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Biosecurity: A 21st Century Challenge

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Introduction

What physicists accomplished by unlocking the atom in the mid-20th century and engineers did by revolutionizing information at the end of that century, the life sciences are doing with molecular biology and genetics at the dawn of the 21st century.

Each great advance in technology, it seems, produces uniquely challenging consequences.

Today, biotechnology is yielding life-enhancing breakthroughs at a thrilling pace. Yet, an elite community of scientists attending to these advances is issuing stern warnings that these powerful new tools may also give rise to fiercely destructive forces. This life-giving science, they insist, must be secured from abuse. Thus far, those who might be expected to respond—authorities of government, private business or the academic community—have reacted sluggishly, if at all, foisting this security policy conundrum onto a very few in the science and policy communities who recognize the vast rewards and potential dangers inherent in today's life sciences.

History demonstrates that many advances in technology are adapted to warfare, bringing about new, more effective forms of weaponization. Advances in mechanized combat killed more people in the 20th century than died in all of history's earlier conflicts combined. With each iteration of technology, the tools of warfare become more accessible, not only to wealthy and powerful nations but also to the relatively unremarkable individual with sufficient access, a modicum of ability and, perhaps most important, determination. And there is reason to believe that the West's most determined enemies are in hot pursuit of these new opportunities.

"Today's world combines the growing access to biological materials and computer power with the anger and hatred it could take to use them as a weapon," said Sam Nunn, a former Carnegie Corporation of New York trustee and a global leader in the struggle to control weapons of mass destruction, in a speech in December 2004. He continued, "This potentially lethal combination creates an accelerating risk of catastrophic terrorism."

Vartan Gregorian, president of Carnegie Corporation, agrees that this is an area to which attention must be paid. He says, "Not only recent history but examples drawn from conflicts stretching back into time show us how quickly humanity can be overwhelmed by forces it wasn't watching for. In that connection, the development of biological weapons certainly represents a force we must watch for with great vigilance."

A June 1999 memo, retrieved from an al Qaeda computer after the fall of Afghanistan in November 2001, instructs that the means for building bioweapons capacity is to be found at western educational institutions, which "allow easy access to specialists." Other reports indicate the terrorist group's interest in obtaining toxins, specifically, anthrax. Official pronouncements assessing terrorist sophistication in bioweapons development run the gamut, from a "fairly rudimentary" facility in Kandahar, Afghanistan, to reports of an "extensive and well organized" program, formerly operated at several Afghani sites, "[t]wo of these sites contained commercial equipment and were operated by individuals with special training," whose "primary interest" was attempting to create "Agent X" —a reference to a so-called unconventional, man-made, designer bug.

Critics charge that there is entirely too much hype and too little evidence of a clear and present threat; some are particularly concerned with the tendency to take for granted that a disaster is just waiting to happen. They say the learning curve for producing a significant bioweapon is far more

complicated than is generally acknowledged. They claim the massive infusion of U.S. spending on "incident response," also known as "civilian biodefense" —rising from $410 million in FY01 to more than $7.65 billion in FY 05—might be better invested elsewhere, for example, in the battle against malaria, tuberculosis and AIDS, which collectively claim five million lives annually. They argue for a comprehensive, international approach to biosecurity.

The necessary alternative, they argue, is a course of action that addresses the underlying problems, not merely the threats.

"I want to change the boundary conditions to the problem, the environment in which the problem exists, not just say, 'it is inevitable that it will happen so here is what we will do.' I want to change the environment so that the problem itself takes a different form," says Matthew Meselson, a microbiologist who is the director, at Harvard University, of the Harvard Sussex Program on Chemical and Biological Warfare Armament and Arms Limitation. Meselson has been a leading biosecurity activist for more than 30 years.

