FORUM ON EDUCATION

of the American Physical Society
Summer 2003

Message from the Chair

Wolfgang Christian

In keeping with the Forum on Education's charter to promote "the advancement and diffusion of knowledge regarding the inter-relation of physics, physicists and education" and to involve its members in activities related to physics education, the FEd has undertaken a new initiative to sponsor an annual session at a national meeting of the American Association of Physics Teachers (AAPT). The first such session is being organized by the Division of Physics of Beams (DPB) at the 2004 AAPT summer meeting in Sacramento, CA.

The DPB was chosen to organize the first FEd-sponsored AAPT session because of the expertise available at the national laboratories in Northern California. Speakers will be chosen so as to present a wide-ranging comprehensive picture of different aspects of beam physics and accelerators and their applications to a diverse range of research areas. Free educational materials will be provided and the FEd will sponsor a reception following this session. The DPB Education and Outreach Committee chaired by Ernie Malamud will be working closely with members of AAPT to maximize the usefulness of this session to the physics education community.

Sponsoring a session at an AAPT meeting is an excellent opportunity for APS Units to provide outreach to non-specialists in the physics teaching community. The FEd is currently seeking a Unit to organize a session at the 2005 AAPT summer meeting. If your Unit is interested in such a session, please contact the 2005 FEd Program Committee Chair, Ramon Lopez, with your Unit's proposal. (Email: relopez@utep.edu)

As reported by Ken Krane in the Fall 2002 FEd newsletter, the Committee on Education (COE) appointed a subcommittee comprised of Beth Cunningham, Fred Stein, and me to study the feasibility of establishing an APS Education Award. We now have a preliminary proposal to present. Please feel free to contact me or any member of the COE if you have comments. If this or a similar proposal is approved, the FEd and the COE will work together to develop a fundraising plan in order to endow the award.

Finally, the FEd is seeking to develop resources and provide expertise for states developing standards for teacher licensure. If you know of teacher licensure activity in your state, or if you are knowledgeable about teacher licensure and would be willing to serve as an expert, please contact Ted Hodapp. (Email: thodapp@nsf.gov)

Excellence in Physics Education Award
Committee on Education
April 12, 2003

Awarded yearly to recognize and honor an individual, team, or group of individuals (such as a department) who have exhibited a sustained commitment to excellence in physics education. Such a commitment may be evidenced by, but not restricted to, such accomplishments as:

- Outreach programs
- A specific program or project that has had a major ongoing influence on physics education at the national level
- Outstanding teacher enhancement or teacher preparation programs over a number of years

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- Long-lasting professional service related to physics education that has had a demonstrated positive impact

Nominations must be submitted to the Chair of the Selection Committee. A complete nomination packet consists of the following:

- A letter of nomination outlining the candidate's significant contributions related to education in physics
- A current curriculum vita
- A minimum of three additional supporting statements, of which at least two should come from individuals not associated with the nominee's workplace

The awardee receives recognition during the APS April Meeting. Nominations must be received by July 1.

Please forward comments about this proposal to any COE member.

Wolfgang Christian is Professor of Physics at Davidson College. He is Chair of the Forum on Education.

Editorial: Random thoughts from the editor.

Stan Jones

Here are some random thoughts I've had recently:

Thought #1: Why do we spend so much time and effort reforming introductory physics education when the vast majority of these students are not physics majors?

I don't mean to say we shouldn't do this: here at Alabama we are reformatting our intro classes in an integrated lecture/lab style along the lines of project SCALE-UP. This is exciting, and is where the bulk of my non-administrative time goes. But what motivates us to do this? Surely, not to gain more majors, although this may happen if we really do it right.

I can give a partial answer. We do it because we believe in the importance of a physics education for all students, and we think we have found better ways to do it. Moreover, it is satisfying to us to know we are doing a better job of teaching. And for me, teaching studio style is much more fun, as I get to talk to the students one-on-one now.

Related thought #2: Why don't we reform the way we teach physics *majors* courses?

There are, to be sure, reformed courses and curricula in some schools, but by and large, the effort and the publicity focus on the introductory courses. There is in particular a great deal of innovation in the use of technology in the introductory classes, which makes sense because these tend to be large enrollment classes. But can we make use of technology in advanced courses as well? I don't see a lot of effort (but some) going into this. Chalk, or perhaps marker pens, seems to be the technology of choice.

Thought #3: Has the FEd decided what its purpose is?

I think the answer to this is *yes*. A forum is meant to be a place where issues can be discussed, and the FEd has developed in recent years a great lineup of sessions at APS meetings. We have moved into the divisional meetings, which is very important since attendance at the general meeting has declined. And the newsletter has done a good job of spreading news of the truly impressive number of innovative educational projects going on around the country. We need more "discussion," meaning more letters from the membership, but by and large the FEd has become both visible and valuable. I wonder if you agree??

Random Thought #4: Is a physics degree still relevant?

I once was going to write a column comparing physics to philosophy; both are intellectual explorations of the inner workings of reality, but both can be said to be of only intellectual, not practical value. Only "pure thinkers" would want to major in philosophy, right? Was physics becoming the scientific version of philosophy? I then discovered, however, that our philosophy department graduates about twice as many undergraduate majors as we do, and decided it was too late to make that comparison. Why are fewer and fewer students choosing to major in physics?

