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insert in this issue

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Montréal Set to Host Largest March Meeting in APS History

A record number of physicists is expected to converge on the Palais des Congrès in Montréal, Quebec, this month for the annual APS March Meeting, the largest physics meeting of the year. More than 6000 abstracts have been submitted, spanning fields as diverse as condensed matter and materials physics, chemical and biological physics, fluid dynamics, molecular and optical physics, magnetism, laser science, industrial and applied physics, and high polymer and computational physics, among others. In addition to the technical program, there will be numerous nontechnical sessions on physics history (including one focusing on physics in Canada), education, international physics, and women in physics, as well as several special events.

Facilitating CMP Research. Speakers at a Monday morning session will describe opportunities for condensed matter research at national user facilities. For instance, high magnetic fields—such as those produced by the National High Magnetic Field Laboratory, among other facilities—are critical for science and technology, and over the last 20 years research in this area has led to such new phenomena as the quantum and fractional quantum hall effects. Meanwhile, Argonne's Advanced Photon Source is the most brilliant source of x-rays in the Western Hemisphere, and its beam lines are widely used by condensed matter physicists for research in such areas as inelastic scattering and nano-imaging, while research at TRIUMF harnesses muons as magnetic probes. On the horizon is the Spallation Neutron Source at Oak Ridge National Laboratory, slated for completion in 2006, with 15 of the 24 beam lines already assigned to neutron scattering instruments for condensed matter research. A concurrent session will focus on synchrotron radiation research facilities in developing countries, such as SESAME in the Middle East, as well as projects in South America and Japan. *[Sessions A3, A4]*

O Canada. In a nod to the meeting's host nation, a Monday afternoon session will focus on the history of physics in Canada. Among the personages featured will be John McLennan, who built the physics department at the University of Toronto into a major research laboratory, conducting research on superconductors and liquid helium. German émigré Gerhard Herzberg is another featured Canadian physicist, a pioneer of molecular spectroscopy who built the world-class Spectroscopy Laboratory for Canada's National Research Council and conducted seminal research on the spectra of free radicals. And from 1950 to 1962, Bertram Brockhouse carried out research that laid the foundation for the field of inelastic neutron scattering at Chalk River Laboratories, inventing many new instruments and techniques in the process. *[Session D5]*

SQUID-Based MRI. Supercon-

See MARCH MEETING *on page 6*

Web Lectures from San Diego Conference Now Available

The APS held the second "Opportunities in Biology for Physicists" conference in San Diego, January 30-February 2, 2004.

The talks from that meeting are available as web lectures (video, audio and slides) at http://www.aps.org/meet/biology-physics2/weblectures.cfm

The talks from the first conference, held in Boston in the fall of 2002, are also available at http://www.aps.org/meet/biology-physics/weblectures.cfm.

Who Painted This Picture?

Photo Credit: Constance Denning

A physicist from the era of Van Gogh and Cézanne took up painting in his spare time. To find out who, and how this picture came to our attention, please turn to page 5.

Physicists Help First Responders Deal with Nuclear Safety Issues

By Ernie Tretkoff

Two nuclear physicists have been sharing their expertise by organizing and teaching classes on radiation detection and safety for first responders and other community members.

Con Beausang

Con Beausang, a nuclear physicist at Yale University, along with members of his lab, started teaching courses on the basics of radiation for first responders in 2002. Though the classes are not about terrorism *per se*, said Beausang, the 9/11 attacks inspired him to reach out to the community.

"The classes are entirely free," said Beausang. "We receive no funding from anyone. All of the people who help to teach and prepare the classes, from professors to graduate students, volunteer their time."

In the classes, which consist of four weekly three-hour sessions, first responders learn "a little about health effects of radiation, how detectors work, what they can find, and what they can't," explained Beausang.

"We're not trying to teach physics. That's not what they want," said Beausang. "They have radiation detectors, and we're trying to demystify the process of radiation."

More than 40 first responders, including police, FBI, and Coast Guard, have taken the course, which Beausang has offered three times so

See BEAUSANG *on page 7*

Welcome to Montréal, Where Down is Up and the Sun Sets in the North

By Alan Chodos

I grew up in Montréal in the fifties and early sixties. Many things were different then. There were streetcars instead of subways. It was pre-world's fair, pre-Olympics, pre-major league baseball (which now seems to be leaving again), and the Montréal Canadians dominated what was then a six-team National Hockey League. Most importantly, it was pre-separatist movement, and the English-speaking community in Montréal dwelt in a cocoon whose fragility would only be revealed by subsequent events.

But some things remain the same, dictated by the immutable geography of the city. Montréal is located on an island in the St. Lawrence River—more precisely, the St. Lawrence flows by to the south, and the island's northern border is the smaller Rivière des Prairies. Rising steeply but not all that impressively behind downtown Montréal is an 800-foot hill called Mount Royal, from which the city may have taken its name. Importantly for what's to come, the island itself is sharply angled, with the St. Lawrence changing its easterly course to a more northerly one as it flows past the island.

These facts explain why Montréalers are directionally challenged. I grew up thinking that the sun sets in the north, and being unable to tell up from down. I was also under the misapprehension that the St. Lawrence flowed away from the ocean toward the Great Lakes.

See MONTRÉAL *on page 7*

Rules Change for Valley Prize; Fluids Merge Two Awards

The George E. Valley Prize, for an outstanding physicist in any field at an early stage in his or her career, has undergone a change in its eligibility rules. The change is designed to better target the best candidates in both theory and experiment, and to bring the Prize more closely in line with the concept that the late George E. Valley Jr. had in mind when he bequeathed the funds for the most lucrative Prize offered by the APS.

The Valley Prize, first given in 2002, carries a stipend of $20,000. The original requirement limited the candidate pool to those under 30; the rules for this year do not refer to chronological age, but require instead that the candidate have received his or her PhD no earlier than April 1, 1999. This change was implemented upon the recommendation of the Prizes and Awards Advisory Committee, and was done with the approval of George C. Valley, son of George E. Valley, Jr.

The nomination deadline for this year's Valley Prize is July 1, 2004, and

See RULE CHANGE *on page 7*

Highlights

8 **The Back Page:** *Peter Zimmerman: "Dirty Bombs" the threat revisited.*

Members in the Media

"In the 1980s, while we were working out all of the theory of this, we were also stimulating our experimental colleagues to keep going to higher and higher levels of accuracy to find out these fundamental fluctuations in the temperature of the radiation that's coming from the Big Bang."
—Dick Bond, University of Toronto, on progress in cosmology, Ottawa Citizen, December 29, 2003

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"If every neuron in your brain gets hit, do you come back being a blithering idiot, or not?"
—Derek Lowenstein, Brookhaven, pointing out that researchers don't know how radiation would affect astronauts on a trip to Mars, New York Times, December 9, 2003

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"This is really very distressing. They're saying, 'Go after it, guys. We're back in the '50s. Come up with all the crazy ideas you can—if there are any crazy ideas left out there.' This is fossil Cold War mentality surfacing again."
— Frank von Hippel, Princeton University, on the Bush administration's nuclear policies urging federal labs to explore a full range of new nuclear weapons, Oakland Tribune, December 12, 2003

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"It means that—if it's right—we need to keep an eye on it. When we think about all these greenhouse gases, we ought also to think about controlling these particles that are also changing the climate."
—Michael Oppenheimer, Princeton University, on a study by NASA showing that soot particles cause as much as a quarter of observed global warming, Milwaukee Journal Sentinel, December 23, 2003

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"In terms of routine emissions, nuclear plants are a lot better option than fossil-fuel plants that emit greenhouse gases and, in the case of coal, a whole series of other nasty pollutants like mercury."
—Thomas B. Cochran, Natural Resources Defense Council, Washingtonian, January 2004

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"It's like chasing a quarry into a corner. If we kill [the Los Alamos experiment], we'll be heroes. And if we find sterile neutrinos, then we're really heroes. Either way, we've made a big step forward."
—Janet Conrad, Columbia University, on looking for sterile neutrinos, Los Angeles Times, December 20, 2003

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"They thought I was either a double agent, or it wouldn't be safe for the security of the United States that an Iranian nuclear physicist would come here and do research."
—M. Hadi Hadizadeh, Ohio University, on his struggle to get a US visa, Los Angeles Times, December 19, 2003

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"It's only a theory of everything if you can explain all the things. The experiments are forcing us to try to understand the theory in places where the calculations are difficult. If you call yourself a theorist and have any self-respect, you have to take the challenge."
—Chris Quigg, Fermi National Accelerator Laboratory, New York Times, December 30, 2003

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Photo Credit: Lalena Lancaster

Twenty-eight of the attendees at the APS Unit Convocation came early and spent a day lobbying on Capitol Hill, visiting an impressive total of 72 Congressional offices. Here Steve Pierson, of the APS Washington office, reports to the convocation on the previous day's events.

This Month in Physics History

Lens Crafters

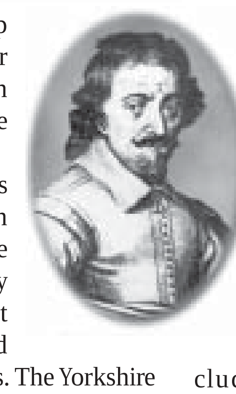
Circa 1590: Invention of the Microscope

Every major field of science has benefited from the use of some form of microscope, an invention that dates back to the late 16th century and a modest Dutch eyeglass maker named Zacharias Janssen. While extremely rough in image quality and magnification compared to modern versions, the Janssen microscope was nonetheless a seminal advance in scientific instrumentation.

