# APS NEWS

August/September 1999 — The American Physical Society — Volume 8, No. 8

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APS 100 years — celebrate a century of physics

## APS Selects New Corporate Minority Scholars

The APS has awarded Campaign-for-Physics sponsored Corporate Minority Scholarships to 31 students who are majoring or planning to major in physics. This is the most ever awarded in a single year. Since its inception in 1980, the program has helped more than 250 minority students pursue physics degrees. Each scholarship consists of $2000, which may be renewed once, and may be used for tuition, room and board.

By far the youngest new scholar is 15-year-old Natalia Toro, who emigrated with her family from Medellin, Colombia in South America, a region with few educational resources in physics and mathematics. But her natural aptitude became apparent during an elementary school science class when she observed that a pendulum's motion was predictable according to strict mathematical laws. "I am fascinated by the process of taking abstract mathematical concepts, then linking them to general physical theory and applying the results to specific problems in physics or engineering," she wrote in her application. In addition to her regular advanced placement high school courses in physics and calculus, Toro has taken several courses at the University of Colorado, Boulder, in physics, optics, thermodynamics, and analytical mechanics, among other subjects. Last summer she attended the Research Science Institute at MIT studying neutrino oscillations, and was an alternate on the US Physics Team for the 29th International Physics Olympiad. Toro is also one of the 40 finalists in the 1999 Intel Science Talent Search competition.

The daughter of a Mohawk mother and Kiowa father, Melody Redbird learned to read at age 2 and gained a love of science from the Montessori school she attended until age 6. Home-schooled until age 10, she plays the violin and writes poetry and short stories, and has interests in astronomy. She also participates in a traveling Native American Dance group that was featured in *People* magazine in 1997. In addition to her regular high school duties, she completed an independent research project on magnetic levitation and its future applications.

Adam Orin of Chula Vista, CA, recalls taking apart a remote control car to see what made it work, and was "rewarded with a treasure of gears, wires and tiny motors." He went on to investigate batteries, small motors, and computers. His interest in astronomy was fostered by his father, who bought him a telescope and took him to watch meteor showers in the Laguna Mountains and took him on a tour of the San Diego Palomar Observatory. As a senior at Eastlake High School, he participated in its Digital High School program, in which students maintain the campus computers and network. The students are also building an observatory, which will be the only one of its kind owned by a California high school.

Yaseen Oweis of Ellicott City, MD, used to make repairs on broken clocks, old typewriters or other machinery, and soon graduated to building and flying radio-controlled model airplanes, becoming intrigued about the scientific principles that enabled them to remain airborne, as well as the harmonic motion creating the sound from violin strings. "Physics has helped me look onto the universe not as an incomprehensible assortment of random processes, but as a huge machine that has worked and will always work in the same way," he wrote in his application essay. Oweis plans to go on to medical school after earning a

*Continued on page 5*

### US Physics Olympiad Team Trains in Maryland

Physics Olympiad coach demonstrates an experiment to team members Natalia Toro (also a new Corporate Minority Scholar and finalist in the Intel Science Talent competition) and Andrew Lin.
[*See article on page 5.*]

## APS Ramps Up Public Outreach Efforts with New Media Coordinator

The APS is shifting its media relations and outreach efforts into high gear with the creation of a new position to coordinate the Society's interactions with national print and broadcast media. Randy Atkins, formerly senior science writer and television producer with the American Chemical Society (ACS), joined the APS staff in July as a senior media relations coordinator. The creation of the position was one of the principle recommendations of the APS Task Force on Informing the Public, chaired by Leon Lederman of the University of Chicago, which presented its interim report to the APS Council in May.

Randy Atkins

Appointed earlier this year, the task force was charged with recommending ways in which the Society could enhance its efforts to inform the public, political leaders and other relevant constituencies about the nature and importance of physics to society.

According to Lederman, task force members were unanimous in their recognition of the need for a full-time staff person at the

*Continued on page 7*

## Inside...

NEWS



## Council Debates Proposal to Reduce Council Size

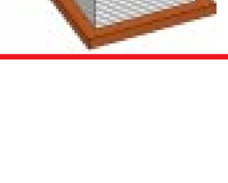
The appropriate size for the APS Council was a major topic of discussion at the May Council meeting. In response to continuing complaints from Councillors that the large size of the Council was making it ineffective, a special Task Force consisting of past and current Councillors was appointed in the fall of 1998 to review "the structure and responsibilities of the Council." The Task Force submitted its report, which consisted of five recommendations, to the Council in May, but because of time constraints, only one recommendation was debated; this was the one concerning the size and composition of the Council. Other recommendations will be considered by the Council at future meetings.

The Task Force report, presented by Stephen Holt (NASA/GSFC), recommended a major reduction in the number of people sitting at the Council table, going from the current 71 to 40. This is to be accomplished primarily by reducing the numbers of General and Divisional Councillors and decreasing the number of non-voting Council Advisors given a seat at the table. "Almost all Council members that we consulted agreed that the APS Council had gotten too big," says Task Force Chair Ernest Henley (University of Washington). "Councillors could barely see each other around the table and it was difficult to hear any ongoing discussion."

Most of the Council discussion centered on two aspects of the size reduction: whether proportional representation of APS units should be abandoned and the role of the geographical Sections. During the last major revision of the APS Constitution in 1990, a representational scheme was established that was based on a quantity X, a percentage of the total APS membership (currently X = 3) specified in the APS Bylaws. Large Divisions were awarded more Councillors (up to four) than small, using X as the basic unit of membership. In addition, Forums would gain a Councillor and Topical Groups could become Divisions (and thus gain a Councillor) when their membership percentage exceeded X. The number of General Councillors was also related to X. The Task Force report recommended reducing or eliminating the role of X and giving each Division only one Councillor while setting the number of General Councillors at 9 rather than the current 16.

Well before the May Council meeting, the Task Force report had been circulated to the Secretary/Treasurer of every APS unit and given to the Committee on Constitution and Bylaws (CC&B). At the Council meeting, the chair of CC&B, Stephen Baker (Rice University) argued against giving up proportional representation. "The Council already has the means to reduce its size without

*Continued on page 6*




**Reminder:**

**Deadline for receipt of APS Officer Election Ballots is September 3, 1999.**

***See July 1999* APS News *for candidate information.***

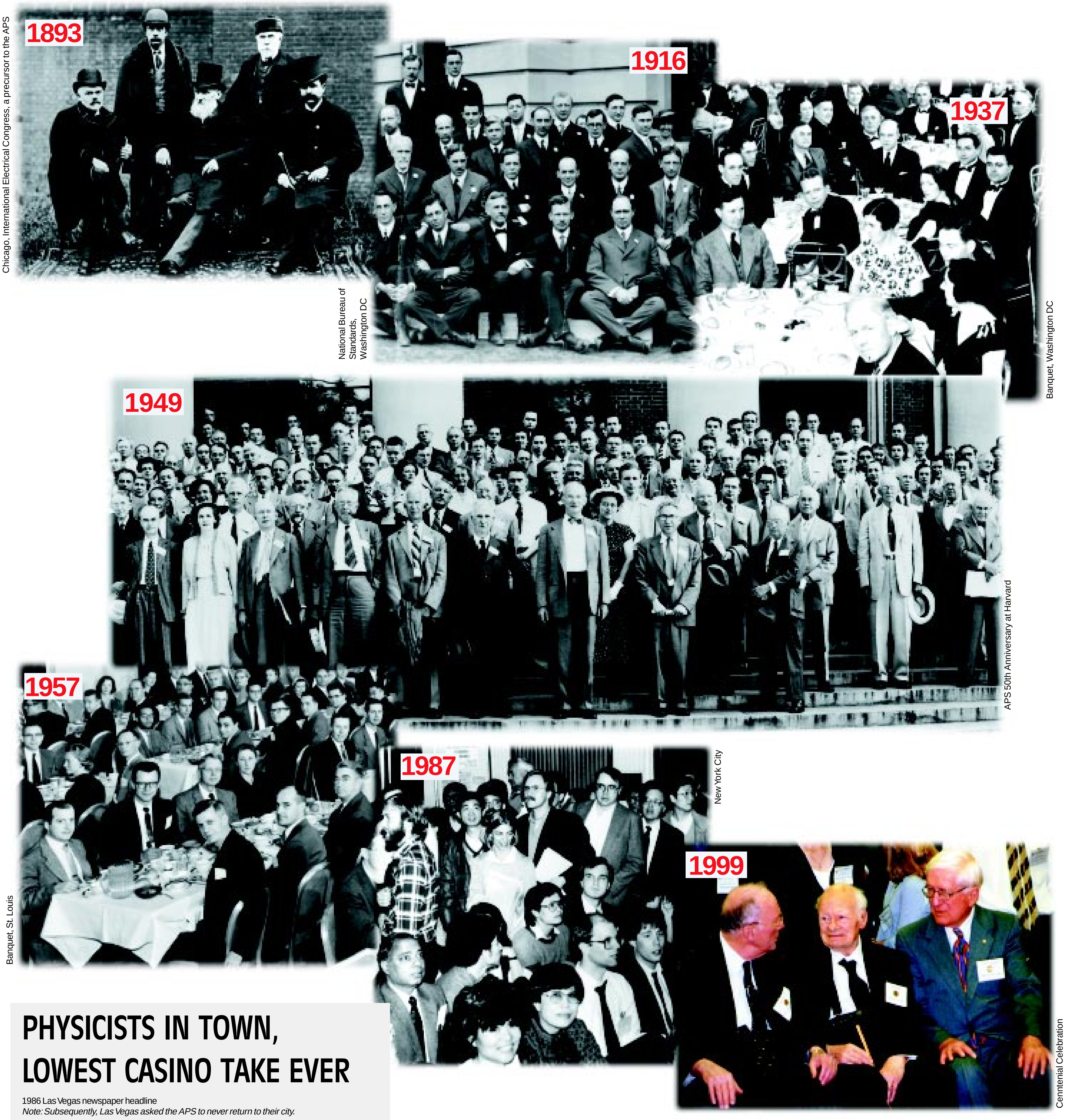
# To Advance & Diffuse the Knowledge of Physics

