, Congressional visits were organized preceding the Convocation. The effort was well planned and scheduled in advance with the assistance of Christina Hood, a Public Affairs Fellow working with Mike Lubell. Both Laurie and I participated in this very educational and useful activity, after being briefed on the APS messages concerning timely legislation and initiatives on Science Education and federal R&D funding issues and given useful handouts for our Congressional offices. Each of us was teamed with another APS Unit official from a nearby state, and met with key legislative staff from our Senators' and representatives' offices. In the afternoon, Mike Lubell discussed the APS agenda to effectively enhance "the national appreciation of the importance of Physics" and with first hand impressions and recommendations from those who lobbied Congressional offices.

There were also opportunities for breakouts led by APS staff on information services, improving unit meetings, increasing unit membership and streamlining financial reporting. The informal lunch allowed unit leaders to exchange views based on their experience and to discuss jointly sponsored activities. The Convocation ended with a presentation on APS education programs and partnerships (see **Error! Bookmark not defined.**).

This year's theme was the need to improve K-12 science education and to increase non-health R&D funding share. A formal agenda was distributed, including a Welcome from the APS President, George Trilling; a report from Judy Franz, APS Executive Officer on the Society structure and activities, as well as formal presentations from the APS Treasurer, Editor in Chief and other APS officers. Martin Blume, Editor in Chief, made a good presentation on APS electronic publishing of traditional and new virtual journals, and of international links maintained. I pointed out to him that it would be desirable to acknowledge the Units newsletters as APS Publications and link them to the APS publications website, so that our international readers can easily access their unit's latest issues and to facilitate browsing. (Activation of a hotlink is now in process).

All units were asked to report on their respective education and outreach activities and program. Several offer student stipends for attending meetings and for presenting papers, an example we might try to emulate if our finances improve. FPS outreach and education efforts do not traditionally go beyond organizing invited and co-sponsored sessions, but we do put on informative and balanced sessions on interesting and timely topics, and have now a much improved and more transparent website. The most vigorous effort to attract and expand student membership was shown by State and Regional Sections. This is an example worthy of our consideration, as suggested below.

The most useful resource distributed is a “Guide for Unit Officers”, which contains basic information about the APS membership, number and make-up of units, APS publications, attendance and program of annual meetings and other outreach activities. Official APS 5- year membership statistics were handed out, which highlight the increasing diversification and fragmentation of the physics community, instead of the desired "Unity of Physics". There are now 41,570 APS members, down from 42,662 in FY00, distributed amongst 14 Divisions, 8 Topical Groups, 5 Forums and 8 Sections, all drawing formula funding shares in spite of considerable overlap (chiefly between Topical Groups and larger Divisions). Some Divisions (e.g. Laser Science) and all Sections hold their own meetings and administer separate budgets and membership programs.

The FPS current FY01 membership is 4,496, down from last year's 4,596, vs. 4,749 in FY97-our highest year both by number and in fractional representation. Our fractional membership share is now 10.82%, down form a high of 11.91% in FY97- when we were the second largest after the Division of Condensed Matter Physics! Compare this with the FIAP membership in FY01, the largest Forum (5,806 representing 12.73% of APS) and consider the budgetary implications. This downward trend in membership is worrisome, and comes in spite of our campaign to increase membership by distributing "Join the FPS" flyers before each FPS session and posting them on tables at last year’s March and April meetings last year and by upgrading our website to become better integrated within the APS and more transparent and accessible as well. Our FPS membership roster on Jan 18, 2001 counted 4,235 members with e-mail out of 4,532 members listed, i.e. 94% reachable by e-mail membership messages (presumably having also web access).

What could the FPS Executive Committee do to increase membership? Obviously, we need to enhance our visibility through more and better sponsored and co-sponsored sessions at the two annual meetings in March and April. But I believe that each of us must become actively involved in regional and State Section meetings and bring our flyers (posted on our website) along, speak to students to raise their social awareness and to attract their interest. For years, I have seen the same set of aging activists at FPS sessions leading me to think that we are preaching to the converted. Perhaps organize a competition and post rewards (award a new FPS prize?) for student papers describing their grassroots involvement in physics and society activities and showcase such student efforts in FPS topical sessions at Section meetings.

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Results of the 2001 Forum Election:

Vice-chair: Andy Sessler
Treasurer: Andrew Post-Zwicker
Ex-com: Sherri Stephan and Brendan Plapp

There were over 700 votes cast. Fortunately, none of the elections was Floridian--the closest was 60 votes.

The bylaws amendments were approved.

