Advances in biotechnology pose grave challenges to arms control for the coming decades. The increasing capabilities of the biological sciences and the global spread of the underlying technologies raise the prospect of misuse of these technologies by small groups or individuals with the necessary technical competence. The challenges lie both in the mismatch between the rapid pace of technological change and the comparative sluggishness of multilateral negotiation and ratification, as well as the questionable suitability of monitoring and inspections to a widely available, small-scale technology.

But this is not a counsel for despair. Rather, this international and human-security dilemma should serve as a spur to construct an appropriate web of prevention and response that allows the world to benefit from this technology while minimizing its dangers.

There is now a well-known list of recent experiments conducted by legitimate researchers that illustrate the dangers inherent in modern biological research and development. One such experiment was the synthesis of the polio virus at the State University of New York (SUNY) using readily purchased chemical supplies. Therefore, even if the World Health Organization succeeds in its important task of eradicating polio worldwide, the virus could still be reconstituted in laboratories throughout the world. Another experimental signpost was work at the Australian National University involving genetic modifications of the mousepox virus, a smallpox-analog virus that infects rodents. The researchers spliced into the mousepox DNA a gene for making a signaling protein that inhibits the mouse immune response to viruses. The unanticipated effect was to make the virus deadly both to mice that had previously been naturally immune and to those that had been vaccinated against mousepox. The experiment inadvertently pointed the way for attempts to make other viruses far more lethal.

These experiments illustrate the potential for misuse of work in molecular biology, immunology, and other forefront areas of research. Techniques developed, systems investigated, and manipulations performed for legitimate medical, food security, commercial, or other reasons may also show the way for extremely dangerous modifications that could cause harm to humans, animals, crops, or species in the natural world. Of course, a dual-use hazard has accompanied technology development since the invention of fire and the domestication of the horse. In the last century, the development of nuclear technology likewise married enormous power with enormous dual-use implications. What is different about biotechnology is its exponential growth, the speed of its spread around the globe, its potential for the creation of agents that could reproduce in the natural world, and its increasing availability and utility to small groups or even individuals.

Exponential Growth

The capabilities of biotechnology have increased at exponential rates in recent years, in some ways akin to the evolution of computer power. The capabilities of computers have exploded over the past several decades because the number of transistors per computer chip—a measure of how much computation can be done in a volume of a given size—has doubled every 18 months or so. This is the famous Moore’s Law, after the co-founder of Intel Corp. who first called attention to the phenomenon in 1965. Moore’s law is the reason that a single laptop today contains more computer power than was once found in entire halls of mainframe computers.

Although biotechnology’s growth began decades later than that of computers, what is striking is that
the rate of increase, as measured, say, by the time required to synthesize a DNA sequence of a certain length, is as fast or even faster than Moore’s law. Just as Moore’s law led to a transition in computing from extremely expensive industrial-scale machines to laptops, iPods, and microprocessors in toys, cars, and home appliances, so is biotechnological innovation moving us to a world where manipulations or synthesis of DNA will be increasingly available to small groups of the technically competent or even individual users, should they choose to make use of it.

There are ever more anecdotes illustrating the power and pace of the biotechnology explosion. The synthesis of the polio virus, completed in 2002, took the SUNY team three years of work. A year later, a research group at the Institute for Biological Energy Alternatives in Maryland manufactured a virus of comparable genomic length in just two weeks. In 2005 a group at the U.S. Armed Forces Institute of Pathology completed and published the determination of the genetic sequence of the 1918 human influenza virus that had killed tens of millions of people. Using this sequence, a research team from the Centers for Disease Control and Prevention and three other institutions recreated the complete 1918 virus and used it to infect mice in order to better understand what made the virus so deadly.

Other technologies have appeared almost out of nowhere, moving rapidly from fundamental research to applications. These include RNA interference, which allows researchers to turn off certain genes in humans or other organisms, and synthetic biology, a fledgling field recognized only since about 2002, intended to allow engineers to fabricate small “biological devices” and ultimately new types of microbes.

