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The Ethical Issues of Dual-Use and the Life Sciences

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Introduction

The destructive use of knowledge is not a new concern. This theme has been revisited throughout the history of science and, indeed, the history of thought. In recent times, particularly post-2001, this topic is playing out in relation to the life sciences. An unsettling concern has been posed about modern biotechnology: might the knowledge being gained further—rather than prevent—the spread of disease? In other words, might the life sciences become the death sciences? If that is the case, then should there be limits to what research is pursued?

The notion of *dual-use* has been widely employed in the past to refer to knowledge and technologies with civilian and military applications or, more generally, those technologies that can serve multiple purposes. Today, in the context of the aforementioned destructive applications of the life sciences, the specific concern attached to this term relates how emerging knowledge and techniques (as opposed to bioagents and lab equipment) might figure in the development of biological weapons. The focus thus is not so much on how research is carried out, but rather on its outputs.

This article will examine dual-use issues related to research in the life sciences. It starts with examples of *dual-use research*, as well as the recent policy developments relating to this notion. In so doing, some of the ethical concerns at stake will be examined. The essay will then consider the limitations associated with the manner in which dual-use is often framed— as

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pertaining to certain *experiments of concern*. From this initial unpacking, the remainder of the entry will consider important variations in the manner this term is conceived across the globe.

An Evolving Sense of Concern

> The practice of scientific research and the use of knowledge from that research should always aim at the welfare of humankind, including the reduction of poverty, be respectful of the dignity and rights of human beings, and of the global environment, and take fully into account our responsibility towards present and future generations.
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> (United Nations Educational, Scientific, and Cultural Organization, 1999)[2]

As advocated in the above quote from the *Declaration on Science and the Use of Scientific Knowledge*, modern ethical interpretations of science emphasize applications that improve humanity. In line with this widely acknowledged aspiration, scientists, engineers and others are viewed as having twin duties towards beneficence and non-maleficence. As these are necessarily linked with societal implications of research, the identification of such principles directs attention to responsibility in scientific research.[3]

To this end, the development of a "socially aware" science has been advocated by many. For instance, in the 2009 publication *On Being a Scientist*, the U.S. National Academy of Sciences (NAS), National Academy of Engineering, and Institute of Medicine contended that:

> The standards of science extend beyond responsibilities that are internal to the scientific community. Researchers also have a responsibility to reflect on how their work and the knowledge they are generating might be used in the broader society. (NAS, 2009, p. 48)[4]

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[2] 1999 World Conference on Science, a collaboration of the International Council for Science (ICS) and the UN Educational, Scientific, and Cultural Organization (UNESCO), produced the Declaration on Science and the Use of Scientific Knowledge. See http://www.unesco.org/science/wcs/eng/declaration_e.htm.

[3] If one considers the generation of knowledge as the primary goal of science, then the responsibilities of the scientists will be more in line with their duties towards their peers and not society.

[4] As quoted on page 48. This is the most recent edition of the widely used introduction to responsible conduct of research from the National Academies. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (Committee on Science, Engineering, and Public Policy). (2009) *On Being a Scientist: a Guide to Responsible Conduct in Research: Third Edition.* Washington: National Academies Press. It can be downloaded at http://www.nap.edu/catalog.php?record_id=12192.

In other words, the attention to responsibility needs to extend beyond the traditional views of misconduct related to plagiarism or consent for experimentation.[5] As modern thinking emphasizes the interweaving of science and society, what counts as appropriate standards must be open to continuous reevaluation as part of an exchange between publics and technical experts.

Such demands raise a number of far-reaching issues. In particular, one must question whether a more socially responsible science requires limitations to preserve its beneficence. As the common phrase goes, "With great knowledge comes great responsibility," and the question of whether the rapid advances across life science research can readily facilitate the deliberate spread of disease is increasingly present. Such dual-use debates attend to how the knowledge derived from civilian life science fields— such as virology, molecular genetics, neuroscience, synthetic biology and elsewhere—are helping to lower the barriers to, and enhance the power of, bioweapons (see, for example, Royal Society, 2006). These discussions thus shift the focus beyond the limits of traditional preoccupations in the life sciences about biosafety and the physical security of pathogens.

The remainder of this section will further discuss this sense of dual-use aspect of science, the challenges associated with addressing it in the life sciences, and some of the associated ethical issues.