LETTERS

More on Heinz Barschall

My article “The APS in an Age of Litigation” [Physics and Society 30, 1 (January 2001) , 3 - 5] includes an account of the lawsuits by the Gordon & Breach publishing group against the late H.H. (Heinz) Barschall, the American Physical Society, and the American Institute of Physics. The origin and object of these suits were two articles by Barschall on the cost-effectiveness of physics journals. Readers may be interested in learning more about the life and times of Heinz Barschall, whose many contributions to physics and its community include service as Secretary - Treasurer of the Forum on Physics and Society. They can find this information in an autobiographical memoir that appeared in the journal Physics in Perspective [H. H. Barschall, Reminiscences, Phys. perspect. 1 (1999,) 390 - 444). Requests for reprints should be addressed to Anne E. Barschall, 80 Benedict Avenue, Tarrytown, NY 10591; e-mail<ANNE.BARSCHALL@WORLDNET.ATT.NET>.

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Pro Fiction in P&S

I read with interest Carl Iddings complaint against the use of fiction in FPS. In fact, physicists have long used fiction to convey their message to both colleagues and the commoners, notably Leo Szilard in THE DAY OF THE DOLPHIN. Science has its own genre, and science fiction has often led physics, as when Szilard was inspired by H.G. Wells' prediction of nuclear weapons (from 1913). Physics is about the possible, not merely the actual.

But as a professional writer, if physicists wish to hobble their own free discussions by omitting other methods of discourse, I certainly won't complain. People should pay for fiction, as God intended.

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More Kudos

-- the electronic Forum newsletter is great. Fun to read. Lots of substance. I like the fiction! I loved the discussion of Copenhagen. Keep it up!

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A Flawed Picture of Nuclear Workers

The review of *The Woman Who Knew Too Much: Alice Stewart (1906 -) and the Secrets of Radiation* gives a seriously flawed picture, especially as it pertains to Dr. Stewart’s studies of Hanford workers. The review’s brief description of these studies suggests two key points:

1. On joining the Hanford study, Stewart observed high cancer rates among the workers: “…she could see workers…dying of radiation-induced cancers. Safety standards were low, high exposures were concealed…”
2. Stewart’s position was eventually vindicated: “Gradually, her conclusions were confirmed by other scientists.”

Neither of these points is valid.

First, the cancer rate was not high. It was significantly *lower* for Hanford workers than for the general population, matched for age and gender, as found through calculations of standard mortality ratios (SMR) for white male workers — the bulk of the exposed Hanford population.[2] The SMRs were 75% for all causes of death and 85% for cancer fatalities (for deaths before April 1, 1974 among workers employed for at least two years). In particular, there had been 414 cancer

[2] Ethel S. Gilbert and Sidney Marks, “An Analysis of the Mortality of Workers in a Nuclear Facility,” *Radiation Research* 79, 122-148 (1979).

deaths compared to an expected 488 deaths. The favorable record of Hanford workers was explained as being due to the "healthy worker effect."

Dr. Stewart and colleagues accepted the existence of the healthy worker effect, attributing it in part to "selective recruitment" and to the fact that "the proportion of really dangerous work performed by men with professional and technical qualifications was exceptionally high."[3] However, they concluded from comparisons of different groups of Hanford workers that there were excess radiation-induced cancers. This conclusion was highly controversial from the first, and the controversy has continued for close to two decades of additional analyses. During this period, Dr. Stewart's position has not won broad support.

It is indicative of the lack of general mainstream acceptance of Stewart's Hanford work that the latest comprehensive United Nations report on radiation effects (UNSCEAR 2000) does not even cite her publications in its section on occupational exposures of workers at nuclear facilities.[4] It only cites a paper by Stewart's chief scientific adversary, Ethel Gilbert, and a 17-author study coordinated by the International Agency for Research on Cancer in which Gilbert participated.[5] For Hanford workers, the study reports a non-significant *negative* correlation between radiation exposure and cancer incidence. This result does not imply that the radiation exposures were beneficial, because the 90% confidence limits also included zero and positive correlations.

It is not the purpose of this letter to criticize Dr. Stewart. But it is important to clarify the record to the extent that it bears upon Hanford and, by unwarranted extension, upon other U.S. nuclear activities. There is an exaggerated popular image of negligence, danger, and damage. A misrepresentation of the health record of the Hanford workers can act to strengthen this image and indirectly contribute to unwarranted fears of all things "nuclear."

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Anti-Fireplace Hoax

Heads of state visiting the white House often pose in front of one of its 27 fireplaces, but rarely benefit from the warmth of a fire. Americans spend a third of a trillion dollars on fifty million fireplaces, but rarely feel any warmth from them. Why this cold-hearth diplomacy and cold-house policy? Or, worse still, why do so many gas-fired hearths now flare Greenhouse Gases? A host of Americans believe that a wood-burning fireplace is energy counterproductive.

Burning one pound of wood yields 8,500 BTU, and draws 6 pounds of air. For air to be so cold as to offset this benefit, its temperature would be far below minus 100^o F. The fireplace has been a haven of warmth, not a cave of frosty winds for seventy thousand generations. It is used today in coldest Siberia. Why this sudden Change of Hearth?

