funding was available to build modest national telescopes but not to build still larger telescopes for private and state universities. NSF could not do both, although it was able to fund instrumentation for those observatories.

Up to the late 1970s, there was an unwritten agreement, monitored by the Office of Management and Budget, that NSF would fund ground-based astronomy and NASA would fund US space observatories and the space-oriented programs associated with them. But after the mid-1970s, NASA began to fund construction of ground-based telescopes and provide more broadly defined ground-based support. That shift has tended to erode the role of the ground-based astronomy program at NSF. Any decrease by NASA in funding for ground-based activities without a commensurate increase in NSF's program would have a serious negative effect on the nation's research contributions to astronomy.

Throughout its history, NSF's astronomy program has been responsible for assuring the health of the entire ground-based enterprise in the US by providing a balance among its grantees, its instrumentation programs, its centers, and all astronomical subdisciplines. Moreover, NSF strives to ensure, through cooperative programs with other nations, that the US will remain internationally competitive. To do this, it takes into account the degree of funding from other sources and uses its limited funds to achieve a good national balance.

NSF's purpose was never to make the national optical observatories dominant; the organization has always taken steps to ensure that only excellent research is pursued at places that receive federal funding. NSF officials are still trying with some success to give visitors greater access to those observatories that are not primarily nationally funded.

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The article on the history of national observatories makes for interesting reading. The current trend is for these facilities to devote their increasingly pressured budgets to their large telescopes at the expense of smaller ones that historically have been extremely productive per square meter of aperture.

Astronomers who are based at smaller institutions and who pursue modest (but still valuable) research goals are largely being shut out of the game. Few small departments or institutions have the resources or administrative commitment to join a private consortium that would give them access to only a small amount of telescope time each year. Societies and science thrive best under a system of democratic meritocracy in which both private and public support are available.

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McCray replies: I am pleased at the interest my article generated. Both William Howard and Cameron Reed bring up excellent points.

As Howard suggests, one feature that distinguishes American astronomy from its counterparts in other countries is its long tradition of private, state, and philanthropic support, which continues to this day. Unlike many other areas of science—nuclear physics, for example—optical astronomy's private patrons continued to provide generous support even after the federal government became an important postwar patron. The complementary and often competitive relationship between the private and public observatory systems in the US continues to be a powerful force in the community. An indication of the importance of that relationship is the ongoing debate over how to fund and build the next generation of giant telescopes (see PHYSICS TODAY, August 2003, page 22). One is struck by the similarity between optical astronomy and the private–public race in the 1990s to decode the human genome.

As J. Merton England's book *A Patron for Pure Science: The National Science Foundation's Formative Years, 1945–57* (NSF, 1982) shows, NSF saw astronomy as an especially promising area in which to invest in large-scale science facilities. Given the monopoly that the Atomic Energy Commission had on the funding of big accelerators for high-energy physics, fields like astronomy and multidisciplinary endeavors like Antarctic exploration and the International Geophysical Year offered a way for NSF to invest in postwar big science.

Although making the national optical observatories dominant may not have been NSF's stated purpose, the decision to not pursue that goal certainly raised eyebrows in the scientific community. It is hard to identify many areas of postwar science in which national research facilities were of lesser size, scale, or power compared with their private counterparts. During numerous interviews for my recent book *Giant Telescopes: Astronomical Ambition and the Promise of Technology* (Harvard U. Press, 2004), astronomers frequently mentioned that, in the 1970s, the national telescope's 4-meter mirror on Kitt Peak was smaller than that in the privately owned 5-meter telescope on Palomar. The situation—indeed, the same ratio—persisted with the two 10-meter Keck telescopes versus the two 8-meter Gemini telescopes.

Reed makes a salient point. Whether to close smaller observatories in favor of building new and bigger facilities is a critical issue in the formulation of US science policy for astronomy. Such decisions are made more difficult by the productivity of smaller telescopes and their role in training students. As Reed notes, perhaps the best system is one that favors "democratic meritocracy." The continuing challenge facing the science community would appear to be how to achieve that ideal.

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US Climate Research Plan May Ask Wrong Question

The Bush team's 10-year climate change research plan as discussed in the September 2003 issue of PHYSICS TODAY (page 34) bears an eerie resemblance to the 10-year acid rain research plan instituted by an earlier administration. That plan was also funded by the government, undertaken by numerous laboratories, and continued for the designated decade. However, in the acid rain case, the US Congress surprised many by passing effective legislation to reduce sulfur dioxide and nitrogen oxide emissions, and did so some time before the 10 years had passed and before the research leaders had submitted any report.

