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Site Visits To Identify Strong Candidates for New Education Program

Over the course of 12 weeks, several key staff members from the APS, the American Institute of Physics (AIP) and the American Association of Physics Teachers (AAPT) are visiting colleges and universities around the country to identify institutions to participate in a new joint project to improve science teacher preparation. In the past year, several national reports have emphasized that the most effective way to improve programs that prepare future teachers is by involving faculty from several academic departments across the institution. Called the Physics Teacher Education Coalition (PhysTEC), the project will enlist physics departments in collaboration with education departments to revise required courses and to enhance field experiences for prospective physics and science teachers.

With the help of planning grants from NSF and the Department of Education's Fund for the Improvement of Post Secondary Education (FIPSE), initial site visits have been made to Florida State University, the University of Arkansas, Fayetteville, the University of Western Michigan, the University of Maryland, Oregon State University, Xavier University in New Orleans, the University of Arizona, and Ball State University. Fred Stein, APS Director of Education and principal investigator on these grants, brought his previous experience to APS to help shape this new program.

Alicia Chang/APS

APS Education Director Fred Stein heads out the door on another site visit for the PhysTEC program.

Not all of the above university programs are expected to match perfectly with the PhysTEC model, but by later this fall six to eight universities will be selected as test sites for the new program. In addition, another 5-10 colleges and universities will serve as Resource Institutions. Ultimately, says Jack Hehn of AIP and a co-principal investigator, "the long-term vision would be a few hundred colleges and universities whose physics departments are intensely interested in improving the way they educate teachers."

There are three key components to the PhysTEC program, according to Stein. The cornerstone of the PhysTEC success strategy is arranging for an outstanding high school teacher to spend a year in the physics department of each participating university. These teachers-in-residence (TIRs) will also work with the college of education and local schools. The concept, says Stein, is that the TIR will bring knowledge and experience gained from teaching student-centered science classes, and provide continuity between the physics courses, the science methods courses, and local high school science programs. They will help physics faculty revise targeted physics courses and will help teach science methods courses. "The TIR can provide a realistic understanding of what science is being taught and how it is now being taught in the schools," says Stein, "as well as offering valuable contacts with local teachers and school districts to improve practicum activities and the placement of student teachers."

Another central component of PhysTEC is restructuring and revision of targeted introductory

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Olympians Return Triumphant

Photo courtesy of AAPT

The five members of the U.S. physics team display their hard-earned medals from the 2000 Physics Olympiad in Leicester, England. From left, silver medalist Gregory Price, and bronze medalists Jason Oh, Michael Vrable, Joseph Yu and Anthony Miller. For more coverage of the Olympiad and training camp, see page 6.

NMD Decision Follows APS Action

On September 1, President Clinton announced that he was deferring a decision on deployment of a National Missile Defense until at least the next administration. This action was consistent with the recommendations made in an APS Council statement on April 29, and with the opinions expressed to the White House by many APS members in response to an e-mail alert that was sent out on July 31.

The APS statement said, in part: "The United States should not make a deployment decision relative to the planned National Missile Defense (NMD) system unless that system is shown – through analysis and through intercept tests — to be effective against the types of offensive countermeasures that an attacker could reasonably be expected to deploy with its long-range missiles."

In his September 1 announcement, President Clinton said, in part: "I simply cannot conclude with the information I have today that we have enough confidence in the technology, and the operational effectiveness of the entire NMD system, to move forward to deployment."

Neutrinos, CP Violation Highlight DPF2000

What are the parameters describing neutrino oscillation? Does the observed violation of CP symmetry agree with the predictions of the standard model? These were among the questions for which preliminary answers were suggested at the August meeting of the Division of Particles and Fields on the campus of Ohio State University.

In a plenary talk on Thursday morning, August 10, Kate Scholberg of Boston University highlighted the recent announcement of the direct observation, by the DONUT detector at Fermilab, of the tau neutrino, the last of the leptons predicted by the standard model, thereby formally completing the structure for which so much evidence has accumulated over the last couple of decades.

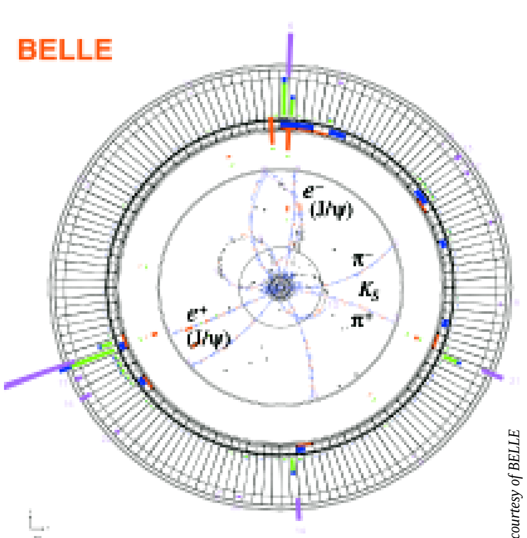

Image courtesy of BELLE

B meson decay candidate in the BELLE detector.

She went on to review the data, not all mutually consistent, determining the parameters of neutrino oscillation. These data come from three basic sources: the deficit of electron neutrinos from the sun, the deficit of muon neutrinos produced in the atmosphere, and the direct observation of muon neutrino to electron neutrino oscillations in terrestrial experiments.

The latest results on the solar and atmospheric neutrinos come from SuperKamiokande, a giant water Cerenkov detector in Japan. In addition, the direct observation of neutrino oscillation by the LSND experiment at Los Alamos, has been looked for but not yet seen by the KARMEN experiment at Rutherford-Appleton Laboratories in England. Given the current sensitivity, however, these two accelerator experiments are not inconsistent.

See DPF2000 *on page 7*

Scientific Visits Encouraged to Palestinian Universities

Scientific research in the universities of the Palestinian-controlled West Bank is only just beginning, and can be greatly helped along by visits from scientists who may already be traveling to nearby institutions.

This was the message conveyed by Najeh M. Jisrawi, a professor of physics at Birzeit University, during a recent visit to the United States. He was in this country both to pursue his own research at Brookhaven, and also to gain support for the fledgling Palestinian research efforts. In this latter goal he has been aided by Irving Lerch, Director of the APS Office of International Affairs.

APS members interested in possibly making a visit to a Palestinian university while on a trip to the Middle East are urged to contact Lerch by e-mail (lerch@aps.org) or by telephone: (301) 209-3236. Most of the universities are within easy driving distance of Jerusalem, including the two at Birzeit and Bethlehem that are probably most familiar to western scientists. Jasrawi pointed out that transportation from Jerusalem and incidental expenses can generally be provided by the host institutions. In addition to promoting scientific research on the Palestinian campuses, physicists on

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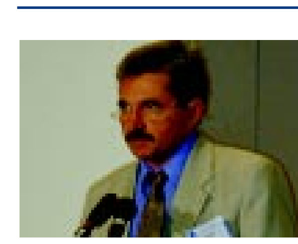
HIGHLIGHTS



Alan Chodos/APS

EDUCATION, *from page 1*

courses and their instructional approaches to promote active learning, preferably in an integrated lecture and laboratory format. It is hoped that the redesigned courses "will encourage less reliance on the standard, teacher-dominated, transfer model of science instruction, and require a more spontaneous interchange of ideas," says Stein. Curriculum reform will likely draw from the burgeoning field of physics education research taking place at universities around the nation, according to Hehn, and will focus on instructional strategies such as bringing more inquiry-based, student-centered experiences into lecture sections through cooperative learning and peer-coaching techniques, and using appropriate learning technologies to enhance instruction.

The third key component to the PhysTEC program is to replace traditional science methods courses with inquiry-based courses that integrate learning theory, teaching methods and physics content. "This course should enable prospective teachers to teach future students to actually do science, which includes helping them develop scientific habits of mind," says John Layman, an emeritus University of Maryland professor and second co-principal investigator. "Hands-on experiences followed by structured reflection about what the student observed and what can be inferred, and how this improves understanding of science content, should be a significant part of the course."

Strong administrative support at all levels of the institution is also required to ensure the success of the PhysTEC model, according to Hehn. This includes the support of academic deans and provosts, as well as department chairs. A memorandum of understanding will be executed with each institution selected as part of PhysTEC, and these will be an important part of a major proposal that will be submitted to the NSF and FIPSE by the end of the year.

The prevailing question to be answered, according to Stein, is whether the PhysTEC model is a replicable concept. "If it is true that teachers teach as they were taught, then our vision for improving physical science and physics teaching and learning in K-12 is to have the universities model effective teaching/learning approaches in science courses for both majors and non-majors," he says. "This should impact all prospective physics and physical science teachers, including chemistry, geology and mathematics teachers, as well as elementary school teachers."

For more information about the PhysTEC program, contact Fred Stein, (301) 209-3263, or stein@aps.org.

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the West Bank and in the broader region are excited by the prospect of a new research facility, SESAME, to be located in Jordan on a site in a wooded area with rolling hills about midway between Amman and the Jordan River. The core of the facility is planned to be an upgraded version of the BESSY-I synchrotron, which is now being disassembled and crated in Germany. When funding is available, it will be shipped to Jordan for re-assembly. Jordan has promised both the site and a contribution towards the operating expenses, but the majority of the necessary financial support is still being sought. More information can be obtained from the SESAME web site, www.sesame.org.jo.