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[3] G.W. Kneale, T.F. Mancuso, and A.M. Stewart, "Job Related Mortality Risks of Hanford Workers and their Relation to Cancer Effects of Measured Doses of External Radiation," paper IAEA-SM-266/58 at *International Symposium on the Biological Effects of Low-Level Radiation with Special Regard to Stochastic and Non-Stochastic Effects*, Venice, 1983 (sponsored by the International Atomic Energy Agency).

[4] *Sources and Effects of Ionizing Radiation*, United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR 2000 Report to the General Assembly, Volume II (United Nations, New York, 2000), pp. 117-118.

[5] E. Cardis *et al.*, ""Effects of Low Doses and Low Dose Rates of External Ionizing Radiation: Cancer Mortality among Nuclear Industry Workers in Three Countries," *Radiation Research* **142**, 117-132 (1995).

Is it a result of anti-fireplace and anti-physicist propaganda? If so, this is a good time to put it behind us. As the price of fossil fuels soars and their Greenhouse Gases poison our atmosphere, wood, which soaks up Greenhouse Gases and beautifies as it grows in your backyard, will be forever the great good friend that it has been for more than one million years. And today, with the benefit of modern physics principles, it will be a better friend than ever. Let us put a costly, shameful hoax behind us and START THE FIRE.

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NEWS

New Kansas Board Reinstates Evolution

In an expected move, the new Kansas State Board of Education voted 7-3 to adopt science education standards that include the teaching of biological evolution. The new standards also require study of cosmology including the big bang theory, and the evolution of the earth and its geology. In August 1999 the previous Board had dropped the teaching of those subjects as speculative. Several members of that Board were subsequently defeated in primary elections (reported in Physics and Society,http://www.aps.org/units/fps/oct00.html). More information and a link to the new standards can be found at http://www.aip.org/enews/fyi/2001/016.html.

Breaking News in Planetary History???

In news emerging at the time this issue of Physics and Society is being put together: Geochemists have reported the detection of noble gases-with isotopic composition suggesting a meteoritic, rather than terrestrial, provenance-trapped within fullerines found at the Permian-Triassic boundary, at several geographically dispersed sites.
(See http://www.sciencemag.org/cgi/content/summary/291/5508/1469 for a summary
and http://www.sciencemag.org/cgi/content/abstract/291/5508/1530for abstract).
The P-T extinction, 251 million years ago, was the most extensive mass extinction in earth's history and laid the groundwork for the emergence of the dinosaurs.

Separately, in reports published in the Proceedings of the National Academy of Sciences (http://www.pnas.org/cgi/content/abstract/98/5/2164
and http://www.pnas.org/cgi/content/abstract/98/5/2176),
two teams reported that chains of magnetite crystals, strikingly like those formed by terrestrial magnetotactic bacteria (in composition, structure, and the formation into chains) have been identified in a Martian-origin meteorite, Allen Hills 84001. The researchers strongly suggest a Martian biological origin, approximately 3.9 billion years ago.
Others are considerably more skeptical
(http://www.sciencemag.org/cgi/content/summary/291/5510/1875a).
Stay tuned….

New Climate Change Reports: Planetary History in the Making?

The United Nations Intergovernmental Panel on Climate Change (IPCC) released reports which predict significant consequences of global warming-a warming that the reports now principally attribute to human activity. In Shanghai on 20 January, the IPCC Working Group I approved "Climate Change 2001: The Scientific Basis" which ascribes most of the warming of the last 50 years to greenhouse gas concentrations
(see http://www.sciencemag.org/cgi/content/summary/291/5504/566a
or http://sciencenow.sciencemag.org/cgi/content/full/2001/122/1).
In Geneva on16 February, the IPCC Working Group II approved "Climate Change 2001: Impacts, Adaptation and Vulnerability" suggesting that the effects could include a wide range of ecological dislocations, and significant economic and health-related challenges to the human population. The global temperature rise by 2100 could be even larger than previously predicted (in part, because of a wider range of future pollution scenarios considered). Both uncertainty regarding future socioeconomic and technology paths, as well as remaining uncertainty in climate models, are noted. Information on these reports is accessible through http://www.ipcc.ch/. Recent news reports quote new EPA head Whitman as saying "There's no question but that global warming is a real phenomenon." Subsequently the administration declined to cap CO_2 emissions as a pollutant.

