Biological weapons and the life sciences: the potential for professional codes

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> Two items in this issue of *New Scientist* … re-emphasize a theme which is now always recurring in our pages. This is the responsibility which the scientist bears towards society for the new and often awesome powers which he generates in his laboratory. … Throughout civilized history it has been recognized that certain groups which exercise a special influence and wield a peculiar power within the community must, for the common good, abide by certain rules and accept certain limitations and restrictions. … But except in special cases, scientists as a group have no such corporate law to help the individual act in a way that will preserve the health and reputation of the whole. … [U]nless some principles of conduct are established for the men and women who manipulate the materials of nature, anarchy will develop, and with anarchy, disaster.

So argued the journal *New Scientist* in February 1968 in an editorial entitled "Wanted—a code of conduct".[1] The quote illustrates both the relatively long-term interest in formulating a code of conduct for scientists[2] and the importance of the threats of biological weapons as part of that. In their most basic form, codes seek to formalize existing or idealized standards of practice. Recently, as part of a renewed concern about the dual-use possibilities afforded by molecular biology, neuroscience and immunology vis-à-vis bioweapons (BW), the calls for a code have once again intensified. The adoption of a code is being offered as both a complement and an alternative to traditional international arms control regimes.

This article briefly traces current initiatives to formulate a BW-related code. It does so with a view to highlighting the diversity of proposed codes. Lessons from the analysis of professional codes more generally are referenced to suggest some of the problems and possibilities associated with the adoption of a BW code. Building on this, the outline of a "code matrix" is presented to suggest a range of possible activities that might be taken up under the name of a code. Finally, this article proposes content for a code of conduct and lays out the reasoning behind it. In doing so, the argument seeks to present ideas for discussions under the Biological and Toxin Weapons Convention (BTWC) work programme for 2005.

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BW codes today

Since 2001, with the growing concern about BW threats, many governments, NGOs and professional bodies have forwarded the notion that a code of conduct introduced in conjunction with other initiatives might be useful.[3] Box 1 lists many of the calls made. Moreover, the adoption of a code has entered into the formal agenda of key institutions. "The content, promulgation, and adoption of codes of conduct for scientists" will be discussed as part of the annual meeting of the BTWC States Parties in 2005. The US National Science Advisory Board for Biosecurity has as one of its central aims the development of "Professional codes of conduct for scientists and laboratory workers that can be adopted by professional organizations and institutions engaged in life science research".[4] Following on from decisions by the UN General Assembly and the Security Council,[5] the InterAcademy Panel and the International Centre for Genetic Engineering & Biotechnology are formulating a code of conduct for the life sciences.

Box 1. A biological weapons-related code of conduct could:

include "general safety and ethical standards such as potential conflicts of interests, plagiarism and misrepresenting or exercising bias in recording and publishing state [as well as potentially specific elements] of safety and security such as the handling of potentially dangerous materials. … Good practice should also include the responsibility of scientists to be aware of and comply with the requirements of international conventions and treaties in their research areas. This needs educational and research institutions to put in place the appropriateness measures to enable this requirement to be met."

—British Royal Society, 2004, *The Individual and Collective Roles Scientists Can Play in Strengthening International Treaties,* April

"aim to prevent the involvement of defence scientists or technical experts in terrorist activities and restrict public access to knowledge and expertise on the development, production, stockpiling and use of weapons of mass destruction or related technologies."

—Policy Working Group on the United Nations and Terrorism, 2002, *Measures to Eliminate International Terrorism,* annex

be set up for "those who do laboratory work with pathogenic organisms [and] could underscore that scientists, clinicians, and laboratory workers have personal responsibility to prevent accidental and deliberate releases of such organisms into the environment. Such a code could be an element within a multi-faceted approach to promoting responsible handling and use of pathogenic microorganisms."

—US Department of State, 2001, *New Ways to Strengthen the International Regime Against Biological Weapons,* October

be established as a means of "self-regulation for scientists working with dangerous pathogens and toxins."

—Wellcome Trust, 2003, *Position Statement on Bioterrorism and Biomedical Research*

"be developed by academic and professional bodies to lay out standards internationally for work relevant to the prohibition of the Convention. Such codes could include, *inter alia*, a statement that scientists will use their knowledge and skill for the advancement of human, animal, and plant welfare and will not conduct activities directed towards the use of micro-organisms or toxins or other biological agents for hostile purpose or in armed conflict."