Janssen was the son of a spectacle maker named Hans Janssen, in Middleburg, Holland, and while Zacharias is credited with inventing the compound microscope, most historians surmise that his father must have played a vital role, since Zacharias was still in his teens in the 1590s. At that time, eyeglasses were beginning to be used widely among the populace, focusing a great deal of attention on optics and lenses. In fact, some historians credit both the Janssens and a fellow Dutch eyeglass maker, Hans Lippershey, with concurrent, though independent, invention of the microscope.

Historians are able to date the invention to the early 1590s thanks to Dutch diplomat William Boreel, a longtime family friend of the Janssens who wrote a letter to the French king in the 1650s detailing the origins of the microscope. He described a device that rose vertically from a brass tripod almost two and a half feet long. The main tube was an inch or two in diameter and contained an ebony disk at its base, with a concave lens at one end and a convex lens at the other; the combination of lenses enabled the instrument to bend light and enlarge images between three and nine times the size of the original specimen.

No early models of Janssen microscopes have survived, but a Middleburg museum has a microscope dated from 1595, bearing the Janssen name. The design is somewhat different, consisting of three tubes, two of which are draw tubes that can slide into the third, which acts as an outer casing. The microscope is handheld and can be focused by sliding the draw tube in or out while observing the sample, and is capable of magnifying images up to ten times their original size when extended to the maximum.



As ingenious as the Janssen invention was, it would be more than half a century before the instrument found widespread use among scientists. The Yorkshire scientist Henry Power was the first to publish observations made with a microscope, and in 1661 Marcello Malphigi used a microscope to provide clinching evidence in support of Harvey's theory of blood circulation when he discovered the capillary vessels in the lungs of a frog.

Micrographia author Robert Hooke was among the first to make significant improvements to the basic design, although he relied on London instrument maker Christopher Cock to actually build the instruments. Hooke's microscope shared common features with early telescopes: an eyecup to maintain the correct distance between the eye and eyepiece, separate draw tubes for focusing, and a ball and socket joint for inclining the body. For the optics, Hooke used a bi-convex objective lens placed in the snout, combined with an eyepiece lens and a tube or field lens. Unfortunately, the combination caused the lenses to suffer from significant chromatic and spherical aberration, yielding very poor images. He attempted to correct the aberrations by placing a small diaphragm into the optical pathway to reduce peripheral light rays and sharpen the image, but this only resulted in very dark samples. So he passed light generated from an oil lamp through a glass filled with water to diffuse the light and illuminate his specimens. But the images remained blurred.

It fell to a Dutch scientist, Anton van Leeuwenhoek, to make further improvements. Van Leeuwenhoek is sometimes popularly credited with the microscope's invention. He wasn't the inventor, but he was a great admirer of the *Micrographia*, and his instruments were the best of his era in terms of magnification: he achieved magnifying power up to 270 times larger than the actual size of the sample, using a single lens. He used his microscopes to describe bacteria harvested from tooth scrapings, and to study protozoans found in pond water.

By the dawn of the 18th century, British instrument designers had introduced improved versions of the tripod microscope invented by Edmund Culpeper. Other improvements included advanced focus mechanisms, although lens design remained rough and most instruments continued to be plagued by blurred images and optical aberrations. In the first half of the 19th century, dramatic improvements in optics were made, thanks to advanced glass formulations and the development of achromatic objective lenses. The latter had significantly reduced spherical aberration in the lens, making it free of color distortions.

The 20th century brought the introduction of instruments enabling the image to remain in focus when the microscopist changed magnification. Thanks to vastly improved resolution, contrast-enhancing techniques, fluorescent labeling, digital imaging, and countless other innovations, microscopy has revolutionized such diverse fields as chemistry, physics, materials science, microelectronics, and biology.

Today, it is possible to perform real-time fluorescence microscopy of living cells in their natural environment, while in 1999 Intel and Mattel collaborated on producing the $100 Intel Play QX3 Computer Microscope (since discontinued), bringing the instrument into the consumer marketplace. And in the spirit of the early pioneers of microscopic research, scientists at Florida State University have brought the field full circle, turning their advanced instruments on common everyday objects like that All-American staple, burgers and fries, detailing thin sections of wheat kernel, onion tissue, starch granules in potato tissue, and crystallized cheese proteins.

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zero gravity
The Lighter Side of Science

Renormalization Tribute Shocks Conferees

By Martin Bridge

A well-known advocate of using the arts to promote science has come under attack. Physics impresario Brian Schwartz, with several previous successful productions to his credit, is facing questions regarding his latest creation, "Homage to Renormalization", after its first performance took an unexpected turn.

The performance was staged before more than a thousand physicists at the recent conference on "Fifty Years of Field Theory". With a stellar list of speakers including many Nobel Prize winners, the meeting had been dubbed the Super Bowl of physics conferences, and the organizers wanted something special for the entertainment at the conference banquet. They turned to Schwartz to provide it.

Working with contacts at MTV, Schwartz designed a musical number that portrayed the dramatic battle with infinite integrals. "To be honest, I was more worried about the violence as the battle reached its climactic moments," Schwartz said. "I was completely unprepared for what actually happened. The performers did it on their own—there was never a hint of it in rehearsal."

The trouble arose because of a scene in which the bare mass, an unrenormalized quantity, is "dressed" by higher-order corrections. The dancer representing the bare mass apparently took the concept too literally. " At first I thought it was a flesh-colored body stocking," one shocked audience member recalled. "But then I realized it was the real thing."

"It was only for a brief moment," Schwartz remarked ruefully, "because the —ahem—singularity was quickly removed by the process of renormalization. But apparently that moment was enough."

Indeed it was. Gasps were heard in the audience. At least one Nobel Prize winner fainted, falling head first into his dessert. "Many of the Nobel Prize winners are quite elderly," an outraged conference organizer said. "You can't subject them to something like this. They were raised in a more genteel era. They can't take it."

Schwartz promised to be more careful in the future. His next effort is all about the quark model, but, he says, "the bottom quark will appear fully clothed."

Ed. Note: *The above account is not entirely true. Brian Schwartz, Vice President for Research at the Graduate Center, CUNY, is indeed a well-known promoter of science and the arts.[see http://web.gc.cuny.edu/sciart/] His current effort involves the production of a new musical play based on Alan Lightman's novel "Einstein's Dreams" and is suitable for all audiences, including Nobel*

Executive Board: More Science Needed in NASA Decisions

The APS Executive Board has passed a resolution calling on NASA to have greater involvement of research scientists in decisions that affect science programs. The resolution carried unanimously at the Board's meeting in early February.

The action came after NASA Administrator Sean O'Keefe announced in January that NASA intends to cancel a maintenance mission to the Hubble Space Telescope that had been scheduled for 2006, thereby considerably shortening the Hubble's useful scientific life.

The Board's resolution refers specifically to the Hubble mission, urging NASA to heed calls for an independent panel to review the cancellation decision. Administrator O'Keefe cited safety concerns for the shuttle crew as the primary reason for scrapping the mission, but a pair of internal reports by a NASA engineer concluded that the data do not support O'Keefe's contentions. The reports were made public in a story in the *New York Times* on February 7.

The resolution expresses the opinion of the Executive Board, but it has not been passed by the APS Council and is therefore not an official statement of the Society. The Council's next meeting is in late April. The text of the resolution follows:

"The Executive Board of the American Physical Society calls on the leadership of NASA to increase the involvement of research scientists in decision-making processes that strongly affect scientific programs. In this context, the Executive Board urges the NASA Administrator to heed calls for an independent assessment of NASA's recent decision not to provide a servicing mission to the Hubble Space Telescope. The assessment panel should include research scientists."

An Especially Elegant Universe

Joe McMaster, producer, director, and writer of Nova's *The Elegant Universe*, is not a physicist. Fortunately, he had the patient help of the show's star and narrator, physicist Brian Greene, as he put together the PBS production delving into string theory.

McMaster relied heavily on Greene's book, also titled *The Elegant Universe*, throughout the production of the program, which was filmed on locations ranging from downtown Manhattan to a piano factory to the desert of New Mexico.

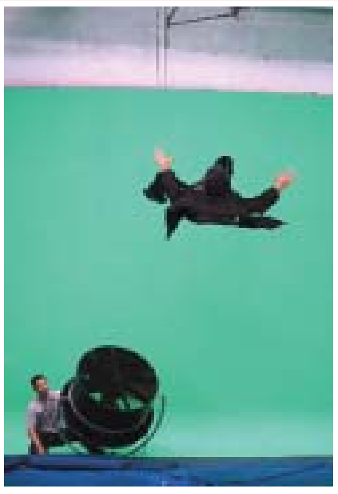


Photo Credit: by Andrea Cross for WGBH

Attached to wires and blown by a wind machine, Brian Greene "flies" through the air against a green screen background, replaced in the editing process by footage of a city street scene.

Much of the program required intense cooperation of camera crews and computer experts who melded live action shots with sound stage footage and animation. Some were high-tech interpretations of illustrations from Greene's book.

Image courtesy of NOVA

A Calabi-Yau shape: a two dimensional visualization of the six additional spatial dimensions required by string theory.