A brief history of dual-use

Records from previous centuries indicate that the generation of new knowledge and techniques were often accompanied by misgivings about their abuse and misuse.6 Nowhere have these concerns been more prominent that in relation to the potential of the research to contribute towards destructive applications. Thus, while science and engineering have been

[5] Misconducts within science have been well examined by many sources. For a good review of the "FFP" misconducts of falsification, fabrication and plagiarism see (NAS, 2009).
[6] For example, both Leonardo da Vinci and Sir Francis Bacon both explicitly recorded hesitations regarding the misuse of their work, and detailed plans for avoiding the research from falling into the wrong hands.

central in enabling new forms of medical treatment, they have also provided the means for the development of novel war-fighting technologies. These attempts to harness science in the service of "security," "national defense," or "conflict" have led to many questions being posed as to what research should be funded, what link exists between science and innovation, and what role technical experts should play in setting military priorities and policies.

These concerns are important for many reasons, not least because the pace and breadth of developments often challenge the prospects of achieving security. To the extent that science contributes new military technologies, it plays a part in fueling arms races, producing even more powerful capabilities, and fostering global power asymmetries. The development of nuclear weapons remains the quintessential example of the indefinite and pained relationship between science and security. Nonetheless, while the advent of nuclear sciences offered considerable opportunities for the development of weapons (as unmistakably captured in the image of an explosive mushrooms cloud), it must be acknowledged that the same research also offered the potential for significant beneficial civilian applications. Thus, the nuclear sciences presented a situation in which the possibility of great benefit or great harm was widely recognized as early on as possible from the same work (Evans, 2010).

The quandaries identified with the nuclear research pertaining to the multiple uses for the same item came to be denoted as dual-use. Following World War II, this concept of dual-use has diversified to include a number of different meanings. These meanings included how notionally civilian facilities can be used to develop military items, how equipment and materials intended for peaceful purposes can be used for destructive ones, and how the knowledge and techniques generated through science can aid the development of weaponry (Atlas & Dando, 2006). For each, the dual potential could stem from the use of a number of different items of research and methodological advances and may not be limited to one single item of research being misappropriated.[7] Thus, dual-use is a continually evolving concept—but one generally concerned with some sort of non-benign application.

[7] While it had previously been suggested that technology emerged from scientific research in a rather linear fashion, modern interpretations suggest that technological innovations are a composite result of many different areas of research. Thus, the modern interpretation of the dual-use concept as used in discussions pertaining to

A brief history of dual-use life sciences

Arguably the most influential statement of dual-use life science was the U.S. National Academies report *Biotechnology Research in an Age of Terrorism* (commonly known as the Fink Report), first released in late 2003. As declared in the report, its focus was "the intentional use of biotechnology for destructive purposes" (National Research Council, 2004, pp. 14–15). Professor Gerald Fink of the Whitehead Institute for Biomedical Research chaired the Committee and offered this depiction of the issued at stake:

> … [A]lmost all biotechnology in the service of human health can be subverted for misuse by hostile individuals or nations. The major vehicles of bioterrorism, at least in the near term, are likely to be based on materials and techniques that are available throughout the world and are easily acquired. Most importantly, a critical element of our defense against bioterrorism is the accelerated development of biotechnology to advance our ability to detect and cure disease. Since the development of biotechnology is facilitated by the sharing of ideas and materials, open communication offers the best security against bioterrorism. The tension between the spread of technologies that protect us and the spread of technologies that threaten us is the crux of the dilemma.
>
> (National Research Council, 2004, p. vii)

Thus, even at first glance, concerns about destructive applications of biology pose a vexing dilemma, since the promising aspects go hand in hand with its threatening ones.

Yet, once the basic issues are examined in further detail, the situation becomes ever thornier. Despite presenting a recognizable danger, there remains considerable uncertainty and disagreement over the severity of the threats associated with biological weapons. As exemplified in the quote by Professor Gerald Fink, in recent discussions of international security, there has been considerable emphasis on the possible use of biological weapons by terrorist groups. However, the likelihood of the successful weaponization of bioagents has been hotly disputed. The limited number of bioterrorist attacks in the past and the difficulties experienced by even well-funded groups and states in weaponizing pathogens are

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the life sciences are defined by their plurality of research inputs that might contribute towards a nefarious application (McLeish 2007).

key factors cited to indicate a low likelihood of attacks. Skeptics argue that this will remain the situation even if sub-state groups act in concert with likely states of concern for the West. Following from this overall evaluation, the possibility that sub-state groups could make use of advanced life science research—as so often the focus today—is even more remote.

Of course, at issue in such disagreements is just what counts as a successful or highly consequential attack. For example, while the 2001 U.S. anthrax letter mailings might not have caused mass casualties, they were highly disruptive and economically costly. In other words, whether biological weapons are treated as worrying because they are "weapons of mass destruction" or "weapons of mass disruption" becomes an important consideration when assessing the potential for dual-use research.

