Chapter 10: Biosecurity Awareness-raising and Education for Life Scientists: What Should be Done Now?

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Introduction: Awareness

The 1975 Biological and Toxin Weapons Convention (BTWC) added to the ban on the use of biological weapons embodied in the 1925 Geneva Protocol by what was termed the 'General Purpose Criterion' of Article 1. This stated that: [1]

> Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:
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> 1. Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes...

Thus, peaceful uses of the modern life sciences are fully protected, but there is an all-encompassing prohibition of non-peaceful development, production, stockpiling, acquisition or retention of microbial or other biological agents or toxins (and toxins here are understood to cover all mid-spectrum agents such as bioregulators).

As early as the Second Five-Yearly Review Conference of the BTWC in 1986, the 'States Parties' [2] recognised the importance of the awareness and education of life scientists in regard to the Convention. In the Final Declaration of

1 For the text of the Convention, see: www.opbw.org.

2 The term 'States Parties' refers to the membership of the Convention. The Biological Weapons Convention currently has 163 States Parties and 13 signatories. There are 19 states which have neither signed nor ratified the Convention.

the Conference, States Parties [3] noted, in relation to Article IV on national implementation measures, that: [4] 'The Conference notes the importance of ...inclusion in textbooks and in medical, scientific and military educational programmes of information dealing with the prohibition of microbial or other biological agents or toxins and the provisions of the Geneva Protocol.'

Similar statements were subsequently agreed at following Review Conferences. However, during the 1990s, when concerns about Biological Warfare (BW) returned, the attention of diplomats was centred on the problem of how confidence in compliance with the Convention might be improved and there was very little involvement of the civil life-science community. [5] After the failure of these efforts, when states decided to discuss and promote common understandings on more tractable issues, Australia reported in a 2005 Intercessional Meeting on Codes of Conduct that: [6]

> 1. Amongst the Australian scientific community, there is a low level of awareness of the risk of the misuse of the biological sciences to assist in the development of biological or chemical weapons. Many scientists working in 'dual-use' areas simply do not consider the possibility that their work could inadvertently assist in a biological or chemical weapons programme...

At the same meeting we reported work carried out with the editor of this volume, Brian Rappert, in which we had interactive seminar discussions with life scientists at 15 UK universities. Analysis of the tape recordings of these seminars led us to conclude that: 'There is little evidence from our seminars that participants: a. regarded bioterrorism or bioweapons as a substantial threat; b. considered that developments in life-sciences research contributed to biothreats; c. were aware of the current debates and concerns about dual-use research; or d. were familiar with the BTWC.' [7]

In the next year we reported to the Sixth Review Conference on further seminars in several other countries. In regard to the UK seminars we concluded that: 'The results from the remainder of the seminars were consistent with all

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3 States Parties refers to States that have both signed and ratified the Biological and Toxin Weapons Convention. (BTWC). The BTWC currently has 163 States Parties and 13 signatories. There are 19 states which have neither signed nor ratified the Convention.

4 Again, for the text of the Final Declaration, see: www.opbw.org.

5 Dando, M. R. 1994, *Biological warfare in the 21st century: Biotechnology and the proliferation of biological weapons*, London: Brasseys; Dando, M. R. 2002, *Preventing biological warfare: The failure of American leadership,* Basingstoke: Palgrave.

6 Australia 2005, *Raising Awareness: Approaches and Opportunities for Outreach,* BWC/MSP/2005? MX/WP.29, available: www.opbw.org.

7 Dando, M. R. and Rappert, B. 2005, *Codes of Conduct for the Life Sciences: Some Insights from UK Academia*, Briefing Paper no. 16 (2nd series), University of Bradford, May, available: www.brad.ac.uk/acad/sbtwc.

of these points [enumerated above]. A particular surprise was that so few of the participants (less that 10 per cent in most groups) had heard of the mousepox experiment that has figured largely in security literature.' [8]

There were, of course, some differences in the interactions that we reported in the seminars in the Netherlands, Finland, the US and South Africa but we stated that '[D]espite such differences between the seminars held in the different countries, the degree of similarity between the responses in the seminars was much more pronounced'. Our subsequent experience of carrying out seminars in 16 different countries with a few thousand life scientists in over 110 different departments has consolidated these findings. [9] Indeed, we used the seminars more as an awareness-raising mechanism rather than as a means of investigative research into the attitudes of life scientists.