—UK Foreign Office, 2002, *Strengthening the Biological and Toxin Weapons Convention,* April

Despite the widespread endorsement given to the formulation of a code (or codes), at the time of writing, its aims and audiences have not been developed in detail. A close reading of the quotes in Box 1 indicates a variety of aims and audiences. Many other calls for codes could be listed that would indicate a still greater degree of diversity.[6]

The lack of agreement on these issues is of some importance because existing professional scientific codes vary greatly in terms of their functions and content. Codes of conduct (the term is often used interchangeably with "codes of ethics" or "codes of practice") vary from brief statements that lay out aspirational aims in the desire to raise awareness of key issues or establish principles; to educational/ advisory guidelines that suggest considerations to be borne in mind when considering appropriate action; to detailed enforceable rules that specify what should and should not be done.[7]

The need to mind the diversity of codes is all the more important because social scientists and ethicists have often expressed scepticism about the utility of codes. This has been the case particularly for those codes that just aim to aspire, educate or guide action. Problems identified include the manner in which codes are often open to numerous interpretations; the limitations of codified rules to guide action in complicated cases; the limited practitioner referral to the provisions of codes; and the "public relations" potential of codes to act as way of staving off other forms of regulation.[8] To the extent that codes take the form of binding regulations, then the proper topic for examination is not so much the code itself, but the underlying forms of regulation that it embodies. More positive analyses of codes in professional life suggest they can heighten awareness of issues, enable individuals to re-interpret their situations, clarify how individuals and groups share responsibility, and influence action in areas where standards have not yet formed.[9]

Whatever assessment one makes about the value of codes, different types of code options exist (i.e. aspirational, educational/advisory, or enforceable) and there are important differences between them in terms of their goals. Table 1 indicates the range of codes possible, how they are often designated by name, what overall aims each could serve, what types of objections have been made about them,

Table 1. A typology of codes

Type	*Aspirational*	*Educational/ Advisory*	*Enforceable*
Common name	Code of Ethics	Code of Conduct	Code of Practice
Main aims	Alert; set realistic or idealistic standards	Provide guidelines, raise awareness and debate; foster reflective moral agents	Prescribing or proscribing certain acts
Principal criticisms	Standards too broad to guide action; lack of adherence	Often contain conflicting ethical demands and therefore ambiguous; of limited utility with enforcement mechanisms, yet guidelines rarely list definitive do's and don'ts; mainly function as public relations device	Formal codes not able to specify ethical conduct in diverse situations; regulation burden on science base; existing national regulations for the physical and biological containment of pathogens
Functioning	Establish an organizational basis for future action by initially affirming the prohibition against the development of bioweapons	Provide elaboration of individual and collective responsibilities of those associated the life science work; set a basis for long term discussion about what needs to be done, in part by challenging existing agenda and framing of issues	Incorporate BW and biosecurity concerns within day-to-day work procedures
Principal agents	Policy makers in funding and professional organizations	Life science professionals	Administrators, regulators, funders, and practitioners associated with scientific and medical practice

how they would function in more practical terms, and who could be the likely main agents to take their adoption forward.

The lack of codes directly relevant to matters involving biological weapons despite the long-term interest in developing them should alert us to the potential difficulties of agreeing and implementing them. While codes might seem a fairly non-controversial option, particularly relative to other issues associated with biological weapons, if codes are to go beyond reiterating platitudes about the abhorrence of using modern biology toward malign ends, then they are likely to confront major issues of controversy. For instance, codes could comment on the acceptability of disputed attempts to develop "non-lethal" incapacitating agents or the permissibility of contentious biodefence activities. Determining the responsibilities of scientists for the future implications of their work raises many demanding questions about the foreseeable consequences of science and what should be done about them (and by who). To indicate a sense of the range of potential issues that could be raised, Box 2 lists a variety of possible questions about efforts to develop codes.

