Dreaded Risks and the Control of Biological Weapons

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One week after the September 11, 2001, terrorist attacks on the World Trade Center and the Pentagon, letters containing anthrax spores were mailed to the offices of NBC News, the *New York Post*, and the publisher of the *National Enquirer.* Contaminated letters were subsequently sent to, among others, then Senate Majority Leader Tom Daschle (D-S.D.) and Senator Patrick Leahy (D-Vt.). By the end of the year, anthrax- contaminated letters had infected eighteen people, five of whom died.[1] Although the anthrax attacks resulted in relatively few casualties, at least one poll suggested that public concern about biological terrorism had increased.[2] Some 10,000 people, actually or potentially exposed to virulent anthrax spores, were prescribed prophylactic antibiotics with unknown long-term effects on their health or the health of the public at large.[3]

In the aftermath of the September 11 attacks and anthrax mailings, U.S. policymakers scrambled to enact new legislation to address the terrorist threat. The urgency of the effort precluded careful balancing of competing interests, with potential adverse effects on civil liberties, public health, and national security. The U.S.A. Patriot Act, passed by both Houses of Congress in the space of weeks, was signed by President George W. Bush on October 26. Among its provisions, the act overrides laws in forty-eight states that made library re-

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1. Centers for Disease Control, "Update: Investigation of Bioterrorism-Related Anthrax," *MMWR Weekly,* December 7, 2001, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5048a1.htm (accessed March 2, 2002). For more information, see Barbara Hatch Rosenberg's writings at http://www.fas.org/bwc/news/anthraxreport.htm (accessed June 28, 2002).
2. Harvard University School of Public Health/Robert Wood Johnson Foundation, *Survey Project on Americans' Response to Biological Terrorism,* November 8, 2001. Fifty-seven percent of those surveyed stated that they had taken one or more precautions in response to reports of bioterrorism.
3. Individuals were advised to take ciprofloxacin for up to sixty days. U.S. military researchers concluded, however, that increasing exposure to ciprofloxacin can result in fluoroquinolone resistance in *Bacillus anthracis*. Abstracts of Fourth International Conference organized by the U.S. Army Medical Research Institute, the British Defense Research Agency, the National Institutes of Health, and the Pasteur Institute. L. Price, A.G. Vogler, S. James, and P. Keim, Board 42A, "In Vitro Selection and Characterization of High-Level Fluoroquinolone Resistance in *Bacillus anthracis*." For treatment recommendations, see T.C. Dixon, M. Meselson, J. Guillemin, and P. Hanna, "*Bacillus Anthracis:* Infection Revisited," *New England Journal of Medicine,* September 9, 1999, pp. 815–825.

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cords private.[4] In March 2002 the White House ordered all federal agencies to remove from their websites sensitive, but unclassified, documents that terrorists could use to produce weapons of mass destruction (WMD).[5] George Poste, a prominent biologist and science adviser to the U.S. Department of Defense urged that some aspects of basic microbiological research be made classified, prompting heated debate among biologists about the costs and benefits of openness in science.[6] The Patriot Act also criminalizes inappropriate possession of biological agents except for medical purposes or "bona fide" research and prohibits "restricted persons" from working with them.[7] Critics argue that these policies could hinder legitimate research on naturally occurring and deliberately disseminated infectious disease.[8]

Risk analysts have long observed a tendency for policymakers to respond rapidly to visible crises, even if the baseline rate of danger has not changed.[9] Examples include the enactment of Superfund in response to the furor over the 1978 declaration of Love Canal as a hazardous site and the Oil Pollution Act enacted after the Exxon *Valdez* oil spill of 1989, each of which was found to have serious drawbacks.[10] This tendency to respond quickly encourages reactive "risk of the month" policies crafted in the wake of visible or highly publicized events, resulting in ad hoc policymaking with little regard to competing interests, as John Graham and Jonathan Baert Wiener have observed in regard to environmental and health policy.[11] This dynamic may partly be explained

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4. Bob Egelko, "FBI Checking Out Americans' Reading Habits: Bookstores Can't Do Much to Fend Off Search Warrants," *San Francisco Chronicle,* June 23, 2002, p. A5. See also Brad Smith, "FBI Can Check Out Reading Habits," *Tampa Tribune,* July 5, 2002, p. 1.
5. Bill Sammon, "Web Sites Told to Delete Data," *Washington Times,* March 21, 2002, p. A1.
6. Peter Aldhous, "Biologists Urged to Address Risk of Data Aiding Bioweapon Design," *Nature,* November 15, 2001, pp. 237–238.
7. The bill was signed into law as Public Law 107-56 (the *U.S.A. Patriot Act*), which became title 18, sec. 175B.
8. Egelko, "FBI Checking Out Americans' Reading Habits"; and Aldhous, "Biologists Urged to Address Risk of Data Aiding Bioweapon Design." The *Public Health Security and Bioterrorism Preparedness and Response Act of 2002* was signed as Public Law 107-188 on June 12, 2002.
9. In this article, the term "risk" is used to denote the possibility of an adverse outcome whose probability is between zero and one. It is important to point out at the outset that one school of thought, more prevalent in Europe, rejects many of the assumptions appealed to in this article. The alternative school questions the following assertions: that risk (other than actuarial risk) exists and can be quantified or that risk trade-off analysis can be accomplished; that experts and laypeople are different from one another; that "dread" is a property of risks; and that publics are anxious and irrational and that policy should compensate for these qualities. Sheila Jasanoff, email communication, August 18, 2002. I do not enter into this debate here.
10. John D. Graham and Jonathan Baert Wiener, eds., *Risk vs. Risk: Tradeoffs in Protecting Health and the Environment* (Cambridge, Mass.: Harvard University Press, 1995), p. 234.
11. Ibid.

by what Anthony Patt and Richard Zeckhauser refer to as "action bias"—that is, decisionmakers' penchant for taking action without necessarily considering its long-term effects, coupled with a tendency to choose those actions for which they are likely to receive the most credit.[12] At the same time, national attention often drifts once a crisis appears to be over. Perhaps then the biggest challenge for policymakers in responding to the fall 2001 terrorist strikes is to avoid overreacting while the strikes remain vivid in people's minds—what risk analysts refer to as "availability"—and to sustain the effort to reduce the threat, even during periods when the risk recedes from the national consciousness.

This article argues that effective policymaking requires an assessment of countervailing dangers introduced by remedies intended to decrease a target risk (the one the policy aims to reduce), even when it is particularly dreaded and when both target and countervailing risks are difficult to quantify. Such risk trade-off analysis has become commonplace in evaluations of medical procedures, health risks of pesticides, and policies for protecting the environment, but it is not yet practiced in foreign policy or national security decisionmaking.[13] Risk trade-off analysis differs from cost-benefit analysis, which Robert McNamara made popular in the U.S. Department of Defense during the Vietnam War. Cost-benefit analysis compares the benefits of policies with their financial costs, whereas risk trade-off analysis compares target and countervailing risks in nonfinancial terms. People make risk trade-offs regularly in their daily lives, for example, in deciding whether to take aspirin for a headache, despite the increased risk of stomach upset. Patients whose doctors prescribe a new medication will want statistics on purported benefits as well as possible side effects. Such statistics are less likely to be readily available to foreign policy and national security decisionmakers, but even a qualitative analysis of risk versus risk can improve policy design.

My goal is to demonstrate the utility of risk trade-off analysis to national security policy by applying it qualitatively to policies for reducing access to dangerous pathogens and related information. The framework developed in this article can also be applied to policy problems where both the target and the countervailing risks are difficult to quantify. As disciplines become more spe-

12. Anthony Patt and Richard Zeckhauser, "Behavioral Perceptions and Policies toward the Environment," in Rajeev Gowda and Jeffrey C. Fox, eds., *Judgments, Decisions, and Public Policy* (Cambridge: Cambridge University Press, 2002), pp. 265–302.
13. The concept of risk trade-off analysis was developed by Graham and Wiener, *Risk vs. Risk.*

cialized and government agencies more compartmentalized, decisionmakers are more prone to choose remedies that substitute new risks for old ones in the same population, transfer risks to new populations, or transform risks by creating new risks in new populations.[14] Among such countervailing dangers is the possibility that bioterrorism legislation could diminish researchers' willingness or ability to work with select agents, with the result of reducing U.S. preparedness for biological weapons (BW) attacks as well as infectious disease. Another possibility is that the risk could be transferred from the United States to the developing world, where diseases caused by select agents are endemic. The risk trade-off framework developed here entails determining whether emotions, such as dread, are influencing U.S. government decisionmaking; balancing competing policy priorities; taking core values explicitly into account, even if the demands of national security ultimately trump such concerns; and seeking "risk-superior" strategies.

I argue further that risk trade-off analysis is especially useful for assessing "dreaded risks," which evoke disproportionate fears and are likely to be maximally available in the sense defined above.[15] The image of a mad scientist spreading "weapons-grade" anthrax is difficult to forget, and the need to do something—anything—seemed critically important in the immediate aftermath of the anthrax mailings.[16] The countervailing long-term danger—a possi-

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14. Graham and Wiener, *Risk vs. Risk,* lay out a four-part framework for considering trade-offs in health care and environmental policy, which is summarized in this sentence. In addition to these countervailing dangers, the framework I develop here assesses trade-offs in policy priorities and values.

15. In a survey comparing expert and lay judgment, experts ranked nuclear power twentieth on a list of thirty dangerous technologies and activities, whereas most lay respondents ranked it first. Paul Slovic, "Perception of Risk," *Science,* Vol. 236 (1987), pp. 280–281; Paul Slovic, Baruch Fischoff, and Sarah Lichtenstein, "Facts and Fears: Understanding Perceived Risk," in Richard Schwing and Walter Albers, eds., *Societal Risk Assessment: How Safe Is Safe Enough?* (New York: Plenum, 1980), pp. 181–216. In subsequent studies, Slovic and others have examined the emotional content of risks and its impact on assessment. See, for example, Paul Slovic, "Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield," *Risk Analysis,* Vol. 19. No. 4 (August 1999), pp. 689–701; and Melissa L. Finucane, Ali Alhakami, Paul Slovic, and Stephen M. Johnson, "The Affect Heuristic in Judgments of Risks and Benefits," *Journal of Behavioral Decision Making,* Vol. 13, No. 1 (January/March 2000), pp. 1–17. See also George F. Loewenstein, Christopher K. Hsee, Elke U. Weber, and Ned Welch, "Risk as Feelings," *Psychological Bulletin,* Vol. 127, No. 2 (March 2001), pp. 267–286; and Jonathan Baert Wiener, "Risk in the Republic," in *Duke Environmental Law and Policy Forum,* Vol. 8, No. 1 (Fall 1997), pp. 1–22, as well as the articles in part 3 of that issue.

16. Then House Democratic leader Richard Gephardt (D-Mo.) referred to the material as "weapons-grade" anthrax. Earl Lane, "America's Ordeal: Tracking the Anthrax," *Newsday,* October 18, 2001, p. A4. Laura Dohonue argues that heightened emotions are caused by the interplay between liberal democracy and terrorism. Donohue, "Fear Itself," in Russell D. Howard and Reid L. Saw-

ble chilling effect on research on natural and deliberately spread infectious disease—is less immediate, less visceral, and less likely to attract high-level governmental attention.

