New Genetics and Society, Vol. 22, No. 2, August 2003

Biological weapons, genetics and social analysis: emerging responses, emerging issues—I

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ABSTRACT *Recent terrorist attacks in the USA have generated significant attention in many countries to the threats posed by biological weapons. In response to these events and the spectre of future attacks, bioscientists and professional organizations have begun or intensified asking questions about the possible malign applications of their research. As Part I of a two-part article, this paper surveys how genetics might contribute to the development of novel forms of weaponry. It is further argued that the dilemmas and difficulties facing bioscientists pose pressing and thorny questions for the hitherto agendas and orientations of those concerned with the social, ethical and political implications of genetics. Part II will examine the emerging responses initiated by biomedical organizations and spokespersons in the US and the UK. This will be done with a view to asking how scientific and medical research communities are defining and policing notions of professionalism, responsibility and accountability. On the basis of this, suggested lines for future social analysis will be offered.*

Introduction

Developments in science and engineering have long provided the basis for more sophisticated weaponry. In the 20th century, that connection was perhaps most explicit in the case of weapons of mass destruction, including nuclear, chemical and biological capabilities. Attention to these topics by the public, scientists and policymakers has tended to wax and wane, depending on events and perceptions of the security situation (Balmer, 2001). While some level of concern has existed throughout the last fifty years regarding the possible use and proliferation of nuclear weapons, arguably the same could not be said of chemical and biological ones. Although certain individuals, professional bodies and policymakers have drawn attention to possible threats (e.g. Henderson, 1999; British Medical Association, 1999), generally this has not been that sustained or widespread. Whatever the complacency of the past, since 11 September 2001 and the bioterrorism that followed in the USA, substantial anxiety has been experienced across many countries about possible biological and chemical threats (e.g. Poste, 2001).

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ISSN 1463-6778 print/ISSN 1469-9915 online/03/020169-13 © 2003 Taylor & Francis Ltd
DOI: 10.1080/1463677032000102585

With the increasing recognition of the disturbing possibilities enabled by current scientific know-how, a wide variety of individuals and organizations within Western science and policy circles are asking what actions should be taken to prevent research from facilitating death and injury. This two-part paper surveys initial responses by biological and medical science communities to the growing societal concern with the application of their expertise. Specifically, it addresses this by considering the role of genetics research in enabling and forestalling novel forms of biological weapons targeted at humans (see Whitby, 2002; Whitby, Millet & Dando, 2002 for a discussion of animal and plant bio-weapons). The immediate policy response in many countries has been geared towards countering imminent dangers of established biological agendas by, for instance, placing further restrictions on access to dangerous pathogens (Epstein, 2001; Home Office, 2002). In contrast, this paper focuses on responses to novel prospective possibilities that may be created by genomics research. It seeks to address several questions:

- How might current genetics and genomics research contribute to the development of biological weapons?
- What is the range of responses being considered to mitigate against the threats identified?
- How are notions of professionalism, responsibility, and accountability defined within these responses?

In examining the latter two points in Part II, this paper draws on general literature within the social sciences to comment on and assess the measures being proposed. The possibilities surrounding bio-weapons have not only been of arguably marginal concern hitherto for those in the biological sciences. Despite the substantial amount of investigation into the social, legal and ethical aspects of genetics, few analysts have turned their attention to biological weapons. As argued in Parts I and II an examination of the possibilities surrounding such technologies not only poses difficult questions for the priorities and purposes of biological and medical researchers, but also for those concerned about the "social" implications of modern technoscience. This paper asks what issues biological weapons raise for the social, political and ethical studies of technology as it considers what such analyses have to say to biological weapons. It sets out a number of questions for future research, some of which will be pursued in a project by the author and Malcolm Dando (University of Bradford, UK) funded by the UK Economic and Social Research Council (see Rappert & Dando, 2002).

The threats of biological weapons

Biological warfare dates back to antiquity (Barnaby, 1997; Stockholm International Peace Research Institute (SIPRI), 2001). The fouling of water sources with animal carcasses or the catapulting of disease-infected corpses over city walls are some of the earliest recorded examples of warfare techniques designed to spread disease. During colonization, French and British forces gave smallpox infected blankets to Native Americans with the intent and effect of infecting them.