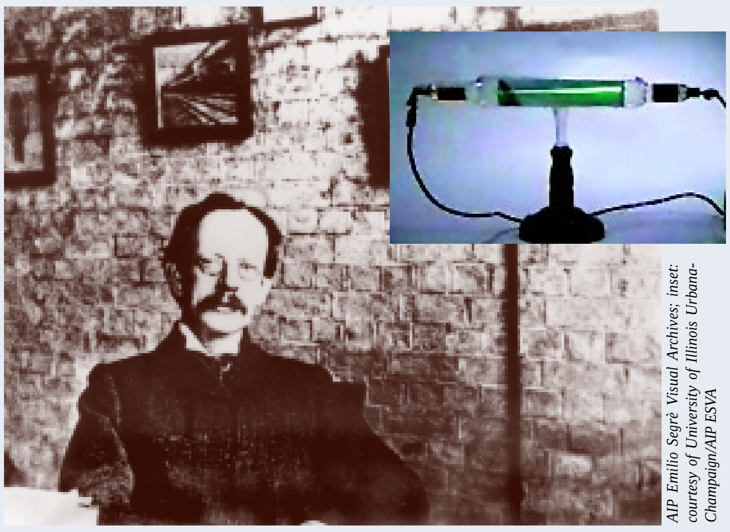
Eliezer Rabinovici, Professor at the Racah Institute of Physics of the Hebrew University in Jerusalem, is among those Israeli scientists who are very supportive of scientific exchanges between Israelis (and visiting Americans) and Palestinians. "From the Israeli point of view," he says, "it may be easier to agree on scientific relations than on political ones, and one hopes that these scientific contacts will promote greater mutual understanding in other ways as well." Rabinovici believes that Americans can play a very positive role in this process. He feels in particular that lectures by visiting scientists can help stimulate interest among students in pursuing scientific careers.

Image courtesy of Najeh Jisrawi

Location of Palestinian institutions of higher learning on the West Bank and in Gaza. Al-Quds is located in Jerusalem itself.

This Month in Physics History

October 1897: The Discovery of the Electron



AIP Emilio Segrè Visual Archives; inset: courtesy of University of Illinois Urbana-Champaign/AIP ESVA

Thomson in his office. Inset: a simple cathode ray tube.

Science lecturers traveling from town to town in the mid-19th century delighted audiences with a device that could be considered the ancestor of the neon sign. They took a glass tube with wires embedded in opposite ends, administered a high voltage and pumped out most of the air. The result: the interior of the tube would glow in lovely fluorescent patterns. Scientists theorized that the glow was produced by some kind of ray emitted by the cathode, but it took the seminal research of a British professor in Cambridge University's Cavendish Laboratory to finally provide a solution to the puzzle.

J.J. Thomson refined previous experiments and designed new ones in his quest to uncover the true nature of these mysterious cathode rays. Three of his experiments proved especially conclusive. First, in a variation of a pivotal 1895 experiment by Jean Perrin, he built a pair of cathode ray tubes ending in a pair of metal cylinders with a slit in them, which were in turn connected to an electrometer. The purpose was to determine if, by bending the rays with a magnet, Thomson could separate the charge from the rays. Failing this, he concluded that the negative charge and the cathode rays were somehow stuck together.

All previous attempts to bend cathode rays with an electric field had failed, so Thomson devised a new approach in a second pivotal experiment. A charged particle will curve as it moves through an electric field, but not if it is surrounded by a conducting material. Thomson theorized that the traces of gas remaining in the tube were being turned into an electrical conductor by the cathode rays themselves, and managed to extract nearly all of the gas from the tube to test his hypothesis. Under these circumstances, the cathode rays did bend with the application of an electric field. From these two experiments, Thomson concluded, "I can see no escape from the conclusion that (cathode rays) are charges of negative electricity carried by particles of matter."

However, he still lacked experimental data on what these particles actually were, and hence undertook a third experiment to determine their basic properties. Although he couldn't measure directly the mass or electric charge of such a particle, he could measure how much the rays were bent by a magnetic field, and how much energy they carried, which would enable him to calculate the ratio of the mass of a particle to its electrical charge (m/e). He collected data using a variety of tubes filled with different gases. Just as Emil Wiechert had reported earlier in the year, the mass-to-charge ratio for cathode rays turned out to be over one thousand times smaller than that of a charged hydrogen atom. Subsequent experiments by Philipp Lenard and others over the next two years confirmed the conclusion that the cathode rays were particles with a mass far smaller than that of any atom.

Thomson boiled down the findings of his 1897 experiments into three primary hypotheses: (1) Cathode rays are charged particles, which he called "corpuscles. (The term "electron" was coined in 1891 by G. Johnstone Stoney to denote the unit of charge found in experiments that passed electrical current through chemicals; it was Irish physicist George Francis Fitzgerald who suggested in 1897 that the term be applied to Thomson's corpuscles.) (2) These corpuscles are constituents of the atom. (3) These corpuscles are the only constituents of the atom.

Thomson's speculations met with considerable skepticism from his colleagues. In fact, a distinguished physicist who attended his lecture at the Royal Institution admitted years later that he believed Thomson had been "pulling their legs." Gradually scientists accepted the first two hypotheses, while later experiments proved the third to be incorrect, thanks to the efforts of Ernest Rutherford and subsequent researchers. The electron itself turned out to be somewhat different from what Thomson imagined, acting like a particle under some conditions and like a wave under others, a phenomenon that would not be explained until the birth of quantum theory. Physicists also discovered that electrons were only the most common members of an entire family of fundamental particles, which are still the subject of intensive research to better understand their properties.

Thomson's work earned him recognition as the "father of the electron," and spawned critical experimental and theoretical research by many other scientists in the United Kingdom, Germany, France and elsewhere, opening a new perspective of the view from inside the atom. The knowledge gained about the electron and its properties has made many key modern technologies possible, including most of our society's computation, communications, and entertainment.

—Adapted from an online exhibit by the History Center of the American Institute of Physics developed in 1997 to commemorate the 100-year anniversary of the discovery of the electron. To view the full exhibit, see http://www.aip.org/history/electron/.

Birthdays for October:

7 Niels Bohr (1885)
23 Il'ja Mikhailovich Frank (1908)

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PHYSICS AND TECHNOLOGY FOREFRONTS

Code Division Multiple Access: Enabler of the New Wireless Era

By Andrew J. Viterbi

Between 1895 and 1901, Guglielmo Marconi first demonstrated the feasibility and tremendous potential of wireless communication, progressing during that time from small homegrown experiments to transmission of the first transatlantic wireless messages. In the century that followed, our lifestyle and culture has been modified dramatically by a series of culture altering wireless applications, including broadcasting (both audio and video) and radar. An even greater cultural change is occurring through wireless voice and data communication from and to virtually anywhere at any time. The key to unlocking these benefits is the implementation of efficient means for multiple access by numerous simultaneous users and the provision of multiple services to a population with diverse requirements and resources.

The origins of multiple access date back to Patent No. 7777 awarded in 1900 to Marconi for the "Tuned Circuit" which was the enabling technology for both Frequency Division Multiplexing (FDM) and Frequency Division Multiple Access (FDMA). (FDM refers to transmission of multiple sources from a single location by modulating each on a separate carrier sufficiently separated from the other, while in FDMA the sources and their respective modulated carriers emanate from different transmitters, generally not co-located.) FDM and FDMA are the only multiplexing and multiple access techniques, that can be used with both analog and digital transmission.

For digital sources, two alternative technologies have evolved for multiplexing and multiple access: time division (TDM and TDMA) and code division (CDM and CDMA). With the beginnings of the computer industry in the 1950's, TDM evolved naturally since it is a way to multiplex several parallel data streams generated in a single location into one serial data stream. Thus time division multiplexing is synonymous with parallel-to-serial conversion. TDMA, on the other hand, was used beginning in the 1960's for geosynchronous satellite networks of small numbers of large antenna earth stations.

Code division multiple access (CDMA) has a far different pedigree, also dating back to the 1950's. As its name implies, users' signals are isolated not by separate time or frequency slots, which are occupied in common by all users, but rather by unique underlying codes, which when decoded restore the original desired signal while (ideally) totally removing the effect of the other users' coded signals. For this ideal case the codes must be time-synchronized and orthogonal, meaning that any two users' codes must differ in half their symbols and agree in the other half. This synchronization in time is easily achieved for code division multiplexing, where all sources destined for all users are transmitted from the same location, such as a base station. For multiple access, on the other hand, time synchronization is generally not practical since users are separated by distances which change with motion. Additionally, multiple paths may produce different time shifted replicas of each user's transmitted signal and code. Thus for CDMA, users' codes are generally chosen to be non-repetitive over a very long period, which does not guarantee orthogonality over the shorter period of each user's transmission, but does ensure a small effect on the demodulators of other users.

Dr. Andrew Viterbi is a co-founder of QUALCOMM Incorporated. He has spent equal portions of his career in industry, having also co-founded a previous company, and in academia as Professor in the Schools of Engineering first at UCLA and then at UCSD, at which he is now Professor Emeritus.

