BioWeapons Prevention Project

BWPP Biological Weapons Reader

Edited by

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Geneva 2009

About BWPP

The BioWeapons Prevention Project (BWPP) is a global civil society activity that aims to strengthen the norm against using disease as a weapon. It was initiated by a group of non-governmental organizations concerned at the failure of governments to act. The BWPP tracks governmental and other behaviour that is pertinent to compliance with international treaties and other agreements, especially those that outlaw hostile use of biotechnology. The project works to reduce the threat of bioweapons by monitoring and reporting throughout the world. BWPP supports and is supported by a global network of partners. For more information see: http://www.bwpp.org

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Preface

It has been predicted that the 21st century will see a biological epoch to rival revolutions in information technology, industrial chemistry, and manufacturing processes. Such developments, heralded as offering unparalleled benefits for humanity, have all ultimately been used for hostile purposes. We know that some have already used biology for malign ends (Chapter 1) and that such efforts have not been the preserve of states alone (Factsheet 1). We must work diligently to ensure that this 'Century of Biology' does not result in a new biological arms race.

There is a rich history of efforts to ensure biology is used only for peaceful purposes (Chapter 2). The most recent chapter of this saga focuses on the treaty to ban the acquisition of biological weapons – the Biological and Toxin Weapons Convention (Chapter 3). This convention tries to ensure that robust domestic arrangements are put into place to translate international commitments into effective national action (Factsheet 2). Strong national efforts and international action cannot, however, take place in a vacuum. They are ultimately driven by, and depend upon the support of, civil society. Prior to the creation of the BWPP, civil society lacked a coherent voice in discussion on how to prevent the malign use of the life sciences. This book is a testimony to the important contribution that civil society can make to international peace and security.

There can be little doubt that the life sciences are advancing faster than ever before (Chapter 4) and that this brings with it a raft of new challenges – for civil society, to understand increasingly arcane technological developments; for scientists, to ensure that their work is not misused by others; for policy makers, to design oversight frameworks capable of keeping abreast of such rapid progress; and for industry, to find ways to talk about issues that can be both unfamiliar and uncomfortable. Efforts to prevent other related technologies from being used as weapons have faced similar hurdles in the past. There are important lessons that we can draw from these efforts and it is useful to compare and contrast approaches in the biological field with, say, efforts to prevent the hostile use of chemistry through the Chemical Weapons Convention (Chapter 5).

As the former United Nations Secretary General, Kofi Annan, pointed out in April 2006, dealing with the threat posed by biological weapons is unique and requires "innovative solutions specific to the nature of the threat".[1] This will require us to better characterize what that threat actually is. We need to look at the issue of biological weapons through a variety of lenses, including as a public health issue (Chapter 6), an environmental issue (Chapter 7) and as a biodiversity issue (Chapter 8). It is clear that oversight efforts will require the support of all relevant stakeholder communities but will require particular buy-in from the scientists and technologists who pursue biology on a day to basis. This makes mechanisms for raising awareness and inculcating a culture of responsibility (Chapter 9) ever more important. It is hoped that this book will be a useful tool for future efforts.

This book was funded and created through the unwavering support of the Swedish government. BWPP's thanks must go out to Magnus Hellgren of the Geneva Disarmament Mission for his personal championing of this project. This book would not be here without him. Equally, the personal thanks of the editors go out to the chapter authors, who showed remarkable flexibility in putting together such impressive texts under trying circumstances. Finally, our personal thanks also go out to Piers Millett who helped put the final text together into its final format. Although every effort has been taken to remove errors and inconsistencies from this text, undoubtedly some will have slipped through – they must remain the sole responsibility of the editors.

Kathryn McLaughlin, for the editors
April 2009

[1] K. Annan, *Uniting Against Terrorism: Recommendations for a Global Counter-Terrorism Strategy* (New York: United Nations) April 2006. Available at: http://www.un.org/unitingagainstterrorism

Abbreviations

ABWs	Advanced Biological Warfare Agents
ASM	American Society for Microbiology
BSE	Bovine Spongiform Encephalopathy
BW	Biological Weapons
BWC or BTWC	Biological and Toxin Weapons Convention
CBMs	Confidence-Building Measures
CCD	Conference of the Committee on Disarmament
CDC	Centers for Disease Control and Prevention
CNAs	Compendiums of National Activities
CW	Chemical Weapons
CWC	Chemical Weapons Convention
DNA	Deoxyribonucleic Acid
DSTO	Defence Science and Technology Organisation
DOC	Discrete Organic Chemical
ENDC	Eighteen Nation Disarmament Committee
FBI	Federal Bureau of Investigation
FMD	Foot and Mouth Disease
FBCA	Fungal Biocontrol Agents
GOARN	Global Outbreak Alert and Response Network
GP	Geneva Protocol
iGEM	International Genetically Engineered Machine Competition
ICRC	International Committee of the Red Cross
IL	Interleukin
ISU	Implementation Support Unit to the Biological and Toxin Weapons Convention

NBC	Nuclear, biological and chemical
NID	National Implementation Database
NIM	National Implementing Measures
NIM Project	VERTIC's National Implementing Measures Project
OPCW	Organisation for the Prohibition of Chemical Weapons
RHD	Rabbit haemorrhagic disease
RNA	Ribonucleic acid
RRL	Roodeplaat Research Laboratories
SARS	Severe Acute Respiratory Syndrome
TNFα	Tumour necrosis factor alpha
UN	United Nations
UNSCOM	United Nations Special Commission
USAMRIID	US Army Medical Research Institute for Infectious Diseases
VEREX	Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint
VERTIC	Verification Research, Training and Information Centre
VHF	Viral haemorrhagic fever
VVND	Velogenic Viscerotropic Newcastle Disease
WHO	World Health Organization
WHA	World Health Assembly
WMD	Weapons of mass destruction

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Chapter 1. An Introduction to Biological Weapons[1]

Malcolm R. Dando and Kathryn Nixdorff

Long before it was understood that microorganisms are the causative agents of infections, contagious disease was exploited as a means of biological warfare.

A Brief History of Biological Warfare[2]

There have been many stories told about the use of biological warfare in antiquity and the Middle Ages. The best known account was the Tartar attack on the city of Caffa (now Feodosia in Ukraine) in 1346, when plague–infected corpses were catapulted into the city in an attempt to break resistance.[3] However, as Mark Wheelis rightly points out, such accounts are usually not well documented, and because there was little understanding of the mechanisms underlying the phenomenon of contagion, these accounts need to be examined critically. Another factor that complicates the picture is that infectious disease always accompanies societal disruption resulting from military action, and "natural outbreaks can provoke suspicion and lead to false accusations".[4]

One historical example that has credibility is that of the deliberate use of smallpox by the British against the North American Indians at Fort Pitt in 1763. This is the only incident of biological warfare in North America that is convincingly documented.[5] Following the French surrender of Canada, many of the British troops had returned home and those that remained were badly overextended. In this situation, Indians mounted almost simultaneous attacks on several military outposts. Eight forts were overrun and even Fort Pitt, a major outpost, was in danger of falling. Weeks of hostilities had driven traders and settlers to the fort, and the conditions were accordingly overcrowded. Smallpox broke out, and when two Delaware Indians came to the fort for a meeting to try to persuade the British to leave without a fight, the Indians were given two blankets and one silk handkerchief taken from smallpox patients in the fort hospital. It was clear from the wording on an accounting sheet and a note signed by the fort commander that this was done in a deliberate attempt to infect the Indians with smallpox. Indeed, smallpox broke out among the relevant Indians about the time of that incident, but it is not clear whether this was a direct result of infection via those

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[1] Some material in this chapter has been excerpted from M. Dando, *Bioterror and Biowarfare. A Beginner's Guide*, (Oxford: One World Publications, 2006) and K. Nixdorff, M. Hotz, D. Schilling, D. and M. Dando, *Biotechnology and the Biological Weapons Convention*, (Münster: Agenda Verlag, 2003).

[2] There are two excellent, detailed studies on the history of biological weapons. One covers the period from the Middle Ages up to 1945: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999); the other covers the period since 1945: M. Wheelis, L. Rozsa, M. Dando (eds.), *Deadly Cultures. Biological Weapons since 1945*, (Cambridge: Harvard University Press, 2006). Most of the brief history of biological warfare recounted in the present chapter is based upon these accounts. The reader is referred to these studies for details.

[3] E.M. Eitzen and E.T.Takafuji, 'Historical overview of biological warfare', in: F.R. Sidell, E.T. Takafuji and D.F. Franz (eds.), *Medical Aspects of Chemical and Biological Warfare*, (Washington D.C.: Office of the Surgeon General, 1997), pp. 415-423.

[4] M. Wheelis, 'Biological warfare before 1914', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 8-34.

[5] Ibid, pp. 21-24.

blankets. There were many other chances for contacts between the Indians and British settlers, some of which might have had smallpox. Wheelis concludes that "although the act of biological aggression at Fort Pitt is indisputable, its effect is impossible to determine".[6]

Towards the end of the 19th century, when it began to be recognised that microorganisms were the causative agents of infectious diseases, microbiology was on the way to becoming established as a science. The application of scientific methodology led to the rapid elucidation of the causes of many major bacterial infections, and this in turn sparked development of better methods of disease prevention, diagnosis and treatment. One very positive result was a spectacular decrease in infant mortality rate. At the same time, this knowledge could also be used for hostile purposes, as was clearly seen during the First World War.

Biological Warfare in the First World War

It is significant that the first countries to apply the new knowledge gained about bacterial infections to investigate the potential of biological warfare were Germany and France, whose scientists had contributed most to the establishment of microbiology as a science.[7]

Germany was subject to a British blockade during the First World War. It developed a broad programme of biological sabotage that was directed mainly, but not exclusively, against neutral suppliers of the Allied Powers from 1915-1918. The sabotage operation was most extensive in the United States during the period prior to its entry into World War I, but Romania, Norway and Argentina were also targets. At that time, cavalry and draught animals were of crucial tactical importance on all fronts, and German sabotage operations involved the use of biological agents to damage horses and livestock. These agents included the bacteria *Bacillus anthracis* (causative agent of anthrax) and *Pseudomonas mallei* (causative agent of glanders). No bacterial warfare was waged against humans by Germany. Regarding the legal restrictions that were in operation at that time, the 1899 Hague Convention among other agreements banned the use of poison and poisoned weapons, so that biological warfare was clearly illegal. It has been speculated that the General Staff of the German Army interpreted the Hague Convention as prohibiting anti-human biological warfare only. In any case, German sabotage efforts in the US involved such acts as painting cultures of bacteria onto the nostrils of horses purchased by the Allied Forces for shipment overseas. These acts were carried out by agents in the supplying country. Operations in Norway involved the introduction of small capillary tubes filled with the bacterial agent into sugar cubes, presumably to be fed to the animals.

France apparently also had a biological sabotage programme directed against Germany.[8] This was confirmed in the minutes of a meeting in May 1923 of the Commission de Bacteriologie, created by the French Ministry of War. A veterinary inspector noted that a "virus" harmless to humans but transmissible to horses was used to cause an infectious anaemia. Other reports reveal that prisoners of war may have been involved in biological sabotage, as they were twice found to possess

[6] Ibid, p.24.

[7] See M. Wheelis, 'Biological sabotage in World War I', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 35-62.

[8] Ibid, pp. 56-57.

microbial cultures. Although the nature of these cultures was not reported, they were presumably the causative agent of anthrax, as they were designated to be used to infect cattle and pigs.

Biological Warfare Programmes between the Wars

Following the large-scale use of chemical weapons in World War I, which generally horrified civilized society, and with the realisation that biological weapons could be just as dangerous, a concerted effort was made after the war to limit the use of such weapons. This finally resulted in the 1925 Geneva Protocol. This treaty, which subsequently entered into force in February 1928, prohibits the "...use in war of asphyxiating, poisonous or other gases and of bacteriological methods of warfare",[9] thus banning the use of both chemical and biological weapons. Although the treaty allows states to have reservations on retaliation which renders the protocol a no-first-use agreement only, it has now become accepted as customary international law binding on all countries.[10] It should also be noted that the treaty only prohibits *use* of biological weapons while permitting the development and stockpiling of such potential weaponry. For more information surrounding the Geneva Protocol see chapter 2.

In any event, a number of major states developed offensive biological weapons programmes in the years between the two world wars. Data on most European countries has not been well researched for this period, but there is evidence that France[11] and Hungary[12] did have such programmes. There was little activity in Germany.[13] German military scientific experts had discussed the possibility of biological warfare in the 1920s, but it was concluded that it should not be used because it was not practical as a method of warfare. Outside of Europe, Japan[14] pursued a huge offensive biological warfare programme in the inter-war years. It should be noted that Japan had signed but not ratified the 1925 Geneva Protocol. The driving force behind the biological warfare programme was Ishii Shiro, an army medical doctor. The programme ran from 1931 until 1945, and probably involved at its peak fifteen thousand people. It was unique in that it used humans for experimentation, and it also employed biological agents in military field operations in China, which led to the death of many thousands. At the infamous Ping Fan facility located south of the city of Harbin, capabilities were developed for producing kilogram quantities of bacteria that cause plague, anthrax, typhoid, cholera, dysentery and other diseases. Little work was done on viruses, rickettsia or toxin agents. Thousands of tests on humans were conducted over the years at the Ping Fan facility. The operation changed its name in 1941 to Unit 731.

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[9] United Nations, Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, (Geneva: United Nations, 1925). Available at: http://www.opbw.org.

[10] M.R. Dando, *Preventing Biological Warfare: The Failure of American Leadership*, (Basingstoke: Palgrave, 2002), pp. 3-4.

[11] See O. Lepick, 'French activities related to biological warfare, 1919-1925', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 70-90.

[12] G. Faludi, 'Challenges of BW control and defense during arms reduction', in: E. Geissler et al. (eds.), Conversion of Former BTW Facilities, (Dordrecht: Kluwer Academic Publishers, 1998), pp. 67-72.

[13] See E. Geissler, 'Biological warfare activities in Germany, 1923-1945', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 92-126.

[14] See S. Harris, 'The Japanese biological warfare programme: an overview', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 127-152.

Biological Warfare in the Second World War

JAPAN.[15] The uniqueness of the Japanese offensive biological weapons operation has already been referred to. During World War II, Manchuria became the major theatre for secret Japanese biological warfare. After Japanese troops suffered heavy losses in fighting with Soviet troops on the Soviet-Manchurian and the Manchurian-Inner-Mongolian borders, Ishii was able to persuade his superiors to use biological weapons. In 1939, artillery shells filled with pathogens were fired against advancing Soviet troops, even though it was known that earlier field tests with prototype shells had been failures. The results of this offensive were inconclusive. Many Japanese and Soviet soldiers later developed cholera, dysentery and plague, but it remains uncertain as to whether these diseases were caused by the biological warfare offensive or by natural outbreaks. From 1939 to 1942 many field tests were carried out by Unit 731 all over China and Manchukuo, which caused extensive human and animal losses. In 1939 and 1940 more than 1000 water wells were contaminated with typhoid bacteria, causing outbreaks in and around Harbin. Biological weapons operations caused a devastating cholera outbreak in 1940 in Changchun, the capital of the puppet Manchukuo regime. Two years later more than 130 kg of paratyphoid A and anthrax bacilli were spread over a large area in the vicinity of Nanking in central China. Epidemics raged in that region later that summer and fall. Also, plague-infested rats were let loose in densely populated areas, resulting in epidemics shortly thereafter. These so-called field tests declined after August 1942, with only some desultory attacks that were infrequent and half-hearted. The reason for this decline in activity is unknown. Curiously, despite its scientific approach and over fifteen years of work, no really effective means of delivering these agents were developed by the Japanese.

GERMANY.[16] Several foreign intelligence agencies feared the worst with regard to German preparations for biological warfare. This is understandable given the ruthlessness of the Hitler regime. In fact, however, Germany did not have an offensive warfare programme during the Second World War. Indeed, it was apparently Hitler himself who prohibited offensive biological warfare activities in Germany. The reason for this decision is not known, but it had the support of the German commanders and the scientific community as well.

SOVIET UNION.[17] Russia was hard hit by chemical weapons attacks in the First World War, suffering thousands of casualties. No doubt for this reason the Soviet Union wanted to be well prepared for possible future chemical and biological weapons threats. The Red Army began in the 1920s to investigate biological warfare, studying a range of agents and carrying out subsequent field tests. The agents included *Bacillus anthracis* (anthrax), *Clostridium botulinum* (bacterial source of botulinum toxin), *Yersinia pestis* (plague) and foot-and-mouth disease virus (to be used against animals). However, during the purges of the mid-1930s, large numbers of biological specialists were arrested and some were charged with sabotage. The loss of specialists as a result of the purges must have had an effect on the Soviet biological weapons programme, because it seems unlikely that the Soviet Union had an offensive capability *during* the war. However, a firmly-based conclusion as to this capability will have to await access by scholars to the relevant archives.

[15] Ibid.

[16] See E. Geissler, 'Biological warfare activities in Germany, 1923-1945', op. cit.

[17] V. Bojtzov and E. Geissler, 'Military biology in the USSR, 1920-45', in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999), pp. 153-167.

ALLIED FORCES.[18] Starting in 1940 a Bacteriological Warfare Subcommittee that had been established by the Committee of Imperial Defence in the United Kingdom directed both defensive and offensive studies. The UK had ratified the Geneva Protocol in 1930, but with the reservations that it would be bound only in regard to other parties to the Protocol and that it would not be bound with respect to states and their allies who broke the prohibition. This meant that it reserved the right to retaliate with chemical and biological weapons. The immediate need in 1940 was for some means to retaliate if Germany should use biological warfare. Paul Fildes, an eminent civil scientist, was appointed to head the operation, which was carried out in the biology department at Porton Down. The need to retaliate was met by the production of five million cattle cakes laced with anthrax spores. These were to be dropped from planes over German farming land in order to wipe out cattle and thus deal an economic blow to Germany.

The other particularly significant development in the UK was the design of an anti-personnel biological weapon. Fields concentrated on the possibility of infection by inhaling aerosolized agents (particles suspended in air or water droplets). At Porton Down, Fildes could draw on the experiences gained during the First World War to begin work on an apparatus that could produce clouds of bacteria to be inhaled by experimental animals in order to determine the required doses. It was also shown that a bursting munition could be used to create the aerosol. This was tested for safety reasons on Gruinard Island off the coast of Scotland. A modified, thirty-pound, chemically high-explosive bomb was charged with a suspension of anthrax spores and suspended from a fixed frame. Sheep were located in an arc 90-100 yards downwind. On detonation, a cloud could be seen moving downwind. Seven days later, all but two of the sheep were dead. It was later determined that a lethal effect extended some 250 yards downwind. Calculations suggested that a lethal dose was likely up to four hundred yards downwind. The weapon was more powerful than any known chemical weapon. Gruinard Island was eventually decontaminated in 1987.

Development of the bomb continued during the Second World War in cooperation with the United States and Canada. Canada's Suffield site was used for testing weapons based on anthrax and botulinum toxin. On the defensive side, Canada managed to develop vaccines against the rinderpest virus and against botulinum toxin. By the end of the war, capabilities in the US for anti-personnel biological warfare were nearing completion. The Vigo production plant, which was not yet operational when the war ended, was designed to manufacture and load 500,000 four-pound anthrax bombs per month. Efforts by the United States led eventually to the establishment of the basis for what was to become, after the war, a massive offensive biological warfare programme, that included development of an anti-plant biological weapons capability using fungal agents and synthetic chemicals.

[18] See G.B. Carter and G.S. Pearson, 'British biological warfare and biological defence, 1925-45', pp. 168-189; D. Avery, 'Canadian biological and toxin warfare research, development and planning, 1925-45', pp. 190-214; J.E. van Courtland Moon, 'US biological warfare planning and preparedness: the dilemmas of policy, pp. 215-254', all in: E. Geissler, J.E. van Courtland Moon (eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*, (Oxford: Oxford University Press, 1999).

Biological Warfare Programmes after the Second World War[19]

At the end of the Second World War all the major victors (United States, Soviet Union, United Kingdom and Canada) had developed significant offensive biological warfare programmes. Although the French programme had been interrupted by the German invasion, France resumed its biological weapons development activities soon after the war ended. All of these countries continued developing biological weapons up until the agreement of the Biological and Toxin Weapons Convention (BWC)[20] in 1972. It should be recalled at this point that under the Geneva Protocol and until agreement of the BWC, the development of biological weapons was not illegal (see chapter 2).

USA. The US clearly had an extensive programme in which a wide array of highly infectious microorganisms and extremely poisonous toxins were studied along with several anti-crop and anti-animal agents.[21] Moreover, the utility of biological agents was tested in the laboratory (small scale), in closed chambers (medium-scale) and in the open air (large scale). Tests were carried out in the anti-personnel program both with simulant microbes and with pathogens. With regard to munitions development, the US started with adaptations of the burster-type bombs developed by Britain during the war, but soon extended its program to include "…submunitions, gas expulsion bombs, various types of line spray tanks and highly specialised projectiles and generators as well as insect vectors".[22] The US programme did, however, not weaponize contagious agents.

UK. In the UK, some research on offensive aspects continued after the Second World War, but given the restraints of a limited defence budget, the offensive programme ceased by 1957. The same is evident in the history of the French post-war offensive biological weapons programme. Canada was cooperating with the US and Britain on offensive biological weapons research and development. Although Canada may never have possessed biological weapons, it did a great deal to assist the British and American offensive programmes, developing vaccines and providing its Suffield site to the US for large scale testing of chemical and biological weapons. Canadian involvement in field testing continued apparently up to the end of the US programme after agreement of the BWC.

There is definite evidence that three state-level offensive biological weapons programmes (in Iraq, South Africa and the Soviet Union) were being carried out after the agreement of the BWC, which made them clearly illegal operations.

IRAQ. Iraq had signed the BWC in 1972, which bound it to respect the convention, but it did not ratify the BWC until it was forced to do so in 1991 after it was defeated following its invasion of Kuwait. Despite Iraq's efforts to hide its biological weapons programme, it was pinned down by the

[19] See J.E. van Courtland Moon, 'The US biological weapons program', pp. 9-46; B. Balmer, ' The UK biological weapons program', pp. 47-83; D. Avery, 'The Canadian biological weapons program and the tripartite alliance', pp. 84-107; O. Lepick, 'The French biological weapons program', pp. 108-131; J. Hart, 'The Soviet biological weapons program', pp. 132-156; G.S. Pearson, 'The Iraqi biological weapons program', pp. 169-190; C. Gould and A. Hay, 'The South African biological weapons program', pp. 191-212; all in: M. Wheelis, L. Rozsa, M. Dando (eds.), *Deadly Cultures. Biological Weapons since 1945*, (Cambridge: Harvard University Press, 2006).

[20] Sometimes referred to as the BTWC. The full text of the Convention is available at http://www.opbw.org.

[21] Department of the Army, *U.S. Army Activities in the U.S. Biological Warfare Programs*, Volumes 1 and 2, (Washington: Department of the Army, 24 February, 1977).

[22] Ibid.

United Nations Special Commission (UNSCOM) inspectors in 1995. According to the Iraqis, they began their biological programme in earnest in 1985, during the war with Iran. Iraq has declared that a total of 19,000 litres of concentrated botulinum toxin and 8,500 litres of concentrated anthrax spores were produced. Other agents were produced in smaller quantities and research on viruses (hemorrhagic conjunctivitis viruses, rotavirus and camel pox virus) and genetic engineering of the anthrax bacillus was carried out. Work was also done on the drying of anthrax spores. There was also apparently testing of weaponized biological agents. Field tests of a crude dissemination device began in 1988 and this was followed by more sophisticated biological bombs and spraying devices. It is certain that when Iraq went into the 1991 Gulf war, it had some biological weapons available for use. The period from the late 1990s until Iraq's defeat in the second Gulf war is shrouded in mystery and controversy. At present it does not appear that Iraq was engaged in producing or stockpiling biological weapons during that time, although it is not clear why it refused to clarify what it was doing.

SOUTH AFRICA. The South African programme, codenamed Project Coast, was highly secret and operated through front companies. No publicly available document about Project Coast provides a clear picture of the nature and extent of the activities. Most of what is known about the programme came from material presented to the Truth and Reconciliation Commission, the trial of Wouter Basson (who was head of the programme), and in the personal recollections of some of the scientists who participated.[23] The programme was initiated in 1981 by the minister of defence, General Magnus Malan for the South African Defence Force. The main biological weapons development facility was located north of Pretoria at the military front company Roodeplaat Research Laboratories (RRL), a complex built in 1986. Scientists involved in the work there have claimed that the main aim was to provide the military and police with covert assassination weapons for use against individuals perceived to be a threat to the apartheid government. One such project (that was ultimately unsuccessful), was the development of an anti-fertility vaccine, with the expressed aim of administering it to black women without their knowledge. The final laboratories and buildings at the facility were completed in 1988, just a few years before the offensive programme was ended after the installation of the new South African government in 1994. Since that time, the new government has played a very positive role in strengthening the BWC.

SOVIET UNION. In the latter part of the cold war, the Soviet Union ran the largest offensive biological weapons programme of the twentieth century. It started in 1973 and ran at least until 1992, when President Yeltsin acknowledged its existence. A great deal of information about the programme is not available in the public domain. Some reliable information has been provided by defectors from the Soviet Union. Vladimir Pasechnik, a senior biologist in the system, defected to the UK in 1989 and revealed that the programme was ten times larger than had been previously suspected. His revelations were confirmed by Colonel Kanatjan Alibekov (who later changed his name to Ken Alibek), second in charge of the civilian component of the system, who defected to the US in 1992. The structure of the offensive programme was very complex. Biopreparat, the civilian component, was enormous, operating in at least twenty different locations. Although supposedly a civilian enterprise, Biopreparat was directed by the military. To give an idea of the capability of the system, a major Biopreparat facility was said to be able to produce two hundred kilograms of weaponized plague agent (*Yersinia pestis*, a contagious agent) material each week. In addition to the well known biological weapons agents such as those causing anthrax, tularemia and glanders, work was done on highly lethal viruses including Ebola virus, Marburg virus and the smallpox virus. Also, genetic engineering was carried out, with attempts to render the plague bacillus resistant to

[23] C. Gould and P. Folb, *Project Coast: Apartheid's Chemical and Biological Warfare Programme*, (Geneva: United Nations Institute of Disarmament Research, 2003).

multiple antibiotics and to modify pathogens to overproduce one of the body's chemical signalling molecules in order to disrupt physiological function. The Soviet Union also carried out extensive testing of the weapons, for example at a major test site on Vozrozhdeniye Island in the Aral Sea. There are still questions about the status of the programme today, because no official account of any credibility has been produced and some military facilities have remained closed to outsiders.

Biological Agents of Biological Weapons Relevance

The vast majority of microorganisms do not cause disease, but are instead beneficial to humankind in that they contribute decidedly to our health and general well-being in many cases. A few microorganisms can, however, cause infectious diseases and these are designated as pathogens. The pathogenicity of a microorganism is sometimes difficult to define, but the term generally means the ability to inflict damage, or the ability to cause disease. Potential biological weapons can be found among these pathogenic microorganisms, and some agents that have been frequently named as having possible military use are listed in Table 1.1. Bacteria can be characterised as the smallest living beings. They possess a very simple cell structure and reproduce by binary fission, that is, by dividing into two daughter cells. Rickettsia are also bacteria, but they are traditionally placed into a separate category. The rickettsia listed in Table 1.1 can only reproduce within animal cells (intracellularly) because they cannot synthesize co-factors needed for the activity of certain enzymes. These rickettsia are therefore dependent upon the host cells for a supply of those essential substances.[24]

Table 1.1. Some agents of particular biological weapons relevance[25]

Bacteria (disease)	**Viruses (disease)**
Bacillus anthracis (Anthrax)	*Variola major* (Smallpox)
Yersinia pestis (Plague)	Ebola virus (Haemorrhagic fever)
Fransicella tularensis (Tularemia)	Lassa virus (Haemorrhagic fever)
Vibrio cholerae (Cholera)	Crimean-Congo haemorrhagic fever virus
Burkholderia mallei (Glanders)	Yellow fever virus (Haemorrhagic fever)
Burkholderia pseudomallei (Melioidosis)	Tick-bourne encephalitis virus
Salmonella typhi (Typhoid fever)	Venezuelan equine encephalitis virus
Rickettsia (disease)	**Toxins**
Coxiella burnetti (Q fever)	Botulinum toxins
Rickettsia prowazekii (Typhus)	Ricin
Rickettsia rickettsii (Spotted fever)	Staphylococcus enterotoxin B
	Saxitoxin
	Several Mycotoxins

[24] H.H. Winkler, '*Rickettsia prowazekii*, ribosomes and slow growth', *Trends in Microbiology*, vol. 3, 1995, pp. 196-198.

[25] See the Glossary of this volume for a brief description of several of these agents that have been most frequently mentioned as potential biological weapons, along with the diseases they cause.

Viruses are microorganisms, but are not considered to be living beings, because they lack practically all the biosynthetic capability of living cells. However, their nucleic acid directs the synthetic machinery of the cell they infect to produce new virus particles. This is very different from the way in which rickettsia use cells for growth; rickettsia contain respectful biosynthetic capabilities and reproduce within the host cell by binary fission in the usual bacterial fashion.[26]

Toxins are not microorganisms, but are poisonous or damaging substances produced by living beings. Toxins cannot reproduce themselves, and as potential biological weapons they may be deployed in a way similar to chemical weapons. However, some toxins are much more poisonous than chemical substances. For example, botulinum toxin is ten thousand times more deadly than the most poisonous nerve gas, VX.[27]

When concerns about possible biological weapons attacks grew in the 1990s, the Centers for Disease Control and Prevention (CDC) in the United States drew up a list of agents posing the greatest threat. These were designated Category A agents and included the causative agents of anthrax, botulism, plague, tularemia and the viral haemorrhagic fevers.[28] The list of agents in Table 1.1 includes mainly those that are capable of causing disease or damage in humans.[29] However, it should be pointed out that there are animal and plant pathogens that are potential biological weapons, underscoring the fact that biological warfare can be directed against animals and plants as well as humans.

