DUAL USE DILEMMA IN THE BIOLOGICAL SCIENCES: ETHICAL AND PHILOSOPHICAL ASPECTS

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1. Post the 11th September 2001 and anthrax attacks in the US, bio-terrorism is widely considered to be a real threat, especially to populations in western countries and given groups such as al-Qaeda seek to maximise loss of life (unlike IRA, Red Brigades, PLO etc.).

2. Bio-terrorism is seen as a greater threat from non-state terrorist groups than, say, nuclear WMDs, given the availability of the technical knowledge necessary to produce the relevant biological agents and the feasibility of weaponisation.

3. There is a non-negligible bio-terrorist threat, and it is increasing, given that a small number of animal, human and plant pathogens are readily obtainable from nature and that bioterrorists with some microbiological training could use these to inflict causalities or economic damage and given the new possibilities provided by synthetic genomics (creation of pathogens de novo).

4. "Dual-use dilemma" arises in the context of research in the biological and other sciences as a consequence of one and the same piece of scientific research having the potential to be used for evil as well as for good, e.g. research on the mousepox virus.

5. Dilemma: Option 1 – research on mousepox virus should go ahead since lead to genetically engineered sterility treatment that would have helped combat periodic plagues of mice in Australia.

Option 2 – research should not have been pursued since it led to the creation of a highly virulent strain of mousepox and the possibility of the creation – by, say, a terrorist group contemplating a biological terrorist attack – of a highly virulent strain of smallpox able to overcome available vaccines.

6. A dual-use dilemma is an *ethical* dilemma, and an ethical dilemma for the *researcher* (and for those who have the power or authority to assist or impede the researcher's work, eg. governments).

7. It is an *ethical* dilemma since it is about promoting good in the context of the potential for also causing harm, e.g. the promotion of health in the context of providing the wherewithal for the killing of innocents.

8. It is an ethical dilemma *for the researcher* because of the potential actions of *others*. Malevolent non-researchers might steal dangerous biological agents produced by the researcher; *other* researchers – might use the results of the original researcher's work for malevolent purposes eg bio-terrorism and bio-warfare.

9. In not so recent past, a number of governments have sought to develop weapons of mass destruction (WMDs), including biological weapons, and in some cases have actually used them, eg. the use of mustard gas by the German and British armies in WW1, the dropping of atomic bombs on Hiroshima and Nagasaki by the US air force in WW2, the existence of a large-scale biological weapons program in the Soviet Union from 1946-1992, and the use of chemical agents against the Kurds by Saddam Hussein's regime in 1988.

10. The expression "dual-use dilemma" is in need of some conceptual unpacking. Here we need to introduce a number of sets of distinctions.

11. In relation to the *purposes* (or ends) of the research, we can distinguish the following conceptual axes: (i) good/evil; (ii) military/non-military; and (iii) within the category of military purposes, the sub-categories of offensive/protective. Consider the aerosolisation of a pathogen undertaken for a military purpose. The purpose might be offensive, eg. bio-warfare; or it might be protective, eg. to understand the nature and dangers of such aerosolisation in order to prepare protections against an enemy known to be planning to deploy the aerosolised pathogen as a weapon.

12. Categories good/evil and military/non-military do not necessarily mirror one another. Some non-military purposes are evil, eg. the supplier of a vaccine releasing a pathogen to make large numbers of people sick in order that the sick buy the vaccine against the pathogen and, thereby, increase the supplier's profits. Some military purposes are good, eg. the above-mentioned research on

the aerosolisation of a pathogen undertaken for purely protective purposes in the context of a just war.

13. (2) Dual-use refers to two temporally and logically distinct "users" of the research: (i) those who initially undertake the research (original users); and (ii) those who use the results of the work of these original researchers for some purpose other than that intended by the original researchers (secondary users). For example, research on the aerosolisation of a pathogen (conducted by the original users) might be used for offensive purposes by those fighting an unjust war (the secondary users).

14. (3) In relation to "use" we can distinguish: (i) actually or potentially used in accordance with the purpose for which it was designed (design-purpose);
(ii) actually or potentially used for some purpose other than that for which it was specifically designed.

15. Dual-use dilemmas can involve original researchers whose purpose is a design-purpose, eg. demonstrate how to render a vaccine against a highly transmissible pathogen ineffective. This design-purpose can itself be in the service of a benevolent purpose of the original researchers, eg. the purpose of enhancing the effectiveness of the vaccine. Alternatively, the achievement of this design-purpose could be used for a malevolent non-design purpose by secondary researchers, eg. to render the vaccine ineffective in the context of spreading the pathogen in question.