Modern biology and medicine has facilitated the production of biological weapons throughout the 20th century (Dando, 1999). On the basis of 19th century advances in bacteriology, for instance, both sides in World War I attempted to employ micro-organisms against their opponents' animals. During World War II, Japanese scientists conducted horrific experiments during their occupation of China. After the war, many industrialized countries began or furthered systematic programmes into offensive and defensive capabilities (see, e.g. Balmer, 2001). Most of these programmes were abandoned by the signing of the 1972 Biological and Toxin Weapons Convention (BTWC). The BTWC has become the cornerstone of international efforts to limit the production and proliferation of biological weapons. Article I states:

> Each State Party to this Convention undertakes never in any circumstances to develop, produce or stockpile or otherwise acquire or retain:
>
> 1. Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes.
> 2. Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

While the BTWC represents one of the most significant international agreements to restrict the means of warfare, its terms have been a source of contention and negotiation. A consideration of why indicates some of the major topics of concern about biological weapons today. One major limitation of the convention is that no mechanisms exist for verifying adherence by state parties. Attempts throughout the last decade to agree such measures were halted for the time being shortly before 11 September 2001, when the US withdrew any support for inspection regimes, stating they would be both ineffective as well as reveal biodefence capabilities and commercial secrets.

Given the lack of verification measures and the widespread availability of the general materials, equipment and biological expertise necessary for weapons development, the possibility that some state parties are violating the BTWC has long been a cause of concern. The defection of high-ranking scientists from the Soviet Union post-Cold War indicated that it had an extensive offensive programme. This consisted of tens of thousands of staff and incorporated genetic engineering techniques. Likewise, Iraq had a clandestine offensive programme prior to and after the Gulf War (Wallerstein, 1998).

Outside flagrant violations, just what activities are permissible is likewise disputed. Under the BTWC, undertaking defensive measures against biological weapons is acceptable. No criteria are given though to differentiate offensive from defensive development, production or stockpiling activities. As specified by the BTWC, what counts is the intent of actions. All biological agents and toxins are banned unless otherwise justifiable. Yet, predictably, it has not been straightforward to establish intent. For instance, during the Clinton administration, the US began several projects of a questionable status. These consisted of planning to genetically engineer a potent variant of the bacterium that causes anthrax; building and testing an imitation Soviet-designed germ bomb; and assembling a mock biological weapons factory from products openly available on the commercial market (Miller, Engelberg & Broad, 2001). None was reported under the provisions of BTWC. Each was justified on the basis of needing to test current defensive capabilities against likely threats, yet each had offensive potential. Limited *offensive* developments done to test defensive measures (e.g. vaccines) have been interpreted as permissible under the BTWC (see Huxsoll, 1992). Because offensive and defensive activities are so interlinked and difficult to distinguish, there has been much disagreement regarding what counts as an infringement and what evidential basis would be needed to support particular evaluations (Wright, 1990).

Much of the most recent concern about biological weapons has centred on those outside the BTWC—specifically sub-state and terrorist groups (see, e.g. Knobler, Mahmoud & Pray, 2002). The release of the chemical nerve gas sarin during 1995 into the Tokyo subway system by the religious cult Aum Shinrikyo and its failed attempts to develop biological weapons signalled that some sub-state groups or individuals were interested in employing chemical and biological weapons. For some commentators, the ability to mask offensive programmes under civilian ones, the weight-for-weight potency of biological weapons and the relative ease of access to pathogenic agents and toxins make bio-weapons a potentially attractive option for terrorist attacks (e.g. Danzig & Berkowsky, 1997).

