A TALE OF TWO STUDIES

Ethics, Bioterrorism, and the Censorship of Science

by MICHAEL J. SELGELID

Some scientific research should not be published. The risks to national security and public health override the social benefits of disseminating scientific results openly. Unfortunately, scientists themselves are not in a position to know which studies to withhold from public view, as the National Research Council has proposed. Yet neither can government alone be trusted to balance the competing interests at stake.

"How and why is it that I do not describe my method for remaining underwater and how long I can remain there without coming up for air? I do not wish to divulge or publish this because of the evil nature of men, who might use it for murder on the sea-bed." [1]

—*Leonardo Da Vinci*

Heightened concerns about bioterrorism and new scientific developments in genetics have prompted a debate about whether scientific discoveries that might facilitate bioweapons development should be published, or whether publication of those discoveries should be suppressed. Much of this debate has focused on two particular studies. In the first, Australian researchers found that a genetically engineered strain of mousepox killed mice that would have been resistant (because of natural immunity or vaccination) to ordinary strains of mousepox. Some fear the same technique might be used to produce vaccine-resistant smallpox. In the second study, American scientists manufactured a polio genome from scratch by stringing together commercially available strands of DNA in accordance with the map of the RNA polio genome, which has been published on the Internet. The addition of protein created a "live" virus that paralyzed mice. The concern here is that similar techniques might be used to produce other dangerous pathogens such as smallpox. Critics complain that publishing studies like these both alerts potential bioterrorists to possible biological weapons and actually gives them explicit instructions to produce them.

In this article I review these two cases and the debate surrounding them. The censorship of science

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would be worrisome. Scientific freedom and freedom of speech argue against it. In addition, the same discoveries that may be used to create weapons can often have important societal benefits. For example, the mousepox and polio studies may advance medical science and biodefense preparation. However, I believe that there are at least imaginable cases where censorship would be justified. The important question, then, is what the censorship process should be. Because scientists are usually not security experts, and because they usually lack classified information required to assess the publication risks in cases like the mousepox study, we cannot rely on the scientific community's voluntary self-governance, as the United States National Research Council (NRC) proposes we do.

The Dual-Use Dilemma

Scientists commonly believe that knowledge is good in itself[2] and that both freedom of inquiry and the free sharing of information are essential to the purity and progress of science. Robert Oppenheimer expressed such views when discussing his work on atomic weapons:

> If you are a scientist you believe that it is good to find out how the world works; that it is good to find out what the realities are; that it is good to turn over to mankind at large the greatest possible power to control the world. . . . It is not possible to be a scientist unless you believe that it is good to learn. . . . It is not possible to be a scientist unless you think that it is of the highest value to share your knowledge, to share it with everyone that is interested. It is not possible to be a scientist unless you believe that the knowledge . . . and the power that this gives, is a thing which is of intrinsic value to humanity, and that you are using it to help in the spread of knowledge, and are willing to take the consequences.[3]

"Secrecy," on the other hand, according to Oppenheimer, "strikes at the very root of what science is, and what science is for."[4]

Similar sentiments—along with the admission that knowledge can be used for evil purposes as well as good—are expressed by physicist Richard Feynman, who was also involved with nuclear weapons development:

> Once in Hawaii I was taken to see a Buddhist temple. In the temple a man said, "I am going to tell you something that you will never forget." And then he said "To every man is given the key to the gates of heaven. The same key opens the gate of hell."
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> And so it is with science. In a way it is a key to the gates of heaven, and the same key opens the gate of hell, and we do not have any instructions as to which is which gate. Shall we throw away the key and never have a way to enter the gates of heaven? Or shall we struggle with the problem of which is the best way to use the key? I think we cannot deny the value of the key to the gates of heaven.[5]

This illustrates what is now commonly known as the "dual-use dilemma." Given that the same scientific knowledge that can benefit humanity can also be used to harm it, how should we control the generation and dissemination of such knowledge?