This article is not a comprehensive analysis of the bioterrorist threat, which has largely been covered elsewhere.[17] Rather it presents a framework for analyzing foreign and national security policy that takes countervailing risks explicitly into account. A more comprehensive analysis would require quantifying the risk of biological attacks as well as the countervailing risks to public health. I do not attempt such an assessment here. As more information about terrorists' intentions and capabilities becomes available, which is likely to happen only if the demand for human intelligence persists once the fall 2001 attacks lose their salience, a more complete analysis may become possible, especially for government agencies with access to classified information.

The first section of this article provides a brief overview of the threat of bioterrorism. The second section discusses risk analysis and explains why this threat is difficult to quantify. The third discusses dreaded risks and offers reasons why bioterrorism falls into this category. The fourth section introduces a framework for risk trade-off analysis for national security threats and applies it qualitatively to policies for controlling access to pathogens and related information. The conclusion proposes two ways to restrict terrorist access to biological weapons and related information while limiting the negative impact on legitimate scientific research.

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yer, eds., *Terrorism and Counterterrorism: Understanding the New Security Environment* (Guilford, Conn.: McGraw-Hill, 2002), chap. 7.1.

17. See Jeffrey Simon, *Terrorists and the Potential Use of Biological Weapons* (Santa Monica, Calif.: RAND, 1989); W. Seth Carus, *Bioterrorism and Biocrimes: The Illicit Use of Biological Agents in the 20th Century: "The Poor Man's Atomic Bomb?" Biological Weapons in the Middle East,* Policy Papers No. 23 (Washington, D.C.: Washington Institute for Near East Policy, 1991); Jessica Stern, "Will Terrorists Turn to Poison?" *Orbis,* Vol. 37, No. 3 (Summer 1993) pp. 393–410; Ron Purver, "The Threat of Chemical/Biological Terrorism," *Commentary,* August 1995, http://www.csis-scrs.gc.ca/eng/comment/com60_e.html; Jonathan B. Tucker, "Chemical/Biological Terrorism: Coping with a New Threat," *Politics and the Life Sciences,* Vol. 15, No. 2 (September 1996), pp. 167–184; Leonard A. Cole, "The Specter of Biological Weapons," *Scientific American,* December 1996, pp. 17–21; Michael Moodie and Brad Roberts, eds., *Terrorism with Chemical and Biological Weapons: Calibrating Risks and Responses* (Alexandria, Va.: Chemical and Biological Arms Control Institute, 1997), pp. 71–90; Richard A. Falkenrath, Robert D. Newman, and Bradley A. Thayer, *America's Achilles' Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack* (Cambridge, Mass.: MIT Press, 1998); Joshua Lederberg, ed., *Biological Warfare: Limiting the Threat* (Cambridge, Mass.: MIT Press, 1999), Raymond A. Zilinskas, *Biological Warfare: Modern Offense and Defense* (Boulder, Colo.: Lynne Rienner, 1999); Jonathan B. Tucker, *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons* (Cambridge, Mass.: MIT Press, 2000); and Amy Smithson and Leslie Anne Levy, *Ataxia: The Chemical and Biological Terrorism Threat and the U.S. Response,* Report No. 35 (Washington, D.C.: Henry L. Stimson Center, October 2000).

Bioweapons and Bioterrorism: An Overview of the Threat

Four aspects of the bioterrorism threat are discussed below: supply-side issues; demand-side issues; changes in terrorist organizations that make them harder to penetrate and stop; and governments' inadequate preparations to meet the terrorist threat, including possible confusion about the source of a particular outbreak.

THE SUPPLY OF BIOLOGICAL AGENTS

Experts have been warning for some time that weapons of mass destruction are proliferating not only to states but also to subnational groups, and that the United States is particularly vulnerable to a bioterrorist strike.[18] On the supply side, several states known to sponsor terrorism have made improvements in their BW arsenals.[19] Iraq, in particular, was discovered to have produced a wide variety of lethal biological agents.[20] The Soviet Union was reported to have developed antibiotic-resistant pathogens for use as weapons.[21] Perhaps most troubling were revelations that the Soviet Union had produced several tons of smallpox—a particularly virulent biological weapon—and indications that both Iraq and North Korea may have acquired the virus.[22] Smallpox, which killed some 300 million people in the twentieth century alone, is highly contagious and lethal to 30 percent of those it infects. There is no treatment other than vaccination within four days of exposure. Since 1980, when

18. In addition to the material cited above on biological weapons, see also Brian Jenkins, "The Future Course of International Terrorism," *Futurist,* July–August 1987, p. 8; Bruce Hoffman, "Viewpoint: Terrorism and WMD—Some Preliminary Hypotheses," *Nonproliferation Review,* Vol. 4, No. 3 (Spring–Summer 1997), pp. 45–53; Philip B. Heymann, *Terrorism and America: A Commonsense Strategy for a Democratic Society* (Cambridge, Mass.: MIT Press, 1998); Ashton B. Carter, John Deutch, and Philip Zelikow, "Catastrophic Terrorism: Tackling the New Danger," *Foreign Affairs,* Vol. 77, No. 6 (November/December 1998), pp. 80–94; Gavin Cameron, *Nuclear Terrorism: A Threat Assessment for the 21st Century* (New York: Palgrave, 1999); and Ashton B. Carter and William J. Perry with David Aidekman, "Countering Asymmetric Threats," in Carter and John P. White, eds., *Keeping the Edge: Managing Defense for the Future* (Cambridge, Mass.: MIT Press, 2001).
19. A good source on biological weapons proliferation is the Henry L. Stimson Center website, http://www.stimson.org/cbw/?sn?CB2001121274 (accessed July 10, 2002).
20. Raymond A. Zilinskas, "Iraq's Biological Warfare Program: The Past as Future?" and Stephen Black, "Investigating Iraq's Biological Weapons Program," in Lederberg, *Biological Weapons: Limiting the Threat,* pp. 137–158 and 159–164, respectively.
21. Ken Alibek, *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World* (New York: Random House, 1999).
22. William Broad, "Smallpox: The Once and Future Scourge?" *New York Times,* June 15, 1999, p. F1.

the World Health Organization (WHO) certified that smallpox had been eradicated, few countries have maintained vaccine stocks. If smallpox were released, much of the world's population would be vulnerable.[23]

Another supply-side issue is that inputs to biological weapons are inherently dual-use. Unlike special nuclear materials (highly enriched plutonium and uranium), which are man-made at great expense and effort and produced only at government-sanctioned facilities, biological agents (with the single exception of variola virus, the causative agent of smallpox) exist in the environment.[24] Pathogens listed by the government as potential agents for terrorists are used in thousands of clinical and diagnostic laboratories.[25] The same equipment used to produce beer, for example, could be used to produce biological agents. The underlying research and technology base is available to a rapidly growing and increasingly international technical community.[26]

Until recently, germ banks routinely sent samples to virtually anyone who requested them in the belief that they were promoting public health. For example, during the 1980s the U.S. Commerce Department indiscriminately approved exports of *Bacillus anthracis*, the organism that causes anthrax, and *Clostridium botulinum*, the organism used to produce botulinum toxin, from the American Type Culture Collection.[27] The Centers for Disease Control (CDC) once sent cultures of West Nile virus to Iraq.[28] Because of growing concern about BW proliferation, in February 1989 the Commerce Department banned export of pathogen cultures to Iran, Iraq, Libya, and Syria; and in 1984 several

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23. For a comprehensive analysis of the smallpox issue, see Jonathan B. Tucker, *Scourge: The Once and Future Threat of Smallpox* (New York: Atlantic Monthly Press, 2001).
24. Fomer Defense Department official Mitchell Wallerstein points out that the Russians have argued for years that smallpox may be found "in the environment in the form of bodies of deceased individuals trapped in the permafrost of Siberia. The concern may be real, imagined, or purposely made up during Soviet times as a cover for their illegal program." Email communication, December 17, 2002.
25. Lisa D. Rotz, Ali S. Khan, Scott R. Lillibridge, Stephen M. Ostroff, and James M. Hughes, "Public Health Assessment of Potential Biological Terrorism Agents," *Emerging Infectious Diseases*, Vol. 8, No. 2 (February 2002), pp. 225–230.
26. Gerald Epstein, "Controlling Biological Warfare Threats: Resolving Potential Tensions among the Research Community, Industry, and the National Security Community," *Critical Reviews in Microbiology*, Vol. 27, No. 4 (January 2001), pp. 321–354. For the impact on arms control, see Mark Wheelis, "Investigating Disease Outbreaks under a Protocol to the Biological and Toxin Weapons Convention," *Emerging Infectious Diseases*, Vol. 6, No. 6 (November–December 2000), pp. 595–600.
27. Kevin Merida and John Mintz, "Rockville Firm Shipped Germ Agents to Iraq, Riegle Says," *Washington Post*, February 10, 1994, p. A8.
28. Centers for Disease Control and Prevention, "Draft: West Nile Virus Strain, New York, 1999," CDC Media Relations 404 639-3286, April 2000, in files.

Western countries formed the Australia Group, which urges its members to restrict such exports.[29] In response to a neo-Nazi's acquisition of *Yersinia pestis* (the causative agent of plague) from an American germ bank in 1995, the U.S. government tightened the rules for shippers and receivers of select agents.[30] But cultures are also available from germ banks outside the United States; and according to one study, few of these are adequately regulated or secured.[31] And because of the difficulty of detecting biological agents, the ability of U.S. Customs to stop illegal imports of small quantities of pathogens, such as seed cultures, is minimal.[32]

Another problem is that the manufacture of biological weapons is relatively easy to hide. Enrichment and reprocessing of nuclear weapons materials emit chemical signatures that can be picked up by sensors placed at long distances from the production site. There are no equivalent, easily identifiable signatures for BW production.