16. Secondary users might build on the original research to create a new pathogen, eg. more virulent strain of smallpox as opposed to more virulent strain of mousepox, i.e. they had a new *design*-purpose (a malevolent one).

17. In relation to the *outcomes* of the research, distinguish: (i) intended outcomes;
(ii) unintended but foreseen outcomes and;
(iii)unforeseen and perhaps unable to have been foreseen outcomes.

18. An example of an unintended outcome is an outbreak of smallpox resulting from inadequate safety procedures in a laboratory setting. Such accidents are not instances of the dual-use dilemma. For something to be an instance of a dual-use dilemma, both outcomes (the two horns of the dual-use dilemma) need to be (actually or potentially) intended (or at least foreseen) by someone; there needs to be two sets of (actual or potential) *users*.

19. An outcome might be unintended and unforeseen (even unforeseeable) by the original researcher but, nevertheless, intended by the secondary user. Thus, scientists who preserve a small number of smallpox samples for pure research purposes in the context of a policy of mandatory destruction of samples might not intend or foresee that they might be used for malevolent purposes by others, eg. weaponised.

20. The dual-use dilemma is a dilemma for researchers, viz. those researchers involved in biological research that has the potential to be misused by bio-terrorists, criminal organisations and governments engaged in bio-warfare.

21. It is a dilemma for the private and public institutions, including universities, that fund or otherwise enable research to be undertaken. The dilemma is made more acute for university-based researchers and for universities, given their commitments to such values as academic freedom and the unfettered dissemination of research findings; and for private companies, given their commitment to free-enterprise.

22. It is a dilemma for the individual communities for whose benefit or to whose potential detriment, the research is being conducted.

23. It is a dilemma for the national governments who bear the moral and legal responsibility of ensuring that the security of their citizens is provided for.

24. Finally, in the context of an increasingly interdependent set of nation-states – the so-called, global community – the dual-use dilemma has become a dilemma for international bodies such as the United Nations.

25. Given the general threat to public health posed by transmissible pathogens, and given that biological agents can be used as WMDs in the hands of state actors, terrorist groups and criminal organisations, there is an imperative to strictly regulate the development, production, stockpiling, weaponisation and use of pathogens. At the international level, a key instrument in this regard is the Biological Weapons Convention (BWC)

26. The BWC does not provide for any robust verification processes, eg. unlike the Chemical Weapons Convention (CWC) there is no international organisation or national authority to verify compliance with the BWC.

27. Human knowledge and understanding of the natural world is both desirable in itself and a means to the provision of other human goods, such as health and longevity.

28. Human freedom, including freedom of intellectual inquiry, is agreed on all hands to be an intrinsic human good.

29. So research in the biological sciences is morally permissible, absent special considerations in relation to specific kinds of such research.

30. What, if any, research in the biological sciences is morally impermissible? Research in the biological sciences undertaken for the purpose of weaponising

biological agents so that they can be used to kill or cause illness in human populations is presumably morally impermissible, whether the research in question is undertaken by state actors, (non-state) terrorist groups, criminal organisations or malevolent individuals.

31. The moral problem that now arises concerns research in the biological sciences that is not undertaken *by the original researchers* for the ultimate purpose of using weaponised biological agents, but might be used by secondary researchers (or other users) for this impermissible purpose, ie. the moral problem presented by so-called dual-use dilemmas.

32. In relation to the dual-use dilemma in the biological sciences, the approach of the US National Research Council (NRC) in its 2004 report, *Biotechnology Research in an Age of Terrorism,* is to map the range of these dual-use dilemmas by identifying and taxonomising a set of salient "experiments of concern".

According to the NRC report "experiments of concern" are those that would:

1. demonstrate how to render a vaccine ineffective;
2. confer resistance to therapeutically useful antibiotics or antiviral agents;
3. enhance the virulence of a pathogen or render a non-pathogen virulent;
4. increase the transmissibility of a pathogen;
5. alter the host range of a pathogen;
6. enable the evasion of diagnosis and/or detection by established methods; or
7. enable the weaponization of a biological agent or toxin.

In addition we would add the following:

8. Genetic sequencing of pathogens;
9. Synthesis of pathogenic micro-organisms;
10. Any experiment with *variola* virus (smallpox); or
11. Attempts to recover/revive past pathogens.

33. By definition, dual-use research is morally problematic. On the one hand, such research provides benefits (at least potentially); on the other hand, there is the risk of misuse by rogue states, terrorists groups and the like.