The dual-use dilemma is not altogether new. Early in the twentieth century, nuclear physicists recognized that discoveries like atomic fission and the chain reaction might benefit humanity by providing a new source of energy; but they also saw the potential for these discoveries to facilitate creation of monstrously devastating weapons. When he discovered the nuclear chain reaction and recognized its implications for weapons-making, Leo Szilard—who later went on to work for the Manhattan Project, which gave birth to the first atomic bombs—initially argued that his discovery should be kept secret. He tried to convince colleagues that dangerous discoveries like this should be censored, but the debate came to an end when a similar discovery was made and published in France. Given the regrettable history that unfolded—the bombings of Hiroshima and Nagasaki and the nuclear arms race following World War II—the censorship debate initiated by Szilard was obviously important.

Ethics and Genetics Revisited

Central to current concerns about bioterrorism is the increasing recognition that advances in biology—and genetics in particular—may facilitate development of a new generation of biological weapons. The power of genetics is often compared to the power of nuclear physics. Given how frequently funding for research on the ethical, legal, and social implications of genetics has been justified by a need for more ethical consideration than atomic physics received in the early days, it is ironic that issues surrounding the weapons implications of genetics have not been discussed more in bioethics. While initial discourse on genetics largely focused on the worry that dangerous material might result from recombinant DNA research and escape into the environment, more recent discussion has predominantly concerned issues of genetic testing, genetic therapy, discrimination, selective reproduction, enhancement, cloning, stem cell research, DNA fingerprinting, and the patenting of genetic sequences.

Meanwhile, biological weapons development may turn out to be the most serious consequence of the genetic revolution.[6] To appreciate this point, briefly consider this passage from an unclassified CIA document titled "The Darker Bioweapons Future":

> A panel of life sciences experts convened for the Strategic Assessments Group by the National

> Academy of Sciences concluded that advances in biotechnology . . . have the potential to create a much more dangerous biological warfare (BW) threat. The panel noted [that t]he effects of some of these [genetically] engineered biological agents could be worse than any disease known to man.[7]

This is no small claim—and it originates from eminent scientists rather than the CIA itself.

There are a number of reasons why scientists and security experts take seriously the threat that terrorists might use biological weapons. One is the fact that—with regard to the expertise, equipment, and materials required—the manufacture of biological weapons is relatively easy and inexpensive, especially when compared with nuclear weapons. Recognition of this was a primary motivation behind the 1972 Biological Weapons Convention, the idea being that an arms race in biological weapons would be particularly bad.[8] Another reason is that the knowledge required to produce biological weapons is—and is increasingly becoming—widespread. In comparison with nuclear physics—an area of knowledge that involves a long history of secrecy, and where discoveries with weapons implications are "born classified"—information sharing in the life sciences has traditionally been completely open.[9] It is no small irony that wide dissemination of information has prevailed in the context of biological weapons while secrecy has prevailed in the context of nuclear weapons. Given that biological weapons are so much easier to make than nuclear weapons, one might think that censorship is more important in the former context than the latter.

A Tale of Two Studies

The question of whether to restrict dissemination of life sciences information with weapons implications has thus become prominent in debates about biosecurity. Much of the debate has focused on two studies in particular. The first was conducted by microbiologists Ron Jackson and colleagues in Canberra, Australia. In experiments aimed at developing ways to induce mouse infertility as a means of pest control, they used straightforward genetic engineering techniques to insert the IL-4 (interleukin) gene into the virus that causes mousepox, a disease closely related to smallpox. To their surprise, they found that they had accidentally produced a superstrain of mousepox in the process. The resulting virus killed both mice that were naturally resistant to mousepox and mice that had been vaccinated against it.

