

Governance of dual-use research: an ethical dilemma

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Abstract Scenarios where the results of well-intentioned scientific research can be used for both good and harmful purposes give rise to what is now widely known as the “dual-use dilemma”. There has been growing debate about the dual-use nature of life science research with implications for making biological weapons. This paper reviews several controversial publications that have been the focus of debates about dual-use life science research and critically examines relevant policy developments, particularly in the United States of America. Though the dual-use dilemma is inherently ethical in nature, the majority of debates about dual-use research have primarily involved science and security experts rather than ethicists. It is important that there is more ethical input into debates about the governance of dual-use research.

الترجمة العربية لهذه الخلاصة في نهاية النص الكامل لهذه المقالة. Al final del artículo se facilita una traducción al español. Une traduction en français de ce résumé figure à la fin de l'article.

Introduction

In the early days of atomic physics, it was realized that discoveries regarding nuclear fission and the chain reaction might be used for both beneficial and harmful purposes. The scientists involved recognized that, on the one hand, such discoveries could have important applications for medicine and energy production but that, on the other hand, they might also lead to the production of unprecedented weapons of mass destruction.¹ Foreseeing the potential weapons implications of experimental results regarding the chain reaction, Leo Szilard engaged colleagues in debate about the virtues of self-censorship. If dangerous discoveries were kept secret, he argued, then the development and use of such weapons might be avoided. However, similar discoveries were made and published by other physicists and atomic bombs were subsequently developed and used by the United States of America (USA) during the Second World War. Governmental regulation and censorship of nuclear science has since been common.²

Life science researchers find themselves in a similar situation today. The biological sciences are progressing rapidly and recent developments in biotechnology may have tremendous medical (and other) benefits for humankind. In many cases, however, the same discoveries that promote advancement of medicine could also facilitate production of biological weapons of mass destruction. An unclassified Central Intelligence Agency (CIA) document entitled *The darker bioweapons future* claims that:

“advances in biotechnology ... have the potential to create a much more dangerous biological warfare threat ... engineered biological agents could be worse than any disease known to man.”³

Though the dangerous implications of contemporary biology had been recognized earlier,⁴ heightened concern followed the anthrax attacks in the USA in 2001.

There are numerous reasons to take the threat of biological weapons seriously. In comparison with nuclear weapons, the production of biological weapons is relatively easy and inexpensive; and information about how to produce biological weapons is readily available in published scientific literature. In comparison with nuclear science, where discoveries with weapons implications are usually classified, information sharing in the life sciences has traditionally been completely open.² The anthrax attacks in the USA and other recent episodes, finally, have revealed that the threat of bioterrorism is real.

The dual-use dilemma

Scenarios where the results of well-intentioned scientific research can be used for both good and harmful purposes give rise to what is now widely known as the “dual-use dilemma” and there has been growing debate about the dual-use nature of life science research in particular. Four recent cases involving the publication of dual-use discoveries have been particularly controversial.

In Australia, researchers inserted the mouse IL-4 gene into the mousepox virus hoping that the altered virus would sterilize mice and thus provide a means for pest control. To their surprise they discovered that they had produced a super-strain of mousepox that killed mice that were naturally resistant to, and mice that had been vaccinated against, ordinary mousepox.⁵ This discovery implies that the same technique might enable production of vaccine-resistant smallpox. Because there is no known treatment for smallpox, vaccination is our only defence. This study was published in the *Journal of Virology* in 2001.

In a second study, researchers at the State University of New York at Stony Brook artificially synthesized a “live” polio virus from scratch.⁶ Following the map of the polio virus RNA genome, which is published on the Internet, they stitched together corresponding strands of DNA, which they purchased via mail-order. The addition of protein resulted in

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the creation of a virus that paralysed and killed mice. Upon publication of results in *Science* in 2002, the researchers said they “made the virus to send a warning that terrorists might be able to make biological weapons without obtaining a natural virus”.⁷ Similar techniques might enable production of smallpox or Ebola.

In a third study, published in the *Proceedings of the National Academy of Sciences* in 2002, researchers used published DNA sequences to engineer a protein – known as SPICE – produced by the smallpox virus.⁸ The study revealed the ways in which, and the extent to which, this protein defeats the human immune system. Though the findings may facilitate development of protective medicines, they may also reveal ways to increase the virulence of the closely-related *vaccinia* virus (which is used in the smallpox vaccine).

A more recent study, published in *Science* in 2005, employed techniques of synthetic genomics (similar to those used in the polio study) to “reconstruct” the Spanish Flu virus, which killed between 20 and 100 million people in 1918-19.⁹ Though further research on the reconstructed virus may facilitate development of drugs and vaccines that provide protection against a major influenza pandemic, such a virus could also be used for nefarious purposes by malevolent actors.