34. Broadly speaking, the most obvious benefits of research in the biological sciences of the kind in question are: the protection of human life and physical health against diseases (including novel ones), the protection of existing, and (more controversially) the provision of novel, food sources; and the protection of human populations against biological weapons.

35. By contrast, the potential burdens of such research are death and sickness caused by the use of biological agents as weapons in the hands of malevolent state actors, terrorist groups, criminal organisations and individuals.

36. More fine-grained analyses of the benefits and burdens of such research would elaborate on the additional kinds of benefit/burden and recipients/bearers thereof, eg. the economic wealth accrued by large pharmaceutical corporations and their shareholders, the economic costs of expensive, unsuccessful (or only marginally beneficial) research programs in the biological sciences and, more generally, the dis/utility and in/justice of specific allocations of resources to, and the distribution of benefits and burdens from, different research programs in the biological sciences, eg. the evident disutility of the large 1946-1992 Soviet biological weapons program.

37. Fine-grained ethical analyses of dual-use research in the biological sciences would seek to *quantify* actual and potential benefits and burdens, and actual and potential recipients/bearers of these benefits and burdens. These analyses would also identify a range of salient policy options. Each option would embody a set of trade-offs between present and future benefits and burdens, and recipients and bearers thereof. The construction of these options and the process of selection between them would consist in large part in the application of various ethical principles, including human rights principles – eg. right to life, freedom of inquiry, and free speech – and principles of utility and of justice.

38. Note that scientific freedom does not necessarily have to be traded off against security, e.g. increased regulation might have financial costs but not render any research impermissible or unable to be disseminated.

39. Let us focus (somewhat simplistically) on a single ethical consideration, namely, human health (including human life) that gives rise to the dilemma; and do so without exploring questions of which human populations or how many individual humans have benefited/been burdened or are likely to benefit/be burdened, and so on.

40. Now the dual-use dilemma concerns human health (as a simple, unquantified human good), and the dilemma consists in the fact that research undertaken to promote human health might instead be used to destroy human health. As such, the dilemma gives rise to questions of security; what are reasonable and ethically justified forms and degrees of security in this context?

41. The security in question is a complex notion. It consists in part in the physical security of, for example, samples of biological agents against theft. Relatedly, security consists in part in the processes in place to ensure, for example, that the researchers themselves cannot, or will not, conduct research for malevolent purposes.

42. Security in this sense also consists in part in restrictions that might be placed on the dissemination of research findings.

43. A static mode of analysis of the dual-use dilemma consists only of the quantification of harms and benefits, the identification of salient options, and the selection of an option on the basis of ethical principles. However, a more dynamic, creative, mode of analysis is called for.

44. Firstly, options are not static. Scientists, malevolent actors and security personnel are *responsive* to the problems that they confront. The response of scientists to a pathogen with enhanced virulence might be a new vaccine. Response of security personnel to a new bioterrorist threat might be an enhanced regulatory system. Mode of analysis of the dual-use dilemma must be dynamic in character.

45. Secondly, ethical dilemmas are not necessarily to be resolved by careful calibration of the differential ethical weight that attaches to the options provided for in the dilemma. The dilemma might be resolved by *designing* a new third or fourth option, i.e. by bypassing the dilemma.

46. Consider the question of whether or not to disseminate dual-use research findings: scientific freedom versus security. Solution is to create a third option, eg disseminate them in a manner that will not enable the experiments to be replicated. What Jeroen van den Hoven calls *designing-in ethics*.

47. Dual Use Dilemma involves at least three separable ethical questions. Firstly, the ethical question as to whether or not a putative biological agent to be researched ought in fact to be eliminated (or, if already eliminated, not retrieved). Here the *possibility* of research is removed; no possibility of research because no biological agent to be researched, eg the elimination of all samples of smallpox.

48. Secondly, the ethical questions arising from dual-use research in relation to a biological agent whose present and/or future existence is taken as a given; no intention to eliminate or not retrieve or not bring into existence the biological agent, eg research to determine whether or not avian influenza could trigger a human pandemic might lead to the creation of dangerous new strains useable by terrorists. Such research might create novel pathogens or synthesising existing ones - work whose ultimate purpose was to develop a vaccine against these pathogens.

49. Thirdly, the ethical question of whether to undertake dual-use research for purpose of protection against weaponised pathogens, e.g. research on aerosolisation of pathogens.

50. Consider second question ie research on presently existing or novel pathogens (where their present and/or future existence is accepted).