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They published their findings, along with a description of materials and methods, in the *Journal of Virology* in 2001.[10] Their results have since been replicated, and methods have been improved to produce even deadlier strains of mousepox and rabbitpox. In October 2003, *New Scientist* reported that the U.S. government produced a strain of mousepox that "kills mice even if they have been given antiretroviral drugs as well as vaccine that would normally protect them" and that "[t]he cowpox virus, which infects a range of animals including humans, has been genetically altered in a similar way."[11]

In the second study—sponsored, ironically, by the U.S. Department of Defense—American scientists Jeronimo Cello and colleagues at the State University of New York at Stony Brook synthesized a polio genome from scratch by stringing together commercially available strands of DNA purchased over the Internet in accordance with the map of the RNA polio genome, which is published on the Internet. The addition of protein resulted in a "live" polio virus that paralyzed mice. This study was published in *Science* in 2002, and the article again included description of materials and methods.[12] Upon publication the scientists involved said they "made the virus to send a warning that terrorists might be able to make biological weapons without obtaining a natural virus."[13]

Perils of Publication

Critics complain that neither of these two studies should have been published. They worry that publication of studies such as these both alerts terrorists and "rogue" nations to possible ways of making biological weapons and provides them with explicit instructions for doing so. At the very least, they claim, the materials and methods sections should have been (at least partially) omitted from the published articles to address the second concern.

Both of these studies have implications for smallpox in particular. Though the World Health Organization declared it eradicated in 1980, smallpox usually tops lists of feared biological weapon agents. The fact that routine vaccination against smallpox ended worldwide when eradication was achieved means that the world population is now highly susceptible to the disease, which is believed to have killed more people than any other infectious disease in history, and perhaps three times more people in the twentieth century than were killed by all the wars of that period.[14] Smallpox is highly contagious and kills a third of its victims. There is no known treatment for the disease (except for the vaccine, which works as a prophylactic). Modeling has shown that a smallpox attack could cause as much destruction as a series of nuclear attacks.

The obvious concern about the polio publication is that methods similar to those employed in the study may allow bioweaponeers to manufacture pathogens to which they would not otherwise have access. Smallpox falls within this category—officially, anyway. When the disease was declared eradicated, all of the world's remaining samples of the smallpox virus, which has no nonhuman hosts, were supposed to have been either destroyed or sent to one of two high security facilities: the U.S. Centers for Disease Control and Prevention in Atlanta, or the Ivanovsky Institute of Virology in Moscow.[15]

> Many in the scientific community believe that the benefits of these two publications outweigh the risks. First, they argue, publication is important to inform the scientific community about new kinds of threats revealed.

There is perhaps reason to doubt that the polio methodology would enable the synthesis of smallpox, whose genome is also published on the Internet. This is largely because the smallpox genome is so much larger. While the genome of polio contains only seventy-five hundred base pairs, the genome of smallpox contains almost two hundred thousand.[16] Before taking too much comfort in this difference, however, we should note how quickly technology has progressed in this area. Though it took the SUNY scientists several years to synthesize the polio virus, just one year later Craig Venter and colleagues used a newer, faster technique to synthesize the genome of a bacteriophage containing six thousand base pairs in a fortnight.[17] Venter "is currently working on making a bacterium Mycoplasma genitalium from scratch which has a genome around twice as large as smallpox."[18] The 1918 flu, which killed twenty to one hundred million people, was also reconstructed in 2005 using similar methods of synthetic biology.[19]

The primary concern about the mousepox study is that it might be possible to produce vaccine-resistant smallpox via the very same methods used with mousepox, given that the two viruses are so closely related. The genetic engineering techniques used in the mousepox study are routinely described in microbiology textbooks. The procedure does not require expertise beyond that found in talented graduate students, nor are extraordinary laboratory facilities required.

Because no treatment exists for smallpox, a vaccine-resistant strain would make a daunting weapon to say the least. In addition to scientific uncertainty about whether inserting the IL-4 gene into the smallpox genome would actually result in vaccine-resistant smallpox, however, the significance of this threat depends on the likelihood that would-be bioterrorists have or might obtain access to the smallpox virus. One must have the smallpox virus in hand in order to apply the mousepox technique to it.