The goal, as Meselson and others define it, is to manage problems that may enable the use of bioweapons. Thus, the thinking is to construct a security regime for biology. While the terminology of this realm is still in flux, there is some agreement that *biosecurity* can be viewed as a subset of *biosafety,* which encompasses the broad concept of practicing biological science in a safe environment. Put another way, *biosecurity* is about keeping the work safer and implies the prevention of the deliberate misuse of pathogens and toxins.

"Both biosafety and biosecurity require that scientists exercise their judgment—Is the project safe? What safety level should the experiment be performed at? Are we taking all the right safety/security precautions?—and it is important to inform that judgment with training," says Gigi Kwik Grönvall, an associate at the Center for Biosecurity and assistant professor of medicine at the University of Pittsburgh Medical Center (UPMC).

In any case, it stands to reason that securing biotechnology requires training to certain standards and establishing some verifiable form of oversight. But who decides? Academia? Industry? Government? The international community?

The United States has opted for a go-it-alone, domestic approach. In 2001, the U.S. blocked efforts to create enforcement provisions for the 1972 Biological Weapons Convention (BWC), signed by 151 nations, including the United States, which have agreed to ban—to forgo developing, creating or stockpiling—biological weapons. The U.S. position was that the proposed enforcement mechanism was too weak.

The United States has created a domestic regulatory environment for biosecurity overseen by the National Institutes of Health. Any facility—such as a university, and in some cases, private industry—receiving federal funds, must maintain a self-governing, peer-review panel to secure sensitive research and resolve ethical dilemmas, such as the appropriateness of publishing research findings that could be abused.

"It is entirely appropriate for the United States to develop a system to provide oversight of research activities domestically, but the effort will ultimately afford little protection if it is not adopted internationally," according to the non-partisan, National Academies' report entitled, *Biotechnology Research in an Era of Terrorism.* Better known as the Fink Report, after Gerald R. Fink of MIT who chaired the eighteen-member Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology that developed it, the report has set the benchmark—both within the U.S. and interna-

tionally—for biosecurity discussions since its release in January of 2004.

Biosecurity is, by its nature, an international problem, for neither the spread of disease nor the dissemination of scientific information respects geopolitical borders. The world is only as secure from the abuse of biotechnology as the weakest standards applied by any single nation.

"Without international consensus and consistent guidelines for overseeing research in advanced biotechnology, limitations of certain types of research (in the U.S.) would only impede the progress of biomedical research here and undermine our own national interests" to engage in work overseas, the Fink report concludes.

Increasingly, there is momentum toward treating biosecurity as a management problem, necessitating shared understanding by two divergent communities: biologists and policymakers.

"Any effort to ameliorate the problems posed by biological weapons requires … recognition that there is no solution to this problem: it requires ongoing and permanent management," declares the current, interim report of the international Weapons of Mass Destruction Commission (WMDC). Furthermore, the WMDC contends, "managing the biological problem requires a set of policies and commitments stretching from the individual to the international."

In this context, the fundamental approach adopted by Carnegie Corporation of New York focuses on the individual whose responsibility it is to inform the broader community of science and civilization. Therefore, the Corporation devotes much of its work in this area to convening and promoting influential partnerships in science and policymaking to enhance communications intended to resolve security dilemmas arising from biotechnology.

A Life Sciences Perspective

The Fink Report describes the problem in a nutshell: "Biotechnology represents a '*dual use*' dilemma in which the same technologies can be used legitimately for human betterment and misused for bioterrorism."

Put another way, every advance in biotechnology presents a double-edged sword.

For example, ongoing efforts to develop an aerosol measles vaccine promises relief to the developing world where infectious diseases are rampant and often fatal. (Measles kills at least a half-million children annually in the developing world.) Traditional treatments involving injections are logistical nightmares. An aerosol would be a vast improvement.

But once a microbe is aerosolizable, there is potential for misuse. A deadly organism could be added to or used in place of the original microbe and, employing that same technology, be disseminated not as a vaccine but a harmful organism.

That's "dual use."