51. The general problem here is the unintended (by the original researcher) untoward consequences of otherwise benign research. These consequences are threefold. First, there is an unintended dangerous biological research outcome, eg. a pathogen with enhanced virulence or transmissibility or at least the knowledge of how to create such a pathogen. Whether or not such an unintended and untoward outcome is possible or likely is a scientific question, best answered by biological scientists.

52. Secondly, there is an outcome not intended by the original scientist but, nevertheless, intended by some malevolent state actor, non-state terrorist group, criminal organisation or individual, eg. the weaponisation (and use as a weapon) of the pathogen that has been unintentionally created. Whether or not this outcome is possible or likely – given, say, a pathogen has already been (unintentionally) created – is a security question, best answered by security experts (with input from relevant non-security specialists such as engineers).

53. Thirdly, there is the ultimate outcome intended by the malevolent individual or organisation, namely, the public health outcome consequent on the biological attack. What the public health outcome of a given biological attack is likely to be, eg. the extent of loss of life, is a public health question, best answered by public health experts or teams thereof (including biological scientists, medical personnel and weapons experts, but also those knowledgeable about public health resources and infrastructure).

54. The danger attendant upon a given dual-use research program can be crudely quantified by determining the probability, be it low, medium or high, of a given untoward outcome, and multiplying this probability by the (quantified) disvalue (or disutility) of that outcome, eg. in terms of the numerical loss of human life. A more fine-gained ethical analysis would explore the variety of decision making/ risk-taking strategies – including the precautionary principle.

55. So there are a complex mix of scientific, security, public health and ethical considerations in play. The process of moral reasoning involved will require trade-offs between ethical considerations and involve creative solutions that bypass the dilemma.

56. The result will be that some putative experiments of concern will be relegated to the impermissible category and others to the permissible category, albeit in the latter case under stringent conditions of safety and security.

57. Consider an experiment of concern eg enhancing virulence of a pathogen. If there is no evidence of a threat posed by, say, a genetically engineered strain of cowpox that attacks the immune system, then no reasonable justification for developing such an organism. There needs to be some evidence of a threat. This raises questions: What counts as evidence? How immediate is threat? Is development of more virulent pathogen greater threat than original threat it is

supposed to protect against? When microbial threat exists only in scientist's imagination, an experiment to create the microbe is both unnecessary and overly risky.

58. Two additional points. First one concerns the process of moral reasoning. Utilitarian and consequentialist reasoning use notions of future benefits/burdens, quantified loss of life, disvalue and disutility. Consequentialist reasoning is one-dimensional and fails to give sufficient weight to the intrinsic moral properties of current actions, eg. perhaps human rights of current persons override future utility.

59. Second point pertains to uncertainty. Risk assessment assumes that probabilities of specific outcomes can be determined; risk assessment is more than mere guesswork. Reliability of probability judgments in relation to outcomes from dual-use research is open to question e.g. the possibility of the development of a vaccine-resistant strain of smallpox based on research undertaken on mousepox to develop a contraceptive for mice could not have been realistically predicted.

60. This is not to say that attempts should not be made to foresee untoward outcomes; it is merely to caution against over-confidence in the results of such attempts.

61. Because the actors involved in dual-use dilemmas are responsive to problems and to one another's actions, probability judgments need to take this into account. For example, a security risk from bioterrorists can be analysed in part in terms of a complex set of variables including the ability, opportunity and motivation of the bioterrorists, the likely intelligence possessed by, and the likely assessment made by, the terrorists, the capacity to respond to specific forms of bioterrorist attack, the likely movements of innocent third parties at risk from specific security responses, the relevant moral principles, the rights and duties of the various actors involved, and so on.

62. What might be crucial here is the capacity to generate a creative response to the security problem thus analysed, eg. reducing opportunities for bioterrorists by establishing a licensing system for laboratories using dual-use technologies, licensing of DNA synthesisers, certification of people who place orders to have DNA synthesised.

63. A further ethical question arising from dual-use research pertains to weaponisation. A particularly morally problematic species of the dual-use dilemma arises in the case of R&D projects on biological weapons (BW). In order to develop defences against a putative BW agent, it is necessary to understand the underlying mechanisms for pathogenicity and the ways in which the biological agent may be dispersed. An understanding of these factors is also exactly what would be required for the development of BW.