As I stated above, all samples of the smallpox virus are supposed to be stored in only two secure facilities worldwide. A legitimate fear, however, is that Soviet supplies of smallpox were not well controlled. Defectors from the enormous Soviet biological weapons program, called *Biopreparat*, confess that the Soviet Union manufactured tens of tons of smallpox for weapons purposes right until its collapse in the early 1990s.[20] The whereabouts of most of the sixty thousand scientists who worked in this program are now unknown, and destruction of Soviet smallpox weapons stocks has never been verified. Considering the size of microbes compared with nuclear warheads, proliferation is an especially serious concern in the context of biological weapons. That the U.S. government takes the smallpox threat seriously is revealed by its post-September 11th stockpiling of smallpox vaccine, its policy of vaccinating military personnel against smallpox coercively, and its (admittedly failed) attempt to vaccinate health care workers against smallpox on a voluntary basis.[21]

Why Publication Is Important

Despite the undeniable dangers associated with publishing the mousepox and polio studies, the editors and authors involved (along with many others in the scientific community) firmly believe that the benefits of those two publications outweigh the risks. On the one hand, they argue, publication is important to inform the scientific community about new kinds of threats revealed. Such awareness, they claim, is needed for biodefense preparations. The scientific community must understand the real threats before they can develop technologies to defend against them.

These studies and others like them may also fuel important medical breakthroughs in the fight against infectious disease. The dual-use dilemma is commonplace in science, and this is especially true in the life sciences. Discoveries about how microbes penetrate or fail to penetrate immune systems, how drugs kill microbes, how resistant microbes evade drugs, how vaccines work against particular pathogens, how genes build pathogens, and so on, can be used for both good and bad purposes. This kind of knowledge can be used to advance medicine, but it can also facilitate biological weapons-making. The most recent examples of this quandary arose in October 2005 with the publication of the complete genome of the 1918 flu and the reconstruction of the 1918 flu virus.[22] While these may help us to prepare ourselves against—or perhaps even prevent—the next major flu pandemic, they could also assist aspiring bioterrorists. But the mere fact that a discovery has implications for biological weapons development should not be sufficient grounds for censoring it unless we are willing to make enormous sacrifices regarding the progress of science and medicine.

The suggestion that at least the materials and methods sections of the mousepox and polio studies should have been omitted from the published articles is at odds with the scientific importance of verification and replication: "To limit the information available in the methods section of journal articles," according to the NRC, "would violate the norm that all experimental results should be open to challenge by others."[23] Once again, unless we are willing to sacrifice scientific progress, we cannot omit essential components of scientific publications.

A final defense of publication of the mousepox and polio studies holds that neither produced surprising discoveries to begin with. Some claim that previously published articles made the outcomes of both of these studies predictable. Arguably, one sufficiently familiar with the scientific literature could have already guessed that producing a more virulent strain of mousepox and synthesizing polio via such methods would be possible.[24] According to Ian Ramshaw, an author of the mousepox publication, plenty of published information already exists for anyone who wants to do serious damage: "It's too late for censorship now."[25]

Aftermath

The aftermath of these publications included a series of meetings to foster dialogue between experts from scientific and security communities regarding the future handling of dual-use discoveries like those described above. These meetings resulted in public statements by scientific journal editors and authors, a series of reports by the U.S. National Academy of Sciences, and the establishment in the United States of the National Science Advisory Board for Biosecurity (NSABB).

In February 2003, a joint "Statement on Scientific Publication and Security" of the "Journal Editors and Authors Group" was simultaneously published by *Science*, *Nature*, the *Proceedings of the National Academy of Sciences*, and the American Society for Microbiology journals. The statement read as follows:

> FIRST: The scientific information published in peer-reviewed research journals carries special status and confers unique responsibilities on editors and authors. We must protect the integrity of the scientific process by publishing manuscripts of high quality, in sufficient detail to permit reproducibility. Without independent verification, a requirement for scientific progress, we can neither advance biomedical research nor provide the knowledge base for building strong defense systems.
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> SECOND: We recognize that the prospect of bioterrorism has raised legitimate concerns about the potential abuse of published information, but also recognize that the research in the very same fields will be critical to society in meeting the challenges of defense. We are committed to dealing responsibly and effectively with safety and security issues that may be raised by papers submitted for publication, and to increasing our capacity to identify such issues as they arise.
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> THIRD: Scientists and their journals should consider the appropriate level and design of processes to accomplish effective review of papers that raise such security issues. Journals in disciplines that have attracted numbers of such papers have already devised procedures that might be employed as models in considering process design. Some of us represent some of those journals; others among us are committed to the timely implementation of such processes, about which we will notify our readers and authors.
>
> FOURTH: We recognize that on occasion an editor may conclude that the potential harm of publication outweighs the potential societal benefits. Under such circumstances, the paper should be modified or not be published. Scientific information is also communicated by other means: seminars, meetings, electronic posting, etc. Journals and scientific societies can play an important role in encouraging investigators to communicate results of research in ways that maximize public benefits and minimize risks of misuse.[26]

Whether the mousepox and polio studies should have been published or not, we should agree with the fourth point that censorship may sometimes be appropriate. There may be cases where censorship is essential to human security. If a scientist (accidentally or otherwise) discovers an easy way to produce a pathogen as contagious, deadly, and untreatable as smallpox, for example, then the widespread dissemination of the instructions for doing so would be disastrous if, as would be prudent to assume, some would use this information for malevolent purposes. In an imaginary case like this one, limited dissemination to those who are most able to develop protection against the microbe in question would be called for. The idea that everyone should have access to this information is like the idea that everyone should have access to instructions for making nuclear weapons. Scientific openness and the progress of medicine matter, but security matters, too. There is no reason to give absolute priority to the former over the latter; rather, a balance must be struck between the two.

Having accepted that censorship may sometimes be legitimate, the more important and difficult question is how decisions about censorship should be made. Little is said in the "Statement on Scientific Publication and Security" about the criteria that editors will or should use to determine when the potential harms outweigh potential benefits[27]—or why, for that matter, one should believe that editors are especially qualified to make such judgments in the first place. The U.K. Royal Society's subsequent statement, in a related policy paper, that "filtering is clearly appropriate in the case of . . . papers where there is a *tangible* cause for concern in terms of harmful applications"[28] clarifies little in this regard, despite the claim by Brian Eyre, chair of the Royal Society committee on scientific aspects of international security, that

> What you really have to be alert to is whether or not you can identify a *tangible link* between the outcome of the research and the possible use in some sort of harmful device. . . . It is this *tangible link* that is the key work. We need to explore ways we can look at . . . research papers that can identify those *tangible links*.[29]

Not to mention the prohibitive vagueness of the criterion proposed here, "tangible links" to both harms and benefits will be commonplace among life sciences publications. Unless Eyre suggests that no discoveries involving dual-use technologies should be published, he says little of substance about the means to predict and weigh potential costs and benefits.

The extent to which the government will—or should—exert control over what gets published is also not clear. The U.S. government mandates secrecy of classified information, but usually only "work done in government laboratories or under government contract" may be classified. The only exceptions to this condition of classification are that "information related to nuclear weapons may be 'born classified' without any prior involvement of the government in its generation" and that "information received as part of the patent application process may be deemed classified in special circumstances."[30]

The government may also exert control over dissemination of information deemed to be "sensitive," though not "classified," when national security is at risk. The scientific community, however, has strongly and repeatedly resisted the idea that unclassified and/or unclassifiable "sensitive" information resulting from scientific research should be subject to this kind of control. The NRC's Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology, in its landmark report on the dual-use dilemma titled *Biotechnology Research in an Age of Terrorism*, stated that "the chief concern in any government-imposed requirement to shield 'sensitive' information lies in the potential fuzziness of the category, coupled with the severity of possible penalties for failing to protect the information."[31] The complaint is that the idea of "sensitive" information is too vague. A clearer line of demarcation (such as classification) is needed to preclude a situation where scientists are deterred from important research because of doubts about what they will be permitted to publish and fears that they will be punished if they publish in areas that are later, and perhaps arbitrarily, determined to be "sensitive." The same report expressed concern that too much restriction on dissemination of information would impede the progress of science in other ways as well. "The norm of open communication," it claimed, echoing Oppenheimer, "is one of the most powerful in science."[32]