Properties of Biological Weapons Agents

One of the earliest and most comprehensive studies on the possible military applications of available microbiological agents and the means for protection against them appeared in an article entitled „Bacterial Warfare“ by Theodore Rosebury and Elvin A. Kabat, published in 1947 in the *Journal of Immunology*, a renowned scientific journal in the field of immunology.[30] The authors prepared this review as private citizens right after the US entered into World War II. They withheld publication of the article voluntarily and the review was indeed treated as classified by the government; it was published only after removal of wartime restrictions.

That this was a critical, scientific review is reflected in the fact that the properties of potential biological weapons agents are so comprehensively defined that shortcomings concerning battlefield use of these agents are readily apparent. The following discussion of the properties of pathogenic microorganisms is taken in large part from the Rosebury and Kabat review.

In some respects, biological weapons are very similar to chemical weapons. Both microorganisms and chemicals can be diffused over large areas by deployment in aerosols (particles suspended in the air). There is also a strong psychological effect involved with the use of both types of weapons;

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[26] M.T. Madigan and J.M. Martinko, *Brock Biology of Microorganisms*, Eleventh Edition, (London: Pearson Prentice Hall, 2006).

[27] E. Geißler and K. Lohs, ‘The changing status of toxin weapons’, in: E. Geißler (ed.), *Biological and Toxin Weapons Today*, (Oxford; Oxford University Press, 1986), pp. 36-56.

[28] See CDC, ‘Bioterrorism Agents/Diseases, A to Z by Category, Category A agents’, *Emergency Preparedness and Response*, Centers for Disease Control and Prevention. Available at: http://www.bt.cdc.gov/agent/agentlist-category.asp

[29] Glanders is a disease of horses that is occasionally transmitted to humans.

[30] T. Rosebury and E. Kabat, ‘Bacterial warfare’, *Journal of Immunology*, vol. 56, 1947, pp. 7-96.

both may be more or less invisible, and the terror evoked by something mysterious or intangible is particularly demoralising. However, the types of biological weapons that are the causative agents of infectious disease have characteristic properties that set them apart from chemical weapons and, at the same time, limit their military usefulness.

Incubation period: There is an intervening period between contact with the causative agent and the first appearance of symptoms. This incubation period can encompass several days to a couple of weeks.

Epidemicity: Many infectious agents are contagious; the infection can be transmitted from one individual to another through contact. The infectious disease can spread out over a wide area to cause an epidemic. This makes containment of the disease in a designated area particularly difficult.

Infectivity: Infectivity is defined as the frequency with which an infectious agent is able to induce symptoms in a random group of individuals. Simply said, it is how many microorganisms it takes to infect an individual. Among other things, infectivity is influenced by the health and immune status of the individual. The infectivity of an agent is a property that imposes strong limitations on its military use, particularly because it is so dependent upon conditions difficult to define outside the laboratory.

Persistence: A few infectious agents are able to survive for long periods of time in the environment. These include microorganisms that are able to produce endospores and those that are carried by animal vectors. The persistence of a potential source of infection over a long period of time would, however, be disadvantageous from a military viewpoint.

Instability: With the exception of the few microorganisms that remain viable and infective over a long period of time in the environment, most infectious agents are unstable. Outside of the specific host, these labile organisms lose their infectivity quite rapidly and have a short life span. The inverse relationship between persistence and instability can readily be seen: the most stable agents are easiest to deploy, but they also persist for periods that may be longer than desired. On the other hand, unstable agents do not persist, but they are difficult to deploy effectively.

Retroactivity: Biological weapons that are pathogenic microorganisms are potentially capable of working against those using them, more so than chemical weapons, due to such properties as epidemicity, infectivity and persistence. If a nation is planning biological warfare, it has to have a remedy at hand, or accept the fact that the contaminated area cannot be occupied for a particular time.

Although some aspects of the stated properties of infectious microorganisms may serve to limit their usefulness in waging war, several microorganisms are still of interest from a military viewpoint (Table 1.1). The causative agents of anthrax (*Bacillus anthracis*), smallpox (*Variola major*), plague (*Yersinia pestis*), tularemia (*Francisella tularensis*) and the haemorrhagic fever viruses (e.g. Ebola) are microorganisms that have frequently been mentioned as potential biological weapons. From a military viewpoint[31] biological weapons agents should:

- Be infectious through the aerosol route
- Be stable during storage, delivery and dissemination

[31] W.C. Patrick, 'Biological warfare: an overview', in: K.C. Bailey (ed.), *Director's Series on Proliferation*, Vol. 4, Lawrence Livermore National Laboratory, (Springfield: U.S. Department of Commerce, National Technical Information Service, 1994), pp. 1-7.

- Be producible on a sufficient scale to meet target requirements
- Be amenable to vaccination and treatment (to prevent or minimise casualties to allied forces and civilian populations) and
- Not be contagious (to reduce the probability of an epidemic that spreads beyond the battlefield).

Looking at this list of requirements, it becomes obvious that no one microbiological agent can meet all of these demands.

Mass Production of Biological Agents

It is characteristic of many microorganisms that they can be grown rapidly starting with minute amounts. Bacteria reproduce generally by binary fission, and some bacteria have extremely short generation times (time to cell division). *Escherichia coli* (an intestinal bacterium; most strains are non-pathogenic) is one of the fastest growing bacteria, with a generation time of about 15 minutes under the best conditions. However, even among the bacteria, there are great differences in the ease of cultivation and the rapidity of growth. Nevertheless, the bacteria in the list of Table 1.1 can all grow quite rapidly. Even the cultivation of *Clostridium botulinum* for the production of botulinum toxin is relatively easy, despite the fact that this must be done in the absence of oxygen, which it does not tolerate well. In contrast, the bacteria referred to as rickettsia in Table 1.1 can only reproduce within animal cells because they can not synthesize certain cofactors needed for the activity of some enzymes.[32] The cultivation of rickettsia is correspondingly tedious, and they grow much more slowly than *Escherichia coli*. For example, the generation time for rickettsia is about eight to ten hours.

Viruses lack practically all the biosynthetic capability of living cells. In effect, their nucleic acid directs the synthetic machinery of the cell they infect to synthesize new virus particles. This is very different from the way in which rickettsia use cells for their growth; these bacteria lack a few essential metabolites, but they still contain respectful biosynthetic capabilities and reproduce within the host cell in the usual bacterial fashion by binary fission. The actual pathway of reproduction that a virus takes depends on its type and the cells it infects. However, the point to be made is that viruses depend on animal cells for their reproduction, and so, as with the rickettsia, animal cell cultures have to be employed in order to cultivate them. Accordingly, their production in large quantities is much more involved and laborious than the mass production of bacterial agents.

Deployment of Biological Agents as Weapons

More problematical than the production of biological warfare agents is the process of their weaponization, which involves the development and testing of particular methods for dissemination of the substances over a designated area. Fortunately, all the evidence in the open literature strongly suggests that it is very difficult to achieve effective dissemination of the agent in order to cause mass human casualties. The majority of biological agents might best be deployed in the form of aerosols; almost all pathogenic microorganisms and toxins are able to exert their effects after being inhaled.

[32] H.H. Winkler, '*Rickettsia prowazekii*, ribosomes and slow growth', op. cit.

The particle size of aerosols is relevant. For one reason, particles of different size will reach different areas of the nasal and respiratory tracts. In the case of the causative agent of anthrax, the infective spores must be in particles between 0.5 and 5.0 micrometers in diameter in order to reach the alveoli (air sacs) of the lungs, where they would be taken up by macrophages and spread throughout the lymph system and the circulation. Smaller particles would be exhaled and larger particles would be deposited in the nasopharynx area, without ever reaching the alveoli. As far as other agents are concerned, the particle size of the aerosol is not so critical, as many microorganisms and toxins can gain access to the body readily over the mucous membranes (mucosa).

Nevertheless, aerosol size is critical for all agents inasmuch as particles smaller than 10 micrometers in diameter will be suspended longer in the air than larger particles. In this way they can be distributed over greater areas and have a better chance to be inhaled before they fall to the ground. Particles up to 5 micrometers in diameter can penetrate into closed buildings. Therefore, specialised aerosol generators that can produce the desired particle size would be required. At the same time, the deployment of microorganisms or toxins in aerosols is very susceptible to adverse meteorological and environmental conditions: the method must guarantee the survival and/or efficacy of the agents.

Biological agents can also be deployed in the form of bombs or missile warheads. The experiments of the UK with anthrax bombs during the Second World War may be recalled from the discussion earlier. In addition, investigations of the United Nations Special Commission (UNSCOM) revealed that Iraq not only produced large amounts of agents for biological warfare in connection with the Gulf war in 1990-1991, some of these agents were filled in bombs and scud rocket warheads and their efficacy was tested using animals in specially designated test areas. The way the bombs burst is of particular relevance. Most biological agents are exquisitely sensitive to heat and pressure. Except for the agent of anthrax, which produces heat-resistant endospores, deployment of biological agents in the form of bombs may not be an effective method.

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Chapter 2. History of BTW Disarmament

Marie Isabelle Chevrier[1]

Prior to the 20th century, biological, chemical and toxin weapons were not distinguished from one another and were lumped together under the category of poisons. A number of 19th century agreements, including the 1874 Brussels Convention on the Law and Customs of War and the Hague Convention of 1899,[2] attempted to restrict or ban the use of poisons in war. Following the extensive use of chemical weapons (CW) during World War I, the international community began a prolonged effort to outlaw chemical, biological and toxin weapons. These efforts produced the 1925 Geneva Protocol (GP), the 1972 Biological and Toxin Weapons Convention (BWC) and the 1993 Chemical Weapons Convention. This chapter will present the history of BWC disarmament efforts concentrating on the GP and the BWC.

The Geneva Protocol

In May 1925, under the auspices of the League of Nations, the "Conference for the Supervision of the International Trade in Arms and Ammunition and in Implements of War" considered provisions prohibiting international trade in poisonous or asphyxiating gases. A Polish proposal to the Conference was the first to separate biological weapons (BW) from CW. It stated that, "inasmuch as the materials used for bacteriological warfare constitute an arm that is discreditable to modern civilisation, the Polish delegation proposes that any decisions taken by the Conference concerning the materials used for chemical warfare should apply equally to the materials used for bacteriological warfare."[3] Prohibiting trade in poisonous chemicals and bacteriological materials, without first rejecting their manufacture or use however, proved contentious. Banning the export of these weapons materials would not halt their manufacture in states already capable of doing so, or their use in conflicts involving those states.

In response, the delegates to the Convention concluded the "Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare" on 17 June 1925. The Protocol first acknowledged that "the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids materials or devices, has been justly condemned by the general opinion of the civilised world." The signatories of the Protocol agreed to be bound by this prohibition against the use of such arms in war and applied the Polish proposal by agreeing to "extend this prohibition to the use of bacteriological methods of warfare." Moreover, the Protocol goes on to establish that the prohibition "shall be universally accepted as part of International

[1] This chapter relies heavily on my previous work, M.I. Chevrier, 'Chapter 15, The politics of biological disarmament', in: M. Wheelis, L. Rozsa, and M.R. Dando (eds.), *Deadly Cultures: Bioweapons since 1945,* (Cambridge: Harvard University Press, 2006), pp. 304-328.

[2] The full title of the Hague Convention is "Convention (II) with Respect to the Laws and Customs of War on Land and its annex: Regulations concerning the Laws and Customs of War on Land. The Hague, 29 July 1899."

[3] League of Nations, Document A.13.1925.IX First and Second Meetings of the General Committee of the Conference, quoted in SIPRI, Stockholm International Peace Research Institute, *The Problem of Chemical and Biological Warfare, Volume IV: CB Disarmament Negotiation, 1920-1979*, (Stockholm: Almqvist and Wiksell), p. 60.

Law."[4] The inclusion of the prohibition as part of International Law is significant, binding even those states that are not parties to the treaty, creating a universal standard against the first use of BW.[5]

Prior to the conclusion of the BWC and the 1993 Chemical Weapons Convention, thirty-five states reserved the right to retaliate with the prohibited weapons if another state used the weapons first against them. Nevertheless, the vast majority of States Parties did not have reservations to the Protocol. The Netherlands in 1930 and the United States in 1975 made a distinction between CW and BW and limited their retaliation reservation to CW only.[6] Both states bound themselves not to use BW under any circumstances, even if BW were to be used against them.[7]

1925-1968: Between the GP and the BWC

The linking of BW with CW in arms control discussions persisted for nearly fifty years after the implementation of the GP but there was little progress on CBW disarmament. The prohibition on the use of BW, even in retaliation, surfaced at the second phase of the League of Nations Disarmament Conference in 1932-1933 in a United Kingdom draft convention for general disarmament. The proposed convention would have absolutely prohibited the use of bacteriological weapons, even in retaliation.[8] In 1936, however, the conference was postponed and never reconvened.

One of the earliest tasks of the newly established United Nations (UN) was to grapple with weapons of mass destruction. UN General Assembly resolutions in 1946 called for disarmament of atomic and other weapons of mass destruction.[9] In 1948 the UN Commission for Conventional Armaments included BW in its definition of "weapons of mass destruction."[10] The Modified Brussels Treaty of

[4] The full text of the Geneva Protocol is available at: The International Committee of the Red Cross, International Humanitarian Law - Treaties & Documents, "Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare. Geneva, 17 June 1925." Available at http://www.icrc.org/ihl.nsf/FULL/280?OpenDocument, accessed January 6, 2009.

[5] N. Sims, *The Diplomacy of Biological Disarmament: Vicissitudes of a Treaty in Force, 1975-1985,* (New York: St. Martins Press, 1988), p. 60.

[6] Full texts of the reservations are contained in D. Schindler and J. Toman, *The Laws of Armed Conflicts, 3rd Ed.* (Dordrecht, The Netherlands: Nijoff, 1988) p. 173.

[7] For a more comprehensive discussion of the legal aspects of the Geneva Protocol see N. Sims, 'Chapter 16: Legal Constraints on Biological Weapons', in: M. Wheelis, L. Rozsa, M.R. Dando (eds.), *Deadly Cultures: Bioweapons since 1945, (*Cambridge: Harvard University Press, 2006), pp. 329-354.

[8] SIPRI, *The Problem of Chemical and Biological Warfare, Volume IV: CB Disarmament Negotiation, 1920-1979*, op. cit., p. 60.

[9] United Nations General Assembly Resolution 1(1), 'Establishment of a Commission to Deal with the Problems Raised by the Discovery of Atomic Energy' 24 January 1946. Available at: http://daccessdds.un.org/doc/RESOLUTION/GEN/NR0/032/52/IMG/NR003252.pdf?OpenElement, accessed January 6, 2009 and United Nations General Assembly Resolution 41(1) 'Principles governing the general regulation and reduction of Armaments' 14 December 1946. Available at http://daccessdds.un.org/doc/RESOLUTION/GEN/NR0/032/92/IMG/NR003292.pdf?OpenElement accessed January 6, 2009.

[10] SIPRI, *The Problem of Chemical and Biological Warfare, Volume IV: CB Disarmament Negotiation, 1920-1979*, op. cit., p. 195.

1954 obligated Germany not to produce BW.[11] Nevertheless, nuclear arms control dominated the arms control agenda in the decades following World War II. Proposals dealing with CBW were typically viewed through their potential implications on nuclear policy and the Cold War.

During the 1960's CBW control and disarmament focused on the United States. At that time the US had not ratified the GP and was accused of using CW in Vietnam. Discussions of disarmament issues took place both in New York at the UN's First Committee and in Geneva at the Eighteen Nation Disarmament Committee (ENDC). In 1966 Hungary presented a draft resolution to the First Committee that demanded "strict and absolute compliance by all States" with the GP.[12] The US responded that the draft resolution was "motivated purely by propagandistic ends."[13] A watered down resolution passed on a close vote.

In 1967 Malta introduced a draft resolution to the First Committee suggesting that the GP be revised, updated or replaced. The Maltese representative argued, for example, that the scope of the Protocol covered bacteriological weapons but not fungal or viral agents. Hungary and the USSR rejected Malta's interpretation of the GP arguing that the Protocol covered all existing bacteriological weapons and any being developed.[14] Faced with US opposition to the resolution as well as a compromise resolution offered by The Netherlands, Malta withdrew its draft resolution. Nevertheless, a request that the Secretary General prepare a report on the effects of CBW was implemented. The report was concluded in 1969 and was influential in the subsequent negotiations.[15]

The 1968 UK Working Paper on Microbiological Warfare

Throughout the 1960's the United Kingdom's Ministry of Defence produced a series of papers assessing CW and BW policy. The paper summarising the policy assessments emphasised three elements that motivated the UK's BW policy initiative throughout the 1960's: 1) the UK was vulnerable to a BW attack, 2) BW had limited strategic and limited military tactical value, and 3) the USSR was not a suitable BW target. Consequently, in 1968 the UK tabled a working paper on microbiological warfare at the ENDC describing the principle elements of a draft convention. These elements included:

- A common understanding that any use of microbiological warfare and in any circumstances was contrary to international law and a crime against humanity and therefore a complete prohibition of use

[11] Western European Union, *Text of the Brussels Treaty and the Protocols Modifying and Completing That Treaty, Signed in Paris, 23 October, 1954,* Article I, Protocol No. III.

[12] 'Hungarian Draft Resolution Submitted to the First Committee of the General Assembly: Use of Chemical and Bacteriological Weapons', 7 November 1966, A/C.1/L.374, in United States Arms Control and Disarmament Agency (ACDA), *Documents on Disarmament, 1966,* (Washington D.C.: USGPO, 1967), pp. 694-695.

[13] 'Statement by ACDA Director Foster to the First Committee of the General Assembly, November 14, 1966' in ACDA *Documents on Disarmament, 1966,* op. cit., p. 740.

[14] 'Statement by the Hungarian Representative (Castorday) to the First Committee of the General Assembly: Chemical and Biological Weapons,' 12 December 1967, A/C.1/PV.1547, in ibid., 657-662. 'Statement by the Soviet Representative (Shevchenko) to the First Committee of the General Assembly: Chemical and Bacteriological Weapons', 13 December 1967, A/C.1/PV.1548, in ibid., p. 667.

[15] United Nations Report No. E 69 I24, *Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use* (New York: Ballantine Books, 1970).

- A ban on the production of agents for hostile purposes while recognising the necessity of production of agents for peaceful purposes
- A ban on the production of ancillary equipment
- An obligation to destroy stocks of agents or equipment
- A ban on research aimed at production of prohibited agents and equipment
- Provisions for access by authorities to "all research which might give rise to allegations" of non-compliance
- Openness of relevant research to international investigation and public scrutiny[16]

The working paper recommended a "competent body of experts, established under the auspices of the United Nations," to investigate allegations of breaches of the convention and a commitment by parties to cooperate with any investigation.

The UK support for a prompt ban on the use and possession of BW contained four arguments:

1. BW "are regarded with general abhorrence, possibly more so than any other means of waging war";
2. "it seems unlikely that development or use of biological weapons is, at the moment, regarded by any state as essential to its security";
3. new technological developments could lead to BW becoming an integral part of some states' armaments; and
4. it would be easier to achieve a ban before such armament took place than after.[17]

Arguments for separating BW from CW were based principally on political pragmatism. BW were at an earlier stage of development; therefore, prohibiting BW would face less opposition. Moreover, differences between East and West during the Cold War concerning verification, and US use of anti-crop and anti-personnel chemicals in Vietnam, made tackling CW disarmament a daunting political task.

Recognising that verification as understood in the nuclear field was not feasible for BW, the UK recommended an approach for receiving complaints and investigating allegations of non-compliance that would allow very quick investigations that would be automatically implemented as far as possible.[18] Despite major scepticism from the UK Ministry of Defence that the USSR, China or the US would ever accept an agreement that would ban research, development and production on what would amount to an unverifiable basis, the Foreign and Commonwealth Office prevailed and introduced a Draft Convention in July of 1969.

UK and Soviet Draft Conventions

The Biological Warfare Draft Convention tabled in 1969 contained stronger provisions than the 1972 BWC. Article I of the Draft Convention prohibited the use of biological agents for hostile purposes in any circumstances and explicitly outlawed the hostile use of BW against humans, other

[16] Eighteen Nation Disarmament Committee (ENDC) /231 'Working Paper on Microbiological Warfare'.

[17] Talking Points on Biological Warfare for the ENDC Informal Meeting on 14 May 1969, in I.F. Porter, United Kingdom Delegation to the 18 Nation Disarmament Conference, to Mulley, 31 March 1969, FCO 73/114, PRO.

[18] Ibid.

animals, or crops. Article II extended the prohibition on use to possession and research and required parties to destroy or divert to peaceful purposes stocks of weapons agents, ancillary equipment and vectors. Article III described the procedures for complaints of violation of the Convention, with allegations of use to be treated differently from other allegations of non-compliance. Allegations of use were to be taken to the UN Secretary-General along with a recommendation for an investigation. Allegations of breaches of the Convention that did not involve use were to be taken to the Security Council along with a request for an investigation. Such requests, of course, would be subject to the veto power of the permanent members. Bifurcating the investigation procedures for allegations of the use of BW and allegations of other noncompliant activities would have great significance as the UK Draft Convention was altered through negotiations.

In September of 1969 the Soviet Union responded to the UK Draft Convention by tabling its own Draft Convention prohibiting the development and production of both BW and CW. In contrast to the UK Draft Convention, the Soviet Draft combined CW and BW, excluded the explicit prohibition against use, and tabled the Convention at the UN General Assembly instead of at the Conference of the Committee on Disarmament (CCD).[19]

Meanwhile in Washington D.C., the US government was in the midst of a review of all CBW policies.[20] Following the review, in November 1969, the US announced its decision to unilaterally terminate its offensive BW programme, to destroy its BW stocks, to place a moratorium on CW production and to submit the 1925 Geneva Protocol to the US Senate for ratification. The US also declared its intention to support the UK Draft BW Convention. In February of 1970, the US extended its BW policy to toxins as well.

During 1970 Western delegations to the CCD concentrated their efforts on trying to convince others of the advisability of a Convention separating BW from CW. Then, on 30 March 1971, the Soviet Union unexpectedly tabled a second Draft Convention, this time at the CCD. The 1971 draft dropped the USSR's long-standing opposition to separating CW and BW. The new Soviet draft differed from the UK draft in several crucial respects. First, it ignored Article I of the UK draft which obligated parties never, in any circumstances, to use biological methods of warfare. Second, it omitted the UK draft's prohibition of research aimed at offensive production. Third it required all complaints concerning a breach of obligation to go to the Security Council, including those of alleged use of BW. The Soviet draft included a few features absent from the UK draft. It required states to undertake legislative and administrative measures for prohibiting BW. It also created an obligation for states to facilitate the exchange of equipment, materials, and information for the use of biological agents and toxins for peaceful purposes.

Negotiating the BWC

Several states responded negatively to the attempt in the new Soviet Draft Convention to conform with the UK and US desires to separate CW and BW. Sweden, Mexico, Morocco, and other states expressed both dismay and doubt that effective controls on CW would ever be achieved if the two weapons programmes were separated. The neutral and non-aligned countries, however, recognised

[19] The CCD succeeded the ENDC as the forum for disarmament negotiations in 1969; it in turn was succeeded by the Conference on Disarmament in 1978.

[20] For a thorough account of the US policy review see J. Tucker, 'A Farewell to Germs: The U.S. Renunciation of Biological and Toxin Weapons, 1969-1970', *International Security,* vol. 27, summer 2002, 107-148.

that critical momentum was behind the initiative as soon as the USSR and its Warsaw Pact allies tabled a Draft Convention that was similar to the UK draft supported by the US.

Although an internal UK document raised a number of concerns about the Soviet Draft Convention, the US, following consultations with its allies, decided to negotiate on the basis of the Soviet text. UK reservations to the Soviet draft were threefold. First, a concern that the USSR might wish to retain the right to retaliate with BW since its draft excluded a prohibition on all use of BW. Second, the UK was worried that the USSR might want to manufacture and stockpile the components parts of prohibited BW weapons, enabling swift production of BW. Third, the UK did not think that the language of consultation and cooperation procedures to resolve problems of implementation of the convention was a realistic deterrent to would-be violators.[21] For its part, the US firmly rejected the Soviet interpretation of the Geneva Protocol—that the GP prohibited tear gas and herbicides. The US recognised the advantages of a complaints procedure on use that went to the UN Secretary-General rather than through the Security Council; nevertheless, it did not feel that those provisions were essential to its security interests.[22] Ultimately the most contentious issues in the negotiations process concerned the references in the BWC to CW. US National Security Advisor Henry Kissinger considered those references, in the Preamble and Articles VIII, and IX of the BWC, to have been "the price for general support of a BW ban" from the nonaligned nations and the Soviets.[23]

On April 10th 1972, the "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological, (Biological) and Toxin Weapons and on Their Destruction" was signed in Washington, London and Moscow. The Convention was the first to outlaw the possession, production, stockpiling and development of an entire class of weapons. Despite the failure of efforts to strengthen the Convention it still stands as a bulwark, as stated in the Preamble, against weapons that are "repugnant to the conscience of mankind."

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[21] Confidential Saving Telegram, Foreign and Commonwealth Office to Abidjan, 29 September 1969, DEFE 24/551, PRO.

[22] Department of State Telegram, ACDA/IR:RLMCCORMACK, April 1971, NSC Files, Chemical, Biological Warfare (Toxins etc.), vol. 4 pt. 1, box 312, National Archives and Records Administration.

[23] Memorandum for Kissinger from Guhin, Convention Banning Biological Weapons and Toxins. 17 September 1971, ibid.

Chapter 3. The Biological Weapons Convention: Content, Review Process and Efforts to Strengthen the Convention

Piers D. Millett

The Biological Weapons Convention

As a result of prolonged efforts by the international community to establish a new instrument that would supplement the 1925 Geneva Protocol, the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, better known as the Biological and Toxin Weapons Convention (BWC), opened for signature on 10 April 1972. The BWC, the first multilateral disarmament treaty banning the production and use of an entire category of weapons, entered into force on 26 March 1975. Over the intervening years, increasing numbers of States joined the Convention, which currently has 163 States Parties and 13 Signatory States. The BWC effectively prohibits the development, production, acquisition, transfer, stockpiling and use of biological and toxin weapons and is a key element in the international community's efforts to address the proliferation of weapons of mass destruction. A summary of the key provisions of the BWC can be found in Table 3.1.

Table 3.1. Key provisions of the Biological Weapons Convention[1]

ARTICLE	PROVISION
Article I	Never under any circumstances to acquire or retain biological weapons.
Article II	To destroy or divert to peaceful purposes biological weapons and associated resources prior to joining.
Article III	Not to transfer, or in any way assist, encourage or induce anyone else to acquire or retain biological weapons.
Article IV	To take any national measures necessary to implement the provisions of the BWC domestically.
Article V	To consult bilaterally and multilaterally to solve any problems with the implementation of the BWC.
Article VI	To request the UN Security Council to investigate alleged breaches of the BWC and to comply with its subsequent decisions.
Article VII	To assist States which have been exposed to a danger as a result of a violation of the BWC.
Article X	To do all of the above in a way that encourages the peaceful uses of biological science and technology

[1] See the website of the BWC at http://www.unog.ch/bwc.

States Parties to the BWC have striven to ensure that the Convention remains relevant and effective, despite the changes in science and technology, politics and security since it entered into force. Throughout the intervening years, States Parties have met at five yearly intervals to review the operation of the BWC. These meetings have built up a raft of additional understandings and agreements that expand upon how it should be implemented.[2] The Seventh Review Conference is to be held in 2011. Between review conferences States Parties have pursued various activities and initiatives to strengthen the effectiveness and improve the implementation of the BWC.

Reviewing the Convention

Article XII of the BWC states that a conference was to take place within five years of entry into force and was to review its operation, relevant scientific and technological developments, as well as progress towards the negotiation of a convention to prohibit the development, production, stockpiling and use of chemical weapons.[3] The First Review Conference took place in Geneva from 3 to 21 March 1980.[4] It decided that a Second Review Conference would take place about five years later, as well as concluding that texts of national implementation measures should be provided to the United Nations.

The Second Review Conference took place in Geneva from 8 to 26 September 1986.[5] The Final Document of the conference asserted that the provisions of the BWC cover all relevant current and future scientific and technological developments as well as applying to all international, national and non-State actors, thereby bringing the issue of bioterrorism within the scope of the Convention. It also permitted the World Health Organization to coordinate emergency response measures in cases of the alleged use of biological and toxin weapons. The Second Review Conference laid down procedure for resolving doubts about compliance, known as the Formal Consultative Process, and established an annual exchange of information, known as Confidence-Building Measures (CBMs). The CBMs were intended to reduce the occurrence of ambiguities, doubts and suspicions, and improve international cooperation in the field of peaceful biological activities. An Ad Hoc Meeting of Scientific and Technical Experts was held (31st March to 15th April 1987) to establish the precise format of the CBMs.

The Third Review Conference, held in Geneva from 9 to 27 September 1991, asserted that the BWC covers agents relating to humans, animals and plants; requested States Parties to re-examine their national implementation measures; revised the format for Formal Consultative Meetings; revised the CBMs; indirectly encouraged the United Nations Secretary-General to conduct investigations into allegations of the use of biological and toxin weapons; expanded upon the coordinating role of intergovernmental organizations in the response to such occurrences; asserted that information on the implementation of Article X on peaceful uses of the biological sciences

[2] BWC Implementation Support Unit, *Additional Understandings and Agreements reached by Review Conferences Relating to Each Article of the Biological Weapons Convention*, August 2007. Available at: http://www.unog.ch/bwc.

[3] United Nations, Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, *General Assembly Resolution 2826*, 16 December 1971.

[4] United Nations, Final Document of the First Review Conference of the BWC, *Document BWC/CONF.I/10*, (Geneva: United Nations, 21 March 1980). Available at: http://www.opbw.org.

[5] United Nations, Final Document of the Second Review Conference of the BWC, *Document BWC/CONF.II/13*, (Geneva: United Nations, 30 September 1986). Available at: http://www.opbw.org.

should also be provided to the United Nations; and established an Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint (VEREX).[6]

The Fourth Review Conference, held in Geneva from 25 November to 6 December 1996, established that the BWC effectively covers the *use* of biological and toxin weapons, as well as asserting that all destruction and conversion activities of former weapons and associated facilities should take place prior to accession to the Convention.[7] It also recommended a series of specific measures to enhance the implementation of Article X.