The demand for biological agents

Several incidents before the 2001 anthrax attacks made clear that terrorists have been interested in acquiring and using WMD. Perhaps the most significant of these was the sarin gas attack by Aum Shinrikyo, a Japanese cult, on the Tokyo subway in 1995. During the 1990s the cult also attempted to use biological weapons, apparently unsuccessfully.[33] The U.S. government has repeatedly stated that Osama bin Laden is interested in acquiring biological agents.[34] George W. Bush and members of his administration continue to ex-

29. The Australia Group, composed of thirty-four countries plus the European Commission, lists twenty-four biological agents and eleven toxins (exports of which its members have agreed to control). See http://www.australiagroup.net/index.html (accessed June 25, 2001).
30. The Antiterrorism and Effective Death Penalty Act of 1996 requires the U.S. Department of Health and Human Services to regulate the transfer of "select agents." The CDC developed a list of twenty-four microbial pathogens and twelve toxins, which, if transferred to another facility, would require registration with the CDC. *Code of Federal Regulations,* title 42, pt. 72.
31. Michael Barletta, Amy Sands, and Jonathan B. Tucker, "Keeping Track of Anthrax: The Case for a Biosecurity Convention," *Bulletin of Atomic Scientists,* Vol. 58, No. 3 (May/June 2002), pp. 57–62.
32. Barry Kellman, "Biological Terrorism: Legal Measures for Preventing Catastrophe," *Harvard Journal of Law and Public Policy,* Vol. 24, No. 2 (Spring 2001), pp. 425–488.
33. William Rosenau, "Aum Shinrikyo's Biological Program: Why Did It Fail?" *Studies in Conflict and Terrorism,* Vol. 24, No. 4 (July 2001), pp. 289–302; and Milton Leitenberg, "The Experience of the Japanese Aum Shinrikyo Group and Biological Agents," in Brad Roberts, ed., *Hype or Reality? The "New Terrorism" and Mass Casualty Attacks* (Alexandria, Va.: Chemical and Biological Arms Control Institute, 2000), pp. 159–172.
34. Testimony by George Tenet, director of central intelligence, before the Senate Foreign Relations Committee, "The Formulation of Effective Nonproliferation Policy," 106th Cong., 2d sess., March

press concern that terrorist groups could join forces with states to carry out WMD attacks.[35] During the last decade, several American antigovernment individuals and groups were found to have acquired biological agents, revealing gaps in existing regulations regarding the sale or possession of lethal or incapacitating biological agents.[36]

THE TRANSFORMATION OF TERRORIST GROUPS

Another troubling development is that terrorist groups have begun organizing themselves into networks or virtual networks rather than large organizations, often with the explicit purpose of evading law enforcement detection.[37] International terrorist organizations, similarly, are forming loose affiliations that operate across national boundaries, making them harder to identify, penetrate, and stop. Ironically, the success of the U.S. operation in Afghanistan against the Taliban may have induced remaining al-Qaeda operatives to strengthen their ties with other groups, including Jaish-e-Mohammed in Pakistan and Jemaah Islamiyah in Southeast Asia, in effect creating franchise outfits around the world.[38] As a result, the leadership of the movement is more dispersed, and the network thereby made more robust.[39]

INADEQUATE PREPAREDNESS AGAINST THE TERRORIST THREAT

U.S. efforts to characterize the terrorist threat have entailed assessments of the country's vulnerability. Exercises in the 1990s tested the U.S. government's preparedness for responding to WMD attacks. The tests revealed that hospitals were likely to quickly exhaust their supplies of antidotes and vaccines; first responders (police, firefighters, and other emergency workers) were inadequately trained and likely to succumb themselves; and coordination among

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21, 2000, Senate Serial 106-655, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=106_senate_hearings&docid=f:64521.wais (accessed September 29, 2002). See also Gavin Cameron, "Multi-track Microproliferation: Lessons from Aum Shinrikyo and Al Qaida," *Studies in Conflict and Terrorism*, Vol. 22, No. 4 (November 1999), pp. 277–309; and Kimberly Mclound and Matthew Osborne, *WMD Terrorism and Usama bin Laden* (Monterey, Calif.: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2001), http://cns.miis.edu/pubs/reports/binladen.htm (accessed September 29, 2002).

35. Lydia Adetunji, "Bush to Lay Out First-Strike Policy against Terrorism," *Financial Times* (London), June 11, 2002, p. 11.

36. Tucker, *Toxic Terror.*

37. L.R. Beam, "Leaderless Resistance," http://www2.mo-net.com/~mlindste/ledrless.html (accessed February 28, 2002).

38. Rohan Gunaratna, *Inside Al Qaeda: Global Network of Terror* (New York: Columbia University Press, 2002); and Jessica Stern, *Terror in the Name of God* (New York: HarperCollins, forthcoming).

39. For more on this, see Stern, *Terror in the Name of God.*

federal, state, and local officials was all but nonexistent. Hospital laboratories were poorly prepared for biological attacks. Secure communication links among doctors, veterinarians, and local and federal public-health officials were inadequate. Systems for ensuring that medication and personnel were distributed appropriately were undeveloped. The public health infrastructure was—and remains—unprepared for timely response and containment of outbreaks. Moreover, critics argue that the lack of a fully coordinated global disease surveillance system could obstruct early response to a bioterrorist attack. Congress enacted legislation to address some of these shortfalls, but many of these problems remain unresolved.[40]

A particularly frightening aspect of biological warfare or terrorism is that it may be difficult to distinguish from a natural outbreak. Although discerning natural from unnatural outbreaks proceeds more rapidly than in the past, suspicions and fears resulting from such outbreaks can still occur.

After Cuba suffered an epidemic of dengue hemorrhagic fever in 1981, it accused the United States of biological aggression. In 1997 Cuba made another allegation of biological warfare, charging that the United States had dropped crop-eating pests from a low-flying plane.[41] When West Nile encephalitis was first diagnosed in New York in the summer of 1999, CIA officials reportedly speculated that the virus, which had never been seen in the Western Hemisphere, might have been deliberately introduced.[42] Ultimately, the CDC concluded that the outbreak was not deliberate. But the difficulty of identifying the virus and its origin, exacerbated by the lack of communication between public health officials and the veterinary community, illustrates the complexity of distinguishing a BW attack from a natural outbreak of disease. This difficulty will grow as urbanization, crowding, travel, poverty, and misuse of

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40. See Smithson and Levy, *Ataxia;* Tara O'Toole, Michael Mair, and Thomas V. Inglesby, "Shining Light on Dark Winter," *Clinical Infectious Diseases,* April 1, 2002, pp. 972–983; Christopher Chyba, "Biological Terrorism and Public Health," *Survival,* Vol. 43, No. 1 (Spring 2001), pp. 93–106; Christopher Chyba, "Toward Biological Security," *Foreign Affairs,* Vol. 81, No. 3 (May/June 2002), pp. 122–136; and Gregory Koblentz, "A Survey of Biological Terrorism and America's Domestic Preparedness Program," in Arnold Howitt and Robyn Pangi, eds., *Countering Terrorism: Dimensions of Preparedness* (Cambridge, Mass.: MIT Press, forthcoming), and much of that volume. For ongoing assessments, see the following websites: http://www.esdp.org; www.cns.miis. edu; and http://www.stimson.org/cbw/?SN=CB2001112951 (accessed August 14, 2002).

41. Raymond A. Zilinskas, "Cuban Allegations of Biological Warfare by the United States: Assessing the Evidence," *Critical Reviews in Microbiology,* Vol. 25, No. 3 (September 1999), pp. 173–227.

42. Richard Preston, "West Nile Mystery: How Did It Get Here? The CIA Would Like to Know," *New Yorker,* October 18–25, 1999, pp. 90–127. The virus was originally misdiagnosed as St. Louis encephalitis.

antibiotics continue to increase the incidence of infectious diseases once thought to be under control.

On the rare occasions when biological weapons were used or accidentally released, scientists and government officials often first assumed that the epidemics were natural outbreaks. For instance, when 751 people in Oregon became infected with salmonella in 1984, public health authorities suspected a natural outbreak, not bioterrorism. A year later, an unrelated law-enforcement investigation revealed that the Rajneeshee cult had deliberately spread pathogens causing the disease.[43] And when Robert Stevens, an avid outdoorsman and a photo editor for the supermarket tabloid *The Sun,* was found to have contracted anthrax, Florida State health officials initially attributed the source of the disease to a naturally occurring strain of the bacteria found in some soils.[44]

Terrorists have yet to employ successfully biological agents to carry out mass casualty attacks. Most incidents to date have involved readily available and easily deployed food-borne pathogens, resulting in relatively few casualties. Although the perpetrator of the fall 2001 attacks used a highly sophisticated powder, the letters in the envelopes identified the material as anthrax and warned recipients to seek treatment, suggesting that the intention was not to kill people. This could change if a state chose to sponsor a biological attack or if a group managed to secure assistance from former government scientists. Moreover, as aerosolization technologies continue to improve, high-casualty biological attacks will become easier to carry out.

Risk Analysis and the Bioterrorist Threat

Terrorist attacks are purposeful, unlike chemical hazards or earthquakes. Moreover, they threaten not only human lives but also political values, interests, and institutions. Government legitimacy is based on the state's monopoly over the use of force and protection of citizens. Terrorists threaten both of those norms.[45] Thus, there are inherent limits to our ability to assess the risk of ter-

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43. Thomas J. Torok, Robert V. Tauxe, Robert P. Wise, John R. Livengood, Robert Sokolow, Steven Mauvais, Kristin A. Birkness, Michael R. Skeels, John M. Horan, and Laurence R. Foster, "A Large Community Outbreak of Salmonellosis Caused by Intentional Contamination of Restaurant Salad Bars," in Lederberg, *Biological Weapons,* pp. 167–184; and W. Seth Carus, "The Rajneeshee (1984)," in Tucker, *Toxic Terror,* pp. 115–138.

44. "Timeline: America Strikes Bioterrorism," *St. Petersburg Times,* October 14, 2001, p. 13A; and Laura Johannes, "Doctor Who Treated Florida Anthrax Case Criticizes Government's Early Reaction," *Wall Street Journal,* November 9, 2001, p. 8.

45. I am grateful to both Laura Donohue and Gregory Koblentz for encouraging me to make these differences clear.

rorism. Two additional kinds of uncertainties are discussed below. First, terrorists' capabilities and intentions are unknown. Second, there are uncertainties about the effects of the weapons themselves.

terrorists' capabilities and intentions

Terrorists rarely make their capabilities and intentions known. Their motivations and intentions also change over time in ways that are hard for analysts to predict. No statistically significant database of previous attacks exists that can be extrapolated, even if that were a valid technique for predicting future terrorist behavior. Terrorists may respond to risk-reduction strategies by finding more vulnerable targets or more effective or less detectable weapons. When metal detectors made it harder to bring guns onto airliners, terrorists began blowing up planes with plastic explosives or taking control of them by threatening pilots and passengers with box cutters.[46] Concrete barriers at U.S. embassies and government buildings have made driving onto these sites more difficult. Now terrorists use more powerful explosives. If cockpit doors are sealed, terrorists could put plastic explosives in luggage or attack other forms of mass transit or large buildings. If plastic-explosive detectors are deployed routinely at airports for checked-in luggage, terrorists might disseminate biological agents on planes or in other enclosed spaces.

technical difficulties with predicting the impact of bw attacks

There are also technical problems with predicting the likely impact of a biological attack. Biological weapons are potentially as deadly as thermonuclear weapons. For example, one U.S. government study concluded that 100 kilograms of *Bacillus anthracis*, a fraction of the amount produced by Iraq, could kill from 1 to 3 million people if dispersed under optimal conditions.[47] In comparison, a Hiroshima-type fission bomb could kill as many as 80,000, while a more powerful hydrogen bomb could kill 600,000 to 2 million.[48] Contagious agents could kill even more people than anthrax. Joshua Lederberg calls the 1918 flu pandemic, which is estimated to have killed more than 20 million people worldwide, a model for the type of disaster that a biological weapon containing a contagious pathogen could wreak.[49] The public health infrastructure

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46. According to Indian government officials, the group of Pakistani extremists who hijacked flight IC814 in December 1999 had box cutters, as did the September 11 attackers.
47. U.S. Congress, Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks*, OTA-ISC-559 (Washington, D.C.: Government Printing Office, 1993), p. 54.
48. Ibid.
49. Quoted in Dan Vergano, "Bioterrorism Defense Under Fire: Doctors Say Military Plans Are Wrong Approach," *USA Today*, June 21, 2000, p. 10D.

was overwhelmed in the first couple of weeks, despite the low case fatality rate of influenza compared with a typical biological warfare threat agent.[50]

Ideal conditions are unlikely to prevail in the field, making the actual results of a BW attack uncertain. The movement of aerosols, the virulence of microorganisms, and the susceptibility of victims all depend on exogenous variables, some of which the perpetrator will be unable to influence and most of which government analysts will be unable to predict.[51] Warfare agents are killed by strong sunlight. Contagious viruses can mutate to become harmless, but they can also mutate to become more contagious and more lethal. Bacteria can be made—or may become—antibiotic resistant over time.