Another case in point: the Pentagon's research arm, DARPA (Defense Advanced Research Projects Agency), is working to create what biologists are referring to as "the human immune system on a chip," which would permit scientists to conduct simulated human trials of new drugs without endangering human guinea pigs. The technology promises to substantially reduce the time it currently takes to bring a new drug to market, which is typically more than a decade. The Defense Science Board predicts that a breakthrough of this type could help streamline the "bug-to-drug" timeframe to 24 hours within the next 20 years.

However, the dual-use threat means that the same technology could also assist in the rapid development of a particularly nefarious toxin.

Perhaps the best known and most frequently

cited example of the dangers of dual use arose from research in Australia in the late 1990s, intended to create a viral contraceptive to curb a rampant rabbit and mouse population. During that research, scientists stumbled upon a way to supercharge mousepox, increasing its virulence and making it resistant to vaccines, causing fatalities in 60 percent of test cases. Fortunately, mousepox is harmless to humans. Unfortunately, if smallpox was substituted for mousepox, it could—*could*—create a strain of the disease without any known treatment, and double the normal fatality rate for smallpox in humans.

Ignore for the moment the fact that the only samples of smallpox virus in existence are as tightly controlled as highly enriched uranium: after the World Health Organization declared smallpox eradicated in 1980, the only remaining samples were secreted away at a U.S. lab in Atlanta and a Soviet lab in Koltsovo, Russia.

The significant issue facing the Australian researchers was what to do with their findings: publish the results or bury them. They hesitated. But ultimately, they shared their findings, publishing the results just two years after they first realized what they had produced. In part, their decision to publish was predicated on finding that others were working in the same area and it seemed reasonable to assume that it was only a matter of time before someone came upon the same findings. And, there was the need to set out some warning and create awareness so that countermeasures could be researched. Publication of the findings, however, created a firestorm of media reaction and wrenching soul searching for the life sciences.

Life scientists typically bridle at the suggestion of keeping research results secret, arguing that a greater good is almost always served by sharing results, regardless of whether those findings may be of use to an outlaw nation or terrorists.

"Biotechnology aims at improving medical and public health responses and thus saving lives; if you don't share information, the science slows down and people die daily," says Ronald Atlas, co-director of the Center for the Deterrence of Biowarfare and Bioterrorism at the University of Louisville, in Kentucky.

Atlas, an authority on bioethics who served on the Fink Committee, notes the slippery slope involved in defining information as "good," and therefore worthy of publication, versus "dangerous."

"You get into a debate about things of value versus dangers," he says. "You could go back to the invention of steel, which gave us skyscrapers and bridges but you have to balance that with the fact that the same material is used for making guns."

Still, in an age of terrorism, the dual-use issue demands that someone take responsibility for controlling knowledge that could cripple civilization.

The Fink Report's discussion of dual use and biosecurity comes down heavily in favor of a bottom-up approach, advocating self-governance by the life sciences community; perhaps not surprisingly, the panel was dominated by academicians whose own interests favor self-governance and a "publish-or-perish" approach to research findings.

The report found that the U.S. Patriot Act of 2001 and the Bioterrorism Preparedness Act of 2002 do a good job of addressing dual use by establishing a set of controls and regulations over federally funded biotechnology. Those laws, still being phased in, mandate a regulatory scheme that tracks the use of dangerous pathogens creating a database of labs working in sensitive areas.

"However," the Fink Report continues, "they do not currently address the potential for misuse of tools,

technology or knowledge … for offensive military or terrorist purposes. In addition, no national or international review body currently has the legal authority or self-governance responsibility to evaluate a proposed research activity prior to its conduct to determine whether the risks associated with the proposed research, and its potential for misuse, outweigh its potential benefits."