His principal research contribution, the Viterbi Algorithm, is used in most digital cellular phones and digital satellite receivers, as well as in such diverse fields as magnetic recording, speech recognition and DNA sequence analysis. In recent years he has concentrated his efforts on establishing CDMA as the multiple access technology of choice for cellular telephony and wireless data communication.

An important side effect of code division is that each user's transmitted bandwidth is greatly enlarged by making the coded signal's symbol rate, or clock, run much faster than the digital data rate of the source. For example, if the data rate is 10K bits/sec, the code clock symbol rate may be 1Mbit/sec or 100 times as fast. The result is an occupied bandwidth approximately equal to the coded rate; hence the term "spread spectrum" is often used interchangeably with CDMA. This, in fact, better describes the origins of CDMA. As early as World War II but with greater intensity and sophistication beginning in the 1950's, spread spectrum was employed in military communications to protect against hostile interception and interference or jamming. If the enemy does not know the communicator's code, the latter's signal will appear merely as noise. More significantly, if the enemy tries to jam the transmission with any form of radio signal, the intended friendly receiver's demodulator in the process of decoding the desired signal will transform the hostile signal into a spread spectrum form approximating wideband noise. The effect is to reduce the hostile jammer's effectiveness by a factor known as the "processing gain" or "spreading factor" which is the ratio of the code rate to the original source's bit rate (100 for the example just given). Essentially, spread spectrum or CDMA is the "best" signaling modulation for even the "worst" form of jamming signal. (This is sometimes called the mini-max solution of a game between communicator and jammer.)

This historical military application, took on added importance with the proliferation of military geosynchronous communication satellites in the 1970's and 1980's, which are particularly vulnerable to jamming from almost anywhere. The first commercial applications of CDMA were also in transmissions to communication satellites because as the geosynchronous orbit space became more crowded and earth antennas became much smaller with consequently wider apertures, transmission to and from satellites began to interfere more severely with one another. Hence the interference suppression properties of CDMA made this the multiple access technology of choice.

Terrestrial mobile cellular telephony became the overwhelmingly pervasive multiple access application of the 1990's with approximately 400 million subscribers today and possibly over a billion by the end of the decade. The industry moved from analog modulation in the 1980's to digital modulation in the 1990's and now employs voice compression and advanced modulation and coding techniques to serve more subscribers per base station in the allotted frequency spectrum. Though the early impetus from the European cellular telephony standard of the 1980's was toward a hybrid TDMA/FDMA approach known as GSM, the establishment of a CDMA standard in 1993 has helped make CDMA the most rapidly growing technology, already serving over a quarter of the digital cellular population. Its technical advantages are particularly important as the number of users served by a base station increases and hence suppressing the effects of multipath, avoiding interference between users, and performing soft handover between base stations become ever more critical. And as bandwidth efficiency needed for high-speed access to the Web becomes essential in third-generation wireless systems, CDMA is expected to become the global standard.

Powers of Ten: Astronomy's Greatest Hits

Compiled by Virginia Trimble

Editor's Note: Owing to the huge response generated by prior "Top Ten" lists published in APS News, we offer the following list of great discoveries in astronomy. As always, readers are welcome — nay, encouraged — to take issue with the rankings, omissions, erroneous inclusions, and the like. We also encourage those in other fields to compile their own "Powers of Ten" lists for possible future publication, modeled on the format below.

Top Ten Astronomical Triumphs of the Last Millennium

1. Celestial objects are:
- NOT immutable (Tycho's supernova of 1572 and comet of 1577 not in atmosphere)
- NOT perfect (mountains on the moon, Galileo 1610; sunspots, Harriot, 1610)
- NOT marching to a different drummer (apples and the moon, Newton 1687)
- NOT fully inventoried (W. Herschel discovery of Uranus, 1781)
- NOT made of anything funny (Bunsen & Kirchhof, spectroscopy, 1858).

2. Eclipses and some periodic comets are predictable. (Halley 1695/1758, eclipses, 1715; Neptune was also predicted and discovered in 1844).

3. We are not at the center of
- the solar system (Copernicus 1500/1543)
- the galaxy (Shapley, 1920)
- the universe (Digges, 1500 for infinite universe; Einstein 1915 for finite universe).

4. There exist
- other galaxies (Hubble, 1924)
- other solar systems (Mayor/Queloz/Marcy/Butler, 1995+)
- other universes (Steinhardt, Linde, Guth, Hawking, Hartle, Rees, etc., 1990s).

5. The universe is expanding (Hubble 1929 and eventual elimination of tired light alternative) and went through a hot dense phase 10-20 Gyr ago. (Gamov, Alpher, Herman, 1948; Ryle & Scheuer 1955; Penzias & Wilson, 1965).

6. Light moves at finite speed. (Roemer, 1675, eclipses of the moons of Jupiter; Bradley, 1729, aberration of starlight. Also requires Earth to move and stellar distances at least 10^5 times the solar distance).

7. Continued expansion of our ideas about the size of the universe.
- Sun at 1079 Earth radii; stars ten times as far (Greeks to Kepler)
- Parallax of Mars; Sun more than 50,000,000 miles away (Cassini, Flamsteed, 1672)
- Stars at least 10^4 times further (Huygens, Gregory, Newton, 1650-1700)
- Measurement of stellar parallaxes; all stars at least 2×10^5 x solar distance (Struve, Bessell, Henderson, 1838)
- Distances to other galaxies from 10^5 to 10^6 parsecs (Hubble, using Shapley scale)
- Extragalactic distance scale expands by a factor of between 5 and 10 (Walter Baade, Allan Sandage, and others, 1952-1999).

8. Celestial objects are born and die, and must have energy sources.
- Conservation of energy (Kelvin, Helmholtz and others, 1850s)
- Giant-and-dwarf theory of stellar evolution (HN Russell, 1910)
- Stars run on nuclear energy (Eddington to Bethe)
- Star formation is real, ongoing process (Spitzer, Schwarzschild et al., 1940s)
- Galaxy evolution can be calculated (Tinsley 1967)
- Galaxy formation can be observed (everybody, 1990s).

9. Leadership in science can move from one place to another. Chinese astronomy, Mayan astronomy, and Arabic astronomy all once outranked Europe. Recent history has seen the gradual migration of the largest population of astronomers and journals from Germany and England to the United States, and from there, who knows?

10. Multiplication of wavebands and tools beyond wildest dreams. (And

See ASTRONOMY *on page 7*

Physics Planning Committee Meets in Washington DC

Ken Cole/APS

The PPC met on September 7 to discuss the APS role in supporting science and math education. Seated clockwise around the table (some partially obscured) are: James Langer, Robert Richardson, Janice Sunley (NSF), Judy Franz, Burton Richter, Ken Haas, Lee Ridinger, Francis Slakey, Beverly Hartline, Jerry Friedman, Ken Heller, George Trilling, Gerry Yonas, Mike Lubell.

LETTERS

How Much Energy in an Ounce?

Albert Bartlett's letter in the June *APS News* corrects an estimate of the "energy in an ounce" from "85 million tons" to "607 thousand tons" of TNT.

However, the energy released from even one ton of trinitrotoluene is quite a bit greater when it is burned slowly in air vs allowed to detonate. In any event, the energy in an ounce would be exactly equal to the energy of an ounce, not the energy of xxx tons! You know what I mean?

John Michael Williams
Redwood City, California

Whose Famous Constant?

A common misunderstanding of the history of "Newton's" universal gravitational constant is repeated in the July issue of *APS News*. Newton did not use a constant in expressing the universal law of gravitation; he expressed it verbally in terms of direct and inverse proportionalities. In an interesting review of the history of "Big G" titled, "The Cavendish experiment as Cavendish knew it" (Am. J. Phys. v. 55, p. 210 [1987]), B. E. Clotfelter points out that this constant is introduced for the first time only near the end of the Nineteenth Century. Cavendish referred to his own work as "Experiments to Determine the Density of the Earth." Clotfelter points out that there was no unit for force until the dyne was proposed in 1873, and that "...the idea of measuring such a constant (as G) is less likely to occur to an experimenter when no unit for force is available."

David Gavenda
University of Texas at Austin

Advice Given to Budding Chemical Engineer

The July issue of *APS News* included a question from a parent whose son has taken the AP Physics exam and is interested in a career in chemical engineering. As an APS member with a degree in physics who now works in a chemical engineering department, I can only suggest to Mr. Levitt that chemical engineering is an excellent discipline for a scientifically curious young person to consider. The best chemical engineers regularly use their fundamental understanding of the physical world based on physics, chemistry, and mathematics to solve complex and fascinating problems. One useful source of information for young people interested in chemical engineering is a website hosted by the American Institute of Chemical Engineers (http://www.aiche.org/careers).

Many other disciplines also offer intellectually challenging career options, but I can think of no reason why Mr. Levitt should discourage his son from exploring a career in chemical engineering.

David Sholl
Carnegie Mellon University, Pittsburgh, Pennsylvania

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I suppose I am in a unique position to offer advice in that I started as an Engineering major (Electrical) but switched to Physics after my first college Physics course. And I worked with many Chemical Engineers during my career as a Polymer Physicist with DuPont. However, the most important advice I can give would be general advice I would give any parent with a child at this stage of life.