In an attempt to get a handle on the issues at stake, the Fink Report made a series of practical suggestions towards ensuring the responsible oversight of the life sciences.[8] In the report, seven classes of experiments were identified which the committee suggested illustrated the types of endeavors or discoveries that required informed consideration before they are undertaken or, if carried out, before they are published in full detail.[9] These categories, commonly labeled *experiments of concern*, included:

- Demonstrate how to render a vaccine ineffective.
- Confer resistance to antibiotics or antivirals.
- Enhance a pathogen's virulence or render a nonpathogen virulent.
- Increase a pathogen's transmissibility.
- Alter a pathogen's host range.
- Enable evasion of diagnostic tests.
- Enable weaponization of pathogens and toxins.

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[8] The Fink Report made seven recommendations: (1) educating the scientific community, (2) review of plans for experiments, (3) review at the publication stage, (4) creation of a national science advisory board for biodefense, (5) additional elements for protection against misuse, (6) a role for the life sciences in efforts to prevent bioterrorism and biowarfare, and (7) harmonized international oversight.

[9] The committee went further to state that "The seven areas of concern listed here only address potential microbial threats....Over time, however, the Committee believes that it will be necessary...to expand the areas of concern to cover a significantly wider range of potential threats to humans, animals or crops..."

These classifications have been highly influential in policy discussions, and the vocabulary of "experiments of concern" has made its way into many subsequent discussions on the topic, in particular relating to the publication of information (as will be discussed further in the next section).

The fourth recommendation of the Fink Report called for the establishment of a national board to advise on policy responses. In 2005, the National Science Advisory Board on Biosecurity (NSABB) was established to provide guidance and leadership in the US for a system of review and oversight of experiments of concern. In 2006, two members of NSABB lead a report entitled *Globalization, Biosecurity and the Future of the Life Sciences*, commonly known as the Lemon-Relman Report.[10] Taking a broader approach than the Fink Report, the committee addressed concerns about how new developments in the life sciences, including how they are intersecting with other rapidly advancing fields such as nanotechnology and materials science, may enable the creation and production of wholly new threats of biological origin (NSABB, 2006a).

The Lemon-Relman Report commented on the difficulty with which future predictions about scientific research can be made, and how the task of surveying current technology trends in order to anticipate what new threats may appear in the future needs to be a continual task. It was suggested that while existing paradigms have worked effectively for controlling nuclear arms proliferation, initiatives such as information control, materials inventories, and so forth have limited relevance for use in the control of biological weapons capabilities. Nonetheless, it was stated that it is of vital importance that life scientists, and the funding agencies and editors that support their research, take "every possible step to ensure that the fruits of their work are not exploited in a malevolent fashion, to the detriment of society" (NSABB, 2006a, p. 9). In order to achieve this, those working in the life sciences require a greater appreciation of the

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[10] The full report of the Committee on Advances in Technology and the Prevention of Their Application to Next Generation Biowarfare Threats (National Academies) and National Research Council (2006). Biosecurity and the Future of the Life Sciences. Washington D. C.: The National Academies Press, is available at http://www.nap.edu/catalog/11567.html.

dangers associated with their work, and a "greater willingness to shoulder this responsibility" (NSABB, 2006a, p. 9).

The Lemon-Relman Report went on to recognize and emphasize the counterproductive nature of efforts to control the flow of biological research. It argued that, given the widening threat spectrum, the best means of future protection may be through the regulation of science that might be a source of dual-use concern. However, as science is rapidly becoming a global endeavor, the committee emphasized the need to—and the problems of seeking to—regulate on global as well as national levels. Importantly, they stated, "it is clear that different societies may have vastly different perspectives on these issues and may adopt divergent paths while aiming to achieve similar goals. To succeed in reducing the threats posed by these advancing technologies will require an appreciation of these differences and an understanding that science does not stop at our borders" (NSABB, 2006a, p. 10).

Framing the problem: Experiments of concern

In many respects the Fink and Lemon-Relman Reports promoted two contrasting ways of understanding the problem of dual-use life science research. The former drew prominent attention to the risks for malign use of individual research experiments while the latter cast a wide vision over the iterative and cumulative potential of science and technology raised by ever more geographically dispersed activities.