The Fifth Review Conference opened in Geneva on 19 November 2001, but because of divergent positions on the Ad Hoc Group (see next section), it was suspended on 7 December 2001.[8] A resumed session was held in Geneva from 11 to 22 November 2002, which decided that a series of annual Meetings of Experts and Meetings of States Parties would be held to discuss, and promote common understanding and effective action on a range of topics to strengthen the Convention (see sections on the intersessional processes).[9]

The Sixth Review Conference was held in Geneva from 20 November to 8 December 2006.[10] It was the most substantive review of the BWC since the Third Review Conference. It produced a Final Declaration which: closed a loophole on destruction deadlines for states that had signed but not previously ratified the BWC (as well as strengthening requirements for safety, security and reporting for destruction and conversion activities); established a need for national export control regimes as a means to mitigate direct or indirect transfers of relevant material; developed a basic requirement for ensuring safety and security of relevant material when used for permitted purposes; required national penal legislation and other measures to implement the BWC and a call for their extra-territorial application; developed basic requirements for national education, outreach and awareness-raising activities for relevant stakeholder communities; included a commitment to develop national, regional and international capabilities for the detection and surveillance of disease; included a commitment to review national legislative and regulatory frameworks to ensure they comply with Article X and to report on how this article is being implemented; called for an efficient coordination mechanism for relevant scientific cooperation and technology transfer in the UN system; noted the increasing importance of public-private partnerships in implementing the BWC; and institutionalised the use of Arabic as an official language of future BWC meetings.

The Sixth Review Conference also took concrete action to strengthen the BWC, including: creating a plan of action to increase the membership of the treaty; reaching an agreement for States Parties to nominate national contact points to facilitate communications relevant to the BWC; officially endorsing the common understandings reached during the first intersessional process (see below);

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[6] United Nations, Final Document of the Third Review Conference of the BWC, *Document BWC/CONF.III/23*, (Geneva: United Nations, September 1991). Available at: http://www.opbw.org.

[7] United Nations, Final Document of the Fourth Review Conference of the BWC, *Document BWC/CONF.IV/9*, (Geneva: United Nations, December 1996). Available at: http://www.opbw.org.

[8] United Nations, Interim Report of the Fifth Review Conference of the BWC, *Document BWC/CONF.V/12*, (Geneva: United Nations, 14 December 2001). Available at: http://www.opbw.org.

[9] United Nations, Final Document of the Fifth Review Conference of the BWC, *Document BWC/CONF.V/17*, (Geneva: United Nations, December 2002). Available at: http://www.opbw.org.

[10] United Nations, Final Document of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva: United Nations, December 2006). Available at: http://www.unog.ch/bwc.

establishing an Implementation Support Unit, addressing a long-standing need for institutional support for the efforts of States Parties, and tasking them with updating the reporting procedure for CBMs to take into account modern information technology; and initiating a detailed second intersessional work programme to help ensure effective implementation of the BWC until the Seventh Review Conference.

The Seventh Review Conference is due to be held in Geneva in 2011. The Conference will review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention are being realized. It will also take into account: any new scientific and technological developments relevant to the Convention; the content and implementation of the CBM regime; progress made by States Parties on the implementation of the obligations under the Convention; and progress of the implementation of the decisions and recommendations agreed upon at the Sixth Review Conference (including the work of the Meetings of Experts and Meetings of States Parties held between 2007 and 2010).

Efforts to Strengthen the Convention

As early as the Second Review Conference in 1986 States Parties realised that enhanced transparency and information sharing would help reduce the occurrence of ambiguities, doubts and suspicions, in order to improve international co-operation in the field of peaceful biological activities. As a result, the Second Review Conference mandated the first set of meetings outside of the review conference process; it was dedicated to strengthening one particular area of the implementation of the BWC. The two week Ad Hoc Meeting of Scientific and Technical Experts from States Parties to Finalise the Modalities for the Exchange of Information and Data took place in March and April 1987 and resulted in the annual CBMs.[11] The format and content of the information to be exchanged has been revised and updated over the years and there are currently seven CBMs which cover: research centres and laboratories, and national biological defence research and development programmes; outbreaks of infectious diseases and similar occurrences caused by toxins; the encouragement of publication of results and promotion of use of knowledge; active promotion of contacts; legislation, regulations and other measures; past activities in offensive and/or defensive biological research and development programmes; and vaccine production facilities.[12]

The first CBM returns were collated by the United Nations Department (now Office) for Disarmament Affairs in 1987. They have been compiled every year since and are currently handled by the BWC Implementation Support Unit. As the establishment of this exchange of information in the form of the CBMs has the status of an "additional agreement" (see the Conclusion section, below), this is a politically (as opposed to legally) binding obligation of the States Parties. A total of 105 States have submitted CBMs at least once but only 9 States have submitted a CBM every year. Between the Fourth and Fifth Review Conferences, 26 States submitted CBMs every year. Similarly, 26 States submitted CBMs every year between the Fifth and Sixth Review Conference. So far, 47 States have submitted CBMs every year since the Sixth Review Conference. Submission of CBMs peaked in the early-1990s with almost 50% of States Parties submitting in 1991 but seems

[11] United Nations, Report of the Ad Hoc Meeting of Scientific and Technical Experts from States Parties to Finalise the Modalities for the Exchange of Information and Data, *Document BWC/CONF.II/EX//2*, (Geneva: United Nations, 21 April 1987).

[12] See the BWC Implementation Support Unit information on CBMs at: http://www.unog.ch/bwc/cbms.

to be going through something of a resurgence. Since the Sixth Review Conference participation in the CBM regime has held roughly constant at around 40%.[13] CBMs, however, were not the only mechanism to be examined by States Parties to strengthen the Convention.

Towards a Legally Binding Instrument

A group of governmental experts (VEREX) was established at the Third Review Conference to identify and examine potential verification measures from a scientific and technical standpoint. The Final Report of VEREX concluded that there were some potential verification measures which might contribute to strengthening the effectiveness and improve the implementation of the Convention.[14] At a Special Conference (September 1994) States Parties, on the basis of the VEREX findings, agreed to establish the Ad Hoc Group of the States Parties to the BWC in order to negotiate and develop a legally-binding verification regime for the Convention.[15] To this end, the Ad Hoc Group was mandated to consider four specific areas, namely: definitions of terms and objective criteria; incorporation of existing and further enhanced confidence-building and transparency measures, as appropriate, into the regime; a system of measures to promote compliance with the Convention; and specific measures designed to ensure the effective and full implementation of Article X on international cooperation and exchange in the field of peaceful bacteriological (biological) activities. The Ad Hoc Group was destined to hold 24 working sessions over the next seven years.[16]

The work of the Ad Hoc Group was discussed at the Fourth Review Conference in 1996 and the progress made thus far was welcomed. It was also decided that the Ad Hoc Group should conclude its work on the future protocol, at the latest, by the Fifth Review Conference to be held in 2001. On 23 September 1998, an Informal Ministerial Meeting of the States Parties to the BWC was held in New York at the initiative of Australia in order to demonstrate high-level political support for the negotiations.

At its 24th session (23 July –17 August 2001), which was the last scheduled session before the Fifth Review Conference, the Ad Hoc Group was unable to conclude the negotiations on the draft protocol and could not reach consensus on the report of its work, effectively ending that effort to strengthen the BWC.[17]

[13] United Nations, 2008 Report of the Implementation Support Unit, *Document BWC/MSP/2008/3*, (Geneva: United Nations, 28 November 2008). Available at: http://www.unog.ch/bwc.

[14] United Nations, Report of the Ad Hoc Group of Governmental Experts to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint, *Document BWC/CONF.III/VEREX/9*, (Geneva: United Nations, 24 September 1993). Available at: http://www.opbw.org.

[15] United Nations, Final Report of the Special Conference of the BWC, *Document BWC/CONF.V/17*, (Geneva: United Nations, December 2002). Available at: http://www.opbw.org.

[16] Ad Hoc Group documents are available at: http://www.opbw.org.

[17] For a more detailed history of the efforts of the Ad Hoc Group, see: J. Littlewood, *The Biological Weapons Convention: A Failed Revolution* (London: Ashgate, 2005).

The First Intersessional Process

The Fifth Review Conference saw a change in direction. States Parties adopted a Final Report that included a decision to hold annual meetings of States Parties and experts meetings in the years leading up to the Sixth Review Conference in 2006. These meetings were meant to bridge gaps between divergent national positions and demonstrate that States Parties could still work together to improve the functioning of the BWC. They were tasked with discussing, and promoting common understanding and effective action on a number of predetermined topics. In practice, these meetings turned out to be a much greater success than predicted. The value of the first intersessional process was succinctly summed up in the Indian opening statement to the Sixth Review Conference in 2006:

> *When the [first] inter-sessional process started, there was some scepticism about its prospects. Contrary to these forebodings, however, States Parties gained considerably from it. Treating the BWC regime as one of the live issues of the multilateral disarmament agenda strengthened the regime. Besides, the States Parties benefited from a most useful exchange of information and experiences on issues relevant to the effective implementation of the Convention. The knowledge creation and its dissemination, which characterised the exchanges, were enriched by the participation in the process of relevant international organisations and national public-health stakeholders.*[18]

The first intersessional process laid much of the groundwork for the successes of the Sixth Review Conference. The common understandings reached during these meetings translated into many of the additional agreements that emerged in 2006.

BWC MEETINGS IN 2003. The first Meeting of States Parties, held in Geneva from 10 to 14 November 2003, was chaired by Ambassador Tibor Toth of Hungary.[19] It developed the work begun at the Meeting of Experts, held from 18 to 29 August 2003.[20] Both meetings covered two topics: (1) the adoption of necessary national measures to implement the prohibitions set forth in the Convention, including the enactment of penal legislation; and (2) national mechanisms to establish and maintain the security and oversight of pathogenic microorganisms and toxins.

At this meeting, States Parties stressed the need for undertaking national activities to strengthen and implement the Convention, including reviewing national regulatory and penal measures to ensure effective implementation of its prohibitions as well as those which enhance the security of pathogens and toxins. States Parties also noted the positive effect of cooperation between States Parties with differing legal and constitutional arrangements. The need for comprehensive and concrete national measures to secure pathogen collections and the control of their use for peaceful purposes was also acknowledged. There was a general recognition of the value of biosecurity measures and procedures, to ensure that such dangerous materials are not accessible to persons who might use them for purposes contrary to the Convention.

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[18] J. Prasad, Indian Statement to the Sixth Review Conference of the Biological and Toxin Weapons Convention, *Statement*, 20 November 2006. Available at: http://www.unog.ch/bwc.

[19] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2003/4*, (Geneva: United Nations, 26 November 2003). Available at: http://www.unog.ch/bwc.

[20] United Nations, Report of the Meeting of Experts, *Document BWC/MSP/2003/MX/4*, (Geneva: United Nations, 18 September 2003). Available at: http://www.unog.ch/bwc.

The 2003 meetings established the modality of all subsequent meetings. The Meeting of Experts is used as an information gathering and exchange opportunity and benefits from attracting as many relevant experts as possible. The Meeting of States Parties is then used to consider how the data gathered relates to the Convention, what its implications are and for identifying common understandings on what action is needed as a result.

BWC MEETINGS IN 2004. The second Meeting of States Parties was held in Geneva from 6 to 10 December 2004 and was chaired by Peter Goosen of South Africa.[21] It developed the work begun at the Meeting of Experts, held from 19 to 30 July 2004.[22] Once again both meetings covered two topics: (1) strengthening and broadening national and international institutional efforts and existing mechanisms for the surveillance, detection, diagnosis and combating of infectious diseases affecting humans, animals, and plants; and (2) enhancing international capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease.

On the first topic, the States Parties recognised that infectious disease outbreaks can be contained and suppressed through early detection, immediate response and co-operation and support at the national and international level; that strengthening and broadening national and international surveillance, detection, diagnosis and combating of infectious disease may support the object and purpose of the Convention; that the primary responsibility for surveillance, detection, diagnosis and combating of infectious diseases rests with States Parties, while intergovernmental organizations have global responsibilities (within their mandates) in this regard, and that the respective structures, planning and activities of States Parties and intergovernmental organizations should be co-ordinated with and complement one another; and that scientific and technological developments have the potential to significantly improve disease surveillance and response.

The States Parties consequently agreed on the value of: supporting the existing networks of relevant international organisations for the surveillance, detection, diagnosis and combating of infectious diseases and acting to strengthen intergovernmental organizations programmes in these endeavours; improving, wherever possible, national and regional disease surveillance capabilities, and, if in a position to do so, assisting and encouraging, with the necessary agreement, other States Parties to do the same; and working to improve communication on disease surveillance with intergovernmental organizations, and among States Parties.

On the second topic, the States Parties recognised that capabilities for responding to, investigating and mitigating the effects of cases of alleged use of biological or toxin weapons or suspicious outbreaks of disease promote the object and purpose of the Convention; that States Parties' national preparedness and arrangements substantially contribute to those international capabilities; and that the United Nations Secretary-General's investigation mechanism, set out in A/44/561 and endorsed by the General Assembly in its resolution A/Res/45/57,[23] represents an international institutional mechanism for investigating cases of alleged use of biological or toxin weapons.

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[21] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2004/3*, (Geneva: United Nations, 14 December 2004). Available at: http://www.unog.ch/bwc.

[22] United Nations, Report of the Meeting of Experts, *Document BWC/MSP/2004/MX/3*, (Geneva: United Nations, 11 August 2004). Available at: http://www.unog.ch/bwc.

[23] For more information on these procedures see the background paper prepared by the BWC Secretariat 'Mechanisms available to States Parties to investigate the alleged use of biological or toxin weapons and to provide assistance in such cases', Document BWC/MSP/2004/MX/INF.3. Available at: http://www.unog.ch/bwc.

The States Parties consequently agreed on the value of: continuing to develop their own national capacities for response, investigation and mitigation, in cooperation with the relevant international and regional organisations, and, if in a position to do so, assisting and encouraging, with the necessary agreement, other States Parties to do the same. Moreover, the Meeting encouraged States Parties to inform the forthcoming Sixth Review Conference (due to be held in 2006) of, *inter alia*, any actions, measures or other steps that they may have taken on the basis of the discussions at the 2004 Meeting of Experts and of the outcome of the 2004 Meeting of States Parties. This concept has since become a staple principle of the intersessional processes and a comparable paragraph has been included in the report of every Meeting of States Party since 2004.

The 2004 meetings saw two significant developments in the evolution of the intersessional process. It saw the Secretariat of the meeting charged with putting together substantive background papers on and the topics under consideration. It also established the mechanism for processing information that has been used every year since. Substantive elements from contributions to the Meeting of Experts are extracted and compiled into a central list which is then annexed to its report. This list is processed and compressed under the authority of the Chair between the two meetings. The resulting synthesis is fed into the Meeting of States Parties, which uses it to facilitate efforts to identify common understandings and often forms the basis of the substantive paragraphs in the report of the meeting. The Chair's synthesis paper is annexed, in full, to the report of the Meeting of States Parties.

BWC MEETINGS IN 2005. Ambassador John Freeman of the United Kingdom chaired the third Meeting of States Parties, held in Geneva from 5 to 9 December 2005.[24] It developed the work begun at the Meeting of Experts, held from 13 to 24 June 2005.[25] It covered the topic of the content, promulgation and adoption of codes of conduct for scientists.

States Parties recognised that codes of conduct can support the BWC in combating present and future threats posed by biological and toxin weapons. States Parties noted that a range of different approaches exists to develop codes of conduct in view of differences in national requirements and circumstances, and that whenever possible, existing mechanisms and frameworks should be used. It was understood that codes should avoid impeding scientific discovery, or placing undue constraints on research or international cooperation and exchange for peaceful purposes. Codes were considered to be most effective if they, and their underlying principles, are widely known and understood. It was recognized that all those with a responsibility for, or legitimate interest in, codes of conduct should be involved in their development, promulgation and adoption.

States Parties agreed on the importance of codes being: compatible with national legislation and regulatory controls and contributing to national implementation measures; simple, clear and easily understandable both to scientists and to wider civil society; relevant, helpful and effective for guiding relevant actors in making decisions and taking action in accordance with the purposes and objectives of the Convention; sufficiently broad in scope; and regularly reviewed, evaluated for effectiveness, and revised as necessary.

[24] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2005/3*, (Geneva: United Nations, 14 December 2005). Available at: http://www.unog.ch/bwc.

[25] United Nations, Report of the Meeting of Experts, *Document BWC/MSP/2005/MX/3*, (Geneva: United Nations, 5 August 2005). Available at: http://www.unog.ch/bwc.

The 2005 meetings were the first time that experts from outside of government delegations and international organisations were invited to participate in a BWC meeting. Given the nature of the topic under consideration and under his own authority, the Chairman invited a number of stakeholders to participate in the Meeting of Experts as Guests of the Meeting. Guests were able to address the meeting during its working sessions and contribute papers, presentations and statements. They included members of scientific academies, professional bodies and other stakeholders.

The Second Intersessional Process

The new opportunities offered by the intersessional processes provided a sound basis for additional efforts under the BWC. In his address to the Sixth Review Conference, the then Secretary-General of the United Nations, Kofi Annan, described the BWC's efforts as "multilateralism as it should be: flexible, responsive, creative and dynamic; and above all, focused on overcoming obstacles and delivering results."[26] This was a high standard to attempt to reproduce but States Parties committed themselves to do exactly that when they agreed to a second intersessional process at the Sixth Review Conference.

BWC MEETINGS IN 2007. Ambassador Masood Khan of Pakistan chaired the first Meeting of States Parties of the second intersessional process. It was held in Geneva from 10 to 14 December 2007.[27] It developed the work begun at the Meeting of Experts, held from 20 to 24 August 2007.[28] Both meetings covered two topics: (1) ways and means to enhance national implementation; and (2) regional and sub-regional cooperation on implementation.

States Parties agreed on the value of: developing a coordinated and harmonised domestic mechanism to manage implementation; effective enforcement; regular national reviews due to the ongoing nature of these undertakings; regional and sub-regional cooperation to complement and reinforce national measures; ensuring the existence of the necessary resources; and promoting international cooperation at all levels in order to exchange experiences and best practices.

On the scope of national implementation measures, States Parties reached a common understanding that they should: penalize and prevent activities that breach any of the prohibitions of the Convention; prohibit assisting, encouraging or inducing others to breach any of the prohibitions of the BWC; not only enact relevant laws, but also strengthen national capacities, including the development of necessary human and technological resources; include an effective system of export/import controls, adapted to national circumstances and regulatory systems; and avoid hampering the economic and technological development of States Parties, or international cooperation in the field of peaceful uses of biological science and technology.

States Parties also reached a common understanding that regional and sub-regional cooperation on this issue should: develop common approaches to implementation and provide relevant assistance and support; engage regional resources (such as those concerned with police, customs, public health

[26] K. Annan, Remarks of the Secretary-General to the Sixth Review Conference of the Biological Weapons Convention, *Statement*, 20 November 2006. Available at: http://www.unog.ch/bwc.

[27] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2007/5*, (Geneva: United Nations, 7 January 2008). Available at: http://www.unog.ch/bwc.

[28] United Nations, Report of the Meeting of Experts, *Document BWC/MSP/2007/MX/3*, (Geneva: United Nations, 3 September 2007). Available at: http://www.unog.ch/bwc.

or agriculture) which may have relevant expertise or technical knowledge; and include the implementation of the BWC on the agendas of regional meetings and activities, including ministerial and high-level regional consultations.

The 2007 meetings of the BWC saw further progress made on engaging with stakeholder communities. The heads of three international organisations participated in the Meeting of States Parties, illustrating the increasing importance and value placed on the BWC intersessional process. This meeting also included a session dedicated to industry participants, highlighting the focus being placed on improving engagement with the private sector. It also saw the first use of discussion panels, allowing for a more interactive experience between stakeholders and delegates and maximising opportunities for taking advantage of the expertise present around the margins of the meeting. The 2007 meetings also took advantage of the presence of institutional support for the BWC to put in place longer term information resources. Earlier efforts to catalogue national measures taken by States Parties to implement the BWC (that had lain dormant since the issue was discussed in 2003) were updated to form the National Implementation Database (NID). The ISU were charged with continuing to add information, as it became available, throughout the second intersessional process.

BWC MEETINGS IN 2008. Ambassador Georgi Avramchev of The former Yugoslav Republic of Macedonia chaired the 2008 Meeting of States Parties. It was held in Geneva from 1 to 5 December 2008.[29] It developed the work begun at the Meeting of Experts, held from 18 to 22 August 2008.[30] Both meetings covered two topics: (1) national, regional and international measures to improve biosafety and biosecurity; and (2) oversight, education, awareness raising, and adoption and/or development of codes of conduct with the aim of preventing misuse of advances in bio-science and bio-technology research for purposes prohibited by the Convention.

Given the inter-related nature of the topics under consideration, States Parties came to a number of common understandings that applied to them all, including: the need for proportional measures; for carefully assessing risks; for balancing security concerns against the need to avoid hampering the peaceful development of biological science and technology; for taking national and local circumstances into account; for balancing 'top-down' government or institutional control with 'bottom-up' oversight by scientific establishments and scientists themselves. States Parties further recognised the value of being informed about relevant advances in bioscience and biotechnology; and the necessity of strengthening ties with the scientific community.

On biosafety and biosecurity, States Parties reached common understandings on: the use of the terms; the role to be played by national authorities; how best to improve inter-departmental interaction; the importance of various oversight and regulatory tools and approaches; the need for risk assessment, management and communication; the centrality of building networks with stakeholder communities; making better use of the ISU; how these concepts under the BWC relate to similar concepts in other regimes; the value of cooperation and assistance to build related capacity; and the provision of necessary assistance.

[29] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2008/5*, (Geneva: United Nations, Forthcoming). Available at: http://www.unog.ch/bwc.

[30] United Nations, Report of the Meeting of Experts, *Document BWC/MSP/2007/MX/3*, (Geneva: United Nations, 8 September 2008). Available at: http://www.unog.ch/bwc.

On oversight of science States Parties agreed on the value of: developing national frameworks to prohibit and prevent the possibility of biological agents or toxins being used as weapons; covering people, materials, knowledge and information in all sectors and throughout the scientific life cycle; involving national stakeholders in all stages of the design and implementation of oversight frameworks; and harmonising national, regional and international efforts.

On education and awareness-raising, States Parties came to a common understanding that such activities should: explain the risks associated with the potential misuse of the biological sciences and biotechnology; cover the moral and ethical obligations incumbent on those using the biological sciences; provide guidance on the types of activities which could be contrary to the aims of the BWC, relevant national laws and regulations, and international law; be supported by accessible teaching materials, train-the-trainer programmes, seminars, workshops, publications, and audio-visual materials; address leading scientists and those with responsibility for oversight of research or for evaluation of projects or publications at a senior level, as well as future generations of scientists, with the aim of building a culture of responsibility; and be integrated into existing efforts at the international, regional and national levels.

On codes of conduct, States Parties agreed that such codes can complement national legislative, regulatory and oversight frameworks and help guide science so that it is not misused for prohibited purposes. States Parties also recognised the need to further develop strategies to encourage national stakeholders to voluntarily develop, adopt and promulgate codes of conduct in line with the common understandings reached in 2005.

The meetings in 2008 continued momentum on improving stakeholder engagement and in practical tools to assist States Parties in their efforts. The online database of national implementation measures (NID) was supplemented with Compendiums of National Activities (CNAs) on the topics under consideration. These provide descriptions of how the legislative and regulatory measures are operationalized (who is in charge, what bodies are involved, how they interact, etc.). These descriptions are taken from the documents of the meetings, statements and presentations, as well as other contributions. Given the nature of the topics under consideration, the Guest of the Meeting status was revised and non-governmental expertise enjoyed unprecedented access to and interaction with the Meeting of Experts. Guests were able to address the meeting (as in 2005) but were also able to ask questions and make clarifications. In addition, the 2008 Meeting of Experts held all of its substantive session in open, public settings. Finally, these meetings also saw the first use of Poster Sessions at a BWC meeting. Following feedback on the desirability of increased interaction amongst the experts present, poster sessions were held to increase opportunities for more informal, content-driven opportunities to discuss the issues covered by the meetings.

BWC MEETINGS IN 2009 and 2010. In accordance with the mandate for the second intersessional process, which was decided upon by the Sixth Review Conference in 2006, there will also be annual meetings in 2009 and 2010. The Meeting of States Parties in 2008 elected Ambassador Marius Grinius of Canada to chair the 2009 meetings, and it also set the dates for these meetings. Both meetings will be held in Geneva, Switzerland. The Meeting of Experts will run from 24 to 28 August 2009 and the Meeting of States Parties from 7 to 11 December 2009. With a view to enhancing international cooperation, assistance and exchange in biological sciences and technology for peaceful purposes, the 2009 meetings will discuss, and promote common understanding and effective action on promoting capacity building in the fields of disease surveillance, detection, diagnosis, and containment of infectious diseases.

The 2010 meetings of the BWC will cover the provision of assistance and coordination with relevant organisations upon request by any State Party in the case of alleged use of biological or toxin weapons, including improving national capabilities for disease surveillance, detection and diagnosis and public health systems. The dates for the meetings and the individual that will chair them will likely be decided by the 2009 Meeting of States Parties. The Chair will come from the Non-Aligned Movement and Other States.

Conclusion

The BWC is the primary international arrangement to address threats posed by biological and toxin weapons and the hostile use of biology. Its obligations underpin all successive efforts to deal with these issues. Advances and resources relevant to ensuring that the life sciences are used solely for our collective benefit are found in increasingly diverse geographic locations. The threats posed by these weapons have also expanded to incorporate the possibility of their acquisition and use by non-state actors. Over the decades since the BWC entered into force, a wide number of international, regional and national organisations, initiatives and arrangements have engaged with various facets of biological and toxin weapon threats. This expanding community offers important benefits in terms of resources and expertise, if only the various efforts are complementary and well coordinated. The BWC increasingly acts as the central reference point and primary forum for inter-organisation, inter-national and inter-agency interaction and cooperation. It continues to evolve to best fit contemporary security environments and manage the threats posed by the weaponization of disease.

Efforts to strengthen the BWC can be thought of as active attempts to ensure that it continues to evolve. They can be characterised as relating to either *what* States Parties have agreed to do (scope) or *how* it is to be achieved (practical tools).

Strengthening the Scope of the BWC

The evolution of the BWC's review process, supported by its intersessional processes, has created a layered concept of undertakings to meet its obligations (see Figure 3.1). The BWC itself contains a number of legally binding obligations. Had it been successful, a verification protocol would have expanded these legally binding obligations. Legally binding obligations can be considered the things that States Parties MUST do.

The review conferences reached additional agreements as to how to implement the obligations of the BWC. They represent active agreement by States Parties to do certain things. As they have not been endorsed by a specific act of parliament or Presidential Decree, they are considered to be politically (as opposed to legally) binding. Politically binding obligations are the things States Parties SHOULD do.

Finally, the intersessional processes have led to the development of common understandings on elements that might be useful when a States Party addresses its politically or legally binding commitments. These are shared national positions on mechanisms that might strengthen the implementation of the BWC – or the things States Parties COULD do.

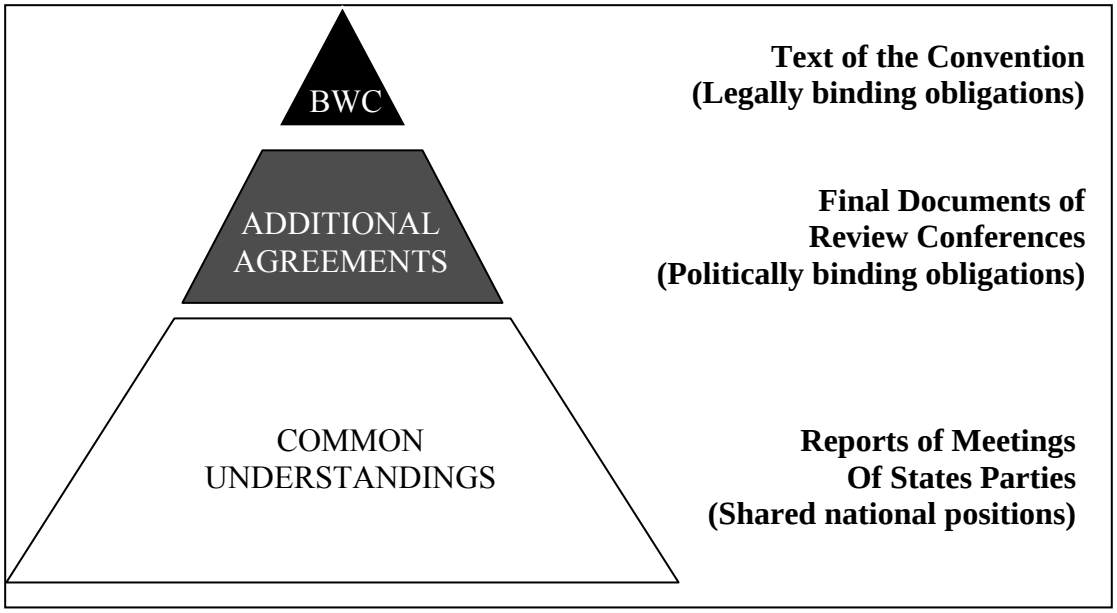

Figure 3.1. Layers of undertakings under the Biological and Toxin Weapons Convention.

Practical Tools to Strengthen the BWC

To assist States Parties in these undertakings, a number of practical tools have been developed. The CBM regime was designed to increase transparency and decrease compliance concerns. The creation of a network of National Contact Points has facilitated communication amongst and between States Parties and yielded results in drawing together a community of invested representatives. The NID and CNAs provide a catalogue of measures taken to implement the obligations of the BWC, an important resource for those looking to improve their own regimes or for reassurance as to what is in place in another country. The universalization action plan has provided both focus and motivation to increase the membership of the BWC. In the two years since its adoption, eight new States Parties have joined the treaty. The creation of the ISU, to support States Parties in their endeavours, has also addressed a long standing need for an institutional presence and has facilitated the BWC's role in the broader international environment.

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Chapter 4. Developments in Science and Technology: Relevance for the BWC[1]

Kathryn Nixdorff and Malcolm R. Dando

Introduction

The hallmark of the developments in science and technology over the past three decades is the explosive nature of the accumulation of knowledge concerning the molecular mechanisms and functions of biological systems. While this knowledge is essential for countering disease and promoting public health security in general, it can at the same time be malignly misused for waging biological warfare. This is what is known as the dual-use dilemma.