The Education Gap

These findings demand some serious explanation. Many physicists are clearly aware of the dangers of the misuse of their science and have played important roles, for example, in the Pugwash movement. In the 1980s and 1990s, chemists were also influential in helping to bring negotiations of the Chemical Weapons Convention (CWC) to a successful conclusion, and the International Union of Pure and Applied Chemistry (IUPAC) has contributed major reviews of relevant science and technology to the first two Review Conferences of the CWC. Therefore, it is not unreasonable to ask why practising life scientists are so unaware of the BTWC and the problem of dual use despite increasing attention being given to these issues, for example, by national science academies.

One possible explanation is that life scientists are uninformed of biosecurity issues because they do not feature in their university education. In order to investigate this possibility, in cooperation with the Italian Landau Network Centro-Volta, we carried out an internet survey of a sample of courses in the EU. As detailed further in the chapter by Mancini and Revill, the results were quite startling: 'This research suggested that only three out of 57 Universities identified currently offered some form of specific biosecurity module and in all cases this was optional for students.' [10] On the other hand, the survey noted:

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8 Rappert, B., Chevrier, M. I. and Dando, M. R. 2006, *In-depth Implementation of the BTWC: Education and Outreach*, Review Conference Paper no. 18, University of Bradford, available: www.brad.ac.uk/acad/sbtwc.

9 Rappert, B. 2007, *Biotechnology, security and the search for limits: an inquiry into research and methods*, Basingstoke: Palgrave; Rappert, B. 2009, *Experimental secrets: International security, codes, and the future of research*, University Press of America.

10 Mancini, G. and Revill, J. 2008, *Fostering the biosecurity norm: Biosecurity education for the next generation of life scientists*, London Network, Centro Volta and University of Bradford, available: www. Dual-use bioethics.net.

> There is evidence of a considerable number of bioethics modules and nearly half of the degree programmes surveyed evidenced some form of bioethically-focused module. In terms of biosafety modules... roughly one-fifth of life-science degrees in the sample contain a specific dedicated biosafety module although several of these specific modules were optional.

So we found a reasonable number of biosafety modules, a large, and we suspect, increasing number of bioethics modules, and virtually no biosecurity modules.

We attempted to investigate in more detail by looking for any kind of reference to biosecurity issues in the course material. Again the picture was bleak:

> Exactly what constitutes a reference varies; however, based on the quantitative data from the investigation, we found a total of 37 life-science degree courses out of our sample of 142 where there was clear evidence of a reference to biosecurity. Only a minority of the degree courses in the study — a total of 22 out of 142 — made a reference to the BTWC, BW and/or arms control, and a similar number, 29 degree courses, exhibited some reference to the dual-use issue.

When we carried out a similar survey in Japan, and as can be seen from the analysis presented by Minehata and Shinomiya, we found a similar picture. Of 197 life-science degree courses in 62 universities we found only three specific biosecurity modules. [11]

In Japan we took the investigation a stage further by sending out a questionnaire to lecturers asking why biosecurity and dual use was not being taught. Clearly some lecturers did not see these subjects as relevant to their courses, but others certainly did. Where people thought the topics relevant but did not teach them, the reasons cited were a lack of expertise and access to necessary resources, and a lack of space on a very crowded timetable in the modern life sciences.