Whether it is feasible that individuals, sub-state groups or even many states can develop and effectively employ bio-weapons has been a topic of much debate (Broad, 2001). The ease or difficulty one believes of crafting such weapons has a direct bearing on assessments of the likelihood of attack and the necessary responsive measures. Producing a biological weapon requires obtaining a strain of an agent, culturing it in sufficient quantities, and then finding an adequate means of dispersal. Leitenberg (2000) argues there has been little or no acquisition of biological weapons by non-state actors in the 20th century because each step is highly demanding. Even though many bacteria are available from natural sources, for instance, they may not be virulent enough to act as agents in weapons.[1] Such assessments stand in sharp contrast to claims by Carl Ford, Assistant Secretary of State for Intelligence and Research in the US Department of State, who said:

> Terrorist interest in chemical and biological weapons has been growing and probably will increase in the near term. The threat is real and

proven. The ease of acquisition or production of some of these weapons and the scale and terror they can cause, will likely fuel interest in using them to terrorize. The transport and dispersal techniques also are manageable and can be made effective easily … (Ford, 2002, cited in Leitenberg, 2002; also Pearson, 1998).

Of course some amount of disagreement may result from alternative interpretations of what counts as effective—whether that be judged by casualty figures or political, financial and psychological costs. If the latter is taken as the criterion, then heightening public attention to the dangers of biological weapons may well end up amplifying the costs of any attack by enhancing fear levels. Focusing public health attention and training into the prevention and response to bio-attacks may well end up diverting resources from the types of specific actions that are needed to address pressing health problems.[2]

Possible biological agents include viruses, bacteria, toxin, rickettsiae and fungi. Each has various strengths and weaknesses as warfare agents. *Bacillus anthracis*, the agent that causes anthrax, has long been seen as one of the principal threats because it can be found naturally, strains of it are highly potent and long lasting, an effective vaccine exists, and it is not communicable. The last two points might limit its lethality, but they also make it easier to handle and target the agent. Table 1 indicates some general characteristics of biology weapons likely to be sought for those wishing to acquire them.

TABLE 1. Sought-after properties of biological agents

Requirements	Desirable characteristics
Consistently produce a given effect (death, disability or crop damage).	Possible for the using forces to protect against.
Be manufacturable on a large scale.	Difficult for a potential enemy to detect or protect against.
Be stable during production and storage, in munitions and during transportation.	A short and predictable incubation period.
Be capable of efficient dissemination.	A short and predictable persistency if the contaminated area is to be promptly occupied by friendly troops.
Be stable after dissemination.	Capable of infecting more than one kind of target (for example, man and animals) through more than one portal of entry, being disseminated by various means, producing desired psychological effects.

Source: Taken from Cohen (1997): http://www.defenselink.mil/pubs/prolif97/annex.html, which adopted the chart from US Departments of Army and Air Force (1964) *Military Biology and Biological Agents*. Departments of Army and Air Force Technical Manual 3–216/Air Force Manual 355–6, 12 March.

Biological weapons and the new genetics

In recent years, the knowledge and techniques gained from genetics, genomics and other fields of research have grown apace. Genetic sequencing has helped to locate specific genes and to identify their associated proteins. Combinatorial chemistry has enabled the automation of discovery process for identifying new drug candidates through the creation of large libraries of chemicals. High throughput screening provides a rapid means of finding compounds against various biological targets. Genechips generate indicators for complex multifactorial conditions. Developments in bio-informatics have supported the collection and dissemination of vast quantities of data.

As such developments become widely commercialized, the danger is that this increases the chance that new forms of bioengineered weapons can be produced to augment or replace existing capabilities. Peaceful commercial applications of genetics and genomics research can enhance the possibility that others might achieve the sought-after characteristics listed in Table 1. To use the jargon, the technology and techniques developed are of "dual-use". In 1996, the Fourth Review Conference of BTWC highlighted the danger of general advances in stating:

> The Conference, conscious of apprehensions arising from relevant scientific and technological developments, *inter alia*, in the fields of microbiology, biotechnology, molecular biology, genetic engineering, and any applications resulting from genome studies, and the possibilities of their use for purposes inconsistent with the objectives and the provisions of the Convention, reaffirms that the undertaking given by the States Parties in Article I applies to all such developments.[3]