It is the former approach of assessing the future risks associated with individual elements of research that has been most predominant in both academic and policy discussions to date. For instance, in recent years, especially immediately after 2001 (World Health Organization, 2010), a handful of so-called report's experiments of concern have been repeatedly cited as a way of characterizing concerns. One such example is the mousepox experiment published in 2001. Scientists from the Australian National University and CSIRO Sustainable Ecosystems aimed to genetically modify the mousepox virus in the hope of creating a vaccine which would induce infertility in rodents (Jackson et al, 2001). It was undertaken in response to the problem of rodent-related crop destruction in the agricultural sector. The insertion of the interleukin-4 gene into the virus created an extremely virulent strain of mousepox that could kill even vaccinated mice. The researchers recognized the possibility that this modification could be adapted for use in human smallpox, thereby creating a highly dangerous biological weapon. Considerable discussion took place regarding the publication of this research, the release of data that could potentially be misused, and the responsibilities of those involved; not least because the Australian scientists proactively drew attention to the misuse potential.[11]

Examples of experiments of concern, such as this one, have been highly influential in subsequent dual-use debates and policy development. By drawing attention to discrete instances of research, this heading has help guide subsequent debates about governance measures. In this regard, a considerable amount of the debate has focused on the choices presented at salient moments—such as whether results should be published, or whether a given experiment should be given approval and/or funding. Much effort has gone into examining methods by which these critical moments can be assessed.

For instance, a central task of the NSABB has been the development of recommendations on "guidelines for the oversight of dual-use research, including guidelines for the risk/benefit analysis of dual-use biological research and research results" (NSABB, 2006b, p. 1) for the U.S. federal government. The guidelines for risk/benefit analysis and oversight represent attempts to define, evaluate, and handle concerns about the dual-use potential of research through the creation of formal bureaucratic procedures. Of particular importance to the international debate was the NSABB-proposed split between research that might have some sort of dual-use potential and that which is "of concern." Thus, for the NSABB, the term dual-use research is used to refer to new technologies and the generation of information with the potential for

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[11] The scientists involved recognized a sense of responsibility towards the misuse of the research with Jackson quoted as saying, "We wanted to warn the general population that this potentially dangerous technology is available. We wanted to make it clear to the scientific community that they should be careful, that it is not too difficult to create severe organisms." (Novak 2001)

benevolent and malevolent purposes (NSABB, 2007, p. 2). In contrast, *dual-use research of concern* refers to the "subset of life sciences research with the highest potential for yielding knowledge, products, or technology that could be misapplied to threaten public health or other aspects of national security" (NSABB, 2006b, p. 16).

In line with the experiments of concern and the NSABB approach, since 2003 a number of civil science funders, publishers, and organizations, largely in the West, have introduced processes to assess the risks and benefits of individual instances of research to determine whether they need to be modified or withdrawn (Rappert, 2008). For instance, in 2003, a group of 32 science journals agreed general guidelines for modifying and perhaps rejecting manuscripts where "the potential harm of publication outweighs the potential societal benefits" (Journal Editors and Authors Group, 2003). Despite this agreement, however, it would seem no manuscript has been rejected on security grounds thus far (van Aken & Hunger, 2009).

In late 2011, the NSABB initially recommended that certain publication details be redacted with regard to research undertaken on a mutated H5N1 virus in a ferret model (Maher, 2012). Concerns were raised about what this work would mean for mammal transmission, particularly human-to-human transmission. In March 2012, the NSABB revised this redaction recommendation by citing new details had come to like about the potential public health benefits of unadulterated publishing. While the clamour and controversy associated with the communication and control of this set of experiments is very much alive at the time of writing, what is perhaps most notable of this case is its exceptionality.

Similarly, in funding applications and submissions, there has been a concerted effort to include dual-use prompts on funding forms.[12] Yet, as far as is known to the authors, no proposal has been rejected because anticipated security risks were seemed to outweigh social benefits. Perhaps even more notable with all of these review processes is the infrequency with which

[12] These include the UK Biotechnology and Biological Sciences Research Council, the UK Medical Research Council, the Wellcome Trust, the Center for Disease Control, and the Southeast Center of Regional Excellence for Emerging Infectious Diseases and Biodefense.

they have identified items "of concern" in the first place.[13] So while some lament that such review procedures are still relatively uncommon in the life sciences (Resnik et al, 2011), the ones that are in place are finding little to attend to, let alone determining whether risks outweigh benefits.

The lesson that one draws from such experience is key to defining "the problem" of dual-use. While it might be suggested that recent experience with risk-benefit procedures indicates a working system and little potentially problematic, one may question whether trying to assess the future potential on individual instances of research is the most effective—or even a viable—manner of viewing this problem.