Correcting the Deficiency

Correcting this deficiency in education- and awareness-levels of life scientists will be a massive task that will require action by a range of constituencies involved in life-science education including, *inter alia*, governments, bodies

11 Minehata, M. and Shinomiya, N. 2009, *Dual-use education in life science degree courses at universities in Japan*, National Defence Medical College of Japan and Bradford University, available: www.dual-use bioethics.net.

responsible for the administration of standards in higher education, funders of life-science education, civil society groups and non-governmental organisations involved in the production of educational material, and teachers and trainers. [12]

As is evidenced by the convergence of ethics and medicine in the area of biomedical ethics, [13] the consideration of moral dilemmas is not new in life-science research. However, current concern about dual use [14]— where science findings can be used for malign as well as benign purposes — arises from a new range of security threats. These include the changing nature of warfare, the possibility of new forms of mass-casualty terrorism, a discernable commitment by States Parties to the BTWC to address these threats through seeking to improve awareness and education amongst life scientists, reviews of scientific oversight regarding dual-use research performed by national scientific academies [15] (particularly in the US), and a genomic and biotechnology revolution in life science with the rapid and worldwide spread of advanced science and technology. Thus concerns about dual use are being discussed in the context of a distinctly new phenomenon — namely, a convergence between security concerns and the practice of life scientists in what might be termed a novel biosecurity problem.

The term 'biosecurity' has been used in different ways in different contexts. We should, therefore, be very clear about usage of the term here. In our view the threat spectrum ranges from natural disease through to inadvertently caused disease. We deal with natural disease by public-health measures and inadvertently caused disease is restricted by 'biosafety' — good laboratory practice. The concept of laboratory biosecurity has also arisen to ensure that dangerous materials are kept secure from those with malign intent. We see laboratory biosecurity as part of biosecurity, but for us the term has a much wider meaning related to the concept of a web of preventative policies centred on the prohibition of the misuse of the life sciences embodied in the General Purpose Criterion of the BTWC. Thus biosecurity is the objective of the whole range of policies, such as export controls, biodefence and national implementation of the Convention, that minimise the possibility that the life sciences will be misused for hostile purposes. Within that range of policies there is, in our opinion, a role for practising life scientists in being aware that the materials, technologies and knowledge they produce may be misused and for contributing their expertise to the development and maintenance of preventative policies.

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12 Dando, M. R. 2009, Dual-use Education for Life Scientists, *Disarmament Foru*m, vol. 1, pp. 41–4.

13 Jonsen, A. R. 1998, *The birth of bioethics,* 1st edition, USA: Oxford University Press.

14 Atlas, R. and Dando, M. 2006, 'The dual-use dilemma for the life sciences: Perspectives, conundrums, and global solutions', *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*, vol. 4, pp. 276–86.

15 The US National Academy of Sciences' (Fink Committee) classification of seven classes of experiment sought to illustrate the types of endeavour that would require careful review by informed experts.

In order to begin building capacity in biosecurity education, a new range of creative and innovative interventions are required. As set out in the following argument, it is seen that biosecurity education can be easily accommodated by current standards in higher education in the UK. In the US, recommendations for the adoption by federally funded institutions of biosecurity education have already been set out.

Scope for Biosecurity Education in the UK and US

Whilst ethical consideration of the implications of dual-use science and technology is conspicuously absent from the vast majority of curricula in UK higher education, in the US, and indeed worldwide, it is apparent that a codified response through the development of new guidelines and policies that reflect biosecurity concerns will not necessarily be required within UK higher education. In order to satisfy its statutory obligation to ensure that publicly funded teaching provision is of a high standard, the UK's Higher Education Funding Council (HEFCE) [16] contracts the Quality Assurance Agency (QAA) [17] to 'devise and implement quality- assurance methods' and is responsible for the conduct of audit and review of teaching quality in both higher and further education. Although not a national curriculum that sets standards in UK higher and further education, the Subject Benchmark Statements produced by the Quality Assurance Agency [18] require the inclusion of an ethical dimension in all undergraduate bioscience programmes. These are largely aspirational; however, they 'set out expectations about standards of degrees in a range of subject areas. They describe what gives a discipline its coherence and identity, and define what can be expected of a graduate in terms of the abilities and skills needed to develop understanding or competence in the subject.' [19]

The 2002 QAA bioscience benchmark statements made a number of references to 'ethical' aspects of this subject-area, including the following requirements:

> Students should expect to be confronted by some of the scientific, moral and ethical questions raised by their study discipline, to consider viewpoints other than their own, and to engage in critical assessment and intellectual argument. [20]

16 http://www.hefce.ac.uk/Learning/qual/qaa.asp.
17 http://www.qaa.ac.uk/academicinfrastructure/benchmark/default.asp.
18 UK Quality Assurance Agency (QAA) 2002 & 2007, *Honours Degree Subject Benchmark Statements*, Bioscience, available: http://www.qaa.ac.uk/academicinfrastructure/benchmark/statements/Biosciences07.pdf.
19 Ibid.
20 Ibid.