In Other News:

Sequences and analyses of the human genome were published by two teams.... both domestic and international discussions of missile defense broaden, as the Bush administration engages the topic.....the new administration begins to review defense strategy ....US energy proposals are starting to be put on the table, spotlighted if not spurred by the crises in California.....education will clearly be a major topic for both the administration and Congress....University of California President suggests reducing the role of the SAT-I in admissions

REVIEWS

The APS's DEW Study: Genesis, Influence on SDI, and Lessons for Renewed APS Involvement During the George W. Bush Administration

By Bernd W. Kubbig. Peace Research Institute Frankfurt, 2001, 58 pages, DM 10 (about $5) from info@hsfk.de. Also available via .PDF file at www.prif.org or www.hsfk.de.

The US is again engaged in a political war over national missile defense (NMD), and the American Physical Society (APS) seems about to become an active participant. . The APS has appointed, in Fall, 2000, a panel to determine whether it should carry out a scientific study on technical aspects of the NMD system. It seems wise to reexamine the previous involvement of the APS in these wars - its production of a report on Directed Energy Weapons (DEW) in response to President Reagan's Strategic Defense Initiative (SDI, also commonly known as "Star Wars"). That at least is the premise of this report, published, in English, by a German Peace Research Institute. Using interviews with the major participants and a thorough review of the written record, the German report seeks to establish lessons, from the previous study, initiated by the APS Council in June 1983, ending up in the DEW report published in Reviews of Modern Physics in April 1987, which may be applicable to future studies by the APS and comparable scientific societies.

Among the issues raised, and successfully answered in my opinion, are: should the study be exclusively scientific rather than include political and strategic issues? should it concentrate on only one proposed technological model (e.g., the previous study examined DEW only, omitting kinetic energy weapons; should the new study look beyond the Clinton-era mid-course-interception model?)? should the study participants be selected only from individuals active in the field who have appropriate security clearance, thus allowing a cooperative study with the Pentagon not hindered by secrecy (but subject to Pentagon preemption and delay)? should financing be sought, in part, from government agencies? Other important issues are not discussed. Three groups were important in creating the previous APS study: the panel of "wise men" who initiated the study and persuaded the APS Council to do it, the study panel itself, and the review panel. How were the members of these three groups chosen? How were they responsible to the APS membership?

The results of the previous APS study had major national and international repercussions. Towards its end, even before release and publication of the report, the Pentagon had drawn back from DEW to concentrate on a kinetic energy weapon defense scheme. Shortly after, the whole SDI was downgraded; NMD was quiescent until the latter part of the Clinton years.

It is clear that "the arguments put forward in the eighties, to the effect that a study should only be conducted on the basis of unlimited access to classified knowledge, ultimately paid off." Even though there were periods of heart-stopping delay and uncertainty, awaiting Pentagon clearance, and even though "the kinetic technology which became the nucleus of all later SDI concepts" was shielded from independent scrutiny, critics of the study (and there were many, inside and outside of APS) were deprived of the "'If you knew what we know...' argument." The coalition, between APS and Pentagon, rendered the critics - politicians and/or scientists - ineffectual. On the other hand, if such cooperation proves infeasible for the next study, this report reminds us that "in the initial stages of the project, the experts involved (many of whom had years of experience of working with governments of various complexions) had unanimously concluded that a study based on publicly available information would indeed be worthwhile."

Also important to the previous successful study was "the balanced composition of the scientist group, the prestige which individual members enjoyed as specialists in their fields, and the authoritative nature of their overall findings, based on consensus." Finally, "The clear demarcation between solid specialist investigation and equally legitimate political pronouncement is one which the APS should continue to insist on."

I think our American readers will gain greatly from considering this European study which concludes by advising the APS to "play it again."

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Recent Articles in Science on Global Warming

Before addressing several articles in Science, some web sites should be mentioned.
There is a NASA site at http://gcmd.nasa.gov/, and an NOAA site at http://www.noaa.gov/.
There also is a site by the "Center for the Study of Carbon Dioxide and Global Change" at http://www.co2science.org/. This group opposes action against further warming apparently because increased warming has not been proven to have been caused by human activity, and because a warmer Earth and more CO2 are good for us. While this reviewer also is not certain that human activity can affect warming, a view diminishingly held among Science authors this year, he is forced to note that the Center authors make several common errors in concluding that further warming might somehow be a good thing.

There have been over 50 relevant papers in Science since Spring 2000--too many to treat individually in a limited space. The Annotated References section given below lists them chronologically. Preceding the Annotated References, I have grouped these articles into two major categories: Trends, and Mechanisms, each with several subcategories. I have omitted papers concerning human hardship or recent political activity because they did not bear on the physics of this complex problem. This reviewer's goal is not to shuffle physics and society together, but rather to provide science for physicists interested in problems affecting society. The recent United Nations IPCC meeting is reported [53] to have concluded that human activity is responsible at least for some of the recent global warming. This seems reasonable, but this reviewer is not entirely convinced. One hopes the IPCC has not made its decision because of mere warming to the idea.