Others required decidedly low-tech, on-the-spot improvisation. "When we were filming at White Sands," says McMaster, "we wanted to show how an attractive force could be demonstrated by two people throwing a baseball back and forth." The result was a scene in which Greene apparently plays a game of catch with himself.

Many of the most striking images in the program, however, required Greene to recite his lines on an empty sound stage, with animation added later. For one segment, the crew even suspended Greene on wires over a wind machine to simulate the intrepid physicist in flight.

It's clear from McMaster's descriptions of the multidimensional universes, quantum fluctuations, and gravitational wells depicted in the program that his work on the show has given him a profound, intuitive appreciation of string theory.

It's an appreciation that he hoped was imparted to PBS viewers when *The Elegant Universe* began airing October 28.

—Adapted from PhysicsCentral.Com

Dedicated Supercomputers Probe QCD Theory

By Ernie Tretkoff

In order to meet the enormous computing power requirements of Quantum Chromodynamics (QCD), the theory of strong interactions, researchers have built supercomputers specifically for that purpose.

Experiments at national accelerators and labs need these calculations. "Many of these tests actually require this numerical work," said Norman Christ, of Columbia University, who has led the development of special purpose computers, "It's a critical part of the international experimental program."

At the moment, however, researchers lack the computing power to bring the precision of the calculations up to that of the experiments. "We're just beginning to be able to make accurate calculations, "said Robert Sugar of the University of California, Santa Barbara.

To compute the quantities of QCD, physicists use lattice gauge theory, which represents fields on a four-dimensional space-time grid, or lattice. A large lattice with closely spaced points provides a good approximation to continuous space. The technique, invented in the US by Ken Wilson in 1974, remains the only known way to calculate some values.

Several characteristics of lattice calculations make them simpler than other large problems. For instance, researchers can easily divide the uniform grid evenly among the processors of a parallel computer, in such a way that individual processors rarely need to trade information. Also, lattice calculations don't require much input and output, and compared to other calculations, need relatively little memory.

Since 1982, Christ's group at Columbia has been taking advantage of these simplifications to build special purpose parallel computers that cost much less than general-purpose machines. The most recent version is QCDOC, for Quantum Chromodynamics On a Chip, developed in collaboration with IBM. Each chip contains a 500 MHz 440 PowerPC processor core with a 1 Gigaflops, 64-bit floating point unit, and each of these nodes is connected to six others.

In November Christ's group tested a prototype version of QCDOC with 128 processors. With 2,000 processors, the machines will be capable of sustaining a teraflop—one trillion arithmetic operations per second. Machines with 10,000 nodes, which Christ hopes to implement by summer 2004, should be able to sustain five teraflops, with a peak speed of 10 teraflops. A variety of calculations should work well on the QCDOC machines.

The first involves the properties of weak decays of strongly interacting particles. Experiments at SLAC and KEK B factories, for instance, are trying to measure some of these properties, and such efforts require theoretical calculations of the effects of strong interactions. Lattice calculations will also provide precise values for other standard model parameters, such as quark masses and the strong coupling constant, and may help find physics beyond the standard model.

A second area of great interest is the quark-gluon plasma. Though quarks and gluons are normally bound up in other particles, many scientists believe that at sufficiently high temperatures or densities there will be a transition to a quark-gluon plasma. Experiments at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory have aimed to create such a state. A quark-gluon plasma probably existed in the early universe, and may exist in neutron stars. Lattice calculations are underway to determine the properties of this plasma.

Third, lattice gauge theorists want to better understand the internal structure and interactions of hadrons, such as protons and neutrons. Calculations can show their distribution of quarks, magnetic moment, and other properties.

The QCDOC machines may not even be limited to QCD calculations according to James Glimm, of the State University of New York at Stony Brook. "We are targeting specifically molecular dynamics with long range forces, with bio-applications in mind," he said. "It would also be good for atomistic equation of state studies, and probably a number of other problems, " In fact, the computers would be good for any "problems for which the amount of data is significantly smaller than the amount of work done on this data."

IBM has based its new supercomputer, Blue Gene/L, on the QCDOC model. The machine which is still in development, will reach a peak speed of 360 teraflops. A prototype version was tested in November. Blue Gene/L was designed with protein-folding problems in mind, but will be capable of many other calculations. The first version, expected to be complete in 2005, will be placed at Lawrence Livermore National Laboratory, where, according to Glimm, they regard it as nearly general-purpose.

Although these special-purpose computers may be a very cost-effective way of getting the needed computing power for these calculations, scientists still get a lot of use out of general-purpose machines. One approach is to use clusters of general-purpose workstations, possibly optimizing the clusters for these particular applications.

QCDOC may have the speed and cost advantage now, but the clusters could catch up as commercial machines get better and cheaper. Steven Gottlieb, a lattice gauge theorist at Indiana University who uses a variety of supercomputers and clusters for his own calculations, estimates the cost of clusters could soon drop to several dollars per megaflop, making them competitive with QCDOC machines at one dollar per megaflop.

Also, using the cluster approach, the lattice gauge community can take advantage of power increases and cost decreases in commercial machines, without having to spend

See **SUPERCOMPUTERS** *on page 6*

LETTERS

Millikan, Einstein, and the Birth of Relativity

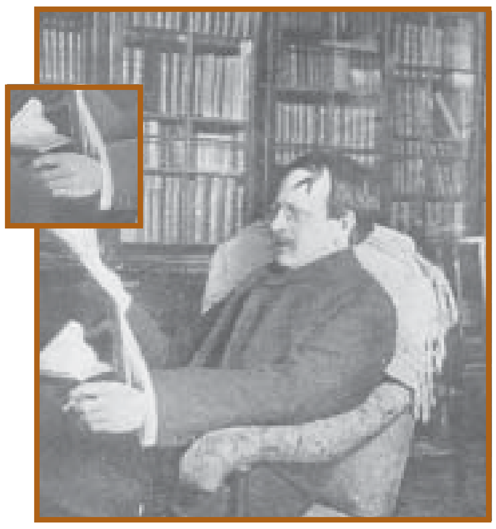
Everyone can appreciate the noble impulse to republish Millikan's 1949 article on Einstein and Millikan's praise of Einstein on his 70th birthday. Unfortunately, however, although Millikan had many virtues, fidelity to history was not one of them.

Convinced of the primacy of experiment, Millikan asserts that Einstein took the Michelson-Morely experiment "as an established experimental fact" and from it drew "its inevitable consequences... Thus was born the special theory of relativity." Gerald Holton established decades ago, however, that the Michelson-Morely experiment exerted no significant influence on the genesis of special relativity in Einstein's thought.

Millikan argues from a similar empiricist stance, though less egregiously, for the origin of Einstein's theory of Brownian motion, but when he turns to Einstein's paper on "photoelectric stopping potentials," he again falsifies history. In 1949, two years after Lenard had died an unrepentant Nazi, Millikan judiciously avoided citing Lenard's 1902 experiments as the origin of Einstein's light-quantum hypothesis, but he made that connection in his 1923 Nobel Lecture, which he quoted verbatim in his 1950 *Autobiography.* Martin J. Klein showed decades ago, however, that Einstein's arguments for light quanta were based on the second law of thermodynamics in its statistical interpretation, and that Lenard's experiments constituted only one of three different kinds of experimental evidence that Einstein cited in support of it.

Moreover, by referring to Einstein's paper as being on "photoelectric stopping potentials," and by discussing his own 1915 experiments, Millikan laid claim to confirming Einstein's photoelectric-effect equation and consequently Einstein's light-quantum hypothesis. Indeed, in his *Autobiography* Millikan stated explicitly that in 1915 he thought that his experiments had "proved simply and irrefutably" that Einstein's equation "scarcely permits of any other interpretation than that which Einstein had originally suggested, namely that of the semi-corpuscular or photon theory of light itself." I invite everyone, however, to read Millikan's original paper, where Millikan argues precisely the opposite, namely, that his confirmation of Einstein's equation meant that it had to be interpreted along semiclassical lines, and that it did not confirm Einstein's light-quantum hypothesis.

Millikan's 1949 article thus perpetuated—and its republication now has further perpetuated—historical myths that still seem to be quite widespread. Millikan was more on target at the end of his article when he praised Einstein's "greatness of soul and keenness of intelligence and understanding rarely found in the history of mankind." Einstein demonstrated those qualities once again in 1949 when he declined to challenge Millikan's description of the content and significance of his three great papers of 1905.



The original 1899 photo of J. J, Thomson, discussed in the letter by Roger Stuewer, and (inset) his left hand as it appeared in the version that Millikan published in 1906.

I have discovered an amusing instance and photographic proof of what I have come to call Millikan's philosophy of history: "If the facts don't fit your theory, change the facts." There exists a picture taken in 1899 of J.J. Thomson in his study at home in Cambridge in the book, *J.J. Thomson and the Cavendish Laboratory* [London: Nelson, 1964, p.53]. In 1906, Millikan reproduced this picture in *A First Course in Physics*, but he carefully etched out the cigarette in Thomson's left hand. Millikan presumably did not want to corrupt young physics students, and therefore thought he had best change the moral tenor of the great physicist's image. Millikan, in short, was absolutely shameless in his falsification of history.

Roger H. Stuewer
Minneapolis, MN

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It was interesting to reread Robert Millikan's 1949 tribute to Einstein (*APS News*, January 2004.) We should be reminded, however, that Millikan's version of the genesis of special relativity is grossly inaccurate. According to Millikan, Einstein was led to his theory directly by the null result of the Michelson-Morley ether-drift experiment, but that scenario is almost surely untrue.