A 1997 a US Department of Defense publication suggested a number of significant technological trends likely to influence how readily infectious agents can be used for biological warfare:

- Genetically engineered vectors in the form of modified infectious organisms will be increasingly employed as tools in medicine and the techniques will become more widely available.
- Strides will be made in the understanding of infectious disease mechanisms and in microbial genetics that are responsible for disease processes.
- An increased understanding of the human immune system function and disease mechanisms will shed light on the circumstances that cause individual susceptibility to infectious disease.
- Vaccines and antidotes will be improved over the long term, perhaps to the point where classic biological warfare agents will offer less utility as a means of causing casualties (Cohen, 1997).

Genetics and genomics figure directly or indirectly into each of these.

How might such research enable the production of new biological weapons?

The possibilities are numerous (for overviews, see Drell, Sofaer & Wilson, 1999; Fraser & Dando, 2001):

- Bacterial agents such as bacillus anthracis can be made resistant to current antibiotics. Reports about the Soviet weapons' programme, for instance, indicated it was able to make the casual agent for plague resistant to numerous antibiotics (Barnaby, 1997).
- Transferring the genes responsible for pathogenic qualities into non-pathogenic organisms (such as *E. coli*) would make them so, or such genes could be transferred to already pathogenic organisms to increase their virulence (in relation to novel influenza viruses, see the *Lancet Infectious Diseases* (2002)).
- The survivability of a bacterium across a range of environmental conditions could be improved through gene splicing.
- Cells could be modified to produce greater quantities of toxins.
- Detection, mitigation and remediation from exposure to agent strains could become much more difficult if they were modified to hide telltale signatures. Russian scientists in the mid-1990s reportedly made detection tests for anthrax ineffective though genetic engineering techniques (Sunshine Project, 2002).

As elsewhere with bioengineering, there are questions about possibility and feasibility of such steps. The complexities of genetic expression and limits to understanding still hamper such efforts. The primary genes responsible for pathogenic properties might be transferred to another micro-organism but, in doing so, the virulence of the donor strain may be significantly decreased.

Two further points about the manipulations above are worth noting here. First, the know-how and tools required for these are fairly generic in genetic engineering. Attempts to develop vaccines for HIV, for instance, have inserted HIV genes into Salmonella. A major source of difference, however, is the type of materials utilized. Secondly, many of the modifications of pathogenic agents could be/are undertaken as part of efforts to develop new vaccines and diagnostic techniques or further knowledge about the basic mechanisms of virulence (see Leitenberg, 2002).

In addition to whatever possibilities are opened up for those deliberately setting out to create biological weapons, suggestions for novel approaches might arise "unintentionally". This prospect received a fairly widespread airing when Australian researchers publicized creating a particularly potent strain of mousepox as part of experiments into a genetically based contraceptive for mice. This was done by altering the mousepox virus through the insertion of the interleukin-4 gene (Jackson *et al.*, 2001; Dennis, 2001). If parallel modifications could be made to human smallpox, then it might evade existing vaccination measures.

As a further elaboration of the dilemmatic relation between "weapon" and "non-weapon" biological research, the same advances in microbial genomics used to produce bio-weapons can also set up countermeasures against them.

The completion of the human genome sequence provides a new starting point for better understanding of the infectious disease process, and this has potential *against* bio-warfare. So, too, with sequence data for the casual agents of anthrax, tuberculosis and cholera (Venter, 2001). While the free availability of such data in open sources might further the proliferation of knowledge, it also enables additional prevention and treatment steps. New vaccines, compounds and diagnostics, perhaps specific to different agent strains, might be produced. Gene chips could aid in the identification of strain-specific differences in agents after an attack starts to ensure rapid and effective treatment. Each such counter-response to a potential threat in turn could bring attempts to counter it through yet a further utilization of bioengineering techniques. Such is the history of weapons development.