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A code of conduct in a code matrix

In order to cover a broad range of aims and the deficiencies of individual types of codes, one idea that has been put forward is to strive for a "matrix of codes".[10] This would entail the adoption of different aspirational, advisory and enforceable codes that could meet a variety of goals for diverse audiences.[11] This matrix should not only be relevant to individual bioscientists, but researchers in related fields, regulators, policy makers and others associated with conducting and commercializing the life sciences. Elsewhere I have suggested something of the elements of such a matrix. It could include aspirational codes that raise the profile of biological weapons with funding, professional, regulatory and other bodies in order to raise awareness and facilitate future action. Enforceable codes could be devised that further existing controls on the physical and biological containment of pathogens and toxins by incorporating them within the routine practices of researchers and others.[12]

Because working examples of aspirational and enforceable codes are already in place as models for future action, the remainder of this article concentrates on elaborating a possible code of conduct. Although enforceable or aspirational BW-related stipulations might be incorporated within existing codes and regulations, arguably a distinct document is needed in the case of an educational code to elaborate a "thick" appreciation of the possible issues at stake. The main aim of this type of code could be to promote widespread discussion regarding what threats are posed by the dual-use capability of the life sciences and the appropriateness of responsive measures. Codes can seek to encourage individuals and groups to assume a position of responsibility as moral agents, though their ultimate ability to do this is highly dependent on the process of their adoption, promotion and revision.

Box 3 gives an example of a code for those that conduct, fund, administer and regulate work in the biosciences and biomedicine. It has been assembled, in part, by directly drawing on varied declarations, codes and conventions; this including the *Ethical Principles of BIOTECanada,*[13] a statement by Matthew Meselson,[14] the IEEE-CS/ACM Joint Task Force on Software Engineering Ethics and Professional Practices' *Software Engineering Code of Ethics and Professional Practice*,[15] the 2002 World Medical Association's *Declaration of Washington,*[16] the Preamble to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction[17] and the International Committee of the Red Cross's *Responsibilities of Actors in*

the Life Sciences to Prevent Hostile Use.[18] It includes a wide range of stipulations, some which might be classified as "advisory", others as "enforceable" and others as "aspirational".

The code is intended as a modest contribution in a few important respects. First, offering such content is not meant to render superfluous the process of debating what any code should be. Rather it serves as an example of what could be done, i.e. to promote grounded discussion. The adoption of

Box 2. Some key questions for codes

Who is the relevant community to make decisions about what codes should be adopted? Should the scientific communities alone determine the composition of codes intended for them? In what ways is the "prevention against biowarfare and bioterrorism … too important to leave to the scientists and politicians"?*

How will a code combine both individual and collective responsibilities?

Will codes consist of standards that go beyond existing regulatory provisions in terms of their rigor or specificity?

What is the question to which codes are being sought as an answer? As part of this, what is the potential for current scientific developments to facilitate the development of BW?

Does a long-term and widespread commitment exist among the relevant organizations to turn codes into more than pieces of paper? If this is lacking, should codes be pursued at all?

By what measures might a code be deemed effective? Is "keeping the conversation going" about the potential security problems of science sufficient?

To what extent are differences in the adoption of codes as well as other regulatory measures acceptable?

Should codes seek to elaborate and clarify existing international conventions or should discussions undertaken as part of such conventions elaborate and clarify the meaning of codes? Related to this, is the purpose of codes to resolve or reflect international disagreements about the advisability of some actions?

Who are codes for: workers on the bench, professional organizations, government negotiators, those in industry, the public or others?

Are codes being brought in to stave off other controls?

Is it realistic to expect common standards in practice for scientific communities across sub-disciplines and nations?

Can guiding principles for setting and interpreting codes be agreed?

What positive commitments exist for scientists to consider the social and ethical implications of their work?

Is calling for "compliance" to existing national legislation and international agreements sufficient? To what extent is it possible?

How can the effectiveness of codes be gauged? Is it realistic or helpful to assume that common criteria should apply across disciplines and countries?

Are governments, professional organizations, funders, NGOs and others willing to take a stance on the proper interpretation of international weapons agreements?

Could new codes alleviate or exacerbate the deficiencies of existing codes?

Irrespective of questions about scientists' knowledge of international prohibitions, is there sufficient recognition of the dual-use possibilities stemming from research? Is there a significant problem to be recognized at all?

Is the discussion of a code a way of engaging with potentially contentious political questions or a way of avoiding them?