There is some question as to whether Einstein even knew of Michelson's result when he wrote his 1905 relativity paper. In a 1950 interview, Einstein told Robert Shankland that he became aware of the result through the writings of Lorentz, *but only after 1905*! "Otherwise", he said, "I would have mentioned it in my paper."

When Shankland raised the question again two years later, Einstein gave a different response. "This is not so easy", he said. "I am not sure when I first heard of the Michelson experiment. I was not conscious that it had influenced me directly during the seven years that relativity had been my life."

He added that in the years 1905-1909 he thought a great deal about Michelson's result. He then realized that he had also been conscious of the result before 1905, partly from the papers of Lorentz and more because he had "simply assumed this result of Michelson to be true."!

Abraham Pais, who knew Einstein well and wrote his scientific biography, was certain that Einstein did know about Michelson's experiment before 1905. He points out that Einstein was over seventy and in poor health when he spoke to Shankland; at the first interview he probably did not remember that Michelson's experiment is discussed in Lorentz's 1895 monograph, the famous "Versuch", which Einstein had definitely read before 1905.

Even if Einstein was aware of Michelson's result, however, we must accept his assertion that it was not a major motivating factor in his discovery of relativity. He repeatedly uses terms like "negligible", "indirect", and "not decisive" to describe the influence of Michelson's experiment on his thinking. In a penetrating analysis of the issue, Gerald Holton concludes that "the role of the Michelson experiment on the genesis of Einstein's theory appears to have been so small and indirect that one may speculate that it would have made no difference to Einstein's work if the experiment had never been made at all." In the light of this assessment, Einstein's achievement looms all the more remarkable.

If Einstein was not guided by the result of Michelson's experiment, how then did he arrive at relativity? That is the intriguing question. Einstein's paper provides little guidance. In it the postulate of the constancy of the velocity of light is presented with no explanatory remarks or motivation, almost as though it were a routinely accepted proposition instead of a daring departure from conventional notions.

In an autobiographical essay written in 1949, Einstein describes a paradox that had occurred to him at age sixteen. If one pursues a beam of light at the velocity c, he notes, one should observe a spatially oscillatory electromagnetic field at rest. But there seems to be no such thing, either on the basis of experience or according to Maxwell's equations.

"From the very beginning it appeared to me intuitively clear that, judged from the standpoint of such an observer, everything would have to happen according to the same laws as for an observer who, relative to the earth, was at rest." The seed of the theory of relativity had evidently been planted when Einstein was only sixteen years old! The idea that light has the same speed for all inertial observers, so difficult for an ordinary mind to accept, seemed quite natural to Einstein. He was fully prepared to accept it even without strong experimental evidence.

In the Shankland interview, Einstein said that the experimental results that had influenced him most were the observations on stellar aberration and Fizeau's experiment on the speed of light in moving water. "They were enough", he said. This assertion is perplexing because both stellar aberration and the result of Fizeau's experiment are readily accounted for without relativity. Fizeau in fact thought he had confirmed Fresnel's ether drag theory.

Millikan emphasizes that modern science, unlike Greek philosophy and all medieval thinking, takes as its starting point well-authenticated, carefully tested experimental facts. This is almost universally true, but relativity appears to be one of the few exceptions. It is easy enough to understand Millikan's desire to give Michelson credit. He was an experimenter and he greatly admired Michelson, under whom he had worked as a young man. The scenario he described was one he wanted to believe. But the true genesis of special relativity apparently lay in Einstein's inspired intuition.

As is well known, Einstein's paper contains no references whatever. It does refer to "unsuccessful efforts to discover any motion of the earth relative to the 'light medium,' " without identifying any of those efforts. The Michelson-Morley experiment was only one of them. Einstein's first reference to the M-M experiment was in a review article he published in 1907.

Leo Sartori
Lincoln, NE

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The relativistic correction to the classical aberration formula is only about 10^{-7} seconds of arc, much too small to be detected.

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In the January 2004 edition of the *APS News*, an article by Robert A. Millikan has been reprinted which is considered to be "especially noteworthy because it describes the content and significance of Einstein's three great papers of 1905". In this article, Millikan writes that "the special theory of relativity may be looked upon as starting essentially in a generalization from Michelson's experiment." Regarding the null effect of the Michelson-Morley experiment, Millikan quotes Einstein as calling out to us all, "Let us merely accept this as an established experimental fact and from there work out its inevitable consequences".

But there is no evidence that Einstein ever made such a remark. On the contrary, in his 1905 paper "On the Electrodynamics of Moving Bodies", Einstein did not refer to the Michelson-Morley experiment or to any other papers. Instead, Einstein motivated his "principle of relativity" by calling attention to "the reciprocal electrodynamic action of a magnet and a conductor", pointing out that the "observable phenomenon" (the current induced in the conductor) depends only on the relative motion of the magnet and the conductor.

In 1920, Einstein recalled that "in setting up the special theory of relativity, the following...idea about Faraday's electromagnetic induction played a guiding role. According to Faraday, relative motion of a magnet and a closed electric circuit induces an electric current in the latter. Whether the magnet is moved or the conductor doesn't matter; only the relative motion is significant...The phenomena of electromagnetic induction...compelled me to postulate the principle of relativity." And again, in 1952, Einstein wrote that "My direct path to the special theory of relativity was mainly determined by the conviction that the electromagnetic force induced in a conductor moving in a magnetic field is nothing other than an electric field. But the results of Fizeau's experiment and the phenomena of aberration [discovered by James Bradley in 1727] also guided me."

Einstein's reticence to acknowledge the Michelson-Morley experiment has been well documented. In a letter to the historian F.C. Davenport, written a year before his death, Einstein consistently remarked that "in my own development, Michelson's result has not had a considerable influence. I even do not remember if I knew of it at all when I wrote my first paper on the subject (1905). The explanation is that I was, for general reasons, firmly convinced that there does not exist absolute motion, and my problem was only how this could be reconciled with our knowledge of electrodynamics. One can therefore understand why in my personal struggle, Michelson's experiment played no role, or at least no decisive role."

One would hope that next year, while commemorating Einstein's monumental 1905 achievements, long standing myths like the one propagated by Millikan's article, that Einstein was motivated by the Michelson-Morley experiment to

See **LETTERS** *continued on page 5*

LETTERS

Continued from LETTERS *on page 4*
discover the special theory of relativity, should finally be dispelled.
Michael Nauenberg
Santa Cruz, CA

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Robert Millikan writes about Einstein's character being an example of "the distinguishing feature of modern scientific thought...that takes...as its starting point...experimental facts."

It's true that the Michelson & Morley experiment took place well before Einstein published his theory; but, as Polanyi says he confirmed with Einstein himself, the theory of relativity was not based on news of that experiment but on entirely independent thought begun before it: *"Its findings were, on the basis of pure speculation, rationally intuited by Einstein before he had ever heard about it"* (page10 in Personal Knowledge). The positivistic account, says Polanyi, is therefore "an invention" and "the product of a philosophical predjudice": "When Einstein discovered rationality in nature, unaided by any observation that had not been available for at least fifty years before, our positivistic textbooks promptly covered up the scandal by an appropriately embellished account of his discovery."

Einstein said that Ernst Mach's Die Mechanik in ihrer Entwicklung (1889) had a "profound influence" on his thought. This influence was a positive force in the development of relativity theory, but the irony is that it was not the sort of influence Mach himself could have imagined having. It grew out of Mach's objection to Newton's idea of absolute space, on the ground that since it could not be tested by experiment it was meaningless.
Doug Mounce
Seattle, WA

Hydrogen Economy: Pleasant Ideas vs. Basic Science Constraints

In "Revolutionary Breakthroughs Needed for Hydrogen Economy" (*APS News* November 2003), Andrew Lenard's response (*APS News* January 2004) points out that contrary to representations or public impressions, *hydrogen is not an energy source*. It can be created only by consumption of a *still greater amount of an existing energy form*. That is fundamental thermodynamics. That is not the only basic problem with the "hydrogen economy". As scientists and educators, must we not point out other prevailing misconceptions (or ignorance?) of fundamental and limiting laws of nature?

The interest in hydrogen as a fuel arose decades ago from environmental pollution concerns, now specifically directed to prevent continued increase of global warming by continued addition of some 2.5 x 10^9 tons/year of CO_2 (and more every year). If hydrogen fuel was generated from existing fossil energies, this would conveniently concentrate the task of CO_2 removal to the location of the hydrogen production facility. Such technology for large-scale and permanent capture is conveniently termed CO_2 "sequestration", but it does not exist. It offers challenges and research support for innumerable ideas in many branches of science, technology and business. It behooves the scientist community to point out that very fundamental physical and chemical science and arithmetic seriously handicap its accomplishment.

Physically pumping high concentrations of CO_2 into selected deep sea or geological locations is possible but permanence of such disposal would be variable and uncertain for different locations. It would be similar to 'hiding' in a remote location with duration poorly predictable for our descendents or ourselves.

Any process system to permanently capture CO_2 requires its transformation to a stable solid product on earth. Thermodynamics requires a reaction partner of sufficient chemical free energy. There are no large quantities of such material readily available. Some minerals such as serpentine (MgO) could form solid carbonates. But this would require locating, mining, transporting, activating the mineral, processing the CO_2 reaction and burial of the products in amounts greater than some 2.5 x 10^9 tons per year. The entire operation would itself consume additional fuel energy and further increase the amount of CO_2 to be eliminated.