> Recognising the moral and ethical issues of investigations and appreciating the need for ethical standards and professional codes of conduct. [21]
>
> All students should: Have some understanding of ethical issues and the impact on society of advances in the biosciences. [22]
>
> Good students should: Be able to construct reasoned arguments to support their position on the ethical and social impact of advances in the biosciences. [23]

Honours Degree Subject Benchmark Statements were re-stated by QAA again in 2007, where the Subject Benchmark Statement for Biosciences again reiterated the importance of the inclusion of an ethical dimension in undergraduate programmes. Whilst ethics teaching forms an important component in many bioscience courses and courses address a range of ethically related issues, ethics in bioscience or bioethics education could easily be extended to accommodate and incorporate the ethical concerns of biosecurity education. Institutional audits of teaching-quality assessment by the QAA strengthen incentives to extend teaching in ethics into the area of biosecurity.

Further to this, a report [24] published in December 2008 by the US National Advisory Board for Biosecurity (NSABB) sets out a Strategic Plan for Outreach and Education on Dual-Use Research Issues. As specified in a related contribution to this book, this strategy envisages the implementation of a series of recommendations on 'the development of programmes for outreach, education, and training on dual-use research issues for all scientists and laboratory workers at federally funded institutions in the US'.

Funders of Science

Increasingly, recipients of research funding must be willing to comply with requirements set out by funders of science that are intended to ensure bioscience-research activities are in full compliance with guidance on ethics. Indeed, in the case of some funders of bioscience, reference to dual-use research is now explicit.

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21 Ibid.
22 Ibid.
23 Ibid.
24 National Science Advisory Board for Biosecurity 2008, *Strategic plan for outreach and education on dual use research issues*, December, Washington, DC.

As outlined in its position statement [25] on Research Ethics, the UK Biotechnology and Bioscience Research Council (BBSRC) states that it has:

> a responsibility to ensure that its funds are used ethically and responsibly. Potential applicants should consider whether their work is likely to give rise to societal concerns about the purpose of the research, or includes any social or ethical issues regarding its conduct or potential outcomes (for example, relevance to development of biological weapons; products and processes that might be used in social discrimination), or other aspects of potential public concern.

As stated in its Terms and Conditions [26] for Research Council Grants, according to the Research Councils UK (RCUK), recipients of its funding are responsible for ensuring that:

> …ethical issues relating to the research project are identified and brought to the attention of the relevant approval or regulatory body. Approval to undertake the research must be granted before any work requiring approval begins. Ethical issues should be interpreted broadly and may encompass, among other things, relevant codes of practice, the involvement of human participants, tissue or data in research, the use of animals, research that may result in damage to the environment and the use of sensitive economic, social or personal data.

The UK Medical Research Council (MRC) [27] sets out detailed guidance on ethics that addresses a broad range of areas including 'clinical research governance', 'global bioethics' and 'good research practice'. Additionally, the MRC Position Statement on Bioterrorism and Biomedical Research recognises the 'dual-use nature of life science and the importance in funding research of due consideration of ethical dilemmas presented by research'.

Adopting a similar approach, the Wellcome Trust specifies the importance of appropriate processes existing at institutional, national and international levels for the review and oversight of dual-use research. In its Position Statement on Bioterrorism and Biomedical Research, the Wellcome Trust [28] cites the US National Academy of Sciences' (Fink Committee) classification of seven classes of experiment to illustrate the types of endeavour that would require careful review by informed experts. The experiments this committee specified are those that would:

- demonstrate how to render a vaccine ineffective

25 http://www.bbsrc.ac.uk/funding/apply/grants_guide.pdf.
26 http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/documents/tcfec.pdf.
27 http://www.mrc.ac.uk/Ourresearch/Ethicsresearchguidance/index.htm.
28 http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002767.htm.