The revolution in biotechnology is continuing on into the revolution in pharmacology with the emphasis on drug discovery and drug delivery, in which biochemical bioregulators and systems biology will be gaining more and more significance for biochemical arms control as time progresses.[2,3] Bioregulators are "naturally occurring organic compounds that regulate diverse cellular processes in multiple organ systems and are essential for normal homeostatic function".[4] They are diverse in structure and play key roles in many vitally important bodily functions such as respiration, blood pressure, heart rate, body temperature, mood and consciousness, as well as innate and adaptive immune responses. Most bioregulators operate by targeting specific cell receptors and components of biochemical signal transduction pathways, ultimately leading to the transcription of genes and production of bioactive proteins.

Recent warnings have made it clear that we could well face an increasing range of different biological agents being used for hostile terrorist and warfare purposes in the coming decades. George Poste[5], for example, has emphasised the need to think "beyond bugs", and, more generally, Mathew Meselson has argued convincingly that as the century progresses more and more of life's fundamental processes will become open to both benign and malign manipulation.[6]

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[1] Some material has been excerpted and up-dated from earlier reports: K. Nixdorff, 'Scientific and technological challenges to the BTWC', in: G. Lindstrom (ed.), *Enforcing non-proliferation. The European Union and the 2006 BTWC Review Conference. Chaillot Paper No. 93*, (Paris: Institute for Security Studies, European Union, 2006), Available at http://www.iss.europa.eu/index.php?id=143; and A. Kelle, K. Nixdorff and M. Dando, *A Paradigm Shift in the CBW Proliferation Problem: Devising Effective Restraint on the Evolving Biochemical Threat*, (Osnabrück: Deutsche Stiftung Friedensforschung, 2008), available at http://www.bundesstiftung-friedensforschung.de/publikationen/forschung.html.

[2] M. Wheelis, 'Biotechnology and biochemical weapons' *The Nonproliferation Review*, Spring 2002, pp.48-53.

[3] M. Dando, 'Genomics, bioregulators, cell receptors and potential biological weapons' *Defense Analysis*, vol. 17, 2001, pp. 239-258.

[4] E. Kagan, 'Bioregulators as instruments of terror', *Clinics in Laboratory Medicine*, vol. 21, 2001, pp. 607-618.

[5] G. Poste, *Advances in biotechnology: promise or peril*. Lecture presented at the 2000 Second National Symposium on Medical and Public Health Response to Bioterrorism, University of Pittsburg Medical Center. Available at www.upmc-biosecurity.org/website/events/2000_symposium-2/poste/trans_post.html

[6] Meselson, M., 'The problem of biological weapons'. Cambridge Mass: Presentation given to the 1818th Slated Meeting of the American Academy of Arts and Sciences, 13th January, 1999.

An analysis by Petro et al.[7] from the US Department of Defense sets a framework for thinking about future trends in this context. These authors consider the future evolution of biological warfare in three phases:

(i) As there a only a limited number of traditional biological warfare agents suitable for use they suggest that defence will eventually be able to counter all of these.

(ii) Moreover, as there are only a limited number of ways in which traditional agents may be effectively modified, defence will also eventually be able to counter all of these.

(iii) However, as the process described by Meselson continues through the century, an ever increasing number of targets will become available for which specific Advanced Biological Warfare Agents (ABWs) may be designed. Thus defence will be confronted with the problem of a diffuse and fundamentally unknowable range of potential agents, a situation that makes it highly unlikely that a biodefence programme alone would be able to deal with adequately.

Two reports of the US National Academies in the past few years have dealt in particular with the dual-use dilemma regarding advances in science and technology in a biosecurity context. The work of the Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology was chaired by Gerald R. Fink and hence called the Fink Committee Report.[8] It made several recommendations, but most important for this discussion the committee identified seven classes of "experiments of concern" that should "require review by an Institutional Biosafety Committee". These experiments of concern include those that:

1. Would demonstrate how to render a vaccine ineffective.
2. Would confer resistance to therapeutically useful antibiotics or antiviral agents.
3. Would enhance the virulence of a pathogen or render a nonpathogen virulent.
4. Would increase transmissibility of a pathogen.
5. Would alter the host range of a pathogen.
6. Would enable the evasion of diagnostic/detection modalities.
7. Would enable the weaponization of a biological agent or toxin.

This report has served to shape some of the approaches of the US to biosecurity. The work of the Committee on Advances in Technology and the Prevention of Their Application to Next Generation Biowarfare Threats followed directly behind the Fink Committee and was co-chaired by Stanley M. Lemon and David A. Relman, hence called the Lemon-Relman Report.[9] Most notably, the report on a workshop[10] conducted early on by this committee dealt with the very newest of advancing technologies within the framework of managing dual-use risks.

[7] J.B. Petro, T.R. Plasse and J.A. McNulty, 'Biotechnology: impact on biological warfare and biodefense', *Biosecurity and Bioterrorism: Biodefense, Strategy, Practice, and Science*, vol. 1, 2003, pp. 161-168.

[8] The National Academies, *Biotechnology Research in an Age of Terrorism*, (Washington, D.C.: The National Academies Press, 2004). Available at: http://www.nap.edu.

[9] The National Academies, *Globalization, Biosecurity, and the Future of the Life Sciences*, (Washington, D.C.: The National Academies Press, 2006). Available: at http://www.nap.edu.

[10] The National Academies, *An International Perspective on Advancing Technologies and Strategies for Managing Dual-Use Risks*, (Washington, D.C.: The National Academies Press, 2005). Available at: http://www.nap.edu.

We have to remember that we not only have to be concerned about the deliberate misuse of science and technology for the production of biological weapons but also about the inadvertent creation of biological agents that have enhanced potential for causing disease that could be used for malign purposes. There have been several examples of such work reported in the scientific literature over the past few years that no doubt was one factor that prompted the National Academies studies. A prime example is the inadvertent creation of a "killer" mousepox virus by researchers in an attempt to develop a contraceptive vaccine that was designed to control the rodent population in Australia.[11] Another example concerns the potentiation of a virulence factor of vaccinia virus, the strain used for smallpox vaccinations.[12] In this case a property (factor) of the virus was engineered to more effectively eliminate the activity of an essential component of the innate immune system, which acts as the first line of defence against an infection.

In a further example, Russian researchers transferred AB cereolysin genes from a soil bacterium to *Bacillus anthracis*, the causative agent of anthrax.[13] Cereolysin is an enzyme that can damage cell membranes and cause especially labile red blood cells to burst (hemolysis). According to the authors, the study was undertaken to investigate changes in immunogenic properties of vaccine strains in connection with hemolytic characteristics. The pathogenicity of the engineered bacterium was not increased by this manipulation per se, but hamsters that had been vaccinated against anthrax were not protected after challenge with the engineered strain. In some way which was never clarified, the engineered agent was able to evade immune defences normally afforded by vaccination. Thus, there was concern in the West that the standard vaccine would not be effective against this engineered strain.

Another study[14] by then Soviet scientists concerned the introduction of beta-endorphin, a well-known bioregulator, into a vaccine strain of the bacterium *Franciscella tularensis* (causative agent of tularaemia, see Chapter 1). This bacterium has long been regarded as a prime candidate for a biological weapon. When injected into mice, the engineered bacterium mediated an enhanced pain-reducing effect over that seen when the bioregulator alone was administered to the mice. This showed that the bacterium carrying the gene encoding the beta-endorphin survived in the mice and the gene was expressed, which caused an over-production of the bioregulator. Subsequent studies achieved higher levels of expression of the gene in other bacteria. In any case, these studies showed that bacterial vectors can be used to successfully carry bioregulator genes that will be expressed in a host (in this case an experimental animal).

Since the time of these studies, there have been rapid advances that enable even wider-reaching creation and manipulation of biological agents. This chapter will provide a look at some of these

[11] R.J. Jackson, A.J. Ramsay, C. Christensen, S. Beaton, D.F.R. Hall and I.A. Ramshaw, 'Expression of mouse interleukin-4 by a recombinant ectromelia virus suppresses cytolytic lymphocyte responses and overcomes genetic resistance to mousepox', *Journal of Virology*, vol. 75, 2001, pp. 1205-1210.

[12] A. M. Rosengard, Y. Liu, Z. Nie and R. Jimenez, 'Variola virus immune evasion design: expression of a highly efficient inhibitor of human complement', *Proceedings of the National Academy of Sciences USA,* vol. 99, 2002, pp. 8808-8813.

[13] A. P. Pomerantsev, N.A. Staritsin, Yu.V. Mockov and L.I. Marinin, 'Expression of cereolysine AB genes in *Bacillus anthracis* vaccine strain ensures protection against experimental infection', *Vaccine,* vol. 15, 1997, pp. 1846-1850.

[14] V.M. Borzenkov, A.P. Pomerantsev and I.P. Ashmarin, 'The additive synthesis of a regulatory peptide in vivo: the administration of a vaccinal Francisella tularensis strain that produces beta-endorphin', Biull. Eksp. Biol. Med. [*Byulleten' Eksperimental'noi Biologii i Meditsin*], vol. 116, 1993, pp. 151-153; V. M. Borzenkov, A. P. Pomerantsev, O. M. Pomerantseva and I. P. Ashmarin, *Byulleten' Eksperimental'noi Biologii i Meditsiny,* vol. 117, 1994, pp. 612-615, translated.

developments in science and technology in the context of their relevance for the Biological and Toxin Weapons Convention (BWC).[15]

Advances in Science and Technology in the Life Sciences

Genomics

Genome analyses are concerned with the determination of the nucleotide base sequence of the genomic (chromosomal) deoxyribonucleic acid (DNA) of organisms. In its widest application, genomics includes efforts to determine the functions of the genes delineated through the sequence analyses. Recently, considerable progress has been made in the area of high-throughput automated DNA sequencing in connection with many genome sequencing projects that will ensure an even more rapid pace of data gathering in the future. It has furthermore been pointed out that productivity improvements in DNA synthesis and sequencing are increasing as "fast as Moore's Law".[16] These methods are being intensively applied to the sequencing of the genomes of pathogenic microorganisms, with the aim of discovering and identifying new virulence determinants. It is hoped that targets for the development of diagnostic and chemotherapeutic reagents as well as vaccines can be defined in the course of these investigations.[17]

The sequencing of the entire human genome was carried out with the expressed aim of gaining insight into the organisation and function of genetic material, providing a solid, molecular base for physiology and medicine, while at the same time obtaining knowledge about inherited genetic disorders as well as the development of cancer.[18] Not withstanding the potential benefits that this could render to the fields of biology and medicine, critics have expressed the fear that the information gained from this project may be used to create genetic or ethnic biological weapons, that is, weapons that can be used to attack a particular racial or ethnic group. Although the development of such weapons seems unlikely at present for several reasons,[19] "it would be a great mistake to assume that they never can be, and therefore that we can safely afford to ignore them as a future possibility"[20], especially considering the enormous amount of new information that is increasingly being provided by genomic studies.

Remembering that biological warfare may be directed against plants and animals as well as humans, equivalent weapons targeting specific varieties of plants and animals are a real possibility. For

[15] Sometimes referred to as the BTWC. See United Nations, Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, *General Assembly Resolution 2826*, 16 December 1971. Available at: http://www.opbw.org.

[16] R. Carlson, 'The pace and proliferation of biological technologies', *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*, vol. 1, 2003, pp. 203-214.

[17] Jenks, P.J. Sequencing microbial genomes--what will it do for microbiology? *Journal of Medical Microbiology*, vol. 47, 1998, pp. 375-382.

[18] Bartfai, T., Lundin, S.J., and Rybeck, B., Benefits and threats of developments in biotechnology and genetic engineering. Appendix 7A. *SIPRI Yearbook 1993: World Armaments and Disarmament.* (New York: Oxford University Press, 1993), pp. 293-305.

[19] K. Nixdorff, 'Scientific and technological challenges to the BTWC', op. cit.

[20] M.R. Dando, V. Nathanson and M. Darvell, **'**Chapter 4, Genetic weapons', *Biotechnology, Weapons and Humanity* (London: Harwood Academic Publishers, 1999), pp. 129-136.

example, agriculture, particularly in many developed countries, employs monocropping of large acreages with genetically identical cultivars, which would be highly vulnerable to genotype-specific weapons.[21]

PRODUCTION OF BIOLOGICAL AGENTS USING GENOMICS. Of particular concern is the use of modern methods of genomics, molecular biology and information technology to create microorganisms that has been the subject of recent reports. A prominent example is the work of a research group at the State University of New York at Stony Brook[22] in which the authors reported that they built the virus that causes polio from "scratch", that is from the genomic sequence information contained in public databases and readily available molecular biology technology. In the same vein, another report in the scientific literature described the generation of a bacterial virus within two weeks using synthetic segments of DNA.[23] Many experts are quick to point out that the poliovirus and the bacterial virus that have been synthesized have fairly simple compositions, so that this feat could not be readily repeated at least at the present time in the case of more complex viruses, such as the smallpox virus.

Be that as it may, there have been recent improvements in the ability to manipulate poxviruses[24,25] that could lead to the creation of dangerous pathogens from less virulent strains. This has been clearly documented by work describing the resurrection of the extinct 1918 Spanish influenza virus. The feat was accomplished by outfitting a relatively avirulent influenza virus with the complete coding sequences of all eight viral gene segments of the 1918 strain, which conferred the unique high-virulence 1918 strain phenotype on the engineered virus.[26] Thus, with each new advancement in methodology, the manipulation of complex viruses to meet designer specifications is becoming easier, and this is more of a reality and has just as wide if not wider implications as creating organisms from scratch.

ARTIFICIAL VIRUSES. Another area of advancement that is rapidly growing and needs to be closely monitored is the creation of so-called "artificial viruses" (also called non-viral vectors) for gene and cancer therapy. These are polymer-based complexes of nanoparticle[27] size containing

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[21] Wheelis, M. Agricultural biowarfare and bioterrorism: an analytical framework and recommendations for the fifth BTWC review conference, Paper presented at the 14th Workshop of the Pugwash Study Group on the Implementation of the Chemical and Biological Weapons Conventions: Key Issues for the Fifth BWC Review Conference 2001, Geneva, Switzerland, 18-19 November, 2000.

[22] J. Cello, A.V. Paul and E. Wimmer, 'Chemical synthesis of poliovirus cDNA: generation of infectious virus in the absence of natural template', *Science*, vol. 297, 2002, pp. 1016-1018.

[23] H.O. Smith, C.A. Hutchison III, C. Pfannkoch and J.C. Venter, 'Generating a synthetic genome by whole genome assembly: ϕX174 bacteriophage from synthetic oligonucleotides', *Proceedings of the National Academy of Sciences USA*, vol. 100, 2003, pp. 15440-15445.

[24] X.-D. Yao and D.H. Evans, 'High-frequency genetic recombination and reactivation of orthopoxviruses from DNA fragments transfected into leporipoxvirus-infected cells', *Journal of Virology*, vol. 77, 2003, pp. 7281-7290.

[25] A. Domi and B. Moss, B., 'Cloning the vaccinia virus genome as a bacterial artificial chromosome in *Escherichia coli* and recovery of infectious virus in mammalian cells', *Proceedings of the National Academy of Sciences USA*, vol. 99, 2002, pp. 12415-12420.

[26] T.M. Tumpey, C.F. Basler,P.V. Aguilar, H. Zeng, A. Solorzano, D.E. Swayne, N.J. Cox, M. Katz, J.K. Taubenberger, P. Palese and A. Garcia-Sastre, A., 'Characterization of the reconstructed 1918 Spanish influenza pandemic virus', *Science*, vol. 310, 2005, pp. 77-80.

[27] Nanoparticles can be defined as structures of sizes between 1 nanometer (10^{-9} or a billionth of a meter) and 100 nanometers. Nanoparticles are taken up by cells more efficiently than larger particles and can thus be used for effective transport and delivery.

DNA, and are being developed in an attempt to overcome the negative aspects of using viruses to deliver genes, such as safety and manufacturing problems, immunogenicity, limited targeting ability and limited transport capacity. Artificial viruses usually consist of DNA compacted into particles with polycationic substances[28,29] to enhance their uptake into cells. Shielding molecules such as polyethylenegylcol to protect the DNA cargo and specific targeting ligands to direct the vectors to particular tissues can be added to these basic particles. However, the main problem with non-viral vectors is that they have not yet consistently demonstrated transfection efficiency comparable to that of viruses, which limits their practical use. At any rate, there is great interest in developing these vectors so that rapid advancement in this area can be expected, which could pose a huge potential for misuse in the near future.

Synthetic Biology

Another emerging technology that is "on the threshold of synthesizing new life forms" [30] is that of synthetic biology, which is the design and assemblage of interacting genes into circuits in order to direct cells to perform new tasks. As an example, the bacterium *Escherichia coli* was refitted with a gene circuitry that enabled it to synthesize a precursor to the antimalarial drug artemisinin.[31] This technology requires collaboration in different disciplines such as engineering, computer science and biology. There is, however, concerted effort to make biological engineering simple, primarily through standardisation, decoupling and abstraction. [32] Standardisation envisions devising and promulgating a set of "standard, interchangeable biological parts"[33], a catalogue of "BioBricks" that can be built together and placed into living cells, where they can impart new functions to those cells. Decoupling of design and fabrication is seen as a further step towards simplification. Abstraction would allow individuals to work at one level of complexity without having to know any details of the work going on at another level. These principles have been tested in International Genetically Engineered Machine competition (iGEM) at Massachusetts Institute of Technology (MIT) in which students, some with little background in biology, design and build new genetic circuits that can function in living cells. Synthetic biology has "opened up extraordinary possibilities for biomedical discovery and environmental engineering", but at the same time the "scope for abuse or inadvertent disaster could be huge".[34] While the debate about the biosecurity implications of synthetic biology has made some progress in the US, a recent survey has shown that the level of awareness of European practitioners of synthetic biology concerning biosecurity risks is disappointingly low. [35]

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[28] K.L. Douglas, C.A. Piccirillo and M. Tabrizian, 'Cell line-dependent internalization pathways and intracellular trafficking determine transfection efficiency of nanoparticle vectors', *European Journal of Pharmaceutics and Biopharmaceutics*, vol. 68, 2008, pp. 676-687..

[29] V. Russ, H. Elfberg, C. Thoma, J. Kloeckner, M. Ogris and E. Wagner, 'Novel degradable oligoethylenimine acrylate ester-based pseudodendrimers for *in vitro* and *in vivo* gene transfer', *Gene Therapy*, vol. 15, 2008, pp. 18-29.

[30] P. Ball, 'Starting from scratch', *Nature*, vol. 431, 2004, pp. 624-626.

[31] V.J.J. Martin, D.J. Pitera, S.T. Withers, J.D. Newman and J.D. Keasling, 'Engineering a mevalonate pathway in *Escherichia coli* for production of terpenoids', *Nature Biotechnology*, vol. 21, 2003, pp. 796-802.

[32] Endy, D. Foundations for engineering biology. Nature, vol. 438, 2005, pp. 449-453.

[33] MIT hosted Registry of Standard Biological Parts, available at http://parts.mit.edu

[34] P. Ball, 'Starting from scratch', op. cit.

[35] A. Kelle, 'Synthetic Biology & Biosecurity Awareness in Europe', *Bradford Science and Technology Report No. 9*, available at http://www.brad.ac.uk./acad/sbtwc.

Systems Biology: From Genes to Complex Networks in the Post-Genomics Era

The relative new area of systems biology looks at interacting physiological systems and seeks to understand how all the parts of the body operate as a whole. It is "an emerging field that is characterised by the application of quantitative theoretical methods and the tendency to take a global view of problems in biology."[36] Over the past few years the systems biology approach has been applied to aid in the elucidation of the complexity, structure and function of some physiological networks in different organisms. An example of how systems biology relates to the dual-use problem can be seen in the interaction of vital physiological systems in the human body, which will be discussed below in more detail in the next section.

Developments in Pharmacology

The revolution in biotechnology is continuing on into the revolution in pharmacology with the emphasis on drug discovery and drug delivery, in which biochemical bioregulators and systems biology will be gaining more and more significance for biochemical arms control as time progresses.[37,38] Bioregulators are "naturally occurring organic compounds that regulate diverse cellular processes in multiple organ systems and are essential for normal homeostatic function."[39] They are diverse in structure and play key roles in many vitally important bodily functions such as respiration, blood pressure, heart rate, body temperature, mood and consciousness, as well as innate and adaptive immune responses. Most bioregulators operate by targeting specific cell receptors and components of biochemical signal transduction pathways, ultimately leading to the transcription of genes and production of bioactive proteins. Several different types of bioregulators are considered potential threat agents: cytokines, e.g. the pro-inflammatory agents interleukin (IL) 1 beta (IL-1β), IL-6 and tumor necrosis factor alpha (TNFα) or cytokines regulating immune responses (IL-2, IL-4, IL-12, IL-10); hormones (e.g. catecholamines, insulin); neurotransmitters and neuropeptides; eicosanoids (e.g. prostaglandins, leukotrienes) and nucleic acids (e.g. DNA, RNA).[40]

The dual-use relevance of biochemical bioregulators is most evident when considering interacting physiological systems. The nervous, the endocrine and the immune systems are three vital physiological systems that interact intricately and interdependently with one another, and the proper functioning of these systems is regulated to a great extent by biochemical bioregulators (such as the examples cited above) produced by the body itself. The normal functions of these systems are extremely vulnerable to modulation or manipulation with these same biochemicals, if the body encounters them in greater or lesser than normal concentrations. The perturbation of one system with a bioregulator will also have profound effects on the others. In other words, a potential offender can wage an assault with just one agent that could produce compounded effects. "If malign

[36] A. Goldbeter, 'Computational biology: a propagating wave of interest', *Current Biology*, vol. 14, 2004, pp. R601-R602.

[37] M. Wheelis, 'Biotechnology and biochemical weapons', *The Nonproliferation Review*, Spring 2002, pp. 48-53.

[38] M. Dando, 'Genomics, bioregulators, cell receptors and potential biological weapons' *Defense Analysis*, vol. 17, 2001, pp. 239-258.

[39] E. Kagan, 'Bioregulators as instruments of terror' *Clinics in Laboratory Medicine*, vol. 21, 2001, pp. 607-18.

[40] The National Academies, 'Chapter 4. Emerging and converging technologies', *An International Perspective on Advancing Technologies and Strategies for Managing Dual-Use Risks. Report of a Workshop*, (Washington D.C.: The National Academies Press, 2005), pp. 57-71.

manipulation of one system can affect two or three systems, the defender's problem of diagnosis and treatment increases out of all proportion to the attacker's effort."[41]

Many of the biochemicals that are being produced in drug discovery programmes have properties of incapacitants similar to those of bioregulators and close to those of some of the so-called "non-lethal" (bio)chemical weapons. Thus, there is an overlap in the BWC and the CWC in that both cover toxins, and in the BWC the understanding is that the word toxin covers bioregulators. There is a determined interest in developing incapacitants that "threatens to undermine the current CBW control regimes and calls into question their future robustness".[42, 43] The BWC prohibits any agent categorically "for hostile purposes or in armed conflict". However, it may be difficult to determine just what a "hostile" purpose might entail. The Chemical Weapons Convention (CWC)[44] prohibits all chemical agents for non-peaceful purposes, but the convention contains an exception, permitting the use of such agents for purposes of "law enforcement", in which case this is also difficult to define. From a scientific and technical point of view the major problem with "non-lethal" weapons lies in the fact that they are not non-lethal, as the Moscow theatre hostage crisis in 2002 clearly demonstrated.[45] Although it can be claimed that the use of the fentanyl derivative by the Russian security forces in the Moscow theatre incident falls under the CWC law enforcement provision, a thorough discussion of the matter in the interest of clarification has not yet occurred.

Advances in Targeted Delivery Technology

The possibilities of either use or misuse of biological agents depend in great part on the ability to deliver the payload to the target in a way that it will be effective. In Chapter 1 a short discussion about the deployment of biological agents as weapons is presented. Here some of the advances in delivery technology that have been made recently will be described.

Viral Vector Delivery Technology

Recent advances in molecular biology, immunology and tumor genetics have led to the design of novel viral vectors for the very legitimate use in such areas as vaccine therapy, cancer, drug and immunotherapy.[46] In general, these viruses act as ferries or vehicles that carry and deliver foreign genes to the body. The strategy is that infection with the virus would lead to expression of the foreign gene in the cells of affected tissues, with the subsequent synthesis of the active substance

[41] A. Kelle, K. Nixdorff and M. Dando, *A Paradigm Shift in the CBW Proliferation Problem: Devising Effective Restraint on the Evolving Biochemical Threat*, op. cit.

[42] A. Kelle, 'Science, technology and the CBW control regimes', *Disarmament Forum*, vol. 1, 2005, pp. 7-16.

[43] N. Lewer and N. Davison, 'Non-lethal technologies – an overview', *Disarmament Forum*, vol. 1, 2005, pp. 37-51; See also the website of the Sunshine Project for documentation of the US non-lethal weapons programmes, at www.sunshine-project.org.

[44] United Nations, Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction, *General Assembly Resolution 2826*, 16 December 1971. (full text available at www.opcw.nl/cwcdoc.htm).

[45] P.E. Wax, C.E. Becker and S.C. Curry, 'Unexpected gas casualties in Moscow: A medical toxicology perspective', *Annals of Emergency Medicine*, vol. 41, 2003, pp. 700-705.

[46] P.A. Gilbert and G. McFadden, 'Poxvirus cancer therapy', *Recent Patents on Anti-Infective Drug Discovery*, vol. 1, 2006, pp.309-321.

(the gene product), which would then exert its calculated effect on those tissues. The use of viral vectors is the subject of intense research and development at present. While these efforts should certainly be encouraged and supported and in no way impeded, they might serve as a basis for making dissemination of biological agents for malign purposes more feasible. Clinical trials with humans have shown that several of the vectors already developed and armed to deliver specific payloads in cancer and gene therapy have proven to be successful in principle and in some cases in effect. Particularly vaccinia virus[47,48] and retrovirus[49] vectors have exhibited substantial efficacy. In the case of retroviruses, the future of lentiviral vectors is "wide open".[50] Changing the tropism (target range) of a virus by the method of pseudotyping[51] or by genetic engineering can greatly improve efficacy of delivery.

Aerosol Delivery Technology

In most research and clinical studies viral vectors were administered by injection, in some cases using repeated application, which would not be applicable for delivery of weapons. However, some studies have indicated that administration over natural routes such as inhalation is feasible.[52,53] Furthermore, new improvements in methods to protect sensitive viral vectors from inactivation by harsh conditions in the environment add to the feasibility of their aerosol dissemination.[54] Indeed, great strides are being made in aerosol delivery techniques, particularly in connection with interests in drug development and delivery. In this regard, the production of defined nanoparticles[55] combined with new methods for making substances absorbable through the nasal and respiratory tracts[56] create a potential for greatly improved delivery of bioactive compounds. Addition of substances to improve absorption have also offered ways of overcoming the blood-brain barrier in the administration of drugs.

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[47] T.C. Liu, E. Galanis and D. Kirn, 'Clinical trial results with oncolytic virotherapy: a century of promise, a decade of progress', *Nature Clinical Practice Oncology*, vol. 4, 2007, pp. 101-117.

[48] S. Chalikonda, M.H. Kivlen, M.E. O'Malley, X.D.E. Dong, J.A. McCart, M.C. Gorry, X.-Y. Yin, C.K. Brown, H.J. Zeh III, Z.S. Guo and D.L. Bartlett, 'Oncolytic virotherapy for ovarian carcinomatosis using a replication-selective vaccinia virus armed with a yeast cytosine deaminase gene', *Cancer Gene Therapy*, vol. 15, 2008, pp. 115-125.

[49] Nature Methods Editorial, 'The double life of lentiviruses', *Nature Methods*, vol. 3, 2006, p. 69.

[50] Ibid.

[51] J. Cronin, X.Y. Zhang and J. Reiser, 'Altering the tropism of lentiviral vectors through pseudotyping', *Current Gene Therapy*, vol. 5, 2005, pp. 387-98.

[52] B. Laube, B., 'The expanding role of aerosols in systemic drug delivery', *Respiratory Care*, vol. 50, 2005, pp. 1161-1176.

[53] S.-K. Hwang, J.-T. Kwon, S.-J. Park, S.-H. Chang, E.-S. Lee, Y.-S. Chung, G.R. Beck Jr., K.H. Lee and L. Piao, 'Lentivirus-mediated carboxyl-terminal modulator protein gene transfection via aerosol in lungs of K-*ras* null mice', *Gene Therapy*, vol. 14, 2007, pp. 1721-1730.

[54] M. Iqbal, W. Lin, I. Jabbal-Gill, S.S. Davis, M.W. Steward, and L. Illum, 'Nasal delivery of chitosan-DNA plasmid expressing epitopes of respiratory syncytial virus (RSV) induces protective CTL responses in BALB/c mice', *Vaccine*, vol. 21, 2003, pp. 1478-85.

[55] J. Haystead, 'New particle engineering technology improves drug solubility', *Pharmaceutical Technology*, vol. 27, 2003, pp.18-19 and 114.

[56] S.S. Davisand L. Illum, 'Absorption enhancers for nasal drug delivery', *Clinical Pharmacokinetics*, vol. 42, 2003, pp. 1107-1128.

Several examples of clinical applications and other studies of delivering biochemical bioregulators over the aerosol route (insulin[57], oxytocin[58], opiates[59]) have shown that aerosol delivery of bioactive biochemicals is also feasible in effect. Furthermore, when advances in aerosol delivery technology are combined with improvements in targeting and gene transfer efficacy of viral vectors, the potential synergy effects indeed raise the dual-use risk aspect to a whole new dimension.

Relevance of Advances in Science and Technology for the BWC

The situation is clear. We not only have to be concerned about advances in science and technology leading to the creation of novel biological warfare agents, we have to recognise that new and improved ways of delivering them are already at hand and will be developed further at a rapid pace. This greatly compounds the challenges to the BWC and underscores the urgency of the need for action in devising ways to meet these challenges.