Even for traditional warfare agents such as anthrax, physicians remain uncertain about the dose response (the number of inhaled spores likely to cause infection in what percentage of the population) and the effectiveness of medical countermeasures.[52] There are ethical problems with carrying out the kinds of experiments that would be required to understand fully the effects of biological weapons. The gaps in physicians' knowledge about anthrax, which became clear during the fall 2001 attacks, suggest that even greater uncertainty would attend biological strikes employing less common disease agents.

Standard theories for evaluating risk—utility theory, for example—are not that useful for assessing risks of virtually unlimited cost and finite probability. Moreover, even if an attack were carried out successfully, the range of consequences runs from minor annoyance to society-altering catastrophe. The probability of infection for a given individual is the joint probability that a terrorist or terrorist group decides to use a biological agent; acquires an infectious agent in usable form; and disseminates it successfully in the vicinity of the

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50. See Laurie Garrett, *The Coming Plague: Newly Emerging Diseases in a World Out of Balance* (New York: Farrar, Straus and Giroux, 1994); and Laurie Garrett, *Betrayal of Trust: The Collapse of Global Public Health* (New York: Hyperion, 2000).

51. On the varying susceptibility of victims, see Larry M. Bush, Barry H. Abrams, Anne Beall, and Caroline C. Johnson, "Bioterrorism in the United States," *New England Journal of Medicine,* November 29, 2001, pp. 1607–1610.

52. On the positive side, it was discovered that antibiotics may be effective even after symptoms appear; on the negative side, however, there may be no "safe" dose of inhaled spores. David Brown, "New Questions Raised on Anthrax Perils: Study Finds Spores in Daschle Office Easily Stirred Up, Complicating Risk Analysis," *Washington Post,* December 11, 2001, p. A15. See reference to Meselson in Jonathan Knight, "Bioweapons: Delivering Death in the Mail," *Nature,* December 20, 2001, pp. 719–720. Data from the largest recorded outbreak of inhalation anthrax, in 1979 in the Soviet city of Sverdlovsk, showed for the first time that anthrax spores could remain dormant in the human lung as long as six weeks after exposure, then germinate and cause fatal illness. See Matthew Meselson, Jeanne Guillemin, Martin Hugh-Jones, Alexander Langmuir, Ilona Popova, Alexis Shelokov, and Olga Yamploskaya, "The Sverdlovsk Anthrax Outbreak of 1979," *Science,* November 18, 1994, pp. 1202–1208.

person or, in the case of a contagious agent, in the vicinity of his contacts; and that the person is sensitive to the dosage received; medical countermeasures are not prescribed; or the medical countermeasures are not effective for that person.

Terrorists aim to make a target group feel vulnerable, and they often succeed. A key question for decisionmakers is whether policy responses should be based in part on perceptions of peril, including feelings of fright, or on a calculation that considers every potential casualty to be equal—whatever the emotional and symbolic content of the threat. Certain hazards evoke particular dread, which can lead to the overestimation of risks or the design of reactive policies whose costs may exceed their benefits.

Dreaded Risks

For more than a quarter century, psychologists and risk analysts have sought to identity the attributes of risks that are especially feared. They have found that fear is disproportionately evoked by certain characteristics of risks, including: involuntary exposure, unfamiliarity, and invisibility, as well as instances when victims may not realize that they were exposed or the effects are delayed, when the mechanism of harm is poorly understood, or when long-term effects or the number of people likely to be affected is difficult to predict.[53] In contrast, when risky activities are perceived as voluntary or familiar or when the actor feels—perhaps wrongly—that he or she is in control, danger is likely to be underappreciated.[54] On average, more than 100 Americans die in automobile accidents every day in the United States.[55] Yet because the risk is largely voluntary and seemingly under the driver's control, and because drivers perceive a direct benefit to themselves, most Americans blithely expose

53. Slovic, Fischoff, and Lichtenstein, "Facts and Fears"; and Slovic, "Perception of Risk," pp. 280–281.

54. N.D. Weinstein, "Optimistic Biases about Personal Risks," *Science,* December 8, 1989, pp. 1232–1233; and F.P. McKenna, "It Won't Happen to Me: Unrealistic Optimism or the Illusion of Control?" *British Journal of Psychology,* Vol. 84 (1993), pp. 39–50, cited in Lynn J. Frewer, Chaya Howard, Duncan Hedderley, and Richard Shepherd, "Methodological Approaches to Assessing Risk Perceptions Associated with Food-Related Hazards," *Risk Analysis,* Vol. 18, No. 1 (February 1998), pp. 95–102. According to Frewer et al., the more individuals feel they know about food-borne health hazards, the more they feel they have control over their exposure. Food deliberately contaminated with unknown biological agents could be expected to fall into the category of less controllable hazards.

55. The National Center for Statistics and Analysis (which reports to the National Highway Traffic Safety Administration) estimates there were 41,800 automobile-related fatalities in the year 2000, an average of 115 per day. See http://www.nhtsa.gov/ (accessed June 25, 2001).

themselves to this risk.[56] Bioterrorism is unusual in that it possesses all of the characteristics that psychologists have shown to be conducive to disproportionate dread.

Most of us rely on rules of thumb in calculating risks. Rather than carefully weighing pros and cons, we use heuristic devices. Supreme Court Justice Stephen Breyer explains, "We simplify radically; we reason with the help of a few readily understandable examples; we categorize (events and other people) in simple ways that tend to create binary choices—yes/no, friend/foe, eat/abstain, safe/dangerous, act/don't act."[57]

The media tend to focus on dramatic events, including tornadoes, fires, drownings, homicides, and accidents. Spectacular terrorist attacks—including those with biological agents—have become commonplace in literature and film, seeping into people's collective imagination. But as the September 11 terrorist strikes and the anthrax attacks that followed made clear, the threat is real. The U.S. Environmental Protection Agency observes that people tend to ignore hazards that seem routine, such as indoor air pollution, but fear those that are "high profile," such as hazardous waste sites, which actually pose lower aggregate risks to human health. Terrorist incidents are also high-profile events: They tend to be dramatic and generate media attention.[58] Studies show that people often exaggerate the likelihood of such events, which are easy to imagine or recall. We feel a gut-level fear of terrorism and are prone to trying to eradicate the risk with little regard to costs.[59]

Four aspects of dread: disgust, horror of disease, loss of faith in the ability of scientists to protect us, and implications for risk analysis and policy are particularly relevant to the discussion of the bioterror threat.

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56. See J.K. Hammitt, "Evaluating Risk Communication: In Search of a Gold Standard," in M.P. Cottam, D.W. Harvey, R.P. Pape, and J. Tait, eds., *Foresight and Precaution,* proceedings of the ESREL 2000, SARS, and SRA-Europe annual conference (Rotterdam, the Netherlands: A.A. Balkema, 2000), pp. 15–19. See also Cass Sunstein, "A Note on 'Voluntary' versus 'Involuntary' Risks," *Duke Environmental Law and Policy Forum,* Vol. 8, No. 1 (Fall 1997), pp. 173–180.

57. Stephen Breyer, *Breaking the Vicious Circle: Toward Effective Risk Regulation* (Cambridge, Mass.: Harvard University Press, 1993), p. 35.

58. Amos Tversky and Daniel Kahneman, "Judgment under Uncertainty: Heuristics and Biases," *Science,* September 27, 1974, pp. 1124–1131; and Slovic, Fischoff, and Lichtenstein, "Facts and Fears." People also tend to be overconfident in the accuracy of their assessments, even when those assessments are based on nothing more than guesses. Moreover, people seem to desire certainty: They respond to the anxiety of uncertainty by blithely ignoring uncertain risks and by believing that although others may be vulnerable (to, for example, being involved in an automobile accident), they are not.

59. People are more willing to pay for risk reduction when they believe that zero risk is attainable, according to Kazuya Nakayachi, "How Do People Evaluate Risk Reduction When They Are Told Zero Risk Is Impossible?" *Risk Analysis,* Vol. 18, No. 3 (June 1998), pp. 235–242.

DISGUST

In *The Anatomy of Disgust,* William Miller explains that horror is "fear-imbued" disgust; it is a subset of disgust for which "no distancing or evasive strategies exist that are not themselves utterly contaminating."[60] As Miller observes, "Because the threatening thing is disgusting, one does not want to strike it, touch it, or grapple with it."[61]

Diseases infect us and inhabit us. We cannot physically remove them like a bullet; we cannot escape being defiled. In a conventional bombing campaign, we can run from collapsing structures; and we know immediately whether we have escaped. When biological agents spread, we may not know whether we have been poisoned, and we may not be able to escape no matter how fast we run.

The idea of involuntary exposure is inherently fear inducing. Nearly 40 percent of those queried in a recent study agreed with the statement that "if a person is exposed to a chemical that can cause cancer in humans, then that person will probably get cancer some day." The question provided no specifics about the magnitude of exposure. When the question referred to a specific quantity ("an extremely small amount"), 80 percent of respondents disagreed with the statement that the person exposed would "probably get cancer some day."[62] While the authors of the study conclude that inferences about chemical exposure relate to "the pragmatics of language interpretation,"[63] the study also reveals that the idea of exposure is inherently dread inducing, especially when specifics are not provided—as was the case with the 2001 anthrax attacks and could well be the case for future attacks.

HORROR OF DISEASE

Part of our fear of biological weapons attacks is related to fear of disease and contagion. Disease is familiar to us: We have all been sick and or seen loved ones suffer from disease. What makes bioterror particularly frightening, disgusting, and infuriating is the idea that someone would deliberately contaminate us, and that we in turn might contaminate others.

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60. William Ian Miller, *The Anatomy of Disgust* (Cambridge, Mass.: Harvard University Press, 1998), p. 26; and Susan Miller, "Disgust: Conceptualization, Development, and Dynamics," *International Review of Psychoanalysis,* Vol. 13 (1986), pp. 295–307.
61. Miller, *The Anatomy of Disgust,* p. 26.
62. Donald G. MacGregor, Paul Slovic, and Torbjorn Malmfors, "How Exposed Is Exposed Enough? Lay Inferences about Chemical Exposure," *Risk Analysis,* Vol. 19, No. 4 (August 1999), pp. 649–659.
63. Ibid., p. 649.