- confer resistance to therapeutically useful antibiotics or antiviral agents
- enhance the virulence of a pathogen, or render a non-pathogen virulent
- increase transmissibility of a pathogen
- alter the host range of a pathogen
- enable the evasion of diagnostic and detection modalities
- enable the weaponisation of a biological agent or toxin.

Improved grant-application procedures, more stringent reporting requirements and management, and oversight of the grants by funders will help ensure that grantees live up to stipulated ethical obligations and efficient and effective implementation of such requirements will facilitate the development of best practice in the financing of life-science research. Given the low levels of awareness amongst life scientists of biosecurity issues it is not surprising that progress has been slow in the implementation of measures such as effective training programmes to address the issue. However, it can be expected that these measures will be implemented in coming years: the question is, how quickly and how well?

Civil Society Groups and Non-Governmental Organisations

In the meantime, there does seem a potential role for civil society in providing models of what might be done to close the gap most effectively in the shortest timeframe. This is what we have been attempting to do over the last few years in developing a Dual-use Biosecurity Education Module Resource (EMR). The NSABB report 'Strategic Plan for Outreach and Education on Dual Use Research Issues' [29] mentioned previously considers what needs to be done in some detail. In its view, developing a strategic plan requires: 'First and foremost, the target audience must be identified and assessed as to their level of understanding of the issues since this will guide educational strategies…[Then]…messages should be tailored to specific target-audiences. Key points must be identified and specifically crafted.' And because there are so many different possible methods of communication, 'it is important to select those methods that will most effectively reach the intended audiences'.

Therefore, when we applied a similar method of analysis to our work, it was clear that our intended target audience — university-level lecturers and students — did not have a high level of awareness of biosecurity and dual-use issues. Furthermore, given the prevalence of the use of the internet in universities it

29 National Science Advisory Board for Biosecurity 2008, op. cit.

was clear that providing information on the web was by far the most efficient and effective way forward. However, given the pressure on the timetable we thought it unwise to design a one-size-fits-all educational module and decided to design an EMR that could be used by different lecturers to fit relevant parts into their own courses.

Our thinking was also much influenced by the developing consensus about education of life scientists that developed at the 2008 BTWC Intercessional Meetings. The final report of these meetings states: [30]

> 26. States Parties recognised the importance of ensuring that those working in the biological sciences are aware of their obligations under the Convention and relevant national legislation and guidelines, have a clear understanding of the content, purpose and foreseeable…security consequences of their activities, and are encouraged to take an active role in addressing the threats posed by potential misuse of biological agents and toxins as weapons, including bioterrorism.

This paragraph of the report then continues, significantly: 'States Parties noted that formal requirements for seminars, modules or courses, including possible mandatory components, in relevant scientific and engineering training programmes and continuing professional education could assist in raising awareness and in implementing the Convention.'

In the paragraph that followed, States Parties set out what they agreed would be of value in such programmes:

> (i) Explaining the risks associated with the potential misuse of the biological sciences and biotechnology
>
> (ii) Covering the moral and ethical obligations incumbent on those using the biological sciences
>
> (iii) Providing guidance on the types of activities which could be contrary to the aims of the Convention and relevant national laws and regulations and international law
>
> (iv) Being supported by accessible teaching materials, train-the-trainer programmes, seminars, workshops, publications, and audio-visual materials

30 Meeting of the States Parties to the Convention on the Prohibition of the Development, Protection and stockpiling of Bacteriological [Biological] and Toxins Weapons and on their Destruction (2008) Report of the meeting of States Parties, BWC/MSP/2008/5, United Nations, Geneva, 10 December.

(v) Addressing leading scientists and those with responsibility for oversight of research or for evaluation of projects or publications at a senior level, as well as future generations of scientists, with the aim of building a culture of responsibility

(vi) Being integrated into existing efforts at the international, regional and national levels.