Novel options might be viable in the future. New bacteria or viruses might be created from component genetic parts rather than merely modifying existing agents (Fraser & Dando, 2001; Whitehouse, 2002). Viruses could be secretly introduced into a target population and then activated by a signal at some later time (Drell *et al.*, 1999). A fair amount of speculation has taken place as to whether increasing the information on the structure and function of the human genome might enable so-called "ethnic genetic weapons". In 1993, the Stockholm International Peace Research Institute warned that genetic differences between population groups might provide a basis for vectors to attack DNA sequences inside cells specific to certain sub-populations (Bartfai, Lundin & Rybeck, 1993). Whether the complexity of gene influence in disease susceptibility will allow for such targeting remains uncertain (British Medical Association, 1999).

Genetics may well offer opportunities for utilizing new agents. Consider so-called bioregulators. A US review entitled *The Biological and Chemical Warfare Threat* defined bioregulators as:

> natural substances produced in very small quantities that are essential for normal physiological functioning of the body. They control cell and body physiological functions and regulate a broad range of functions such as bronchoconstriction, vasodilation, muscle contraction, blood pressure, heart rate, temperature, and immune responses. (US, 1996; quoted from Dando, 2001)

It suggested that altering the concentration of these substances would disrupt basic body functions, with the potential for almost immediate effects. Short of inflicting outright death through, say, heart failure, bioregulators could act as incapacitants. Kagan (2001) identified several likely categories of biological warfare/terrorism bioregulators: altering levels of cytokines can cause serious illness, lethargy and fever; eicosanoids manipulations can induce asthma; and plasma proteases modifications can bring bronchoconstriction, hypertension and pain.

Neurotransmitters and hormones make up another category of bioregulators, one that has far reaching potential. Past uncertainties about the role of receptors and bioregulators in drug action have limited the possibility of devising appropriately specific drugs. As genetics and genomics research brings a greater understanding of the function of neurotransmitters in nervous system communication and the diversity of receptor types, with this comes the opportunity to affect cognition, sensory processing and mood selectively. The code for those neurotransmitters that are peptides, for instance, can be inserted into a virus in order to affect behaviour. The military applications are potentially enormous. In the 1950s and 1960s, both the UK and the US experimented with glycollates, such as the psychotropic drug BZ (3-quinuclidinyl benzilate), to see if they could be employed to cause hallucinations, disorientation or stupor. Such efforts largely failed because the biological targets were not properly characterized (see Dando, 2001). These barriers may now, or soon, be overcome.

This brief survey has indicated possible technological options as well as some of the terms for contention about biological weapons. Disagreement abounds about what threats are posed, who these come from, what should be taken as fact rather than fiction, and what steps will be required to mitigate against dangers. There are basic problems about the categorization of activities (e.g. what counts as offensive work) and the limits to empirical evidence (because of secrecy or unknowns). Those wishing to respond to the threats posed by biological weapons must operate in relation to unstable notions of anticipated future risks where the issues faced about what ought to be done are thoroughly dilemmatic. Claims about the threat of biological weapons help constitute the very issue they are commenting on. Attempts said to "talk up" or merely "highlight" potential dangers in order to unsettle complacency might well end up magnifying the social and economic damaged caused by any such attack.

The social sciences and biological weapons

What insights might be offered by past social science research to make sense of the varied and multiply conceived issues associated with biological weapons, particularly in relation to the contribution of contemporary genetics and genomics?

Most of the past interest from social scientists in biological weapons has come from those in areas aligned with international relations, such security and peace studies. The main concerns herein have been with the proliferation of production capabilities (e.g. Brauch *et al.*, 1997); the possibility of establishing effective export controls and disarmament measures (e.g. Robinson, 1998; *The CBW Conventions Bulletin*), particularly given the dual-use status of much technology (e.g. Molas-Gallart & Robinson, 1997); and the assessment of threats posed by the use of biological weapons from states, criminals or terrorist organizations (Barnaby, 1992). Practitioners in fields such as microbiology, immunology or toxicology (Hay, 1999)—many formerly part of biodefence establishments—have conducted many similar studies. Pearson (1993) has argued that any overall strategy for the reduction of the threat of biological weapons requires a "web of deterrence", consisting of such initiatives as international arms controls, export and monitoring procedures, defensive and protective measures, counter responses to the use of biological weapons, and prevention steps undertaken by the bioscience community. Outside international relations, other social analysts have examined historical transitions in major offensive biological weapons programmes (e.g. Balmer, 2001; Gould & Folb, 2002; Regis, 1999).