Many proposed methods of 'sequestration' involve generation of added biological growth in the marine or terrestrial ecosystem. The great kinetic complexity of the huge number of interactive phenomena makes it difficult to determine the course and ultimate result of any proposed intervention. However, basic thermodynamics, kinetics and arithmetic dictate definable limits of performance for the overall system regardless of detail.

Any biological growth will consume atmospheric CO_2 during its life cycle. Then, CO_2 is returned by decomposition (oxidation, directly or via 'food' chains involving biological intermediates, burning, etc.), with only a minor fraction 1/n of permanent earthly residue remaining. Thus 'sequestration' is achieved initially to the extent new growth is added. However, as steady state is achieved, only 1/n of added growth remains 'sequestered'. Therefore, capture of a magnitude of some 10^9 tons per year would require addition of n x 10^9 tons of biological—maritime or terrestrial—living matter. This is an objective of rather fantastic magnitude.

In any event, how can we create additional living biochemical matter, anyway? It requires photosynthesis, *i.e.* solar energy. We cannot increase solar energy flux. Can we increase its effectiveness? In terrestrial agriculture we use "fertilizers".

They are carriers of additional chemical free energy. For terrestrial use we *produce them using fossil fuel energy*. (Remember, fertilizers have occasionally been used to make explosives). We also produce fertilizer by photosynthesis, by dedication (rotating) land acreage, *i.e.* a fraction of available solar input received, to grow nitrogen-fixing legumes to subsequently fertilize the soil for the next harvest.

Marine life is also stimulated by marine photosynthesis of high chemical energy (nitrate) 'fertilizers'. But can we increase total photosynthesis of the biological products and the energy intermediates we call 'fertilizers' from the same surface of solar radiation received? This does present a very challenging fundamental research question: Can we *catalyze* biological photosynthesis, *i.e.* find a catalyst that will not be consumed itself?

Creation of a "hydrogen economy" is a fascinating objective for funding and investigation of innumerable ideas. However, as long as fossil fuel energy must be used to generate the hydrogen, the very basic difficulty, if not impossibility, is the return of the vast amount of carbon extracted and oxidized by *Homo sapiens* back to permanent fossil status on earth.
Paul B. Weisz
State College, PA.

Need Guidelines For Objective Evaluation

I am surprised at David Thouless's assertion that scientific ethics is culture-dependent. Culture certainly impacts the practice of science: our work-hours and work-habits, our interpersonal relationships, our demeanour, our informal interactions. Such factors often influence which students get noticed as early achievers, which early researchers get propelled on the scientific fast-track, which senior researchers break in more forcefully to have the last say in a group discussion. But they can, and should, be judiciously screened out by any physicist during the objective process of academic evaluation and scientific review.

Are we physicists doing a sufficiently conscientious job in this regard? What I believe is necessary is not so much a longer set of rules on eliminating conflicts of interest. This has the problem that, in an era of specialization, it often leaves nobody adequately competent to review a given grant proposal or manuscript. Instead, we need a tool kit of guidelines on *how* to evaluate objectively—screening out information about the candidate that should be clearly irrelevant from the viewpoint of professional ethics. I would urge the APS to begin the process of formulating consensus on such guidelines. Accurate and objective evaluations are central to the continued health of our field.

Finally, I strongly support the APS's new guideline that a submission be reviewed by all listed co-authors. Co-authorship can cover a variety of contributions: a key idea, helpful physical intuition, calculation or data analysis, significant scientific programming assistance, coherent pedagogical presentation of previous work, or, best of all, equal research contribution. (Not management. If relevant, as in a large project, that belongs with the acknowledgment of financial and administrative support item.) The distinctions in author contribution are usually spelled out in peer review letters, or in informal exchange.

As a junior postdoc, I remember including co-author names on my conference proceedings even when I was both sole presenter, and sole author of the written-up talk. This was unnecessary, possibly stemming from a lack of confidence. This could well be a cultural issue: I'm Indian-educated, and female. Of course, I had the submission reviewed by my senior co-author. This was no ethical dilemma. But I have also had the reverse experience of a fellow postdoc publicly posting the proceedings of a talk listing all four co-authors, but without our prior review. The APS guideline prevents such professional embarrassments: I could have simply removed my name from what I thought a totally inaccurate presentation of our research goals and results.
Shyamoli Chaudhuri
Bellefonte, PA

Huey is Screwy

I enjoyed the Zero Gravity in January's *APS News*—except that Huey screwed up at the end, thinking that he was pitching from first base, rather than from the mound (60' 6" from the plate).
Kermit Smyth
Darnestown, MD

Use Renewable Energy to Make Hydrogen

Andrew Lenard in his letter in the January issue of *APS News* is correct in stating that hydrogen obtained from hydrocarbons would gain nothing, in fact would result in a net loss of available energy and would do more damage to the environment than a direct use of these hydrocarbons. Apparently he does not consider producing hydrogen or electricity by solar cells, wind energy or other renewable sources. At the present time these methods are more expensive but with mass production and improved engineering the cost could be reduced.

How does one put a price tag on the needless waste of human lives resulting from wars and other aggressive actions to insure the flow of oil?
Clarence M. Cunningham
Stillwater, OK

First American Physics Nobelist Paints Pretty Picture

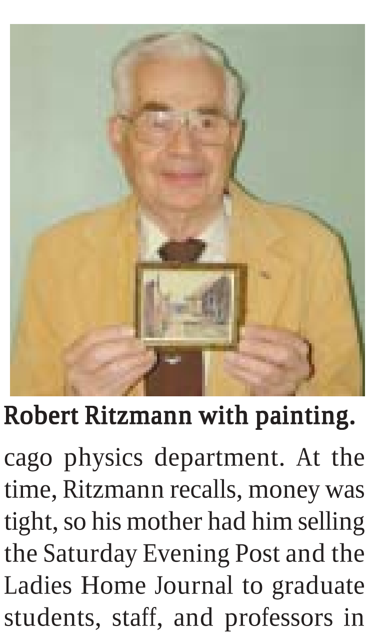
By Ernie Tretkoff

The painting on page one is by Albert A. Michelson (1852-1931), best known for his measurements of the speed of light that helped put to rest the concept of the ether. (See the extensive discussion on page 4.) Michelson became the first American to win the Nobel Prize in physics, in 1907.

Among his hobbies, which included billiards, chess, and playing the violin, Michelson enjoyed painting, mostly watercolors of California landscapes, many of which he hung on the walls of his house and office at the University of Chicago.

This particular painting, a small, 10 x 13 cm watercolor, belongs to Robert Ritzmann, a retired nuclear engineer whose mother worked as a secretary and stockroom clerk in the University of Chicago physics department in the early 1930's. Mrs. Ritzmann worked across the hall from Michelson's office, and during his recuperation after a cerebral hemorrhage in 1930, she would deliver Michelson's mail to his house and let him dictate replies to her.

Ritzmann said the reprint of Robert Millikan's 1949 article, "Albert Einstein on His Seventieth Birthday," [*APS News* Back Page, January 2004] brought back memories of tagging after his mother in the University of Chicago physics department. At the time, Ritzmann recalls, money was tight, so his mother had him selling the Saturday Evening Post and the Ladies Home Journal to graduate students, staff, and professors in the department, though at the time he didn't know who these people were. "As a seven year old I hadn't the slightest idea of the accomplishments of Drs. Michelson, Compton, Millikan and others," said Ritzmann.



Robert Ritzmann with painting.

According to Ritzmann, one day in Michelson's office across from the stockroom, his mother told Michelson she'd like to have one of his paintings. He reached up, took this small, framed watercolor off the wall, turned it over, and signed it, "*With Kind Regards A.A. Michelson.*" Mrs. Ritzmann kept the painting for over fifty years and passed it on to her son.