Our idea for the EMR was to capture as many of these ideas as possible based on the concept of having a web of integrated preventative policies that together would persuade everyone thinking of breaking the prohibition that the costs would far outweigh the benefits. [31] However, in work with colleagues at Japan's National Defence Medical College on designing and testing the EMR (under British Council Funding) it became clear that we needed to start the lecture series with material that could be readily grasped by life scientists.

Thus the EMR consists of 21 lectures, each with 20 PowerPoint slides and notes for the lecturer, and direct links to the references used via the web. Each lecture also has some suggested essay questions and the EMR has an introduction to all the material for lecturers and a small number of Briefing Papers cover material that would be less familiar to life scientists. Several lectures are also duplicated, with material in the second set being more scientifically orientated.

Therefore, our EMR is designed in five parts as follows:

Outline of the EMR

A. Introduction and Overview

Lecture 1

B. The Threat of Biological Warfare and Biological Terrorism and the International Prohibition Regime

Lectures 2–10

C. The Dual-Use Dilemma and the Responsibilities of Scientists

Lectures 11–18

D. National Implementation of the BTWC

Lectures 19–20

E. Building an Effective Web of Prevention

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31 Rappert, B. and McLeish, C. 2007, *A Web of prevention: Biological weapons, life sciences and the governance of research*, London: Earthscan.

Lecture 21

Thus the first lecture gives a brief overview of the whole of the module resource in order to orientate the user.

The second section takes up the story of the misuse of modern biology after the discovery of the causes of infectious diseases in the late nineteenth century by scientists such as Pasteur and Koch. This history is largely unknown amongst life scientists and forms a basis for consideration of the possible misuse of future advances. In this section we have also introduced modern accounts of the traditional agents such as anthrax, smallpox and botulinum toxins to better engage scientists' interest.

The lectures in Section B are set out as follows:

Section B of the EMR

2. BW from Antiquity to World War I

3. BW from WWI to WWII

4. BW during the Cold War

5. The impact of BW Agents

6. Assimilation of BW in State Programmes

7. International Legal Agreements

8. Strengthening the BTWC 1980–2008

9. The 2003–2005 Intercessional Process

10. The 2007–2010 Intercessional Process

Section B ends by briefly reviewing how the international community has attempted to deal with the threat of the proliferation of biological weapons through the 1925 Geneva Protocol, the 1975 BTWC and the 1997 CWC (given that there is an overlap between the BTWC and CWC in the area of mid-spectrum agents such as toxins and bioregulators).

It can be seen that these lectures begin with a consideration of the history of biological warfare and end with the BTWC recent annual meetings in which scientists have become increasingly involved — at least at the level of national academies and industrial leaders. This then sets the basis for the third section of our module.

The lectures in Section C are set out as follows:

Section C of the EMR

11. Bioethics methodology

12. Obligations derived from the BTWC

13. The growth of dual-use bioethics

14. Dual-use: The Fink Report

15. Dual-Use: Examples

16. The Lemon-Relman Report

17. Weapons targeted at the nervous system

18. Regulation of life sciences

Although present evidence strongly suggests there is little biosecurity or dual-use content in university life-science modules dealing with bioethics, it is our belief this is probably the best place to focus on these issues. Life scientists are becoming familiar with the ethical problems that new research brings up, and the teaching of bioethics is growing in universities. Our view is that biosecurity and dual-use issues are best presented to life scientists in the context of the moral and ethical implications of research (see item (ii) in the 2008 report of the BTWC meeting on education above). [32] Therefore, this section of the module starts with a review of standard bioethical analyses that students are likely to have encountered before, introducing the growing literature on dual-use bioethics. The section then leads to a consideration of the key US National Academics Reports (Fink and Lemon-Relman) that began the closer examination of the dual-use problem from within the scientific community. Some lectures examine classic dual-use experiments such as the mousepox experiment in lecture 15 and the contention by Lemon-Relman that the dual-use problem is far wider than just research in microbiology, as illustrated in lecture 17 regarding concerns over the misuse of advances in neuroscience. The section ends with a lecture that reviews the various papers that have recently discussed regulation of the security implications of the life sciences.

