

was to actually join—or attempt to join—Nazi German institutions.

Giving aid, comfort, and scientific knowledge to countries run by barbarous regimes is not necessarily a good thing, no matter how virtuous it might make some of us feel.

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Sanders replies: These letters provide a welcome alternative viewpoint to my support for scientific conferences independent of politics. The central disagreement between me and the writers of these letters is whether a conference should be held completely independently of the host nation's politics—provided of course that safety of participants is guaranteed—or whether political matters, such as banning people based on citizenship or human rights violations, should militate against organizing such conferences.

I support the goal of the universal right of all scientists, regardless of citizenship, to participate in open scientific meetings, and equally support the goal of universal respect for human rights. The question before us then is whether it is better to hold conferences, even under compromised conditions, or not to hold them, with the hope that the lack of engagement will drive change.

In our complex world, we need the yin and the yang of political and cultural engagement. Sanctions and boycotts have a place, but scientists in every country have a need for contact with others with whom to share ideas, to collaborate, and to learn and teach.

In the sports, music, and science worlds, we are seeing exchanges that somewhat transcend politics. This year the Summer Olympics were held in China, and the New York Philharmonic played a concert in North Korea. In 2007 the 38th International Physics Olympiad was held in Iran. These events are important in bringing together athletes, musicians, and scientists, but also in catalyzing change in our global society.

The letter writers have in common the view that holding these conferences is tantamount to appeasement. If they think that threatening to cancel a conference or holding it once and refusing to do so again is an effective tool for creating a better world for science, they may do so, either on their own or with some allies. Personally I regard threats and cancellations as counterproductive. Perhaps the letter writers see a way forward that I do not see.

As I write this letter (1 October 2008), I am returning from the First Interna-

tional Iran Summer School on Quantum Information, which I co-organized and which featured top international speakers. Sixty-eight students chose to participate, including several international students; unfortunately Israelis were forbidden. In our imperfect world, the students were grateful for the opportunity to learn, and the speakers for the opportunity to share knowledge. Despite the compromises, the school was a positive event that built scientific discourse independent of politics but constrained by reality.

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Physics: A calling or assembly line

I find my physics education useful nearly every day in my job for a large semiconductor chip manufacturer, and I am still glad that I struggled through a PhD from the University of California, Berkeley, about a decade ago. However, I agree with Anita Mehta (PHYSICS TODAY, June 2008, page 50) when she suggests that the physics research enterprise must overcome challenges if it is to remain relevant.

Around the beginning of the 20th century, one of Max Planck's professors famously declared that there was nothing significant left to be discovered in physics. Einstein's relativity and quantum mechanics followed; physics became paramount when the atom bomb helped end World War II and largely maintained the global peace for decades afterwards.

Times have changed. The Soviet Union is gone. The challenges with global climate change are also mostly political and economic. The microelectronics revolution has transformed the world, but with personal computers, cell phones, and the internet being everywhere, it is easy to take the underlying physics for granted. Do most people care, for instance, that the storage of songs and videos in iPods depends on the precise control of electrons' quantum tunneling through an insulating barrier?

Nearly all the practical successes of physics in the recent past are the consequences of physical understanding developed more than half a century ago. Meanwhile, nuclear fusion remains unavailable for power generation; high-temperature superconductivity is inadequately understood; and

no mass-market application of carbon nanotubes has yet been found.

So what is new, and why should the taxpaying layperson care? Any new research proposal raises two pertinent questions: Is it likely to reveal anything fundamentally new about how nature works? If only confirming established physical theories, is the work going to be of any practical consequence in the near term?

Physics, like everything else, has to compete in the marketplace of ideas. Further inquiry in physics may remain relevant only if it continues to be widely perceived as a useful art or otherwise generates concepts that excite the imagination of young people.

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In Anita Mehta's collection of inconvenient truths, she chronicles the evolution of the physicist from a craftsman doing research for "pleasure rather than work" to a "physics professional" working for the research corporation that is the modern university. Having earned a bachelor's in physics and a doctorate in psychology, I feel compelled and ever-so-slightly qualified to conclude that, if anything, Mehta has done us a disservice by being far too polite.