My purpose for phrasing this question as I have is this: physics, or what physicists do, has changed dramatically in the past 10-20 years. The borderlines between physics and other disciplines have become extremely vague, and "multi-

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disciplinary" has become the catch phrase of both the administrators and the federal funding agencies. Public interest in the search for the fundamental particles has waned dramatically, although excitement about cosmology has taken its place. Unusual and exotic materials consume the interest of many researchers. What does all this mean for undergraduate physics education? Are we still to teach our majors as though we are preparing them to explore the fundamental world, or should we instead prepare them for the inter-disciplinary world of the 21st century? What is important for a physics graduate to know? What skills are essential? Is the traditional physics degree still the way to go, or should we be changing with the centuries? I don't claim to know, but I just wonder.

Parting Thought: This will be my last newsletter issue as co-editor of the FEd newsletter. You will notice that the leaves have already started to change, and the summer issue is just appearing. I have always tried to publish "my" issue during the season represented in its header, but my other duties have become so time-consuming that I have finally missed that goal. It is time for someone to take over who can devote more time to this important job. I have very much enjoyed working with the Forum on Education, and with the other editors. I have been introduced to many innovative programs going on throughout the country, and have met many outstanding educators. I compliment my co-editors, who do an outstanding job. It has been a pleasure working with them. I plan to stay active in the FEd, and I thank you for your support of this newsletter.

One Physics and Astronomy Department's Unique Demographics

Robert Ehrlich and Maria Dworzecka,
George Mason University

The Physics and Astronomy Department at George Mason University is demographically unique in the U.S. Its 17 full-time faculty include seven females -- five times as many as would be expected, based on the national average. While women now earn 35% of Ph.D.'s in all science and engineering fields combined -- not far from their fraction of all Ph.D.'s (42%) -- the figure for physics is a mere 13%. Thus, there is no significant shortage of women in science, but there is one in physics.

Some critics of affirmative action argue that efforts to recruit women and minority faculty may lead to compromises with regard to merit. They may believe that a department that has been as successful as GMU in reducing its average testosterone level could do so only by putting considerations of affirmative action ahead of merit. On the contrary, the department has been able to assemble a large group of highly talented female physicists and astronomers without paying any such price.

However, the department does consider itself to be a very female friendly one. In contrast, some women physicists and astronomers now here can recount experiences at previous institutions where their gender caused considerable grief, particularly with older male colleagues. The existing pool of female talent now at GMU has made it that much easier for the department to recruit additional highly qualified women as colleagues. This has been perhaps the most important factor in the department's being able to attain a critical mass of female talent.

Even more striking than their sheer numbers, the female physicists and astronomers at GMU include a truly awesome pool of talent, and they have collectively amassed awards and grants that would be the envy of many first tier research departments. This development was largely unplanned, but occurred in part because the department has taken advantage of many individual opportunities over the years and it has had the strong support of its administration.

George Mason is a relatively young university, having split off from the University of Virginia in 1972. During the intervening years the physics department has had a total of six department chairs, but its founder, Eugenie Mielczarek (now professor emeritus and still very active) and its current chair, Maria Dworzecka, are both women. Mielczarek notes that when she was hired in '65 there were zero tenured or tenure track women physics faculty in the entire mid-Atlantic region.

In recent years many physics departments have been losing positions, as the numbers of physics majors have declined nationwide. GMU, however, has been able to add faculty positions largely by sharing these positions with other academic units of the University -- including the Krasnow Institute for Advanced Study, the School of Computational Sciences, and the

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departments of Chemistry and Electrical Engineering. New positions have also been gained in one case because the University won a Luce Fellowship for searching for a female astronomer by agreeing to support her after the first five years of outside funding. More recently, the department has added a female experimental physicist on a tenure track position, largely as a result of an NSF-funded ADVANCE Fellows grant. Currently the seven women in the department include two non-tenure track faculty, three assistant professors, and two full professors. The five tenured and tenure track women faculty between them currently have a total of about 2 million dollars in federal research funding, and are currently supporting close to 10 undergraduate students on research projects. Many of those research students are themselves female, but no effort is made to seek out female students specifically for such research.

"The faculty dedication to teaching, research, and students creates a supportive and comfortable atmosphere -- an extended family of physicists and astronomers," notes graduate student Jessica Kristin (Reitz) Gambill.

The women faculty in the department have certainly not formed a clique that the men find threatening. Quite the contrary, the men in the department are proud of the accomplishments of their female colleagues, especially the recent additions to the department.. The GMU physics department has always desired to add faculty of the highest statue it could find, even if that meant eclipsing the status of more senior members.

Finally, by specifically adding so many women faculty the department has not discovered any new female way of teaching physics. Some feminists may believe that physics could become more interesting to women by developing methods of instruction and themes that are more oriented towards women. However, the department has no interest in such ideas, even while it remains very interested in expanding the numbers of female (and male) majors, and it remains a very female-friendly place.

Robert Ehrlich is a professor of physics at George Mason University
Maria Dworzecka is professor and chair of physics at George Mason University.

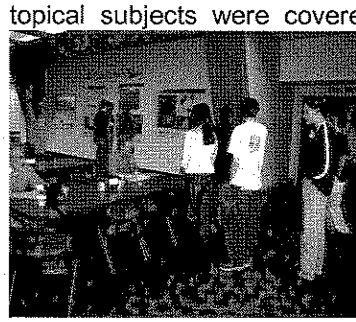
The Evolution of the Saturday Morning Physics

Roger L. Dixon

Increasing the enthusiasm for science among young people was surely the motivation behind the idea for Saturday Morning Physics at Fermilab back in the early 80's when Leon Lederman brought the idea to Fermilab. A group of volunteers from the Laboratory staff led by Drasko Jovanovic executed the idea. High school students interested in physics and nominated by their teachers and principals were invited to Laboratory on Saturday mornings for a series of 10 two-hour lectures, which introduced them to the basic ideas and instruments of particle physics. The program was an immediate success.