Between 1990 and 2000, the speed of DNA synthesis increased more than 500 times. Moreover, laboratory processes have become more automated and black-boxed so that less and less tacit knowledge is needed to employ the technologies. By contrast, multilateral arms control treaties can take a decade to negotiate and ratify; a proposed protocol to the Biological Weapons Convention (BWC) took most of the 1990s to develop, reach the stage of a bracketed text, and have a chairman’s text proposed for final discussion. In the end, no agreement was reached. The BWC protocol was not intended to deal with the biotechnology revolution; the comparison is simply to illustrate that the pace of technological change in some fields is outstripping that of the global political tools available for addressing the resulting implications.

The dilemma is being recognized internationally. Earlier this year, UN Secretary-General Kofi Annan called the use of biological weapons “the most important under-addressed threat relating to terrorism” and warned of the potential development of “designer diseases and pathogens.” He asserted that an approach is needed as ambitious as the one developed at the dawn of the nuclear age for harnessing nuclear power while minimizing the spread of nuclear weapons. Finding such an approach that makes sense and that does more good than harm is the biotechnological challenge to arms control for the coming decades.

Framing the Issue

Any effort to find solutions to the security dilemma posed by biotechnology should be informed by key features of the biological challenge. The problem requires urgent attention, but those urging action must avoid apocalyptic dramatization, which will attract interest initially but will risk undermining the credibility of the issue in the long term. Gregg Easterbrook has published a sarcastic and garishly illustrated piece titled “We’re All Gonna Die!” as a reminder that scientists can readily make long lists of possible disasters for civilization. The examples of dual-use biological research just mentioned, as well as a comprehensive recent U.S. National Academies of Sciences study of the issue, demonstrate that the problem is real, not hype, but care is required to maintain perspective and avoid stirring opposition to possible solutions when cooperation is badly needed. Besides biotechnology’s exponential growth, there are at least four key aspects of the issue.

Contrast With Infectious Disease

About 14 million people die annually from infectious diseases. Most of these deaths are in the developing world where infectious disease is the leading killer; in the developed world infectious disease typically ranks much lower, well behind heart disease and cancer. Five people died in the
2001 anthrax attacks in the United States. Any approach to the dual-use challenge that significantly curtails the use of biotechnology to counter disease runs the risk of being seen by much of the world as sacrificing actual Third World lives in the service of heading off hypothetical risks. An African meeting on these issues in October 2005 issued the Kampala Compact, which declared that although “the potential devastation caused by biological weapons would be catastrophic for Africa,” it is “illegitimate” to address biological weapons threats without addressing infectious disease and other key public health issues.[14]

**Few Actual Biological Attacks**

For all the attention paid to bioterrorism, there have been very few actual biological attacks by nonstate groups. Apart from the still mysterious 2001 anthrax attacks, there were the nonlethal food poisonings by followers of Bhagwan Shree Rajneesh in 1984 and the unsuccessful efforts by Aum Shinrikyo to attack Tokyo with anthrax in 1993. Beyond these, there is evidence that al Qaeda made use of one doctoral-level microbiologist and perhaps several with undergraduate degrees in a quest for biological weapons. It is difficult from the open literature to determine the level of sophistication of their program, but what is currently available suggests it may have been more aspirational than effective at the time al Qaeda was expelled from Afghanistan.[15]

The rarity of modern bioterrorist attacks emphasizes the importance of understanding why there have been so few, the extent to which this has been due to capabilities or motivations, and how we might work to preserve whatever inhibitions have been at play.[16] It is certainly true that modern travel will mean that a biological attack with a contagious agent could rapidly spread the resulting disease globally. Under what conditions this globalization of an epidemic would prove a deterrent to the use of contagious agents is unclear; an apocalyptic group such as Aum Shinrikyo might view global catastrophe as an incentive, whereas others might be reluctant to loose a plague that would boomerang against their own populations. The greatest damage might well be done in the developing world, regardless of where the initial target of the attack was located, because of the weak disease surveillance and response capacity of many developing countries.

It is striking to compare the focus on capabilities in many threat assessments with the tenor of one of the most successful threat assessments in U.S. history, that of George Kennan’s famous “X” article in Foreign Affairs in 1947.[17] Kennan’s analysis was a keystone to the establishment of the successful decades-long Cold War policy of containment of the Soviet Union, yet in re-reading that piece today, one is struck by how little of it addresses Soviet capabilities. Instead, nearly all of it concerns Soviet motives and intentions, informed by a deep knowledge of Russian and Soviet history and culture.[18] Similar sophistication must be brought to the biological threat posed by modern terrorist groups.