On the basis of review experiences with journals which indicated a low identification rate for research of concern, for a number of years the NSABB has justified promoting a particular type of evaluation procedure—one that starts with a tick box form that research investigators can quickly complete.[14] This would exclude the vast majority of research from further formal consideration. NSABB proposed that the initial review of whether or not research is of concern be undertaken by the senior project leader. Herein, this person would be asked if the work:

> [...] based on current understanding, can be reasonably anticipated to provide knowledge, products, or technologies that could be directly misapplied by others to pose a threat to public health and safety, agricultural crops and other plants, animals, the environment, or material. (NSABB, 2007, p. 17)

That assessor must be able to reasonably anticipate a direct threat based on current understanding sets a high threshold for proof. At this initial stage of the review process, the determination of the status of research is not intended to impose significant demands on Principal Investigators. Should research be found to match the criterion, then it would be subjected to institutional risk review (NSABB, 2007, Appendix 4).

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[13] Across all the journals in the Nature Publishing Group, roughly 15 papers were subjected to a special security review in 2005 and 2006, see previous note. For further figures, see Rappert, B. (2008).

[14] As in comments made during National Science Advisory Board for Biosecurity 20 March 2006.

It is possible to think of alternative means for handling the assessment of research. One such alternative approach has been proposed by the Center for International and Security Studies at Maryland (CISSM) through its Biological Research Security System. This model envisions a legally binding system, requiring the licensing of personnel and research facilities that would be applied to all such institutions, and have international coverage. The Maryland system requires independent peer review wherein an oversight body would need to approve work going ahead, rather than the investigators making the initial determination. This was justified on the basis that "[i]n addition to having a self-interest in seeing their research proceed, such individuals are also unlikely to have the security and other expertise necessary to recognize the possible dual-use risks of their work" (Harris, 2007, p. 120).

The criteria proposed as part of the risk–benefit analysis in the Biological Research Security System also go further than the NSABB proposal. When assessing research, for instance, individuals are supposed to consider whether the same experimental outcome could be pursued through alternative means, whether the research is being done in response to a validated (credible) threat, and whether it will yield results definitive enough to inform policy decisions. Such questions place additional demands on those taking part in the assessment process than those as part of NSABB recommendations and require forms of knowledge that the average senior investigator is unlikely to possess. As another contrast to the NSABB proposals, the Maryland one provides a metric for evaluating research based on the responses given to the criteria mentioned.

Despite their differences, both the NSABB and Maryland control proposals trade heavily on the concept of experiments of concern, and the need to evaluate individual items of research. While they have been very important in developing the discussions on dual-use and the life sciences, it is possible that by closely linking the concept of dual-use to the rhetoric of experiments of concern limitations may unwittingly constrain future initiatives.

An Evolving Response

Proposals for responsibility

Attempts to control dual-use within life science research are associated with the identification of responsibilities. Despite the broad obligations of beneficence and nonmaleficence discussed above, what specific responsibilities do life scientists have for their research vis-à-vis dual-use? There have been many different interpretations of this question. One prevailing position, as promoted in an online dual-use training module, is that scientists have duties to:

- Prevent bioterrorism.
- Engage in response activities to bioterrorism attacks.
- Consider negative implications of research.
- Not to publish or share sensitive information.
- Oversee and limit access to dangerous materials.
- Report activities that arouse suspicion.
- Educate, as in raising awareness of dual-use, promoting anticipation of dual-use applications, and informing public authorities of dangers, keeping knowledge secret.[15]

While such types of duties are in line with the generalized duty to care based on the principles on beneficence and nonmaleficence,[16] their application in daily research practice have been critically questioned elsewhere (Ehni, 2008; Kuhlau et al., 2008; Dando, 2009). In particular, an area of contention is the extent to which individual scientists, and life science communities as a whole, can be held accountable for future applications of knowledge and techniques.

For such duties to be feasible, a number of conditions are required which may or may not be present. Two such are: 1) the ability to recognize of dual-use considerations as well as 2) to possess capabilities to assess the malign applications of one's work. With regard to the latter,

[15] Bradford Teaching module lecture 11 (www.bioethics.brad.ac.uk)
[16] The duty to care was developed in the early 20th century by Hans Jonas, Emmanuel Levinas and Hannah Arendt. In its application to the issue of dual-use, it suggests that all scientists have responsibility for dual-use issues based on their obligations to care for humanity. Thus, all scientists are complicit in the outcomes of dual-use issues, which can be extended to provide a global responsibility for dual-use issues (Ehni, 2008). While this notion of generalized responsibility is important to develop awareness for dual-use issues, the limits for which this is a practical interpretation of responsibilities have been questioned.