Between fifty and two hundred students attended the lectures, which were given in 3 sessions per academic year. Lecturers were chosen on the basis of their expertise and ability to communicate with young people. Enthusiasm for the task was also an important requirement for keeping a position on the roster. Drasko and Leon set the example, and the rest of us did our best to emulate it. Drasko brought a combination of rich experience in experimental particle physics and an ability to teach to the task. Leon combined his powerful intellect with a sense of humor to stir the imaginations of the young people. The Saturday Morning Physics students adored both of these men.

Lecture topics included an introduction to the Standard Model of particle physics, cosmology, quantum mechanics, relativity, accelerators and detectors, and a final lecture on the interaction between physics and society. In addition, more topical subjects were covered, which allowed the students to use some of the new knowledge to understand something of the physics that was on the forefront of our research. Of course, not all of the lectures worked as planned for one reason or another. Drasko was never hesitant about changing the agenda if he felt it was necessary. Of course,



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there were many good topics contributed by lecturers themselves. For example, Chris Hill developed a lecture on symmetry that is one of the best for tying the fundamentals of physics together for the students.

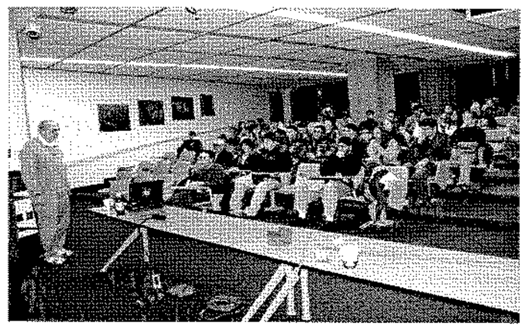
With Drasko's retirement in 1997, Erik Ramberg and I inherited the program. At the time I had been a lecturer for some 10 years, Erik had more recently begun teaching the students about the detectors used in particle physics. We continued to follow Drasko's example of continuous improvement while keeping the fundamental ideal of the program intact. There was also one problem that appeared along the way. This resulted in a natural and subtle evolution of both the lectures and the philosophy.

The problem involved attendance. During the early 90's we had experienced a period when the attendance was falling. To counter this, Erik and I became more proactive in contacting the schools and advertising the program. The World Wide Web also became a positive factor in our rescue.

Early in our tenure we recognized that most of the students attending the lectures were not likely to be particle physicists, or even scientists. This was not a new revelation as Drasko had certainly been aware of this before. We decided that it was important to communicate with the group of people who would one day be lawyers, bakers, and candlestick makers. Furthermore, we wanted them to be there and to become enthusiastic about science. We began an unadvertised policy of never turning down a student whether or not a physics teacher nominated them. If they showed enough interest to contact us about getting into the program, they were automatically in. This had a subtle effect on the emphasis of the course. We came to realize that we weren't really trying to teach our students as much as we were developing an appreciation for science in them.

When a lecturer would complain to me that he or she could not teach quantum mechanics to the students in a two-hour lecture it became apparent that this person was attempting too much. We preferred that they be given enough facts to mystify them and to make them want to learn more about the subject. These are students who have seen thewonders of Star Trek on television, so they are not easy to impress. It always gave me a good deal of satisfaction to find that I could amaze them with an account of the Twin Paradox and convince them that real science can be more fantastic than science fiction.

As a result, the idea behind the entire program has moved away from rigorously teaching physics, and toward a program designed to kindle a curiosity in the students that will be self-sustaining. This is a difficult concept for some of the lecturers, yet it is the most important. Scientists are fascinated by the details of their science, and they want to pass all of these fascinating details along. There is nothing wrong with this in principle, but the lecturer has to be certain that he is connecting with the students in the process. In other words, the details must be fascinating to the students as well, and some rigor may have to be sacrificed in order to accomplish this.



We know we are successful when the parents tell us how fascinated their sons and daughters have been and ask us why there is no such program for adults. To remedy this, we have been asking parents to sit in on the class, in addition to giving them their own special lecture on graduation day.

The bottom line is that the Saturday Morning Physics program continues into the 21st century the strong tradition set by Leon Lederman and Drasko Jovanovic. Close to 200 participants qualify for a certificate each year by attending 7 out of 10 lectures in a session. And most satisfying of all, we have been seeing former Saturday Morning Physics students show up as colleagues in our research for some time now.

Editor's Note: Drasco Jovanovic was the first chair of the Forum on Education.

Roger Dixon is an experimental high energy physicist at Fermilab, where he participates in SMP. On his CV, he describes his health as "banged up."

A Small First Step

Jesús Pando, Phillip Cervantes, Ruth Howes

Even with the slight upturn in enrollment of the last two years, undergraduate physics enrollments have dropped 20% during the past decade. Physics departments have offset a similar decline in US students entering graduate school by recruiting foreign students who now make up more than half of all entering grad students in physics. In many physics departments, the low number of graduate students has forced them to rely more on undergraduate teaching assistants while at the same time faculty lines are not being replaced as faculty retire. In light of these developments, it is perhaps time for physicists to consider changing the way we conduct business in order to attract new people and new ideas to **the field.**

Ironically, just at the time the physics departments most need students, historically under-represented groups that form a large and increasing pool of students are not being drawn to the field. Only 5% and 3% of Bachelor's degrees earned in the year 2000 went to US citizens who are African-Americans and Hispanics, respectively. At the graduate level, the numbers are even more disappointing. In 2000, only 17 Ph.D.s (3%) in physics were granted to African-Americans and 14 (2%), to Hispanic-Americans. These proportions are well below those that characterize the general population of U.S. college students. Clearly, it is enlightened self-interest for physics departments to discover how to increase the numbers of Hispanic-American and African-American students who major in physics.