Each of these studies aroused substantial controversy. Given their implications for making biological weapons, critics complained that these studies should not have been conducted and/or that they should not have been published. Publication of studies like these, they argued, alerts bioterrorists to new ways of producing biological weapons and provides them with explicit instructions for doing so. At the very least, they argued, the materials and methods sections of the published articles should have been omitted or amended.

Though they understood the dangers, the scientists and editors involved defended their actions. Among other things, they argued that these publications would play an important role in alerting the scientific community to the importance of developing protection against newly revealed dangers. In the case of the influenza study, it was argued that medical benefits of publication outweighed the risks associated

with terrorism, especially given current concerns about pandemic influenza. In response to suggestions that materials and methods descriptions should have been omitted or altered, they argued that inclusion of such information is crucial to scientific method, i.e. for replication and verification.

Policy development

Whether or not these studies and others like them should have been conducted and/or published, they have attracted attention to the problem of dual-use biological research and the potential need for increased governance of science. Dual-use research is a primary area of focus in debates about biosecurity and bioterrorism, and there have been numerous relevant policy developments. In 2003 (before the influenza study), for example, a journal editors and authors group issued a joint “Statement on scientific publication and security” in *Science*, *Nature*, the *Proceedings of the National Academy of Sciences* and the American Society for Microbiology journals. The statement indicated that these journals would screen submissions for “safety and security issues” and that when “harm of publication outweighs the potential societal benefits ... the paper should be modified or not published”.¹⁰

In 2004, the USA's National Research Council (NRC) published an influential report entitled *Biotechnology research in an age of terrorism*, also widely known as “the Fink report”.² Among other things, the NRC called for increased education of the scientific community about the dual-use dilemma; recommended that the role of institutional biosafety committees be expanded to include review of research proposals for dual-use risks (as well as environmental dangers); recommended self-governance of the scientific community (as opposed to governmental censorship) in matters related to publication of dual-use research findings; and called for the establishment of a new advisory board to provide guidance to the government regarding the oversight of dual-use research. Such a body, the National Science Advisory Board for Biosecurity (NSABB), was established in 2004; and its working groups have been developing criteria for identifying dual-use research of concern, tools for

controlling dissemination of information, science codes of conduct, policy recommendations regarding synthetic genomics and means for international collaboration in the oversight of dual-use life science research.¹¹

The NSABB has also played a role reviewing papers raising dual-use issues. The above-mentioned influenza study, for example, was sent to the NSABB for review before publication in 2005, and members voted unanimously that the paper should be published. The editor-in-chief of the journal, however, subsequently wrote that he would have published the study even if the NSABB had voted otherwise.¹² This highlights the fact that the status quo in the USA (where dual-use life sciences research has received the majority of attention) relies on voluntary self-governance of the scientific community in matters of censorship, as recommended by the NRC. Referral of papers to the NSABB is voluntary and its decisions are not legally binding.

It is questionable, however, whether reliance on voluntary self-governance of the scientific community in matters of censorship is advisable. Because scientists generally lack training in security studies, they may lack the expertise required for assessment of the security risks of publication in any given case. This point is especially well illustrated by the mousepox experiment. Assessing the security risks of the mousepox publication requires knowledge about the likely proliferation of the smallpox virus (e.g. from alleged former Soviet bioweapons stockpiles) because would-be bioterrorists would need to have access to the smallpox virus to apply the mousepox genetic engineering technique to it (if their aim is to produce vaccine-resistant smallpox). Detailed information about the likelihood of smallpox proliferation, however, is classified information held by intelligence and security experts (if anyone). In the case of the mousepox study, scientists (lacking security clearance) are systematically denied access to information essential to assessment of the security risks of the relevant publication.¹³

A second reason for doubting that voluntary self-governance of scientists in matters of censorship would be appropriate is that conflicts of interest arise insofar as publication is crucially

important for career advancement in science. A final reason is that the dual-use dilemma potentially involves conflict between the promotion of security and the progress of science. In cases where publication of scientifically important dual-use research conflicts with security, neither the goal to promote security nor the goal to advance science should be given (absolute) priority over the other. Both scientific progress and security matter; in cases of conflict a balance should be struck between the two. Given what they do for a living, however, it is likely that the values of scientists will be biased in favour of science over security.