Kuhlau et al. (2008) suggested that scientists should not be required to estimate probability and magnitude of misuse, as it is beyond the scope of the individual researcher's capacity. Instead, they proposed a number of considerations for orientating to how moral obligations to prevent harm that need to be embedded in the research community:

- Responsibility is determined by the social role or position.
- Responsibility must be within that person's professional capacity and ability to enact.
- The harmful consequences must be reasonably foreseeable.
- The benefits of a research project should be weighed against the risks.
- Results should not be reasonably achieved through other means.

Thus, as they contend, although "[t]he misapplication of peacefully intended research may cause moral distress among scientists ... it is difficult to argue that researchers should (solely) be held morally accountable for harm caused by unforeseen acts of misuse" (Kuhlau, 2008, p. 483). As the manner in which responsibilities of scientists are interpreted has a direct implication for the development of any control measures, this topic is of major significance.

Building responsibility through ethical deliberation

Even if one accepts that scientists may be absolved from certain responsibilities for the later use of their work, it is generally agreed that they and others still should have some understanding of its potential implications. To this end, ethics education as a tool for dual-use governance has become a topic of considerable activity, especially based on the often expressed preference of research communities for self-governance (Rappert, 2010b). Professional associations such as the World Medical Association and the American Association for the Advancement of Science (AAAS), international organizations such as the International Committee of the Red Cross, advocacy groups such as FAS, science academies such as the British Royal Society, and funders such as the Wellcome Trust are some of those that made a call recently for widespread regard among those associated with the life sciences.

In 2011, the National Research Council (NRC) published a report titled *Challenges and Opportunities for Education about Dual-Use Issues in the Life Sciences*. This report, presenting findings proceeding from a workshop, suggested that the available evidence indicated that there has been limited introduction of education about dual-use issues (NRC, 2011, p. 4).[17] At present the introduction of dual-use issues into science education in most countries results primarily from the work of an interested, committed individual or a specific project, often by nongovernmental organizations. In general, it was contended that most of the examples of dual-use education occur as part of a broad education about the conduct of scientific research, in basic life sciences courses, as part of biosafety training, or within bioethics (NRC, 2011, p. 4). In its analysis of gaps, needs and potential remedies, the report identified the need to develop educational materials and pedagogical options, while recognizing the challenges faced by implementing any new material into crowded curricula without overburdening students and teachers. It recommended the development of an international open access repository of materials that can be tailored to and adapted for the local context (NRC, 2011).

In addition to ethics education, there has been substantial talk about the development of codes of conduct for life scientists. For instance, in 2005 the InterAcademy Panel released guidelines for the development of codes by their member bodies[18] that advocated five fundamental principles: awareness, safety and security, education and information, accountability and oversight. Codes, or most often guidance for codes, have subsequently been developed by a number of national academies, professional bodies and international organizations. Despite the enthusiasm with which they have been promoted, the usefulness of the codes that have emerged from these activities is limited. While talk about codes has provided a shared topic for discussions between varied communities, to date the relevance of dual-use inspired professional codes[19] for day to day practice has been limited (Rappert, 2009). Thus, while the concept of an international culture of responsibility and awareness supported by ethics education and codes of conduct remains much discussed, the practicalities of

[17] The report did recognise that a significant amount of information and training about responsible conduct and biosafety is provided informally, either through dedicated modules outside regular coursework or in-laboratory mentoring by senior researchers. Thus the current information about the amount of education on these general issues may understate the amount of education available to students.
[18] *Inter Academy Panel Statement on Biosecurity*: "This statement presents principles to guide individual scientists and local scientific communities that may wish to define a code of conduct for their own use."
[19] As distinct from the limited number of relevant regulatory and organizational codes produced.

translating this ideal into efforts meaningful for a large number of individuals have limited activities.

The explicit endorsement of "the adoption and promotion of a common culture of awareness and a shared sense of responsibility within the global community of life scientists," as in the fourth recommendation of the Lemon-Relman report, recognized that the efforts to establish and facilitate individual responsibilities often go hand in hand with attention to the collective responsibilities of scientists as a group and those associated with the life sciences. The examination of collective responsibilities within the problem of dual-use is becoming an important topic of discussion, as the increasingly international nature of science has led to some to contend that contemporary ethical theories did not adequately address the ethical and social challenges of scientific and technological development (von Schomberg, 2007; Malsch, 2009). In particular relation to dual-use, it has been suggested that the unintended consequences of science, as well as the cumulative implications of actions, could not be adequately exhausted by existing theories that dealt with individual responsibility for intentional actions (von Schomberg, 2007; Malsch, 2009). Nonetheless, as with individual responsibility, it is generally agreed that scientists as a community do not bear full responsibility for controlling the dual-use potential of their research. This, however, in turn raises many questions regarding who should be responsible for what aspects of the dual-use problem in the life sciences.