Trends. The following papers present data showing or detailing a trend relevant to global warming:
Human Activity: 1, 6, 7, 18, 19, 22, 30, 36, 37, 38, 43, 44, 53.
Temperature: 7, 13, 14, 15, 16, 17, 18, 20, 22, 26, 28, 30, 33, 35, 39, 40, 41, 42, 43, 44, 46, 49, 53, 54. *Ice Cover*: 3, 8, 9, 10, 12, 13, 14, 16, 17, 20, 39, 40, 41, 42, 46, 49, 50. *Precipitation:* 13, 14, 18, 39, 41, 45, 47, 48, 52. *Solar & Other Astronomical Cycles*: 16, 17, 47, 51.

Mechanisms. The following papers elucidate physical or other mechanisms that might enter into the global warming equation:
Atmospheric aerosols: 2, 4, 34.
El Nino: 3, 5, 25, 33, 35.
Ice Cover: 3, 12, 13, 14, 16, 17, 30, 40, 41, 42, 49, 50.
Carbon Dioxide and Carbon Cycle: 7, 11, 16, 17, 19, 20, 21, 24, 27, 30, 31, 32, 36, 37, 38, 50.
Oceanic Circulation: 12, 13, 14, 30, 40, 41, 42, 49, 50, 54.
Human Activity: 7, 11, 19, 21, 30, 31, 32, 37, 38, 43, 44, 53.
Nitrogen Oxides & Nitrogen Cycle: 19, 23.
Solar and Other Astronomical Cycles: 16, 17, 29, 43, 44, 47, 51.

Annotated References.
The volume, pages, month, and day are given. All volumes are in year 2000, except for Volume 291 which is in year 2001.

1. R. A. Kerr, "[IPCC] Draft Report Affirms Human Influence", 288, 589-590 (4/28).
2. S. E. Schwartz & P. R. Buseck, "Aerosols", 288, 989-990 (5/12). Atmospheric science perspective on [4]: Aerosols do not always reduce surface and near-surface air temperature.

3. T. M. Rittenour, J. Brigham-Grette, & M. E. Mann, "El Nino-Like Climate Teleconnections in New England During the Late Pleisotcene", 288, 1039-1042 (5/12).
4. A. S. Ackerman, et al, "Reduction of Tropical Cloudiness by Soot", 288, 1042-1047 (5/12).
5. A. V. Fedorov & S. G. Philander, "Is El Nino Changing?", 288, 1997-2001 (6/16). A review.
6. M. E. Mann, "Lessons for a New Millennium", 289, 253-254 (7/14). Climate Change Perspective on [7], suggesting that greenhouse-gas warming accounts for the recent global temperature increase.
7. T. J. Crowley, "Causes of Climate Change Over the Past 1000 Years", 289, 270-277 (7/14).
8. D. Dahl-Jensen, "The Greenland Ice Sheet Reacts", 289, 404-405 (7/21). Climate Change Perspective on [9] and [10]. Different high-elevation regions of the Greenland ice are reacting differently. Coastal ice is thinning.
9. R. Thomas, et al, "Mass Balance of the Greenland Ice Sheet at High Elevations", 289, 426-428 (7/21).
10. W. Krabill, et al, "Greenland Ice Sheet: High-Elevation Balance and Peripheral Thinning", 289, 428-430. Estimates a net loss of ~51 cubic km of ice per year. As water, this would raise sea level by ~0.13 mm/ yr, but the measured rise is ~0.02 mm/yr.
11. P. H. Abelson, "Limiting Atmospheric CO2", 289, 1293 (8/25). Editorial suggesting carbon disposal mechanisms.
12. E. Bard, et al, "Hydrological Impact of Heinrich Events in the Subtropical Northeast Atlantic", 289, 1321-1324 (8/25). A Heinrich event is a massive surge of icebergs, implying ice sheet melting.
13. D. Nurnberg, "Taking the Temperature of Past Ocean Surfaces", 289, 1698-1699 (9/8). Paleoclimate Perspective on [14].