In Chapters 2 and 3 the strengths and weaknesses of the BWC have been discussed. Its great strength lies in the general purpose criterion of Article I, which is comprehensive in prohibiting any use of biological agents that is intended for non-peaceful purposes, while at the same time allowing any use intended for "prophylactic, protective or other peaceful purposes". The Convention thus applies to all possible agents and future developments. Indeed, during the various Review Conferences every five years, the relevance of the advancements in science and technology for the Convention have been assessed, with States Parties submitting background papers on biotechnology developments to aid in this assessment. At the last (Sixth) Review Conference in 2006, ten States Parties provided input and the Secretariat produced a summary of that information.[60] While up to the present time all developments have been assessed by States Parties to be covered by the provisions in Article I of the Convention,[61] the explosive nature of advances in science and technology have highlighted the main weaknesses of the BWC, which are the incomplete implementation of the Convention and the lack of adequate means to test the compliance of States Parties to the Convention. It has been repeatedly suggested that if these developments continue unchecked, there is a real danger that the prohibitions will be undermined.

In the light of the difficulties associated with attempts to agree a compliance regime for the BWC (see Chapters 2 and 3), a multifaceted approach to security against misuse of science and

[57] Guntur, V.P. and Dhand, R., 'Inhaled insulin: extending the horizons of inhalation therapy', *Respiratory Care*, vol. 52, 2007, pp. 911-922.

[58] Kosfeld, M., Heinrichs, M., Zak, P.J., Fischbacher, U. and Fehr, E., 'Oxytocin increases trust in humans', *Nature*, vol. 435, 2005, pp. 673-676.

[59] P.E. Wax, C.E. Becker and S.C. Curry, 'Unexpected gas casualties in Moscow: A medical toxicology perspective', op. cit.

[60] United Nations, Background Information Document on New Scientific and Technological Developments Relevant to the Convention, *Document BWC/CONF.VI/INF4*, (Geneva: United Nations, 28 September 2006). Available at: http://www.opbw.org.

[61] See United Nations, Final Document of the Sixth Review Conference of the States Parties to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction. *Document BWC/CONF.VI/6*, (Geneva: United Nations, 20 November – 8 December 2006). Available at: http://www.opbw.org.

technology[62] is one way forward, and strengthening the BWC is a cornerstone of that policy. However, while the risks are growing at an enormous pace, arms control regime developments to deal with these risks are lagging way behind. This is especially true for the BWC. Of course efforts to strengthen the BWC nationally and within the Intersessional Process can certainly be constructive. Indeed, biosecurity regulations including effective oversight of activities perceived to be of concern are essential steps that could decidedly help to minimise the risks. However, efforts in this direction simply *must* lead to collective, concerted action on the international level by the States Parties to the BWC within the regime. Without international harmonisation of regulations and effective methods for testing compliance there is little hope that the BWC will be substantially strengthened in the end.

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[62] see G.S. Pearson, 'Prospects for chemical and biological arms control: The web of deterrence', *The Washington Quarterly*, vol. 16, 1993, pp. 145-162; and International Committee of the Red Cross, *Biotechnology, Weapons and Humanity*, ICRC Publication Ref. 0833, 2003. Available at http://www.icrc.org/; and see B. Rappert, C. McLeish (eds.), *A Web of Prevention: Biological Weapons, Life Sciences and the Governance of Research*, Science in Society Series, (London: Earthscan, 2007).

Chapter 5. A Brief Comparison of the Biological and Chemical Weapons Conventions

Scott Spence and Ralf Trapp

Introduction

The Biological and Toxin Weapons Convention (BWC)[1] and Chemical Weapons Convention (CWC)[2] have the objectives of ensuring that disease and toxic chemicals will never again be used as weapons of war, or as tools of death, injury and fear, by State and non-State actors alike. This is not an insignificant accomplishment: the Nuclear Non-proliferation Treaty acknowledges five nuclear weapons States (China, France, Russian Federation, United Kingdom, and United States) while aiming at complete nuclear disarmament, as well as general and complete disarmament under strict and effective international control.[3] Thirty-eight years later, this goal is still illusory. The BWC and CWC, on the other hand, impose a complete ban on biological and chemical warfare and these weapons remain morally repugnant and unacceptable anytime, anywhere.

History

The issues of chemical and biological weapons have been connected throughout the centuries. Building on the generally-accepted norms of land warfare as codified in The Hague Conventions of 1899 and 1907, States agreed under the "Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare" (1925) that the *use* of toxic chemicals (poison) and disease in war would be illegal under international law. The BWC extended this prohibition in 1972 to the development, production, stockpiling, acquisition and retention of biological weapons. The BWC also gave impetus to the negotiation of a CWC in Article IX:

> *Each State Party to this Convention affirms the recognised objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.*

In 1993, the CWC opened for signature; it entered into force in 1997. The CWC has arguably been the more successful treaty of the two: it has significantly more States Parties than the BWC, a Technical Secretariat to carry out its implementation at the international level, and a solid track record of chemical weapons (CW) and CW production facility destruction combined with a robust industry verification system based on data monitoring and on-site inspections. The BWC has limped along, wounded by the collapse of a Protocol in 2001 which, among other things, would have strengthened its implementation through the establishment of a verification regime.

[1] Sometimes referred to as the BTWC; For the text of the Convention see the website of the BWC at http://www.unog.ch/bwc.

[2] For the text of the Convention, see www.opcw.org.

[3] Nuclear Non-proliferation Treaty, Article VI.

Nevertheless, it still has legs with a second set of treaty-related activities underway[4] since the resumed Fifth Review Conference in 2002 and Sixth Review Conference of 2006, and it has gained more attention and additional Member States in the past several years.

Membership

The BWC has 163 States Parties, 13 signatories,[5] and 19 States which have taken no action on the treaty, as at 26 February 2009.[6] The most recent State to join the BWC was Cook Islands on 4 December 2008. Most of the non-Members are African or Pacific Island States. A few, however, are located in the Middle East and pose concern for their unwillingness so far to join the treaty. Since the Sixth Review Conference in 2006, a combination of high-level contacts by the Chairmen of the BWC Intersessional Process and the Implementation Support Unit (ISU) with senior officials of States not Party, support from the European Union with a joint action, national and regional events sponsored by the ISU and organisations such as the BioWeapons Prevention Project, and bilateral work by a number of BWC States Party have contributed to an increase in the number of States that have joined the BWC.[7]

Table 5.1. Membership in the CWC and BWC

	States Parties	*Signatories*	*States not Party*
BWC	163	13	19
CWC	186	4	5

The CWC has 186 States Parties and four signatory States,[8] and there remain five States which have taken no action on the treaty, as at 26 February 2009.[9] These impressive figures can largely be attributed to the adoption of a 'universality action plan' (Action Plan) at the twenty-third meeting of the Executive Council of the Organisation for the Prohibition of Chemical Weapons (OPCW) in October 2003,[10] inspired by a recommendation of the First CWC Review Conference in 2003. The objective of the Action Plan was to achieve universal adherence to the Convention ten years after its entry into force. Subsequent decisions by the Conference of the States Parties, at its Tenth and Eleventh Sessions, gave further support to this objective.[11] At the time of the adoption of the Action Plan in 2003, there were forty States not Party. That number has since decreased to nine. Lebanon

[4] See United Nations, Final Document of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva: United Nations, 2006), pp. 19 and 21. Available at: www.unog.ch/bwc.

[5] Burundi, Central African Republic, Côte d'Ivoire, Egypt, Guyana, Haiti, Liberia, Malawi, Myanmar, Nepal, Somalia, Syrian Arab Republic, and United Republic of Tanzania. (www.unog.ch/bwc).

[6] Andorra, Angola, Cameroon, Chad, Comoros, Djibouti, Eritrea, Guinea, Israel, Kiribati, Marshall Islands, Mauritania, Micronesia (Federated States of), Mozambique, Namibia, Nauru, Niue, Samoa, and Tuvalu (www.unog.ch/bwc).

[7] United Nations, Report of the Chairman on Universalization Activities, *Document BWC/MSP/2008/4 dated 28 November 2008*, (Geneva: United Nations, 2008).

[8] Bahamas, Dominican Republic, Israel, Burma (www.opcw.org).

[9] Angola, North Korea, Egypt, Somalia, Syrian Arab Republic (www.opcw.org).

[10] OPCW, *Documents EC-M-23/Dec.3, dated 24 October 2003*, (The Hague: OPCW).

[11] OPCW, *Documents C-10/Dec.11, dated 10 November 2005 and C-11/Dec.8, dated 8 December 2006*, (The Hague: OPCW).

and Iraq became the most recent members of the CWC confirming that the Action Plan has been highly successful, including in the world's most volatile and dangerous regions.

Disarmament and non-proliferation

The BWC does not have a Technical Secretariat to verify and monitor the destruction of biological weapons or weapons facilities or to ensure that activities involving biological materials and toxins are only conducted for peaceful purposes. States Parties have, therefore, been left to rely on one another to comply with the treaty and respect its obligations in good faith. Towards this objective, the Second Review Conference in 1986 agreed a set of four Confidence-building measures (CBMs), which were expanded upon by the Third Review Conference in 1991. The Third Review Conference also established the forms for use in annual submissions, which have remained the same to this day.[12] These CBMs, which are politically but not legally binding, are listed in Table 5.2.

Table 5.2. Confidence-building measures for the BWC

Form	*Measure*
None	"Nothing to declare" or "Nothing new to declare"
CBM "A"	Research centres, laboratories and biological defence research and development programmes
CBM "B"	Exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins
CBM "C"	Encouragement of publication of results and promotion of use of knowledge
CBM "D"	Active promotion of contacts
CBM "E"	Declaration of legislation, regulations and other measures
CBM "F"	Declaration of past activities in offensive and/or defensive biological research and development programmes
CBM "G"	Declaration of vaccine production facilities

In contrast to the BWC, the CWC established a comprehensive regime for the verification of destruction of chemical weapons stockpiles and former CW production facilities. To date, some 30,657 of the 71,316 metric tonnes of declared chemical agent, and 3.11 million of the 8.67 million declared munitions or containers, have been verified as destroyed since entry into force.[13] The OPCW has conducted more than 2,040 inspections at nearly 200 chemical weapons-related sites including chemical weapons production, destruction and storage facilities and abandoned and old chemical weapons sites.[14] Of the six Member States that have declared chemical weapons stockpiles – Albania, India, Libya, the Russian Federation, South Korea, and the United States – Albania and South Korea have already destroyed their entire weapons stockpiles.

The OPCW is also mandated to ensure that chemicals are only used for permitted purposes. Chemical weapons non-proliferation is accomplished through national enforcement measures and, at the international level, a complex industry verification regime involving three sets of scheduled

[12] United Nations, Final Document of the Third Review Conference of the BWC, *Document BWC/CONF.III/23*, (Geneva: United Nations, 1991).

[13] www.opcw.org.

[14] www.opcw.org.

chemicals which are categorised according to their historical relevance for chemical weapons production, and chemical plants producing discrete organic chemicals (DOCs). Facilities that produce, process or consume scheduled chemicals pose a risk to the objectives of the CWC given the nature of these chemicals. Certain DOC producing plant sites pose a risk given their technological versatility that allows them to be easily converted for chemical weapons purposes. To date, the OPCW has conducted more than 1,539 inspections at over 1,100 industrial sites.[15]

Scientific and technological developments

In 2006, in preparation for the Sixth Review Conference to the BWC, the ISU identified major developments in life sciences and technology in such areas as biotechnology; genomics; proteomics; bioinformatics and computational biology; systems biology; drug discovery, design and delivery; synthetic biology and biological engineering; as well as other developments (nanotechnology, gene therapy, genetic engineering of viruses, anti-viral drugs, detection technology, and biological pest control).[16] In view of this background report, the Sixth Review Conference reaffirmed that Article I of the BWC applies to all scientific and technological developments in the life sciences and in other fields of science relevant to the Convention.[17] Article I defines 'biological weapon' on the basis of the 'general purpose criterion'. Under this definition, it is illegal under international law to use biological and toxin agents, which may be discovered or developed as a result of life science research, for harmful or deadly purposes. The Conference also acknowledged that scientific and technological developments had the potential for co-operation as well as for misuse, and encouraged States Parties with advanced biotechnology to "… adopt positive measures to promote technology transfer and international cooperation on an equal and non-discriminatory basis, particularly with countries less advanced in this field, while promoting the basic objectives of the Convention, as well as ensuring that the promulgation of science and technology is fully consistent with the peaceful object and purpose of the Convention".[18]

At the most recent Meeting of the States Parties to the BWC in December 2008, as part of an ongoing intersessional process, the ISU discussed further developments in the life sciences and technology including genomics, synthetic biology and the open-source publication of raw research data.[19] The next Review Conference in 2011 will no doubt consider all of these scientific and technological advances, and again confirm the relevance of Article I as a bulwark against their misuse.

Recent advances in the chemical industry may also pose challenges to the CWC's non-proliferation regime. On the technology side, such changes include smaller, more easily adaptable production operations; smoother switchover capabilities for the production of different chemicals depending on market demands; micro- or mini-reactors and related production equipment; and the speed with

[15] www.opcw.org.

[16] United Nations, Background Information Document on New Scientific and Technological Developments Relevant to the Convention, *Document BWC/CONF.VI/INF.4* (Geneva: United Nations, 28 September 2006).

[17] United Nations, Final Document of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, p. 9 (Geneva: United Nations, 2006).

[18] Ibid.

[19] United Nations, Background Information on Scientific and Technological Developments That May Be Relevant to the Convention. *Document BWC/MSP/2008/INF.1*. (Geneva: United Nations, 2008).

which new compounds can be synthesised and screened. Most importantly, the shape of the chemical industry itself is changing, with production moving from traditional locations in the USA, Western Europe and Japan to the rest of Asia, South America and other parts of the globe. Some of the countries where new chemical operations are being set up have weak administrative systems and gaps in their national implementation measures to enforce the CWC. This challenges the effectiveness of treaty verification and compliance, as well as of traditional non-proliferation measures to prevent the spread of chemical weapons.

The CWC and BWC are also more closely related now because biotechnology is playing a larger role in chemicals production, particularly in the areas of pharmaceuticals, biofuels, pesticides and plastics. New physiologically-active compounds are being developed, and biologically-mediated processes are being used for chemicals manufacturing. At the same time, chemical methods and principles are being used in fundamental biological research, for example, in DNA synthesis. The traditional barriers between chemistry and biology are gradually disappearing, not just in research but also in production.

National Implementation

Article IV of the BWC requires States Party, in accordance with their constitutional processes, to "…take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition or retention of the agents, toxins, weapons, equipment and means of delivery specified in Article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere".[20]

Conferences to review the operation of the BWC have developed a series of understandings on how Article IV can best be implemented. Most recently, the Sixth Review Conference in 2006 called upon States Parties to adopt legislative, administrative, judicial and other measures such as penal legislation to:

> *(i) enhance domestic implementation of the Convention and ensure the prohibition and prevention of the development, production, stockpiling, acquisition or retention of the agents, toxins, weapons, equipments and means of delivery as specified in Article I of the Convention;*
>
> *(ii) apply within their territory, under their jurisdiction or under their control anywhere and apply, if constitutionally possible and in conformity with international law, to actions taken anywhere by natural or legal persons possessing their nationality;*
>
> *(iii) ensure the safety and security of microbial or other biological agents or toxins in laboratories, facilities, and during transportation, to prevent unauthorised access to and removal of such agents or toxins.*[21]

The Conference encouraged States Parties to report any measures taken to the United Nations Office[22] for Disarmament Affairs, and to designate a national focal point for coordinating national implementation of the BWC and communicating with other States Parties and relevant international

[20] For the text of the Convention see the website of the BWC at http://www.unog.ch/bwc.

[21] United Nations, Final Document of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva: United Nations, 2006).

[22] Known until 2007, and referred to during the Sixth Review Conference, as the Department for Disarmament Affairs.

organisations. It also encouraged States with relevant experience to provide assistance on request to other States Parties.[23] These requests echo those found in the CWC national implementation action plan described below.

The Conference reaffirmed that national measures should be taken to strengthen methods and capacities for surveillance and detection of outbreaks of disease, and underlined the importance of training and education about the BWC and the utility of codes of conduct and self-regulation. Importantly, the Conference drew a connection between UN Security Council Resolution 1540 and Article IV, noting that the provision of information by States Parties to the Security Council on measures to prevent the proliferation of biological weapons by non-State actors, would also assist them in fulfilling their obligations under Article IV.[24]

These measures above are sensible, but a tall order for a treaty without a Technical Secretariat with the resources and capacity to assist States Parties in fulfilling them. In the absence of an organisation, implementation assistance is being carried out on a bilateral basis between States; through joint actions such as those sponsored by the European Union; and through dedicated assistance programmes such as VERTIC's National Implementing Measures Project (NIM Project). Under this project, VERTIC is analysing the existing legislation in countries around the world for the implementation of the BWC[25], and has already begun engaging directly with over a dozen countries that have requested assistance. By the end of the current phase of its NIM Project (late 2011), VERTIC aims to have completed 140 analyses of implementing legislation and worked directly with 30 countries to draft BWC implementing measures.[26]

Article VII of the CWC requires all States Parties to adopt the necessary measures to implement their treaty obligations. This is normally accomplished through the adoption of legislation and the promulgation of regulations, a complex and lengthy undertaking. Recognising that the OPCW's membership was not making significant progress in this area, and acknowledging that proper national implementation was key to preventing access by non-State actors to materials that could be used as chemical weapons, the Conference of the States Parties adopted an action plan at its Eighth Session in 2003 (Action Plan),[27] and subsequently a series of follow-up measures to it.[28]

Table 5.3. Some statistics concerning implementation of the CWC

	2003	*2009*
Establishment of a National Authority	127	178
Notification of legislation to implement the CWC	94	126
Comprehensive legislation	85	53

[23] United Nations, Final Document of the Sixth Review Conference of the BWC, op. cit.

[24] Ibid.

[25] VERTIC analyzes 96 legislative criteria including: definitions, offences and penalties, preparations to commit offences, jurisdiction over offences, control lists, biosecurity measures and transfer controls, and enforcement measures.

[26] See www.vertic.org/NIM.

[27] OPCW, *Document C-8/DEC.16, dated 24 October 2003*, (The Hague: OPCW).

[28] OPCW, *Documents C-9/DEC.4, dated 30 November 2004; C-10/DEC.16, dated 11 November 2005; C-11/DEC.4, dated 6 December 2006; C-12/DEC.9, dated 9 November 2007*, (The Hague: OPCW).

The number of States Party that have designated or established a National Authority (a point of contact as well as a national focal point to co-ordinate implementation) has increased from 127 to 178 since adoption of the Action Plan in 2003 (see Table 5.3).[29] In 2003, 94 States Party had notified the OPCW that they had at least some legislation to implement the CWC; that number rose to 126 in 2009.[30] The number of States Parties with comprehensive legislation is lower – 83 now have comprehensive legislation against 51 in 2003[31] – but this does not reflect the number of States that are in the process of drafting bills or shepherding them through their legislative processes. These results have been achieved through a series of technical assistance visits, sub-regional meetings, thematic workshops, various types of meetings and training courses for national authorities and publications and electronic tools.

Conclusion

The BWC and CWC have their earliest origins in treaties and protocols of the 19th and early 20th centuries. It was recognised early on that the use of disease and toxic chemicals in war was dishonourable, causing needless and indiscriminate suffering, and should be effectively banned. Today, these treaties confirm that biological and chemical warfare are illegal under international law. These prohibitions have been extended to non-State actors such as terrorists.

In the areas of disarmament and non-proliferation, the future appears brighter for the CWC as there is an inspectorate conducting industry inspections as well as inspections of chemical weapons stockpiles and facilities destruction; there is at this moment no equivalent for the BWC. Both regimes are faced with leaps in chemistry and life sciences and technology, but these challenges are being matched by steady application of the 'general purpose criterion' by which any illegal uses of toxic chemicals and microorganisms and toxins are, by definition, prohibited under international law.

Universality of the two treaties has yet to be achieved: the CWC has many more adherents, including in the world's most dangerous regions, but there remain important gaps. There is an equally strong commitment now to ensuring that the BWC will soon have universal membership. Implementation of the two treaties through national measures is a slow, lengthy process and, for the BWC, there is no international secretariat to oversee this process. Nevertheless, the OPCW and civil society are ensuring that this essential activity is underway for each of the Conventions.

Finally, the adoption of United Nations Security Council Resolution 1540, and its renewal through Resolutions 1673 (2006) and 1810 (2008), is fostering increased policy and technical co-operation and co-ordination among the nuclear, chemical and biological weapons treaties. In view of the entwined histories of the BWC and CWC, further collaboration among the OPCW, the ISU and the civil society actors working towards the more effective implementation of the two Conventions seems only natural.

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[29] www.opcw.org.

[30] Ibid.

[31] Ibid.

Chapter 6. Biological Weapons as a Public Health Issue

Nicolas Isla

Introduction

If the notion of "Health for All"[1] was the guiding paradigm which drove global public health campaigns and policy during the 1970s, today it is health's securitization that is changing the face of global public health. With ever more frequency, infectious diseases are being described in terms of security. This trend is supported and driven by an increasing number of international organisations including the World Health Organization,[2] as well as associations of national actors, for example the Global Health Security Initiative.[3] The securitization of health can be considered part of the growing international relations concept of human security, whose motivation is the individual's access to human rights, health and education. Global health threats, such as SARS and avian flu, have also forced states to reconsider the terms under which their security is preserved. There is, however, an additional factor which has encouraged a convergence between elements of the security discourse and global health governance. This is the effort made to provide the public health infrastructure with capabilities to mitigate the threat posed by biological weapons.

Biological weapons could cause a significant public health crisis. The anthrax letters, which killed five people, showed that in addition to causing fatalities, an event of this nature can stretch the public health system by the number of people seeking prophylactic drugs. However, besides the use and the threat of use, there are a number of other ways in which the policy against biological warfare (BW) overlaps with public health, for example the effect of this policy on developing countries' access to technology and the efforts taken in developed countries to prevent dangerous pathogens and knowledge falling into the hands of the would-be terrorist, giving rise to an entirely new field of policy now popularly referred to as biosecurity. This chapter will discuss the areas of convergence between biological weapons and public health.

Public health response or BW preparedness, and the differences

The most obvious place to begin a chapter on the convergences between biological weapons and public health is the negative health effects of the use of a biological weapon. The interdependency, however, is a little deeper than that. Previous chapters in this book have described the events which give rise to the public health concerns posed by biological weapons and give fuel to the policy convergence of security and public health. The salmonella salad bar attack by the Rajneeshee Cult in 1984, the unsuccessful biological development efforts of Aum Shinrikyo in 1995 and the anthrax letters, which followed 9/11 in 2001, demonstrate that the public health systems have to be equipped with the capabilities to manage the deliberate use of a biological agent.[4] The emerging

[1] World Health Organization, *Alma Ata Declaration* (1978). Available online: www.who.int/hpr/NPH/docs/declaration_almaata.pdf

[2] See World Health Organization 'World Health Report 2007 – A Safer Future: global public health security in the 21st century.' Available online: http://www.who.int/whr/2007/en/index.html

[3] See Global Health Security Initiative website. Available online: http://www.ghsi.ca/english/index.asp

[4] A. Kelle 'Securitization of International Public Health – Implications for Global Health Governance and the Biological Weapons Prohibitions Regime,' Bradford Regime Review Paper No. 1, University of Bradford. May 2005. Available at: http://www.brad.ac.uk/acad/sbtwc

possibility of biological terrorism further heightens this need. Furthermore, the more a public health system is prepared the lesser the consequences of any deliberate use of a biological agent will be.

An important question is where does the capacity to respond to a deliberate outbreak diverge from the response to a natural or accidental event? An efficient public health system would manage an outbreak regardless of its origins. On practical terms, the divergence occurs with elements of forensics and the preparedness for an unpredictable epidemiological footprint which requires contingency planning, training, and more specifically the know-how to create and maintain inter-institutional links between law enforcement, public health and other relevant institutions in the event of a deliberate use. Figure 7.1 shows how biological weapon preparedness and the public health system overlap.

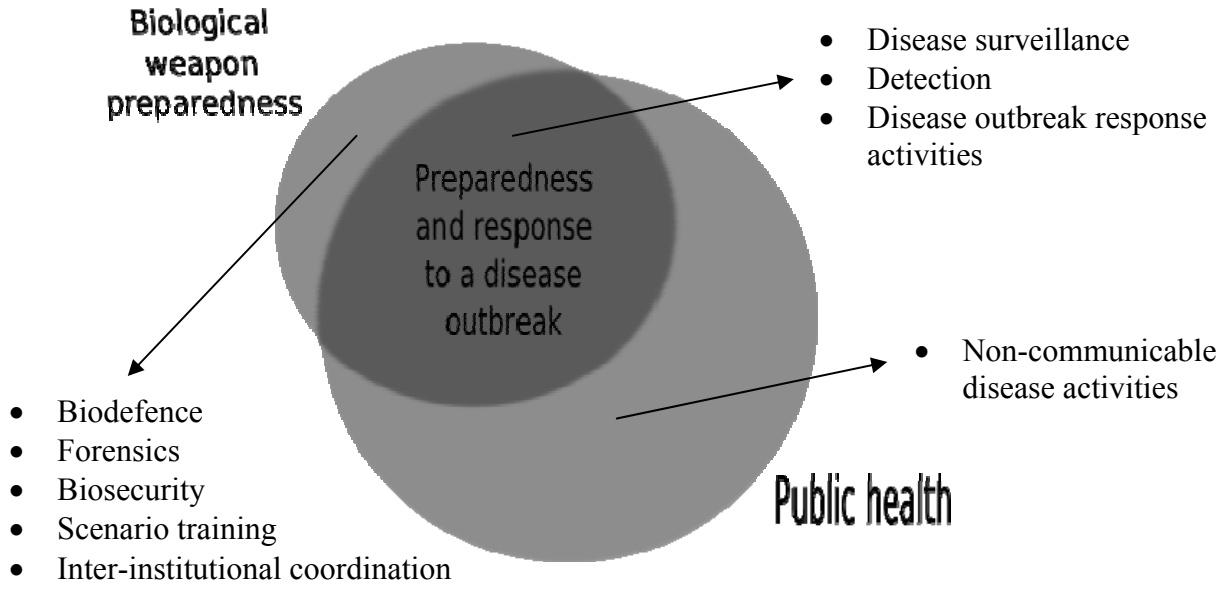

Figure 7.1. Overlap between biological weapons preparedness, outbreak response and public health

The public health response to both natural and deliberately caused outbreaks, however, should be almost identical. On a political level the motivations for capacity development are worlds apart. The sudden realisation on the part of the security institutions during the mid to late 1990s that an efficient public health system was critical to the national and international security agendas brought these previously distinct areas of policy crashing together, giving rise to the policy convergence we see today.[5] The realisation was made not only on a national level but with the threat of bioterrorism being recognised as an international challenge; United Nations Secretary General Kofi Annan highlighted the need to improve health systems in order to manage such events. "This [a concerted effort to build public health capacity throughout the developing world, at both local and national levels] will not only yield direct benefits by preventing and treating disease in the developing world

[5] D. P. Fidler and L. O. Gostin 'Chapter 4: The Securitization of Public Health' in: D. P. Fidler and L. O. Gostin (eds.), *Biosecurity in the Global Age: Biological Weapons, Public Health and the Rule of Law*, (Stanford, Stanford University Press, 2008) pp. 136.

itself, but will also provide the basis for an effective global defence against bio-terrorism and overwhelming natural outbreaks of deadly infectious disease."[6]

The sudden impact of the security institutions brought with it a great deal of investment into the civilian biodefense, particularly in the United States where the assumption was that investments used to improve the capability to detect and respond to a bioterrorist event would spill over into the public health system creating added value throughout the system. While this was true to some degree, research focussing solely on bioterrorist agents, and the surveillance program termed BioWatch, a 100 million dollar project which placed detectors in 30 US cities for bioterrorist agents, did little to benefit the public health system as a whole. On the international stage, WHO's Global Outbreak Alert and Response Network (GOARN) was created with both functions in mind. In the area of response, the US also invested heavily in the stockpiling of smallpox and anthrax vaccines under the program BioShield, which provides no benefit to other more likely sources of infection, such as influenza, for which the vaccine stockpiles are often dangerously low. Critics of this strategy suggest that the focus on low probability and possibly high impact events is misguided. This is supported by the 2007 US federal budget in which funding for civilian biodefence (excluding military)[7] was more than double that of HIV/AIDS funding.[8] Incidence data for natural disease outbreaks versus biological weapons use (shown in Figure 7.2) also shows a striking divergence. In addition, the nature of biodefence work is such that the products of this research are likely to have some restrictions in access. Results of any research, therefore, that have some non-bioterrorism related public health application, domestically or in a foreign country, might not ever reach those individuals that need that information most.

World incidence of natural disease **only in 2004** (Global Burden of Disease WHO 2008) [9]	Incidence of biological weapons use **since 1978** [10] [11]
Tuberculosis (new cases): 7.8 Million HIV (new cases): 2.8 Million Malaria (episodes of illness): 241.3 Million Lower respiratory infections (episodes of illness): 429.2 million	1978: Ricin – 1 dead 1984: Salmonella – 778 sick 2001: Anthrax – 22 cases (5 dead)
Total: 681.1 Million in 1 year	Total: 801 in 31 years

Figure 7.2. Incidence of sickness caused by natural disease outbreaks versus those caused by biological weapons use

[6] United Nations 'A More Secure World: Our Shared Responsibilities, Report of the Secretary-General's High-Level Panel on Threats, Challenges and Change, 2004. Available online: http://www.un.org/secureworld/report2.pdf.

[7] C. Franco 'Billions for Biodefense: Federal Agency Biodefense Funding FY2008-FY2009' *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science,* Volume 6, Number 2, 2008.

[8] Henry Kaiser Family Foundation HIV/AIDS Policy Factsheet, April 2008. Available at: http://www.kff.org/hivaids/upload/7029-041.pdf.

[9] World Health Organization, 'Chapter 3, Disease Incidence, Prevalence and Disability', *Global Burden of Disease 2004 Update (Edition 2008).* Available at http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index.html

[10] Includes only verified cases of biological weapons use.

[11] V. Asal 'Chapter 9, A quantitative overview of biological weapons' in: A. L Clunan, P. R. Lavoy and S. B. Martin (Eds.), *Terrorism, War, or Disease*? (Stanford: Stanford University Press, 2008) pp. 190-195.