Continuing, the report urges the creation of "a comprehensive system, both nationally and internationally" to address those policy shortcomings. "Only a system of international guidelines and review will ultimately minimize the potential for the misuse of biotechnology," the report states. It also made seven recommendations for a more comprehensive biosecurity regime:

1. **Educating the Scientific Community**. Professional societies should create programs to educate scientists about the dual-use issue and their responsibilities to mitigate risks.
2. **Review Plans for Experiments.** The Department of Health and Human Services should establish stronger review processes for experiments representing potential misuse.
3. **Review at Publication Stage**. Scientists should review submissions for publication to determine the potential national security risks. "This part of the system," the report says, "should be based on the voluntary self-governance of the scientific community rather than formal regulation by government."
4. **Creation of a National Science Advisory Board for Biodefense (NSABB)**. Created by the Department of Health and Human Services, the board would be a vital forum for advice, guidance, oversight and review.
5. **Protection Against Misuse**. Permit the National Science Advisory Board for Biosecurity the authority to periodically review current laws regulating biological materials and personnel.
6. **Engage Life Sciences in Security**. Develop channels of sustained communications between security officials and the life sciences community.
7. **Harmonize International Oversight**. The scientific community, with the support of international organizations, should create an International Forum on Biosecurity to "harmonize national, regional and international measures," with those of the United States.

Responding to the Fink Report, the Department of Health and Human Services announced its intent, in March 2004, to create a 25-member National Science Advisory Board for Biosecurity, charged with duties that will include advising or providing guidance on:

- Strategies for local and federal biosecurity oversight for all federally funded or supported life sciences research.
- Development of guidelines for biosecurity oversight of life sciences research and providing ongoing evaluation and modification of these guidelines, as needed.
- Strategies to work with journal editors and other stakeholders to ensure the development of guidelines for the publication, public presentation and public communication of potentially sensitive life sciences research.
- Development of guidelines for mandatory programs for education and training in biosecurity issues for all life scientists and laboratory workers at federally funded institutions.
- Development of a code of conduct for life scientists and laboratory workers that can be adopted by federal agencies as well as professional orga-

nizations and institutions engaged in the performance of life sciences research domestically and internationally.

The NSABB, however, remains only a work in progress.

In a related development, in April 2005**,** after years of efforts, organizers launched the International Council for Life Sciences (ICLS), a private, membership-based organization, intended to identify and manage "biological risks" while facilitating a community partnership for "governments, international intergovernmental organizations and the life sciences community—private industry, academia, nonprofit laboratories and nongovernmental organizations."

The ICLS is the creation of two independent research groups, the Chemical and Biological Arms Control Institute (CBACI) and the International Institute for Strategic Studies-US (IISS-US), with the support of the Nuclear Threat Initiative.

The ICLS laid claim to serving as the international harmonizing influence described in the Fink Report.

Michael Moodie, president of CBACI, said the creation of the ICLS was modeled on the nuclear power industry's actions after the meltdown at the Chernobyl nuclear power plant in Ukraine, when an international consortium of power plant operators came together to adopt strict safety standards, intended to reassure a terrified public and, more importantly, stave off draconian government regulation of the industry.

However, Moodie sees the ICLS as engaging a much broader set of stakeholders in "managing the potential implications of rapidly spreading knowledge."

He says the goal of ICLS is to "create an environment where all the key players and all the key stakeholders are contributing partners to the management of risk …and that imposes a set of requirements on government and a wider array of players than traditionally has been the case," which includes private enterprise, academia, insurance companies, the media, the medical community and public interest organizations, to name a few.

A more traditional, top-down, management approach to biosecurity is advocated by John Steinbruner, director of the Center for International and Security Studies at the University of Maryland, who, in stark contrast to others, insists that the stakes are too high to have anything less than a mandated, legally binding international system of checks and balances scrutinizing the research and procedures of every facility involved in biotechnology. The goal should be "complete transparency" he says.