## 100 Years of the American Physical Society

**Excerpts from an exhibit displayed at the APS Centennial Meeting.**

**Curator:** Sara Schechner Genuth, *Gnomon Research*
**Exhibit Director:** Barrett Ripin
*With contributions by Harry Lustig, R. Mark Wilson, and others.*

## Changing Faces of Meetings




1893: Chicago, International Electrical Congress, a precursor to the APS

1916: National Bureau of Standards, Washington DC

1937: Banquet, Washington DC

1949: APS 50th Anniversary at Harvard

1957: Banquet, St. Louis

1987: New York City

1999: Cenntenial Celebration

**PHYSICISTS IN TOWN, LOWEST CASINO TAKE EVER**

1986 Las Vegas newspaper headline
*Note: Subsequently, Las Vegas asked the APS to never return to their city.*

**Next month: *Growth***


# APS News

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**Editor ............................... Barrett H. Ripin**
**Associate Editor .......... Jennifer Ouellette**
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# INSIDE THE BELTWAY

*A Washington Analysis*

## Watch Out, Science! Here Comes Campaign 2000!

*by Michael S. Lubell, APS Director of Public Affairs*

It's not even September 1999, and the countdown has begun. Check out the headlines. Trouble in the Gore Campaign! Hillary Woos New York! Bush Dollars Stun Foes! Forbes Web Site A Hot Ticket!

Brace yourselves for Campaign 2000. Election Day might be fifteen months away, but the way the pols are acting and the way the media is hyping it, you'd think we would be casting our votes tomorrow. Whatever the outcome of the campaign, we're all likely to weary of it before it's over.

Already, however, science is feeling its effects: in the Cox Report, the presidential budget, the congressional spending plan, funding for the Spallation Neutron Source (SNS), the congressional high-tech summit and the information technology authorization bill. Election-year politics lurks behind each of these, some of it benign and some of it pernicious.

Consider first the Cox Report. Released in May, the bipartisan document contained stunning allegations of espionage and theft of nuclear secrets from Los Alamos and Livermore National Laboratories by agents of the Peoples Republic of China. Revelations or claptrap?

I asked a close family member, a former OSS and CIA agent, for his take. "It's been going on for years," he said, "from the start of the Manhattan Project. It's a clash of cultures: scientists believe in openness, and counterintelligence thinks spies are prowling everywhere. Every so often they catch somebody and tighten up security. A year passes, and it's back to normal. But you don't read much about it."

"So why the big hoopla over Wen Ho Lee and Peter Lee, two of the alleged spies?" I asked.

"Politics, my boy. Remember how it started. Illegal Chinese campaign contributions to the Democrats in the '96 election. That's what's driving it, election-year politics, starting a year early."

Politics or not, the Cox Report rapidly led to the Rudman Report, prepared by four members of the President's Foreign Intelligence Advisory Board. The panel included, in addition to its chairman, Former Senator Warren B. Rudman, members Ann Z. Caracristi, a former Deputy Director of the National Security Agency, Sidney Drell, a former President of the American Physical Society, and Stephen Friedman, Chairman of the Board of Trustees of Columbia University.

The Rudman Report pulled no punches, calling the Department of Energy "dysfunctional" and taking it to task for gross laxity in matters of national security. It called for setting up a semi-autonomous agency within the Department to run all aspects of the defense laboratories, directed by a new Under Secretary of Energy who would be subject to Senate confirmation.

The Rudman recommendation dovetailed nicely with a strikingly similar proposal that Senators Kyl (R-AZ), Domenici (R-NM) and Murkowski (R-AK) had already placed before Congress. No sober Washington denizen believes that was a coincidence. Quick to take credit for moving against Chinese espionage, the White House quietly distanced itself from Energy Secretary Bill Richardson, who initially argued vehemently against the plan, but finally came to terms with its inevitability.

The reorganization plan poses two vital problems for physics at the DOE. What happens to the unclassified research at the weapons laboratories that the Office of Science now supports? And what happens to communication across the boundaries between DOE's classified and unclassified activities? If you have the solutions, call Secretary Richardson.

Election-year politics has also ratcheted up the normally contentious debate over the Federal budget. Republicans claim that the White House began the assault last February, when the President released his spending proposals for Fiscal Year 2000.

With projections for a surplus in excess of $100 billion, the President, seeking to eviscerate GOP plans for a major tax cut, fenced off two thirds of it to save Social Security. His rationale was simple: Social Security was generating the excess revenues today, and those revenues should be used to postpone the day of reckoning thirty years hence when outflows are expected to exceed collections.

To provide added funding for education, health care and defense, the President proposed using the remainder of the Social Security surplus and about $50 billion in revenues from a new tobacco tax, reflecting his stillborn formula from a year earlier. Characterizing his balanced budget plan as literally nothing more than smoke and mirrors, congressional Republicans unveiled their own spending plan in April. Theirs dedicated the entire surplus to saving Social Security, added almost $20 billion to defense and still managed to keep the balanced budget caps in place. But it required almost $40 billion in cuts to civilian discretionary programs. From the day the GOP plan hit the Hill, you could almost see the opposition salivating. It's one thing to talk about cutting spending; it's quite another to finger the programs that will absorb the cuts. Score one for the Democrats.

With a narrow margin of six votes to play with on the floor of each House, Republican appropriators quickly found themselves hemorrhaging politically. Their eyes set on the 2000 election, Democrats predictably have not rushed in with offers of a transfusion.

So the budget sits, waiting for a bipartisan bailout. Some analysts believe it will happen behind closed doors in September. Others predict that the "true believers" in the Republican Party will prevail and force their leadership to hack away at popular programs.

While the future is clouded, the strategy for physicists is clear. The final days of August and the opening days of September provide a window of opportunity to get a strong science message across to legislators in their home offices during the congressional summer recess. That may be difference between ten-percent cuts and modest increases for research and education.

There are some indications that Congress will pay attention. Take the case of the House Science Committee Chairman James Sensenbrenner (R-WI). During a rather messy mark-up of the Energy Authorization Bill, he retreated from his promise to slash SNS funding under strong pressure from his GOP colleagues, among them Vern Ehlers (R-MI), who argued that American neutron science would suffer tremendous harm. Democrats joined in, questioning behind the scenes, whether the chairman's opposition had been politically motivated, since the SNS is to be located in the Vice President's home state of Tennessee.

# FESTIVAL PROFILE

## Chasing Rainbows at the South Pole

Along the Antarctic coast one finds a rich source of wildlife: penguins, sea lions, whales and sea birds, for example. But further inland the raw materials are simply ice and air, making the Pole a desolate area where the nearest rock is two miles below the icy surface. The isolation makes it an ideal site for scientists studying neutrinos from exploding stars and meteorological air quality. And of course, the spectacular ice crystal halo effects that occasionally appear in the atmosphere. The latter are the passion of Robert Greenler, a professor (now emeritus) of the University of Wisconsin, Milwaukee and one of the featured public lecturers at the APS Centennial meeting in Atlanta.