The emerging concept of biosecurity deals with minimising potential bioweapons threats brought on by research with dangerous pathogens or experiments. Biosecurity policy generally attempts to prevent individuals with malevolent intent from accessing dangerous pathogens and the results of research, through laboratory protection, transfer control of material and information, etc. Overly burdensome biosecurity policy, however, can also harm public health capabilities, by limiting transparency and collaboration over research which could be applied to public health problems.[12]

Public health and international disarmament

In actuality, the link between biological weapons and public health has waxed and waned since the beginning of the 20th century. The post war period until the mid 70s saw a number of national biological weapons programmes pursue offensive capabilities, although biological weapons use is limited to the Japanese Unit 731 during World War II. The number of deaths resulting from the human testing experiments and civilian attacks during this campaign is estimated to be between several tens of thousands to 400,000 people. Although not primarily motivated by public health concerns, the international community was able to agree on two multilateral conventions: the Geneva Protocol of 1925, which prohibits the use of bacteriological and chemical agents in war, and the Biological and Toxin Weapons Convention (BWC)[13] of 1972. This Convention, which became the gravitational centre of the norm against biological weapons, prohibited the development, production, stockpiling or otherwise acquisition or retention of microbial or other biological agents. These international agreements aimed to stem the dangers of biological weapons being used against civilian populations. Following the coming into force of the BWC the weight of the preparedness against biological weapons was lifted from the shoulders of the public systems for a short while. The increased threat perception arising from non-state actors has once again put the strain on the public health system because as long as the threat of biological weapon use emanated from state programmes, the capacity for preparedness remained primarily the responsibility of the armed forces.

Within the framework of the BWC, there is some overlap with public health through Article X on "the fullest possible exchange of equipment, materials, and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall cooperate in contributing… to the further development of scientific discoveries in the field of bacteriology (biology) for prevention of disease…"[14] Generally, this article has been understood to consist of assistance provided to developing countries with preventing and mitigating outbreaks of infectious disease. As such, one of the intersessional process meetings in 2004, a series of annual topical meetings organised between successive Review Conferences of the BWC (see Chapter 3), dealt with "strengthening and broadening national and international institutional efforts and existing mechanisms for the surveillance, detection, diagnosis

[12] Zmorzynska, A., Hunger, I., 'Restricting the role of biosecurity' *Bulletin of the Atomic Scientists*, 19 December 2008.

[13] Sometimes referred to as the BTWC.

[14] United Nations, Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, *Assembly Resolution 2826*, 16 December, 1971. Available at: http://www.opbw.org.

and combating of infectious diseases affecting humans, animals, and plants."[15] Another meeting in August 2009 will develop a "common understanding and effective action on promoting capacity building in the fields of disease surveillance, detection, diagnosis, and containment of infectious diseases".[16] With little other reference to health in the texts or proceedings of BWC meetings, these two intersessional meetings, along with requests for WHO presence at BWC conferences, represent the BWC States Parties' acknowledgement that biological disarmament has some convergence with public health.

The World Health Organization

WHO's outreach towards the security began with the drafting of its constitution in 1946, stating in its preamble that "[t]he health of all peoples is fundamental to the attainment of peace and security and is dependent upon the fullest co-operation of individuals and States." [17] Although, "security" in this context is not likely a reference to the protection against biological weapons but rather the concept of human security, the connection is made. Approximately 20 years later the WHO was requested by the Secretary-General of the United Nations to prepare a report on public health effects of biological and chemical weapons. WHO's Public Health Response to Biological and Chemical Weapons was published in 1970. This report modelled various bioweapon usage scenarios and brought a degree of reality to the dangers of biological and chemical weapons. In 2001, the World Health Assembly (WHA), the decision-making body of the WHO, mandated the Director General to "provide technical support to Member States for developing or strengthening preparedness and response activities against risks posed by biological agents…" [18] and a second edition to the Public Health Response to Biological and Chemical Weapons was produced in 2004. In addition, the CBW Scientific Advisory Group, composed of individuals from non-governmental organisations (NGOs), academia and other international organisations, was created. The role of the group was to provide advice on scientific and technical issues related to chemical biological weapons (CBW) and provide guidance for the newly created CBW preparedness and response programme. As a strictly public health actor, WHO's complicated involvement with biological weapons issues has been primarily motivated by the need to be able to provide some degree of assistance in the event of a biological weapons attack. The intention was not necessarily to "securitize" public health, but to acknowledge the convergence with its work and the need to develop appropriate strategies and guidelines against biological weapons.

Public health and biological weapons in the larger context

In this chapter we make the rather simple association between biological weapons and public health. The internationally perceived threat of biological terrorism has been polemic, raising questions about misplaced spending and misguided priorities. It is clear, however, that a functioning

[15] United Nations, Final Document of the Fifth Review Conference of the BWC, *Document BWC/CONF.V/17*, (Geneva: United Nations, December 2002). Available online: http://www.opbw.org/rev_cons/5rc/docs/final_dec/BWC-CONF.V-17-(final_doc).pdf.

[16] United Nations, Final Document of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva, United Nations, December 2006). Available at: http://www.opbw.org/rev_cons/6rc/docs/6/BWC_CONF.VI_6_EN.pdf.

[17] World Health Organization, *WHO Constitution* (1946). Available online: http://daccessdds.un.org/doc/UNDOC/GEN/G07/600/30/PDF/G0760030.pdf?OpenElementhttp://www.who.int/governance/eb/who_constitution_en.pdf.

[18] World Health Organization WHA 54.14

public health system is the pillar of an effective management of the dangers posed by both naturally occurring diseases and by biological weapons. The security institutions' realisation of the importance of public health in biological weapon preparedness has, perhaps, made public health a partner, albeit reluctantly, in the security agenda. However, the acknowledgement of the threats posed by biological weapons related diseases might eventually lead to a greater capacity to manage those posed by other naturally occurring diseases. International public health stands to gain from an increasing political desire from states to protect its population from biological threats of all kinds.

The much larger debate, which is alluded to in the opening paragraph, concerns a broadening of the term security to include the dangers of all infectious disease outbreaks. There are those that believe that reconceptualising avian flu, SARS and the existing HIV/AIDS pandemic as existential threats is the only way to motivate states to make the necessary political decision to diminish these risks. Others, however, find inherent dangers with giving health issues security implications. This debate remains outside of the scope of this book chapter, but let the reader keep only in mind, that at the heart of this debate there is the understanding of the term biosecurity. In this chapter, we refer to biosecurity as the steps taken to prevent the nefarious or accidental misuse of biological agents, information or equipment. Biosecurity with its wider interpretation can be understood to mean any infectious disease that impacts the normal functioning of society.[19] The discussion on biological weapons as a public health issue provides only a stepping stone towards this debate.

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[19] D. P. Fidler and L. O. Gostin 'Chapter 4: The Securitization of Public Health' in: D. P. Fidler and L. O. Gostin (eds.), *Biosecurity in the Global Age: Biological Weapons, Public Health and the Rule of Law*, (Stanford, Stanford University Press, 2008) pp. 136 and N. R. F. Al-Rdhan, L. Nayazuk, M. Finaud, J. Mackby, 'Situating Global Biosecurity' in: *Global Biosecurity, Towards a New Governance Paradigm* (Geneva: Édition Slatkine, 2008) pp. 13-20.

Chapter 7. Biological Weapons as an Environmental Issue

Kathryn McLaughlin

Clearly there have been developments intrinsically connected to biological weapons, such as those in science and technology (see Chapter 4 on Developments in Science and Technology: Relevance for the BWC), which define what they are and what they can do. However, there have also been developments in the context in which they are viewed. As a result, whilst it is true to say that the biological weapons threat now is different from that which existed 50 years ago, it is also true to say that we view that threat in a different way. Certain facets of the intentional malign use of biology increases in relevance, while others decrease over time. The socio-political framework in which we live and work today is strikingly different from that which existed both when biological arsenals were being pursued by countries all over the world (see Chapter 1 concerning the history of biological weapons use) and when the international community acted in concert to ban their acquisition, retention and use (see Chapter 2 on the History of BTW Disarmament). The context in which we view this threat is no less important than the internal dynamics of the threat itself.

The Importance of Context

Contextualising the biological weapons threat in such a way as to make it relevant in the world today is one of the strongest elements in our toolbox. If the wrong lens is used to view this issue, it becomes antiquated, irrelevant and undermines all efforts to confront the attendant threat. A prime example of this would be unwillingness on behalf of the international community to engage in 'Cold War Arms Control'. It is seen as the wrong approach to address present day threats given the current socio-political context. Alternative approaches have been developed (see Chapter 3 on The Biological Weapons Convention: Content, Review Process and Efforts to Strengthen the Convention and Chapter 9 on Awareness-raising, Education and Codes of Conduct within the Framework of the BWC). Novel initiatives, such as UN Security Council resolution 1540[1], attempt to address the threat posed by weapons of mass destruction in a way that makes more sense given prominent present day concerns, such as the possibility of a bioterror incident. Hence the international community has redefined the ways it views threats in parallel to the evolution of the threat itself. Just as concerns over State-based programmes evolved into worries over terrorists obtaining access to unconventional weapons,[2] multilateral disarmament agreements have been supplemented by non-proliferation initiatives.

However, this re-contextualising of the threat posed by biological weapons has largely been confined to a small international community of experts. Little work has been done in presenting biological weapons related issues in a way that they are better brought to the attention of the general public. Indeed, if the broad-based public support that has been critical in other disarmament fora (such as public support for the ban on landmines) and demonstrated on an even larger scale in addressing other issues on the international stage (for example efforts to tackle poverty through Live8, etc.) is to be realised, then it will be necessary to package the topic in such a way so as to

[1] United Nations, Security Council Resolution 1540 (2004), adopted by the Security Council at its 4956th meeting, on 28 April 2004 (the 'WMD non-proliferation' Resolution). Available at: www.un.org/Docs/sc/unsc_resolutions04.html.

[2] See for example E.D. Harris, 'Chemical and Biological Weapons: Prospects and Priorities after September 11' Brookings, Summer 2003. Available at http://www.brookings.edu/articles/2002/summer_defense_harris.aspx

ensure that it fits comfortably into the world view of individuals who are proponents of, and become actively involved with, such causes. There are, of course, aspects of biological weapons which do already attract popular attention. Surprisingly, the best example of this is in the developing world. In such countries, disease tends to be much higher on national priorities and impinges to a much greater extent upon the everyday lives of individuals than it does in developed countries. Therefore the public health aspects of these weapons are particularly important in countries where shortcomings in public health top domestic agendas. These issues, as well as broader public health aspects of biological weapons are discussed in more detail in Chapter 6.

The first step to repackaging the biological weapons threat so that it makes sense in the socio-political context of the 21st century is to consider what issues are informed members of the general public interested in? Then perhaps it will be possible to find a bridge between current priority topics and the threat posed by biological weapons. Perhaps the international issue which has recently received the greatest media attention is the environment. Concerns over global warming and the damage we are doing to the environment has prompted discussions on many levels, including amongst those who determine the broad-based public support which is of interest in this chapter.

There are clear parallels between environmental concerns and the threats posed by biological weapons – both are highly scientific in nature, thereby requiring some interpretation and packaging to make them accessible to those of us without a background in the relevant scientific disciplines. They also both pose direct threats to international peace and security. The case for biological weapons is clear cut – as weapons of mass destruction, their use (or even the suspicion of their development) can have regional, if not global, impact and destabilising effects. Until the most prestigious award for efforts to preserve international peace and security, the Nobel Peace Prize, was awarded for environmental campaigning in 2007, it might have been more difficult to make the case for the environment. Now it is clear that preserving the environment is a security issue.

The linkage between these two topics, however, is not only conceptual but can also be discussed from a practical perspective. The following section examines the potential effects of biological weapons and their control on the environment.

Effects on the Environment

Biological weapons can have primary, secondary or tertiary environmental impact. By this we mean that these weapons can directly degrade the environment, or that the use of biological weapons can have a knock-on but unintentional impact, or equally that the response to a biological weapon-related incident could have a negative environmental impact.

Environmental Biological Weapons (Primary Impacts)

Recent decades have seen considerable progress in using biological agents for bioremediation, environmental alteration and biocontrol. Mechanisms have been developed to use naturally occurring microbes as well as those engineered specifically for the task, to clear up wastes, spill and contaminants[3]. For example, microbes have been used as part of the response to oil spills.[4] Equally,

[3] See http://www.sciencedaily.com/releases/2005/05/050517063708.htm

other microbes have been used to break down inorganic deposits surrounding economically important minerals and metals. Biological solutions to refining have proven more efficient and more economical than traditional industrial and chemical processes. Finally, chemical pesticides, insecticides, and fungicides have gradually been replaced with biological agents. Reports over the development of biological agents designed to destroy illicit drug crops captured headlines around the world a couple of years ago[5] (see Chapter 8 on Biological Weapons as a Biodiversity Issue).

Such developments have clear peaceful applications. However, they could also contribute to the development of weapons designed to have an environmental impact – either by degrading useful organic constructs, such as plastics, oils, lubricants, etc; or by breaking down inorganic structures and machines in common usage which often contain components made from metals, minerals, etc.. Either application has already been discussed in great deal under the heading of anti-material weapons[6]. Furthermore, depending upon what constraints are placed upon the concept of the environment, biological agents used to intentionally attack animals and plants (which are key parts of environmental stability) can also be considered. The direct application of agents designed to destroy illicit crops, if used with a host country's consent might be legal, but the use of the same agent in a country without their consent might be considered contrary to the norm against the weaponization of disease (see Chapter 3).

As this book has chapters elsewhere dealing with the implications of biological weapons for humans from the public health perspective but no specific chapters dealing with parallel impacts on animals and plants, they will be addressed in part in this chapter and in part in the chapter on biodiversity (see Chapter 8). The section of this chapter on food security (see below) explores various aspects of anti-animal and anti-crop biological weapons. At this point, it is sufficient to note that depending upon the definition of the environment used, anti-animal and anti-crop weapons could be considered as having primarily an environmental impact.

Unintentional Environmental Affects (Secondary Impacts)

In addition to those weapons that could intentionally target aspects of the environment, it is feasible that biological weapons designed to target humans could have an indirect environmental impact. For example, some biological agents have been associated with weapons programmes because of certain biological characteristics (see Chapter 1). One such characteristic is their environmental stability. Perhaps the best example of this would be the ability of the causative organism of anthrax, *Bacillus anthracis* to form endospores. These endospores confer on this bacterium (possibly the biological weapons agent with the largest public profile) virtually unprecedented capacity for environmental stability.[7] These spores can survive for decades, if not centuries, in environments that would lead to the degradation of most other agents. Releasing anthrax bacteria into the environment can have a significant impact upon the uses to which the contaminated land can be put

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[4] R.C. Prince, 'Petroleum spill bioremediation in marine environments', *Critical Reviews in Microbiology*, vol. 19(4), 1993, pp. 217-242.

[5] See G.E. de Vries, '*Fusarium* considered to kill coca plants', *Trends in Plant Science,* vol. 5, 2000, p.417; and, Sunshine Project Backgrounder No.14, 'Risks of Using Biological Agents to Eradicate Drug Plants'. September 2005. Available at http://www.sunshine-project.org/publications/bk/bk14.html

[6] See for example N. Lewer, *The Future of Non-Lethal Weapons: Technologies, Operations, Ethics and Law* (Taylor & Francis Inc: 2002);

[7] See R.M. Swiderski, *Anthrax: a history* (Jefferson, N.C.: MacFarland & Company, Inc., Publishers, 2004).

as demonstrated by the case of Gruinard Island – a small island located off the North West Scottish coast used as an anthrax field testing site by the UK government in the 1940s, which was quarantined for 48 years before decontamination attempts were eventually successful[8] Allowing susceptible animals to graze on the land can lead to additional outbreaks of disease, effectively preventing agricultural uses. For similar reasons land contaminated with high concentrations of anthrax-causing spores would be unsuitable for human habitation, industrial or commercial use. In fact, such land would either have to be left fallow almost indefinitely or decontaminated, which can have its own tertiary impact (see below).

It is not just the use of biological weapons that can have secondary impacts; their production and development can also lead to environmental damage. Although most noted for its human infections, the release of a cloud of weaponized *Bacillus anthracis* from the production plant in Sverdlovsk in 1979[9] also had significant environmental impact. Not only was a wide area contaminated with these bacterial spores due to the size of the plume released, but enough animals were infected with anthrax that authorities attempted to pass the incident off as an animal outbreak that had led to human infections.[10]

Also pertinent are the environmental considerations of the former biological weapons testing site of the Soviet Union (USSR) located on Vozrozhdeniye Island in the middle of Aral Sea.[11] Environmental degradation in the region and the diversion of water sources has led to a significant drop in water levels in the sea. As a result, what used to be a highly isolated geographical location (an island surround by water) is becoming increasingly accessible (it will soon, if not already, be joined to the mainland by a spit of land).[12] For some years, there were concerns that the receding water levels would reveal contaminated land and that resistance spores would lead to new outbreaks of disease. Intervention under non-proliferation programmes has minimised the likelihood of such an occurrence. Fish populations in the region of this facility during its active life, however, were not so lucky, and many local fishermen reported that the fish had died.[13] Thus, this biological weapons facility had a considerable impact on the local environment, one with knock-on effects for the social and economic stability of the people in the surrounding area.

Environmental Affects of Responses to Biological Weapons (Tertiary Impacts)

The resilience of certain biological weapons can make decontaminating sites at which they have been released a considerable challenge. The lengths that had to be gone to in cleaning US postal sorting offices after only a handful of contaminated letters passed through them in 2001

[8] For a brief history of the use and subsequent decontamination of Gruinard Island, see G.S. Pearson, 'Gruinard Island returns to civil use' *ASA Newsletter,* vol. 01-5, 2001No.86. Available at http://www.asanltr.com/newsletter/01-5/articles/015c.htm

[9] M. Meselson , J. Guillemin, M. Hugh-Jones, A. Langmuir, I. Popova, A. Shelokov and O. Yampolskaya, 'The Sverdlovsk anthrax outbreak of 1979', *Science*, vol. 266, 1994, pp. 1202-1208.

[10] Ibid.

[11] For a brief history of Soviet biological weapon activities at Vozrozhdeniye Island, see http://www.globalsecurity.org/wmd/world/russia/vozrozhdenly.htm

[12] T. Waltham and I. Sholji, 'The demise of the Aral Sea – an environmental disaster', *Geology Today*, vol. 17, 16 May 2002, Issue 6, pp.218-228.

[13] Ibid.

demonstrates the scale of the problem.[14] In dealing with open-air releases, chemical decontaminants are one of the likely primary responses. These chemicals are by their very nature toxic – their job after all is to kill living organisms. Such agents must be handled with considerable care if they in turn are not to have a negative environmental impact. This can be quite a challenge due to the amount of chemicals needed and the mechanism through which they must be used to coat all external surfaces of structures, buildings, etc. Such open air releases are also likely to require the removal of large amounts of top soil. Not only will dealing with this potentially contaminated material pose environmental issues, but the removal of the topsoil can have implications for plant life in the area, with a knock-on impact on the local ecosystem.

Should a biological attack take place, there could also be environmental issues raised when dealing with corpses. As noted elsewhere in this work, not all biological weapons will have a lethal effect – but some likely will. Of even more relevance, in the case of an anti-animal attack, it may be necessary to carry out large-scale culls to control the spread of disease. Disposing of such large numbers of carcasses can pose significant problems. For example, the 2001 outbreak of foot-and-mouth disease in the UK resulted in the death of over 6 million animals, of which approximately 4 million were culled as part of disease control and others died under the need for 'welfare culls'.[15] Disposing of these carcasses caused a series of environmental concerns. At first bodies were buried, but this led to concerns that the virus might seep into the water supply, contaminating rivers and streams and lead to additional infections. The most graphic demonstration of the environmental drawbacks to burying carcasses was seen at the site of a mass grave for sheep in Wales, where blood began to bubble up through the topsoil.[16] Such incidents led to a change in policy and efforts were initiated to burn carcasses. However, environmental monitoring soon established that pollutants and toxins were being released considerably in excess of the relevant international standards.

The discussion so far in this chapter demonstrates that there could be significant environmental impacts from virtually all activities associated with biological weapons, from the development and production, throughout their use and even with measures designed to respond to them and mitigate their impact. Thus, it is possible that a biological weapons event could manifest first as an environmental disaster, just as it could present as a public health emergency. At present environmental detection, mitigation and response mechanisms are geared almost exclusively to an accidental release, not a deliberate attack.

Such an assertion appears to be nothing more than common sense but actually carries with it some profound implications. Considerable time and effort has been devoted internationally and nationally over recent years to sensitising health communities (human, animal and plant health communities) to the dangers of a biological weapons incident, to facilitate its rapid identification as an unusual event, to mitigate the eventual impact and ensure an effective and appropriate response. Furthermore, significant efforts have been made to establish protocols to allow health and security responses and investigations into such an event to run smoothly in parallel. Similar efforts with the environmental communities are much less developed. Incorporating environmental emergency management communities into ongoing discussions between health and security communities

[14] See A. Oppenheimer, 'The challenge of anthrax decontamination', *Jane's News Online*, 3 June 2004. Available at http://www.andyoppenheimer.com/articles/Jane's%20Chem-Bio%20Web%20anthrax%20decon.htm

[15] Royal Society, 'Infectious Diseases in Livestock', 16 July 2002. Available at http://royalsociety.org/inquiry/index.html

[16] P.D. Millett, Anti-Animal Biological Warfare, PhD Thesis, University of Bradford Peace Studies Department, 2003.

should be seen as a priority. The all-hazards approach must truly address all hazards – including those to the environment. This may require the investment of considerable additional resources and may ultimately lead to re-thinking current planning and development of response mechanisms, setting international preparedness and response mechanisms back several years.

Food Security

In addition to these primary, secondary and tertiary impacts, environmental considerations of biological weapons encompass concepts of food security. If the concepts of the environment encompass all of the living things that make up local ecosystems, then sources of food are obviously of relevance. Being able to ensure the access of a population to sufficient, safe and secure food sources is a primary role of a state. Attacking food animals and crops, therefore, not only has an environmental impact but also damages socio-political stability and has economic consequences.

Direct attacks on the Food Chain

For the purposes of this work, as already noted, the direct implications of biological weapons for humans will be dealt with in other chapters. Consideration of anti-animal and anti-crop biological weapons will be considered in this chapter and the one dealing with biological diversity. Such programmes directly target food production. In some cases this has a direct socio-political impact, as some countries rely almost exclusively on domestic production to meet demands for food. As a result, contaminating, destroying or removing from use a percentage of the national food production can lead to decreases in calorific intake, increases in political instability and the erosion of trust and public confidence in the administration's ability to govern successfully.

Indirect attacks on the Food Chain

Most countries, however, obtain their food from a variety of sources, both domestic and foreign and spread their network of acquisition over a geographically diverse area. If one source of food is shut off, or is incapable of meeting demand, alternative sources can, and will, be found. As a result, the direct impact is likely to be more marginal. Some impact may still be felt as the market takes time to adjust, but ultimately the system recovers quite rapidly and food supplies are restored. More significant in these cases is the psychological impact. The temporary disruption of food supplies might be significant enough to undermine public trust in an administration. It is likely to convince a population, no matter how well protected, that it remains vulnerable to attack by biological weapons. This in turn might lead to fear and widespread panic.

Even when food supplies are restored, there may be additional indirect effects. In such a scenario, when alternate sources for food are found, it would be unlikely that the producer whose capacity was impaired with a biological weapon will be able to recapture the market share they have lost. A prime example of this would be the boycott of British Beef years after it had been declared free of Bovine Spongiform Encephalitis, despite being in contravention of European law to maintain the boycott.[17] Such incidents illustrate the potential indirect economic implications of an attack on the

[17] R. Uhlig, 'French reject EC call to end British beef boycott', *The Telegraph*, 26 June 2006. Available at http://www.telegraph.co.uk/news/worldnews/europe/france/1398499/French-reject-EC-call-to-end-British-beef-boycott.html

food chain – not only should the direct losses of a disease outbreak be considered but the long-term trading impact this has on the import and export markets.

Unintentional Affects of an Attack on the Food Chain

Recent disease outbreaks have demonstrated that there is a disease interface between wild, domestic and commercial animal populations. For example, avian influenza has caused mass casualties in commercial birds, killed pets and domestic fowl as well as being spread by and finding a reservoir in wild birds.[18] As a result, an attack with an anti-animal or anti-crop biological weapon, irrespective of whether large numbers of food-related animals or plants are infected, could spread to wild populations. This can complicate efforts to deal with the outbreak and might have secondary impacts of its own. Such was the case during the 2001 outbreak of foot-and-mouth disease in the UK, when it was feared the disease would become endemic in wild animals on public land. This would make it practically impossible to get rid of the disease completely, jeopardising the UK's disease free status and the attendant commercial and economic benefits.

Furthermore, attacking the food chain could have implications for the diseases themselves. As detailed in reports over the current avian influenza outbreaks, the close proximity of such viruses to relatives in other hosts, such as influenza viruses in pigs and humans, can lead to the exchange of genetic material and physiological characteristics, which can have profound implications for the infectivity, transmissibility and pathogenicity of the agent, as well as its host spectra.[19] There have been concerns that such a proximity might allow the current avian strain to evolve to allow person-to-person transmission. Equally, tertiary modelling of key structural elements within avian, animal and human influenza viruses have revealed that simple changes in the construction of these sites can vastly influence the ability of a virus to infect a host. Similar studies have also revealed that the series of deadly influenza virus pandemics to strike humans during the 20th century were almost certainly down to a combination of these factors leading to particularly pathogenic strains of high infectious viruses capable of person-to-person transmission. Hence, attacking the food chain with biological weapons could have implications for human health.

Conclusions

Biological weapons can clearly have an environmental impact. This can be categorised as the intent of an attack (primary impact), an unintentional side effect of an attack (secondary impact) or an unintentional side effect of the response to an attack (tertiary impact). Considering how best to deal with these environmental considerations can complicate preparedness, mitigation and response efforts. Further efforts are needed to increase the priority placed upon environmental consideration when all-hazard plans are being developed. Environmental preparedness, mitigation and response capabilities can compliment existing resources for dealing with biological weapons and should be better integrated into ongoing coordination between health and security communities.

As a key element of the environment, food chains are particularly vulnerable to attack with biological weapons, either directly or indirectly. Such attacks could have profound unforeseen or

[18] J.M. Katz, V. Veguilla, J.A. Belser, T.R. Maines, N. Van Hoeven , C. Pappas, K. Hancock and T.M. Tumpey, 'The public health impact of avian influenza viruses', *Poultry Science*, vol. 84, 2009, pp. 872-879.

[19] See CDC, 'Avian influenza: Current situation', June 15, 2007. Available at: http://www.cdc.gov/flu/avian/outbreaks/pdf/current.pdf.

unintentional implications, including for the future characteristics of naturally occurring disease. Food security is a topic of increasing importance and one that should not be sidelined by the ongoing development of biosecurity standards. There will be opportunities to better integrate food security concepts into biosecurity discussions.

When viewed from the current socio-political context, the environmental implications of biological weapons are especially important. Although historical precedent appears to indicate that environmental impact is most likely to be unintentional, in this day and age it will clearly have a significant psychological impact. If current societal trends continue, the psychological impact of these biological weapons issues may develop to the extent they motivate certain parties to pursue biological weapons in the first place. How these weapons are viewed and the psychological response they prompt might become more important than the physical damage they do. This suggests that how messages about these weapons are related to the public becomes vitally important – i.e. psychological preparedness, mitigation and response will be needed in concert with physical measures. As a result, incorporating environmental considerations of biological weapons into national and international efforts will necessitate a renewed and reinvigorated focus being placed on the development and implementation of risk communication strategies. Although such strategies likely exist in a very limited number of countries, there is great potential to increase the number of countries that have adopted this approach, harmonise the various national systems, and even develop international risk communication standards.

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Chapter 8. Biological Weapons as a Biodiversity Issue

Kathryn McLaughlin

Ecological changes brought about by human activity are occurring at a rapidly accelerating rate.[1] As with the phenomenon of global warming being an inadvertent by-product of human activities on the environment and world ecology, so can the deliberate or accidental spread of naturally-occurring and genetically engineered bioweapon agents adversely affect the ecology and its components with potentially devastating, wide-ranging and deadly impact.

This chapter demonstrates that the use of biological weapons or the failure to contain bioweapon and emerging disease outbreaks among wildlife and human populations (especially indigenous populations in developing countries) *"could result in severe erosion of genetic diversity in local and regional populations of both wild and domestic animals, the extinction of endangered species and the extirpation of indigenous peoples and their cultures.*"[2,3]

To fully understand the potentiality of these problems, and why they necessitate immediate action against biological weapons, it first becomes necessary to define biodiversity and place it into the proper context.

Definition of Biodiversity

Biological diversity or biodiversity refers to the variation of life forms among species as well as within a species. Biodiversity encompasses the multitude of plants, animals and microorganisms, the genes they possess, as well as the ecosystems they form and their interactions with the abiotic (non-living) aspects of their environment. In this respect the living world and its processes are interrelated and constantly shifting.

Biological diversity is usually considered at three different levels: genetic, species, and ecosystem.

- **Genetic diversity** - the variety of genetic information contained in all of the individual plants, animals and microorganisms. Genetic diversity occurs within and between populations of a species as well as between species.
- **Species diversity** - the variety among all living species.

[1] F.A. Murphy, 'The threat posed by the global emergence of livestock, food-borne, and zoonotic pathogens' *Annals of the New York Academy of Sciences*, vol. 894, 1999, pp. 20-27.

[2] J.P. Dudley and M.H. Woodford, 'Bioweapons, bioterrorism and biodiversity: potential impacts of biological weapons attacks on agricultural and biological diversity', *Scientific and Technical Review,* Office International des Epizooties (World Organisation for Animal Health), vol. 21 (1), April 2002, p. 126.

[3] J.P. Dudley and M.H. Woodford, 'Potential impact of biological weapons on biological diversity and indigenous peoples in Asia', *Asian Biotechnology and Development Review*, vol. 8 (1), 2005, p. 45.

- **Ecosystem diversity** - the variety of habitats, biotic communities, and ecological processes, as well as the tremendous diversity present within ecosystems in terms of habitat differences and the variety of ecological processes.[4]

Many people consider humans to be a part of nature, and therefore a part of biodiversity. Whilst this view is challenged by some,[5] it is difficult to deny the relationship between humans, their activities and ecosystems, as human influence is so pervasive and varied.[6] If one takes humans as part of nature, then cultural diversity of human populations and the ways that these populations use or otherwise interact with habitats and other species on Earth are a component of biodiversity too.[7]

For the purposes of this chapter, biodiversity will be understood as the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.