14. D. W. Lea, D. K. Pak, & H. J. Spero, "Climate Impact of Late Quaternary Equatorial Pacific Sea Surface Temperature Variations", 289, 1719-1724 (9/8).
15. J. J. Magnuson, et al, "Historical Trends in Lake and River Ice Cover in the Northern Hemisphere", 289, 1743-1746 (9/8). Records imply air temperature increased ~1.2 C/100 yr since 1850.
16. R. A. Kerr, "Ice, Mud Point to CO2 Role in Glacial Cycle", 289, 1868 (9/15). News Focus on Climate discusses [17]. Antarctic ice and deep-sea cores suggest that orbital cycles couple through CO2, not ice-sheet area, to drive ice-age phase: So, eccentricity --> greenhouse gas change --> temperature change.
17. N. J. Shackleton, "The 100,000-Year Ice-Age Cycle Identified and Found to Lag Temperature, Carbon Dioxide, and Orbital Eccentricity", 289, 1897-(9/15). Oxygen-18 ratios used to track ice ages.
18. L. G. Thompson, "A High-Resolution Millennial Record of the South Asian Monsoon from Himalayan Ice Cores", 289, 1916-1919 (9/15). Tibetan ice reveals human activity and warming.
19. G. P. Robertson, E. A. Paul, & R. R. Harwood, "Greenhouse Gases in Intensive Agriculture: Contributions of Individual Gases to the Radiative Forcing of the Atmosphere", 289, 1922-1925 (9/15). Analysis from 1991 to 1999.
20. J. Kaiser, "Ecological Society of America", 289, 2031-2032 (9/22). News Focus on annual meeting: Lake-bed cores showed short-term climatic extremes during the warm, arid midHolocene ~8000 ypb when compared with ~2000 ybp. Also, live trees can warm ground under snow by ~5 C, suggesting an early spring CO2 sink in tundra.
21. E. Schulze, C. Wirth, & M. Heimann"Managing Forests After Kyoto", 289, 2058-2059 (9/22). Climate change perspective on CO2 dynamics.
22. D. R. Easterling, "Climate Extremes: Observations, Modeling, and Impacts", 289, 2068-2074 (9/22). An atmospheric science review estimating warming effects on civilization.
23. M. T. Lerdau, J. W. Munger, & D. J. Jacob, "The NO2 Flux Conundrum", 289, 2291-2293 (9/29). An Atmospheric chemistry perspective describing the plant and soil regulation of nitrogen oxides. 24. U. Fehn, G. Snyder, & P. K. Egeberg, "Dating of Pore Waters with 129I: Relevance for the Origin of Marine Gas Hydrates", 289, 233- 2335 (9/29). The methane at Blake Ridge, Atlantic ocean, probably is from the early tertiary.
25. R. A. Kerr, "Second Thoughts on Skill of El Nino Predictions", 290, 257- 258 (10/13). This News Focus on Climate Prediction reports a Meteorological Society evaluation showing that complex supercomputer climate models did no better than rudimentary ones.
26. D. T. Rodbell, "The Younger Dryas: Cold, Cold Everywhere?", 290, 285-286 (10/13). Paleoclimate perspective on evidence in [28] that the ~1000 year YD cooling was local to the North Atlantic.
27. P. Falkowski, "The Global Carbon Cycle: A Test of Our Knowledge of Earth as a System", 290, 291-296 (10/13). Climate change review, recommends a system approach, concludes we don't know enough yet about the global increase in CO2.
28. K. D. Bennett, S. G. Haberle, & S. H. Lumley, "The Last Glacial-Holocene Transition in Southern Chile", 290, 325-328 (10/13). Lakebed sediments in southern Chile show no Younger Dryas cooling.