Epidemic disease has killed more people than war. Thus far, fear of disease is a reasonable response to the threat. But people tend to fear unusual diseases more than well-known, more common killers. Malaria, an ancient disease, kills 1 million people a year worldwide. Marburg has killed only 10 people; Ebola has killed 891 since its discovery in 1976.[64] Yet it is Ebola and Marburg that have inspired terrifying books and movies. We respond to the likelihood of death in the event the disease is contracted, rather than the compound probability of contracting the disease and succumbing to its effects.[65] The pneumonic plague that broke out in Surat, India, in 1994 reportedly caused hundreds of thousands of people to flee in panic, including 80 percent of the city's private doctors. The disease is estimated to have cost India $2 billion because of its impact on tourism and exports, even though outside experts estimated that there were fewer than 100 cases of plague in Surat and fewer than 100 cases of plague in Beed.[66] Bioterrorism could involve diseases that seem exotic, especially in industrialized societies, increasing their hold on our imagination and increasing the dread factor.

loss of faith in the ability of scientists to protect us

In 1957 the National Association of Science Writers surveyed American views of science. Nearly 90 percent of those polled believed that the world was "better off because of science." Eighty-eight percent believed that science was "the main reason for our rapid progress," and 90 percent of those polled felt that there were no negative consequences of science.[67] Beginning in the 1970s, technological optimism began to erode. A series of environmental disasters, including those at Three Mile Island in 1979 and Chernobyl in 1986, contributed

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64. See http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/ebotabl.htm (accessed February 20, 2002).

65. National BW programs have included work on Ebola and antibiotic-resistant bacteria. If terrorists do try to spread disease, they are probably more likely to choose more ordinary diseases. Still, the very idea of deliberately disseminated disease—whether ordinary or rare—is terrifying. Audrey Kurth Cronin points out that diseases for which there are no cures elicit particular dread, even if they are rare. Interview with Cronin, April 24, 2001.

66. Garrett, *Betrayal of Trust;* and Philip M. Boffey, "Lessons of the Plague," *New York Times,* November 14, 1994, p. 16. The response to the foot-and-mouth disease epidemic in the United Kingdom is perhaps a counterexample, in that there seems to have been little panic. The disease is fairly common but affects humans only very rarely. Perhaps these factors, together with the (possibly false) perception that the government was in control, fed into the public's response. This issue requires further study.

67. U.S. Congress, Office of Technology Assessment, *The Regulatory Environment for Science: A Technical Memorandum* (February 1986), pp. 130–132, cited in Charles Piller, *The Fail-Safe Society: Community Defiance and the End of American Technological Optimism* (New York: Basic Books, 1991), p. 5.

to the public's loss of faith. In a series of polls in the 1980s, 25 percent or more of those surveyed believed that technology would do more harm than good to the human race or that its risks outweighed its benefits.[68]

Kristin Shrader-Frechette argues that scientists contributed to the public's loss of faith in their work by presenting their opinions as established facts, noting that when scientists "present their own educated (but controversial) guesses as science, they can jeopardize the credibility of science. The result can be the anti-science sentiment that is widespread today."[69] Given this, it is perhaps not surprising that Europeans distrust the government scientists who are telling them that the outbreak of bovine spongiform encephalopathy (mad cow disease) is under control, and the risk of contracting its fatal human form, new-variant-Creutzfeldt-Jakob disease, is minimal.[70]

implications for risk analysis and policy

What happens in risk versus risk trade-offs when the target risk evokes disproportionate fears? The literature provides few answers. But Americans' attitudes toward nuclear power provide some clues about the danger of overreaction.[71] The countervailing risk of relying on carbon fuels—air pollution and global warming—may be far more dangerous for human health than the target risk. But fear of radioactive hazards has made it difficult to increase reliance on nuclear power. The image of a mushroom cloud stays fixed in our subconscious—despite the physical impossibility of a nuclear power plant detonating like a nuclear bomb—whereas the dangers of relying on carbon fuels are far less graphic.

Bioterrorism is also a dreaded risk, suggesting that policymakers may rush to develop countermeasures to this terribly frightening threat without assessing countervailing dangers. They may feel politically vulnerable, knowing how their constituents would react if, after a BW attack, preparations were shown to be inadequate. They may also overestimate the risk of panic.[72] The

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68. Piller, *The Fail-Safe Society.*
69. Kristin S. Shrader-Frechette, "Science versus Educated Guessing: Risk Assessment, Nuclear Waste, and Public Policy," *BioScience,* Vol. 46, No. 7 (July–August 1996), p. 498.
70. See Sheila Jasanoff, "Civilization and Madness: The Great BSE Scare of 1996," *Public Understanding of Science,* Vol. 6 (1997), pp. 221–232. For discussion of the impact of risk communication, see Nakayachi, "How Do People Evaluate Risk Reduction When They Are Told Zero Risk Is Impossible?" pp. 235–242; and MacGregor, Slovic, and Malmfors, "How Exposed Is Exposed Enough?"
71. Slovic, "Perception of Risk," pp. 280–281; and Slovic, Fischoff, and Lichtenstein, "Facts and Fears."
72. Social psychologists have shown that people tend to see others as overly emotional and to at-

purpose of this assessment is not to suggest that people should not fear terrorism, or that policymakers should not seek to reduce the risk, but to point out that fear can encourage "risk of the month" responses, without careful consideration of countervailing dangers.

The public's "irrational" overvaluation of dreaded risks may partly reflect ethical concerns (such as a desire for equity), concern about long-term effects on the environment, and the notion that people should be protected from involuntary risks more than from voluntary ones. Tensions between expert and lay communities are likely to rise unless each side fully understands the other's interests and values.

Moreover, one individual's expert is another's layperson. National security experts in the White House and Congress see microbiologists as naïve and reckless for publishing findings potentially of interest to terrorists. To them, microbiologists' attachment to the notion of openness in science looks like a dangerous indulgence. Microbiologists, on the other hand, are dismayed by government regulators' ignorance of basic science and of scientific methods. They see the publication of their results as the only way to develop better medical countermeasures for infectious disease.

There is a more general problem with the distinction between experts and laypersons: We all play both roles. As Sheila Jasanoff explains, although experts may consider fecal matter in breakfast cereal to be medically acceptable, provided the quantity is kept relatively low, the expert is likely to become a layperson if informed that the particular bowl of cereal his child is about to eat is contaminated with the maximally acceptable amount.[73]

The Need for Risk Trade-off Analysis

Americans are increasingly unwilling to accept involuntary risks. They demand cleaner water, tougher air-pollution standards, better treatment for disease, and safer cars. The effects of national risk-reduction campaigns are mixed, however, because remedies for reducing one danger often create new

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tribute their reactions to their personalities, while judging themselves to be rational and flexible. See Lennart Sjoberg, "Worry and Risk Perception," *Risk Analysis,* Vol. 18, No. 1 (February 1998), p. 92. Thomas A. Glass and Monica Schoch-Spana, "Bioterrorism and the People: How to Vaccinate a City against Panic," *Clinical Infectious Diseases,* Vol. 34 (2002), pp. 217–223, http://www.journals.uchicago.edu/CID/journal/issues/v34n2/011333/011333.html (accessed September 30, 2002).

73. Interview with Sheila Jasanoff, science-studies scholar, Cambridge, Massachusetts, June 25, 2001.

ones. Doctors, regulators, and ordinary citizens make risk versus risk trade-offs every day, but sometimes it takes years before the adverse consequences of risk-reduction strategies become known.[74]

To prevent reactive, "risk of the month" responses to national security crises, decisionmakers could benefit from carrying out the kind of risk trade-off analysis employed to evaluate environmental and health policies. To this end, decisionmakers should ask themselves the following questions:

- What are the problems to be addressed?
- What are the proposed policy responses?
- In what ways might the policy affect other governmental priorities, for example, broader foreign policy objectives or domestic political concerns?
- In what ways might the policy adversely affect fundamental values, for example, civil liberties, fairness, or in the case of bioterror, the desire to promote cooperation among scientists conducting basic research? Are these values shared by the population at large or only by certain stakeholders?
- How effective is the proposed remedy: What percentage of the threat would be eradicated by the policy, with what probability?
- Do risk-superior strategies exist?

the problems to be addressed

Policymakers perceive two kinds of problems regarding access to biological agents. First, regulations governing access to pathogens are too lax. Second, information related to the production of biological agents is too loosely controlled.

perceived problems in regulating access to pathogens. Prior to September 11 and the anthrax scare, no law prohibited individuals from possessing biological agents. The Biological Weapons Act of 1989 makes it illegal knowingly to develop, produce, acquire, retain, or transfer biological agents, toxin, or delivery systems for use as a weapon. This law cannot be used to prosecute those who possess biological agents—even if they do not appear to have any legitimate reason to do so—unless the government can prove they intended to use those agents as weapons. Larry Wayne Harris, a neo-Nazi who ordered the causative agent of plague through the mail in 1995, was charged only with mail fraud because he claimed that he needed the plague for defensive purposes and the FBI could not prove otherwise.[75] Congressman Tom

74. Graham and Wiener, *Risk versus Risk*.
75. See Jessica Eve Stern, "Larry Wayne Harris (1998)," in Tucker, *Toxic Terror,* pp. 227–246.

Bliley (R-Va.) noted, "We permit anyone in this country—including felons, foreign nationals from sensitive countries, and members of extremists [*sic*] groups—to lawfully possess even the most deadly biological agents, including anthrax, the plague, and the Ebola virus. They don't even have to notify or register with any federal agency or gain government approval to possess them."[76]

The Antiterrorism and Effective Death Penalty Act of 1996 requires the Department of Health and Human Services to regulate the transfer of select agents. But the regulations apply only to those who acquire the agents through a self-disclosed transaction with a legitimate supplier. They do not apply to organizations or individuals who isolate threat agents from nature, who acquire them surreptitiously, or who possessed them prior to April 15, 1997, the date that the CDC issued the regulations. Animal and plant pathogens are not covered.[77] When individuals request to be registered to receive select agents, law enforcement personnel are not informed.[78]

Two laws passed in the wake of the anthrax mailings criminalize the possession of biological agents, except for medical purposes or "bona fide" research, and prohibit "restricted persons" from working with them.[79] But individuals known to have acquired biological agents in the past for questionable purposes might not have been included on the list. For example, Larry Wayne Harris was not a restricted person, as far as is publicly known. Thus he would presumably have been allowed to work with listed agents under the new rules.[80] And if the FBI is correct in its reported belief that the person responsi-

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76. Statement by Congressman Tom Bliley of Virginia before the House Subcommittee on Oversight and Investigations of the Energy, and Commerce Committee, "Threat of Bioterrorism in America: Assessing the Adequacy of Federal Law Relating to Dangerous Biological Agents," 106th Cong., 1st sess., May 20, 1999, House Serial 106-19, http://com-notes.house.gov/cchear/hearings106.nsf/a317d879d32c08c2852567d3005399463/3aeb445f3c2d91e8852567cf0048bc27?OpenDocument (accessed September 29, 2002).

77. Epstein, "Controlling Biological Warfare Threats," p. 332.

78. Testimony by Robert Burnham, Federal Bureau of Investigation, "Threat of Bioterrorism in America: Assessing the Adequacy of the Federal Law Relating to Dangerous Biological Agents."