Robert Greenler lectured at the APS Centennial Meeting this past March.

A former president of the Optical Society of America, Greenler has made three trips to the South Pole over the last 20 years to directly observe ice crystal halos, most recently last November and December. He traces his interest to a childhood fascination with rainbows that continued long after he'd become a physicist. He helped develop computer simulations to trace rays of light through ice crystal forms to explain the origins of the phenomena, and eventually applied to the National Science Foundation for a grant to study them *in situ* at the South Pole. In 1980 he published *Rainbows, Halos and Glories*, to be re-issued this fall in paperback by Peanut Butter Publishing, detailing his investigations of ice crystal halos. Also due out this fall is a new book, *Chasing the Rainbow: Recurrences in the Life of a Scientist*, which Greenler describes as a recounting of incidents in his life foreshadowed by earlier events, rather than a traditional autobiography.

The halo effects he studies occur when small droplets of water in the atmosphere freeze into hexagonal crystalline form, arising from two varieties in particular: a hexagonal plate crystal, and a cylindrical, pencil-shaped hexagonal crystal. A preponderance of these crystals in the atmosphere, with proper orientation, behave much like prisms when light is shone through them, defracting the ray by specific degrees (22 and 46 degree deviations trigger the most common halo effects), known as the "angular radius." Halo effects are recorded with a device affectionately dubbed "R2D2", which contains a video camera operating in time-lapse mode to track the sun around the sky and keep an extended record of the effects. But the notorious fickleness of Nature in granting such a display can be frustrating, Greenler admits: "You get all your equipment set up and then you wait. And wait. And wait. Either halos come, or they don't."

The importance of his work goes beyond a simple admiration and desire to understand Nature's optical "art." Mapping the characteristics of ice crystals in the atmosphere is of particular interest to meteorologists conducting climate modeling. In fact, Greenler believes he can "teach" a LIDAR system—the radar-like instrument meteorologists use to probe the atmosphere, similar to radar — to recognize the morphology of the crystals based on these optical effects. Still, the halos are a self-described sideline for Greenler. His primary research has been in optics, particularly the phenomenon of iridescence in biological organisms, which he defines as "colors that don't originate from pigments, but from structure." Examples would be colors in an oil film on the surface of a water puddle, or a particular genus of beetle whose color changes depending on the angle from which one views it. He also co-founded UWM's "Science Bag" program 25 years ago, a series of public lectures that has drawn a cumulative attendance of roughly 120,000 since its inception. Many of these have been collected onto videotape for sale to educational institutions.

While his interest in halo effects remains undiminished, Greenler doesn't foresee any more trips to the South Pole in his future. "It's very demanding, both physically and emotionally," he says. Simply getting there requires 9 airline flights over 9 days, and the final leg — an 800-mile flight from the coast of Antarctica to the Pole itself in an LC-140 cargo plane — is dependent on the notoriously unpredictable weather. Once there, individuals often find it difficult to function in an effective air pressure elevation of over 9000 feet. There is also the biting cold, with temperatures averaging -40 degrees F during the research season, and wind chills of more than 100 degrees below zero. Not surprisingly, the average age for those involved in research in Antarctica is 36.

However, Greenler will continue to lecture extensively about ice crystal halos and other optical phenomena, through the "Science Bag" program and other venues. "This particular sideline has given me a lot of pleasure because I've been able to share some of the excitement of science with non-scientists," he says. "And it's taken me places I never dreamed of going when I first started asking questions about what causes all those pretty things in the sky."

*For information about Robert Greenler's books or videotapes of "Science Bag" lectures, contact Blue Sky Associates at 414-377-1398.*

## Inside the Belway, *continued*

This June's high-tech summit is another prime example of the impact of R&D on the political gestalt. Although critics charged that it was nothing more than a blatant grab by campaign fundraisers for Silicon Valley money, the event, which drew leading information technology (IT) CEOs from around the country, received top Capitol Hill billing. It was timed to coincide with an authorization bill that would double the investment in IT research over five years. Ironically, Chairman Sensenbrenner, a staunch opponent of the Frist-Rockefeller R&D doubling bill (S. 296), was the leading advocate of the IT bill.

Sure it smells of election-year politics, but that's to be expected. Think back five years, when no part of R&D was on the political radar screen. With today's booming economy driven by science and technology, politicians are beginning to wake up. It's up to the practitioners and the economists to keep reminding them of the realities. They are, after all, a pretty savvy bunch.

# OPINION

## LETTERS

### Dyson Debate: Prophet or Heretic?

Freeman Dyson's article, "The Science and Politics of Climate," (The Back Page, May 1999) is both misleading and ill-informed. Dyson begins with the premise that politicians have blindly accepted the predictions of greenhouse gas induced global warming coming out of the general circulation models (GCM) of Manabe and others. Actually, many members of Congress seem to deny the possibility of the greenhouse effect. Some members of Congress have even tried to kill funding for the very observational programs that Dyson esteems.

Dyson goes on to claim that "the public is led to believe that the carbon dioxide problem has a single cause and a single consequence. The single cause is fossil fuel burning, the single consequence is global warming." Does Dyson really think that there is much doubt as to why the levels of atmospheric carbon dioxide have risen from 280 ppm to the present value of about 370 ppm during the span of the industrial revolution? There is an extensive body of data which strongly supports the anthropogenic origin of the increased carbon dioxide. Yes, the carbon cycle is poorly understood, and many things affect the levels of atmospheric carbon dioxide. For example, during warmer years more carbon dioxide is released into the atmosphere from carbon reservoirs and this could be a type of positive feedback which might worsen global warming. But if the public thinks that there is a single cause to the increased levels of carbon dioxide — burning of fossil fuels — they at least have a good first approximation to reality.

Dyson ignores the large body of knowledge known as paleoclimatology. For example, it is easy to make a simple estimate of the consequences of greenhouse-gas forcing on the climate by looking to past ice ages. Also ignored are the results of a number of studies of the past climate over the same timescales as the ATOC project. (Dyson seems to have an axe to grind about the concerns of some marine biologists and environmentalists over the deafening levels of sound produced by the ATOC experiment.) Recent results from the deconvolution of geothermal profile of boreholes, tree-rings and other records indicate that global temperatures had been roughly constant, and perhaps even declined slightly in accord with the astronomical theory of origin of the ice ages, before the advent of the industrial revolution. Strong warming, however, is observed after 1900.

It is certainly true that complicated and incomplete models leave much to be desired. It is also true that even very simple estimates, based on the laws of physics, lead to the same conclusion as most supercomputer models: a doubling of atmospheric carbon dioxide will likely lead to an increase in the average global temperature by several degrees centigrade. Left unsaid is the potential for nasty surprises such as drastic changes in oceanic circulation (which have occurred in the past). This should be the real message of the science and politics of climate: Undesirable warming is likely and the consequences of greenhouse-induced climate change are generally harmful. Do we really want to carry out the global climate experiment to completion?

**Brad Marston,** *Brown University*

With regard to Freeman J. Dyson's piece, "The Science and Politics of Climate", one rarely sees such eco-blasphemy in print these days. After all, we all know that catastrophic global-warming caused by man-induced $CO^2$ is an established scientific fact. How do we know? Because the popular media have told us so. But there does exist another, heretical point of view, which almost never sees the light of day. Dyson's piece is part of that heresy. And there are others. If you dig, you can find them. I've assembled a rather large collection of notes I've assembled over the past few years on radical environmentalism in general and specifically on the topic of the $CO^2$/global warming hypothesis. [***Editor's note****: Readers interested in acquiring Dr. Switalski's list of references may contact him directly at switabern@juno.com.*]

**Bernard Switalski**

Freeman Dyson identifies four coupled reservoirs of carbon, the atmosphere, the ocean, vegetation and soil. He failed to mention the equally important carbon reservoir consisting of the global human population, which is an integral part of the equation. In the absence of any serious scientific study of how to reduce unsustainably large populations, both scientists and politicians seem to be accepting the inevitability of nature's standard methods, famine, disease and holocaust.