**The WMD Continuum**

In 1948 the Commission for Conventional Armaments of the UN Security Council defined “weapons of mass destruction” (WMD) to mean “atomic explosive weapons, radio-active material weapons, lethal chemical and biological weapons, and any weapons developed in the future which have characteristics comparable in destructive effect to those of the atomic bomb.”[19] This definition has the great virtue of specificity, in contrast to the loose way in which “weapons of mass destruction” and “WMD” are often used today. However, few now would want to include radiological weapons under the WMD label, and lumping biological weapons together with nuclear weapons is greatly misleading.

The strengthened monitoring and inspection regime implemented by the International Atomic Energy Agency in the nuclear realm can be reasonably effective because of the significant industrial bottlenecks (barring nuclear theft) through which any would-be nuclear weapons program has to pass: uranium conversion and enrichment or plutonium production and reprocessing. The weaponization of biological agents presents far less severe bottlenecks. The trajectory of advances in biotechnology will only reinforce these differences.

There is an argument among some nuclear experts that tacit knowledge, the real-world engineering experience of actually having worked with nuclear weapons design and explosive materials, is a
tremendous asset that mere blueprints or articles cannot convey. However true this claim might be for nuclear weapons technology, the thrust of biotechnological development is to make powerful applications increasingly black-boxed so that key procedures are available to be used by a broad audience. Undergraduates at a ten-week Synthetic Biology Jamboree in 2004 made use of “BioBricks” from an MIT database for students and, in the words of one senior observer, “did world-class work, yet their level of training was embryonic.”

This is not to say that weaponizing biological agents—going from the laboratory organism to a treatment ready to be sprayed or otherwise spread—is not challenging. In fact, Aum Shinrikyo, despite substantial financial resources, ran into trouble in this step, among others. Yet, if the terrorist group’s approach were to create a contagious agent such as smallpox or influenza, sophisticated spray preparations might not be necessary.

**Globalization Requires Global Response**

The biotechnology explosion is being driven by academic, private, and government research. The allure of biotechnology for public health, food security, and commercial applications is so great that its globalization is unstoppable. Singapore is establishing biotechnology as the “fourth pillar” of its economy; China’s Office of Genetic Engineering Safety Administration approved more than 250 genetically modified plants, animals, and microorganisms for field trials between 1996 and 2000; India claims 96 biotechnology companies; Mexico has established a new Institute of Genomic Medicine; the Pakistani Atomic Energy Commission has committed itself to training scientists from Muslim countries in biotechnology; South Africa is working to develop a national biotechnology sector; Nigeria is considering a $5 billion endowment for science and technology, with agricultural biotechnology a major focus; and the list goes on.

To be effective, any attempt to address the dual-use biotechnology challenge must be global in scope and therefore must find common ground among the developed and developing world on the issue. There is simply no way to duck a global approach to this problem, and the fact that many contagious organisms have incubation times longer than international flight times means that isolation is an insufficient strategy.

The nuclear Nonproliferation Treaty establishes a bargain between the nuclear-weapon states and the non-nuclear-weapon states. Under Article IV, the non-nuclear-weapon states have an “inalienable right” to nuclear energy in exchange for living up to their obligation not to pursue nuclear weapons. The dual-use biology dilemma should not be understood as requiring an analogous bargain. Although the BWC’s Article X calls for the sharing of biological science, the convention is an arms control treaty, not a nonproliferation treaty: all signatories are banned from the acquisition of biological weapons. Similarly, all countries have a stake in preventing and fighting pandemic diseases, whether due to natural emergence or laboratory creation. The developing world may have the most to gain from these technologies and therefore the most to lose if misuse or inadvertence leads to biological accidents that then curtail their use worldwide.

**Five Categories of Risk**

One reason that solutions to the biotechnology misuse dilemma are so difficult is that any proposed response must be attentive to at least five categories of risk. These are naturally occurring diseases; illicit state weapons programs; nonstate actors; hackers; and laboratory accidents or other inadvertent release of disease agents. Particular measures may well address only one or two of these concerns, but they must be judged according to their impact, positive and negative, across the board. This kind of overall strategic assessment is largely missing.