79. In Public Law 107-56 (the *U.S.A. Patriot Act*), a "restricted person" is defined as an individual who is under indictment for a crime punishable by imprisonment for a term exceeding one year; has been convicted in any course of a crime punishable by imprisonment for a term exceeding one year; is a fugitive from justice; is an unlawful user of controlled substances; is an illegal alien or an alien from a country that the State Department has designated as a sponsor of terrorism; has been adjudicated as having a mental defect or has been committed to a mental institution; or has been discharged dishonorably from the U.S. armed services. Public Law No. 107-188 repeated these restrictions and also required facilities that possess or transfer select agents to register.

80. See Stern, "Larry Wayne Harris (1998)." The Patriot Act's "restricted persons" definition does not address this case, but under Public Law 107-188, he would be required to register with the government.

ble for the 2001 mailings was a former government insider, he too would probably have been allowed to work with listed agents.[81] Some government regulators believe that the law is still not strong enough.

PERCEIVED PROBLEMS IN CONTROLLING ACCESS TO INFORMATION. Advances in molecular biology have yielded enormous breakthroughs for the treatment of disease. Genome sequencing efforts are expected to deliver the complete sequence of more than seventy major bacterial, fungal, and parasitic pathogens of humans, animals, and plants, with important implications for infectious disease research and comparative genomics.[82] Modern biomedical research is inherently dual-use, however. Advances in medicine and basic science—carried out for commercial or defense purposes—can inevitably be put to hostile use. Biophysicist Steven Block argues that these advances make possible the creation of entirely new biological weapons "endowed with unprecedented power to destroy."[83]

A number of publications have alarmed some observers because of the possibility that they could help a would-be producer of biological weapons—whether a state or a subnational group.[84] The continuously expanding microbial genome databases, many of which are published on the internet,[85] now provide a "parts-list of all potential genes involved in pathogenicity and virulence, adhesion and colonization of host cells, immune response evasion and

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81. Dan Eggen and Joby Warrick, "FBI Still Lacks Identifiable Suspect in Anthrax Probe: Investigators Continue to Focus on People Connected to Labs That Had Strain Found in Letters," *Washington Post,* February 26, 2002, p. A7; and Guy Gugliotta, "Still No Arrests in Anthrax Probe, but 'Progress' Is Noted," *Washington Post,* August 4, 2002, p. A8.

82. Claire M. Fraser and Malcolm R. Dando, "Genomics and Future Biological Weapons: The Need for Preventative Action by the Biomedical Community," *Nature Genetics,* November 1, 2001, pp. 253–265.

83. Steven M. Block, "Living Nightmares: Biological Threats Enabled by Molecular Biology," in Sydney D. Drell, Abraham D. Sofaer, and George D. Wilson, eds., *The New Terror: Facing the Threat of Biological and Chemical Weapons* (Stanford, Calif.: Hoover Institution, 1999), pp. 39–75, at 42. Mitchell Wallerstein points out that it is also possible that in the course of responding to biomedical and other terrorist threats, we may develop treatments, detection systems, and so on that are a positive development for humanity. Email communication, December 17, 2002.

84. National BW programs and disgruntled government scientists can use information on cutting-edge molecular biology more readily than terrorist groups, of course. "Possible Terrorist Use of Modern Biotechnology Techniques," http://thayer.dartmouth.edu/%7Eethreats/ethreats6.html (accessed September 30, 2002). For the purposes of this article, however, any use of BW against civilian populations is considered terrorism. For further discussion of definitions of terrorism, see Jessica Stern, *The Ultimate Terrorists* (Cambridge, Mass.: Harvard University Press, 1999). Gregory Koblentz reports that much of the Soviet Union's efforts to use molecular biology to create new or improved weapons was inspired by research conducted by civilians in the United States for purely scientific purposes. Koblentz, "Pathogens as Weapons: Biological Warfare and International Security," Ph.D. dissertation, Massachusetts Institute of Technology, forthcoming.

85. See http://www.tigr.org/tdb/mdb/mdbcomplete.html (accessed August 12, 2002).

antibiotic resistance from which to pick and choose the most lethal combinations," Clare Fraser and Malcolm Dando observe.[86]

In 1994 the smallpox genome was published. An article published in 2001 showed how a single gene modification can greatly increase the virulence of an influenza virus. Also in 2001, Australian researchers reported that they had inserted a gene into the mousepox genome, inadvertently converting the virus into a highly virulent strain. The recombinant virus was lethal even to mice that were genetically resistant to mousepox and to mice that had been vaccinated against the disease.[87]

In 2002 researchers reported that they had created infectious poliovirus "from scratch," using the published gene sequence for the virus and mail-order DNA.[88] This was the first demonstration that a published genome could be turned into an infectious virus. Gene sequences for Ebola, influenza, smallpox, HIV, and many other viruses are also published on the internet, prompting fears that terrorists could attempt to replicate the experiment with a more virulent agent.[89]

Also in 2002, researchers published an article that described a method for modifying the vaccinia virus (which is used as a vaccine against smallpox) to change a vaccinia protein into a version normally made by the related variola virus (which causes smallpox). The synthesized variola protein proved to be 100 times as potent as the original vaccinia version in inhibiting a component of the human immune system.[90] An editorial accompanying the article conceded that the idea that terrorists might attempt to replicate the experiment had been suggested as a "reason for considering it imprudent to publish observations of this nature." It insisted, however, that information that "can be ex-

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86. Fraser and Dando, "Genomics and Future Biological Weapons."
87. Ronald J. Jackson, Alistair Ramsay, Carina D. Christensen, Sandra Beaton, Diana F. Hall, and Ian A. Ramshaw, "Expression of Mouse Interleukin-4 by a Recombinant Entromelia Virus Suppresses Cytolytic Lymphocyte Responses and Overcomes Genetic Resistance to Mousepox, " *Journal of Virology,* Vol. 75, No. 3 (February 2001), pp. 1205–1210; R. Nowak, "Disaster in the Making," *New Scientist,* January 13, 2002, p. 4; and Carina Dennis, "The Bugs of War," *Nature,* May 17, 2001, pp. 232–235. For analysis of why the results should not have been surprising, see Malcolm Dando, "Defining 'Potentially Dangerous' Biotechnology Research," University of Bradford, February 2002.
88. J. Cello, A.V. Paul, and E. Wimmer, *Science,* July 11, 2002, pp. 1016–1018.
89. Tom Clarke, "Polio Made from Scratch," *Nature: Science Update,* July 12, 2002. http://www.nature.com/nsu/020708/020708–17.html (accessed September 29, 2002).
90. Ariella M. Rosengard, Yu Liu, Zhiping Nie, and Robert Jimenez, "Variola Virus Immune Evasion Design: Expression of a Highly Efficient Inhibitor of Human Complement," *Proceedings of the National Academy of Sciences,* June 25, 2002, pp. 8808–8813.

ploited for beneficial ends" should not be censored "merely because it might give a potential terrorist ideas."[91]

Some observers are increasingly alarmed about the possibility that publications of this kind could be put to malign use. Bioethicist Arthur Caplan argues, "We have to get away from the ethos that knowledge is good, knowledge should be publicly available, that information will liberate us. . . . Information will kill us in the techno-terrorist age, and I think it's nuts to put that stuff on Web sites."[92] D.A. Henderson, a former adviser to President George W. Bush and director of the Center for Civilian Biodefense Studies at Johns Hopkins University, argues, "I can't for the life of me figure out how we are going to deal with this."[93] George Poste warns that biologists will have to regulate themselves or that controls will be imposed on them. Biology must "lose its innocence," he argues, calling the status quo "untenable."[94]

PROPOSED POLICY REMEDIES

Some policymakers would like to see the regulations controlling access to pathogens and related information tightened. The International Traffic in Arms Regulations (ITAR) regulates the export of certain munitions. If a project falls under ITAR, an export license is required before information can be shared with foreign nationals, including scientists and students. The design, development, engineering, and manufacture of defense articles (including chemical and biological agents) come under a provision entitled "defense services," which are also controlled for export.[95] "ITAR is comprehensive, complex, time-consuming, and often inconsistent," and often requires legal interpretation, explains Eugene Skolnikoff.[96] He expects that "it is only a matter of time before ITAR will be extended" to biological research that could be construed as having military applications.[97]

Representative Dave Weldon (R-Fla.) called the 2002 polio paper mentioned above "a blue print that could conceivably enable terrorists to inexpensively

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91. P.J. Lachman, "Microbial Subversion of the Immune Response," *Proceedings of the National Academy of Sciences,* June 25, 2002, p. 8462.
92. Quoted in Ronald M. Atlas, "Bioterrorism: The ASM Response," *ASM News,* Vol. 68, No. 3 (2002), p. 118. Original in Eric Lichtblau, "Response to Terror: Rising Fears That What We Do Know Can Hurt Us," *Los Angeles Times,* November 18, 2001, p. 1.
93. Quoted in Nowak, "Disaster in the Making," p. 4.
94. Quoted in Aldhous, "Biologists Urged to Address Risk of Data Aiding Bioweapon Design."
95. International Traffic in Arms Regulations (22 CFR 120-13), March 2001.
96. Eugene Skolnikoff, "Research Universities and National Security: Can Traditional Values Survive?" p. 67, http://www.aaas.org/spp/yearbook/2003/stvwch6.pdf (accessed September 27, 2002).
97. Ibid., p. 68.

create human pathogens," and introduced a resolution criticizing the decision of the American Association for the Advancement of Science to publish it. The resolution, which did not pass, also called on government agencies that fund molecular biological research to reconsider classification rules.[98]

Poste has called for more classification of research with potential defense applications, as well as a requirement that proposals to the National Institutes of Health include a declaration that the researchers had considered the possibility that their findings could be used for malicious purposes. He has also urged that for projects considered especially risky, manuscripts be vetted prior to publication, with the possibility that permission to publish could be denied.[99] An editorial published in *Nature* together with an article describing Poste's recommendations observed that the "anguished reactions" to some of Poste's suggestions make clear that there are "no simple answers" to the dilemma about protecting information that could be used for malevolent purposes.[100]

other policy priorities threatened by the proposed remedies

These proposed remedies threaten three policy priorities other than counterterrorism. The first is the fight against newly emerging and reemerging infectious disease. The second is arms control. The third is the promotion of advances in fundamental research and biotechnology.

According to a recent National Intelligence Estimate, "new and re-emerging infectious diseases will pose a rising global health threat that will complicate U.S. and global security over the next 20 years. These diseases will endanger U.S. citizens at home and abroad, threaten U.S. armed forces deployed overseas and exacerbate social and political instability in key countries and regions in which the United States has significant interests."[101] Every day, tens of thousands of people around the world die from infectious disease.[102] Thus, if citizens from non-NATO countries were prohibited from working on select

98. House Resolution 514, July 26, 2002, 107th Cong., 2d sess., http://www.fas.org/sgp/congress/2002/hres514.html. For arguments as to why it should not have been published (yet did not represent a security threat), see Steven M. Block and Donald Kennedy, "A Not-So-Cheap Stunt," *Science,* August 2, 2002, pp. 769–770. See also Jennifer Couzin, "Polio Paper Sparks Criticism from Congressional Representatives," *ScienceNOW,* July 29, 2002.
99. Aldhous, "Biologists Urged to Address Risk of Data Aiding Bioweapon Design."
100. "The End of Innocence?" *Nature,* November 15, 2001, p. 236.
101. Testimony by David Gordon, National Intelligence Council, before the House International Relations Committee, "Infectious Diseases: A Growing Threat to America's Health and Security," 106th Cong., 2d sess., June 29, 2000, House Serial 106-146, p. 35, http://www.house.gov/international_relations/fc062900.pdf (accessed September 29, 2002).
102. Testimony by Ronald Atlas, American Society of Microbiology, "Threat of Bioterrorism in America: Assessing the Adequacy of the Federal Law Relating to Dangerous Biological Agents."

agents, public health could suffer first in their countries and eventually worldwide. The potential adverse consequences for research on infectious disease transform the risk of biological terrorism against Americans into health risks worldwide.

