Letters

Statistical Morality

Although few would question the need for strict penalties to deter irresponsible behavior that indisciminately threatens life and limb, Daniel E. Koshland, Jr., in his editorial "Drunk driving and statistical morality" (5 May, p. 513), does not adequately address some important principles and distinctions. Koshland defines "statistical morality" as "the precept that a given course of action that may cause some harm to individuals now will result in greater benefit to more individuals in the future." The implication appears to be that it is morally correct to impose harm on some individuals so that greater benefits accrue to a greater number of individuals. This precept, however, is in dramatic conflict with notions of personal freedom and with basic philosophical principles about interpersonal transfers of utility.

In the case of drug tests, Koshland correctly mentions that volunteers are used, but even then, patients continue getting placebos only as long as the efficacy of the alternative therapeutic substance is in doubt. Where an effective drug is already in use, that drug—rather than a placebo—is what is administered to the control group of volunteers. Drug trials are designed specifically so that if convincing results emerge during the course of the trial, the trial is terminated. Thus, volunteers are not treated as guinea pigs, potentially being harmed for the benefit of other individuals in the future.

Koshland blames apparently lenient judicial decisions in drunk driving cases on a lack of understanding of statistics. No one would challenge the need for any judicial or public policy decision to adequately consider the potential impact on "statistical life," but to consider it to be on the same ethical plane as the impact on a living, breathing individual is not consistent with the way society behaves or with what many believe.

Consider the effort by certain state and county health officials to set priorities for the allocation of limited resources for health services. Because expanded prenatal care holds the promise of saving more lives, funds that might have been used for organ transplantation have been diverted to primary care. While no one argued that this decision would not save more lives, many have found it ethically unacceptable to deny those few identifiable transplant candidates needed care now for the statistical benefit of saving more babies in the future. Although Koshland may support the decision of the public officials, one cannot characterize the opposing view as either ignorant or unsophisticated. Morality is much more than a numbers game.

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To highlight the magnitude of the yearly traffic accident toll of about 50,000 deaths, Koshland states that "motor vehicle accidents . . . kill more people each year than were killed during all of the Vietnam War." While about 56,000 American soldiers died in that war between 1962 and 1975, also killed were 220,000 South Vietnamese soldiers and 5,000 allied soldiers; 666,000 (estimate) Viet Cong soldiers and North Vietnamese soldiers; and 287,000 South Vietnamese civilians and 65,000 North Vietnamese civilians, as well as countless Cambodian civilians (*1*). The total—more than 1,300,000 deaths—is the equivalent of about 26 years of U.S. motor vehicle fatalities.

These overlooked deaths illustrate the point of the editorial—it is easy to forget those who are distantly affected by decisions. Decisions to go to war are made by civil authorities, who receive both civilian and military advice. It is natural for the military to count its own past losses and estimate its future losses. Equally important in such considerations is an estimate of civilian losses, which are tragic in themselves and can have a great effect on future U.S. interests, for example, in terms of lost economic markets or interrupted international cooperation. Especially important to science has been the loss of the scientific infrastructure in such countries as Vietnam, Afghanistan, Iran, and El Salvador.

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The Superconductivity Party

My answer to Robert Pool's question, "Superconductivity: Is the party over?" (Research News, 26 May, p. 914) is, "No; the party has just begun."

The intellectual challenge of high-temperature superconductivity (HTS) is so unusual and its technological promise is so great that serious students in the field cannot afford to stop working on it. Magnetic flux melting is nothing more than just a bump in the long road to full-scale application of HTS. Any realistic person would realize that only steady, hard work with vision ultimately bears fruit; the field of HTS is no exception to this. On the other hand, the progress made in only 2.5 years of HTS research is unprecedented for such a short period of time. This includes the attainment of a critical current density (J_c) at 77 K of 5×10^6 A/cm^2 in Y-123 film by Siemens (*1*), 75×10^3 A/cm^2 in bulk Y-123 by our laboratory (*2*), 15×10^3 A/cm^2 in silver-clad multifilament wire of Y-123 by Sumitomo (*3*), the successful development of HTS SQUIDs operating at 77 K by IBM (*4*), the direct observation of flux melting in high-temperature superconductors by AT&T Bell (*5*), the lowering of the processing temperature to below 600°C for HTS thin films (*6*), the use of inexpensive silicon as a substrate material (*7*), and a wide variety of developments in many other labs.

Magnetic flux creeping, which limits J_c, is a problem common to all superconductors, conventional or new. Solutions have been found for the conventional low-temperature superconductors by the introduction of pinning centers. Recent experiments at Tohoku (*8*) showed the absence of flux creeping, even in HTS materials, when it is in the thin film form. Therefore, in the same way that J_c is an extrinsic property of a superconductor, the flux creeping problem in bulk HTS is extrinsic in nature and should be surmountable by means of ingenious material processing and engineering methods. In fact, preliminary data from Karlsruhe and our laboratory (*9*) show the absence of flux creeping at 77 K in melted textured bulk Y-123 in a magnetic field up to 1 tesla, and those from Nippon Steel (*10*) show a pinning potential in a bulk Y-123 sample prepared by a partial-melting technique comparable to that in the conventional low temperature superconductors at 4.2 K.