The final two sections of the EMR continue this theme of national and international regulation and are set out as follows:

Section D of the EMR

19. International regulation of biotechnology

32 Revill, J. 2009, *Biosecurity and bioethics education: A case study of the UK context*, Wellcome trust Dual-Use Bioethics Group, University of Bradford, available: www.dual-usebioetics.net.

20. National implementing legislation

Section E of the EMR

21. The web of prevention

Looking back at the list of specific suggestions agreed by State Parties to the BTWC in 2008, we would argue that we have covered most. Lectures cover the risks of misuse, the moral and ethical obligations of life scientists, give guidance on the types of activities which could be contrary to the aims of the Convention, and provide accessible teaching materials. Therefore, what else needs to be done?

Increasing Efficiency through Networks

One way to build on the work described here is to carry out more surveys of education provision in the university sector in different countries. These surveys, particularly if carefully followed up by questionnaire, telephone and email, inevitably provide a list of life-science lecturers who are interested in bringing issues of biosecurity and the dual-use dilemma into their courses. By assisting the development of country and regional networks on the basis of these contacts it should be possible to generate a much faster development and uptake of material suitable for different countries and regions. Such an approach would also fit with the States Parties agreement on the value of education efforts being integrated into existing international, regional and national activities.

As shown in a recent report from the US National Academies on 'Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done?' dual-use bioethics developments will fit within a broader effort to develop ethics education.[33]

What is also clear is that these wider developments, whilst showing some advances in understanding how to proceed best in engaging students, have not yet found an adequate means of evaluating the impact of teaching on later ethical behaviour. The report points out that:

> Attempts to evaluate and improve ethics education for scientific and engineering research and practice are just beginning. However, they do show that even though immediate results of some programmes are

33 National Academies 2009, *Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done*? Summary of a workshop, Washington, DC: National Academies Press.

> positive, circumstances and pressures can overwhelm graduate students, postdoctoral fellows, and junior-faculty and researchers and undermine results.

In the longer term, attention to evaluation of the impact of dual-use bioethics education will be central to supporting the prohibition embodied in the BTWC.

More immediately, a further chance of improving efficiency will arise at the 2011 Seventh Review Conference of the BTWC because just after the specific suggestions on education (and codes of conduct) discussed above, paragraph 31 suggested that: 'State Parties are encouraged to inform the Seventh Review Conference of, *inter alia*, any actions, measures or other steps they may have taken on the basis of the discussions…in order to facilitate…decisions on further action.'

Therefore, if networks of life scientists concerned with implementing dual-use bioethics education can be established in different countries and regions, and if they carefully evaluate their efforts, the results could be applied rapidly elsewhere to help quickly close the education gap.

What Should Be Done Now?

Even if all of what has been discussed in this chapter were achieved it would still leave a great deal needing to be done. One specific point in the 2008 agreement amongst States Parties to the BTWC seems particularly important to us: train-the-trainer programmes, being an important capacity-building initiative in developing a worldwide culture of responsibility amongst life scientists. In regard to this objective, we believe rapid progress can be made through the use of modern technology.

Train-the-Trainer

In order to facilitate efficient and effective engagement across a range of life-science constituencies worldwide we developed an expert-level online distance-learning train-the-trainer programme in dual-use bioethics (biosecurity) education. The original iteration of this module consisted of two key elements: 1. the EMR described above, together with 20 expert-level scenarios that introduce users to examples of the complex bioethical dilemmas that have confronted life-science research; and 2. a range of innovative electronic online distance-learning technologies that facilitate outreach on a worldwide basis.