* Pax Christi International, 2004, *Pax Christi International Calls for Ethical Approach to Biological Weapons,* statement at General Assembly Pax Christi International in Brussels, June, at <www.paxchristi.net/PDF/SD08E04.doc>.

a code should be viewed as an occasion for asking questions about the place of science in society at a given time, and how that might change. Second, and a related point, at this stage the stipulations seek to evoke deliberation rather than to provide definitive answers. This orientation is taken on the basis that in these relatively early days of widespread concerted action to define and address the security risks stemming from "fundamental" work in the life sciences and elsewhere, the emphasis should be placed on provoking dialogue about what needs to be done rather than inhibiting dialogue. This discussion should include assessments of the criteria by which codes are judged to be "useful" or "ineffective", which themselves are likely to change over time. Certainly a further elaboration of many of the terms and stipulations listed is needed, for instance, the meaning of "potentially dangerous consequences" or just how work should be "reviewed".[19] Some organizations have already made detailed elaborations of possible do's and don'ts.[20] The purpose here is not to resolve debates, but to raise them as topics of concern that need to be addressed in future discussions. The working through of what particular terms entail could be treated as part of the process related to identifying the benefits of any code. Third, this code is pitched in a largely negative tone regarding the possible detrimental consequences of scientists' work rather than their role in reducing threats from BW. While this or other deficiencies may well need correcting, the rationale in my devising a code has been to flag possible issues of concern rather than resolving its final content.

Box 3. A proposal for a code of conduct for the life sciences

Preventing the Hostile Use of the Life Sciences

Every major technology—metallurgy, explosives, internal combustion, aviation, electronics, nuclear energy—has been intensively exploited, not only for peaceful purposes but also for hostile ones. The rapid developments across the life sciences today not only bring the possibility of improving human health, but the risk that the knowledge and techniques gained will be turned towards the deliberate spread of disease.

This risk is not confined to traditional pathogens and toxins of concern; rather the fields of molecular biology, neuroscience, biological control and many others are offering novel ways of manipulating basic life processes. For instance, through deliberate or inadvertent means, genetic modification of micro-organisms could create organisms that are more virulent, are antibiotic-resistant, or have greater stability in the environment. Advances in gene therapy may allow modification of the immune response system of the target population to increase or decrease susceptibility to a pathogen or disrupt the functioning of normal host genes.

Those of us who conduct, fund, administer and regulate work in the biosciences and biomedicine have an ethical and social responsibility to honour international agreements that we will use our knowledge and skill for the advancement of human, animal and plant welfare and will not conduct activities directed towards the use of micro-organisms, toxins or other biological agents for hostile purposes. In addition, as individuals, collectively as members of professions, and in discussions with other segments of society, we have an obligation to actively deliberate what measures are necessary to minimize the risk that our work will be employed for hostile ends.

Today and in the future, an effective response to the threats from biological weapons can only come from concerted international action by those in governments, the medical and scientific communities, non-governmental and professional organizations, the biotechnology and pharmaceutical industries and others. The history of life science research contains many instances—laboratory biosafety and vivisection to name but two—where standards have transformed and controls have been negotiated out of widespread social concern.

This Code is intended to provoke reflection, dialogue and action regarding the advisability of response measures. The list of points included is not meant to be exhaustive. An understanding of the threats posed from the hostile use of biological weapons from states, groups or individuals will evolve over time and thus so will the necessary responses. The provisions included should not be read as separating the acceptable from the unacceptable in all practical situations. The Code is not a simple algorithm that generates definitive determinations about what needs to be done. In some situations, standards may be in tension with each other or with standards from other

sources. Such situations require that medical and scientific professionals and related individuals consider for themselves and discuss with others what constitutes appropriate action. The provisions of this Code should influence those associated with the life sciences to consider broadly who is affected by their work; to examine if they and their colleagues are acting with due regard; to consider how the public, if reasonably well informed, would view their actions; to analyse how the least empowered will be affected by their actions; and to consider whether their acts would be judged worthy of the ideal working of professionals.

In keeping with this, those that work in the biosciences and biomedicine should:

- acknowledge that minimizing risks from the hostile use of advances in the life sciences is of concern to them and part of their responsibility as professionals;
- recognize their personal benign intent is an insufficient justification for setting aside such concerns;
- strive to become aware of the "dual-use" applications of their work;
- consider the direct and indirect benefits and harms of their work to colleagues, their profession, their communities and society at large;
- be aware of the work of associates;
- ensure they are knowledgeable about and comply with respective national and international regulations regarding the physical and biological containment of agents. Where existing measure are thought inadequate such concerns should be raised with relevant policy officials and professional organizations;
- take actions within their own sphere of influence that will contribute to risk reduction;
- ensure that their actions are known amongst and complement the actions of others; and
- acknowledge they have a responsibility to consider the interests and ideas of all segments of society in assessing what needs to be done.