Additional regulations could dampen researchers' enthusiasm for working on select agents at a time when such research is needed more than ever. It is important to realize that although most select agents pose an esoteric threat to NATO member countries, they cause endemic diseases in the developing world. As CDC scientist Stephen Ostroff argues, "There is a need to expand research involving select agents, not to constrain it. We must bring the best and brightest minds to bear on the development of better vaccines, antiviral agents, antibiotics, and other therapies for exposure to, or illness from, biological agents. To do so, we need to ensure that restrictions on possession or handling of biological agents do not have a chilling effect on the willingness of scientists and research establishments to take part."[103] Ronald Atlas warned in testimony before Congress, "We have to ensure that we do not take actions that will form roadblocks between us and the international community in our effort to in fact combat infectious disease."[104]

Censoring publication of biomedical research could also adversely affect work on infectious disease. Controlling dissemination of basic research findings could discourage research on virulence, transmissibility, pathogenesis, immunology, and other issues that are important for understanding and controlling the spread of infectious disease. This subversion of science could deter research in promising fields of inquiry. Dr. Ariella Rosengard, who modified a benign virus to make it more like the virus that causes smallpox, asks, "How do doctors talk about research if we don't publish it?" She argues that intellectual exchange promotes better science and better conclusions.[105]

Arms control experts also argue that classifying defensive bioweapons programs could give governments an excuse to hide offensive bioweapons research. Three *New York Times* reporters revealed in 2001 that three U.S.

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103. Testimony by Stephen Ostroff, Centers for Disease Control and Prevention, "Threat of Bioterrorism in America: Assessing the Adequacy of the Federal Law Relating to Dangerous Biological Agents," p. 24.
104. Testimony by Ronald Atlas, American Society for Microbiology, before the Subcommittee on Technology, Terrorism, and Government Information of the Senate Judiciary Committee, "Germs, Toxins, and Terror: The New Threat to America," 107th Cong., 1st sess., November 6, 2001, http://judiciary.senate.gov/testimony.cfm?id=123&wit_id=49 (accessed September 29, 2002).
105. Quoted in Diana Jean Schemo, "Sept. 11 Strikes at Labs' Doors," *New York Times,* August 13, 2002, p. D2.

government agencies—the Central Intelligence Agency, the Defense Threat Reduction Agency, and the Defense Intelligence Agency—had been secretly engaged in biodefense projects that appeared to some arms control experts to come close to violating the Biological Weapons Convention (BWC), ratified by the United States in 1975.[106] President Bill Clinton was reportedly not informed of their existence.[107] In the course of the investigation of the source of the anthrax used in the 2001 attacks, the U.S. Army admitted that it had produced a small quantity of anthrax spores in a highly lethal powdered form.[108] "As long as the United States pursues classified projects, other members of the BWC have no way of knowing that these activities are treaty compliant and must accept U.S. assurances on faith," Jonathan Tucker argues.[109] Classifying such work could raise suspicions, creating a climate of fear with the potential to encourage proliferation.[110]

Applying ITAR regulations to biological research, as they have been to space-based technologies, would make American universities less hospitable to foreigners, which in turn could have adverse consequences not only for the advancement of molecular biology and medicine but also for the U.S. economy. More than half a million foreign students are studying at American universities, an increase of 35 percent in fifteen years. Foreign nationals account for more than 50 percent of engineering doctorates and more than 25 percent of science doctorates awarded by U.S. universities. Foreign students and researchers have become vital to the U.S. economy.[111]

VALUES PUT AT RISK BY PROPOSED REMEDIES

Three stakeholders' values need to be considered in contemplating possible remedies for controlling biological weapons agents: researchers, universities,

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106. Judith Miller, Stephen Engelberg, and William J. Broad, *Germs: Biological Weapons and America's Secret War* (New York: Simon and Schuster, 2001), pp. 292–298; and Judith Miller, Stephen Engelberg, and William J. Broad, "U.S. Germ Warfare Research Pushes Treaty Limits," *New York Times,* September 4, 2001, p. A1.
107. Jonathan B. Tucker, "A Farewell to Germs: The U.S. Renunciation of Biological and Toxin Warfare, 1969–70," *International Security,* Vol. 27, No. 1 (Summer 2002), p. 147.
108. William J. Broad and Judith Miller, "U.S. Recently Produced Anthrax in a Highly Lethal Powder Form," *New York Times,* December 13, 2001, p. A1.
109. Tucker, "A Farewell to Germs," p. 148.
110. See quotes by Elisa D. Harris and Barbara Hatch Rosenberg in Broad and Miller, "U.S. Recently Produced Anthrax in a Highly Lethal Powder Form." See also Elisa D. Harris, "Research Not to Be Hidden," *New York Times,* September 6, 2001, p. 23. For more analysis, see http://www.fas.org/bwc/usbiodefense.htm (accessed September 30, 2002).
111. Skolnikoff, "Research Universities and National Security," p. 71.

and the public. Restricting foreign students' research choices and controlling dissemination of basic-research results represent a significant threat to the free exchange of ideas that scientists believe is essential. Research universities consider the commitment to openness and equal opportunity for all students regardless of national origin as essential for maintaining high-quality education and research.[112]

The debate about openness in science is not new. In 1982 the Department of Defense tried unsuccessfully to extend export controls on military hardware to research findings with possible military applications, arguing that controls were necessary because the Soviet Union had "organized a massive, systematic effort to get advanced technology from the West."[113] But a study commissioned by the Department of Defense concluded that the leadership of the United States was based on a scientific foundation, "whose vitality in turn depends on effective communication among scientists." The short-term security achieved by restricting the flow of information would be "purchased at a price." Moreover, "security by accomplishment may have more to offer as a general national strategy," and "openness helps to nurture" vitality in research efforts needed to ensure the long-term security of the United States.[114]

The study concluded that "no restriction of any kind limiting access of communication should be applied to any area of university research, be it basic or applied, unless it involves a technology meeting all the following criteria: 1. The technology is developing rapidly, and the time from basic science to application is short; 2. The technology has identifiable direct military applications; or it is dual-use and involves process or production-related techniques; 3. Transfer of the technology would give the [adversary] significant near-term military benefits; and 4. The U.S. is the only source of information about the technology, or other friendly nationals that could also be the source have control systems as secure as ours."[115] None of these conditions for restricting dissemination of research findings is met for molecular-biological basic-science

112. Skolnikoff, "Research Universities and National Security."
113. Don J. Deyoung, U.S. Naval Research Laboratory, White Paper on Proposed Security Controls on Defense Research, April 2, 2002, http://www.fas.org/sgp/othergov/deyoung.html (accessed August 13, 2002).
114. National Academy of Sciences, "Scientific Communication and National Security" (1982), p. ix; and Deyoung, White Paper on Proposed Security Controls on Defense Research.
115. National Academy of Sciences, "Executive Summary," *Scientific Communication and National Security* (1982), p. 5, http://www.nap.edu/books/0309033322.html. I replaced the acronym "USSR" with "[adversary]."

publications, such as the one on polio that was of particular concern to Congressman Weldon.

In 1985 President Ronald Reagan's administration issued a directive that reflected these findings. National Security Directive 189, which is still in force, argues that U.S. strength in science depends on "an environment conducive to creativity," in which the "free exchange of ideas is a vital component." It stipulates that products of fundamental research should remain unrestricted "to the maximum extent possible." The directive makes clear that no restrictions may be placed on the reporting of research results that are unclassified except as provided in applicable U.S. statutes. The only tool available to the government is classification; there can be no censoring of "sensitive" information that is not classified.[116] Executive Order 12958, issued in 1995, reiterates the prohibition against classifying "basic scientific research information not clearly related to the national security."[117] In November 2001, in a letter to former Defense Secretary Harold Brown, National Security Adviser Condoleezza Rice confirmed that National Security Directive 189 is still in place.[118] Nonetheless, four months later, the White House ordered government agencies to remove sensitive but unclassified documents from their websites.[119]

The public probably does not share the value of openness in science, at least not to the same degree. Policy solutions must be viewed as responsive to the public's concerns, biologist R. Timothy Mulcahy argues. Scientists "can ill afford to be perceived as 'intellectual Taliban,' aiding and abetting terrorists by perceived indifference or outright rejection of national security interests or public concerns."[120] It may be necessary for universities to get involved in educating the public about the contributions of biological science to national security, he argues.[121] Indeed the values and interests of the public, the national

116. "National Policy on the Transfer of Scientific, Technical, and Engineering Information," September 21, 1985, National Security Decision Directive 189, http://fas.org/irp/offdocs/nsdd/nsdd-189.htm (accessed August 12, 2002).
117. Rules for classification are spelled out in Executive Order 12958, April 17, 1995.
118. Letter to Dr. Harold Brown from Condoleezza Rice, November 1, 2001, in files.
119. The designation "sensitive but unclassified" is "potentially a catchall and it could be an invitation to abuse," argues secrecy expert Steven Aftergood, citing the Pentagon's removal of evaluation reports for procurement programs, which, although useless for terrorists, are "enormously useful for both congressional and public oversight of many large programs." Quoted in Sammon, "Web Sites Told to Delete Data."
120. R. Timothy Mulcahy, "The Response to Bioterrorism: Challenges for Universities and Scientists," in files.
121. Ibid.

security community, and the research community differ, and disputes among these communities are likely to grow in the absence of dialogue. "Arriving at a common understanding—the basis for sound policy—will therefore require each to understand the objectives and constraints of the others," Gerald Epstein argues.[122]

effectiveness of the proposed remedies

All threat agents listed by the CDC, except variola, occur in nature.[123] For example, the CDC lists filoviruses, the causative agent of Ebola, which is endemic in Africa, as a high-priority category A organism with the potential to pose significant risks to national security.[124] Multidrug-resistant tuberculosis is listed in category C, which includes emerging, reemerging, and drug-resistant diseases that could be engineered for mass dissemination in the future. Multidrug-resistant tuberculosis is spreading rapidly through Russian prisons. No matter how tight the controls on laboratory research, determined terrorists could attempt to isolate these agents from sick persons' blood or from the soil. Also, as mentioned above, cultures are available from collections outside the United States.