Recently, the National Task Force on Undergraduate Physics completed SPIN-UP (Strategic Programs for Innovation in Undergraduate Physics). SPIN-UP surveyed all bachelor degree granting physics departments in the country and did twenty-one site visits to "thriving" (primarily in terms of majors) physicsdepartments. These departments proved excellent models for building supportive environments for majors. However, even among these thriving departments, none was successful in attracting majors from under-represented groups. Perhaps the nurturing environments that attract majors to these physics departments are nurturing primarily to those students that have historically populated physics. It may be that these environments are necessary to retain these students, but it is clear from the SPIN-UP results that they are not sufficient to attract minorities to the discipline.

Under these circumstances, it is in the interest of physics departments to create a culture to which talented minority students will be attracted. A critical component of such a culture is physics faculty who work at attracting and retaining physics majors from underrepresented groups. These faculty members need not themselves be from under-represented groups, but they should have an understanding of the unique issues minority students face. For example, the very great importance of the family in Hispanic-American culture may cause students from that culture to appear less than dedicated to physics than their majority colleagues. Similarly, African-American students may feel pressure from their peers to pursue academic areas such as law or medicine with a direct relationship to their home communities. All physics departments need at least one faculty member who is familiar with these cultures and can educate other faculty members as well as act as an advisor and mentor to minority students. Departments with no faculty of color probably face a harder time trying to achieve this than those departments that do have faculty from under-represented groups. These efforts take substantial time and effort and should be recognized as a meritorious part of faculty work. Departments must take responsibility for recruiting and hiring faculty able and willing to fill this role.

Typically, physics departments seek new faculty by forming a search committee charged with finding the best candidate for the position based on a set of perceived objective criteria. The reality is that setting these criteria is frequently highly political so that 1) the criteria are not actually objective, and 2) the criteria strongly reflect the makeup of the existing department. The SPIN-UP site visits found that departments tend to recruit individuals like those already in the department. If new faculty members continue to be hired in this way, the historically under-represented groups in physics will remain so because the culture of physics will not have changed.

To facilitate the hiring of faculty that can affect cultural change, we propose two simple and definite actions:

First, the criteria for any new hire in a physics

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department should include a phrase like:

> The candidate should have a demonstrated ability and commitment to the success of students of diverse backgrounds.

Second, when a new faculty member has been hired, the criteria on which the new department member is evaluated must include similar language. Efforts to increase diversity require time that can only be taken from research and teaching. These efforts must be recognized as attributes toward tenure and promotion.

Physics has historically thrived in times when new ideas clash with established ones. It is our belief that physics can also thrive on the kinds of creative ideas that are generated at the interface of diverse cultures. (S.J. Gates, *Physics and Society,* **25**, (July 1996))

Furthermore, we live in an age of global competition, and the United States must cultivate the scientific talent of all its citizens if it is to remain competitive. When all of this is combined with the decreasing enrollments in physics departments, it becomes essential for physics departments to diversify by hiring faculty who can attract and retain students from underrepresented groups. We cannot emphasize enough that this imperative is no longer based solely on ethical reasons, as was affirmative action, but also on the pragmatic realities that physics departments must face in order to thrive.

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Physics and the No Child Left Behind Act

Stan Jones

The new *No Child Left Behind Act*, signed into law by President Bush in January of 2002, is causing a lot of activity on my campus...and also a good deal of confusion. NCLB, as it is known, requires states to revise their certification and accountability standards, in order to retain Title I funding. The Alabama State Board of Education, whose normal condition seems to be one of confusion, has come out with at least two conflicting policy statements that I am aware of, and there will be more. A perusal of several other state education websites indicates that a similar beehive of activity and confusion exists throughout the country.

Among other things, NCLB requires that a teacher be "Highly Qualified" in the subject he/she teaches. Highly Qualified means the teacher has the equivalent of an undergraduate major in that subject. Schools with teachers not Highly Qualified will lose Title I funding. This requirement will take effect June, 2005, for newly hired teachers. Current teachers have other ways of becoming an "HQT" (Highly Qualified Teacher). Only HQT's will be certified to teach after 2005.

This policy sounds like a dream come true for supporters of education, and science education in particular. We are all painfully aware that in many high schools, physics is taught by the biology teacher, or perhaps a math teacher, or even the coach. These teachers have had only minimal college physics or perhaps none at all.

Analyzing the situation a little more deeply, however, one can view NCLB as a zero-infinity conundrum for physics educators. It will require physics teachers to have physics degrees, but will any graduates be available to hire after 2005? Are students now majoring in physics education in such numbers that NCLB will just be a minor correction? Or will we find that there is no one at all left to teach physics?

The problem is one of numbers... small numbers. The first small number is the number of physics majors. It has been steadily dropping over the past decade, and the vast majority of these majors go into a physics related job or graduate school, but not secondary education. In my school, we graduate someone in physics education about every 5-10 years. Much more common is the "comprehensive science" education degree, which requires a focus in one science (usually biology) and 3-4 courses in the other core sciences (chemistry and physics). While this is not the ideal preparation for a physics teacher, it is better than nothing, and NCLB appears to eliminate such an approach.