**Elmer Eisner,** *Rice University*

### Wherefore Art Thou, Chandrasekhar?

I saw myself in a photograph on page 5 of the May issue of *APS News*, identified as being from CSI. My only connection with CSI is that they connect me to the Internet. But thanks to the caption, I am getting a stream of enquiries from friends asking what I am up to now. One wanted to know if I had started an Institute of Superconductivity which I had modestly named after me. I have not, nor do I intend to do so. When asked these days where I am from, I answer, "Groebenzell."

**B.S. Chandrasekhar,** *Groebenzell, Germany*

## VIEWPOINT

### Why I Teach My Students Things that are Incorrect

*by Stanley L. Haan*

We physicists can be sticklers for correctness. It grates on us when we see scientific errors in books, movies and so forth. It especially grates on us when we see errors in educational materials. I remember my first encounters as an assistant professor with elementary school science materials. I was appalled at the errors and wrote letters to publishers to get them corrected. I also made a very conscious effort in my first years of teaching to avoid teaching anything I knew to be wrong. If a concept was too complex to be completely understood by beginning students, but the material was unavoidable, I'd teach them just part of the concept.

Now, I regularly teach things that I know are incorrect. And I'm even admitting publicly that I do it. Among other things, I teach that planets travel in elliptical orbits around the sun. I teach that mass is conserved. I teach that force equals mass times acceleration. I teach that warm air holds more moisture than cold air. I even teach that electrons orbit atomic nuclei somewhat like miniature planets orbiting a sun.

Planetary orbits around the sun are not perfectly elliptical. The interactions between the plants (and occasional asteroids or meteors) perturb them. Each of the things listed is incorrect — but in some ways is "almost correct," and even useful. In fact, I submit that each person should learn that these things are true before he or she can appreciate that they are not true. The equivalence of mass and energy, for example, becomes significant only if one already understands the classical idea that mass and energy are conserved separately.

Am I dishonest with my students when I teach them ideas I know are incorrect? If I am teaching an introductory course in classical mechanics, do I have a responsibility to go beyond teaching "mass is conserved," or "F=ma" to include a disclaimer that it really isn't so? I've tried including disclaimers in the past, but feedback from student journals and exams has led me to conclude that more often than not, my disclaimers just confuse them.

Happily, I have found a way that I can teach incorrect ideas with integrity. I teach my students models, and tell them I am doing so. I don't teach that electrons orbit nuclei like miniature planets orbiting the sun as if it were the final word on atomic structure. Instead, I teach a model of the atom. My goal is that when I've finished, they will understand the model and also recognize that what they have learned is just that, not the "final word."

Of course, for this approach to be effective, students need to understand what models are. Consequently, I spend some class time specifically discussing models. Some models can be physical constructions — e.g., a globe as a model of the earth — while others are sets of analogies or ideas that are intended to help us understand intrinsically complex systems. For example, the "particle model" of matter postulates that all matter is composed of indestructible particles called atoms, whose masses are conserved and which can be rearranged in a host of ways to form different molecules. I'm still very careful to try and get the facts — i.e., the data itself — correct. It's only in the explanatory principles that I allow for "mistruths" to arise. I don't feel obligated to tell my students everything I know about a topic.

Since students must construct a scaffold of understanding in order to learn physics, I have come to the conclusion that it is dangerous to try to avoid teaching something that is wrong by distilling out only certain concepts from complex systems. For example, if we want to teach about atomic structure and only teach that electrons are bound to atomic nuclei and that various atomic states can be described in terms of energy, then as far as I know we haven't said anything wrong. But what have the students learned? Perhaps empty verbalism. Or perhaps they have constructed their own model of an atom and have somehow grafted our teaching onto it. I think they'd be a lot better off learning the Bohr model of the atom in its entirety, including its popular extension into multi-electron atoms that makes my rigorous side cringe. Then, when students are ready, we can refine the model or teach them a new one.

Using models in our teaching is consistent with the historical development of science. Our scientific theories themselves are in many ways just models that have grown in complexity and depth with time, or been replaced by superior models. A hundred years ago someone could teach F=ma and believe it to be fully correct. I believe we should still teach it today without obfuscating it in a cloud of relativity. We just need to let our students know that what we're teaching — and all our scientific theories — should not be considered the "final word" on a subject.

*Stanley L. Haan is professor and chair of the Department of Physics and Astronomy at Calvin College in Grand Rapids, Michigan. A longer version of this article appeared in the Spring 1999 newsletter of the APS Forum on Education.*

*The APS Council adopted two education-related statements at its meeting on 21 May 1999. The text of the statements is below.*

#### APS, AAPT and AIP STATEMENT ON THE EDUCATION OF FUTURE TEACHERS

The scientific societies listed below urge the physics community, specifically physical science and engineering departments and their faculty members, to take an active role in improving the pre-service training of K-12 physics/science teachers. Improving teacher training involves building cooperative working relationships between physicists in universities and colleges and the individuals and groups involved in teaching physics to K- 12 students. Strengthening the science education of future teachers addresses the pressing national need for improving K-12 physics education and recognizes that these teachers play a critical education role as the first and often-times last physics teacher for most students. While this responsibility can be manifested in many ways, research indicates that effective pre-service teacher education involves hands-on, laboratory-based learning. Good science and mathematics education will help create a scientifically literate public, capable of making informed decisions on public policy involving scientific matters. A strong K-12 physics education is also the first step in producing the next generation of researchers, innovators, and technical workers.

#### APS STATEMENT ON RESEARCH IN PHYSICS EDUCATION

In recent years, physics education research has emerged as a topic of research within physics departments. This type of research is pursued in physics departments at several leading graduate and research institutions, it has attracted funding from major governmental agencies, it is both objective and experimental, it is developing and has developed publication and dissemination mechanisms, and PhD students trained in the area are recruited to establish new programs. Physics education research can and should be subject to the same criteria for evaluation (papers published, grants, etc.) as research in other fields of physics. The outcome of this research will improve the methodology of teaching and teaching evaluation.

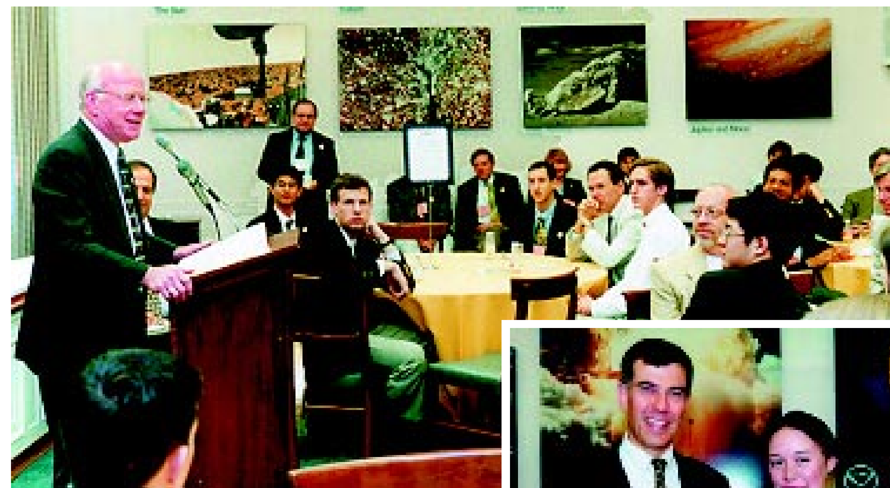
The APS applauds and supports the acceptance in physics departments of research in physics education. Much of the work done in this field is very specific to the teaching of physics and deals with the unique needs and demands of particular physics courses and the appropriate use of technology in those courses. The successful adaptation of physics education research to improve the state of teaching in any physics department requires close contact between the physics education researchers and the more traditional researchers who are also teachers. The APS recognizes that the success and usefulness of physics education research is greatly enhanced by its presence in the physics department.

# US Physics Olympiad Team Hosted on Capitol Hill

In June, the 24 high school students named to the US Physics Olympiad team met with members of Congress at a breakfast in Washington, DC, co-hosted by Rep. Vernon Ehlers (R-MI) and Rep. Rush Holt (D-NJ), both physicists and fellows of the APS.

In addition to the breakfast, the students came from all around the US to attend a grueling physics boot camp at the University of Maryland in College Park, competing to be one of the five chosen to represent the US at the International Physics Olympiad, held in July in Padua, Italy. Teachers at the camp supplied students with guidance on how to solve tough physics problems that ultimately enable physicists to help society, from predicting the size of dangerous, lava-filled areas after a volcanic eruption to designing solar-powered aircraft similar to those used by NASA to monitor the environment and climate change.