To Mr. Levitt:

- Don't sweat the decision. No matter what the choice now, it is likely to change.
- Encourage your son to get advice from a broad cross section of people (but my experience with high school guidance counselors has not been good).
- Most importantly, remember that it is your son's career and the decision must ultimately be his.

To the son:

- Pick something and begin to focus on that. A good place to start is with one of the career exploration programs that let you "shadow" professionals in several occupations. It will give you a small taste of some of the possibilities.
- Until you learn more, keep an open mind. College opens new vistas for most students. Chances are that you will change no matter what you choose.
- Take a broad range of courses in college.
- Above all, if you have an abiding passion about some subject, find a way to pursue it.
- But remember, even with passion, life gets grim unless you can make a comfortable living.
- Keep an eye out for interesting opportunities. No one can predict what doors will be open to them in the future.
- One other point, there are very few jobs with no satisfaction and none without some sort of drudgery.

Specifically addressing Chemical Engineering:

- We will continue to need products made with chemical processes. I would expect demand to remain strong for Chemical Engineers and the salary is usually quite good.
- A wide variety of jobs are open including "hands on" design of plants and equipment, design and operation of systems to control the manufacturing process & basic research in a wide range of industries.
- It also offers an excellent entry into management.

On the other hand, I was able to solve a number of long term problems at DuPont because my Physics training gave me a different perspective and different tools to work with.

Farren H. Smith
Camden, South Carolina

Copernicus and the Scientific Impulse

Owen Gingerich is not the first historian of astronomy to downplay the role of observational evidence in the inception of the heliocentric model and instead elevate the role of what he calls 'the Aesthetic Impulse' ("Copernicus and the Aesthetic Impulse," *APS News*, July 2000, THE BACK PAGE). There are similar sentiments expressed in Thomas S. Kuhn's *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Harvard Univ Pr, 1957), and also in Arthur Koestler's *The Sleepwalkers: A History of Man's Changing Vision of the Universe* (Hutchison, 1959). I have always felt uneasy with this attitude, for these reasons:

It is indeed legitimate to argue, as Owen Gingerich does, that "Copernicus relied on aesthetic principles, ideas pleasing to the mind." However, it is also justifiable to argue that Copernicus also relied on observational evidence, and further, on the epistemological inferences derived from them.

In his life work *De Revolutionibus* (1543), Copernicus made the following relevant points: "The Earth is impregnated by the Sun and generates offspring every year;" and more pertinently, the (brilliant and resplendent) Sun is "named by some the lantern of the universe," and by others the "visible god," "king of the sky," "pilot of the world," "overseer of everything," etc. (Now what is this, if not (literally blinding) observational evidence?) It is from these (quite enlightening) remarks that Copernicus went on to deduce that "the center of the universe is the natural point where to place the Sun so as to best illuminate the cosmos."

Copernicus also cites several ancient authors who assigned one or more motions to the Earth. Moreover, there is a passage in the extant manuscript of *De Revolutionibus* which mentions Aristarchus of Samos (third century BC). Although this passage was not printed in the first published version of *De Revolutionibus* in 1543, it is reproduced in some of the modern editions of the great book. Although Aristarchus's work on the heliocentric model has been lost, it is unambiguously mentioned in several other surviving books from antiquity, notably one by Aristarchus's contemporary Archimedes of Syracuse.

What is more interesting is that the only surviving book by Aristarchus is entitled (very significantly) *On the Sizes and Distances (from the Earth) of the Sun and Moon*. In this book, Aristarchus describes certain measurements that he carried out himself (one of which is inaccurate). Aristarchus then went on to do the correct mathematical analysis and computations from which he derived values for the four quantities mentioned in the title. Whereas Aristarchus's two values for the Moon are impressively accurate, his two values for the Sun are out by a factor of about 20 — owing to the inaccuracy of one measured quantity. This resulted in a solar system about 20 times smaller than true. These became the accepted values until the 17th century, as confirmed by Owen Gingerich when he remarked that "unknown to Tycho Brahe, the solar system was 20 times larger than he or anyone else imagined."

Nevertheless, Aristarchus's work still resulted in a Sun that was nearly seven times larger than the Earth in terms of radius, and about 300 times larger than the Earth in terms of volume. There is a suggestive anecdote about Rutherford's model of the atom. When asked why he placed the nucleus stationary at the center and the electrons orbiting the nucleus and not the other way around, Rutherford is said to have replied: For the same reason why we consider the elephant to be stationary and the fleas jumping up and down on him — and not the other way around.

In *The Copernican Revolution*, Thomas S. Kuhn stated: "the Greeks produced (no) evidence for the earth's motion." (p. 43) I submit that the known work of Aristarchus (discussed by Kuhn at some length) IS evidence, albeit indirect and inconclusive, for the earth's motion.

My reading of Copernicus's writings suggests to me that he wanted to replace the basically (as he obviously believed) untrue geocentric model with the essentially true heliocentric model. Copernicus hinted that a soundly composed heliocentric model would make more accurate predictions and a better calendar than those derived from the existing geocentric model. It was these justifiable beliefs and expectations that motivated Copernicus to go into all the trouble to construct a detailed new model of the universe. It took much more time and work by others, but Copernicus's beliefs and expectations were fulfilled in the end.

In conclusion, I would say that Copernicus was more of a modern scientist than Thomas S. Kuhn, Arthur Koestler, and Owen Gingerich have portrayed him. Moreover, what seems to have motivated Copernicus (and also Aristarchus, Galileo, Kepler, etc.) was the 'Scientific Impulse.'

Theo Theocharis
London, England

Whose Famous Formula?

In *APS News*, August/September 2000, the "This Month in Physics History" column was entitled "September 1905: Einstein's Most Famous Formula," and it stated: "But it was later that year (1905), in a paper received by the Annalen der Physik on September 27, applying his equations to study the motion of a body, that Einstein showed that mass and energy were equivalent, a startling new insight he expressed in a simple formula that became synonymous with his name: $E=mc^2$. However, full confirmation of his theory was slow in coming. It was not until 1933, in Paris, when Irene and Frederic Joliot-Curie took a photograph showing the conversion of energy into mass."

In contrast, the "100 YEARS AGO" item in the 6 April 2000 issue of *Nature* (Vol. 404, p 553) is taken from the 5 April 1900 issue of *Nature* (note the dates), and it states: "The calculations of M. Henri Becquerel show that this energy is of the order of one ten-millionth of a watt per second. Hence a loss of weight of about a milligram in a thousand million years would suffice to account for the observed effects, assuming the energy of the radiation to be derived from the actual loss of material."

The assumption that accounts for the stated figures in the April 1900 issue of *Nature* is $E=mc^2$. But according to *APS News*, this is "Einstein's most famous formula" which in September 1905 was "a startling new insight." I think that there is a problem that ought to be resolved.

Caroline H. Thompson
Aberaeron, United Kingdom

***APS News* replies:**

The author is quite correct that specific instances of the relation between mass and energy predated Einstein's work in 1905. To put this in proper perspective, we offer a quote from the book "Inward Bound" by the late physicist and historian of physics Abraham Pais: "...the strength of (Einstein's equations relating mass, energy and velocity) lies in their generality, their independence of dynamical details, in particular their independence of the origin and nature of the mass m. For specific forms of energy the relation

$E \longrightarrow mc^2$ as $v \longrightarrow 0$

had been known well before 1905. Already in 1881, J.J. Thomson (see this month's This Month in Physics History—ed.) had noted the energy-mass equivalence for the case of an electrically charged body. Shortly thereafter, the first theoretical E-m-v relations appeared, based on a specific model of a charged particle: its shape shall be a rigid little sphere, whatever its velocity. This was the model studied in great detail by Max Abraham, theorist in Goettingen."

VIEWPOINT…

So You Want to be a Critic

by Dean E. Abrahamson

A number of my students and former students have asked me how established interests react to a scientific critic of their ideas and objectives, or what they should do if they aspire to be effective critics. A critic is defined as one who publicly expresses disagreement with established policy or dogma. The following is based on lessons learned from my 30 years of personal experience doing public education work regarding atomic energy.

First and foremost, a critic must be prepared for attempts to be discredited, intimidated, co-opted, and/or fired. Attempts to discredit are a routine part of the agenda for a critic, whether the issue relates to atomic energy, drug or tobacco testing, science policy, etc. The usual steps in this process are as follows:

1. **The critic appears.** The first response is to ignore the critic, hoping he or she will go away.

2. **The critic persists.** The second response is for representatives of the established interest to allege that the critic is not an expert. These allegations can, by themselves, compromise the critic's employment and reputation. It is much more difficult to sustain a claim of incompetence when the critic comes from within the establishment that is the subject of attention. In this case, the critic becomes a whistle blower.

3. **The critic must demonstrate expertise to prove his credibility.** This can be done by convincing experienced members of the written press, by withstanding cross-examination at a hearing or in a court, or by publishing and meeting the tests of refereed journals.

4. **The critic is allowed a fair hearing.** The forum in which the discussions are taking place may respond favorably, the critic will be given what he or she considers to be a fair hearing, and that will more or less be the end of it.