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The other small number is the number of students in high school physics. While this number is growing, there are still many schools that only offer one or two physics classes per year. Such a school cannot afford to hire someone to teach only physics, and has, instead, employed teachers certified in more than one field – especially comprehensive science. This may not be allowed under NCLB. The alternative, which is already practiced in some districts, is to have a traveling physics teacher who drives to as many as four schools a day. This partial solution has some obvious drawbacks, including the difficulty of retaining a teacher saddled with this situation. It is clearly logical to hire a teacher certified in physics and another field. But will NCLB allow this?

There are already some positive outcomes from NCLB. It has, for instance, pointed the spotlight on the pitiful state of secondary physics education. We are now exploring at my school how we can develop dual certification programs in related subjects like chemistry/physics or math/physics. These programs would be a big improvement over the current comprehensive science certification. However, the uncertainty in how NCLB will ultimately be applied to such dual certifications makes it very difficult to know how to design such programs.

There is unquestionably a need for more and better-qualified high school physics teachers. Those that graduate today get hired in a flash. There is also a need for more physics majors in general, and we might look at NCLB as a means for increasing the size of our graduating classes. But will NCLB result in more physics graduates? By itself, there is no reason to believe so. NCLB offers no incentives, only directives. Without incentives such as competitive salaries and believe that the number ing of qualified high school physics teacprofessional workconditions, there is no reason to hers will increase under NCLB.

More information about NCLB can be found at the US Department of Education's NCLB website, http://www.ed.gov/nclb. I have yet to find any discussion of dual certifications on this website, however. Among the states whose websites I have examined, California (http://www.cde.ca.gov/pr/nclb/) seems to have developed the most clear-cut set of guidelines. They have worried about the problem of dual certifications, but I do not see any evidence that they have resolved this issue. A search for "No Child Left Behind" on the Internet will find websites from most states (I believe these websites may be required under the law). One thing NCLB has accomplished is more public awareness of certification policies and other state board policies.

Presumably, most physics departments in universities with education programs have to deal with NCLB. This is a serious situation that all physicists should be concerned about. Your opinion on the views expressed here is invited. If you are involved in your college's planning for compliance with NCLB, please write the editor to let us know what you are doing, so this may be shared with our colleagues.

Stan Jones is Professor and Chair of the Department of Physics and Astronomy at the University of Alabama. He is co-editor of the FEd Newsletter.

A Matter of Degrees – Writing for the General Reader

Gino Segre

About five years ago I decided I wanted to write a book. My impending sixtieth birthday motivated part of the desire. It put me in a reflective mood, setting me thinking about what science means to me. I was trying to integrate my thoughts, my experiences and see if I could shape them, at least for myself, into a coherent narrative of sorts.

My career at the time had been a not untypical one for my generation- undergraduate at Harvard, graduate student at MIT, postdoctoral fellowships at CERN and Berkeley and then a long career on the faculty at the University of Pennsylvania. I was and still am a high-energy theoretical physicist, working on elementary particle physics problems often bordering on areas in cosmology and astrophysics. That, however, was not what I wanted to write about.

Most books written by scientists for a general public are attempts to describe the excitement and accomplishments of their own field, but there

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were a number of excellent books about elementary particles and cosmology and I felt I had little or nothing to add to the existing literature. I also wanted to use writing as an excuse for learning more about aspects of science that were perhaps related, but went beyond my area of expertise. I always have had broad interests, subscribing to Nature, Science and the Scientific American. While I don't read these cover-to-cover, I follow from afar the exciting developments in a number of fields. My book, I postulated, should encourage me to follow up on some of these interests.

Like all scientists, I have specialized in order to succeed but, in writing, I wanted to be more of a generalist. The initial challenge I set myself was to see if the book, whatever its eventual subject matter turned out to be, could include the major scientific advances revolving around the beginnings of the Universe, of life and of the Earth. Alternatively stated, I wanted to include the Big Bang, DNA and Plate Tectonics. How to do it was the question that drove me back to the drawing board.

I started by asking myself a very basic question, the first one usually posed in a physics course for non-scientists. What is science? We normally start, and I know many of you have had the experience of teaching such courses, by trying to explain the scientific method: measurements, incorporating results into a model, testing that model, drawing conclusions and then re-starting the cycle. Attempting to answer the question of what is science, I realized it all begins with measurements and that, at least in the physical sciences, there are only a few basic kinds of measurements.

These are length, time, temperature and perhaps mass. Of course our instruments are extraordinarily sophisticated, but the questions we asked are often quite simple. Focusing on the first three, length, time and temperature, I realized that a book about temperature would give me the opportunity to discuss the three big origins issues I wanted to include and hopefully tie them together in a way that would be accessible to the general public. Temperature would also allow me to give readers a window into problems of contemporary science. Perhaps I should let the book speak for itself. Its introduction concludes