Presently, approximately 400 mostly academic institutions receiving grants from the National Institutes of Health (NIH) for recombinant DNA research must comply with federal oversight guidelines. Some corporate facilities voluntarily comply as a good-faith effort to observe a "gold standard for safety," according to NIH. Those guidelines mandate that each facility appoint and register an Institutional Biosafety Committee (IBC) —a panel of at least five members, at least two representing the local community and one from the lab in question—which must review and approve any biohazardous research at their facility. The IBC is overseen by a 21-member Recombinant DNA Advisory Committee (RAC), which is overseen by the Director of NIH; only the most sensitive projects require review by all three.

Steinbruner says that limiting oversight to those facilities funded by NIH is inadequate and, while the NIH procedures may provide a sufficient degree

of local safety, there is a need to create conforming international standards, "so that a proposal made in the U.S. would get the same treatment in Germany or Nigeria."

He envisions a four-tier system of oversight and, where appropriate, licensing on a local, national and international basis for clearances to conduct sensitive research or access sensitive information and dangerous materials.

However, any real movement toward a resolution is some time off, he says.

"The scientific community is in the embryonic stages of dealing with this," he explains. "And policymakers aren't going to deal with it until there is much more consensus than there is now."

An Event-Driven Society

We live in an event-driven society. Arguably, it's one of the failings of democracy. Dramatic shifts in public policy all too frequently require dramatic events to build a consensus of public opinion.

In some instances, policymakers have succeeded in making the case for change by clearly demonstrating a "clear and present danger."

The popular "clear and present danger" argument made with respect to biosecurity states: The only question regarding a mass-casualty bioweapon incident "is not *whether*, but *when*" it will occur—and the popular time frame ranges from as little as five years to no more than twenty years.

This expression of the biosecurity problem has established the clearest dividing line between factions to the debate.

First, those who embrace the "not *whether* but *when"* concept as inevitable, either by some failure in simple safety procedures or by malfeasance, argue that the necessary toxins are accessible (prairie dogs in the western U.S. carry plague, for example; other toxins can be purchased, some legally, others as stolen goods); the necessary laboratory tools are not extraordinarily sophisticated, and there may be millions of individuals with sufficient knowledge to create large quantities of virulent toxins.

"Only a thin wall of terrorist ignorance and inexperience now protects us," says Richard Danzig, a Fellow at the Center for Strategic and International Studies and author of a forthcoming Aspen Institute report, *Proliferation of Biological Weapons into Terrorist Hands*.

Thus, the reasoning goes, if it's only a matter of time, our nation's best course of action is "incident response," —preparing for the worst, creating surveillance systems to provide early detection and warning, manufacturing huge stockpiles of vaccines and antibiotics, training first responders, expanding hospital isolation wards and designing emergency quarantine plans.

Next, there are those who say that a devastating incident is *possible*, if we do not prevent it from happening. However, many leading activists take issue with a prescription focused solely on responding to a worst-case scenario. While conceding the potential for a crisis, they condemn doomsayers' conclusions as pointlessly alarming and dangerously defeatist. These activists insist that accepting the inevitability of this version of future events threatens fundamental tenets of civilization. If we do nothing to prevent biowarfare or bioterrorism, they say, those worst-case scenarios will most certainly come to pass and the consequences, no matter how they are managed—massive quarantines, curtailing food distribution, closing schools—are unacceptable outcomes for modern society.

The necessary alternative, they argue, is for a course of action that addresses the underlying prob-

lems, not merely the threats. They focus on preventive measures in addition to building response capacity—surveillance, detection and treatment. Those include:

- International security protocols—either in the form of self-governing, peer review regimes or as mandatory oversight imposed by international governance—to manage the knowledge necessary to develop and deploy biotechnology.
- Protocols to existing treaties—the 1925 Geneva Convention and 1972 Biological and Toxin Weapons Convention—that ban nations from creating biological weapons, but lack any effective enforcement mechanism.
- Education of life scientists in ethics and government policy, heightening awareness of their sensitive work and enabling them to advise policymakers.
- Establishing grants and other forms of support from the international scientific community for impoverished scientists, such as those in the former Soviet Union, whose skills and loyalties could be bought by the highest bidder.
- Monitoring pathogens, equipment and people with the skills necessary for creating bioweapons.