The NRC ultimately recommended relying on voluntary "self-governance by scientists and scientific journals" for the screening of publications posing security risks. In the case of unclassified or unclassifiable research, according to the NRC, the scientific community, rather than the government, should control decision-making regarding dissemination of information about dual-use discoveries. The NRC also recommended that a National Science Advisory Board for Biodefense be established "to provide [expert] advice, guidance, and leadership for the [voluntary] system of review and oversight."[33] The establishment of the National Science Advisory Board for Biosecurity in 2004 was a response to this recommendation.

Against Self-Governance

Should we follow NRC recommendations and allow the scientific community to voluntarily govern itself, making its own decisions about what should be published when security is at stake? Since the NRC represents the scientific community and its interests, its resistance to governmental interference with the scientific enterprise is perhaps not surprising. Scientists, like others, desire autonomy. There are straightforward economic and political reasons why the scientific community would not want to be controlled by the state, and there are purely scientific reasons as well. Many consider academic freedom to be the very essence of science. And finally, in addition to interfering with scientific freedom, government-mandated censorship may threaten freedom of speech more generally. Some fear that the censorship of science will be just one more civil liberty infringement in the name of "the war on terror."

Widespread governmental control over what gets published in science would certainly be problematic. Politicians and security personnel would likely favor security and stability over scientific advances. And depending on their particular expertise, politicians and security personnel would often not be especially qualified to judge the scientific importance of findings they might want to censor.

Relying on voluntary self-regulation by scientists and editors, on the other hand, is unacceptable as well. First, because of the reward system in academia, career advancement generally requires a strong publication record. An individual scientist's interest in career advancement may thus conflict with his interest in national security. Second, just as governmental officials are likely to have values biased in favor of security over the promotion of science, scientists and science editors are likely to be biased in favor of the promotion of science over security. Therefore, to place full decision-making power in the hands of the scientific community would be just as much of a mistake as placing full decision-making power in the hands of the government.

Third—and most importantly—scientists and science editors are not security experts. We have no good reason to believe they will have the particular skills or knowledge required to assess the security risks of publication in problematic cases. Scientists might be best able to recognize a discovery's scientific or technical implications for the making of particular biological weapons, but they have no special expertise to determine the identity, abilities, or intentions of potential bioterrorists. And scientists have no special expertise to assess what the *security*—as opposed to health—implications of attack with particular biological weapons would be.

The mousepox study powerfully illustrates scientists' lack of knowledge in this area. The danger of publication in that case, recall, is largely based on the likelihood that the smallpox virus has fallen into the wrong hands, since terrorists (or "rogue nations") would need access to the virus to apply the mousepox genetic engineering technique to it. Any specific details about the probability or extent of smallpox proliferation, however, involve classified information to which scientists and editors generally lack access.[34] Thus the scientific community is systematically denied information that is absolutely essential to estimate security risks. This important point—which justifies rejection of the NRC's recommendation—has apparently not been noticed by either those arguing for or those arguing against voluntary self-governance of the scientific community in matters of censorship.

> Relying on voluntary self-regulation by scientists and editors is unacceptable. Their interests may conflict with national security, and they are not security experts.

Beyond NSABB

Neither the scientific community nor the government should have the unilateral power to make final decisions regarding dissemination of information involving dangerous discoveries with weapons implications. To achieve balance between the competing interests requires that decisions be handled by an individual or group embodying both kinds of values (without being biased toward either) and both kinds of expertise (to a sufficiently high degree).[35]

