Science's
COMPASS
LETTERS SCIENCE & SOCIETY POLICY FORUM BOOKS *ET AL.* PERSPECTIVES REVIEWS

Deterring Bioweapons Development

THE GENETICALLY ENGINEERED MOUSEPOX virus described in Elizabeth Finkel's News Focus article should be seen as a wake-up call for those of us in biological weapons control, and particularly for U.S. diplomats and policy-makers ("Engineered mouse virus spurs bioweapons fears," 26 Jan., p. 585). Researchers were trying to engineer a viral vector that could sterilize rodents, to be used for the control of infestations. But the introduction of a second gene that earlier research indicated would enhance the antibody-producing response (and thus the effectiveness of the engineered virus to sterilize mice) made the virus lethal.

The combination of genetic engineering with the emerging fields of genomics and proteomics holds great potential for the development of new therapeutic agents and research reagents, but many of these will also have utility as weapons, or will suggest ways that new chemicals, toxins, or microbial agents could be developed (*1*). Clearly, we do not want to inhibit the peaceful development of such agents; however, it would be folly to ignore their potential for misuse (*2*). Oversight mechanisms are critical to deter diversion of these new technologies to malign purposes.

Currently, the most promising avenue is to strengthen the 1975 Biological and Toxin Weapons Convention (BTWC). This treaty, quite properly, does not prohibit research, but it does prohibit the development, production, or stockpiling of biological or toxic agents and of devices to deliver such agents for other than peaceful purposes. However, with no provisions for verification, the treaty has proved to be a weak deterrent to nations committed to biological weapons development.

For this reason, States Parties to the BTWC have for 5 years been negotiating an addendum (termed a Protocol) to the BTWC that would (i) require annual declarations of specified types of facilities with the potential for use in a biological weapons program, (ii) mandate random visits to such facilities by teams of international inspectors, and (iii) establish a mechanism for investigation of suspicions of violation of the BTWC. Its adoption would significantly improve international security and reduce the risk of bioterrorism by inhibiting bioweapons development.

"[A]doption [of the BTWC Protocol] would...reduce the risk of bioterrorism..."

The Protocol text is in the last stages of development and only awaits the final push for its completion. Despite the commitment of former President Bill Clinton to the early completion of a strong Protocol, however, the actual negotiating stance of the United States reflects otherwise. The United States has consistently delayed progress and pressed for weakening of the Protocol's provisions, and now might completely derail the negotiations by stalling past the deadline imposed by States Parties for completion of the text before the BTWC Review Conference later this year. Failure to complete the Protocol negotiations on time would represent the loss of our best opportunity to prevent a dangerous and unstable arms race.

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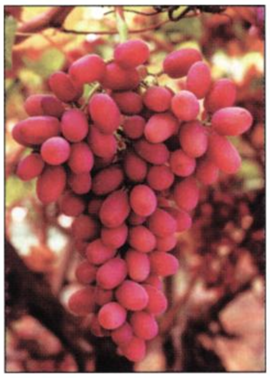
References and Notes
1. M. Wheelis, M. Dando, *Disarmament Forum* **4**, 43 (2000).
2. M. Meselson, *CBW Conv. Bull.* **48**, 16 (2000).

Moribund Funding in Agricultural Research

THE DOUBLE-DIGIT INCREASES IN FEDERAL funding for basic research at the National Science Foundation (NSF) and the National Institutes of Health (NIH) for fiscal year 2001 are a welcome development (*1*), but does recognition of basic research as the engine that drives technology and economic growth not apply to agriculture?

The standard competitive grants program for basic research at the U.S. Department of Agriculture (USDA) began as the National Research Initiative 10 years ago after National Research Council (NRC) reports decried the lack of support for competitive research in the agricultural sciences. The program has outgrown its initiative status, yet it has been stalled for 9 years at a funding level that can only be described as moribund. Whereas support for competitive basic research programs at NSF and NIH combined have grown in constant dollars by 60% since 1992 (*2*), funding for the USDA's competitive grants program has decreased 14% in constant dollars since its 1992 appropriation of $100 million.