> I knew at the outset that I wanted to incorporate in the book a discussion of some of the big questions science has addressed in the past century, many of which remain unsolved. In endeavoring to do this, I was pleased to discover that temperature was necessarily part of the narrative, not a peripheral marker. Consider three examples.
>
> Our Earth was formed about 4.5 billion years ago from a protoplanetary disc, but when did life first appear? Although it was certainly present 3.7 billion years ago, was the intervening period, 800 million years, long enough for primordial organic molecules to assemble into genetic material? Was the necessary aquatic environment present? The answers depend on the early Earth's temperature - how long a favorable climate existed and how resistant life is to thermal jumps. If conditions were such that life could not have formed that quickly on Earth, we must search for its origins elsewhere in the Solar System. If life came from elsewhere, where did favorable conditions exist four billion years ago and how did life make the journey to Earth?
>
> Consider the universe's birth in the cosmic explosion known as the Big Bang. Unimaginably hot in the beginning, the universe cooled over the course of 300,000 years to 5500 degrees Fahrenheit (3000 degrees Kelvin is the way this is usually presented). Experimental evidence says the temperature in that 5500 degree universe was almost completely uniform, the same at one point as at another. Yet it cannot have been completely uniform or else galaxies, stars and planets would not have evolved. The signals from temperature fluctuations of less than a degree, present at that early time, are now studied with the tools of modern astronomy.
>
> As a third example, consider the rather strange concept of a lowest possible temperature, an absolute zero. The notion of approaching that limit, first glimpsed less than 200 years ago, has turned into the -

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exploration of the new world in which rules of quantum mechanics dictate behavior, wires have no electrical resistance and flowing fluids experience no friction. This world, so remote from our own experience, has its counterpart in stellar interiors. Beyond that, it may yield important new technologies that can serve our everyday lives.

Some of temperature's most interesting puzzles, perhaps not as sweeping as the three just mentioned, are no less important. There is no simple answer to why our bodies maintain a constant temperature whether we live in the Arctic or the Sahara, why it is 98.6 or why most mammals and birds have approximately the same temperature. The demand for unvarying brain readiness and response is clearly an important factor. But more is involved, as we see from the myriad adaptive mechanisms our animal brethren have adopted. Nor is there a complete answer to what are the advantages offered to us in having evolved fever as a response to infection.

This book raises many puzzles. Some of the contents may seem paradoxical: for instance it's surprising we know the temperature at the center of the Sun with greater precision than the center of the Earth. However many of the problems addressed have explanations that seem almost obvious upon reflection. While I don't claim to offer an overarching view of science, I stress the connections of the approaches as well as of the solutions. Temperature is the thread.

The step after the idea of a book on temperature was to see if anybody would be interested in publishing it. I knew that, even with the best of intentions, I would be much more likely to complete the project if I had a contract and the best way to get one was to have a good agent. I contacted John Brockmann; he and his wife Katinka Matson are the premiere agents for authors interested in writing science books for the general public. I would even go further, venturing to say that a good deal of the recent growth in publishing these books by major publishing houses is due to them. I was lucky; they agreed to represent me, asked me for an outline of the book, a narrative saying what I hoped to achieve and why readers might be interested and a proposed table of contents. They took that and sold it to Viking Press in the US and Penguin in the UK.

Now I had a contract and had to write the book. I had already been clipping every article related to temperature, global warming, hydrothermal vents, fevers and related topics out of the magazines I subscribed to. Now I started both an elaborate filing system and trying to write. The latter turned out to be hard, leaving me with a greatly enhanced admiration for good science writing. I certainly never would have ended up with the book I wanted without countless feedback from my wife Bettina Hoerlin, almost invariably followed by her mantra "Remember, this is for Viking. It's not your Ph.D. thesis."

In the end, it all turned out well. I don't think authors or publishers really know what will and what won't succeed. I certainly didn't. The turning point was in July 2003, when the Sunday New York Times ran a full-page review with phrases like "Refreshing and rewarding", "Immediately draws you in; it is like listening to a graceful conversation".

I knew I was home free.

Gino Segre is Professor of Physics at the University of Pennsylvania, and author of the book, A Matter of Degrees: What Temperature Reveals About the Past and Future of Our Species, Planet, and Universe.

Evidence That Science Literacy College Courses Have A Significant National Impact[1]

Art Hobson

Jon Miller of Northwestern University (2) pursues a type of science education research that deserves the attention of all science educators, especially physics educators. Trained as a political scientist, Miller brings the social science skills of survey research and quantitative analysis to the study of the public

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understanding of science and technology. For two decades, he has designed and conducted national studies of the public understanding of science and

technology for the National Science Board, published point between secondary regularly as Science and Engineering Indicators. His work in the measurement of scientific literacy and attitudes has been replicated in more than 20 countries. He also directs Northwestern University's International Center for the Advancement of Scientific Literacy, and was vice president of the Chicago Academy of Sciences for nine years. He has published many books and articles in the public understanding of science and technology and in the development of science and mathematics skills during secondary school and college.

Miller's research provides evidence that science literacy courses for non-science university students make a surprising difference in a nation's overall level of scientific literacy (3-8). Using carefully developed

instruments, Miller builds on two decades of national surveys in the United States and two European studies to measure civic scientific literacy in several nations. In Miller's work, "scientific literacy" means, first, an understanding of basic scientific concepts such as the molecule, DNA, the structure of the solar system; and second, an understanding of the nature and process of scientific inquiry, including the ability to separate scientific sense from pseudoscientific nonsense. In practical terms, scientific literacy reflects the level of skill required to read the science section of a major newspaper.

Miller found that the percentage of American adults who were scientifically literate increased from 10% to 17% during 1990 to 1999. Although these levels are low, surely too low for the requirements of a democratic society in today's world, they are higher than the level for European adults in 1992 (5%), for Canadian adults in 1989 (4%), and for Japanese adults in 1991 (3%) (Ref. 8, p. 2; Ref. 6, p. 98).

In view of the weak showing of U.S. secondary school students on such comparative exams as the Third International Math and Science Study, it is surprising that U.S. adults are significantly more scientifically literate than European, Canadian, or Japanese adults. At some school and full adulthood, the average science literacy level of Americans seems to increase relative to other nations. Why?