A web of prevention

The notion of a *web of prevention* has served as a shared phrase pointing to the need for the involvement of health, security, governmental and societal communities in addressing the dual-use issue (ICRC, 2003; Feakes et al, 2007). This web includes diverse activities such as physical containment and personnel issues, improving the communication between security, law enforcement and life science organizations, and the coordination of international oversight. In one formulation, it was suggested the web of prevention include initiatives such as:

- Export controls

- Disease detection and prevention
- Effective threat intelligence
- Biosafety and biosecurity initiatives
- International and national prohibitions
- Oversight of research
- Education and codes of conduct[20]

This web of prevention model has proven versatile label for envisioning efforts to address dual-use issues in the life sciences in a multidimensional manner. It is designed to distribute responsibility for preventing the development and use of bioweapons. Despite this, there has been considerable debate on the exact role of scientists and others within the web of prevention. It has been noted that an over-reliance on procedural aspects to address ethical problems can generate a culture of compliance instead of a culture of engagement (Benatar, 2002).

Another complication in achieving the web is the lack of international consensus, standardization and enforcement. The difficulties with finding ways to standardize elements of the web of prevention are associated with some of the ethical tensions described above—as varying interpretations of risk, beneficence and responsibility will affect the development and implementation of dual-use controls. In addition, though the security and science communities understand the importance of advancing research there are differing perspectives on what constitutes a proper balance between these activities (AAAS, 2010). Asking how—and what—considerations should be taken into account when assessing what governance measure should be introduced raises fundamental ethical questions about how value can be ascribed to notions such as security, liberty, and research benefit, as well as how those are prioritized, traded off, balanced, or otherwise related to each other.

[20] As taken from the University of Bradford online Education Module Resource, lecture 21, www.bradford.ac.uk/bioethics.

Further Ethical Engagement

As the previous section indicated, a common refrain in discussions about the intersection of security and biology is that preventing the hostile use of the life sciences will require a positive and integrated programme of action. Despite notable and generally high level policy efforts, widespread consideration of these issues is not taking place among practicing life scientists. Attempts to address the destructive potential of life sciences to date have been preliminary, patchy, and problematic:

- Preliminary because there is still arguably limited attention to the destructive potential of the life sciences among its practitioners.
- Patchy because regard is substantively and geographically varied (Douglas and Savulescu, 2010; NRC, 2011).
- Problematic because efforts undertaken to date (such as codes of conduct or the screening of manuscripts) have been based on linear conceptions of how knowledge enables technical capability (McLeish, 2007; Vogel, 2008), how policy informs practice (Rappert, 2009), as well as the relation of science and society in establishing priorities (Lentzos, 2008; Singer & Daar, 2009).

Another concern related to this essay is the extent of existing (bio)ethical analysis of dual-use issues. The ethical issues raised by dual-use biological research are similar to those that have been identified in the past with regard to other types of weapons applications as well as in other areas where dangers and risks have been identified with knowledge. As a result, now-established ethical theories and approaches—such as the precautionary principle and the doctrine of double effect—should be highly informative. In an attempt to question what lessons can be learnt from previous ethical debates, Kuhlau et al. offered a reading of the precautionary principle in relation to matters of dual-use to suggest that:

> When and where serious and credible concern exists that legitimately intended biological material, technology or knowledge in the life sciences pose threats of harm to human health and security, the scientific community is obliged to develop, implement and adhere to precautious measures to meet the concern. (Kuhlau et al, 2009, p. 8)

Nontheless, Clarke (forthcoming) has criticized this formulation of the precautionary principle as vague, ambiguous, and of limited utility in addressing questions about what should be done. These comments appear to be the start of a robust discussion, which will no doubt facilitate further understanding into dual-use bioethics.

Despite such contributions, consideration of dual-use issues to date among bioethicists and other concerned with ethics has been preliminary and limited. Further work is needed in relation to at least five sets of questions:

- What is the present understanding and practice of dual-use bioethics amongst those in the life sciences today? What might be the reasons for any low level of understanding or practice?
- What sort of responses for managing access to research knowledge and technology have been or are being offered (and which not) to render threats associated with the deliberate spread of disease manageable? What are presumptions informing them?
- What would practitioners need in order to be able to at least raise such questions as: How do I recognise a dual-use experiment of concern in my field? What do I do if I have concerns about a dual-use experiment? How do I go about ethically analysing dual-use issues?
- What are the responsibilities of those associated with the life sciences? How could the responsibilities identified be translated into hitherto unrealised means of professional guidance and governance mechanisms?
- How can dual-use bioethics awareness be fostered and taught, especially given the different cultural and religious backgrounds as well as specialities involved? How can the impact of dual-use bioethics awareness raising, education, and action best be measured and evaluated?