29. R. A. Kerr, "Does a Climate Clock Get a Noisy Boost?", 290, 697-698 (10/27). News Focus on Climatology discusses stochastic resonance and locally stable states.
30. R. A. Kerr, "Can the Kyoto Climate Treaty Be Saved From Itself?", 290, 920-921 (11/3). Global maps of surface temperature changes, projected CO2 emissions, and a brief summary of the mechanisms believed to affect temperature.
31. J. Kaiser, "Soaking Up Carbon in Forests and Fields", 290, 922 (11/3). News Focus describing measurement and monitoring problems, which differ between forest and rangeland vs. cultivated or populated areas.
32. K. R. Redeker, et al, "Emissions of Methyl Halides and Methane from Rice Paddies", 290, 966 -969 (11/3).
33. M. A. Cane & M. Evans, "Do the Tropics Rule?", 290, 1107-1108 (11/10). Cites [35] in a climate variability perspective, that tropical decadal variations drive those in the north Pacific. Trends given from ~1700 to 2000.
34. S. J. Smith, T. M. L. Wigley, & J. Edmonds, "A New Route Toward Limiting Climate Change?", 290, 1109-1110 (11/10). A climate perspective summarizing the effects of haze and soot in countering the radiation- trapping effect of greenhouse gasses.
35. B. K. Linsley, G. M. Wellington, & D. P. Schrag, "Decadal Sea Surface Temperature Variability in the Subtropical South Pacific from 1726 to 1997 A. D.", 290, 1145-1148 (11/10). Sr/Ca ratios in coral.
36. J. P. Caspersen, et al, "Contributions of Land-Use History to Carbon Accumulation in U. S. Forests", 290, 1148-1151 (11/10).
37. I. Fung, "Variable Carbon Sinks", 290, 1313 (11/17). Climate change perspective pointing out data in [38] showing that known carbon sinks seem to vary greatly year to year.
38. P. Bosquet, et al, "Regional Changes in Carbon Dioxide Fluxes of Land and Oceans Since 1980", 290, 1342-1346 (11/17).
39. S. W. Hostetler & P. U. Clark, "Tropical Climate at the Last Glacial Maximum Inferred from Glacier Mass-Balance Modeling", 290, 1747-1750 (12/01).
40. L. Labeyrie, "Glacial Climate Instability", 290, 1905-1907 (12/08). Paleoclimate perspective, suggests that trends in [41] and mechanisms in [42] might support thermohaline oscillations as climate drivers. However, higher-resolution dating of the evidence is called for.
41. L. C. Peterson, et al, "Rapid Changes in the Hydrologic Cycle of the Tropical Atlantic During the Last Glacial", 290, 1947-1951 (12/8).
42. K. A. Hughen, et al, "Synchronous Radiocarbon and Climate Shifts During the Last Deglaciation", 290, 1951-1954 (12-/8).
43. F. W. Zwiers & A. J. Weaver, "The Causes of 20th Century Warming", 290, 2081-2083 (12/15). Citing simulations in [44], there must be some natural and some anthropogenic forcing. Trends are given from ~1860 to 2000.
44. P. A. Stott, et al, "External Control of 20th Century Temperature by Natural and Anthropogenic Forcings", 290, 2133-2137 (12/15).
45. M. A. Maslin & S. J. Burns, "Reconstruction of the Amazon Basin Effective Moisture Availability over the Past 14,000 Years", 290, 2285-2287 (12/22). 46. J. R. Marlow, et al, "Upwelling Intensification As Part of the Pliocene-Pleistocene Climate Transition", 290, 2288-2291 (12/22). Deep-sea cores off southwest Africa show radically different Atlantic circulation than at present.
47. F. E. Mayle, R. Burbridge, & T. J. Killeen, "Millennial-Scale Dynamics of Southern Amazonian Rain Forests," 290, 2291-2294 (12/22). Recent rain forest expansion is explainable by Milankovitch forcing.
48. N. Shackleton, "Climate Change Across the Hemispheres", 291, 58-59 (1/5). Paleoclimate Perspective shows trends for past 10,000 years and speculates on the importance of a Panama water-vapor crossing.
49. T. Blunier & E. J. Brook, "Timing of Millennial-Scale Climate Change in Antarctica and Greenland During the Last Glacial Period", 291, 109-112 (1/5). Speculates on an atmospheric and oceanic coupling.
50. E. Monnin, et al, "Atmospheric CO2 Concentrations over the Last Glacial Termination", 291, 112-114 (1/5). CO2 and methane seemed to covary.
51. C. H. Stirling, "Orbital Forcing of the Marine Isotope Stage 9 Interglacial", 291, 290-293 (1/12). Milankovitch predicts coral reef data to ~630,000 ybp.
52. P. A. Baker, et al, "The History of South American Tropical Precipitation for the Past 25,000 Years", 291, 640-643 (1/12). Lake Titicaca cores.
53. D. Voss, "It's Official: Humans are Behind Most of Global Warming", 291, 566 (1/26). Climate change news reporting IPCC conclusion and a simulation trend.
54. J. W. Hurrell, Y. Kushnir, & M. Visbeck, "The North Atlantic Oscillation", 291, 603-601 (1/26). A climate perspective suggests the ocean may store heat to carry over atmospheric changes from year to year.