The Value of Biodiversity

Human existence (and that of most other organisms) is heavily dependent on what biologists call primary producers (organisms that produce their own food through processes such as photosynthesis), mainly plants. Five thousand plant species have been used as food by humans, but less than twenty now feed the majority of the world's population and just three or four carbohydrate crops are staples for a vast majority. One of the important benefits of conservation of biodiversity is the wild plant gene pool which is available to augment the narrow genetic base of these established food crops, providing disease resistance, improved productivity and different environmental tolerances.[8] Plants and other biological resources have also long been used for medicinal purposes. Wild plant, animal and microorganism resources are of great importance in the search for new medically active compounds, and the potential of biota to contribute to modern medicine has scarcely begun to be realised. Many of the drugs presently used are derived from plants; many medicines, in particular antibiotics, are derived from microorganisms, and new chemical structures are being discovered all the time.

As knowledge improves, new bioresources to increase human welfare will be discovered and developed. There is a clear relationship between the conservation of biological diversity and the discovery of new biological resources. The relatively few developed plant species currently cultivated have had a large amount of research and selective breeding applied to them. Many presently under-utilised food crops have the potential to become important in the future. The

[4] Ecosystem diversity encompasses the broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type, and is an essential element of total biodiversity. Ecosystem services provide food, fresh water, lumber, pharmaceuticals, bio-chemicals, and genetic material. Our natural ecosystems also generate soil, recycle and store nutrients, pollinate plants, maintain the water cycle, and control pests and diseases. Ecosystem functions regulate climate and build resiliency to climate change, clean the atmosphere and water, sequester carbon, treat waste and control erosion and flooding.

[5] See for example, K.H. Redford and B.D. Richter, 'Conservation of biodiversity in a world of use', *Conservation Biology*, vol. 13 (6), 1999, pp. 1246–1256.

[6] E.W. Sanderson, M. Jaiteh, M.A. Levy, K.H. Redford, A.V. Wannebo and G. Woolmer, 'The human footprint and the last of the wild', *BioScience*, vol. 52 (10), October 2002, pp. 891-904.

[7] http://cnx.org/content/m12151/latest/

[8] W.V. Reid and K.R. Miller, *Keeping Options Alive: The Scientific Basis for Conserving Biological Diversity*, (Washington, D.C.: World Resources Institute, 1989).

documentation of indigenous peoples' use of plants is often the source for ideas on developing plant species for wider use and/or economic benefit and there are a large number of as yet undiscovered plant species which could prove useful.[9]

Thus, protecting biodiversity is in our self-interest. Nature's products support diverse industries such as agriculture, cosmetics, pharmaceuticals, pulp and paper, horticulture, construction and waste treatment. The loss of biodiversity threatens our food supplies, opportunities for recreation and tourism, and sources of wood, medicines and energy. While the benefits of such resources are considerable, the value of biological diversity is not restricted to these. The natural environment also provides non material benefits that improve our quality of life through recreation, aesthetics, wildlife viewing, education, ecotourism, and spiritual well-being.

Possibly the greatest value of the variety of life may be the opportunities it gives us for adapting to change. The unknown potential of genes, species and ecosystems is of inestimable but certainly high value. Genetic diversity will enable breeders to tailor crops to new climatic conditions, while the Earth's biota is likely to hold still undiscovered cures for known and emerging diseases. A multiplicity of genes, species, and ecosystems is a resource that can be tapped as human needs change.

Potential impact upon biological diversity from biological weapons

Whilst the use of biological weapons against human populations to kill or incapacitate has been employed for centuries as a means of warfare, early instances were only possible on a small, tactical-level scale.[10] Developments in science in the nineteenth century made it possible to deploy biological pathogens on a large scale, but there has so far been no proven instance of such use. However, history provides us with a wealth of instances of human populations being devastated by the introduction of foreign biological pathogens – most often those same pathogens investigated, and sometimes stockpiled, by states for use as biological weapons. From the unintentional killing of indigenous peoples through the so-called “Colombian Exchange” to the modern mishandlings of biological agents, the threat of an epidemic is just as real as it ever was in the 15th through 18th centuries.

Impact on Human biodiversity

An oft-cited early use of a biological agent against humans is that of the British colonial army’s efforts to undermine the Iroquois and Algonquin Indian tribes by infecting them with smallpox through the distribution of infected blankets in 1763.[11] This act allegedly precipitated an epidemic that spread widely and decimated the tribes.[12] Regardless of the ongoing debate regarding whether

[9] H.H. Iltis, 'Serendipity in the exploration of biodiversity: what good are weedy tomatoes?' in: E.O. Wilson (ed.), *Biodiversity*, (Washington, D.C.: National Academy Press, 1998), pp. 98-105.

[10] Such as the catapulting of plague infected corpses into besieged towns, or infecting water supplies with diseased bodies.

[11] E.A. Fenn, ‘Biological warfare in eighteenth-century North America: beyond Jeffery Amherst’, *The Journal of American History*, vol. 86 (4), 2000, pp. 1552-1580.

[12] J.P. Dudley and M.H. Woodford, 'Bioweapons, bioterrorism and biodiversity: potential impacts of biological weapons attacks on agricultural and biological diversity', *Scientific and Technical Review*, Office International des Epizooties, vol. 21 (1), 2002, p. 126.

this act actually occurred and was responsible for death within the tribes[13], what is evident is the devastating effect that smallpox wreaked on the Indians. Whilst epidemics typically had a case fatality rate of 20–40 per cent among Europeans, fatality rates of 90 per cent or higher are repeatedly mentioned in accounts of Native American epidemics, often coupled with very high attack rates. Even after several centuries of exposure to repeated epidemics, Native American fatality rates from smallpox remained high; in the late 19th century, the Indian Service doctor assigned to the Hopi of the South-West recorded that 74 per cent of the smallpox cases who elected traditional medicine died.[14]

This was not the first time that populations had been brought low by the introduction of a new disease. The European exploration and colonization of the New World, beginning in the late 15th century, brought devastating cultural, social and ecological changes.[15] The mixing of the Eurasian and American disease pools, whose disastrous consequences for the Native Americans underlay their demographic collapse, was the phenomenon often called the "Colombian Exchange"[16] - meaning the unequal exchange of pathogens between the New World populations and the Europeans[17]. According to one commentator: "*The arrival of Columbus in the New World brought about one of the greatest population disasters in history*."[18,19] A wave of catastrophic depopulation swept across the continent, sometimes ahead of the advancing fringe of European settlement, sometimes behind.[20,21]

> *When the isolation of the Americas was broken, and Columbus brought the two halves of this planet together, the American Indian met for the first time his most hideous enemy - not the white man… but the invisible killers which these men brought in their blood and breath.*[22]

The most deadly of the early epidemics to ravage the New World were the Eurasian diseases carried by the early explorers and colonists such as smallpox, measles, typhus, plague and influenza. Old

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[13] See for example, E.A. Fenn, 'Biological Warfare in Eighteenth-Century North America: Beyond Jeffery Amherst', op. cit.

[14] M. Wheelis, 'Biological warfare before 1914', in: E. Geissler and J.E. van Courtland Moon (eds.), *Biological and Toxin Weapons Research, Development and Use from the Middle Ages to 1945: A Critical Comparative Analysis*, SIPRI Chemical and Biological Warfare Studies No.18 (Oxford: Oxford University Press, 1999), p. 17.

[15] Ibid.

[16] A.W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Connecticut: Greenwood Press, 1972).

[17] D.E. Stannard, *American Holocaust: Columbus and the Conquest of the New World* (Oxford: Oxford University Press, 1992); H.F. Dobyns, *Their Number Become Thinned: Native American Population Dynamics in Eastern North America* (Knoxville: University of Tennessee Press, 1983), p. 13; R. Thornton, *American Indian Holocaust and Survival: A Population History since 1492* (Norman: University of Oklahoma Press, 1987).

[18] A.W. Crosby, 'Conquistador y Pestilencia: the first New World pandemic and the fall of the great Indian empires', *The Hispanic American Review*, vol. 47 (3), 1967, No.3, p. 321.

[19] See also D.E. Stannard, *American Holocaust: Columbus and the Conquest of the New World*, op. cit.

[20] D.R. Snow, 'Microchronology and demographic evidence relating to the size of pre-Columbian North American Indian populations', *Science*, vol. 268, 1995, pp. 1601–604.

[21] K.F. Kiple and S.V. Beck, 'Biological Consequences of the European Expansion, 1450-1800', *An Expanding World,* vol. 26, (Aldershot: Ashgate Publishing Group, 1997).

[22] A.W. Crosby, 'Conquistador y Pestilencia: the first New World pandemic and the fall of the great Indian empires', *The Hispanic American Review*, op. cit., p. 323.

World tropical diseases such as malaria and yellow fever (and their mosquito vectors) were brought by the African slave trade. Epidemics were unusually virulent, probably because of the lack of prior genetic selection for resistance and because of an unusually narrow range of genetic diversity among Native Americans resulting from their relative isolation from other gene pools.[23]

The first recorded pandemic occurred in December 1518 or January 1519, when a smallpox outbreak ravaged the native Indian population of Santo Domingo in the now Dominican Republic. Whilst few Europeans died, records show that one-third to one-half of the Indian population succumbed, leaving less than a thousand alive on the island. Whilst it is likely that the deaths were due not only to smallpox but also a combination of disease and starvation, modern epidemiologists would agree that they are crudely accurate.[24] From here, smallpox rapidly appeared in Puerto Rico, the Greater Antilles and on to the Yucatán. Smallpox was also responsible for decimating indigenous populations in later centuries; in 1837, only 31 out of 1600 Native Americans of the Mandan tribe in North America survived an outbreak.[25]
This trend is evident not only in the New World, but wherever new diseases were introduced into previously isolated populations. Historical and anecdotal evidence suggests that indigenous peoples of Australia and the Americas suffered exceptionally high rates of mortality from smallpox.[26] Several tribes of the Khoikhoi (Khoisan) in Southern Africa were extirpated by a smallpox epidemic that began in 1775 and mortality rates of 80 per cent were reported in a subsequent outbreak in 1831.[27]

These and countless other incidents demonstrate the devastating impact of newly introduced diseases on human populations, particularly those of indigenous peoples isolated from medical and social support systems. The extermination of human populations has a huge adverse impact on the human genetic diversity of the region, which, in turn, negatively impacts upon the evolution of humankind – physically, socially and culturally.

Many of the biological pathogens identified today as being of great potential danger to human health are those that have been investigated or pursued as a biological weapon by states or non-state actors. These include Ebola virus, smallpox, Marburg virus, Rift Valley Fever, and typhus as well as zoonotic diseases (those capable of being transmitted between humans and animals) such as anthrax, brucellosis, plague, and tularaemia.[28] Whilst smallpox has been eradicated, samples remain in government pathogen culture centres. Spanish Flu – responsible for the decimation of 20-40 million people worldwide in 1918 and 1919 – was re-created in 2002 at the laboratory of the US Armed Forces Institute of Pathology by coupling sequence information with advanced genetic engineering techniques – ostensibly for defensive research purposes.[29]

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[23] F.L. Black, 'Why did they die?', *Science*, vol. 258, 1992, pp. 1739–40

[24] A.W. Crosby, 'Conquistador y Pestilencia: the first New World pandemic and the fall of the great Indian empires', op. cit., pp. 323-324.

[25] J.P. Dudley and M.H. Woodford, 'Potential Impact of Biological Weapons on Biological Diversity and Indigenous Peoples in Asia', op. cit., p. 51.

[26] Ibid.

[27] Ibid.

[28] See M. Wheelis, L. Rózsa, M.R. Dando (Eds.), *Deadly Cultures: Biological Weapons since 1945* (Cambridge: Harvard University Press, 2006).

[29] For more information, see 'Recreating the Spanish Flu?' *Emerging Technologies: Genetic Engineering and Biological Weapons*, Sunshine Project Backgrounder #12, October 2003. Available at: http://www.sunshine-project.org/publications/others/gmoflu.html.

Potential Impact upon Animal Biodiversity

> *Throughout civilisation humans have depended upon animals for food, clothing, tools, traction, transportation, warfare, financial security, companionship, and even sheer enjoyment. That dependency has not changed for thousands of years since humans learned to domesticate animals for their own survival. The difference today is that most people in industrialised urban areas do not realise or appreciate that dependency.*[30]

A few centuries ago, animal diseases affected mostly individual owners or herdsmen, but only occasionally had severe consequences on the larger community. A highly contagious disease can affect history, international economies, and the ecology of a whole region. Rinderpest, for example, has been known as one of the most serious animal plagues since oral and written records began. Rinderpest, also known as cattle plague, is a disease with high morbidity and mortality rates for cattle and water buffalo of more than 90%. In addition, an outbreak in domestic herds necessitates extensive culling. Rinderpest swept westward through Europe out of Asia with the many waves of military campaigns between these two continents and between 1711 and 1768 more than 200 million head of cattle of died of the virus in Western Europe alone after Asian oxen used for transport of military supplies acted as asymptomatic carriers of the virus and spread the disease to native European cattle. This is almost ten times the estimated human mortality during the Black Plague pandemics of the fourteenth and fifteenth centuries.

A similar event today will have not only a negative impact on the animals and their owners, but more importantly will significantly affect the general economy of the region, the entire nation, and even a group of nations.[31] The following examples demonstrate the potentially devastating impact a naturally-occurring or introduced disease can have on animal populations, and on humans as a knock-on effect.

The "Great Rinderpest Pandemic" of 1889-1897 had a severe impact on the African continent. It is thought to have been introduced by the Italian army in Eritrea and eventually spread throughout Africa, resulting in massive mortality of domestic cattle, water buffalo and many species of wildlife including African buffalo, giraffe, eland, oryx and kudu. Mortality rates in cattle and wildlife game reached 90% in some parts of Africa and had long-lasting continental consequences that, amongst other effects, permanently altered the ecological balance of game species in the large plains of East Africa.[32] A second pandemic in Africa occurred from 1969-1973.[33]

Velogenic Viscerotropic Newcastle Disease (VVND) is an extremely serious viral disease of poultry. The virus is highly contagious and can be transmitted in a variety of ways. Vaccination

[30] A. Torres, 'International economic considerations concerning agricultural diseases and human health costs of zoonotic diseases', *Annals of the New York Academy of Sciences*, vol. 894 (Issue: Food and Agricultural Security: Guarding Against Natural Threats and Terrorist Attacks Affecting Health, National Food Supplies, and Agricultural Economics), 1999, pp. 80-82.

[31] Ibid.

[32] J.A.W. Coetzer, G.R. Thomson and R.C. Tustin (Eds.), *Infectious Diseases of Livestock,* Chapter 74. (Oxford: Oxford University Press, 1994), 2nd ed.

[33] A. Torres, 'International Economic Considerations Concerning Agricultural Diseases and Human Health Costs of Zoonotic Diseases', *op. cit.*

does not completely protect a flock, and a small percentage of birds remain susceptible, where mortality rates can be as high as 95%. During an outbreak in 1971 in Southern California, the disease spread from smuggled aviary birds to chicken and turkey farms. Containment of the disease and eradication led to the slaughter of almost 12 million birds.[34]

Foot and Mouth Disease virus (FMD), though not seriously fatal in livestock, has shown that its incredibly contagious nature can in fact cause significant economic loss and trade disruptions.[35] This was clearly portrayed by the 2001 outbreak in the UK, in which economic losses are projected at around £8.5 billion GBP. This loss came from many sources. There were the six million animals that were slaughtered, the UK's loss of both tourism and trade due to the tainted meat, and the government's overzealous response to close the countryside.[36] What makes FMD so devastating is the speed at which it spreads. Capable of being transferred through the milk or meat of infected animals, as well as saliva and excrement, the virus can be carried by dogs, cats, poultry, vermin, and even in the hands and clothing of farmers tending to the infected animals, where it can persist for 12 weeks.[37] This naturally initiated outbreak showed the difficulty governments have in controlling such virulent diseases. Were a similar disease to be released intentionally, as happened in 1997, governments would be just as disadvantaged in attempting to halt its spread.

ANTI-ANIMAL BIOLOGICAL WEAPONS. There are many other diseases capable of ravaging animal populations and thus affecting animal biodiversity. A number of these have been the subject of investigation as feasible biological weapons. Between 1945 and 1975 there were at least four offensive anti-animal biological weapons programmes pursued by states – the United States (US), the United Kingdom (UK), the Soviet Union (USSR)[38] and Canada. Viewed as strategic weapons to be used to reduce enemy food supplies or cause economic damage, these states conducted research on anthrax, FMD, VVND, Rinderpest virus, African swine fever, Rift Valley fever virus, sheep pox virus and Venezuelan equine encephalitis amongst others.[39] Animal disease was also considered for sabotage operations with the possibility of initiating a disease outbreak and preventing the reestablishment of animals in certain areas.

It is not just states that have pursued anti-animal biological agents. In 1952, Mau Mau guerrillas in Kenya poisoned 33 cattle, killing 8, using an extract from the African milk bush plant.[40] In 1995, an escape of the rabbit haemorrhagic disease (RHD) virus from a field test site in Australia led to its rapid dissemination over most of South Australia. The government concluded that eradication was not technically or economically feasible and the disease was accepted as endemic.[41] In an example of a 'biocrime', two years later, a group of New Zealand farmers introduced the RHD virus into that

[34] P. Millett, 'Antianimal biological weapons programs', in: M. Wheelis, L. Rózsa and M.R. Dando (eds.), *Deadly Cultures: Biological Weapons since 1945*, (Cambridge: Harvard University Press, 2006), pp. 224-235.

[35] Department for Environment Food and Rural Affairs, *Foot and Mouth Disease: Commonly Asked Questions,* 14 January 2008. Available at: http://www.defra.gov.uk/animalh/diseases/fmd/qanda/qanda-general.html.

[36] S. Ward, 'The Real Cost of Foot and Mouth', *MSN UK Money,* September 12, 2007. Available at http://money.uk.msn.com/investing/articles/morecommentary/article.aspx?cp-documentid=5738611

[37] M.E. Hugh-Jones, *High-Impact Terrorism: Proceedings of a Russian-American Workshop*, (Washington D.C.: National Academies Press, 2002), pp. 227-229.

[38] see http://cns.miis.edu/pubs/opapers/op1/op1.htm.

[39] P. Millett, 'Antianimal biological weapons programs', in: M. Wheelis, L. Rózsa and M.R. Dando (eds.), *Deadly Cultures: Biological Weapons since 1945*, op. cit.

[40] Ibid.

[41] Ibid.

country. After their requests for government intervention into the control of the rabbit population were denied, the farmers opted to move ahead in a planned campaign that succeeded in secretly importing the virus (from Australia) and distributing the infection over a large area of the South Island before the disease was detected by government officials.[42] The original epidemic in New Zealand devastated the rabbit population and periodic localised epidemics continue to appear. The actions of the farmers can be likened to bioterrorism and whilst their motives have not been the same as terrorists, they demonstrated how efficient organisation can frustrate official efforts to prevent the introduction and establishment of a disease.

The losses suffered by outbreaks of infectious diseases such as Rinderpest, RHD, FMD, as well as VVND highlight the difficulty states have in controlling the outbreak of such virulent diseases, without taking heavy and often times crippling losses politically and economically. While only the New Zealand RHD outbreak was a conscientious, planned attack, state sponsored research into these diseases for possible bioweapons use has increased the likelihood that such methods could be used in a bioterrorist attack to cause societal chaos and economic losses, with a catastrophic secondary effect on other local fauna diversity.

Potential Impact upon Plant Biodiversity

Plants play a vital role in the ecosystem as a primary producer of the fundamental requirements of life – food and oxygen – upon which humans and animals alike rely. Plants also provide the raw materials for many medicines, clothing, shelter and fuel – needs which are increasing rapidly because of a growing world population, increasing incomes and urbanisation. Approximately 2.5 billion people in the world still rely on subsistence farming to satisfy their basic needs, while the rest are tied into increasingly complex production and distribution systems to provide food, fibres, fuel, and other plant-derived commodities. A deliberate or accidental outbreak of disease targeting plant life, especially crops, therefore, could have a potentially widespread and devastating effect upon humans and animals, as well as the rest of the environment on which we all rely for survival.

Much of the world, rich and poor alike, are reliant on a single, or mono-, crop system whereby one crop supplies the basic subsistence needs of a population, for example, rice or wheat. The Great Irish Potato famine of 1845-1851 demonstrates the potential impact of large-scale crop failure. The potato famine killed over a million people and caused another million to flee Ireland becoming refugees.[43] At the time, the potato was the staple crop of the Irish poor with 3 million people subsisting solely on the potato. The cause of the potato crop failure was an airborne fungus (*phytophthora infestans*) originally transported in the holds of ships travelling from North America to England. Winds from southern England carried the fungus to the countryside around Dublin. The blight spread throughout the fields as fungal spores settled on the leaves of healthy potato plants, multiplied and were carried in the millions by cool breezes to surrounding plants.[44] Under ideal moist conditions, a single infected potato plant could infect thousands more in just a few days. Whilst the famine that followed the crops failures were undoubtedly exacerbated by social and

[42] P. O'Hara, 'The illegal introduction of rabbit haemorrhagic disease virus in New Zealand', *Scientific and Technical Review*, Office International des Epizooties (World Organisation for Animal Health), vol. 25(1), 2006, p. 119.

[43] J.S. Donnelly, *The Great Irish Potato Famine*, (Sutton: Sutton Publishing, 2001), p. 15.

[44] W.E. Fry and S.B. Goodwin, 'Resurgence of the Irish potato famine fungus' *BioScience*, vol. 47 (6), 1997, pp. 363-371.

political decisions[45] taken at the time, the event shows the consequences of a wide-scale mono-crop failure.[46] More recent examples include the widespread planting of a single corn variety which contributed to the loss of over a billion dollars worth of corn in 1970, when the US crop was overwhelmed by a fungus. And in the 1980s, dependence upon a single type of grapevine root forced California grape growers to replant approximately two million acres of vines when a new race of the pest insect, grape phylloxera (*Daktulosphaira vitifoliae*) attacked the plants in the 1980s.

ANTI-CROP BIOLOGICAL WEAPONS. In recognition of the importance of crops, some states have featured anti-crop measures in their biological weapons programmes. In fact, one of the earliest documented allegations of using a biological weapon against crops occurred during the American Civil War (1861-1865) when the Union was accused of having introduced the harlequin bug (*Murgantia histrionica*) into the southern United States with the intention of destroying crops of the Confederacy.[47]

Colorado potato beetles (*Leptinotarsa decemlineata*)[48] were investigated by the German offensive biological warfare programme during the Second World War – reportedly in response to German fears that the UK were investigating the beetle themselves as an anti-crop measure. German authorities were disturbed by the potential of the Colorado beetle to reduce their food supplies and therefore weaken the German war effort. Following concerted efforts by the German war machine in breeding and field trials, in June 1944 the German High Command was informed that all preparations were completed, and that the "use [of the Colorado potato beetle] is possible at any time". There is little evidence to suggest the Colorado potato beetle was ever deployed against enemy crops.[49]

The US and the UK were also interested in the potential of anti-crop biological weapons, and investigated a number of plant pathogens and pests including various wheat rusts, rice blast, and potato blight.[50] More recently, Iraq also had an anti-crop component to its state biological weapons programme. Whilst details are scant, it appears that Iraq had focused on research into the crop-destroying capacities of the causal agent of cover smut, a fungal plant pathogen attacking wheat.[51]

USING BIOLOGICAL AGENTS TO ERADICATE DRUG PLANTS (BIOCIDE). The potential of using biological agents to counter the drug trade by using plant disease to target drug plants such as the coca and cannabis plants has been under investigation by the United Nations (UN) since the latter stages of last century and undertaken by various countries such as Burma, Mexico, Paraguay and the United States.

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[45] J.S. Donnelly, *The Great Irish Potato Famine*, (Sutton: Sutton Publishing, 2001), p. 25.

[46] See http://evolution.berkeley.edu/evolibrary/article//agriculture_02.

[47] J.A. Lockwood, *Six-Legged Soldiers*, (New York: Oxford University Press, 2009).

[48] Also known as the potato weevil and potato bug.

[49] B.C. Garrett, 'The Colorado potato beetle goes to war', *The CBW Conventions Bulletin*, No. 33, September 1996, pp. 2-3. Available at: www.sussex.ac.uk/Units/spru/hsp/CWCB33-Garrett.pdf.

[50] S. Whitby, 'Anticrop biological weapons programs', in: M. Wheelis, L. Rózsa and M.R. Dando (eds.), *Deadly Cultures: Biological Weapons since 1945*, (Cambridge: Harvard University Press, 2006), pp. 213-223.

[51] G.S. Pearson, 'The Iraqi biological weapons program', in: M. Wheelis, L. Rózsa and M.R. Dando (eds.), *Deadly Cultures: Biological Weapons since 1945*, (Cambridge: Harvard University Press, 2006), pp. 169-190.

Fungal biocontrol agents (FBCA) involves applying natural fungal pathogens (mycotoxins) to crops in the field or in storage, or to control pests or disease. They have been advocated by some as an effective and, more particularly, an environmentally sound means of controlling pests, disease, and undesirable organisms.[52] An example of FCBA use is the use of *Fusarium oxysporum* to kill coca plants in certain Latin American countries.[53] Interestingly, the idea is to introduce the disease rather than the cure. The ultimate aim is to stop the manufacture of cocaine. Not only is this a use against agriculture, but mycotoxins are considered acutely more toxic than pesticides.[54]

Fungi that harm plants, dubbed 'Agent Green', have been developed since the 1980s in the US for the purpose of destroying opium poppies, coca and cannabis plants. In 2000, the US government halted plans to test such agents in Colombia in response to domestic and international criticism citing concerns over biological weapons proliferation and the threat of undermining the global ban on biological weapons under the Biological and Toxin Weapons Convention (BWC). However, research and development has continued and interest in the use of biological agents to eradicate such plants is on the rise.

A fungus, *Pleospora papaveracea*, initially developed in Uzbekistan in the 1980s as part of the former Soviet Union's offensive biological weapons programme, also became the subject of determined research, development and eventual testing in Central Asia in 1998 following an international project led by the United Nations Office on Drugs and Crime (UNODC) mainly funded by the United States.[55] Another fungus called *Fusarium oxysporum* was developed by the US to eradicate fields of coca plant (from which cocaine is derived).

Fusarium oxysporum is a well-known plant pathogen capable of causing large-scale damage to crops and ornamental plants. Use of this fungus generally involves it being grown en masse and induced to form spores that can then be dispersed through aerial spraying. This method, particularly when dispersed from a high altitude, is very inaccurate and risks infecting other plants and crops. Another method is to coat plant seeds (other than the target plant) with fungal spores and disseminate them throughout the target area. This method also presents a high ecological risk because the contaminated seeds could easily be picked up by migrating birds and spread to a large area nationally, regionally and even globally.[56]

Concerns over the use of such mycotoxins and the possibility of their inadvertent transfer effect on other plants have long been voiced:

> *There is always the possibility we will lose control of the fungus, which then might adversely affect other plants. For example, cocaine is of a class of chemicals called alkaloids. Other common alkaloids that have value to us include nicotine, caffeine, quinine, morphine, and ephedrine. What happens if the fungus affects these crops as well? Furthermore, by using a biological agent to control these plants, we may be forcing them to evolve even stronger*

[52] R. Russell and M. Paterson, 'Fungi and fungal toxins as weapons', *Mycotoxical Research*, vol. 110, 2006, p. 1003.

[53] G.E. de Vries, '*Fusarium* considered to kill coca plants', *Trends in Plant Science,* vol. 5, 2000, p. 417.

[54] J.W. Bennet and M. Klich, 'Mycotoxins', *Clinical Microbiological Review*, vol. 16 (3), 2003, pp. 497-516.

[55] Sunshine Project Backgrounder No. 14, 'Risks of Using Biological Agents to Eradicate Drug Plants'. September 2005. Available at: http://www.sunshine-project.org/publications/bk/bk14.html.

[56] Sunshine Project Backgrounder No. 14, 'Agent Green: Risks of Using Biological Agents to Eradicate Drug Plants', September 2005. Available at: http://www.sunshine-project.org/publications/bk/bk14.html.

> *chemicals. It is frightening to think that in the search for a quick fix, we might cause ourselves more long-term ecological and social problems.*[57]

The narcotic biocontrol agents considered for use are intended for release in complex and fragile ecosystems. Some species rely on wild relatives of narcotic species and may well be affected. For example, a striking and highly-prized butterfly of the *Agrias* genus feeds exclusively on wild relatives of the coca plant. Each kind of *Agrias* relies on a different species of wild coca and several are already endangered. If *F. oxzsporum* is released, reducing populations of wild cocas, the *Agrias* will also suffer. Similarly, the agents could have a negative impact on microbial biodiversity in soils, which is poorly understood. Russian researchers found that, for example, a *F. oxysporum* strain considered for use as a bio-control agent killed other fungi in the soil. This led to an increase of other soil fungi that can produce detrimental toxins and so the microbial biodiversity in soils can be altered.[58]

The use of insects against crops has also been investigated in some depth by various governments. For example, in 1999, the US Department of Agriculture (USDA) initiated a project called "classical biological control of narcotic plants" which aimed at identifying and testing insect pests of coca, opium poppy and marijuana. In 2000, the USDA group reported that it had established cooperation with scientists in India, Nepal, China and Kazakhstan, and that during a first field trip to Nepal and India insects that fed on marijuana were collected.

Classical biological control using insects has long been upheld as environmentally safe, yet in recent years, new concerns about safety have been raised, and in particular, the scope for impact on non-target organisms has been discussed and demonstrated.[59] Non-target effects can be direct (an introduced biological control agent attacks a non-target host) or indirect (through the effects of the target being successfully controlled; the introduced biological control agent competes with or displaces indigenous species; ecosystem and food web changes, etc.)[60]

The Effect of Modern Scientific and Technological Developments

The rapid pace of advances in the biological sciences coupled with the irresponsible or ignorant use of biology has led to a number of worrying developments and trends capable of wreaking havoc in the natural world if accidentally or deliberately released. These include the rise of drug-resistant diseases, failures in laboratory biosafety and biosecurity, and the advent of more powerful and widespread genetic engineering technology.