Mehta uses artful prose to address issues that already make many people uncomfortable. Her insights ring true. As she notes, the broad promise of early theoretical advances made by Renaissance men gave way to specialization in which the skills needed to solve problems became more important than the original thinking needed to recognize them. Mehta writes that too few people are allowed "the postdoctoral researcher's birthright—the luxury of dreaming." But she passes over a concurrent and inseparable phenomenon: the decline in the status of graduate students and postdocs from colleagues doing independent research to glorified laboratory assistants.

Specialization, Mehta writes, has brought coexisting but contradictory interpretations of nature, often achieved through computer simulations rather than experiments; that specialization has led to "the growing estrangement of subfields within physics." Mehta courteously skirts the root cause of what she calls the "assembly-line mindset" and of all the other problems she notes: the advent of international competitiveness as the core motivation for science. In that realm, nations accumulate knowledge to gain economic and military advantage

over perceived enemies or rivals. Remember that the money, although originating with the taxpayers, is ultimately doled out at the discretion of politicians.

With this in mind, we may answer a question that Mehta did not actually ask: When, exactly, did science cease to be a vocation? The answer is World War II, which spurred the notion that science could not only win a war but maintain a permanent technological, and hence economic, advantage. That sort of thinking created the factory mentality in which well-rounded intellects, as Mehta notes, are now actively deselected. The job market presently favors those who stay in the same academic discipline, finish their studies in record time, and thus bring the least perspective—and maturity—to the job. Generalists are not wanted; familiarity with the programming code of the day is now more important than being able to think outside the box.

Mehta also notes the “stifling of merit by politics,” the small-scale corruption of winks, nods, and handshakes that no one wants to acknowledge. Ultimately, she concludes that physics “became a business with very small stakes.” But in that she is dead wrong. Physics, as a largely tax-funded and multibillion-dollar enterprise, became a business with truly enormous stakes: the very supremacy of the old colonial nations. And therein lies the problem.

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Mehta replies: I thank both authors for their thoughtful responses and appreciate the interdisciplinary span of their ideas.

Ramesh Gopalan’s point, about people taking the underlying physics of everyday gizmos for granted, is well made. The “marketplace of ideas” to which he refers puts technology on a far higher pedestal than the basic physics behind it. In my opinion, the way to fight that attitude is not by speed (physicists will never overtake engineers in that regard!), but by innovation. Physics needs to come back to its status as an art and a philosophy, where space is made for originality of thought, rather than sticking to the assembly-line mentalities I’ve alluded to in my article.

Lance Nizami’s letter spells out possible reasons for these assembly-line mentalities—although I’m not convinced that international political competitiveness is the only cause of such academic philistinism, or, indeed, that

physics across the globe could lay claim to being a big-stakes business, as it might be in relatively developed countries. However, his letter certainly provides an interesting perspective.

Finally, I plead guilty to being understated, both for reasons of personal preference, and because it leaves space for interesting discussions such as these by Gopalan and Nizami.

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Fine points on *Productive Learning*

When I read Diane Grayson’s review of *Productive Learning: Science, Art, and Einstein’s Relativity in Educational Reform* (PHYSICS TODAY, September 2007, page 72), I saw it was flawed and chose to ignore it. However, discussions with colleagues convinced me that it should not remain uncontested and presumed accurate.

Grayson suggests that the first four chapters of *Productive Learning* were written by my coauthor Seymour Sarason, and summarizes them as dealing primarily with “educational matters at pre-college levels.” That is wrong. The book states that Sarason drafted the second chapter and that the theme of the initial chapters is how teachers learn to teach *after* they finish college.

It is not true that Sarason and I “make no reference to more than 30 years of systematic research in physics education.” We reference Arnold Arons, Lillian McDermott, and Kenneth Wilson. In addition, we refer to several resources that contextualize the criticism of the educational system; those include a book by Diane Ravitch, an issue of *Daedalus*, and several books by Sarason. The objections appear to stem from superficial reading and lack of familiarity with the depth of issues that hamper educational reform.

Our text states that so far, all systemic reforms have failed. My diagnosis of the review’s superficiality is reinforced by its citation of a website that supposedly exemplifies a successful systemic reform. The site contains a dead link and a one-page promotion with a few sentences quoted in the review about the Discovery program in Ohio.

I visited Discovery in the mid-1990s. My positive experience there is reported in the last chapter of *Productive Learning*, though without naming the program. I was so impressed that I