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Has Radiation Protection Become a Health Hazard? by Gunnar Walinder, 2000, 167 pages (soft cover), Medical Physics Publishing Corporation, Madison, WI 53705, USA. ISBN 91-630-92622-X (Sweden) and ISBN 0-944838-96-0 (USA).

[This review is reproduced from the journal *Health Physics,* with minor alterations, with permission from the Health Physics Society.]

This book is the second edition of a book published by the Swedish Nuclear Training and Safety Center. The author began his career as a physicist and health physicist before taking up biological and medical studies leading to a Ph.D. in radiobiology, a field in which he conducted research for over 30 years. In good scientific manner, the first chapter is a statement of the problem: "Could a complex biological phenomenon, such as the dose-response of radiogenic cancer, really be adequately described by an equation of the first degree, or, in other words, by an expression that geometrically describes a straight line?" Walinder also asks whether the simplification of complex phenomena "result in recommendations and measures which could lead to considerably greater health hazards than those which one sought to avoid in the first place?" He notes that severe mental and psychosomatic diseases following the Chernobyl accident have already surpassed the estimates for late effects of radiation exposure for people living in the Ukraine and Byelorussia.

Chapter 2, the largest chapter, is a discussion of the biological effects of ionizing radiation and human biological complexity. Genetic effects, radiation-induced effects in the fetus, and cancer are the main topics. The complexity of carcinogenesis is highlighted as a "…process which includes a series of genetic, epigenetic and adaptive cell changes. Therefore it is affected by a hereditary propensity for tumor formation, for physiological-organismic conditions, and external factors (living habits, food, carcinogenic substances and promoters in our environment, etc.)." Walinder cites an experiment where the thyroid glands of mice were exposed to a certain radiation dose. It was possible, by merely changing the mice's diet, to determine whether or not tumors will arise in the thyroid gland, whether the tumor will be benign or malignant, and even the degree of malignancy of the tumor. The author suggests that in light of current knowledge, the old Target Theory (where a single event in the genome could transfer a cell into a malignant precursor) is limited in that the basic theory may be correct but that reality is more complex than theory. "A low radiation dose cannot, on its own, cause a malignant cell transformation but, together with other carcinogenic factors, can contribute to such a process. Malignant conversion of a cell is not a stochastic effect of radiation but a highly conditional one…It is impossible to predict, by means of a mathematical expression, the specific outcome of a low radiation dose."

Chapter 3 is a short discussion of epidemiology and pitfalls that often occur when trying to seek "proof" of a causal relationship in a biological context.

Chapter 4 shows the breadth of this book in that it contains an excellent discussion of epistemology. Mathematicians and physicists seem to understand the distinction between what is possible, and what is impossible, to know. But no corresponding analysis has been carried out within biology or medical science. It is suggested that a dose response relationship cannot be determined solely on the basis of taking reductionism to its furthest extreme, i.e. to the level of events in individual genetic molecules. Quantitative determination of the effects of non-dominant radiation doses (amounts low enough that their effects are masked by other competing factors) or non-dominant concentrations of carcinogenic substances cannot be made.

Chapter 5 discusses the biological premises of the recommendations of the International Commission on Radiation Protection (ICRP). The author feels that in the 1977 recommendations of the ICRP (report #26), the ICRP was cautious in warning against a too-literal interpretation of the assumption of a linear dose relationship in the low dose range, but that this caution was abandoned in their 1990 recommendations (report #60). The ICRP view of radiogenic cancer is in conflict with important features of modern oncology highlighting the complexity of the onset of cancer. This is followed by an interesting discussion on the inhibitory effects of accepted doctrines. The author highlights how long it took to correct the value of the charge of the electron because the original determination of the value lead to a Nobel Prize. Many noticed a slight difference, but tended to feel their value was in error because it did not agree with the accepted value. A similar phenomenon occurred with the determination of the number of chromosomes in the human cell. It took a long time to correct the number from 48 to 46. The current radiation protection philosophy, that ionizing radiation induces cancer even at very low doses, produces a similar hinhibition: If a study reveals any evidence to the contrary, something has to be wrong with the study. Most health physicists are well aware of many studies that do not support the linear non-threshold hypothesis, but these studies, including those suggesting hormesis (a beneficial effect), are dismissed by many because they do not fit the prevailing doctrine.

Chapter 6, "Consequences of the Official Approach to Radiation Risk," argues that very cautious approaches to radiation lead the public to believe that if we have to be so extremely cautious, radiation must be much more dangerous than anything else we can be exposed to. High risk figures computed from small doses extrapolated to large populations contribute to the anxiety the ICRP has said it wished to avoid. By 1994, 1,250 people who had been initial responders to the Chernobyl accident had committed suicide. Also, following the Chernobyl accident, the International Atomic Energy Agency estimates 100,000 to 200,000 abortions were carried out in western Europe as the result of advice from physicians who were so ignorant about elementary radiation biology that they gave completely disastrous advice to an anxious people. The author concludes that we must openly admit we cannot have any science-based knowledge of the negative or positive effects of low levels of ionizing radiation. What can be known is that "a non-dominant radiation dose does not involve a greater risk than what is the case when we subject ourselves to many of the living and working conditions necessary for life and which society already accepts and often demands of us…. It has obviously been recognized that the assertion of knowledge about the effects of extremely low radiation doses will probably lead to more harm than protection."

The book does suffer from a number of editorial flaws, which could be corrected by good technical editing. That notwithstanding, it is excellent reading for those who wish to expand their views regarding the response of humans to low-level doses of ionizing radiation.

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[i] Moore, Taylor "License Renewal Revitalizes the Nuclear Industry," EPRI *Journal* Fall: 8-17 (2000).

[ii] See http://www.stanford.edu/~Sailor

[iii] Sailor, William C., David Bodansky, Chaim Braun, Steve Fetter, & Bob van der Zwaan. "A Nuclear Solution to Climate Change? *Science* **288** 1177-1178 (2000).

[iv] Weinberg, Alvin. "The Maturity and Future of Nuclear Energy." *American Scientist* **64** 16-21, (1976).

[v] A comparable opinion series by the Harris organization shows a virtually identical pattern.

[vi] Nuclear News "Nuclear Power in the 21st Century," November, 52 (2000).

[vii] *ibid*, p66.