5. **An attempt to co-opt the critic is made.** This is often the next step in cases where a fair hearing is granted. The critic will be thanked for bringing attention to the issue at hand, and may be asked to serve on a high-level advisory committee, admonished as a result to defer any more public activities until the committee's work is done. Such committees are rarely taken seriously, or they have a lifetime exceeding the schedule for the events of interest. Novice critics often take this bait.

6. **The critic persists and does not succumb to co-option.** The fourth response is usually to threaten the critic's well-being: to get him or her fired, or cut funding, bring a lawsuit, exert pressure on public officials at his or her institution, etc. The discrediting can occasionally involve more personal efforts: investigations into the critic's personal life looking for scandal, or alleging the critic is only interested in personal fame or financial gain.

Above all, effective criticship requires discipline and is in many ways an art form. I offer the following helpful hints to aid aspiring critics in avoiding typical beginners' pitfalls:

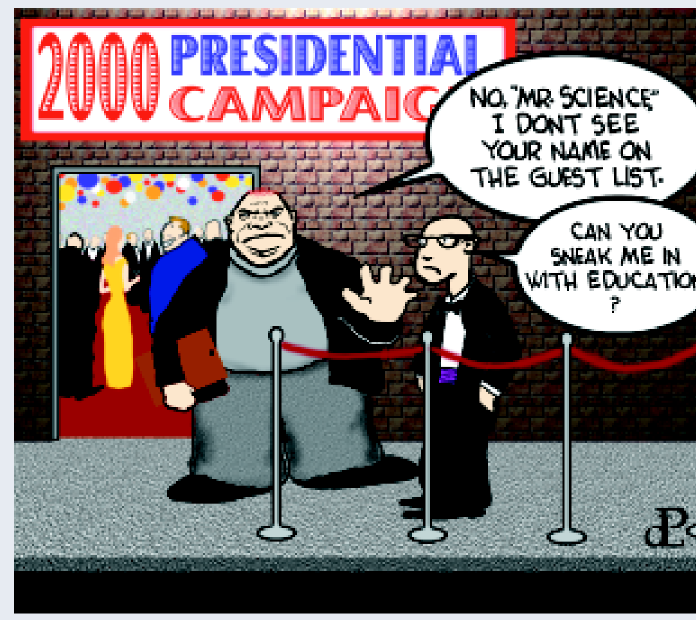
- Make no errors, particularly technical errors. Spokespersons for and employees of established interests will be protected by their institutions unless they demonstrate a truly extraordinary degree of incompetence or mendacity. But the critic stands alone, protected only by his or her credibility. The demonstration of error quickly results in the erosion of such credibility.
- Understand your own motives, purposes and goals: understand what you want, and why you want it. Also try to understand your opponents' assumptions, arguments, evidence and goals as well as you understand your own.
- Cultivate the press. Understand the press, Never mislead the press. The critic's objectives should include being the first person called by the press for comment or explanations. It is also best for the novice critic to avoid TV reporters unless he or she knows that they and their editors know the difference between a scientific or policy disagreement and a train wreck.
- Acquire some friends but avoid the zealots and crackpots who, unfortunately, are found in all camps in serious policy debates.
- Never assume that a conspiracy is underway. This is not to say that there are no conspiracies, but making such an assumption without overwhelming evidence will not only detract from your credibility, but also will lead you down hopeless rabbit trails.
- Beware of strangers bearing gifts. Be particularly wary of copies of supposedly sensitive documents that are delivered anonymously.
- Be scrupulous about your taxes and other financial affairs. A critic's tax returns and credit record will be examined carefully.
- Assume that all telephone, email and other such communications are being monitored. They often will be.
- Remember that so-called scientific or technical experts have no qualifications beyond those of any

See VIEWPOINT *on page 7*

So Near Yet So Far

Jessica Clark/APS

On August 24th, the presidential campaign of Democratic candidate Al Gore came within about a mile of APS headquarters in College Park, MD. Speaking at the University of Maryland, Gore concentrated on educational issues. Neither Gore nor his Republican counterpart George W. Bush has featured science policy as an issue in the campaign.



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zero gravity

An Alternative Theory for Perpetual Motion

We at APS News are continually entertained and enlightened by the various and sundry tidbits we find floating in the ether of the Internet, especially when we discover heretofore unsuspected scientific theories. An unnamed British magazine supposedly held a competition recently, inviting its readers to submit new scientific theories on ANY subject. Below is the winner, on the subject of perpetual motion:

When a cat is dropped, it always lands on its feet, and when toast is dropped, it always lands buttered side down. Therefore, if a slice of toast is strapped to a cat's back, buttered side up, and the animal is then dropped, the two opposing forces will cause it to hover, spinning inches above the ground. If enough toast-laden felines were used, they could form the basis of a high-speed monorail system.

The magazine then got this letter in reply from one of the recipients

I've been thinking about this cat/toast business for a while. In the buttered toast case, it's the butter that causes it to land buttered side down - it doesn't have to be toast, the theory works equally well with Jacob's crackers. So to save money you just miss out the toast - and butter the cats. Also, should there be an imbalance between the effects of cat and butter, there are other substances that have a stronger affinity for carpet.

Probability of carpet impact is determined by the following simple formula: p = s * t(t)/t(c) where p is the probability of carpet impact, and s is the "stain" value of the toast-covering substance - an indicator of the effectiveness of the toast topping in permanently staining the carpet. Chicken Tikka Masala, for example, has a very high s value, while the s value of water is zero. t(c) and t(t) indicate the tone of the carpet and topping - the value of p being strongly related to the relationship between the color of the carpet and topping, as even chicken tikka masala won't cause a permanent and obvious stain if the carpet is the same color.

So it is obvious that the probability of carpet impact is maximized if you use chicken tikka masala and a white carpet - in fact this combination gives a "p" value of one, which is the same as the probability of a cat landing on its feet.

Therefore a cat with chicken tikka masala on its back will be certain to hover in mid air, while there could be problems with buttered toast as the toast may fall off the cat, causing a terrible monorail crash resulting in nauseating images of members of the royal family visiting accident victims in hospital, and politicians saying it wouldn't have happened if their party was in power as there would have been more investment in cat-toast glue research.

It is in the interests not only of public safety but also public sanity if the buttered toast on cats idea is scrapped, to be replaced by a monorail powered by cats smeared with chicken tikka masala floating above a rail made from white shag pile carpet.

Net myth, or genuine magazine contest? We would be most interested to hear from any of our readers as to the origin of this tantalizing theory, as well as whether its proponents have managed to snag from NSF funding to pursue their research.

Nikitin Slams Russian Nuclear Waste

The radioactive fuel contained in the submarine Kursk that sank in the Barents Sea on August 12 is a tiny problem compared to the severe environmental threat to the Russian north posed by the 60 tons of spent nuclear fuel that has been excreted by Russian naval vessels.

This point was made by environmental activist Aleksandr Nikitin in an address to the American Chemical Society at their meeting in Washington in August. Nikitin has been persecuted for his activities in his native Russia and tried for treason. He was acquitted in December of last year by a St. Petersburg court, after intense international protest, including an open letter on his behalf written by then APS President Jerome I. Friedman in November, 1999. His case was appealed by the prosecution to the full Presidium of the Russian Supreme Court, but the appeal was denied on September 13, thereby probably bringing his prosecution to an end.

The Russian solution to the spent fuel problem is to transport it by train to the reactor at Mayak for reprocessing, a procedure Nikitin regards as unacceptable because the transportation is slow and dangerous and the reactor itself is leaky and pollutes the environment. He recommends that on-site storage facilities be built until more permanent disposal alternatives can be found.

On the other hand, Nikitin is spearheading a campaign, both in Russia and abroad, to stymie efforts to turn Russia into the repository of nuclear waste from the rest of the world. He described the Russian leadership as thinking that "Russia is a huge country, there is plenty of room to store nuclear waste without affecting the population," and he appealed to both the US government and the American scientific community to reject any offer to send nuclear waste to Russia.

Calling on his 23 years' experience in the Russian navy, including 11 years on submarines, Nikitin hypothesized that the Kursk sank because of human error in navigating in relatively shallow waters. He believes the craft collided with the seabed, which caused one or more of the torpedoes aboard to explode. In his estimation, this led to the breach of two of the four containment levels for the nuclear fuel, and he thinks that once the third level is breached by seawater, in about a month, some leakage of radiation could occur. This puts him at odds with American expert Andrew Karam of the University of Rochester, who has been quoted in the press as saying that there is no danger of radioactive leakage from the Kursk into the indefinite future.

Alan Chodos/APS

Environmental activist Aleksandr Nikitin.

When asked why the Russians did not ask sooner for international help in reaching the trapped sub, Nikitin said "You have to understand the mentality of the Russian military. The admirals care only about their shoulder boards and their cushy positions. They did not dare tell Putin that they couldn't do the job themselves."

U.S. Team Makes Strong Showing at 2000 International Physics Olympiad

The five members of the 2000 U.S. Physics Olympiad team returned from this year's competition in Leicester, England, carrying one silver and four bronze medals. The competition brings together the top physics students from 62 countries. The 300 participating high school students battled to solve physics problems their own teachers might have had trouble with; nevertheless, Team USA made a strong showing.