According to James Stith, director of physics programs at the American Institute of Physics and a former AAPT president, the breakfast came at a time when Congress is debating the future of science and math education policy. The House will be rewriting the Elementary and Secondary Education Act, the main law that governs Federal support of school programs for K-12 education. "It's important that our teachers continue to keep up with new and engaging approaches to K-12 education," said Holt, who has said that improving the nation's schools is one of his top priorities. Photographs of the students with their Congressional representatives at the breakfast, as well as from the physics training camp, are available online at www.aip.org/physnews/graphics/html/usteam99.html.



Photos from http://www.aip.org/physnews/graphics/html/team99/congress1.htm

**Above:** Rep. Vernon Ehlers (R-MI) addresses the students in the Rayburn House Office Building.

**At right:** Rep. Rush Holt (D-NJ) and Katherine Scott.

# Top High School Students Fair Well in Philly

Talented high school physics students from around the world flocked to Philadelphia, PA, in May to take part in the world's largest pre-college science competition: the 50th Annual Intel International Science and Engineering Fair (ISEF). The APS, in conjunction with the American Association of Physics Teachers (AAPT), contributed to the more than $2 million in scholarships and prizes that were awarded. Each year the Intel ISEF brings together more than 1000 students from all 50 states and 47 nations to compete for scholarships, tuition grants, internships, and scientific fields trips. Finalists emerge from a field of about one million high school students who competed in local fairs. The grand prize: a trip to attend the Nobel Prize Ceremonies in Stockholm, Sweden.

The APS sponsored prizes at ISEF for the first time last year with the AAPT, and this year the two societies once again awarded three top prizes in physics plus three honorable mentions. In addition to monetary awards, all winners received a one-year AAPT membership and one-year APS student membership, and a certificate from both societies. The first place APS/AAPT award of $1000 went to Christopher Cook of Palm City, FL, for his project on Phase IV gravity waves. The second place award of $400 went to David Moore of Potomac, MD, for performing quantum calculations to determine electrical properties for molecular rectifying diodes. And the third place award of $300 went to Han-Chih Chang of Chang-hwa City in Chinese Taipei, for a project on Couette flow of ferrofluid with added particles in magnetic fields. Chang was also honored in the "Best Of" category in physics. In addition, there were three honorable mentions: Alexander Wissner-Gross of New Hyde Park, NY; Kurt Mitman of McLean, VA; and Gregory Studer, Christopher Billman, and Travis Thatcher of Coopersburg, PA.

The ISEF event was founded in 1950 by Science Services, a non-profit organization dedicated to advancing the understanding and appreciation of science among people of all ages through publications and annual programs. ISEF is the only high school global science fair representing all life and physical science—from astronomy to zoology.

For a complete list of the awards presented at the 1999 Intel ISEF, along with photographs, see http://www.intel.com/education/isef. For more information about the ISEF program itself, see the Science Services Web site at http://www.sciserv.org.

Logo courtesy of Intel Corporation

## Minority Scholars,

*continued from page 1*

BS in physics and eventually hopes to specialize in neurosurgery. Through a local mentor program at Mount Hebron High School, he worked with David Durham of Johns Hopkins University on a project to study lunar occultations on the surface of the moon.

While summer physics class at MIT in junior high school inspired Aaron Santos of Fairhaven, MA, to study physics, coupled with a long-standing interest in biology. He plans to specialize in biophysics. In addition to participating in a six-week introductory program in engineering and science at MIT, he was selected to participate in the first cadet training program on board the H.M.S. Bounty, a replica ship built for the 1962 film "Mutiny on the Bounty," starring Marlon Brando. Along with the other cadets, Santos lived on the boat for a nine-week sail around Nova Scotia, learning about the ship's history and the art of sailing.

A complete list of this year's corporate minority scholars can be found at www.aps.org under the Education and Outreach button.

The APS scholarship program operates under the auspices of the APS Committee on Minorities, and is supported by funds allocated from the APS Campaign for Physics. Scholarships are awarded to African-American, Hispanic American and Native American students who are high school seniors, college freshmen or sophomores. For applications for the 2000-2001 competition, contact Arlene Modeste at modeste@aps.org.

### Society Presidents Testify before Congress

Photo by David Schutt of ACS. Reprinted in the FASEB Newsletter

APS President Jerome Friedman (far right) and the presidents of AMS, FASEB, and ACS testify before House VA-HUD Appropriations Subcommittee chair James Walsh (R-NY) (far left).

## Keeper of the Flame

Among the attendees at the Nobel Laureate luncheon at the APS Centennial meeting in March (see *APS News*, June 1999) were four students from Riverwood High School in Atlanta, GA. They came with their physics teacher, Estella Bonilla (now Davison), a former APS Corporate Minority Scholar.

Bonilla was named an APS Corporate Scholar in 19??. While she had always been interested in math and science, as the daughter of a nurse, she originally had dreams of becoming a doctor, but "I didn't really want to dissect anything." At a junior high career day, she met an engineer with the US Air Force whose job description intrigued her. Her choice of college, Xavier University in Louisiana, had a combined physics and mechanical engineering degree program, and she selected that as her major. She found herself enjoying the physics courses she took at Xavier much more than she had in high school. "The teachers did a lot of exploratory activities, instead of just lecturing," she said.

However, when it came time to take her engineering courses, Bonilla found she didn't enjoy them as much as her physics classes. About the same time, the APS sponsored a conference in Chevy Chase, MD, and invited several corporate scholars. She discovered that many of those in attendance were former engineering majors. That same year, her father died at age 44, "and I decided life is too short to be doing something you don't like." She completed her physics coursework at Xavier and then went on to the University of Florida for graduate studies in education. "I'd always wanted to teach, but I'd never seen a physics teacher who looked like me," she said.

Today, she has become the physics teacher she never had in high school. Dissatisfied with the required textbooks and standard physics curriculum, she spends only a third of class times lecturing and having her students take notes. The remainder is spent on problem solving, laboratory activities, and a series of outdoor demonstrations built around the physics of sports: football, baseball, tennis, etc. Usually held during the lunch hour, the demos have the added benefit of piquing the interest of other students sitting outside eating. "Students may write things down, but if they see it and do it for themselves, that's when they remember and understand it." To encourage students with weaker math skills, she doesn't require them to memorize equations, handing out a list of those that are required to complete assignments. "If they don't know how to apply them, it doesn't matter whether they memorize them or not," she reasons.

The approach is paying off with a noticeable increase in the number of students taking physics, and the school is considering hiring a second physics teacher next year if enrollment continues to rise. As for Bonilla, she is reaping the rewards of personal satisfaction in her choice of career. "I love seeing the light bulbs come on when they realize why something works," she says of her students. "I like making them see that physics is not this horrible, wretched thing they have to take in order to graduate."

# DPP Stimulates the First US/Russian Internet Olympiad

The first-ever electronic Physics Olympiad competition was held over the Internet in May. High school physics students in the San Diego area collaborated electronically with their Russian counterparts in Novosibirsk, Siberia, to solve numerous physics-based problems in the event, which effectively demonstrated that holding Olympiads in the physical sciences over the Internet is both technically feasible and capable of drawing the interest and excitement of high school students to physics and new information technologies.

The idea for the Olympiad was conceived during the annual APS Division of Plasma Physics meeting in New Orleans last fall, where Carol Danielson of General Atomics, one of the event's principal organizers, participated in a poster session detailing the growth of the division's outreach activities. Among those attending was Boris Knyazev, a professor of physics at Novosibirsk, Siberia, in Russia, who is also chairman of Physics Education in Siberia, the Upper Urals, and Eastern Russia. Encouraged by his interest, Danielson invited him to attend an outreach collaboration meeting that evening, where tentative plans for an Internet competition between US and Russian high school students were discussed.

She assumed that it would take several months for preparations to begin in earnest, but Knyazev surprised her by almost immediately obtaining approval for the project and enlisting the participation of several Russian professors. US approval soon followed, with General Atomics agreeing to co-sponsor the event.

Three mixed teams of Russian and US high school students were formed — traditional Olympiads feature teams whose members are all from the same country — with the students exchanging emails a few weeks before the Olympiad to become better acquainted before the event, discussing global defense and nuclear power, and playing tic-tac-toe, which apparently is universal (the Russians call it "X-es and aughts"). Many continued to correspond even after the event concluded, and Danielson and Knyazev have formed a solid friendship.

Team #2 for the US/Russian Olympiad. Above: US Team; At right: Russian Team.