MARCH MEETING *from page 1*

ducting Quantum Interference Devices (SQUIDs) have found application as highly sensitive sensors and detectors, and are now being applied in magnetic resonance imaging (MRI) applications. Researchers at UC-Berkeley and Lawrence Berkeley National Laboratory have acquired two-dimensional images of water, mineral oil phantoms and pepper slices in less than two minutes by performing MRI with a low-T_c SQUID detector. The new system is ideally suited for imaging small, peripheral parts of the human body, such as fingers and wrists. The team has also demonstrated ultra-low-field MRI using an untuned SQUID detector, achieving 1-mm resolution images. Both results will be discussed at the meeting. *[Session A39]*

Navigating Landmines. Because of their ease of employment, lost cost, and effectiveness, land mines have become an almost ubiquitous weapon in the last 50 years. There are now more than 45 million potentially threatening land mines around the world, and new mines are being placed much faster than they can be removed, so the problem is worsening. Current estimates of casualties resulting from land mines exceed 15,000 per year, and many are civilians, even children. Thomas Altshuler of Rockwell Scientific Company will provide an overview of the issue, and Frank Rotondo of the Institute for Defense Analyses will discuss advances in new detection technologies, including ground-penetrating radar, improved electromagnetic induction metal detectors, nuclear-quadrupole resonance and acoustic/seismic detectors. *[Session D39]*

Amorphous Imaging. Amorphous silicon is an extremely successful materials technology that is well-suited to a range of imaging applications in both medicine and imaging. For example, amorphous silicon transistor arrays are now changing the technology for medical x-ray imaging, thanks to the ability to create field effect transistors, diodes and other semiconductors. Speakers at a Tuesday afternoon session described some of the latest advances in amorphous silicon devices and applications, including x-ray and infrared sensors for high-resolution detectors. *[Session L5]*

The Science of Middle-Earth. The works of J.R.R. Tolkien can provide a creative means of demonstrating the relevance of science (especially astronomy) to non-science majors, according to Kristine Larsen of Central Connecticut State University, who has designed just such a course. For example, in order to add depth and realism to his mythological creation, Tolkien invented his own constellations, some of which correspond to actual star groupings, and the internal chronology of the "Lord of the Rings" trilogy was timed to the cycle of lunar phases. Also featured in the session is a presentation of a new type of Dunking Bird, the popular physics toy that operates on the chemical potential energy of unevaporated water. The new version operates on the same principle, but is not a heat engine. *[Session L27]*

Cryogenic Cabaret. Among the social highlights will be a Thursday evening performance of "Cryogenic Cabaret," the brainchild of emeritus professor Marcel LeBlanc, who has received the Royal Society of Canada's McNeil Medal for the promotion of science to the public. An expert in cryophysics, LeBlanc chills his audience with a –78º C blizzard, freezes liquid nitrogen by boiling, morphs into a dragon spouting–200º C vapors, and transforms soggy frozen cigars into torches. He also sings, levitates magnetic and electric coils, smashes rubber balls, and explodes hydrogen balloons, all in the interest of presenting the fundamentals of cryoscience to experts and lay audiences alike.

The Sounds of Trumpets. Scientists from SUNY Geneseo are exploring the connections between the methodology of trumpet playing and the quality of the sounds produced, which are poorly understood. For example, they are studying the force with which the instrument is pressed against the lips, especially to hit higher pitches. These forces vary greatly among different players, sometimes by a factor of three or four. The team has modified a trumpet to monitor the force applied by players of all skill levels, along with the sound spectrum and players' facial expressions, and will present its findings during a Monday afternoon session. *[Session D39]*

Tracking Dust in the Ice. Scientists from the University of California, Berkeley, have developed a new paleoclimatological instrument called the Dust Logger. The instrument is a spinoff of the Antarctic Muon and Neutrino Detector Array (AMANDA) project, a collaboration that searches for astrophysical sources of high-energy neutrinos. The Dust Logger emits laser light into glacial ice surrounding the borehole being studied. It records light that re-enters the borehole after being partially absorbed and scattered by dust in the ice. The signal serves as an accurate proxy for global temperature as a function of time over a million years. The team also invented a BioSpectral Logger which emits 224-nm laser light into ice, searching for fluorescence by microbes able to live in liquid veins in ice. The team hopes a miniaturized version can search for life in Martian permafrost. *[Session G1]*

Crossover Physics. Some of the most exciting physics research these days is taking place at disciplinary interfaces, and this will be the focus of a special session exploring some of those emerging areas. For example, neutron stars provide a remarkable setting for problems at the intersection of condensed matter and nuclear physics, such as neutron and proton superfluidity and the sudden speed-ups of pulsars and their relation to nucleic vortices in stellar crusts, as well as achieving a better understanding of the physics of matter under extreme conditions. Other interdisciplinary areas featured in the session include links between string theory and other areas of physics and mathematics, and condensed matter, computational dynamics and the workings of the brain. *[Session G1]*

Captains of Industry. Roland Schmitt (Rensselaer Polytechnic Institute) will discuss the pioneering achievements at the G.E. Research Laboratory, which was founded in 1900 and became the first industrial physics research lab, with such major contributors as William Coolidge, Irving Langmuir, and Ivar Giaever. Princeton University's Philip Anderson will talk about the rise of physics research at Bell Labs, starting in the 1920s with the discoveries of electron diffraction and thermal noise. Closing the session, Allen Fowler will give a brief history of physics at IBM's T.J. Watson Research Center, and Jennifer Chayes will talk about physics research at Microsoft. Thursday morning will feature a session looking to the future of industrial physics, with talks by such major leaders as 2003 Pake Prize recipient Robert White (now at Carnegie Mellon University), Motorola's Iwona Turk on nano-electronic technology, Ford Motor Company's Kennneth Hass, and Charles Duke of the Xerox Wilson Center for Research and Technology. *[Sessions H6, U4]*

Towards the Hydrogen Economy. Last year, the DOE released a report on the basic research needs required to achieve the practical "hydrogen economy" touted in President Bush's 2003 State of the Union address. At the March meeting, a special Tuesday evening session will discuss the findings of that report and summarize some of the latest research results in hydrogen production, storage and use in fuel cells. Topics include schemes for the biomimetic production of hydrogen—sort of a man-made photosynthesis—and for producing hydrogen through solar photolysis of water, as well as promising new techniques for hydrogen storage. *[Session m1]*

Pioneering Women. The meeting will feature several talks on pioneering women in physics. Monday afternoon will feature a presentation on Canada's first woman physicist, Harriet Brooks, who worked under both Ernest Rutherford and J.J. Thomson at Cambridge University's famed Cavendish Laboratory, and later worked with the Curies in Paris. She investigated the nature of "emanation" from radium; discovered that radioactive substances could undergo successive decay; and first reported the recoil of the radioactive atom, all this at a time when women in science were few and far between. On Wednesday morning, various speakers will talk about the lives and accomplishments of Agnes Pockels—a German-born woman scientist who pioneered studies of surface science, particularly monolayers at the air/water interface—and Katharine Blodgett, the first woman scientist to join the GE research staff, and the first to obtain a doctorate from Cambridge University's prestigious Cavendish Laboratory. *[Sessions D5, N7]*

Special Events

Saturday and Sunday, March 20-21
DPOLY Short Course
"Rheology and Dynamics of Polymers and Complex Fluids"
8:00 am – 5:00 pm

Sunday, March 21
Tutorials
Morning: **8:30 am – 12:30 pm**
Afternoon: **1:30 pm – 5:30 pm**

Workshop
Survival Skills for Successful Women Physicists
1:30 pm – 5:45 pm

Career Workshop
3:00 pm – 6:00 pm

Monday, March 22
Awards Program
5:15 pm – 6:15 pm

Welcome Reception
6:30 pm – 7:30 pm

Tuesday, March 23
CSWP/FIAP Networking Breakfast
7:00 am – 9:00 am

Meet the AIP and APS Editors
3:30 pm – 5:30 pm

Student Reception
5:30 pm – 6:30 pm

APS/DCMP/DMP Town Meeting
6:30 pm – 7:30 pm

Alumni Reunions
6:00 pm – 8:00 pm

Wednesday, March 24
Students Lunch with the Experts
12:30 pm – 2:00 pm

CSWP/FED/FGSA/IOP Reception
5:30 pm – 7:00 pm

Thursday, March 25
Cryogenic Cabaret
5:30 pm – 6:30 pm

SUPERCOMPUTERS *from page 3*

money and time developing machines themselves. QCDOC took years to design, and even Christ admits that it's been hard for him to find time to do physics while building the computers, though he said he expects to do more physics soon. "At the moment we're up to our eyeballs in constructing this machine. We'll soon transition to doing what we think will be very exciting science, " he said.

Gottlieb agrees that the QCDOC machine could be tremendously powerful, but points out that some types of calculations, such as those involving Fourier transforms, wouldn't work well on it. QCDOC would also have trouble with sparse matrices and implicitly solved partial differential equations, such as diffusion-type problems, said Glimm. Even for problems that QCDOC could solve well, said Gottlieb, "the expertise needed to program the machine very efficiently is not widespread."

"Probably the right answer is to have a mix of the two approaches," said Sugar, who has organized a large part of the US lattice gauge community—about 150 researchers—behind efforts to increase both computing power and software development for lattice calculations. The group, which will work on both QCDOC and cluster approaches, has received a grant from the Department of Energy under SciDAC, (Scientific Discovery through Advanced Computing). The SciDAC collaboration will also focus on developing efficient, easy-to-use software for both platforms. Sugar pointed out that improved algorithms are often as important as increased computing power.

In fact, many calculations don't even require supercomputers at all, especially as desktop workstations increase in speed, points out Richard Haymaker, a lattice gauge theorist at Louisiana State University. "A tremendous amount can be done on just workstations," he said. Though large groups and powerful computers may have gained the spotlight, many lattice gauge theorists still work on individual machines and produce useful results. Most of these calculations are not the sort that can be directly compared to experimental results, he added, but they do provide a lot of insight into the theory. "There's a whole spectrum of needs for both small and large-scale calculations," said Haymaker.

It's often hard to tell how much computing power is needed for a particular problem. "I've often said the last 20 years of my life are testimony to my inability to estimate how much time it would take to solve this problem," said Gottlieb. In the early 80's people were happy with a megaflop. Several years ago, Gottlieb remembers thinking, "If I only had 10 gigaflop-years, I could clear this up." Gottlieb now estimates 10 teraflops sustained would result in a lot of progress soon.

Though QCDOC looks very cost-effective, the US lattice gauge community needs more funding to buy the machines in order to remain a leader in the field. "This is an opportunity we're about to throw out the window," said Fred Cooper, of the National Science Foundation, when asked whether the NSF could help fund supercomputers for lattice gauge theory.