A third category involves those who firmly reject the "not whether but *when*" scenario as dangerously alarmist and unlikely in the extreme. They suggest that the argument is made without any credible, detailed threat analysis.

Milton Leitenberg, who holds a PhD in biochemistry and is a senior research fellow at the Center for International and Security Studies at the University of Maryland, most recently expressed his skepticism in an April 2005 paper entitled, *Assessing the Biological Weapons and Bioterrorism Threat.* He wrote:

> "For the past decade the risk and immanence of the use of biological agents by non-state actors/terrorist organizations—'bioterrorism'—has been systematically and deliberately exaggerated. It became more so after the combination of the 9/11/2001 events and the 10/11/2001 anthrax distribution that followed immediately afterwards. U.S. government officials have worked hard to spread their view to other countries, and an edifice of institutes, programs, conferences, and publicists has grown up to continue the exaggeration and scare-mongering. In the last year or two the drumbeat has picked up."
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> "Others see this as serving necessary preparation and even acknowledge the exaggeration but argue that it is necessary to obtain political action; that is, the expenditure of public funds for prevention and response programs. 'Bioterrorism' may come someday if societies survive all their other impending crises. However, the persistent exaggeration is not benign: it is almost certainly the single greatest factor in provoking interest in [bioweapons] among terrorist groups, to the degree that it currently exists at all, for example, in the al Qaeda organization."

Additionally, Leitenberg and others argue that some U.S. efforts at threat analysis have been misguided and potentially provocative. They are referring to programs such as one code named Clear Vision, a pre-9/11 exercise in which the CIA built and tested a replica of a Soviet bioweapon—a toxin bomb—which, according to published reports, was real in every respect except that it lacked a detonator. Even so, critics charge that the exercise was a violation of

the BWC, which could also encourage other nations to flaunt the treaty's prohibitions.

Similarly, these critics oppose "war games" or "table-top" exercises, which their organizers say are intended to heighten the understanding for policymakers, but critics condemn as simple fear mongering.

Perhaps the best known of these exercises, "Dark Winter," held in June 2001, and "Atlantic Storm," staged in January 2005, both sponsored by the Center for Strategic and International Studies and the Center for Biosecurity, were attacked for being premised on unrealistic scientific principles.

Indeed, these exercises are imprecise expressions of present dangers. They do not provide specific guidance for developing policy. And they are appallingly misleading, if taken as literal illustrations of the exact public policy actions required. However, as event simulations meant to inform policymakers, they have value in an event-driven society.

The Cultural Divide

There is a cultural divide separating those in government who make security policy from those in the life science community. It's a matter of historical experience. Councils of government have a history of experience with the physical sciences—building bridges, designing power grids, financing weapons research, etc.. The post-World-War-II industries that arose from the military-industrial complex of the 1940s, 1950s and 1960s—the airlines and nuclear power, for example—had a sensitivity to the national security implications of their work and readily adapted to government regulation. This was an experience unique to the post-World-War-II "brick and mortar" industries and government-financed facilities such as the Lawrence Livermore National Laboratory. However, until relatively recently, bioscience and national security rarely had reason to intersect.

"Unfortunately, while there have been recent discussions involving these communities, the relationship between them has been nearly non-existent," according to *Mapping the Global Future,* a report of the National Intelligence Council's 2020 Project, issued in December 2004.

The report followed several efforts by the national security community to find common ground with the bioscience community in 2002-2003.

At one of those sessions, a meeting sponsored by the Defense Department, officials were forced to stop midway into their briefing when they realized that only a few of the twenty-two bioscientists they invited to the session had sufficient security clearance to be shown the full briefing.