The computers for each international team were linked by NetMeeting, a program that allows communication in chat and white-board regimes, blank graphic tablets, or screens attached to computers to enable the US competitors to draw and write simultaneously with their Russian counterparts to solve the problems.

"The students said that in 10 years or so, when the technology used is archaic, they will be able to brag that they were among the pioneers of international Olympiad teleconferencing experiments, enabling technology to advance to higher levels," said Danielson. "They were definitely proud of their accomplishments." The Russian students were equally excited and proud to have participated, agreeing that such events should be continued. "It was great, not only a test of our abilities but also a unique opportunity to communicate with the students from another continent," one Russian student told a reporter from the *Evening Novosibirsk*.

Knyazev reports that the technical staff had heard much talk about "distance learning" and the educational capabilities of the Internet, "but our event was the first real example of how it could work." As evidence of Russia's appreciation of the event, he reported that in light of their victory, the Russian members of Team #2 will be admitted to the university without taking the three entrance exams customarily required for Russian high school students to go to college.

When all the scores were tallied, team #2 emerged as the winner of the $3000 in prize money donated by General Atomics and the DOE. Danielson derived some personal satisfaction from the fact that the winning team included two US female physics students. "It made me feel that perhaps we are finally influencing women to concentrate on science," she said. A US awards ceremony was held on May 27th to honor the winners, attended not only by the organizers and participating high school students, but also representatives from three Congressional offices in San Diego County.

The success of the event and attention it has garnered has piqued the interest of several facilities and institutions interested in participating in future Internet Olympiad projects, including the École Polytechnique in Paris, France, Princeton, and MIT, as well as universities in Montana, Seattle, WA, and Spain. Future events could have as many as six linked sites per Olympiad. As for Danielson, it was "definitely the most rewarding outreach project I have been associated with."

General Atomics, DOE and the DPP put on the first Internet Olympiad, but several institutions around the country host their own local Physics Olympics, such as that held at Yale University last October (see *APS News*, April 1999). The University of Hawaii at Manoa also sponsors an annual Physics Olympics, similar in scope and structure to Yale's, co-sponsored by the AAPT's Hawaii Section. This year's competition, held in February, drew nearly 200 local high school students, who competed with each other in six hands-on events.

"Our Physics Olympiad exemplifies a growing cooperation among the university faculties, high school teachers and university students," says Pui Lam, a professor of physics at UH-M and past president of the AAPT's Hawaii Section, who co-chaired the event. The local chapter of the Society of Physics Students has also become involved in recent years, taking on much of the operation and planning, along with local community college students. For a feature article on UH-M's 1998 Physics Olympics, see http://www.starbulletin.com, and follow links to the March 2, 1998 issue and article, entitled "Physics Can be Phun!"

## Council Debates Proposal, *continued from page 1*

sacrificing proportional representation and without amending the Constitution, simply by increasing the value of X," Baker explained. "This is not a crisis situation that calls for radical amendment of the Constitution." He reminded the group that in 1990 larger units had argued for greater representation on the Council.

However, several Divisional Councillors reported that their Executive Committees had discussed the Task Force report during the APS Centennial Meeting and had voted to give up their additional Councillors to decrease the Council size. Among these was the Division of Condensed Matter Physics that would lose the largest number (3) of Councillors. In addition, Andrew Lovinger (NSF), the Division of High Polymer Physics (DHPP) Councillor, pointed out that increasing X could threaten the DHPP's existence as a division. After considerable discussion, a straw vote by the members of the Council strongly signaled their desire to give up the X-based system of proportional representation.

The Council then turned to the role of the Sections on Council. The Sections currently are represented by non-voting Section Advisors if their membership exceeds X. The Task Force recommendation would have removed these non-voting Advisors from the Council table. Sections Advisors, Perry Yaney (University of Dayton), Joe Hamilton (Vanderbilt University), and Kannan Jagannathan (Amherst College), argued strongly that instead Sections should have one or more voting Councillors, and thus end their "second class status," because they represent many APS members who are not active in other units. Members of the Council indicated that they wanted the Task Force to revise their recommendations to include some form of voting representation for the geographical sections.

Council members ended the discussion by asking the Committee on Constitution and Bylaws formulate recommendations for revisions to the Constitution. These recommendations and others from the Task Force's original report are expected to form a major part of the agenda of the November Council meeting.

***Editor's note:*** *Current Council composition may be found in the masthead box on page 2, as well as online at: www.aps.org under the Governance button. The ins, outs, and mathematics of the X-factor may be found in the APS Constitution and Bylaws at the same web location.*

## zero gravity

### You Might Be a Physics Major If...

... you know vector calculus but you can't remember how to do long division.

... you've actually used every single function on your graphing calculator.

... you'll assume that a "horse" is a "sphere" in order to make the math easier.

... it is sunny and 72 degrees outside, and you are working on a computer.

... when your professor asks you where your homework is, you claim to have accidentally determined its momentum so precisely, that according to Heisenberg it could be anywhere in the universe.

... you frequently whistle the theme song to "MacGyver."

... you always do homework on Friday nights.

... you know how to integrate a chicken and can take the derivative of water.

... you think in "math."

... you have no life - and you can prove it mathematically.

... you've calculated that the World Series actually diverges.

... you hesitate to look at something because you don't want to break down its wave function.

... you have a pet named after a scientist.

... you can't remember what's behind the door in the science building which says "Exit."

... you have to bring a jacket with you, in the middle of summer, because there's a wind-chill factor in the lab.

... you are completely addicted to caffeine.

... you avoid doing anything because you don't want to contribute to the eventual heat-death of the universe.

... you consider any non-science course "easy."

... you laugh at jokes about mathematicians.

... the Humane Society has you arrested because you actually performed the Schrodinger's Cat experiment.

... you can translate English into Binary.

... you understood more than five of these indicators.

... you clip this column and post it on your door.

# Announcements

## 1998 Annual Report Now Available Online

The APS has made its 1998 annual report available online. Covering the fiscal year from July 1, 1997 through June 30, 1998, it is available at the APS Web site [http://www.aps.org]. [A printed copy may be obtained by contacting the Executive Office of the APS at 301-209-3269.] The report covers financial performance and growth in membership as well as highlights of major APS operations. These include research publications, scientific meetings, prizes and awards, international affairs, public affairs and public information, education and outreach, and development.

APS membership rose by more than 1,000 to 41,800 during this period, while net assets rose 12%, from $71.3 million to $80.2 million. Planning for the APS Centennial meeting, held in March in Atlanta, dominated much of the Society's activities. In publishing, the Society's electronic journals are being used extensively worldwide, and the APS has instituted two entirely electronic publications: *Physical Review Special Topics (Accelerators and Beams)* and *Physical Review Focus*. International activities included a unique meeting of 21 physical societies of the western hemisphere, held in Cuernavaca, Mexico. And the lobbying activities of the APS Washington Office helped win passage of the Senate Frist-Rockefeller bill, calling for doubling of the federal research budget. Further details can be found in the online report.

**CORRECTION:**

In the June issue of *APS News*, the article on the international roundtable discussions held at the APS Centennial Meeting in Atlanta incorrectly identified Shang-Fen Ren as president of the Chinese Physical Society. Shang-Fen Ren is with the physics department at Illinois State University in Normal, Illinois.

***—Editor***

## TECHNOLOGICAL INNOVATION FOR ENERGY IN A WORLD WITHOUT WALLS

The 1999 Industrial Physics Forum for Corporate & Academic Leaders sponsored by the AIP and endorsed by the APS Forum on Industrial and Applied Physics (FIAP).

**Hosted by EXXON RESEARCH & ENGINEERING**

October 25-26, 1999 • Clinton, New Jersey

**THEME SESSION:**

Markets & technology, resource exploration, innovation in energy, ultra high strength steels, physics at chemical engineering interface

**ON-SITE TOUR:**

Exxon Corporate Research

**POLICY SESSION:**

Environmental Drivers and Energy Technology

Future resources & environment, $CO^2$ management technology, ground transportation plants

**FRONTIERS OF PHYSICS:**

Protein folding, cascading lasers, accelerating universe, self-assembly

**For further meeting information or to register, contact:**

American Institute of Physics

301-209-3135; fax 301-209-3133 or email: assoc@aip.org

Or visit www.aip.org/aip/corporate/

## PROLA: More Than Just a Pretty Acronym

PROLA, *Physical Review On-Line Archive*, presently consists of a nearly complete electronic version of *Physical Review* from 1985 through 1996. Soon it will allow electronic access to the entire *Physical Review* archive, back through 1893. It is made up of scanned images of the printed journals, most of the original electronic data used in typesetting, and a searchable SGML bibliographic database. PROLA brings the century's achievements in physics straight to the desktop in a form that allows fast customized extraction of data for research purposes or out of pure curiosity.