As the US scientists await funding, a group in the UK and a Japanese group have already invested in QCDOC machines. " It would be odd if there weren't one for the US community," said Sugar. The Columbia group is not the only one working on special purpose computers for QCD. An Italian collaboration, called APE, is also building special purpose computers for lattice QCD.

Japan has traditionally invested a lot of money in supercomputing, and is now home to the most powerful computer in the world, the earth simulator, a climate-modeling system that runs at over 35 teraflops and costs an estimated $250 million.

Though the US lattice gauge community isn't asking for a $250 million machine, they acknowledge that the US will have to invest money in lattice gauge computing in order to stay a leader in the field. "If we don't do anything, we will fall behind," said Sugar, "but I find it hard to believe that will happen."

ANNOUNCEMENTS

See the

"Call for Nominations"

for all APS Prizes and Awards on page 8 of the Prize and Awards insert.

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You will find the following in the online edition of Reviews of Modern Physics at http://rmp.aps.org.

Control of star formation by supersonic turbulence
—Mordecai-Mark Mac Low and Ralf S. Klessen
New stars are created in giant clouds of molecular gas, but the dynamics of these clouds and the processes controlling how rapidly they make stars have long been a puzzle. For many years, internal magnetic fields were thought to play the central role; new evidence suggests that hydrodynamic turbulence may instead be the key.

Also Recently Posted:
Quantum Information and Relativity Theory
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Colloquium: The Quest for High-Conductance DNA
—R. G. Endres, D. L. Cox, and R. R. P. Singh

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If you're looking to fill or find a job, the new APS Online Job Center at **http://careers.aps.org** is your one-stop shop. Jobseekers and employers alike will find the APS Job Center, which now receives over a million hits from 20,000 unique visitors monthly, to be an invaluable resource.

The APS Job Center contains hundreds of new jobs posted monthly and offers a database of thousands of resumes. It covers all physics fields plus related fields such as materials science, computing, biology, chemistry, and engineering.

EMPLOYERS

Whether you're an HR manager or a member of technical staff looking to hire, you can take advantage of valuable services for a low cost.

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- Search jobs by multiple criteria
- Apply for jobs directly online to save time and paper
- Store multiple copies of resumes for different kinds of jobs
- Create automatic job alerts—you'll be contacted as soon as your dream job is posted.

If you have any questions about any of the services, please contact us at **jobs@aps.org.**

BEAUSANG *from page 1*

far. Beausang plans to offer his course again in February.

While many first responders had already received some training dealing with radiation, the amount of the knowledge they had varied. US Coast Guard officer Mike Edgerton said he attended Beausang's course with his unit "to become more knowledgeable regarding the behavior and property of radiation, in order to improve our ability to respond to potential contingencies involving radiation, and to learn about the effects of shielding and other barriers in detecting radiation sources." Edgerton said his unit found the course very helpful. "I believe that we significantly improved our understanding of radiation," he said.

Lee Schroeder, a nuclear physicist at Lawrence Berkeley National Laboratory, has organized a similar course, covering the basics of radiation and offering some hands-on experience.

He started thinking about offering the course in the summer of 2002, when the Department of Energy, the National Science Foundation, and the APS Division of Nuclear Physics (DNP) put a workshop together in Washington on the role of the nuclear physics research community in combating terrorism.

The workshop led to several broad recommendations, one of which was that the nuclear physics community should explore ways of better communicating knowledge of nuclear physics to all interested groups. "The thing that really came out is a sense in the community that one of the things we have to offer is educational outreach," said Schroeder. He decided to get in touch with the Berkeley city council to organize the radiation course.

Several LBNL researchers and staff members, including life scientists and environmental health and safety experts, contributed by teaching a segment of the course. Between 70 and 80 first responders, mainly firefighters and HAZMAT workers, attended the classes. These first responders became more familiar with their instruments and learned what to do when they find radiation or believe that an area is contaminated.

"Although first responders have had information like this, having the opportunity to talk to nuclear scientists on those subjects has been useful," said Schroeder.

The course started in November, and included a total of 12 sessions lasting 2.5 hours each. Now Schroeder is seeking feedback and considering how to modify the course for the future. "We expect this to be going forward," he said.

Both Beausang and Schroeder believe other physicists may be reaching out to their communities in similar ways, but at the moment no organized structure exists for physicists who want to teach these kinds of courses.

The DNP has planned a joint session with the Physics and Society Forum for the April meeting in Denver. Schroeder said the session would include discussion of outreach efforts like the classes Beausang and Schroeder have organized.

Neither Beausang nor Schroeder receive any funding for their courses, though LBNL encourages outreach and offered some release time to scientists and staff members who helped prepare and teach the course. Schroeder also said he would look into getting funding from the Department of Homeland Security or other sources.

Schroeder envisions running the course in Berkeley for first responders about once a year, or maybe offering it to a larger base of community members.

"It's pretty clear that the lack of knowledge regarding the nature of radiation is fairly large, and a lot of people are both concerned and frightened," he said.

MONTRÉAL *from page 1*

Why all the confusion? The explanations are simple.

Downtown Montréal is the strip between the river and the mountain. The streets there were laid out with the convention that the river flowed from west to east, which it predominantly does as it makes its way from Lake Ontario to the Atlantic. But as it goes past downtown Montréal it is flowing much more south to north. Hence the main east-west streets, like Sherbrooke and Ste. Catherine, are really north-south, and the main north-south streets, like the fabled St. Lawrence Boulevard, are basically east-west. On a summer evening, you could look "north" on St. Lawrence Boulevard, and see the red sun just about to set. An unnerving, or at least a disorienting, experience.

Naturally enough, Montréalers' notion of up and down derive from the mountain. "Up" is taken to mean in the direction from downtown toward the mountain, which is "north" (really west). So, "his office is two blocks up Peel Street" means two blocks toward the mountain and away from the river. This all makes perfect sense. When I was growing up, though, we lived in Outremont, a residential area on the other side of the mountain from downtown. But to my mother "up" continued to mean "north" (*i.e.* west). So when she would tell me to go to the store two blocks "up" Rockland, what she meant was literally down, away from the mountain. And vice versa. I've never quite forgiven her for this.

The confusion over the St. Lawrence River was strictly my own fault. It arose from the mismatch between two pieces of data. The first was any normal map, in which north is up and the St. Lawrence flows from left to right. The second is the view of downtown Montréal and the river beyond that I often enjoyed from the lookout on the "southern" (really eastern) slope of Mount Royal. Since the river flowed from left to right on the map, I couldn't shake the intuition that it was also flowing from left to right as I looked at it from the mountain, notwithstanding that this meant it would be flowing away from the Atlantic and toward the Great Lakes.

As the years have gone by, Montréal has evolved into a city that is probably much more interesting than the one I grew up in. I'm looking forward to going back for the APS March meeting, and I'm sure it will be an enjoyable experience. Just don't ask me where to stay or where to eat—I'm clearly not up to the directional challenge.

A Bush Blumes in Kolkata

In November, APS Editor-in-Chief Martin Blume delivered the 14th S. N. Bose Memorial Lecture at the Bose National Centre for Basic Sciences in Kolkata, India. The title of his talk was "X-Rays, Synchrotron Radiation and the Properties of Matter: A Continuing Revolution". To commemorate the lecture, Blume followed tradition in planting a bush on the grounds of the Centre; he then paused to admire his handiwork with his wife, Sheila.

RULE CHANGE *from page 1*

nominations should be sent to: Shelly Johnston, Attn: George E. Valley Prize, American Physical Society, One Physics Ellipse, College Park, MD 20740-3844. Further information about the Valley Prize is available at http://www.aps.org/praw/valley/index.cfm .

In another development, two awards in the field of Fluid Dynamics have been merged to create one major prize. Effective this year, the Otto Laporte Award will be combined with the old Fluid Dynamics Prize to establish a new prize, also named the Fluid Dynamics Prize.

This new Prize will carry a stipend of $10,000.

The Otto Laporte Award began as the Otto Laporte Memorial Lecture in 1972 and became an APS Award in 1985. Previous winners of the Award will continue to be listed on the APS web site at http://www.aps.org/praw/laporte/index.cfm. All new nominations for research in fluid dynamics should be directed to the Fluid Dynamics Prize; the relevant information is at http://www.aps.org/praw/fluid/index.cfm .

The Back Page

"Dirty Bombs:" The Threat Revisited

By Peter D. Zimmerman

Many Americans first heard the term *dirty bomb* on June 10, 2002, when Attorney General John Ashcroft announced the arrest of Jose Padilla on the charge of plotting to detonate a device containing both high explosive and very radioactive material. The attorney general defined it as: "*[A] radioactive 'dirty bomb' involves exploding a conventional bomb that not only kills victims in the immediate vicinity, but also spreads radioactive material that is highly toxic to humans and can cause mass death and injury.*"

On March 6 of the same year, the Senate Foreign Relations Committee held a hearing on the question of radiological dispersion devices (RDDs), the technical term for dirty bombs, and their ability to cause casualties and damage. Experts from inside and outside government testified that an RDD could cause economic harm but was unlikely to cause deaths or injuries beyond the area immediately destroyed by the high explosives used to spread the radioactive material.