64. Research that is defensive in the sense that it serves the purpose simply of enabling combatants and civilians to *protect* themselves against a biological attack by, for example, developing early warning indicators of the presence of aerosolised novel pathogens is *prima facie* morally permissible. Such research is research undertaken for the purpose of *protection* (as opposed to military *defence*). The problem is that such research for protective purposes might itself involve, for example, the creation of a virulent and highly transmissible novel pathogen and the weaponisation of it. Thus the weaponisation of pathogens for protective purpose gives rise to a dual-use dilemma of a very acute kind.

65. The issue resolves itself into whether or not in practice the weaponisation of pathogens for protective purposes can be distinguished from the weaponisation of pathogens for offensive purposes.

66. Presumably, if these two conceptually distinct activities are to be distinguished in practice then this is because there are *verifiable* differences in respect of: (i) intention or purpose; and (ii) physical properties of the weaponised pathogen.

67. In relation to (i), for example, if the intention is protection then the pathogen in question will be one that some identified malevolent state or terrorist group is known to have weaponised (or it is known that they are in the process of weaponising the pathogen).

68. In relation to (ii), for example, if the weaponised pathogen is possessed in large quantities, ie. quantities appropriate for a military offensive but unnecessary for research serving purely protective purposes, then it is a case of weaponisation for offensive purposes. Also one might expect there to be some differences in the *results* of research involving weapons constructed in accordance with the design-purpose only of testing protections against an attack using that weapon from the *results* of research undertaken with the design-purpose of making a successful attack using that weapon, i.e. an attack against which the enemy is not protected. For example, in the case of the former the research result might be a protective vaccine, whereas in the case of the latter the research result might be a weaponised pathogen that is resistant to any vaccine.

69. Moreover, the *results* of such dual-use research on the weaponisation of pathogens undertaken only for protective purposes, e.g. the vaccine mentioned above, might be more likely to be disseminated; after all, it is not only one's own civilians and combatants that ought to be protected from biological attack. Or at least one would expect, other things being equal, there to be less need for secrecy in relation to such relatively benign research and a willingness on the part of those engaged in it to be subject to verification checks.

70. If terrorists get access to dual-use research then they may well be in a position to weaponise virulent pathogens against which we have no immunity or vaccine and, thereby, realise our worst nightmare; a biological attack by terrorists against which we have no protection. Part of the solution to this problem; censor scientific research in order to prevent findings being disseminated to terrorist groups.

71. Whole-sale censorship raises a host of ethical issues including, in the case of university-based research, scientific freedom. Censorship is a clear violation of scientific freedom.

72. Scientific freedom is not an absolute right. Contingencies such as war or a pandemic or a potential terrorist attack typically override the right to disseminate. But censorship of scientific research needs special justification.

73. One way to avoid the dilemma of either censoring scientific research findings or assisting terrorists in their plans to engage in bioterrorist attacks, is to try to find a middle way of partial censorship. Some dual-use publications in the scientific literature are more directly applicable for harmful intent than others.

74. Develop a taxonomy of dual-use publications which at the very least should distinguish between 1st tier and 2nd tier research; the former refers to dual-use research possessed of direct applicability for harmful intent and the latter only with indirect applicability for harmful intent. 1st tier research findings might need to be censored or presented for publication in a manner that would not enable readers to replicate the experiments in question and thereby generate dangerous pathogens and the like.

DECISION-MAKING RE DUAL-USE DILEMMAS IN THE BIOLOGICAL SCIENCES

NB: The decision-making in question pertains only to dual-use research in the biological sciences identified as potentially problematic by virtue of coming under one of the pre-established headings of Experiments of Concern.

OPTIONS

DECISIONS	Option 1 The Complete Autonomy of the Individual Scientist	Option 2 Institutional Control	Option 3 Institutional & Governmental Control	Option 4 An Independent Authority	Option 5 Governmental Control
Who are the Decision-makers regarding Im/permissible Research?	Individual researcher	(i) Scientists in University (collegial) (ii) Corporation (iii) Govt Res. Centre	(i) Scientists in University (collegial) (ii) Corporation (iii) Govt Res. Centre	Independent Authority	Government
Is Physical Safety & Security Regulation Mandatory?	No	Yes	Yes	Yes	Yes
Is Licensing Dual-Use Technology Mandatory?	No	No	Yes	Yes	Yes
Is Education & Training Mandatory?	No	No	Yes	Yes	Yes
Is Personnel Security Regulation Mandatory?	No	No	Yes	Yes	Yes
Who are the Decision-makers regarding Censorship/Constraint of Material proposed for Dissemination?	Individual editor	(i) Individual editor (ii) Corporation (iii) Govt. Res. Centre	(i) Individual editor (ii) Corporation (iii) Govt. Res. Centre	Independent Authority	Government