If an appropriate individual can be found, then he or she could be appointed a sort of dual-use science censorship tsar and given the power to veto publication in problematic cases. This appointment could require the approval of both the government and the scientific community (perhaps, in the latter case, represented by the NRC). If a sufficiently knowledgeable, neutral, and trustworthy individual cannot be found, then a panel comprised of both government and civilian scientists and security experts (all of whom would require high-level security clearance) should be given regulatory authority. Specific details about the constitution of such a panel and what its decision-making procedures might be are beyond the scope of this article. One possibility, however, is a panel comprised of 25 percent civilian scientists, 25 percent government scientists, 25 percent civilian security experts, and 25 percent government security experts. This would enable the group to have an equal mix of both civilians and members of government and scientists and security specialists. Those serving could be nominated by the groups they represent: civilian members, for example, could be nominated by the National Academies, and governmental members could be nominated by the Department of Health and Human Services, the Department of Homeland Security, and so on.[36] And each group might be given some veto power over the nominations of other groups' members.

The important thing is that referral of problematic cases to an individual or panel should be mandated, and that person's or panel's decisions should be binding. The primary problem with the current status quo in the United States is that—with the exception of classified and classifiable research—it relies on voluntary self-governance by the scientific community. As I have shown, voluntary self-governance cannot be justified. The creation of the NSABB "to provide advice and guidance to the federal government" regarding dual-use biological research is a step in the right direction: it is an important advisory body comprised of both scientists and security experts, and its working groups are currently focused on examining issues surrounding synthetic biology and developing criteria for identifying dual-use research, tools for controlling dissemination of information, a code of conduct for scientists, and means for international collaboration in the oversight of dual-use science.[37] However, referral of cases involving problematic dual-use research to the NSABB for guidance is voluntary, and its decisions or recommendations regarding the advisability of publication in particular cases lack legal force.

Though the above-mentioned study involving the reconstruction of the 1918 flu virus was sent to the NSABB for consideration before being published in *Science*, and though NSABB members unanimously agreed that the study should be published, *Science* editor-in-chief Donald Kennedy subsequently wrote that, unless the paper was classified, he would have published it "even if the NSABB had voted otherwise."[38] This implies that, in the case of unclassifiable research at least, important security decisions are currently left to the discretion of scientists and science editors. This is unacceptable. Given its general mandate to advise the government about how the dual-use dilemma should be dealt with, the NSABB should itself recommend establishment of a regulatory authority along the lines of that described above.

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24. Board of Science and Education, British Medical Association, *Biotechnology, Weapons and Humanity II* (London: British Medical Association, 2004). ANU scientist Peter Kerr nonetheless claims that vaccine resistance in the case of the mousepox study was a real surprise. Personal communication.

25. Personal communication.

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28. The Royal Society, United Nations Foundation, "The Individual and Collective Roles Scientists Can Play in Strengthening International Treaties" (policy document), April 2004, p. 3. The emphasis is mine.

29. J. Wilson, "Preventing Test-Tube Terrorism," *The Guardian*, April 22, 2004, at http://education.guardian.co.uk/print/0,3858,4906769-110865,00.html. The emphasis is mine.

30. National Research Council, *Biotechnology Research in an Age of Terrorism*, 91-92.

31. Ibid., 93.

32. Ibid., 117.

33. Ibid, 8-9.

34. G.J. Annas, *American Bioethics* (New York: Oxford University Press, 2005), 15.

35. For further discussion of policy options for dealing with the dual-use dilemma, see S. Miller and M.J. Selgelid, *Ethical and Philosophical Consideration of the Dual-Use Dilemma* (Canberra, Australia: Centre for Applied Philosophy and Public Ethics, Australian National University, and Charles Stuart University, 2006).

36. Though the dual-use dilemma is inherently international, my analysis here is limited to the domestic context. Though I do not offer an international solution, I aim to show that the status quo with regard to the U.S. domestic solution is unacceptable at present. The general idea of a diversely constituted decision-making body could, in any case, in principle be applied to the international arena. Whether that would be politically feasible (and whether there is any good or feasible international solution) is a separate matter.

37. National Science Advisory Board for Biosecurity. See http://www.biosecurityboard.gov.

38. D. Kennedy, "Better Never Than Late," *Science* 310 (2005): 195.