On a simple search screen, users select articles by a certain author, that reference an author, include a designated string in text, abstract or elsewhere, or combinations of these. "One search algorithm I'd like to see," joked Marty Blume, APS Editor-in-Chief, "would produce a list of all papers that didn't reference my work but should have."

PROLA sprang from an effort in 1992-93 by Ben Bederson, then APS Editor-in-Chief, and Bob Kelly, APS Director of Journal Information Services, to create a searchable index for Physical Review from the (presciently) saved keystrokes used in composing the paper journals over the preceding decade. A Los Alamos National Laboratory group eagerly took on the job of converting the arcane data into a searchable archive mounted on a unique 'jukebox' storage system originally developed for weapons data. At about the same time, the Naval Research Laboratory was engaged in a CRADA with APS to scan images of Physical Review and make them available to its researchers as part of their electronic library initiative. In the midst of all this activity, the World Wide Web bounded onto the scene. The result was a cooperative APS-NRL-LANL agreement in which the NRL images were delivered to the Los Alamos PROLA group and integrated into the search engine they were creating for online delivery via the burgeoning Web.

In July of 1996, Mark Doyle, a young physicist who had worked at LANL with Paul Ginsparg on the XXX e-print archive joined the APS staff and took on further development of PROLA among his responsibilities. A prototype web server for PROLA was sufficiently developed by 1997 to be tested at LANL; the project relocated to the APS Editorial Office in May, 1998.

In 1999, the first two years of *Physical Review*, 1893-94, were entered into PROLA. PROLA currently includes half of the roughly 1,600,000 pages that APS has ever published. Phase II, to come online next July, will add another quarter, going back to the beginning for *PRL* (1958) and *RMP* (1929), and to 1970 for the rest of the *Physical Review* journals. Phase III will complete the archive with the years from 1895 to 1969 for *Physical Review*. "*Physical Review* is one of the few physics journals where people are still regularly using the early issues," said Pam Yorks, head of the Physics-Astronomy Library at the University of Washington. "I'm looking forward to having the rest of those older issues scanned. Our print copies are literally falling apart — the paper and bindings are disintegrating."

Enhancements expected by the end of the year include display of references and forward citations, inter-article linking (comments, replies, errata, related papers), a better search engine within PROLA and a *Physical Review* All search engine.

In addition, Doyle says that PROLA is a good test bed for experimental features such as Herbert van de Sompel's (Univ. of Ghent/Los Alamos) SFX feature. SFX would allow APS and other publishers who use it to provide links back to individual libraries within the online journal pages. These links enable the librarian to add customized online services for users based on local resources and environment.

Donations of archival journals that can be unbound and efficiently scanned have come from several sources. A gift of the first series of the *Physical Review*, through 1911, came from its birthplace, Cornell University. A large collection of *Physical Review* from early in the century through the 1970s came from Frances and Herbert Bernstein in 1998. Lancaster Press, publishers for AIP and APS, will round out and fill in the modern day collection. PROLA has made a hit with libraries and their researchers since it was first offered for only $300 in January 1999. In July, it became available to members for $100. Feedback is actively sought as more researchers make use of the archive. Occasional problems may be encountered in scanning quality or links, and suggestions for enhancements are also welcome.

Because it held the copyright, APS was able to bring the archive back to life and offer it to libraries and individuals in this infinitely more useful and durable form. "This experience argues strongly for APS retaining copyright, while extending a broad license to authors to use their work as they see fit." Blume says. "Physics papers are most valuable to the worldwide community in unified accessible collections like PROLA," he continued. "Provided that we have the freedom copyright allows to assemble and reformat the archive as technology changes, we can leave authors with wide-ranging liberties."

You are invited to browse Volume 1 of *Physical Review* from 1893 by going to the APS website www.aps.org under the Research Journals button. PROLA subscription information may be found there also.

## Atkins, New Media Coordinator, *continued from page 1*

APS with strong media experience to "pitch" physics to the general media, coordinating efforts with the American Institute of Physics' Public Information office to achieve maximum effectiveness. "It is important to increase the coverage of science generally [such that] most of the public hears something about physical science on a regular basis," says task force member Julia Phillips of Sandia National Laboratory. "And the APS should collaborate with the AIP in every possible way, since the public will not in general differentiate physics from any other physical science."

Atkins earned his BS in microbiology from the University of Florida in 1983 and subsequently worked at the National Institutes of Health, investigating AIDS, and the US Department of Agriculture, designing and performing bacterial tests on food samples. But he soon discovered that his real interests lay in communicating science through the media, especially radio and television; he began tagging along with local news teams to learn the ropes. After completing internships at two television stations in Washington, DC, he joined WVVA-TV's Channel 6 News team as an on-air reporter, covering a wide variety of stories for three daily newscasts.

In 1987, Atkins joined the ACS as a television reporter and producer for "Inside Science TV News," in conjunction with the AIP. He engaged in all aspects of bringing science and technology stories to TV newscasts worldwide. He has placed science stories on all three major networks, as well as such outlets as "Good Morning America," "Nightline," the Discovery Channel, and CNN. When ACS pulled out of the project in 1998, he became a senior science writer there, sifting through scientific papers to find news stories of interest to the media and general public, and writing news releases on those topics.

Atkins' focus with the APS will be to foster physics coverage in broad-based national popular media, both print and broadcast (radio and TV) formats, drawing on the numerous valuable contacts he has made in those industries over the years. He will coordinate some of his efforts with AIP's Public Information activities, and hopes to draw on physicists tapped as spokespersons for the nascent APS Public Face of Physics project, intended to put journalists in touch with the appropriate scientific "experts" on a topic for articles with a science or technological component (see *APS News*, January 1999).

Whenever possible, Atkins hopes to find ways to tie physics into stories about current events, many of which frequently have a related underlying science story. "Many news stories could be enhanced by the unique perspectives of physicists, from breaking hard news prompted by such events as natural disasters, to soft features like the science behind the techniques of a sports star," says Atkins. "I hope to make the APS the first place journalists turn to when they want to add depth to the news of the day."

The task force also explored other potential ways to enhance the Society's outreach activities, including television, radio, print and electronic media. Of these, revamping the APS Website—to be more dynamic and appealing to a broad audience with appropriate links to related sites—generated the most enthusiasm. Task force member, Michael Barnett of Lawrence Berkeley Laboratory, also suggested the organization of occasional Webcasts with the assistance of an experienced professional organization, such as San Francisco's Exploratorium science museum, which has done this numerous times with a live in-house audience drawn from the general public. Above all, "We must recognize that visuals — images, icons, cartoons, videos, etc. — are essential ingredients in communications, especially with the public," says task force member Eugen Merzbacher (University of North Carolina, Chapel Hill). "Words, written or spoken, are insufficient to get our message across."

*Editor's note:* Randy Atkins welcomes input from APS members with information about new and noteworthy scientific advances to help get maximum coverage in the popular press. He can be reached at 301-209-3238, or via email at atkins@aps.org.

# THE BACK PAGE

## The Impact of Physics on Biology and Medicine

*by Harold Varmus*

For at least several hundred years, physicists—and especially their principles, methods and machines—have been illuminating our views of the human body and of every other living thing.

This notion was brought home to me very early in life when my father — a general practitioner whose office was directly connected to our house — showed me how X-rays and fluorography could reveal the bones and lungs of our pets and his patients, and make diagnoses of disease. The significance of using the discoveries of physics to perceive biological function was further impressed on me at college, when one of my first independent projects required that I try to explain the repeating peaks and valleys of my electrocardiogram as a record of voltage changes in the salty sea of a human body. And yet again at medical school, when I learned that the doyens of our biochemistry department had become famous by being the first to tag red blood cells with easily detected radioisotopes to learn how long such cells survived in the body.

These are just a sampling of the hundreds of physics-based methods that have been applied to view living bodies without the disruption of anatomical dissection or to visualize very small components of living things. Many such methods can be classified as those that permit us to visualize the inner parts of working bodies of humans (and other animals) at successively higher levels of resolution and those that allow us to see smaller and smaller elements of bodily components. The methods of "macro-imaging" include conventional X-radiology, computerized tomography scanning, ultrasound, positron-emission tomography (PET), and magnetic resonance imaging (MRI). The impact of these procedures on medical practice is unquestioned and continues to grow as new methods and new applications appear.