Radiation is said to cause deterministic harm if an individual can be identified who received a known exposure to radiation and became ill as a result. Such illness or injury can include classic radiation sickness (hematological effects, loss of appetite, vomiting and other gastrointestinal damage, hair loss, death) or radiation burns on the skin. It is also conceivable that some individuals exposed to quite small doses of radiation might develop cancers.

Economic and psychosocial effects are likely to be the most serious damage mechanisms from any use of an RDD. The fear of ionizing radiation is a deep-seated and frequently irrational carry-over from the Cold War. The threat of a radiological attack on the US is real, and terrorists have a broad palette of isotopes to choose from. An RDD attack is unlikely to cause mass deaths, but it could cause tens to hundreds of fatalities under the right circumstances, and is essentially certain to cause great panic and enormous economic losses.

From the long list of known radioactive isotopes only a few stand out as being highly suitable for radiological terror. These are cobalt-60 (^{60}Co), strontium-90(^{90}Sr) (and its short-lived daughter, yttrium-90), cesium-137 (^{137}Cs), iridium-192, radium-226, plutonium-238, americium-241, and californium-252. Radioactive material suitable for use in an RDD may be found, stolen, or purchased legally. Those materials most likely to cause great harm are also ones that have significant commercial applications and are widely available. They are employed in thousands of different medical, academic, agricultural, and industrial settings around the world, including medical therapy, food irradiation, communication devices, navigation beacons, and oil well logging. This makes it extremely difficult not only to secure, but also to regulate these sources. Two of the worst radiation accidents, the Goiânia tragedy and the 1984 Juarez, Mexico melting of ^{60}Co as scrap steel (from an abandoned and stolen teletherapy source), were the direct result of the theft of the radioactive material from abandoned radiation therapy facilities.

By far the most likely route for terrorist acquisition of intermediate quantities of radioactive material (100-10,000 curies) is open and legal purchase from a legitimate supplier. Until some time after the World Trade Center and Pentagon attacks, regulation of radioactive sources was geared towards ensuring the safe use of the material by people and organizations presumed to be acting without malice. Inspections of facilities designed to hold moderate to large sources, such as those used in industrial radiography or teletherapy, rarely took place until at least six months after a license was issued and the source shipped.

The US Nuclear Regulatory Commission (NRC) has estimated that approximately one licensed US source is lost every day of the year. NRC officials report that they have begun the process of revising licensing regulations for acquisition of radioactive sources and that they have taken interim steps to determine that license applicants are unlikely to divert material to illicit uses. These steps have not yet been publicly described.

The 1987 Goiânia, Brazil Event

On 13 September 1987, two scrap metal scavengers broke into an abandoned radiotherapy clinic and removed a source capsule from the protective housing of a teletherapy machine. The source capsule contained 1375 curies (Ci) of cesium-137 chloride in soluble form. It had been abandoned when the Goiânia Institute of Radiotherapy moved to a new location in the city two years earlier. The two thieves took it by wheelbarrow to the home of one of the men, a distance of half a kilometer. The same day both men were vomiting because, they assumed, of bad food they had eaten.

On 18 September, one of the thieves punctured the 1-mm thick window of the source capsule, allowing the powder to leak out. That same day the assembly was sold to a junkyard owner, who had an employee take the apparatus to the junkyard by wheelbarrow and leave it in a garage. That night the junkyard operator saw that the powder glowed blue. Intrigued by the glowing blue material, he took the capsule into his house to show it off to his family and friends. Several people sprinkled or rubbed the material on their bodies as they might have done with Carnival glitter. The operator's wife became ill with symptoms of acute radiation sickness a few days later. Over the next few days the rotating assembly of the source was disassembled by two of the operator's employees; both died .

The saddest incident occurred on 24 September. Six-year-old Leide das Neves Ferreira played with the colorful source powder, painted it on her body, and ate a sandwich while her hands were contaminated. She was massively internally contaminated and died on 23 October.

The toll in Goiânia is staggering. The Brazilian authorities monitored over 112,000 people in the city's Olympic-sized soccer stadium for radiation exposure and sickness. A total of 249 people were identified as contaminated by the cesium-137, 151 people exhibited both internal and external contamination, 49 people were admitted to hospitals, with the 20 most seriously irradiated having received doses from 100 to 800 rads. The internally contaminated patients were themselves radioactive, seriously complicating their treatment. In the end, 28 people suffered radiation burns and five people died, including three men, one woman, and one child. Both patients and technicians spread radioactive contamination in Goiânia and even to Rio de Janeiro. For several days nobody remembered to decontaminate the ambulances used in Rio to transport victims from the airport to the naval hospital, which had the country's primary facility for the care of radiation sickness.

What to Expect

Most RDD scenarios tend to focus on a device that uses high explosive to pulverize and disperse radioactive material.

The most attention has been given to the small, readily achievable dirty bomb, which may indeed be the most probable type of radiological attack. However, almost all experts agree that such an attack would be unlikely to cause mass casualties; rather it probably would cause great disruption and panic. Stealthier RDDs, not involving explosions, might actually cause deterministic radiation injuries in more people than would a bomb because remedial action might be delayed or because the RDDs might be designed to promote ingestion or inhalation. Even a small RDD is likely to do a great deal of real economic damage because of two principal effects: suspension of economic activity and long-term contamination of property, possibly resulting in its permanent loss.

While many analysts have suggested that RDDs will neither sicken nor kill very many people, analysis of the Goiânia incident leads to a modification of this conclusion and to a caution: of the 249 contaminated victims of the Goiânia incident, 151 were contaminated internally. That is, they either ate or inhaled radioactive cesium, and the material was incorporated into their bodies. While the amounts ingested seem extremely small (Leide das Neves Ferreira, who died, was the most highly contaminated having consumed only 27 mCi), they were more than adequate to cause death or acute radiation sickness. These minuscule quantities could be transferred from a hand with a little radioactive dust on it to the mouth with the kinds of simple gestures people make all the time.

Peter D. Zimmerman

Because people might ingest or inhale radioactive material, it is not reasonable to assume that the human toll from a large RDD would be small or negligible outside the direct range of a dirty bomb blast. The US should be prepared to cope with tens, hundreds, or conceivably thousands of victims of acute radiation sickness. Patients with internal contamination also pose a hazard to attending medical staff. The caregivers may be forced to limit their time with the patient or to work from behind shields or both.

In Washington, DC, for example, an area the size of the National Mall could be affected by a simple dirty bomb—perhaps a few curies of material and a few kilograms of explosive—though the target would most likely be a government facility or a business or residential district. More efficient RDDs could easily contaminate a significantly larger area.

Fortunately, there are drugs that can assist in purging the body of cesium contamination. The dye Prussian Blue is sold for this purpose under the trade name Radiogardase® by Heyl Pharmaceuticals in Germany. Prussian Blue was found very effective in Goiânia. The national stockpile of products for use in the event of an emergency includes stores of Prussian Blue, but it would be appropriate for the US government to ensure that the stockpile contains more than the amount needed to treat victims of a single, severe attack. The drug is far more effective given within 2-4 hours after exposure to cesium than it is later, so many geographically diverse storage sites are needed.

The economic impact on a major metropolitan area from a successful RDD attack is likely to equal and perhaps even exceed that of the September 2001 Al Qaeda attacks in New York City and in Washington, DC. The estimated cost to return the lower Manhattan area to the condition prior to the September terrorist attacks was in excess of $30 billion. The immediate response costs exceeded $11 billion. Much of the private cost of recovery from the September 2001 attacks was paid by insurance. That would not be the case following an RDD attack, because radiation is a specifically *excluded* risk in virtually all policies written in the US.

Recommendations

Radiological dispersion devices pose a unique threat to the US. While an RDD attack is unlikely to cause mass fatalities, it is apt to cause mass panic and great economic damage. Finally, the plume from an explosively driven RDD is likely to cross city, county, and even state lines and require a high degree of cooperation among unrelated organizations in the face of likely mass panic. A great deal of additional effort to preplan local responses is required.

The following specific recommendations should be implemented:

1. The Department of Energy weapons laboratories, in cooperation with other agencies and institutions, should identify, test, and deploy technologies that will enable rapid cleanup and decontamination of buildings, vehicles, and people.

2. The Federal government should provide some form of national insurance against nuclear terror. There is ample precedent. The Price-Anderson Act already provides insurance in the event of a nuclear accident caused by a licensed company or facility acting within the terms of its license.

3. The US should stockpile Radiogardase® in sufficient quantities to treat at least 1,000 victims in each of ten cities for at least one month. The medication should be available in any city within 2 to 4 hours after an attack.

4. Programs to recover orphan sources in the US and abroad should be fully funded on a continuing basis. Very large radioactive sources, particularly those used in the former Soviet Union, should be retired and replaced with benign technologies.

5. Where feasible, nonradioactive technologies such as X-rays and accelerators should be substituted for radioactive sources.

6. An appropriate program of public education about the high probability of surviving an attack without serious injury or additional risk of cancer should be instituted in a timely manner.

Radiological attacks against the US are a matter for urgent concern, but not for panic.

Cheryl Loeb's contribution has been crucial to this project. See National Defense University publication Defense Horizons, *#38. January 2004.*

Editor's Note: This article has been edited considerably for length. A more complete version is available at http://www.aps.org/apsnews/backpage.cfm.

Peter Zimmerman has held positions with the US State Department and the Senate Foreign Relations Committee. He is now professor and chair of Science & Security and the director of the MacArthur Centre for Science & Security Studies at King's College, London.