Nor should a measure’s failure to address all aspects of the biological challenge necessarily be held against it. For example, the BWC is primarily an instrument for addressing state programs. The likelihood that inspections will not be a successful strategy against small-scale laboratory genetic engineering does not negate the value of transparency and inspections for the “high end” of large-scale production programs. Attention to preventing the misuse of biotechnology should not compromise the continuing need to avoid a state-based biological arms race. Similarly, so-called science-based threat assessment that explores novel pathogens to determine potential terrorist or
state threats must be assessed strategically to weigh defense advantages against dangers of feeding a perception among other governments that something resembling an offensive program is underway, thereby risking fueling the state-program threat even while preparing for other levels of threat.

Within these risk categories, there are important further distinctions. The nonstate actor category, for example, should really be divided into substate actors and nonstate actors. The latter, such as Aum Shinrikyo, receive no state support, in contrast with the former. “Hackers” is used by analogy to computer hackers that launch cyberattacks, for example, by releasing “worms” or viruses over the internet. Bio-hackers could be included in nonstate actors but are separated here to emphasize the possibility that, were dangerous biological manipulations to become sufficiently black-boxed, then careless, mischievous, or hateful individuals might individually pose a substantial risk.

We may not yet have entered a realm where the ability of individuals to do highly consequential biological hacking is widespread. Biological hackers at this point would still need to be sophisticated scientists. In coming years, however, we must worry not only about the rare “evil genius” but also about the intellectual hangers-on. The analogy here is to “script kiddies” in the cyber realm, those who are insufficiently knowledgeable or motivated to create their own sophisticated computer viruses but who make use of online postings of virus computer scripts and then unleash these derivative creations.[24] In the biological case, as the technologies permit increasing ease of use, hackers or nonstate groups will not need to conduct their own sophisticated biological research programs. They will simply have to follow, perhaps with modifications, the steps published by legitimate researchers.

**Addressing the Threat**

Is it possible to fashion an effective international control regime in the face of exponentially expanding biotechnology? The answer to this question carries important implications for our biological future and also for how the world will cope with other technologies, such as nanotechnology, that may pose similar dilemmas further down the road.

The good news is that there is tremendous ferment now with respect to this question. Scientists, lawyers, policy analysts, scientific societies, international nongovernmental organizations (NGOs), and the UN secretary-general have all weighed in with thoughts on the issue. It would be impossible to survey comprehensively this entire landscape of remarks and proposals, but it will be useful to highlight some of the main threads of the discussion, their weaknesses, and possible paths forward.

**An Endless Arms Race?**

If an effective global system for security in the face of biotechnology cannot be put in place, the world could enter a kind of endless offensive-defensive arms race, where bad actors, not just state programs, endeavor to engineer around new antibiotics, antivirals, vaccines, or other defenses against disease-causing agents. The arms race metaphor should be used with caution because, unlike the Cold War arms race, the primary driver for the biological arms race is the ongoing advance of biological research. The hope would be that the defenses arrayed against the rare bad actor by the vastly larger biomedical community would prove sufficient. Nevertheless, although the resource advantage will lie overwhelmingly with the defense, defensive measures also require a series of steps—for example, drug development and distribution—that the offense need not master. The words of the Irish Republican Army after it just missed assassinating the British cabinet in the 1984 Brighton bombing should be recalled: “Today we were unlucky, but remember we have only to be lucky once—you will have to be lucky always.”[25] Rather than concede that this grim and disheartening view of the human future is what biotechnology holds for us, the scientific and arms control communities should try to do better.

**Formal Treaties**

The cornerstones of efforts to control the misuse of biology are the 1925 Geneva Protocol prohibiting the use of “bacteriological methods” of warfare, and the 1972 BWC, which prohibits the development, production, stockpiling, or other acquisition of biological agents for nonpeaceful
purposes. The BWC also calls on states to prohibit such acquisition anywhere within territory under their control so that signatories have an obligation to prevent the offensive misuse of biology. Perhaps a major contribution of the BWC besides setting a global norm against biological weapons is its potential for increasing international transparency and decreasing the mistrust that could drive new state-sponsored weapons programs.

Although a verification protocol even for the largest production facilities is not now a realistic possibility, other mechanisms based on the BWC, in particular, mutual declarations and other confidence-building measures (CBMs), would further transparency and should be strengthened.[26] Efforts to maintain transparency between states will be increasingly important if biodefense research continues to expand with an eye to the terrorist threat.