Miller has studied the factors associated with scientific literacy in the U.S., evaluating the relative significance of the individual's age, gender, highest level of education, college science courses, minor children in the household, and use of informal science education resources. He found that the strongest predictor of adult science literacy is college science courses, followed at a much lower significance level by informal science education, and then by highest level of education.

In his college science course indicator, Miller divided the number of courses into three levels: no college-level science courses, one to three courses, and four or more courses. Those individuals falling into the second level (one to three courses) took college science courses as a part of a general education requirement rather than as part of a major degree program. Thus, this indicator gives significant weight to science literacy courses, and the high significance of this indicator in predicting an individual's science literacy level is evidence for the importance of these courses in educating scientifically literate adults (8).

Miller comments that "it is not well known in the scientific community that the United States is the only major nation in the world that requires general education courses for its university graduates. University graduates in Europe or Japan can earn a degree in the humanities or social sciences without taking any science course at the university level. ...Analysis of the data shows that this exposure to college-level science courses accounts for U.S. performance." (Ref. 8, p. 3)

Three conclusions follow plausibly from Miller's research: All nations, and not only the United States, need to require science literacy courses for all university students. Second, because a 17% science literacy level is too low, and because of the evidence that college science literacy courses raise this level, U.S. colleges need to increase the quality, enrollments, and required number of their science literacy courses. Third, because physicists are especially prone to ignore non-science students in favor of scientists and in favor of personal researchinterests, physics departments in particular need to increase the quality, enrollments, and required number of courses for non-scientists (9).

References

1. Parts of this letter are excerpted, with permission, from a recently-published letter in *Physics Education* (Institute of Physics, Bristol, UK).

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2. Miller's web site is http://www.cmb.northwestern.edu/faculty/jon miller.htm .

3. *Public Perceptions of Science and Technology: A Comparative Study of the European Union, the United States, Japan, and Canada,* (BBV Foundation, Madrid. 1997), with Raphael Pardo and Fujio Niwa.

4. *The Public Understanding of Science and Technology in the United States,* A Report to the National Science Foundation (Chicago Academy of Sciences, Chicago, 1995).

5. "Civic Scientific Literacy in the United States: A Developmental Analysis from Middle-school through Adulthood," in Gräber, Wolfgang and Claus Bolte (Eds.), *Scientific Literacy* (Germany: Institute for Science Education, University of Kiel, Kiel, 1997) pp 121-142.

6. "Civic Scientific Literacy and Attitude to Science and Technology," in Dierkes, Meinolf and Claudia von Grote (Eds.), *Between Understanding and Trust: The Public, Science, and Technology* (Harwood Academic Publishers, Amsterdam, 1999), pp 81-129, with Rafael Pardo.

7. "The Measurement of Civic Scientific Literacy," *Public Understanding of Science*, July 1998, pp 1-21.

8. "Civic Scientific Literacy: A Necessity in the 21st Century," *Federation of American Scientists Public Interest Report*, January 2002, pp. 1-4; available on the web at http://www.fas.org/faspir/2002/v55n1/scilit.htm .

9. Art Hobson, "Physics Literacy, Energy, and the Environment," to be published in *Physics Education*; Art Hobson, "Education Must Capture Student Enthusiasm," letter to *Physics Today*, April 2001, p. 94; Art Hobson, "Academic Bias Toward Research Cripples American Undergraduate Education," letter to *J. of College Sci. Teach.*, September 1998, p. 7; Art Hobson, "Science Literacy and Departmental Priorities," letter to *Am. J. Phys.*, March 1999, p. 177; Art Hobson, "Will Non-Scientists Choose Physics?" *Phys. Teach.*, October 1995, pp. 464-465.

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Browsing Through the Journals

Thomas D. Rossing

- A call to action" is the title of a guest editorial in the May issue of *American Journal of Physics* by Oersted medallist and well-known physics teacher Edwin Taylor. "Would you like to begin the study of Newtonian mechanics using no vectors and no *F=ma?*" he asks. "How about starting quantum mechanics with no complex numbers and no Schrodinger equation? Would you and your students enjoy exploring general relativity with no tensors and no field equations?" Nature's commands to stones and electrons can be expressed as: 1. Follow the path of least action; 2. Follow the path of maximal aging; and 3. Explore all paths. Taylor argues for the use of the principle of least action in first and second year undergraduate physics courses. It is "simple, potent, and fundamental."

- Three groundbreaking papers published by Albert Einstein in 1905 are to be celebrated in a new dance production commissioned by the Institute of Physics, according to a note in the July issue of *Physics World*. The dances, which represent papers on special relativity, the photoelectric effect, and Brownian motion, will be performed for the first time at Sadler's Wells theatre in London in May 2005 and then go on tour. The performances will be part of a yearlong series of events that form the 2005 "World Year of Physics." The Rambert Dance Company will also collaborate with the Institute of Physics to develop practical dance workshops for schools and resource materials that can be used to teach both science and dance.

- The July issue of *Physics Education* includes a special feature on teaching Sound Physics. The five papers emphasize the use of microcomputers and the construction of simple musical instruments. One paper argues that since most music

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reproduction these days uses digital techniques, we should rethink the way we teach about sound.