"That's when I started realizing that these two communities really don't relate to each other very much," says Joe Fitzgerald, a consultant to the Federation of American Scientists on Homeland Security and a former director of biosafety at the Department of Energy, where he worked for twenty years. "There are steps being taken by the government to engage with the [life sciences] community, but government officials are behaving as they would with the physics community, assuming certain things and acting in certain ways, not realizing that it's a completely different group."

For example, at another session, this one hosted by the National Science Federation on behalf of the CIA, several attendees noted the frustration of the intelligence community's representatives at being told that there are no "signatures" or "observables" that could be used to detect the presence of toxins. Rather than making the paradigm shift from nuclear science to molecular biology, CIA representatives apparently believed they would be able to create a device like a Geiger counter to reveal toxins.

Federal regulatory control over nuclear power during the Cold War remains the defining experience for much of national security. At the end of World War II, the federal government had built the wartime academic and industrial community that gave birth to the nuclear era, thus scientists and engineers reacted well to government efforts at securing the new technology. Even after the bomb-building technology leaked to the Soviets and others, an international chokehold on highly enriched uranium and plutonium limited membership in "the club." Later still, advances in missile technology limited those capable of exercising their nuclear will internationally.

A half-century later, government was slow to make the paradigm shift, when the cyber revolution took hold under extremely different conditions. The cyber security issue came about in the era immediately following the collapse of the "Soviet menace," rising amid a tide of post-Cold-War globalization, nurtured by a relatively small crowd of innovators who firmly rejected government's persistent old formula that it must "police" cyberspace. As modern society grew alarmingly reliant upon new cyber technologies—and therefore, deeply vulnerable—the privately created, privately owned and privately operated network of networks refused federal efforts to impose intrusive security over the Internet. A fairly ugly policy brawl dragged on through much of the 1990s, eventually reaching an uneasy détente under terms dictated largely by the private sector, an arrangement under which industry and governments share the management of risk, informing one another of threats, without the intrusive controls initially sought by law enforcement and national security.

Today, when another paradigm shift is needed for government to engage with the bioscience community to manage biosecurity, the Department of Homeland Security is still dominated by entrenched nuclear-era policymakers and scientists.

A collaboration involving the national security and bioscience research communities could be key to minimizing the challenges posed by proliferation of research findings that have bioterror and BW [bioweapon] applications," concluded the 2020 Project report. According to many experts, a promising means of establishing that collaboration is through education, both formal and informal. That may sound simplistic at first, but a "bottom-up" approach to problem solving is sometimes preferable to the "top-down" method.

Meselson makes the case for the bottom-up approach being effective, just as what he describes as "simple, good hygiene" serves as an effective solution to stopping the spread of disease.

Education of scientists and policymakers is key to "fostering the kind of culture of responsibility" needed to establish biosecurity, says Moodie of CBACI. That includes "inculcating this material into the curricula in graduate schools" for students of science and political science.

Frank von Hippel, a microbiologist from Princeton University, has suggested the need for "a career path in biopolicy, specifically, defense policy."

George Atkinson, Science and Technology Advisor to the Secretary of State, agrees that scientists need to have a direct role as policymakers.

"Two or three decades from now, you will find some very distinguished scientists at the table as leaders of the policy community," says Atkinson, who holds a PhD in chemistry. "The goal is to have scientists sitting at the table as negotiators, not sitting in the back, whispering in the ear of the negotiator."

The Federation of American Scientists (FAS) is developing curricula for graduate school programs, in-

troducing students to biosecurity issues, familiarizing them with the ethical standards, laws and international regulations that impact on research. The intent is to provide an understanding of when it is appropriate to publish and when it is not. One case study questions the work of a researcher at SUNY, Stony Brook, who synthesized poliovirus and was widely castigated in the media for publishing the results. Another case study examines the development of aerosolized toxins.