Responsibility for minimizing the risk that life sciences will be used for hostile purposes is not just a matter for individuals, but one for the scientific and medical communities operating as a whole. Collective activities should be undertaken to monitor the threat of biological weapons and to identify actions likely to prevent BW proliferation. As part of this, acting in concert, those representing and funding work in the biosciences and biomedicine should:

- recognize that their expertise means they have a responsibility to contribute to efforts to reduce the risks associated with biological weapons;
- set up procedures whereby those concerned about possible dual-use applications can seek guidance and report any concerns, including whistle blowing on suspicious activities;
- educate their members and the public about the potential for and responses to biological weapons, including through increasing awareness of this Code;
- establish the expectation that where there is disagreement about the implications of experiments and findings, then these should be debated openly;
- institute measures to scrutinize all work with potentially dangerous consequences and to ensure it is submitted to rigorous and independent peer review;
- put in place procedures to survey overall developments in the life sciences to identity emerging areas of concern;
- call for funding to be further directed at alleviating the causes of insecurity and poverty worldwide (e.g. the spread of infectious disease);
- reinforce existing international commitments on states to achieve effective progress towards general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction;
- recognize that international agreements are often written in a vague and abstract manner that leaves standards of appropriate conduct ill-defined. Efforts should be made to actively engage governments to elaborate the meaning of prohibitions; and

- call for states to pursue in good faith disarmament negotiations leading to strict and effective international control that are equitable to the multiple concerns in the international community, including the development of a legally binding verification instrument to strengthen the Biological and Toxin Weapons Convention.

In undertaking these measures, individuals and collective bodies should further recognize that concerns about biological weapons are not limited to activities directly contributing to the stockpiling of agents as part of manifestly offensive programmes. For instance, the recurring interest in some quarters for so-called incapacitating agents threatens to undermine international efforts to prohibit the development, production and retention of biological agents of types and in quantities that serve no prophylactic, protective or other peaceful purpose. In addition, however inadvertently, activities undertaken as part of biodefence programmes to elucidate the mechanism of virulence or assess biological threats can undermine international confidence in and in themselves violate prohibition regimes. To prevent this, efforts should be made to strengthen the confidence between peoples and the general improvement of the international atmosphere. The presumption should be that the details of biodefence programmes should be open for public scrutiny.

Several points about the code are worth stressing. In its terms, following the *Software Engineering Code of Ethics and Professional Practice*, the code recognizes the importance and limitations of trying to establish rules specifying proper conduct on many of the difficult dual-use questions. Rather than setting out certain standards and expectations, it seeks to initiate a process of critical reflection and dialogue. The provisions also seek to challenge narrow focuses on biological and physical containment, the responsibilities of individuals, extensive offensive programmes, or non-proliferation agendas. The disarmament focus is meant to link with initiatives in other areas to reinforce efforts against nuclear, chemical and other proscribed weapons. Furthermore, it not only encourages individuals and associations to be aware of and comply with the requirements of international conventions but to actively work towards the clarification of their meaning. As a final point of emphasis, the code does not seek to just make the issue of responsibility a matter for individuals, but rather highlights the importance of collective action. These are just some of the considerations that might fit into codes of conduct in order to take forward discussions about the dual-use threats stemming from the life sciences.

Conclusion

In response to threats from BW, questions are being asked today in some countries about the implications and appropriateness of activities undertaken in the life sciences. Many organizations and governments have suggested that bioscientists adopt a code of conduct to reduce the security concerns associated with their work. Whatever the widespread interest in such a code, however, little has been offered by way of specific information about its possible content or plans for its promulgation.

This article has briefly surveyed the potential contribution of professional codes—including codes of ethics, codes of conduct and codes of practice. In light of the possible contributions and limitations of each type of professional code, an integrated "matrix of codes" was suggested that would consist of different types fulfilling a range of aims for varied audiences. It has not settled questions about what sorts of matrix would be most beneficial, but instead indicates the significance and general outline of one potential approach for further reflection and debate. The ultimate utility of codes depends on the practical commitments made by organizations in promoting and implementing them, matters which cannot be dictated by analyses.