- The entire physics curriculum can be unified and simplified by adopting space-time algebra (STA) as the standard mathematical language, David Hestenes argues in a paper in the July issue of *American Journal of Physics*. STA simplifies, extends and integrates the mathematical methods of classical, relativistic, and quantum physics while elucidating geometric structure of the theory. This paper is a sequel to the author's Oersted medal lecture (published in the February issue of *American Journal of Physics),* which introduced geometric algebra (GA) as a unified mathematical language for physics.

- Australian universities could receive an extra A$1.5 billion (about US$900 million) from the government over the next four years. However, the increases are linked to major reforms, according to a note in the June issue of *Physics World*. Almost one-fourth of the package depends on universities implementing controversial changes to salary negotiations and university governance.

- A guest editorial "Writing Physics" by N. David Mermin, based on a lecture he gave at Cornell in 1999, appears in the April issue of *American Journal of Physics*. He discusses the problems in writing about such things as relativity and quantum mechanics, and he tells about his successful campaign to introduce "boojum" into the scientific vocabulary. He considers it unfortunate that so few single-author papers are published these days, because "it is now almost impossible to acquire a sense of a physicist's style from a perusal of his or her collected works, because many people have never in their lives written a paper with- out co-authors." He makes an interesting distinction between "writing physics" and "writing up physics."

- An editorial in the April issue of *The Physics Teacher* calls attention to the 40th anniversary of that journal, founded by Professor J. W. Buchta in April 1963. The first issue included an article on "Weight and Weightlessness" by Francis Sears; one on "Electromotive Force and the Law of Induction" by Melba Phillips, and many others that are still of interest to physics teachers today. There is an article about "Physics for Girls" and an ad for Minivac 6010, "The computer that fits in your classroom. This seventeen pound wonder adds, subtracts, multiplies, and divides." Clifford Swartz (SUNY at Stony Brook) was editor of *The Physics Teacher* for 29 of its first 40 years!

- The March issue of *Physics Education* includes a special feature on Energy and the Environment. Various papers address the greenhouse effect, nuclear issues, fusion power, and energy and the environment. The importance of physics literacy is stressed in the lead paper. Citizens really do need to know about energy, the environment, and a host of science-related topics.

- The shortage of female physicists in UK academia and industry stems from the decision made by many girls to stop studying physics at the age of 16, according to an article in the May issue of *Physics World*. Although all pupils study science for their GCSE exams, only 20% of girls pursue physics at A-level, a fraction that is lower than that in almost every other subject. To discuss the problem, a number of teachers gathered at the Institute of Physics headquarters in London. One speaker observed that the quality of the physics teacher matters more to girls because it is likely to affect their confidence more than it would with boys.

Letter to the Editor:

To the Editor of the FEd Newsletter:

I would like to react to the essay "Don't Lecture Me on Lectures" by Kelly Roos, which appeared in the Fall newsletter of the APS Forum on Education. In the last few years I have seen several essays of this kind, where the writer expresses the opinion that the lecture method is not seriously flawed, despite the

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findings of the physics education research community. I want to highlight serious logical errors in these arguments.
To me what is striking in all of these essays is their

common structure: "Physics education research has not proved that the lecture method is seriously flawed, because there is this or that problem with the research methodology or assessment instruments, etc., so one can't believe any of those measurements. I on the other hand believe that I teach really well using the lecture method, and my personal opinion about my teaching is ever so much more trustworthy and believable than any attempts to make actual measurements, to look closely at real data, or to try to make theoretical models to explain student failures."

The analogy is clear: "Physics research has not proved that classical physics is seriously flawed, because there is this or that problem with the research methodology, etc. I on the other hand think that classical physics is ever so much better than relativistic quantum physics, and my personal opinion is ever so much more trustworthy and believable."

Despite my attempt to make cheap debating points, I do agree that it is entirely sensible to question the methods and results of physics education research, just as we should question the methods and results of any other kind of research. Indeed, physics education research is comparatively new, and it studies issues that are much more complex than those studied in other areas of physics, because people are involved. So it is not only reasonable but important that physics education research be continually subjected to careful scrutiny. But the inadequacies and possible mistakes of physics education research are at least subject to debate and scrutiny. In contrast, mere assertions that "I know better" cannot be examined further and lead nowhere.

There was one somewhat novel element in Roos's version of these essays. He says, "Whether the debunkers are right or wrong concerning lecturing, one thing is certain as we gaze across the physics teaching landscape today: the debunking hasn't worked, at least in the sense that the larger physics community has not adopted the anti-lecture stance." This and related comments are presented almost as though they were additional evidence in favor of the lecture method. But just because many respected scientists argued for many years against the existence of atoms didn't mean that atoms don't exist!

My main purpose in writing this letter was to address the serious logical flaws in the arguments presented against the findings of physics education research. But I'll add my own thoughts on the issues raised. The clearest signal from work in the cognitive psychology community as well as in the physics education research community is that students must be actively engaged with the material rather than merely observing passively. For that reason, a pure lecture method is likely to work poorly, at least in introductory courses involving students who are not yet very skilled learners.

This doesn't mean that all aspects of lecturing per se are worthless. Some particularly valuable benefits of lectures include emphasizing which aspects are more important than other aspects, and providing motivation, as happens when one shows enthusiasm for the subject. Moreover, there are ways to mitigate the passiveness of the lecture experience, and Eric Mazur's simple method for improving lectures is a good example (and one which has been adopted rather widely precisely because it requires very little change in the running of a course on the part of busy physics researchers; see "Peer Instruction" by Eric Mazur, Prentice-Hall 1997).

Bruce Sherwood, Research Professor of Physics, North Carolina State University

The Newsletter Editors invite you to write a letter to the editor or propose an article for the next issue.

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