FAS plans to produce a white paper explaining how universities can establish their own centers for biosecurity research and policy. Carnegie Corporation is underwriting the FAS' efforts, which will lead to the establishment of such a center by 2009.

Another Corporation grant is supporting a somewhat less formal education environment. In August 2005, the first "class" of Jefferson Science Fellows will have completed their one-year in service at the State Department. The program, underwritten by Carnegie Corporation and the John D. and Catherine T. MacArthur Foundation, is a unique opportunity for policymakers working on global science issues to interact with career scientists. The five Fellows return to their positions at universities but will remain as consultants on a variety of short-term State Department projects for the next five years.

"The Jefferson program represents an important step toward allowing the scientists to be trusted by the policymakers," says Atkinson, noting the added value science can bring to diplomacy "We Americans do science and technology very well, and we … would be well served if the world saw science and technology as a hallmark of what American society provides."

Carnegie Corporation's role in biosecurity, which began in 2000 by supporting arms control efforts, has evolved. Among other facets of the bioweapons issue, the Corporation now seeks, through its grantmaking, to integrate bioscience and biotechnology expertise within national security by funding education programs that inform postgraduate biologists about the rigors of policymaking as well as introducing influential biologists into the policymaking realm.

Additionally, the Corporation continues to exercise its proven convening power. In the fall of 2004 it hosted a day-long session on biosecurity, bringing together its grantees working on the issue, leading research scientists, medical educators, biologists and policymakers focused on the need for building partnerships of science and policy in biosecurity. In reflecting on the meeting, Patricia Nicholas, the Corporation's International Peace and Security program associate responsible for the biological weapons work, said, "The predominant theme from those around the table, grantees and nongrantees alike, was that if the Corporation wants to strengthen the link between the bioscience and security communities, then the key element is to educate: educate the bioscience research community to recognize that some of its work—despite the potential for beneficial ends—may have security implications. And educate the security community that bioscience has a role to play in policymaking. This represents a wonderful opportunity for the Corporation, because it means that the foundation is occupying a niche that is at the heart of our mission."

In Conclusion

Matthew Meselson has been chewing on this problem as long as anyone—more than 40 years. He worked with President Richard Nixon to bring the United States into the BWC in 1975. Today, he is promoting the Harvard Sussex Convention, which he describes quaintly as: "Something my good friend Julian Robinson [Harvard Sussex director in England]

and I have contrived, a draft convention that would criminalize the use of biological or criminal weapons internationally."

The Harvard Sussex Convention would establish an international set of laws defining abuse of chemical or biological weapons as crimes against humanity and conferring "on national courts jurisdiction over individuals present in their national territory, regardless of their nationality or official position, who order, direct, or knowingly render substantial assistance to the use of biological or chemical weapons anywhere," according to the Harvard Sussex Program web site, http://www.sussex.ac.uk/Units/spru/hsp/.

What makes the Harvard Sussex proposal of particular interest is the logic with which it elegantly erases national borders in the interests of civilization. It also heralds the arrival of the biologist as policymaker, or at the very least, someone who can influence the policy debate, perhaps giving new meaning to the idea of self-governance.

"Some people say the ultimate catastrophe would be an event that killed a great many people and that certainly would be terrible," Meselson says. "But the ultimate tragedy would be if the use of biology for hostile purposes became assimilated into the practice of human beings" because "once this kind of warfare is begun there is a continuous, slow erosion of civilization."

Meselson may be the leading opponent to the mindset of "*when* not *whether,"* arguing that the long, historic view of securing civilization demands a summary rejection of the concept.

"The most important thing our species has achieved is civilization," says Meselson. "An awful lot of blood has been spilled to do that…. That's the thing that matters most. Because biologic warfare would mean an end to all that… Biological weapons have the ability to do great damage. For example, reducing crop yields, even slightly, or doing other things we cannot even imagine, can change the determination of a population. I know this sounds like it's very far off, and it is, but we're playing with fire."

Notes

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