The aim of the module was to introduce educators to the concepts in bioethics and biosecurity education by developing awareness and understanding of a

range of dual-use ethical issues arising from the impact of science and technology on society. The module provided the opportunity to develop knowledge of approaches that give a defence for ethical decisions or recommendations regarding dual-use technologies. Educators were guided through the lecture series by a trainer. Participants were introduced to scenarios where the results of well-intentioned scientific research can be used for both good and harmful purposes which have given, or may in future give, rise to what is now widely known as the 'dual-use dilemma', providing the opportunity to analyse in depth the ethical dilemmas these scenarios raise. Central to this is the importance and role of ethics in informing the debate. The programme was intended to have an applied, practical dimension in that its aim was to enable and facilitate more bioethical research into dual-use issues, and help develop policies and practices that might prevent the misuse of knowledge generated through biomedical research.

The methodological approach relating to the delivery and implementation of this module was developed with UK academic standards in mind, so that the module would furnish participants with knowledge and understanding to review and appraise ethical theories and methods relevant to dual-use bioethics and recognise and discuss ways in which the application of ethics methodologies resolves or leaves unresolved questions relating to dual-use issues. In relation to subject-specific skills, the module would facilitate educators' organisation and synthesis of ideas and questions relevant to assessing ethical dilemmas in specific dual-use issues affecting humans, animals and plants generally, and across a select range of life-science sub-disciplines of relevance including human biology, zoonotic diseases, phytopthology, biotechnology, DNA synthesis, drug control, genomics, genetic engineering and genetic modification, immunology, nanotechnology, neuroscience, scientific freedom, synthetic biology, whistleblowing, and processes relating to ethical review. As to personal transferable skills, educators would be able to evaluate and integrate data from a variety of sources and express ideas clearly, both verbally and in writing; and communicate effectively in an online environment using a range of media.

Technologies

The module was designed to facilitate participation in lectures, seminars, and discussion groups that would all take place online. A novel approach to online distance learning was adopted. This utilised online distance-learning technologies that facilitate the delivery, viewing of, and participation in lectures by real-time video transmission. With this approach participants can see a live video transmission of the teacher, and the teacher can guide the participants through respective online sessions with the support of a range of online teaching technologies and visual aids. Together with the lecture, these

can be broadcast simultaneously, including PowerPoint presentations, word-processing files, graphical images, as well as audio and video. Participants with video cameras can be invited by the teacher to join live online 'face-to-face' discussion and the latter can be viewed online by all members. Those with the capability to transmit audio can raise a (virtual) hand, be invited by the teacher to join live online discussion, and can communicate this way with all of those taking part, regardless of geographical location. Participants without video and audio capability can follow the class online and communicate with the teacher by typing questions via their keyboard. The classes can be recorded and viewed online subsequently.

Working in a fully supported online-learning community, members are able to communicate and interact with peers, developing their practice through sustained reflection and involvement in a range of activities and scenarios. Participants are encouraged to bring their own ideas and experiences to the course, sharing these with peers to contextualise their knowledge and understanding in ways that will help them, as life-science professionals, to meet the ethical challenges thrown up by dual use. As well as participation in a vibrant academic (social-network) web-group where interaction on coursework-related topics between tutors, moderators and students takes places, members undertake independent reading and research. Participants benefit from a supportive and interactive online web-based learning community and work both independently to produce a coursework assignment, as well as in online groups to produce a significant group-work course assignment.

Conclusion: Recommendations for the BTWC

As has been made clear, a major effort will be required to raise awareness levels amongst life scientists and develop a culture of responsibility around the dual-use implications of research. Whilst concerns raised by high-level reviews of scientific oversight of dual-use research are becoming assimilated into the terms and conditions associated with the funding of life-science research, this is a long-term initiative and will necessarily involve a broad range of constituencies. As set out by Mathews and Webb, [34] two practical suggestions would assist in sustaining interest in this area. The first is that States Parties could report to the Seventh Review Conference of the BTWC in 2011 on progress on implementation and capacity building in dual-use/biosecurity education. The second is that

34 Mathews, R. J. and Webb, J. M. 2009, 'Awareness-raising, Education and Codes of Conduct within the Framework of the BWC', Chapter 9, *BWPP Biological Weapons Reade*r, McLaughlin, K. and Nixdorff, K. (eds).

the confidence-building mechanism (CBM) could be extended by appending progress reports on implementation and capacity building in education for life scientists to annual CBM reports.