A report from the NRC noted the high quality of National Research Initiative research, its crucial contributions to agricultural productivity and environmental quality, and the more than three dozen studies that have placed the economic rate of return on public investment in food and fiber research at 35 to 60% per year (*3*). This is a phenomenal rate of return. New markets, new products, and environmental protection require new ideas, new approaches, and levels of research funding commensurate with the importance that society places on a safe, productive, and environmentally benign food and fiber production system.



In 30 years—the approximate time it takes basic research in the public sector to reach marketplace maturity—the world population will have increased by about 3

Letters to the Editor

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billion. Will we have funded the basic research necessary to feed and clothe them?

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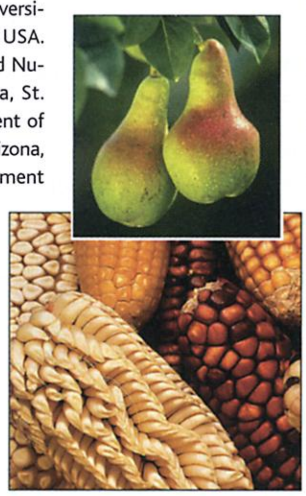

We are reaping benefits from past funding of agricultural research, but are we sowing enough for the future?

References and Notes

1. See, for example, D. Malakoff, *Science* **291**, 33 (2001).
2. American Association for the Advancement of Science, Historical data on federal R&D, FY 1976–2001. Available at http://www.aaas.org/spp/dspp/rd/hist01c.pdf.
3. National Research Council, *National Research Initiative: A Vital Competitive Grants Program in Food, Fiber, and Natural-Resources Research* (National Academy Press, Washington, DC, 2000).

Porous Sediments at the Top of Earth's Core?

IS EARTH'S CORE LOSING MATERIAL AS WELL as heat to the overlying mantle? The idea has been explored in a number of studies over the past 20 years (*1*), and the report in *Science* by Bruce Buffett, Edward Garnero, and Raymond Jeanloz (*2*) is a welcome addition to the list. They propose that light silicate elements are being deposited at the top of the core, an idea that has some appeal. However, the authors suppose a porous, compacting mushy zone several kilometers thick, and this structure is central to their arguments related to Earth's nutation (a sideways nodding of Earth's axis along the precession path). But this assumption won't work—there cannot be a mushy zone.

The separation of nonmetallic impurities from molten iron is an age-old study. But at the high temperature and low cooling rate of the core, any such slag material must be well crystallized. The study of the accumulation and solidification of silicate, oxide, and sulfide crystals from the melt has formed a robust part of igneous petrology since 1939, when Hess (*3*) invented adcumulus growth. This is the process named by Wager and others (*4*) to describe the isothermal, isocompositional solidification of an initially porous crystalline sediment (or cumulate) from the melt, by exchange with an infinite magma reservoir. Solidification may occur through diffusion in the melt alone, or aided or impeded by compositional convection (*5*). If accumulation occurs too fast, the adcumulus growth cannot keep up, and the trapped melt presents as a residual porosity ($p_r > 0$). But if accumulation is slow enough, adcumulus growth may proceed to near-perfection ($p_r \sim 0$), so that solidification occurs at the cumulate interface, as argued here.

The growth of the inner core currently is about 0.03 centimeters per year (*2*), at least an order of magnitude slower than needed for perfect adcumulus growth by diffusion alone (*6, 7*). It is, therefore, many orders of magnitude slower than needed for perfect adcumulus growth in the presence of the strong compositional convection originally proposed by Braginsky (*5*) in respect of the light solute rejected at the inner core boundary, streaming outward to drive the dynamo.

The corresponding accumulation rate of sediment at the top of the outer core would be about 0.004 centimeters per year. [For a mushy zone several kilometers thick (*2*) formed at this rate, accumulation must have outpaced solidification for at least 100 million years.] Such an accumulation would be limited by, and equal to, the supply of impurities to the top of the core. The exchange components for solidification, therefore, reside in the flux of impurities, so that the cumulate is bathed in its own parent liquid. Here also, solidification would be powerfully aided by compositional convection of dense metallic rejected solute, which would drain away into the body of the outer core. There can be no mushy zone solidified by compaction, which cannot occur in a microscopically thin layer (*6*). The electrical conductivity coupling the core to the mantle might better be explained by core metal entrained turbulently into a basal layer of melted mantle.

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