Gregory Price from Falls Church, Virginia, was the top U.S. scorer, placing 16th overall, and winning a silver medal. Anthony Miller from Hopewell, New Jersey, Michael Vrable from Del Mar, California, Jason Oh from Cockeysville, Maryland, and Joseph Yu from Irvine, California, all received bronze medals. The United States team finished seventh overall, with China, Russia and India taking the top three spots respectively. The U.S. was also one of only five countries (China, Russia, Hungary and Iran being the other four) that had all five team members win medals.

Price, a sophomore at Thomas Jefferson High School for Science and Technology, won his silver medal and 16th place ranking despite having never taken a formal physics course. He drew on his long-standing fascination with science and innate mathematical ability — he is a member of his school's math team and spends several hours a week honing his problem-solving skills — along with an old college physics textbook, to solve assigned problems. In addition to the Physics Olympiad, Price took first place among high school sophomores in the largest math competition in the U.S., and placed second among his peers in a major national computing contest.

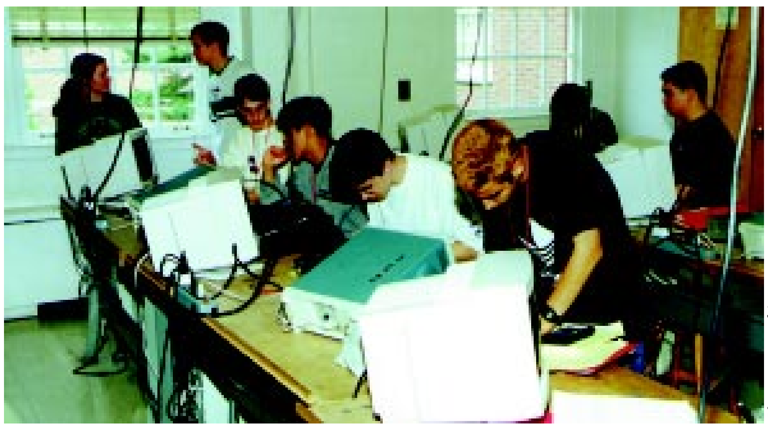

Photo courtesy of AIP

Physics Olympiad students doing lab work at University of Maryland training camp.

Among the bronze medalists, Vrable is a senior at Torrey Pines High School, and has represented his school in science olympiads every year since he was a freshman. A National Merit finalist, he also takes math and computer science classes at the University of California, San Diego, and plans to attend Harvey Mudd College next year. He says his favorite event was called "Mission Possible," with the objective of building "a Rube-Goldberg-like machine." Miller, who attends Hopewell Valley CHS, gained valuable problem-solving experience in physics during a summer internship at Princeton Plasma Physics Laboratory in 1997, where he worked on the development of a residual gas analyzer system for the lab's new NSTX reactor. Joseph Yu is a senior at University High School, where he is president of both the math and science clubs. In addition to being highly active in various physics and math competitions, he plays the piano and enjoys playing basketball and bridge in his spare time. Bronze medalist Jason Oh will be attending CalTech this fall, studying both physics and mathematics.

This competition is "a showcase for the best and brightest in the world," says Dr. Bernard Khoury, American Association of Physics Teachers (AAPT) Executive Director. AAPT hosts the students while they attend the U.S. Physics Training Camp, which prepares them for the rigorous International Olympiad.

During the camp, team members listen to guest lecturers and participate in a grueling five-hour practice exam, designed to simulate the rigorous testing that the team will endure in international competition. Based on this, the final team members are selected. This year's guest lecturers included Charles Bennett, an IBM Fellow who specializes in quantum computing, a discipline which aims to recast and enlarge our notions of information in light of quantum physics and put them to practical use, and Dick Berg of the University of Maryland, who administered a "Physics IQ test" to the team as part of his lecture.

One highlight of this year's training camp was a special tour of Washington, offering the students the rare opportunity to give national science and education leaders insight into the U.S. educational system. Activities included a special breakfast with several members of Congress, hosted by Vernon Ehlers (R-Mich.) and Rush Holt (D-NJ), both PhD physicists, to enable students to interact with their government leaders. Afterwards, they met with Presidential Science Advisor Neal Lane, Secretary of Education Richard Riley, Arthur Bienenstock, Associate Director for Science, Office of Science and Technology Policy, and Duncan Moore, Associate Director for Technology, OSTP. The U.S. team members also met with staff members at the National Science Foundation, who discovered that most of the students developed their interest in physics during their middle school years or later, often encouraged by parents or by teachers who used innovative teaching methods and allowed hands-on work.

APS Co-Sponsors Summer Industrial Internship with IBM/Almaden

It is a generally acknowledged truth that one of the key junctures of a potential scientist's career is his or her undergraduate experience, and that women and under-represented minorities often choose to leave technical fields such as physics or chemistry if that experience is negative or discouraging. A new summer internship program co-sponsored by the APS and IBM/Almaden seeks to assist top students in under-represented groups at this key period, in hopes of persuading them to make science a career.

The idea for a summer internship program at IBM/Almaden came about because many researchers at the company were concerned about the low number of young people from under-represented groups continuing their studies in science and engineering fields, according to Barbara Jones, an IBM researcher who is also a member of the APS Committee on the Status of Women in Physics (CSWP). To that end, IBM decided to fund a group of internships among various disadvantaged groups, and co-sponsored with specific professional organizations in order to focus the advertising and applicant pool. It was decided to focus such programs on undergraduates in their sophomore and junior years, before they make their decisions about graduate school.

The first such program was for black undergraduates, and is operated in conjunction with the National Society of Black Engineers, and similar programs are being developed for Hispanic and Native American engineering majors, as well as women in computer science. The IBM/APS summer internship is specifically targeted to women undergraduate students majoring in physics, chemistry, materials science, or computer science who are completing their sophomore or junior year. Those selected receive a grant of $2500, as well as a salaried research internship at the IBM/Almaden laboratory in San Jose, California.

This year the program received 116 applications, nearly half of which were from students studying physics, with 10% in computer science and the remainder in engineering and other applied fields. Jones finds the mix indicative of "the interdisciplinary nature of physics today, as well as the range of people who belong to the APS." Of these, IBM selected four winners, who spent this past summer at the company. In addition, one of last year's winners deferred her internship until this summer, while the other winner from last year has returned for a second internship through NSF's Research Experience for Undergraduates program. "In a sense we have six women working with us this summer related to this program," says Jones. "So it's already a huge success."

Once selected, interns are assigned to a research group or specific project as closely tailored to their experience and research interests as possible. "So far we've been able to make very good matches, since IBM/Almaden is such a diverse workplace and we can easily encompass most of (the applicants') fields," says Jones. For example, Anelia Delcheva, a physics major at Clark University, worked with a group of IBM Fellows on a magnetism project, while Amy Lytle, a physics major from the College of Wooster, worked with an optics and lithography research group. The other two interns — Andrea Voss, a chemistry major from Seattle University, and Shirley Ni, a computer science major from the University of California, Los Angeles — are also working with research groups closely matched to their interests.

OPA Summer Intern Gains Valuable Hill Experience

Most college students savor the luxury of summer break after grueling academic schedules, preferring sun, sand and surf to serious study. But University of Utah physics major Maria Cranor chose to spend the summer working in the APS Office of Public Affairs (OPA) in Washington, DC, as a summer intern. OPA established the internship three years ago to provide physics undergraduates with first-hand experience in science policy to complement their studies in an era when scientific research is increasingly reliant on federal funding.

Cranor did her original college work at the University of California, Berkeley, studying anthropology and African pre-history under Glyn Isaac and J.D. Clark, two of the leading archaeologists of the 1970s. She then spent several years away from academia, becoming an avid rock climber and traveling all over the world. She even helped found a national climbing advocacy and resource conservation group in 1989, called the Access Fund. Drawing on her enthusiasm for climbing, she took a job as marketing director of a small start-up company in 1989, which eventually became Black Diamond Equipment, Ltd., one of the world's top manufacturers of rock and mountaineering equipment.

However, her career in marketing eventually began to pall, and Cranor returned to college to develop another career path, enrolling at the University of Utah in 1996. She initially intended to become a developmental psychologist, but an introductory physics course ignited her enthusiasm for the subject. "Physics has completely seized my imagination," she says, admitting that she is an unlikely physics student. "My mathematical background was nonexistent and I'd had no real exposure to scientific thinking." She credits her teachers in Utah's physics department with helping her overcome these challenges.

Cranor's undergraduate days at Berkeley sparked a strong interest in politics, and as she pursued her studies in physics, she found herself becoming equally interested in how the scientific community interfaces with government. "I thought the internship with the Washington office would offer a fantastic opportunity to observe these interactions at close hand," she says of her reasons for applying for the position. "There is no substitute for seeing government in action. Getting to attend hearings on the Hill was very exciting and thought-provoking."

During her tenure in the Washington office, Cranor worked on a broad range of issues, including global warming, the federal budget for science, and national missile defense (NMD). She found the latter work especially meaningful. "It's a serious issue of national, even global importance that has tremendous political ramifications, and physicists are making a significant contribution to the debate," she says. "It was wonderful to be involved in such a critical issue." She also enjoyed working with Physics and Government Network (PGNet) volunteers on science funding matters, and relished the opportunity to collaborate with APS Director of Public Affairs Bob Park on his weekly electronic newsletter, "What's New," which gave her the opportunity to put her written skills to good use.