Of course, the goal is to increase the difficulty of acquiring these agents: No regulatory regime, however, can prevent access to materials that exist in nature. The Aum Shinrikyo cult traveled to Zaire in search of Ebola but was apparently unsuccessful in isolating the agent, suggesting that controlling access to select agents can at least slow acquisition. Although everyone agrees that there will never be a leak-proof control system, it is important to compare the necessarily limited effectiveness of the controls with the countervailing dangers and to consider how these dangers can be minimized. Many scientists have voiced concerns that the regulations will impose heavy costs on the "good guys," who are unlikely to isolate cultures from nature or purchase them abroad to circumvent cumbersome regulations, with little effect on "bad guys," who may make such attempts and eventually succeed.[125]

Another consideration is that efforts to control the spread of information and technologies are ultimately doomed to fail. Diffusion of technologies to other

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122. Epstein, "Controlling Biological Warfare Threats."
123. "Biological and Chemical Terrorism: Strategic Plan for Preparedness and Response," recommendations of the CDC Strategic Planning Group, *Morbidity and Mortality Weekly Report*, No. RR-04, April 21, 2000.
124. Ibid.
125. Interviews with CDC personnel, April 2000.

countries and even terrorists can only be delayed, not prevented. This is especially true for biological weaponry. The key questions are: How much delay, and at what cost? In this case, it is difficult to predict how new ideas will be applied—whether to cure diseases or create new, more lethal forms. This issue is particularly pertinent to the debate about whether to publish articles that discuss molecularly engineered pathogens and immune responses.

Toxicologist Eileen Choffnes, a senior program officer at the National Academy of Sciences (NAS), explains why restricting dissemination of basic microbiological research findings is different from classifying nuclear weapons–related information: "The United States had a virtual monopoly over the knowledge base, infrastructure, and processing technologies for nuclear weapons until the early 1950s. That knowledge base spread only very slowly, first to the Soviet Union, and later to other countries. But we have no comparable technological edge in molecular biology related to biological weapons. The technology, the infrastructure, the knowledge base—even the pathogens—are available globally."[126]

seeking risk-superior strategies

It is difficult to design risk-reduction strategies that do not create countervailing dangers. But sometimes it is possible to develop risk-superior policies that provide an equivalent level of benefit while minimizing countervailing dangers or even "coincident risk reductions," which Graham and Wiener define as an unexpected bonus risk reduction accompanying a policy for reducing the target risk.[127] To develop such risk-superior strategies, the needs and values of stakeholders must be known.

One such risk-superior policy would be to improve surveillance systems for human, animal, and plant diseases worldwide.[128] Laboratories need to be built

126. Interview with Eileen Choffnes, August 16, 2002. I am grateful to Eileen also for sharing the briefing books that she prepared for NAS panels that touch on these topics. Gerald Epstein points out that the arguments in favor of openness (which were derived in regard to nuclear weapons during the Cold War) may be sufficiently generic and robust to cover the current situation as well. But we need to reexamine them to convince ourselves (and others who may be pressing for more stringent restrictions) that they still apply. Email communication, August 28, 2002.

127. Graham and Wiener, *Risk versus Risk*, p. 232. Interestingly, there are a number of risk-coincident strategies for counterterrorism, although not necessarily regarding bioterror. Efforts to assist failed or failing states and removing import quotas on commodities produced in countries where terrorists thrive are but two examples. Raising the opportunity cost of young men's time and improving governance in failing states are likely to reduce the appeal of terrorism for the foot soldiers of terrorist groups.

128. Christopher Chyba, "Biological Terrorism, Emerging Diseases, and National Security," a report for the Rockefeller Brothers' Fund, http://www.rbf.org/Chyba_Bioterrorism.pdf (accessed

in the field; a system for transporting samples needs to be developed; and communication links among laboratories, national health ministries, WHO Collaborating Centers, hospitals, and private voluntary organizations need to be established. The revolution in communications technologies needs to be applied to disease surveillance and control.[129] Without such a system in place, physicians will be hard pressed to identify and respond to unusual disease outbreaks, whatever their source. The system would simultaneously assist in identifying bioterror sources and improving public health.

An arguably risk-superior approach to controlling access to pathogens might be to require institutions to register all individuals who work with select agents and to ban unregistered persons from entering laboratories where the agents are stored and used. Gerald Epstein points out that such a system would enable institutions to restrict access only to those whom they know to have a legitimate reason for using such agents and would also facilitate investigations of unlawful activity involving biological agents.[130]

A risk-superior approach to restricting dissemination of basic biomedical research would be to allow scientists to police themselves. John Collier argues that there is no bright line that would distinguish classified from unclassified material in molecular biology. "You can find a reason to censor almost any publication," he says. The only solution is to set up a committee of informed scientists willing to make a judgment about the benefits and costs of publication.[131] Malcolm Dando has proposed the creation of an international oversight board that would review potentially dangerous research projects to determine whether the benefits exceed the dangers and, for contentious projects with dangerous results that slip through the first filter, to determine whether publication of results should be allowed.[132] Epstein suggests a self-governance regime similar to the Asilomar process, which came out of a 1973 meeting of leading researchers studying recombinant DNA. Scientists from around the world agreed voluntarily not to carry out certain kinds of research and to put

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August 16, 2002). See also Jessica Stern, "Reducing the Threat of WMD Terrorism: Opportunities for a New Foundation," recommendations to the Nuclear Threat Initiative, October 11, 2000; Jessica Stern, "Confronting Biological Terrorism," *Harvard International Review,* Vol. 23, No. 1 (Spring 2001), pp. 84–85; Christopher Chyba, "Biological Security in a Changed World," *Science,* September 28, 2001, p. 2349; and Chyba, "Toward Biological Security."

129. *Infectious Disease—A Global Health Threat,* report of the National Science and Technology Council Committee on International Science, Engineering, and Technology Working Group on Emerging and Re-emerging Infectious Disease, September 1995.

130. Epstein, "Controlling Biological Warfare Threats," p. 332.

131. Telephone interview, August 14, 2002.

132. Dando, "Defining 'Potentially Dangerous' Biotechnology Research," p. 23.

security and containment measures in place for other kinds. The challenge was to implement flexible constraints over potentially dangerous research without unnecessarily constraining it. Many of the restrictions put in place as a result of the scientists' concerns turned out to be technically unfounded and were ultimately removed. Asilomar serves as a good model for what is needed today, Epstein argues, in that the approach was voluntary, flexible, and effective.[133] Jonathan Tucker supports a similar approach, proposing that an international oversight board be created to assess potentially contentious research. Some research with direct offensive military applications would be forbidden outright, he proposes, but some would be allowed to go forward with close monitoring by the board.[134] Like Dando, Tucker suggests that the board conduct a prepublication review of research findings with potentially dangerous implications, such as the Australian mousepox discovery, for advice about whether publication should be allowed.[135]

Conclusion

Studies of perceived risk show that fear is disproportionately evoked by certain characteristics of risks. Biological agents are mysterious, unfamiliar, indiscriminate, uncontollable, inequitable, and invisible, all of which are characteristics of dreaded risks. The effects of these weapons are also difficult to predict and poorly understood by science. They are physically disgusting, a factor associated with moral aversion. The media tend to highlight terrorist incidents, heightening dread and panic still further (in a simultaneous relationship). We feel a gut-level fear and are prone to trying to eradicate the risk with little regard to the costs involved. This fear can influence our ability to assess with accuracy risk versus risk trade-offs, for example, between mundane (but common) risks to human health and those that are more spectacular. Experience with nuclear power, another dreaded risk, suggests that decisionmakers should be particularly careful when dealing with target risks that evoke dis-

133. Epstein, "Controlling Biological Warfare Threats," p. 338.
134. Jonathan B. Tucker, "Regulating Scientific Research of Potential Relevance to Biological Warfare," in Michael Barletta, ed., *After 9/11: Preventing Mass-Destruction Terrorism and Weapons Proliferation*, Occasional Paper 8 (Monterey, Calif.: Center for Nonproliferation Studies, Monterey Institute of International Studies, May 2002), pp. 24–27.
135. Tucker, "Regulating Scientific Research of Potential Relevance to Biological Warfare." See also publications and work in process by Elisa D. Harris and John Steinbruner, Controlling Dangerous Pathogens Project, University of Maryland, http://www.puaf.umd.edu/CISSM/Projects/AMCS/Pathogens.htm (accessed October 1, 2002).

proportionate dread, because there is a danger of choosing policies whose costs exceed their benefits. An assessment of countervailing dangers is thus particularly important for dreaded risks.

Risk trade-off analysis demands that decisionmakers think carefully about how to strike an appropriate balance between competing interests—in this case the desire to reduce the threat of terrorism while still promoting legitimate research. The article examined a particular policy remedy: controlling access to pathogens and related information as well as the possible countervailing risks.

Biological weapons are inherently dual-use commodities. All inputs to bioweapons production are used for legitimate purposes, including in medicine. Even variola virus, the causative agent of smallpox, is required for some biomedical research.[136] One of the most critical inputs—the pathogens—can be isolated from nature.[137] Another important input—information—is important to research on infectious disease. Even the tightest imaginable regime cannot prevent the production of biological weapons: The most policymakers can strive for is to make production more difficult. Efforts to frustrate BW production will inevitably affect both licit and illicit activities. Thus the limited effectiveness of the remedy must be balanced against the countervailing costs.

Two policy remedies currently under consideration—restricting dissemination of basic biomedical research findings and prohibiting citizens from non-NATO countries from working with select agents—could have an adverse impact on research on naturally occurring and deliberately disseminated infectious disease. It is likely that the countervailing dangers introduced by these proposed remedies exceed their benefits. Policies aimed at improving the public health infrastructure around the globe are critically important for addressing not only the threat of bioterror but also the threat of emerging, reemerging, and antibiotic-resistant disease. A better approach would be to allow scientists to police themselves by registering their laboratories and personnel with government agencies and by establishing an international oversight board that would review contentious research and publications.

Political scientist Leonard Cole observes that biological weapons have always been seen as "inherently sneaky, unfair, abhorrent," for reasons that are

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136. The World Health Organization has decided not to destroy the official remaining live variola stocks, stored in repositories in Russia and the United States. The National Institute of Medicine recommended that stocks be retained because of their importance for developing antiviral medications and novel vaccines, as well as for use in studying the human immune system. See National Institute of Medicine, "Assessment of Future Needs for Variola (Smallpox) Virus," http://www.nap.edu/catalog/6445.html (accessed August 14, 2002).
137. Smallpox is the sole exception.

hard to explain.[138] Historian John Moon describes the revulsion as deep, mysterious, and ultimately inescapable.[139] As the technology for producing these weapons continues both to improve and to spread, those who oppose their use are in a race with those who would do us harm. Part of the race is technical—to develop better pharmaceuticals and diagnostics. And part of it involves developing better laws. But the challenge will be to ensure that the revulsion invoked by these weapons does not push us to take actions with unacceptable adverse effects on competing interests, including the promotion of legitimate research, civil liberties, and public health.

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138. Leonard A. Cole, *The Eleventh Plague: The Politics of Biological and Chemical Warfare* (New York: W.H. Freeman and Co., 1997), p. 214.
139. John Moon, "Controlling Chemical and Biological Weapons through World War II," in Richard Dean Burns, ed., *Encyclopedia of Arms Control and Disarmament* (New York: Scribner's, 1993), pp. 657–674.