Despite the significant contributions made by many of the above analysts, the study of chemical and biological weapons and its links to biological and genetics research has been a rather specialized topic of study centred in certain subdisciplines. For understandable reasons, the preoccupation of many of those concerned with this topic has been in practically examining ongoing technical and political developments rather than stepping back from the substantive area to ask what it means for wider concerns in social and political theory. In the past, no doubt due to the low public profile of bio-weapons, few outsiders to this area have asked what lessons might be learnt from its study or integrated such lessons into the mainstream of many disciplines. Even in relation to ethical issues, debates in bioethics have not been informed by the possibilities raised by biological warfare (Hooker, 1992). A sense of the marginal priority attached to this topic can be gleaned from the relatively minor attention paid to it, despite the significant sums of money being devoted to the social study of genetics. Major national their research programmes into the legal, ethical and social implications of genetics, such as ELSI, have given little attention to this topic (Greenly, 1998). This lack of attention is perhaps indicative of the general academic decline in funding priorities for defence-related studies since the end of the Cold War.

Arguably, perceptions of the importance of biological weapons have altered significantly for social scientists and funding agencies with the terrorist events of 2001. As with other areas in the past, its ascent in public discussions is likely to be followed by greater attention—as represented by this paper. In doing so, however, the problems about agendas and orientations to be faced go beyond the lack of past consideration of the topic. At stake are quite fundamental questions about what sort of response should be made. Much of past social science research into the general relation between medicine and warfare has taken a somewhat suspicious, if not down right hostile, orientation to such linkages. Sontag (1978) examined how medicine has long drawn on metaphors from warfare (e.g. "targets", "war on cancer", etc.) selectively to define proper medical responses. Others have stressed the manner in which modernity, medicine and war have been inextricably bound together in the 20th century. The mobilization of biomedicine during war has brought with it administration controls, surveillance mechanisms, regulation procedures and rationalization techniques—the overall merits of which are taken as ambivalent at best (Cooter, Harrison & Sturdy, 1998). The possible military control of genetics research has brought calls for caution from various quarters (Piller & Yamamoto, 1988; Wright, 1990; Yoxen, 1983).

Whatever the scepticism that characterized the past study of the interrelations of military, biomedicine and genetics, with the increasing regard for Western countries as targets of bioattacks and the substantial attention dedicated to biodefence measures (see the next section in Part II) the pertinent question arises of what roles those concern with the ethical, social and political implications of genetics ought to take. These might be offering critical outsider commentary that seeks to identify misrepresentations; giving practical inputs into strengthening biodefence structures; cultivating alternative responses to dominant ones; or identifying hitherto ignored security threats. Such roles are not exclusive. While questions about the way forward are hardly unique to the area of biological warfare, they are particularly acute because of the past lack of attention to this area and the speed of its rise as a matter of public concern. The points noted above about the "dual-use" of biodefence research—its potential to minimize the threat of harm from biological weapons while providing the seed of future weaponry—are destabilizing for social scientists just as they are for bioscientists. For each, it can be expected that the demarcation between offensive and defensive activities will loom large in determinations of appropriate conduct. So too will concerns about how to orientate to competing claims about what constitutes "hype" or "reality". As conducting research in this area helps constitute determination of the seriousness of the problem (albeit to varying degrees), the way forward is full of potential pitfalls.

Acknowledgements

My thanks to Brian Balmer, Malcolm Dando and Gigi Kwik for their assistance in producing this paper.

Notes

1. As an indication of this, at the time of writing, the US government considers the most likely suspect(s) for the anthrax attacks to be a biodefence insider.
2. See, e.g. <http://www.redbluffdailynews.com/display/inn_news/news65.txt>.
3. See <http://www.brad.ac.uk/acad/sbtwc/revconf/4final3.htm>.

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