Other Current Multilateral Approaches

There are multilateral approaches outside the BWC process. Most striking among these is UN Security Council Resolution 1540, by which the Security Council required all UN member states to develop and maintain controls over biological weapons materials and their export. It is too soon to be sure of the outcome of this extraordinary experiment in Security Council lawmaking, but it is important that Resolution 1540 not come to be seen as just a hollow set of aspirations. The Australia Group suppliers’ regime and the Proliferation Security Initiative (PSI) are further, more specialized examples of multilateral (but far from global) approaches to biological security. To interdict illicit biological shipments, however, PSI members would need precise intelligence.

Disease Surveillance and Response

Over the past several decades, the world has faced annually a newly emerging disease. Severe Acute Respiratory Syndrome (SARS) spread around the world in 2003 but was nevertheless contained despite its novelty and an absence of vaccines or antiviral drugs targeted against it. This emphasizes the great importance of the early recognition of and response to disease outbreaks, whether natural or human engineered. The World Health Organization (WHO) recognizes that its global disease surveillance systems, including its Global Outbreak Alert and Response Network, will be at the forefront of detection and response either to human-caused or natural disease outbreaks.[27]

Despite WHO efforts within its limited budget, there remains great scope for improving international disease surveillance and response. Because flight travel times to the United States are shorter than many disease incubation times, it is strongly in the self interest of the United States to buttress disease surveillance overseas, even apart from humanitarian reasons for doing so.

Yet, the United States has failed repeatedly to act. The Global Pathogen Surveillance Act has been introduced in Congress in 2002, 2003, and 2005, with similar language in the Foreign Assistance Authorization Act in 2004, 2005, and 2006. The current bill authorizes $35 million to be spent to improve capacity for disease surveillance and response in developing countries, through training, improvements in communications and public health laboratory equipment, and the deployment of U.S. health professionals. It is sponsored by Senate Majority Leader Bill Frist (R-Tenn.) and supported by Secretary of State Condoleezza Rice. Despite some success in the Senate, the bill has never passed the House.

Facing a world where novel microorganisms can emerge or be invented, there should be a strong incentive to budget tens of millions of dollars to improve and sustain international disease surveillance and response. Yet, over and over, it seems imagination stops at the border. Although atmospheric sampling within our cities and buildings may prove a powerful tool, recognizing and shutting down disease outbreaks overseas must be a high priority. The failure to pass, then adequately fund the Global Pathogen Surveillance Act is an extraordinary ongoing failure of U.S. national security policy.

Formal International Oversight of Research

The National Research Council has recommended a variety of oversight mechanisms for research
conducted with federal research grants.[28] John Steinbruner and his colleagues at the Center for International and Security Studies at Maryland (CISSM) have proposed a global system of internationally agreed rules for the oversight of potentially high-consequence pathogens research.[29] Of course, devoted terrorists would not likely be captured by such a system. Most nonstate groups are unlikely to conduct forefront research, but they might attempt to implement discoveries and techniques reported in the scientific literature. By overseeing certain high-consequence research and its publication, we might therefore head off some of the worst misuse. The WHO’s international advisory committee that oversees smallpox research provides a limited model of what oversight of the highest consequence biological research might look like. It is important that that committee demonstrate that such bodies are capable of real oversight.

The CISSM oversight system would require an International Pathogens Research Authority with an appropriate administrative structure and legal foundation to set requirements for its states-parties. It is unlikely that such a system could be negotiated and ratified at the present time, although perceptions of what is possible could change rapidly subsequent to a first human-engineered major pandemic.

Yet, careful thinking is better done before an attack. Other international approaches to provide some level of oversight have also been envisioned, including the creation of additional UN bodies or the establishment of an International Biotechnology Agency (IBTA). An IBTA could be established in a modular way, with modest initial goals, such as helping BWC states-parties meet their CBM requirements and fostering best practices in laboratory safety. However, even establishing such a limited body might look too much like an effort to revive some of the BWC protocol and may not be politically achievable at this time.