A system involving governmental control over publication practices, on the other hand, may promote security; but this would have costs in terms of academic freedom. Scientific progress may also be hindered (to the degree that, as is often claimed, scientific freedom is essential to scientific progress). The scientific community is right to be wary about governmental censorship. Given what they do for a living, bureaucrats and security experts are likely to be biased in favour of security values over scientific values. There is also reason to doubt that governmental decision-makers will always have sufficient expertise to judge the scientific importance of publishing studies they might want to censor. An additional worry about the censorship of science by government is that this could be one more step down the path of liberty infringement in the name of “the war

on terrorism” and that governmental censorship may threaten freedom of speech more generally.

Ethics

To the extent that important values are at stake, the dual-use dilemma is inherently ethical in nature.¹⁴ It is noteworthy, however, that most of the debates about the dual-use dilemma have primarily involved science and security experts rather than ethicists. Bioethicists have to date had relatively little to say about security in general or the dual-use dilemma in particular.^{13,15} This is ironic given the enormous amount of attention bioethics has placed on both: (i) research ethics, and (ii) ethical, legal and social implications of genetics. Research ethics discourse has predominantly focused on the protection of human and animal research subjects, and research ethics guidelines rarely mention problems posed by dual-use research.¹⁶ The literature on ethical implications of genetics has focused on potential environmental hazards of recombinant DNA research, genetic determinism, genetic testing, discrimination by employers and insurance companies, selective reproduction, genetic enhancement, cloning, stem cell research, DNA fingerprinting and the patenting of DNA sequences.¹³ At the time of writing this paper, a huge number of journal articles and books on ethics and genetics had been written; but they include little, if any, discussion of the potential role of genetics in weapons-making.

Robert Cooke-Deegan’s canonical history of the human genome project, *The gene wars*,¹⁷ includes explicit coverage of the politics and ethical debate surrounding the new genetics. Despite all the links that are drawn between genetics and atomic weapons, and despite inclusion of a chapter entitled “Genes and the bomb”, the book never mentions discussion or debates about the implications of genetics for biological weapons development. It is commonly said that the power of genetics is comparable to the power of atomic physics and that we need more ethical discussion and reflection about the former than the latter received when the first atomic bombs were made and used – the idea being that more socially responsible decisions about science should be made in genetics than have been made in the context of nuclear energy. The usual discourse on ethical, legal and social implications of genetics, however, reveals that the power of genetics with regard to weapons development is not what those concerned with the ethics of genetics have usually had in mind. If the previously mentioned claims of the CIA are true – as seems plausible in the light of the examples considered above – then biological weapons development may turn out to be one of the most serious consequences of the genetics revolution in biology. It is thus crucially important that there is more ethical input into debates about the governance of dual-use research. ■

Competing interests: None declared.

Résumé

Gérer le double usage de la recherche : un dilemme éthique

Les scénarios dans lesquels les résultats d’une recherche bien intentionnée sont utilisables à la fois à des fins bénéfiques et néfastes nous confrontent au désormais célèbre « dilemme du double usage » de la recherche. Les débats sur la nature duale des recherches en science de la vie susceptibles de déboucher sur la fabrication d’armes biologiques prennent de l’ampleur. Le présent article analyse plusieurs publications controversées, qui ont fait l’objet de discussions sur le double usage des

recherches en science de la vie et réalise un examen critique des évolutions politiques liées à cette question, notamment aux États-Unis d’Amérique. Bien que le dilemme suscité par ce double usage soit par nature éthique, la majorité des débats sur la double finalité de la recherche ont été menés principalement par des experts scientifiques et des spécialistes de la sécurité et non par des éthiciens. Il importe d’introduire davantage d’éthique dans les débats sur la gestion du double usage de la recherche.

Resumen

La gobernanza del doble uso de las investigaciones, un dilema ético

La posibilidad de usar los resultados de investigaciones científicas bienintencionadas con fines beneficiosos o con ánimo de causar daño da lugar a lo que hoy día se conoce en general como el dilema del «doble uso». Más concretamente, ha cobrado intensidad el debate sobre el doble uso de las investigaciones en ciencias de la vida que puedan facilitar la producción de armas biológicas. En este artículo se examinan varias publicaciones que han generado bastante polémica en ese campo y se analizan críticamente algunas

novedades de interés en materia de políticas, sobre todo en los Estados Unidos de América. Aunque el problema del doble uso constituye en lo fundamental un dilema ético, en la mayoría de los debates sobre las investigaciones de doble uso han participado principalmente científicos y expertos en seguridad más que especialistas en ética. Es importante que haya más aportaciones desde el campo de la ética en los debates sobre la gobernanza de las investigaciones de doble uso.