While I took comfort in the fact that a question mark instead of an exclamation mark was used in the title "Superconductivity: Is the party over?", I am still puzzled at the sense of impatience and short-sightedness conveyed by the article. The media appeared to take this view rather seriously, as evidenced by the many articles that subsequently appeared in newspapers. Where is the perseverance that we in the scientific community have been telling the public is the decisive factor in dictating the future economic welfare of this nation?

Being scientists, we have to be honest and recognize and admit all the problems related to a subject. However, a good scientist tends to see such problems as both a challenge and an opportunity, finding ways to overcome them and, at the same time, taking advantage of them. The weak pinning force and the granular nature of HTS when it is not demonstrated under optimal conditions pose serious obstacles to large-current applications. Yet they provide great opportunities for those working on magnetic field sensors and field effect HTS multiterminal device applications, as demonstrated by Sharp (*11*) and by us (*12*), respectively, not to mention for many other potential applications that do not require a large J_c. Whether something is a problem or an opportunity depends largely on the ingenuity and farsightedness of the executor. With the great intellectual challenges and technological opportunities that HTS has put before us, the HTS party has just begun.

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We take strong exception to Pool's Research News article "Superconductivity: Is the party over?". The main conclusion of this article is based largely on the acknowledged failure of the research community to produce flexible cables from high T_c superconductors with sufficiently high current carrying capability (technical parameter, low J_c) in the presence of high magnetic fields. Such cables are required for many high-power applications envisioned for superconductivity. On the basis of the assertion by some physicists (*1, 2*) that the low J_c values are in fact intrinsic in high-temperature superconductivity because they are caused by a new and thermodynamically justified phenomenon called flux lattice melting, Pool concludes that the "once high hopes for high-temperature superconductivity are nearly gone."

Much more carefully reasoned and balanced statements of the status of superconductivity have been made (*3*). It is now clear that high-field, high-power applications of superconductivity will continue to use the conventional low-temperature materials for near-term applications while researchers investigate and solve the problems of flux dynamics, granularity, anisotropy, and small coherence lengths that now limit the critical current of the high-temperature materials in magnetic fields. On the other hand, low-field, low-power applications, such as SQUID magnetometers, high-frequency electronic devices, low-field magnetic shields, and low-power microwave cavities, may be viable near-term applications for the new high-temperature materials.

It is not universally agreed that flux lattice melting occurs, in spite of the picture of the bismuth superconductor shown with Pool's article (p. 915), which shows some smearing. It appears to us that the magnetic fields are different in the two photographs shown because the average spacing of the vortices seems to be quite different. The spacing, r, is independent of material; it is given by the expression $(\theta_0/B)^{1/2}$ where θ_0 is the quantum of magnetic flux and B is the magnetic induction. The intervortex repulsive energies that cause the Abrikosov lattice to form increase logarithmically with the ratio of the superconducting penetration depth and the average distance between vortices, r. Therefore, the lattice gets much stiffer as the magnetic field is increased toward the upper critical field. It is thus rather improbable that this very stiff lattice melts below the upper critical field H_{c2}, as Gammel *et al.* (*1*) propose. (By the way, the picture accompanying Pool's article was presumably taken at 20 gauss, very far from where Gammel *et al.*'s vibrating reed experiments would have indicated that melting had occurred.)

It is possible that at high fields and high temperatures the effective pinning potential provided by crystal defects is overwhelmed by the depth of the energy minimum of the Abrikosov structure (especially for single crystals and very high-quality films). The flux lattice therefore may be able to move in and out of these materials as a unit. This would show up as nearly total reversibility when measured by magnetization or as nearly ideal flux flow resistance when measured by transport. A vibrating reed experiment would show the transition to a large amount of dissipation as the vortex lattice became totally free to move. All this really proves, however, is that we have not learned how to effectively pin the lattice in the regime that was inaccessible with conventional superconductors. Our future efforts should be directed toward finding a pinning defect that can be introduced in a large enough density so that the average distance between the pinning sites is comparable to the vortex lattice spacing at the magnetic field of interest. Also, line defects rather than point defects might provide a more effective pinning barrier in those materials in which the coherence length is short.

The techniques for providing the high density of effective pinning sites for the conventional superconductors like NbTi and Nb_3Sn took many years. Those of us who have devoted our careers to this field and who are in the game for the long-term feel that the party is *not* over; indeed it has barely just begun!

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Notification to Readers

The editors of *Science* have been notified by the National Institutes of Health of the conclusion of an investigation of a paper by C. David Bridges and Richard A. Alvarez entitled "The visual cycle operates via an isomerase acting on all-*trans* retinol in the pigment epithelium" [*Science* **236**, 1678 (1987)] and a paper by Paul S. Bernstein, Wing C. Law, and Robert R. Rando entitled "Isomerization of all-*trans*-retinoids to 11-*cis*-retinoids *in vitro*" [*Proc. Natl. Acad. Sci. U.S.A.* **84**, 1849 (1987)]. The NIH panel concluded that "Based on this analysis of the published articles, the NIH panel believes that Dr. Bridges did plagiarize the Bernstein-Law-Rando manuscript: he misused the privileged information available to him in formulating the experiments he allegedly conducted and he failed to acknowledge properly the source of that information in his report in *Science*."