“Soft” Oversight

At the other end of the spectrum from the CISSM oversight scheme are efforts at what might be called “soft” oversight of potentially hazardous research. Perhaps most common among these are efforts to promulgate codes of ethics, or the more demanding codes of conduct or codes of practice, for scientists working in the relevant fields. Many national and international groups have made efforts in this direction.[30] The issue was also the focus of the 2005 BWC intercessional meeting. Such codes, coupled with education about the prospects for the misuse of scientific research and the national and international legal framework, would help give the scientific community a better capacity to police itself, a kind of “societal verification.” A National Academy panel has gone further, recommending establishing a global internet-linked network of informed scientists “who have the capacity to recognize when knowledge or technology is being used inappropriately.”[31] The scientific community would conduct its own self-surveillance and initial intervention to prevent malevolent behavior within its ranks.

A more specific kind of community surveillance has been proposed by the participants in the Second International Meeting on Synthetic Biology held in Berkeley, California, in May 2006. They note that DNA synthesis is one obvious pathway toward the creation of hazardous biological systems, but most DNA synthesis companies do not systematically check their orders to ensure that they are not synthesizing DNA for human disease organisms or other hazards. Those that do such screening use existing software tools that are unable to identify novel hazards and that have a high false-alarm rate. The participants called for all companies to screen their synthesis orders, including customer validation, and created a working group to create better software screening tools.[32]

Governance Without Treaties

There is a growing body of international relations literature concerned with the mismatch between the importance of global problems and the absence of international mechanisms to address them in a timely and effective way.[33] The World Bank’s J. F. Rischard advocates the creation of “global issues networks” that bring together representatives of governments, NGOs, and business for “rapid norm production and rapid activation of reputational effects.” The networks would quickly reach a rough consensus and then pressure states, through rating systems and naming and shaming, into performing better on the issue in question. The objective is to effect change within years rather than the longer multilateral treaty and ratification process.
How such an approach might work in the biotechnology realm might be seen by analogy to concrete examples from an altogether different field, that of human rights and transnational corporations.[34] The UN Global Compact is the world’s largest corporate social-responsibility initiative, with more than 2,300 participating companies. These companies publicly advocate the compact and its 10 principles in the areas of human rights, labor, environment, and anti-corruption and share best practices.[35] There are other, overlapping initiatives including the Business Leaders Initiative on Human Rights.[36]

In the absence of an international organization established by treaty to regulate biotechnology research, an initiative analogous to these efforts might begin to fill the gap. As one concrete example, Harvard biologist George Church suggested that all new DNA synthesis machines manufactured be licensed, tagged with electronic locators, and programmed to forbid the synthesis of dangerous DNA sequences.[37] An initiative analogous to the UN Global Compact could, with the support of governments and civil society, put strong pressure on the still-small number of companies manufacturing DNA synthesis machines to adhere to such principles on the grounds of global security. Broader principles to which all member companies would adhere could be explored, as could expansion to academic, governmental, and other biological research entities. The International Council for the Life Sciences is one newly formed membership-based organization that is beginning to assume this role.

**Reasons for Optimism**

The biological challenge differs greatly from the nuclear challenge and is unprecedented with respect to the power it will place in the hands of small groups of the technically competent. The pace of technological advance is daunting and risks outstripping the pace of political response, but there are reasons for optimism. The biological science community has a strong tradition of recognizing the potential for misuse of their work and calling for self-regulation.

Whereas the atomic scientists led by Leo Szilard failed in the 1930s to impose self-censorship in the publication of research in nuclear fission, the biologists succeeded in the early 1970s to restrict their own research in recombinant DNA, the predecessor of today’s far more powerful genetic engineering techniques. One reason for the biologists’ comparative success was that from the outset they enlisted support from prestigious scientific academies. This continues to provide a powerful tool.

The greater challenge is for the policy world. Neither Cold War arms control nor nonproliferation treaties provide good models for how to cope with the nonstate aspects of the biotechnology dilemma. It is unclear whether the international system will be nimble enough to respond effectively. If it cannot, we will simply have to cope with, rather than shape, our biological future. Before we accept that outcome, it is time for the creative exploration of rapid and effective international means for addressing the worst dangers.

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**ENDNOTES**

1. For one such list, inevitably already outdated, see Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology, *Biotechnology Research in an Age of Terrorism* (Washington, DC: National Academies Press, 2004), pp. 24-29.


18. This point is made by the Princeton Project on National Security Working Group on Relative Threat Assessment.


21. Registry of Standard Biological Parts, MIT.


28. Biotechnology Research in an Age of Terrorism.


35. UN Global Compact, found at http://www.unglobalcompact.org.


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