"Micro-imaging" began with the use of optical principles to devise the light microscope, but has progressed to much higher levels of resolution with electron microscopy, X-ray crystallography, and nuclear magnetic resonance. Sometimes a collection of methods proves important, as in the use of molecular hybridization, fluorochrome chemistry, wave optics, and computer science in spectral karyotyping, a procedure that allows rapid identification of each of the 23 pairs of normal human chromosomes and the origins of recombined chromosomes that often appear in cancer cells. Long-awaited success in using a time-honored technique, X-ray crystallography, to solve the structure of proteins embedded in biological membranes has recently transformed the study of cell function and disease.

In a 1967 commentary on the role of physics in biology and medicine, Sergei Feitelberg, a physicist from Mt. Sinai Hospital in New York, noted that while such "spectacular developments created a clear and unequivocal need for physicists and their help, the role of the physicist was that of a glorified technician engaged in methodology and instrumentation, dignified only by the strangeness of his doings and the mysteriousness of his tools." I do not accept that interpretation. We need to show our appreciation of physics-based technology by investing NIH funds more aggressively in its development. We have begun to do just that through a new Bioengineering Consortium and a trans-NIH emphasis on technology development.

### *Physicists and the rise of molecular biology*

There are multiple intellectual lineages connected with physics that helped to create the modern world of molecular biology. Max Delbruck, a leading physicist who had made a conversion to biology some years earlier, had been a student of Niels Bohr; a successful physicist; and then a powerful proselytizer for biology, attracting many other physicists to biology. The effects of his missionary zeal were powerful, not just because some very smart people started to do biology, but because they brought to biological problems a quantitative, analytic approach, creating the atmosphere in which principles of molecular biology were discovered by seeking the physical basis of heredity. Leo Szilard was among the converts, and claimed that what physicists brought to biology was "not any skills acquired in physics, but rather an attitude: the conviction which few biologists had at that time, that mysteries can be solved".

Delbruck and his friends were gripped by some fundamental questions: What is the physical form in which hereditary information is stored? How is it reproduced when a cell divides? Or, even more impressively, when a single virus particle invades a cell and makes hundreds or thousands of copies of itself? How is the information reassorted during sexual reproduction? How does the information change when mutations occur?

Answers to many of these questions came from the so-called "phage school" that he founded, a group of former physicists and some biologists who shared his passion for reducing the problem of heredity to simple rules, physical entities, and conserved energy by studying the replication and genetic behavior of bacterial viruses in their bacterial hosts. The studies culminated in findings that form the pillars of modern molecular biology: the identification of DNA as genetic material, a description of the physical organization of DNA through X-ray crystallography, the deduction of the principles of base pairing and the strategy of replication from the organization of the double helix, and the deciphering of the genetic code as triplets chosen from a set of four nucleotides.

Warren Weaver was a mathematical physicist turned science administrator, who, in 1932, first used the term "molecular biology." British scientists with a strong physical bent, such as Astbury, Bragg, and others, used X-ray diffraction to study the organization of fibers of many kinds, mainly proteins found in textiles, in an intellectual lineage that led to Wilkins and Franklin and, of course, DNA. The American geneticists, T.H. Morgan and H.J. Muller used physical agents, X rays, to induce mutations in fruit flies. Muller's affinity for the principles of physics was especially strong. He was fond of noting the potential similarities of mutation of genes to transmutation of elements, calling the prospect of understanding these events in physical terms "the two keystones of our rainbow bridges to power".

### *Bringing physics to the problems of biology*

In the birth of modern molecular genetics, physicists contributed their analytic skills but they were not really doing physics, and many were not even using the computational or imaging tools of physics as many biologists do. But contemporary biology, especially the deciphering of genomes by nucleotide sequencing, is about to change that. Biology is rapidly becoming a science that demands more intense mathematical and physical analysis than biologists have been accustomed to, and such analysis will be required to understand the workings of cells.

In the past 50 years, molecular and cell biologists have moved much closer to the "radical physical explanation" of cell behavior that Delbruck sought. Certainly the chemical elements — especially the genes, the RNAs, and the proteins — and some of their basic functions are coming into view. What is lacking is a sense of how these functions are integrated to allow cells to manifest their physiological traits. There are three arenas of biology in particular where I believe the skills of physicists can be most productively used.

First, methods are now available for examining the physical and chemical properties of single macromolecules and single complexes of large molecules. These include laser traps ("optical tweezers") to study the energetics of molecular motors used for transport, for contraction, and for flagellar motion. (The recently decorated Nobel Laureate Steven Chu of Stanford has made significant contributions to this problem in collaboration with his cell biologist colleague, Jim Spudich.) Laser traps can also be used to measure the force of an enzyme complex, such as the one that copies DNA sequences into RNA. Fluorescence spectroscopy and scanning tunnel microscopy can visualize the conformation of single large molecules, and methods now in development may soon be able to determine the order of bases in single long DNA molecules.

Second, the computational experience of physical scientists is needed to help interpret complex data sets. New methods, built on the availability of a piece of DNA from each gene, allow measurement of the extent to which genes are read to form RNA (and subsequently protein) in different tissues and under different environmental conditions. These micromethods, called "expression arrays" are coming into wide use to study bacteria (with several hundred to a few thousand genes), yeast (6200 genes), worms (19,100 genes), and vertebrates (whose still incompletely analyzed genomes are predicted to contain about 80,000 genes). Some progress has been made through computer-based "cluster analysis" to begin to interpret the voluminous data that such experiments generate, but biologists are generally unused to such complex data sets. Recently, I spent an evening at the Carnegie Institution's Chilean observatory at La Serena watching astrophysicists gather amazingly similar data sets to search for supernovae and to measure the chemical composition of distant stars. We are all likely to benefit from an interdisciplinary exchange of computational approaches.

Third, in the past 20 years, biomedical investigators have constructed many so-called "signaling pathways" that link molecular interactions at the cell surface to changes in gene expression in the nucleus. While there is consensus that these linear pathways are over-simplified, the way forward is far from clear. The pathways doubtless have many unrecognized components; the information is certainly flowing between, not just along, the several pathways; and the pathways are probably regulated in complicated ways through feedback mechanisms and others. A few investigators are beginning to grapple with these issues but there is an obvious need to apply experiences with potentially analogous complex machines.

Harold Varmus

### *Moving between disciplines*

Self-identification in science is commonly linked to the source of one's graduate degree, and departmental names on diplomas can become limits to exploration in adjacent fields. But many of us in biology expect that, as studies of cells and molecules become more obviously in need of several disciplinary approaches, it will become increasingly difficult to label the sciences and to predict the kinds of degrees people doing it should have. At the NIH, we have become concerned about how people should be trained in college and in graduate studies to pursue biological problems over the next 50 years. I also agree with Leon Lederman, who has been leading the movement to establish a more logical order of sciences — physics, chemistry, and then biology — in high school curricula. But these activities will come to fruition only after many years, and it is important to consider as well the more immediate need to transport intellects across artificial disciplinary boundaries.

I sense increasing interest in attempting to open borders that have been traditionally hard to cross. Workshops on computational biology and approaches to complex systems have recently been organized by the National Institute of General Medical Sciences and the Department of Energy. New funding opportunities for interdisciplinary work are available through our Bioengineering Consortium (BECON) and other programs. (At present, total NIH funding of physics projects is estimated to be about $287 million.) There are many anecdotal accounts of successful interdisciplinary training programs. Within our intramural research program at the NIH, physicists and physics trainees from the US and abroad do graduate thesis work, take courses in biological topics, and engage in post-doctoral training that promotes interactions with biologists and clinicians.

The NIH can wage an effective war on disease only if we — as a nation and a scientific community, not just as a single agency — harness the energies of many disciplines, not just biology and medicine. These allied disciplines range from mathematics, engineering, and computer sciences to sociology, anthropology, and behavioral sciences. But the weight of historical evidence and the prospects for the future place physics and chemistry most prominently among them.

*Harold Varmus, M.D., is director of the National Institutes of Health. The above text was condensed and adapted from his plenary lecture at the APS Centennial meeting in Atlanta on March 22, 1999. The full text, complete with references and illustrations, can be found online at http://www.nih.gov/welcome/director/varmus.htm.*

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