Cranor has since returned to Utah to continue her dual degree in physics and psychology. "My plans now are to resume studying like a maniac," she says, and is contemplating attending graduate school in astrophysics. "The APS internship helped me to realize that my combination of two seemingly disparate sets of skills — marketing and physics — might be tremendously useful in the future."

Committee on Committees Meets at APS

Alicia Chang/APS

The Committee on Committees met at APS headquarters on August 25. Its task is to recommend members for many of the APS standing committees. Taking part in the deliberations are, left to right: front row, Michael Turner, David Aspnes, Rick Heller. Back row, Gloria Lubkin, Danita Boonchaisri, Zachary Fisk, Myriam Sarachik, Judy Franz.

ANNOUNCEMENTS

Now Appearing in RMP...

The articles in the October 2000 issue of *Reviews of Modern Physics* are listed below. For brief descriptions of each article, consult the RMP website at <http://www.phys.washington.edu/~rmp/current.html>. *George Bertsch, Editor.*

The statistical theory of quantum dots — *Yoram Alhassid*
Pairing symmetry in cuprate superconductors — *C. C. Tsuei and J. R. Kirtley*
Nematic liquid crystals as a new challenge for radiative transfer — *Bart van Tiggelen and Holger Stark*
Resonant x-ray emission spectroscopy in solids — *Akio Kotani and Shik Shin*
Geodynamo theory and simulations — *Paul H. Roberts and Gary A. Glatzmaier*
Review of speculative "Disaster Scenarios" at RHIC — *R. L. Jaffe, W. Busza, J. Sandweiss, and F. Wilczek*
Why the universe is just so (colloquium) — *Craig J. Hogan*
Studying the top quark at the Fermilab Tevatron (colloquium) — *S. Willenbrock*

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The Carnegie Academy for the Scholarship of Teaching and Learning Wants You!

The Pew National Fellowship Program for Carnegie Scholars is an opportunity for faculty seeking to investigate issues in the teaching and learning of their fields. Applications will be accepted from the following fields this year:

- Biological Sciences
- Communication
- Economics
- Education and Teacher Education
- Engineering
- Foreign Languages & Literature
- Health Sciences
- Interdisciplinary Studies
- Law
- Physics
- Political Science
- Philosophy/Religious Studies/Theology

THE DEADLINE FOR APPLICATION IS NOVEMBER 1, 2000.

Interested faculty should refer to the Carnegie Foundation website (www.carnegiefoundation.org), where guidelines and further information will be made available. Or, to receive a booklet of information and application, contact Marcia Babb; CASTL Program Director; 555 Middlefield Road; Menlo Park, CA 94025; (650) 566-5145/fax (650) 326-0279 or email: babb@carnegiefoundation.org.

VIEWPOINT, *from page 5*

other citizen to express opinions on policy or policy outcomes. A delicate balance between the roles of credible expert and advocate is difficult to strike.

- It is helpful to have competent legal counsel available from time to time.
- Finally, remember that if bitten when swimming with sharks, the cardinal rule is, Do not bleed!

Dean Abrahamson is a professor emeritus at the University of Minnesota, and a visiting professor at the Institute of Physics and Technical Physics, Chalmers Technical University in Goteberg, Switzerland. The above was adapted from an article appearing in the July 2000 issue of ***Physics and Society****.*

IN BRIEF

APS Members Win Dirac Medal

Three APS fellows have been named co-recipients of the Dirac Medal and Prize, established by the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, in 1985 to recognize contributions to the field of theoretical physics. Helen Quinn of Stanford University and Howard Georgi of Harvard University were honored, along with Jogesh Pati of the University of Maryland, for "pioneering contributions to the quest for a unified theory of quarks and leptons, and of the strong, weak, and electromagnetic interactions."

Georgi was recognized for his discovery of many of the most significant models of grand unification, as well as his role in developing the Georgi-Quinn-Weinberg computation demonstrating that the natural mass scale of unification is relatively close to the Planck scale, and that the proton lifetime can naturally be extremely long.

Quinn is recognized for her contributions to the same computation, as well as her fundamental insights, working with Roberto Peccei, about CP conservation by strong interactions.

Pati is recognized for his role (with Salam) in the formulation of the original gauge theory with quark-lepton unification, and the resulting insight that baryon number violation is a likely consequence of such unification.

Peebles Shares Gruber Foundation's Cosmology Prize

P.J.E. Peebles, Albert Einstein Professor of Science at Princeton University, and a fellow of the APS, has been named co-recipient of the first annual Cosmology Prize of the Peter Gruber Foundation "for his profound contributions to our knowledge of the physical processes that shaped the structure of our universe." His citation continues, "Over more than three decades, (Peebles) has, with rigor and imagination, advanced our understanding of phenomena which range from the creation of the lightest elements to the formation of galaxies and the cosmic distribution of matter and radiation." To be awarded in November at the Pontifical Academy of Science at the Vatican, the Cosmology Prize was created to honor scientific advances in our perception and understanding of the universe, and carries a cash award of $150,000. Peebles shares the inaugural award with Allan Sandage, of the Carnegie Institute in Washington, DC, who is being honored for his work on the respective values of the Hubble Constant, the deceleration parameter and the age of the universe.

ASTRONOMY, *from page 3*

the universe does not look the same through every window!)

Top Ten Drivers of Discoveries in Astronomy

1. Dry photographic plates (and onward to CCDs).
2. Left-over World War II radar dishes, radar operators, and the beginning of radio astronomy.
3. Captured V-2 rockets and the beginning of ultraviolet and X-ray astronomy.
4. "Invasions" by people from particle physics (1980s-1990s), nuclear physics (1930s), chemistry and other disciplines. Also, spectroscopy in the 19th century.
5. Massive relocation of skilled scientists before and after World War II.
6. Admission of women to curiosity-driven research. (Payne and the composition of stars; Tinsley and quantitative evolution of galaxies).
7. Fruitful, although wrong, ideas from people approaching problems for the first time: the classic example is steady state cosmology; another is Russell's giant and dwarf theory of stellar evolution.
8. Revolutions in computation, Monroes to Microscoft.
9. International collaborations become the norm, from Carte du Ciel to the International Astronomical Union and beyond.
10. Gradual erosion of the gentlemanly agreement not to observe someone else's star.

Top Ten Predicted Hits of the 21st Century

1. Neutrino astronomy will find a third source and become routine.
2. Extremely high energy cosmic rays will reveal new kinds of physics or new particles.
3. Gravitational radiation astronomy; backgrounds and sources.
4. What came before the Big Bang? How did large scale structure form? What is the dark matter? It is also predicted that these will turn out to have the same answer.
5. Theory of star formation. (Initial mass function, binary populations, etc).
6. Chemical and dynamical evolution of galaxies will be freed from the Curse of the Variable Parameter.
7. Spectroscopy of extra-solar, earth-mass planets reveal non-equilibrium chemistry (or not).
8. Additional insights into processes under extreme conditions, including astrophysical masers, two-photon processes, induced Raman scattering, Landau levels, and astronomical dynamos.
9. Something I haven't thought of.
10. Something even you haven't thought of.

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If all the neutrino experiments are taken at face value, Scholberg said, they present a puzzle: one can deduce from them three different mass-squared differences for the various neutrino families, but if there are only three families, there can be only two independent such differences, and they do not agree with the data. One looks to several experiments in the next few years to help clarify the situation: the Sudbury Neutrino Observatory in Canada (funded as well by the US and the UK) together with other solar neutrino experiments, the BooNE experiment at Fermilab which will test the LSND results, and a series of long baseline experiments, in Japan, the US and Europe, which send beams of neutrinos from an accelerator to a neutrino detector located many hundreds of miles away.

Two experiments to measure CP violation parameters reported results at DPF2000. The BELLE experiment, at the KEK facility in Japan, was described in a talk by Jorge Rodriguez of the University of Hawaii. The experiment studies the decay of B mesons, which are composed of one bottom quark and one ordinary anti-quark, and their antiparticles the B-bar mesons. If CP (which is a symmetry related to the exchange of a particle with its antiparticle) is violated as inferred from the standard model, then, under certain circumstances, there should be a difference in the time dependence of the decay of B and B-bar mesons into the same final state. Because these are rare events the statistics in these early data are relatively poor, and so far BELLE's results are consistent either with the standard-model prediction or with zero. According to Rodriguez, a significant improvement in statistical accuracy is expected within the next couple of years.

The second experiment is Babar, located at the Stanford Linear Accelerator Center, a detector built by a collaboration of about 550 physicists from nine countries. The results were reported at DPF2000 by Yury Kolomensky of Caltech. Like the KEKB accelerator, the PEP-II accelerator at SLAC features asymmetric colliding beams, which means that the B's and B-bars are moving down the beam pipe after they are produced, allowing experimenters to deduce the time-dependence of the decays from the positions of the decay vertices. Like BELLE, Babar needs more statistics to differentiate between the standard model and zero, and they have plans to increase their data sample tenfold within the next two years. As Kolomensky says, these precision measurements will test the standard model predictions and provide new insights into the nature of CP violation.