Notes

1. New Scientist, 1968, "Wanted—A Code of Conduct", *New Scientist,* 29 February, p. 453.
2. For further precedents see: W. Pigman and E. Carmichael, 1950, "An Ethical Code for Scientists", *Science,* vol. 111, pp. 643–47; C. Hedén, 1968, "Perspective on an Identity Card or Certificate for Scientists", *Scientific World,* vol. 12, nos. 4/5, pp. 24–28; and A. Cournand, 1977, "The Code of the Scientists", *Science,* vol. 198, pp. 699–705.
3. For information about the recent history of biological weapon codes, see <www.ex.ac.uk/codesofconduct/>.
4. United States, National Science Advisory Board for Biosecurity, at <www4.od.nih.gov/nsabb/>.
5. See <www.un.dk/doc/A.57.0273_S.2002.875.pdf>.
6. See <www.ex.ac.uk/codesofconduct/Chronology/index.htm>.
7. See <www.codesofconduct.org> for many written examples; also C. Soskolne and L. Sieswerda, 2003, "Implementing Ethics in the Professions: Examples from Environmental Epidemiology", *Science and Engineering Ethics,* vol. 9, no. 2, pp. 181–90.
8. M. Iverson, M. Frankel and S. Siage, 2003, "Scientific Societies and Research Integrity: What Are They Doing and How Well Are They Doing It?", *Science and Engineering Ethics,* vol. 9, no. 2, pp. 141–58; A. Doig and J. Wilson, 1998, "The Effectiveness of Codes of Conduct", *Journal of Business Ethics*, vol. 7, no. 3, pp. 140–49; N. Higgs-Kleyn and D. Kapelianis, 1999, "The Role of Professional Codes in Regulating Ethical Conduct", *Journal of Business Ethics,* vol. 19, no. 4, pp. 363–74; K. Shrader-Frechette, 1994, *Ethics of Scientific Research,* Lanham, Rowan & Littlefield.
9. M. Davis, 1998, *Thinking Like an Engineer,* Oxford, Oxford University Press; M. Meselson, 2000, "Averting the Exploitation of Biotechnology", *FAS Public Interest Report* 53, p. 5; S. Unger, 1991, "Code of Engineering Ethics", in D. Johnson, *Ethical Issues in Engineering,* Upper Saddle River, Prentice Hall, pp. 105–30; S. Reiser and R. Bulger, 1997, "The Social Responsibilities of Biological Scientists", *Science and Engineering Ethics*, vol. 3, no. 2, pp. 137–43.
10. A term originally forwarded by Vivienne Nathanson of the British Medical Association.
11. B. Rappert, 2004, "Responsibility in the Life Sciences", *Biosecurity & Bioterrorism,* September, at <www.biosecurityjournal.com>.
12. G. Pearson, 2004, *Some Additional Considerations Regarding a Possible Biological and Toxin Weapons Convention (BTWC) Code of Conduct,* 12 February, at <www.ex.ac.uk/codesofconduct/Publications/Reflections%20on%20SeminarFeb04.doc>.
13. At <www.biotech.ca/EN/ethics.html>.
14. At <www.hir.harvard.edu/articles/?id=919&page=4>.
15. The Institute of Electrical and Electronics Engineers–Computer Society and the Association for Computing Machinery, at <www.acm.org/serving/se/code.htm>.
16. At <www.wma.net/e/policy/b1.htm>.
17. At <disarmament2.un.org/wmd/bwc/BWC%20text-English.pdf>.
18. At <www.icrc.org/Web/eng/siteeng0.nsf/html/5VDJLW?OpenDocument>.
19. Models of this as provided by National Research Council, 2004, *Biotechnology Research in an Age of Terrorism,* Committee on Research Standards and Practice to Prevent the Destructive Application of Biotechnology Washington, DC, National Academies Press, and J. Steinbruner and E. Harris, 2003, "Controlling Dangerous Pathogens", *Issues in Science and Technology,* vol. 19, no. 3 (Spring), at <www.nap.edu/issues/19.3/steinbruner.htm>.
20. See, for example, <fas.org/bwc/papers/code.pdf> and <www.gene-watch.org/programs/biowarfare/call-for-ban.html>.