Conclusion

While dual-use has been widely been recognized as a challenge facing the life sciences, achieving international consensus on what is needed to respond to dual-use aspects of modern research has not been possible. In particular, the absence of a feasible international oversight body and a standardized regulatory framework has frustrated such unanimity. Nonetheless, despite these complications, dual-use remains on the agenda of current science discussions.

In order to achieve a harmonized system of dual-use initiatives, it is important to recognize the differences in approaches to dual-use issues. It has nonetheless been recognized that the majority of the dual-use debate remains largely associated with geographically Western countries (Barr, 2008). It is therefore a serious possibility that much of the debate —both on dual-use and attempts to harmonize control structures—continues to reflect a limited range of ethical thinking and includes presumptions that might well not be shared universally.

Recognizing the limitations of the current dual-use discussions is particularly important in light of the rapid scientific advances in recent years by a number of emerging economies. These countries, including India, Brazil, South Africa and China, will need to be drawn dual-use discussions in a more significant way. However, despite a considerable increase in outreach initiatives of late (mainly initiated by government and professional bodies in the U.S.), their engagement with dual-use issues is still limited.

In addition to these emerging research powerhouses it must be remembered that most other countries in the world have some level of life sciences research. Research in these countries is often under-funded and poorly supported by their governments in terms of legislation, policy and support structures. Due to their low profile, there is a tendency for these research communities to be underrepresented in international discussions, and dual-use is no exception. In many cases, these scientists work in very different conditions to their counterparts in resource rich countries, struggling with a range of pressures ranging from lack of funding to lack of infrastructure. In these cases, an increased recognition of not only the cultural variations between communities of scientists, but also resource and support variations will prove vital to dual-use awareness initiatives and avoid the development of a culture of compliance instead of awareness.

Thus, further understanding of the contextual variations of dual-use understanding will serve to make the dialogue more robust and inclusive. Importantly, by including developing countries in dual-use debates it will be possible to identify ethical and practical assumptions currently made through the dominance of Western perspectives (Bezuidenhout, 2012). Being able to identify and address these assumptions will not only strengthen current discourse, but also assist in implementing a web of prevention model in these previously underrepresented countries.

The AAAS report of 2010, *Competing Responsibilities*, explicitly drew attention to the fact that the biological science community is diverse and scientists can be grouped into several categories based on their discipline, educational background, research area and work experiences (p. 7). It suggested that these categories may affect not only the scientist's perception of risk, but also the manner in which they interact with ethical principles such as those making up codes of conduct (AAAS, 2010, p. 13). This will thus of course be exacerbated at the global level if one takes into account cultural variations.[21]

The recognition of the heterogeneity of the scientific population is very important for the future of dual-use dialogues. Assuming that scientists work in similar environments or hale from similar cultures not only weakens any discussions but dangerously pushes skirts ethical imperialism. On the other side of the coin, however, allowing ethical relativism into the dual-use debate possess its own dangers. We must ask ourselves, then how differences in science culture can be sympathetically addressed, and a middle ground be found.

By increasingly accepting heterogeneity in the science population, it may be possible to increase the presence of rather marginalized groups in dual-use discussions. These include not only scientists working in industry, but also the rising number of community scientists.[22] The involvement of individuals from these areas will bring fresh perspectives on management and control issues, as well as the ethical dilemmas currently being confronted. In addition, it will

[21] Research in the sociology of science has identified increasing heterogeneity within science populations. The variations in laboratory cultures, institutional ideals, and governmental regulation are all interdependent and linked to ethical variations. There is considerable literature on the subject, such as Traweek (1988).

[22] Community scientists are a growing phenomenon. One good example is the DIYBio group (www.DIYbio.org), an organization which advocates making biology an accessible pursuit for citizen scientists, amateur biologists and biological engineers who value openness and safety outside of traditional professional settings.

widen the surveillance by scientists of potential dual-use issues, potentially in areas not often patrolled by academic scientists.

It has previously been suggested that without more engagement from practicing researchers, policy and security analysts might be forming inappropriate threat pictures because of the haphazard way certain concerns have received a wide airing (Atlas & Dando, 2006). It is therefore vital that dual-use become a topic of conversation for all scientists in order to develop a robust dialogue that dynamically examines roles and responsibilities for addressing this issue.

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