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DOE Office of Science, APS Membership Share Funding Goals

by Mildred S. Dresselhaus

As I start my term (August 1, 2000) as Director of the Office of Science of the Department of Energy (DOE), I see many opportunities, challenges, and responsibilities that I face together with you, the research community of the physical sciences. The American Physical Society has already done a great deal to improve the health of the physical sciences, and they should be commended for their valiant and thoughtful efforts. Since the Office of Science, DOE is the largest federal funding source of the physical sciences, I feel considerable responsibility in my new position to work closely with the American Physical Society to achieve a healthy physical science enterprise in the United States for the benefit of its citizens.

For several decades after World War II, the United States was in a leadership position in virtually all fields in the physical sciences. This benefited science because of the high level of activity and the high quality of the research that was carried out in the U.S. and because of our policy of welcoming the best and the brightest worldwide to join us in pursuing the scientific adventure of discovery. Our scientific achievements went hand-in-hand with furthering and fueling the industrial enterprise to the benefit of our citizens and society worldwide. According to a National Research report in 1993, the United States should be among the world leaders in all important fields of science. Such a leadership position allows researchers working in the US to follow-up breakthroughs made anywhere and on any topic.

Table 1 shows that the DOE Office of Science, is the dominant funder of physics research in the US and is also the dominant federal funding source for large facilities, such as synchrotron light sources, pulsed neutron sources, and particle accelerators, as well as mid-sized facilities such as sophisticated transmission electron microscopes, state-of-the-art mass spectrometers and ion beam facilities, etc. The Office of Science also has been a principal supporter of graduate students and postdoctoral researchers in early career.

Mildred S. Dresselhaus

The last decade, however, has seen a serious erosion in federal funding in the physical sciences and the Office of Science; has been especially hard hit (see Figure 2). Under these circumstances, we are noticeably slipping in some all-important areas of the Physical Sciences. We now need to turn these trends around before the consequences of this under-investment become more damaging and widespread. I will need the help of the APS and its membership in reversing this trend for the Office of Science.

Let me briefly review how the various offices within the Office of Science map on to the APS Divisions and their members. Our Office of High Energy and Nuclear Physics is the primary funding source for researchers in the APS Divisions of Particles, Nuclear Physics, Physics of Beams, and also for the facilities (Fermi Lab Tevatron, the SLAC B-factory, the Brookhaven Relativistic Heavy Ion Collider, and the Thomas Jefferson Lab CEBAF machine, among others) that are necessary to carry out experimental research in these fields.

Our Office of Fusion Energy Sciences funds the vast majority of researchers in the Division of Plasma Physics and provides them with the sophisticated facilities needed for their research work.

Table 1: Department of Energy Science

Top Five Government Research Organizations for:*

Physical Sciences	Environmental Sciences	Mathematics & Computing
1. Energy (2,012)	1. NASA (1,051)	1. DOD (657)
2. NASA (1, 019)	2. NSF (481)	2. Energy (623)
3. NSF (515)	3. DOD (383)	3. NSF (399)
4. DOD (412)	4. INTERIOR (364)	4. HHS (127)
5. HHS (205)	5. Energy (335)	5. COMMERCE (89)

Engineering	Life Sciences	R&D Facilities**
1. NASA (1,948)	1. HHS (11,838)	1. Energy (939)
2. DOD (1,837)	2. USDA (1,215)	2. NASA (403)
3. Energy (851)	3. DOD (519)	3. DOD (386)
4. NSF (484)	4. NSF (403)	4. NSF (271)
5. TRANS (323)	5. Energy (288)	5. HHS (227)

* *Numbers are FY 1999 Dollars in Millions - Source: NSF — Preliminary Federal obligations for research, by agency and field of science and engineering: fiscal year 1999*
** *Numbers are FY 1999 Dollars in Millions - Source: OMB*

Our Office of Basic Energy Sciences is a major funding source for researchers in the Divisions of Condensed Matter Physics, Materials Physics; Atomic, Molecular and Optical Physics, Polymer Physics and Chemical Physics, providing support for research projects, for staff, graduate students and postdocs to work on these projects, and for special facilities, such as the Argonne Advanced Photon Source, the Brookhaven National Synchrotron Light Source, and many others. Now under construction is the Spallation Neutron Source at Oak Ridge National Laboratory. When completed in 2006, this world class facility will restore a leadership position to the US after more than a decade of difficulty for US researchers trying to work in this research area.

The Office of Biological and Environmental Research provides support to researchers in the Division of Biological Physics among others. It is noteworthy that the impetus to orchestrate the sequencing of the human genome came from the Office of Science. The next thrust of this program, aimed at identifying the functions of the various genes will be dependent on facilities operated by the Office of Basic Energy Sciences, such as the synchrotron light sources and the neutron scattering facilities, for detailed studies of the structure and properties of biological constituents.

Our Office of Advanced Scientific Computing Research, which supports computational science and simulations across all scientific subfields (and funds researchers in the Division of Computational Physics), is now engaged in teaming computer science experts with practitioners in these subfields to develop advanced computer codes for electronic structure, chemical reactivity, time resolved processes and many other challenging and important problems.

The squeeze on the Office of Science budget and the demands coming from the construction and operation of increasing numbers of complex facilities have made it impossible to support the number of excellent research groups we would like, and at a level consistent with the "cost of living" increases associated with scientific research. Major new opportunities exist in the areas of nano-technology, computational physical sciences and biophysics, and we need to fund new initiatives in these areas. State-of-the-art facilities in nano-lithography, focussed ion beam technology, clean room technology, and access to high speed massively parallel computers are among the resources that are needed by the university community, at affordable usage charges and with adequate access times. Coordination of DOE programs with complementary programs sponsored by other major funders in each subfield will be one of my responsibilities.

In the last decade, an increasing fraction of the Office of Science budget has gone into the design, construction, and operation of large facilities. With level budgets, the support for small group research has been seriously eroded. Because of the overall satisfaction with our facilities, user demand has increased, but funding has seriously limited operating time. More effective utilization of the most active facilities is critically needed. Our advisory committees are developing long range plans on the next generation of user facilities, setting priorities for facility selection and timing, so that we will be able to remain among the world leaders and not fall behind in important areas of the physical sciences.

The Office of Science has a major commitment to education and training through grants to small research groups who support the research and provide stipends for many graduate students, postdocs and undergraduates. The DOE world class research facilities also attract many young (under 35 years old) researchers as users. They receive much hands-on training from the staff, and benefit from peers at other institutions doing complementary research. Special programs for undergraduate hands-on research activities have provided an effective source for new entrants into physical science graduate programs, especially for underrepresented women and minority undergraduates. These programs need to be maintained.

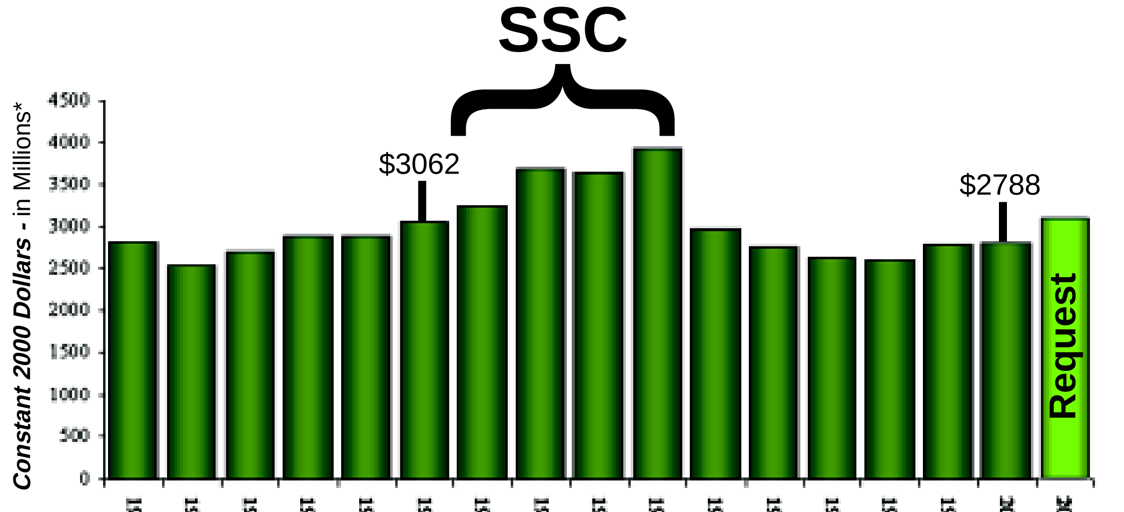
To turn around the declining Office of Science budgets of the last decade we need annual increases on the order of 15%. Budgetary increases of this magnitude have strengthened the NIH over the past decade and more recently the NSF.

Sustained increased funding for the next few years is needed for the Office of Science to provide our unique contribution to the team effort in interdisciplinary research and in the development of important new state-of-the art instruments and user facilities.

I ask my fellow members of the APS to join me in telling the public about the vital contribution made by the Office of Science in the Department of Energy, and to communicate our vision to restore the US as one of the leaders in all important areas of physical science research.

Mildred S. Dresselhaus, an Institute Professor at MIT, recently became Director of the Office of Science at the Department of Energy. She served as APS President in 1984.

Figure 2: Office of Science Budget History*



*Total Science Budget (in Millions of Constant FY 2000 Dollars)