Interviews with various participants indicated that the government had set experts to work on the wrong question. Many members of Congress had long known that sulfur in the air was not a good thing, but they did not know how to outmaneuver the politically powerful representatives from large, coal-producing

states that strongly opposed paying the perceived high price for limiting acid rain. Other members, though, had objected to the claim of the coal-producing states that the costs of reducing emissions should be spread to all states in proportion to their use of coal, mostly to generate electricity. Meanwhile, estimates of the total cost of solving the acid rain problem varied from high to very high.

The impasse was broken by an environmental group that proposed a plan for a "cap and trade" system; through that system, the federal government would issue permits to all emitters for the amount they had emitted the previous year. Then, the permitted amounts would be decreased annually until total emissions reached a level adequate to prevent future harm. Moreover, permits could be bought and sold: Emitters with simple means of decreasing emissions could sell their permits to companies that have difficulty making cuts. Thus the marketplace, and not Congress, would decide both who would pay the costs and how much those costs would be. Relieved of the problem, Congress soon passed the legislation, and President George H. W. Bush soon signed it into law.

The plan got Congress off the hook and put most of the reductions in the hands of those who could make them least expensively. So the total cost turned out to be far below earlier estimates, and the reductions occurred faster than anticipated.

The current Bush administration apparently ignored those lessons as it set out to spend lots of taxpayer money to answer climate questions that have been studied for almost 200 years. Certainly there is much to learn as climate research continues worldwide. But it appears that, again, no one asked the right question: What is holding up political progress toward reducing the annual increase in climate change? Instead, policymakers sought to address imagined deficiencies in the basic science.

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'Physics of Whatever' Relevant but Not Always Accurate

Robert L. Dixon's letter (PHYSICS TODAY, October 2003, page 15) decrying the growth of publications and Web sites with the nominal title "physics of ——— " aims at the wrong target. His thesis that "[nobody] really cares about this kind of 'physics of' stuff" is belied by the enormous popularity of, for example, *The Physics of Baseball* by Robert Adair (Perennial, 2002) and *The Physics of Golf* by my colleague Ted Jorgensen (Springer and AIP Press, 1999).

The serious problem that Dixon doesn't address is that many of these Web sites contain wrong or at least poorly worded physics. An Internet search for topics related to the physics of football, a topic in which I have a passing interest, yields such useful information as "when the football is thrown and a spin is put on it, centrifugal force keeps the ball aligned during its flight," and "momentum can't be lost; it can only be transferred. If you catch a football, then the football's momentum goes through you and into the earth (or else you fall down)."

Physicists have an obligation to teach others about physics. One good way to do this is to connect physics with things that people actually care about. But it is important to make sure that the science is right.

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When Lord Rayleigh wrote his paper "On the Irregular Flight of a Tennis Ball" (*Messenger of Mathematics*, volume 7, page 14, 1877) and J. J. Thomson wrote "The Dynamics of a Golf Ball" (*Nature*, volume 85, page 2147, 1910), were they trying to make physics relevant so as to increase the attendance in an introductory course they were teaching?

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Ethical Dilemmas of US Antiterrorism Policy

I hope that Charles McQueary does not mean to suggest that the research he mentions is without moral and ethical problems (see the McQueary interview, PHYSICS TODAY, July 2003, page 32). Like many who recruit physicists for national security, he ignores the bigger picture. For instance, McQueary says that he would use university researchers to develop sociological profiles on terrorists. Should we ignore that this technology could simply be a sophisticated version of racial profiling, which could lead to the arrest of innocent people? Should we ignore the chance that this technology could be used to violate citizens' civil rights?

Of course the defense of innocent people is important, but McQueary should be honest in his assessment of both the exciting challenges and the possible destructive consequences of defense work.

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Another Side to Roots of Terrorism

Martin Ebert's hypothesis (PHYSICS TODAY, September 2003, page 16) that "the precedents of terrorism are . . . inequality, social suffering, intolerance, and lack of understanding" is not supported by the facts. People become terrorists not because of our intolerance, but because of their intolerance; not because of our lack of understanding, but because of their lack of understanding; not because of suffering inflicted on them, but because of their desire to inflict suffering on others.

There is another reason why I find Ebert's remarks offensive. There exist perhaps a billion or more people throughout the world who truly are victims of terrible deprivation—and have not resorted to terrorism. Let's not commit calumny on these long-suffering people by laying the responsibility for creating terrorists on anyone other than the terrorists themselves and the societies that birth them. We need to help others because it is the right thing to do—not because it will relieve us of the terrorists. It won't.

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Private Funding Could Cut Red Tape for Homestake

Recent articles in PHYSICS TODAY (February 2004, page 32; August 2003, page 24) describe the continuing efforts of neutrino physicists to