ملخص

حكمة الاستخدام المزدوج للبحوث: مآزق أخلاقي

الحياة ذات الاستخدام المزدوج، والتي تنظر نظرة ناقدة لتطورات السياسات ذات الصلة ولاسيما في الولايات المتحدة الأمريكية. ورغم أن مآزق الاستخدام المزدوج في الأصل ذو طبيعة أخلاقية فإن معظم الجدل الدائر حول بحوث الاستخدام المزدوج قد شمل بشكل رئيسي الخبراء في العلوم وفي الأمن أكثر من الاختصاصيين بالأخلاقيات. ومن المهم أن تكون هناك مدخلات أخلاقية أكثر في المناظرات التي تجرى حول حكمة البحوث ذات الاستخدام المزدوج.

يمكن أن تؤدي السيناريوهات الخاصة بنتائج البحوث العلمية التي تجري بنية حسنة والتي يمكن أن تستخدم لكل من الأغراض الحميدة والضارة إلى ما يعرف اليوم على نطاق واسع بالمآزق الأخلاقي. ويتصاعد الجدل حول طبيعة الاستخدام المزدوج لبحوث علوم الحياة التي لها آثار على صناعة الأسلحة البيولوجية. وفي هذه الورقة يراجع الباحثون مطبوعات متعددة مثيرة للجدل استأثرت بالاهتمام وأصبحت في بؤرة الجدل حول بحوث علوم

References

- Schweber S. *In the shadow of the bomb*. Princeton, NJ: Princeton University Press; 2000.
- National Research Council. *Biotechnology research in an age of terrorism*. Washington, DC: National Academies Press; 2004.
- Central Intelligence Agency. The darker bioweapons future, November 3, 2003. Available from: <http://www.fas.org/irp/cia/product/bw1103.pdf> [accessed on 19 June 2009].
- Block S. The growing threat of biological weapons. *Am Sci* 2001;89:28-38.
- Jackson RJ, Ramsay AJ, Christensen CD, Beaton S, Hall DF, Ramshaw IA. Expression of mouse interleukin-4 by a recombinant ectromelia virus suppresses cytolytic lymphocyte responses and overcomes genetic resistance to mousepox. *J Virol* 2001;75:1205-10. PMID:11152493 doi:10.1128/JVI.75.3.1205-1210.2001
- Cello J, Paul AV, Wimmer E. Chemical synthesis of poliovirus cDNA: Generation of infectious virus in the absence of natural template. *Science* 2002;297:1016-8. PMID:12114528 doi:10.1126/science.1072266
- Pollack A. Scientists create a live polio virus. *New York Times*, 2 July 2002.
- Rosengard AM, Liu Y, Nie YZ, Jimenez R. Variola virus immune evasion design: expression of a highly efficient inhibitor of human complement. *Proc Natl Acad Sci USA* 2002;99:8808-13. PMID:12034872
- Tumpey TM, Basler CF, Aguilar PV, Zeng H, Solorzano A, Swaine DE, et al. Characterization of the reconstructed 1918 Spanish Influenza pandemic virus. *Science* 2005;310:77-80. PMID:16210530 doi:10.1126/science.1119392
- Journal Editors and Authors Group. Uncensored exchange of scientific results. *Proc Natl Acad Sci USA* 2003;100:1464. PMID:12590129 doi:10.1073/pnas.0630491100
- National Science Advisory Board for Biosecurity [internet site]. Available from: <http://www.biosecurityboard.gov> [accessed on 19 June 2009].
- Kennedy D. Better never than late. *Science* 2005;310:195. PMID:16223986 doi:10.1126/science.310.5746.195
- Selgelid MJ. A tale of two studies: ethics, bioterrorism, and the censorship of science. *Hastings Cent Rep* 2007;37:35-43. PMID:17649901 doi:10.1353/hcr.2007.0046
- Miller S, Selgelid MJ. Ethical and philosophical consideration of the dual-use dilemma in the biological sciences. *Sci Eng Ethics* 2007;13:523-80. PMID:18060518 doi:10.1007/s11948-007-9043-4
- Dando, M. Biosecurity: upgrading the web of prevention: a view from the UK. In: *Biosecurity challenges for Australia and its region*, National Centre for Biosecurity, The Australian National University, 11 February 2008.
- Green SK, Taub S, Morin D, Higginson D, for the Council on Ethical and Judicial Affairs of the American Medical Association. Guidelines to prevent the malevolent use of biomedical research. *Camb Q Healthc Ethics* 2006; 15:432-47. PMID:17066768 doi:10.1017/S0963180106210569
- Cooke-Deegan R. *The gene wars: science, politics, and the human genome*. New York: Norton; 1994.