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[57] See http://www.scienceagogo.com/news/19980928125243data_trunc_sys.shtml.

[58] V.N. Murasheva and T.P. Sizova, 'Consequences of applying broomrape fusaroid wilt to the soil', *Mikologiya-I-Fitopatologiya,* vol. 29 (5-6), 1995, pp. 41-45, in Sunshine Project Backgrounder No. 14, 'Agent Green: Risks of Using Biological Agents to Eradicate Drug Plants', September 2005. Available at: http://www.sunshine-project.org/publications/bk/bk14.html.

[59] See for example: M.B. Thomas and A.J. Willis, 'Biocontrol – risky but necessary?', *Trends in Ecology and Evolution*, vol. 13 (8), 1998, pp. 325-329; and, P.A. Follett and J.J. Duan, *Nontarget Effects of Biological Control*, (Boston: Kluwer Academic Publishers, 2000).

[60] M.J.W. Cock, 'Risks of Non-Target Impact Versus Stakeholder Benefits in Classical Biological Control of Arthropods: Selected Case Studies from Developing Countries'. Available at: www.bugwood.org/arthropod/day1/cock.pdf.

Drug-resistant Diseases

Human impacts on important fundamental determinants of ecosystem characteristics and dynamics have radically altered the natural ecology of disease pathogens and disease vectors in many areas of the world, eliminating endemic diseases from large areas in which they were formally prevalent whilst also creating epidemic disease problems in areas previously outside the natural, historical range of pathogens.

The once-celebrated human conquest of infectious diseases through sanitation, antibiotics and vaccination has now faltered and newly emerging diseases such as SARS, Nipah virus, Marburg virus and H5N1 avian influenza are proving a major threat to human health worldwide.[61] Inappropriate and improper uses of antibiotics are contributing to the evolution of drug-resistant strains of many bacterial diseases such as tuberculosis, malaria and poliomyelitis which were once thought to have been eradicated, are now re-emerging and even spreading despite concerted international efforts at control and eradication. Globalisation and modern high-speed travel are facilitating the spread of diseases that were once relatively localised within endemic areas.

Laboratory Biosafety and Biosecurity Failures

Should any of these pathogens be accidentally released from research laboratories or deliberately spread as a biowarfare campaign or terrorist act, the results on the human population could be devastating. High-profile outbreaks of emerging and re-emerging disease as well as the perceived mounting threat from bioterrorism have fuelled an unprecedented flood of new high-containment biological laboratories worldwide. At the same time that the number and geographic distribution of high containment facilities has increased, there would seem to be evidence to suggest a related increase in biosafety and biosecurity incidents. For example, in Beijing, in April 2004, two medical students employed at China's Center for Disease Control became infected with SARS, resulting in 6 further confirmed cases and 1 death.[62] Other examples include the outbreak of Foot and Mouth Disease virus in the United Kingdom in August 2007 attributed to a biosecurity breach at the Pirbright laboratory site housing both the government's Institute of Animal Health and Merial Animal Health Ltd labs[63]; the exposure of lab workers at Texas A&M University to aerosolised anthrax and *Coxiella burnetti* (the causative agent of Q Fever)[64]; and a former scientist from Lawrence Livermore National Laboratory, lacking proper credentials, sent two open vials of anthrax across the USA in 2005 resulting in a fine of $450,000.[65] In 2007 alone, 37 "accidents and

[61] J.M. Hughes, 2001 'Emerging infectious diseases: a CDC perspective', *Emerging Infectious Diseases* vol. 7(3) Supplement, 2001, pp. 494-496, cited in J.P. Dudley and M.H. Woodford, 'Potential impact of biological weapons on biological diversity and indigenous peoples in Asia', op. cit., p. 46.

[62] D. Normile, 'Mounting lab accidents rause SARS fears', *Science,* vol.304 (5671), 2004, pp. 659-661.

[63] See official UK government Epidemiology Reports available at http://www.defra.gov.uk/FootandMouth/2007/index.htm.

[64] L. Scnirring, 'CDC suspends work at Texas A&M biodefense lab', available at http://cidrapbusiness.org/cidrap/content/bt/bioprep/news/jul0307bioweapons.html; Sunshine Project, 'Bioweapons Infections Hit Texas A&M University Again (Q Fever Cluster)', News Release - 26 June 2007, available at http://www.sunshine-project.org/publications/pr/pr260607.html.

[65] See for example J.V. Derbeken, 'Livermore lab fined $450,000 for mishandling anthrax', *San Francisco Chronicle* online, 7 October 2007, available at http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/10/07/BA6RSLIUB.DTL.

lost shipments" occurred in the US - double the number of known incidents in 2004 - ranging from bites from infected animals, spills, leaks and unaccounted-for infected rodents.[66]

Such incidents demonstrate that there are obviously still shortcomings in biosafety and biosecurity precautions and practices in facilities throughout the world which increases the danger of an accidental release of a dangerous pathogen.

Genetically-engineered Biological Pathogens

> *A genetically modified bioweapon disease could severely affect human and animal populations at regional, continental, or even global scales.*[67]

Genetic engineering of pathogens and viruses is an additional factor in the threat to human life and biodiversity. Biotechnology now makes genetic manipulation of bacteria and viruses possible even in the most scientifically underdeveloped countries.[68] Genetic engineering techniques have been used to develop disease strains that are more virulent and able to infect vaccinated subjects ('vaccine-subverting' disease strains). Gene transfer experiments have demonstrated that even carefully controlled and monitored experiments using relatively benign viruses may create chimera viruses with entirely new dangerous or lethal properties. Soviet and Russian scientists reportedly used genetic engineering techniques to create vaccine-subverting and/or antibiotic resistant strains of smallpox, anthrax, plague and tularaemia.[69]

In the late 1990s, with the advent of the genomic revolution, serious concerns were raised as to whether new genetic techniques would allow the development of ethnic-specific weapons.[70] At the time, whilst it was considered that the development of such weapons was not technically feasible, one report concluded:

> *...it cannot be ruled out that information from such genetic research could be considered for the design of weapons targeted against specific ethnic or racial groups...* [71]

However, with the continued rapid pace of developments in the genomic sciences, it has since been asserted that these earlier conclusions are no longer correct, and that in fact ethnic-specific weapons may indeed be possible in the near future:

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[66] In one case, a sample of plague bacteria en route to the Armed Forces Institute of Pathology in Washington, DC, went missing only to be later traced to Belgium.

[67] J.P. Dudley and M.H. Woodford, 'Potential impact of biological weapons on biological diversity and indigenous peoples in Asia' op. cit., p. 49.

[68] D.R. Franz, 'Foreign animal disease agents as weapons of biological warfare', *Annals of the New York Academy of Sciences*, vol. 894 (Issue: Food and Agricultural Security: Guarding Against Natural Threats and Terrorist Attacks Affecting Health, National Food Supplies, and Agricultural Economics), 1999, pp. 100-104.

[69] G. Bozheyeva, Y. Kunakbayev, and D. Yeleukenov, 'Former Soviet biological weapons facilities in Kazakhstan: past, present, and future", 1999, Monterey Institute of International Studies, Center for Nonproliferation Studies. Chemical and Biological Weapons Nonproliferation Project. Available at: http://cns.miis.edu/pubs/opapers/op1/op1.pdf

[70] V. Nathanson, M. Darvell and M.R. Dando, *Biotechnology, Weapons and Humanity*. (London: Harwood Academic, 1999).

[71] Ibid.

> *New technologies are indeed available to translate specific genetic sequences into markers or triggers for biological activity. And a recent analysis of human genome data in public databases revealed that hundreds, possibly thousands, of target sequences for ethnic-specific weapons do exist.*[72]

The most significant relevant advances in genetic engineering and technology are those of gene sequencing, gene synthesis and gene silencing.

Gene sequencing allows the genome of an organism to be mapped and its functionality to be understood. A more detailed understanding of how biological organisms function enables better efforts to disrupt that functionality, as well as enhance it. Gene sequencing is the ability to take sequence information (on paper or digitally) and create the physical nucleotide sequence that it lists - effectively the ability to 'write' a gene.[73] Developments in gene sequencing have enabled the synthesis of new organisms. This has resulted in the creation of pathogens from nothing more than its genomic sequence (see earlier mention on the artificial synthesis of the 1918 Spanish Flu virus). It has also enabled the creation of custom-made or tailored new organisms that have not previously existed in nature, as evidenced by the creation of a new bacteriophage virus at the Craig Venter Institute, USA.[74] Gene silencing uses RNA interference techniques to turn off a single gene or a sequence of them, therefore interfering with the functionality of an organism's genome.

One relevant advancement that is most significant is the emergence of a new life science field – that of synthetic biology. Synthetic biology is a process for artificially engineering biological systems. It builds on genetic engineering techniques adding three new technologies: automated sequencing and synthesis (to make it easier to build things); standards (defining the things that are being built); and abstraction (to hide biological complexity).[75] Whilst synthetic biology as a discipline is still in its infancy, it has the potential to allow fast and easy engineering of known and new organisms, including viruses and bacteria.

Conclusions

> *"...human impacts on important fundamental determinants of ecosystem characteristics and dynamics have radically altered the natural ecology of disease pathogens and disease vectors in many areas of the world, eliminating endemic diseases from large areas in which they were formerly prevalent whilst also creating epidemic disease problems in areas previously outside the natural, historical range of pathogens."76*

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[72] Sunshine Project 'Emerging technologies: genetic engineering and biological weapons', Background Paper No.12, 2003. Available at: www.sunshine-project.org.

[73] BWC ISU website, *Scientific and Technological Developments*. Available at: www.unog.ch/bwc.

[74] H.O. Smith, C.A. Hutchinson III, C. Pfannkoch, and J.C. Venter, 'Generating a synthetic genome by whole genome assembly: φX174 bacteriophage from synthetic oligonucleotides', *Proceedings of the National Academies of Science, USA*, vol. 100, 2003, pp. 15440-15445. Available at: http://www.pnas.org/content/100/26/15440.full.

[75] Drew Endy, founder of the synthetic biology discipline quoted on the BWC ISU website, *Scientific and Technological Developments*. Available at: www.unog.ch/bwc.

[76] J.P. Dudley and M.H. Woodford, 'Potential Impact of Biological Weapons on Biological Diversity and Indigenous Peoples in Asia', op. cit., p. 46.

Human capacity for modulating and altering basic ecosystem functions has now reached unprecedented levels, and on a global scale. Deliberate or accidental outbreaks of bioweapon diseases could result in the erosion of genetic diversity in domesticated plants and animals, the destruction of traditional human livelihoods, the extirpation of indigenous peoples, and the extinction of endangered wildlife species. The development and weaponization of animal and plant pathogens for designed use as biological weapons could potentially represent a long-term threat to human populations, agricultural production, and biodiversity worldwide.[77]

It is vitally important, therefore, that we recognise the dangers our activities are having, and can have, on the world around us before it is too late and we have caused further irrevocable damage to our planet – and to ourselves.

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[77] J.P. Dudley and M.H. Woodford, 'Potential Impact of Biological Weapons on Biological Diversity and Indigenous Peoples in Asia', op.cit., pp. 45-46.

Chapter 9. Awareness-raising, Education and Codes of Conduct within the Framework of the BWC

Robert J. Mathews and John M. Webb[1]

Introduction

Under Article IV of the Biological and Toxin Weapons Convention (BWC),[2] each State Party is required, in accordance with its constitutional processes, to take the necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, retention or transfer of biological weapons. This, in effect, means that each State Party is required to enact penal legislation to prohibit and prevent any activity in breach of the Convention conducted within its territory, under its jurisdiction or anywhere under its control.[3]

It was recognised early in the life of the treaty that passing domestic legislation and regulations is not sufficient in itself to ensure effective national implementation of the treaty. The various domestic laws and regulations of biological activities flowing from the international obligations under the BWC clearly have an impact on the biological science and technology communities, meaning that effective domestic implementation of the BWC will require high levels of cooperation between government officials and the relevant scientific communities. Hence, the Second BWC Review Conference in 1986 noted the importance of 'Inclusion in textbooks and in medical, scientific and military educational programmes of information dealing with the prohibition on microbial or other biological agents or toxins and the provisions of the Geneva Protocol.'[4] Similar statements were made at the Third and Fourth Review Conferences in 1991 and 1996.

However, the awareness of the provisions of the BWC and the domestic law flowing from the BWC among the scientific communities has remained low. For example, surveys undertaken by Bradford University in 2005 concluded that the vast majority of life scientists are unaware of the provisions of the BWC and potential dual-use aspects of their work.[5]

The events of September 11 and the anthrax letters in late 2001 led to greater recognition that if all BWC States Parties fully comply with their national implementation obligations under the BWC, this would substantially raise the barriers to the proliferation of biological weapons (including

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[2] *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction*, (BWC), opened for signature 10 April 1972; entered into force 26 March 1975. The BWC is sometimes referred to as the BTWC.

[3] For a detailed discussion, see T. Dunworth, R.J. Mathews and T.L.H. McCormack, 'National Implementation of the Biological Weapons Convention', *Journal of Conflict and Security Law*, vol. 11, 2006, pp. 93-118.

[4] United Nations, Final Declaration of the Second Review Conference of the BWC, *Document BWC/CONF.II/13/II*, (Geneva: United Nations, 8-26 September 1986). Available at: http://www.opbw.org

[5] M. Dando and B. Rappert, 'Codes of Conduct for the Life Sciences: Some Insights from UK Academia'. Bradford University Briefing Paper No. 16, May 2005. Available at http://www.brad.ac.uk/acad/sbtwc/

improvised devices containing biological agent by a terrorist group or a bio-criminal).[6] This led to a decision at the reconvened Fifth Review Conference held in Geneva in November 2002 to conduct a three-year intersessional programme of work to consider various topics designed to strengthen the national implementation of the BWC.

In developing this intersessional programme of work, the States Parties agreed to '*discuss* and *develop common understandings* and *promote effective action'* on the various national implementation measures including an increased awareness of BWC-related issues through the development, promulgation, and adoption of codes of conduct for scientists.[7] The Sixth BWC Review Conference held in Geneva in November 2006 agreed to continue this intersessional programme of work, with one of the topics for 2008 being 'Oversight, education, awareness-raising, and adoption and/or development of codes of conduct with the aim of preventing misuse in the context of advances in bio-science and bio-technology research with the potential of use for purposes prohibited by the Convention.'[8]

This article discusses the various BWC-related activities that have been undertaken in awareness-raising, education and development of codes of conduct among relevant scientific communities.

The BWC in the Contemporary Security Environment

One of the greatest contemporary security challenges facing the international community relates to the possibility of the proliferation of biological weapons, including improvised devices containing biological agents by a terrorist group or a bio-criminal. A key issue is the dual-use nature of much of the biological materials (for example, seed cultures of pathogens and toxins), production equipment (for example, fermenters, centrifuges and freeze dryers), and 'know-how' required for the production of biological weapons (including an improvised biological device by a terrorist group).

The dilemma posed by the dual-use nature of biological materials, equipment and know-how is how to prevent the misuse of biological sciences for biological weapons and other hostile purposes, without hindering peaceful applications of biological sciences. Key issues include:

- The dual-use nature of materials and equipment associated with biological weapons;
- The difficulty in recognising when an apparently innocent transaction may have a hostile intent; and
- The possibility that research being undertaken for beneficial objectives may also have hostile applications.

[6] R. J. Mathews, 'WMD Arms Control Agreements in the Post-September 11 Security Environment: Part of the 'Counter-terrorism Toolbox'', *Melbourne Journal of International Law*, vol. 8, 2007, pp. 292-310.

[7] United Nations, Final Declaration of the Fifth Review Conference of the BWC, *Document BWC/CONF.V/17*, (Geneva: United Nations, 19 November - 7 December 2001 and 11-22 November 2002). Available at: http://www.opbw.org. (Italics added by authors).

[8] United Nations, Final Declaration of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva: United Nations, 20 November - 8 December 2006). Available at: http://www.opbw.org

Furthermore, major advances in biological sciences[9] and the increasing globalisation of biological sciences and biotechnology since the latter part of the 20th Century have led to:

- The possibility of inadvertent assistance of the scientific community to bio-terrorism and BW-proliferation;
- The possibility of a biological weapons programme being obscured within industry; and
- The possibility that 'cutting edge' research being undertaken in universities and other research institutions may result in new knowledge that may lead to more effective biological weapons (sometimes referred to as 'experiments of concern').[10]

In response to these concerns and developments, several initiatives are being pursued to reduce the possibility of the acquisition of biological weapons by proliferators or terrorist groups, including enhanced security of biological materials and related measures to reduce the likelihood that the scientific community (including traders in scientific dual-use materials, equipment and technology) may inadvertently assist a proliferator or terrorist group in its attempts to acquire a biological weapons-capability (bio-security[11]), including through cooperative measures.[12]

Awareness-raising and Education

Historically, there have been a number of educational courses covering various aspects of the BWC. However, these courses have been mainly provided in post-graduate international law, arms control or international security studies, or in military law courses.[13] There have been very limited efforts by educational institutions to provide courses to enable life science students to become aware of the

[9] For a summary report of recent advances in biological sciences, including in genomics, proteomics, computational biology, systems biology and synthetic biology, see United Nations, Background Paper: Background information document on new scientific and technological developments relevant to the Convention, *Document BWC/CONF.VI/INF.4* (Geneva: United Nations, 28 September 2006), available at http://www.opbw.org.

[10] These include experiments that would: demonstrate how to render a vaccine ineffective; confer resistance to therapeutically useful antibiotics or antiviral agents; enhance the virulence of a pathogen or render a non-pathogen virulent; increase the transmissibility of a pathogen; alter the host range of a pathogen; enable the evasion of diagnostic/detection modalities; and enable the weaponization of a biological agent or toxin. See National Research Council, *Biotechnology Research in an Age of Terrorism, ('Fink Report')* (2004). Available at: http://www.nap.edu/openbook.php?isbn=0309089778.

[11] In this article, the term 'biosecurity' is used along the lines of the definition of 'laboratory biosecurity' developed by the World Health Organisation (WHO), namely 'The protection, control and accountability for valuable biological materials within laboratories, in order to prevent their unauthorised access, loss, theft, misuse, diversion or intentional release'. See: World Health Organisation, *Biorisk Management: Laboratory Biosecurity Guidance* (WHO Epidemic and Pandemic Alert and Response Report), (September 2006). Available at: http://www.who.int/csr/resources/publications/biosafety.

[12] One of the early initiatives which recognised the responsibilities of actors in the life sciences was the International Committee of the Red Cross (ICRC) 'Web of Prevention' project, which was designed to foster synergy of action among all people in a position to limit risk of poisoning and the deliberate spread of disease. The idea is that if individual actors in the life sciences are properly informed of the risk, rules and their responsibilities they will make better decisions. For more information, see http://www.icrc.org/web/eng/siteeng0.nsf.

[13] For example, one of us (RJM) has provided a number of courses on the BWC to post-graduate International Humanitarian Law and Arms Control students and to military lawyers.

obligations under the BWC (and more recently the obligations and requirements under the biological component of UN Security Council Resolution 1540).[14]

Likewise, there have been limited efforts by governments to ensure that the scientific communities working with pathogens and toxins are aware of the obligations under the BWC (and Resolution 1540), as well as the domestic laws and regulations which flow from these international obligations. This is most unfortunate, as BWC Review Conferences have encouraged governments to undertake the necessary awareness-raising activities in order that relevant scientific communities become aware of all such laws and regulations.[15]

Furthermore, there have been even less efforts by the managers of biological facilities to ensure that the scientists in their workplace working with pathogens and toxins are aware of the obligations under the BWC (and Resolution 1540), as well as the domestic laws and regulations which flow from these international obligations. This is also most unfortunate, as there is a clear responsibility of facility managers to ensure that their workers are fully aware of all domestic laws and regulations governing the pathogens and toxins that they are using in their workplace.

Notwithstanding the inclusion of relevant elements in some codes of conduct (see below), the vast majority of life scientists have remained unaware of their obligations under the provisions of the BWC and potential dual-use aspects of their work.[16] However, this unsatisfactory situation is now being addressed, based in part on the concerns flowing from the events of September 11 and the anthrax letters in 2001, the outcomes from the BWC intersessional process (in particular the 2005 and 2008 Meetings of Experts), and recognition of the possibility that an individual disgruntled scientist in a workplace which does not have appropriate security measures, awareness-raising strategies and codes of conduct in place can cause a major catastrophe.[17]

For example, in recent years a number of generic educational materials is being prepared, ranging from educational modules that individual students can access through a website, through to various courses and seminars ranging in duration from a half day to a week, that provide an awareness of the full range of issues covered by the BWC.[18]

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[14] United Nations Security Council Resolution 1540 (2004), Adopted by the Security Council at its 4956th meeting, on 28 April 2004 (the 'WMD non-proliferation' Resolution). Available at: http://daccessdds.un.org/doc/UNDOC/GEN/N04/328/43/PDF/N042843.pdf.

[15] For example, the Sixth Review Conference encouraged States Parties 'to take necessary measures to promote awareness amongst relevant professionals of the need to report activities conducted within their territory or under their jurisdiction or under their control that could constitute a violation of the Convention or related national criminal law'. See United Nations, Final Declaration of the Sixth Review Conference of the BWC, *Document BWC/CONF.VI/6*, (Geneva: United Nations, 20 November - 8 December 2006), Article IV, Paragraph 15, p.11. Available at: http://www.opbw.org.

[16] M. Dando and B. Rappert, 'Codes of Conduct for the Life Sciences: Some Insights from UK Academia', op.cit.

[17] In August 2008, the FBI stated that it believed that Dr Bruce Ivins, who had formerly worked at the US Army Medical Research Institute for Infectious Diseases (USAMRIID) at Fort Detrick Maryland, was the sole person responsible for the Anthrax letter incidents in October 2001. See Department of Justice News Conference on Bruce Ivins, 6 August 2008, available at http://www.npr.org/templates/story/story.php?storyId=93415845&ft=1&f=1070.

[18] For a summary report of some of the recent education, outreach and awareness-raising activities, see United Nations, Background Paper: Education, Outreach and Raising Awareness, *Document BWC/MSP/2008/MX//INF.4* (Geneva: United Nations, 15 July 2008), available at http://www.opbw.org.

A number of awareness-raising activities are being undertaken by relevant Government agencies to provide information on more specific aspects on the BWC and its obligations that are reflected in domestic law. For example, Australia's Defence Export Control Office undertakes regular outreach seminars in major Australian cities to provide information on the legislation and regulations covering exports of dual-use biological materials, equipment and technology.[19] And more recently, Australia's Department of Health and Ageing has been undertaking a series of outreach activities (including 'road shows' and training sessions) to ensure that the managers of all biological facilities that will be covered under Australia's *National Health and Security Act 2007* are aware of their obligations under this Act and associated regulations.[20]

There have also been several regional workshops conducted with the objective of supporting the objectives of the BWC intersessional programme of work, including awareness-raising and education activities. For example, Australia and Indonesia have co-hosted BWC regional workshops in Melbourne in February 2005, and in Bali in early March 2006.[21] In these discussions, many participants underscored the importance of fostering further cooperation between States Parties in the Asia-Pacific, both as a region and bilaterally, and encouraged States Parties in other geographic regions to also conduct similar regional workshops.[22] Several other regional workshops have subsequently been conducted by a number of other BWC States Parties and international organisations to assist States in different regions to become more aware of the BWC and to assist them in fulfilling their national implementation obligations.

Codes of Conduct for Scientists

The BWC intersessional meeting in 2005 considered several issues related to codes of conduct including: the types and content of codes of conduct; the role of codes of conduct in assisting the scientific community in supporting the objectives of the BWC; and various outreach and awareness-raising activities among biologists and the broader scientific community to ensure that codes of conduct are effective.

With respect to what information should be contained within codes of conduct, suggestions ranged from a focus on: ethical considerations, including scientific responsibility when working on certain research projects that may lead to discoveries that could make biological weapons more effective (sometimes referred to as a Code of Ethics); to full awareness by the scientific community of national laws related to biological activities and full compliance with all such laws (sometimes referred to as a Code of Practice).

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[19] See, for example, R.J. Mathews, 'Codes of Conduct for Scientists', *Defence Export Controls Bulletin*, Issue 2, 2006, pp. 7-8. Available at: http://www.defence.gov.au/strategy/deco.

[20] United Nations, Working Paper: Communication Issues Associated with implementation of the SSBA Regulatory Scheme – Submitted by Australia, *Document BWC/MSP/2008/MX/WP.30,* (Geneva: United Nations, 21 August 2008), available at http://www.opbw.org.

[21] Participating countries were: Australia, Brunei, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, New Zealand, Papua New Guinea, The Philippines, Singapore, Thailand and Viet Nam. Representatives from the International Committee of the Red Cross (ICRC) and WHO also participated in the first workshop.

[22] For more information, see R.J. Mathews and I. Samihardjo, United Nations, Working Paper: Report of the Biological Weapons Convention (BWC) Regional Workshops Co-hosted by Indonesia and Australia – Submitted by Australia and Indonesia, *Document BWC/Conf.VI/WP.34* , (Geneva: United Nations, 28 November 2006). Available at: http://www.opbw.org

In our preparations for the first BWC Regional Workshop in Melbourne,[23] we came to the view that a major role of codes of conduct is to raise awareness of BWC issues, including:

- International obligations under the BWC;
- BWC-related domestic laws and regulations;
- the dual-use dilemma (including 'experiments of concern');
- the possibility of a well-intentioned scientist inadvertently assisting or supporting either the proliferation of biological weapons or bio-terrorism activities (i.e. those seeking a bio-terrorist capability).

We also recognised that an important role of codes is to facilitate the development of a responsible culture and behaviour in individual scientists in workplaces, and the development of appropriate workplace regulations and oversight processes that will minimise the risk of misuse of biological sciences for hostile purposes.[24]

With bio-terrorism, even more so than with chemical terrorism and nuclear terrorism, so much can be done by one individual scientist who has hostile intent. Therefore, all scientists working with biological materials, and especially those who are working with the more pathogenic materials, need to be aware of the potential for misuse of these materials, and develop a responsible culture in their workplace that ensures that they use, store and transfer those materials in a responsible manner.

Layers of Codes

During the 2005 Meeting of Experts, we suggested that it may be useful to think of codes of conduct as occurring in a number of layers, including: (i) a universal code; (ii) codes developed by scientific societies; and (iii) codes developed by workplaces (or institutional codes).[25] These aspects are discussed in more detail below.

A UNIVERSAL CODE CONTAINING GUIDING PRINCIPLES. This could be a short aspirational code, containing general principles and referring to ethical norms, and could be the basis of a universal code (comparable to the Hippocratic Oath for medical practitioners).[26] Implementation of this code would effectively be a 'top-down' approach.

[23] R.J. Mathews and J.M. Webb, 'The Biological Weapons Convention Three-Year Program of Work 2005: Codes of Conduct for Scientists', in: R.J. Mathews (ed.) *Proceedings of the Biological Weapons Convention Regional Workshop: co-hosted by the governments of Australia and Indonesia: 21-25 February 2005*, (University of Melbourne: 2005) (pp. 175 - 185).

[24] Ibid.

[25] R.J. Mathews and J.M. Webb, United Nations, Working Paper: Codes of Conduct for Scientists: Considerations during a BWC Regional Workshop and Subsequent Reflections – Submitted by Australia, *Document BWC/MSP/2005/MX.35*, (Geneva: United Nations, 24 June 2005). Available at http://www.opbw.org

[26] J. Revill and M.R. Dando, 'A Hippocratic Oath for life scientists', *European Molecular Biology Organisation Reports*, vol. 7, 2006, Special Issue, pp.S55-S60.

SCIENTIFIC SOCIETY CODES. There could be new codes developed by scientific societies, or new elements relevant to the BWC could be added to their existing codes. Based on the work undertaken in June 2005 in Geneva and since, there is a sense that these Scientific Society Codes should include the following elements:

- awareness of the BWC and obligations under the BWC;
- awareness of the dual-use nature of biological sciences; and
- a commitment by all members of the society to not undertake any activities which are prohibited by the BWC and the associated domestic law;
- a commitment by all members of the society to report any issue or activity that they consider may be relevant to compliance with BWC obligations to the appropriate authority.

INSTITUTIONAL OR WORKPLACE CODES. These are more detailed codes applicable to a particular workplace. Scientists in the workplace could develop a new Workplace Code, or add BWC-related elements to an existing workplace code (in effect, this would be a 'bottom-up' approach). In our view, a workplace code should include the following BWC-related elements:

- awareness of international obligations under the BWC;
- awareness of national legislation and associated regulations relevant to implementation of the BWC;
- awareness of the various BWC-related regulatory and oversight mechanisms applicable to the institution and its research programme;[27]
- a personal commitment by all scientists employed by the institution to fully comply with the various obligations listed in the above three bullet points;
- awareness of the dual-use nature of biological materials, equipment and 'know-how' and a personal commitment by all scientists employed by the institution not to deliberately or inadvertently assist anyone in any biological weapons proliferation or bio-terrorism activity;[28] and
- a personal commitment by all scientists employed by the institution to report any issue or activity that they consider may be relevant to compliance with BWC obligations, national legislation and associated regulations, or the institution's own regulations and oversight mechanisms. [29]

[27] The regulatory and oversight processes would include ethical considerations, including scientific responsibility when working on certain research projects that may lead to discoveries that could make biological weapons more effective (i.e. 'experiments of concern'), and adhering to a responsible workplace policy on the publication and dissemination of research results which could be mis-used for hostile purposes.

[28] In our view, if a workplace has an effective awareness-raising and education program for its staff-members, then they should understand the potential for misuse and should be responsible for ensuring that any equipment, materials or information that it provides somebody else is for a peaceful purpose.

[29] This element provides for a personal commitment to report any suspicious activities to management so that an internal investigation can take place, if appropriate, to determine whether there have been activities taking place which shouldn't be taking place.

Drafting Elements

We have subsequently prepared drafting elements that could be used as a starting point in the development of a new Workplace Code, or as elements which could be added to an existing Workplace Code (see Appendix).[30] This document could be used by any biological facility, ranging from a laboratory to a biotechnology production site (with appropriate redrafting) as a basis for developing a code specific for that workplace.[31] In our view, it would be useful for all facilities working with biological sciences to have in place a workplace code which includes these BWC-relevant elements, with a particular priority for those types of facilities which are covered by BWC Confidence Building Measure (CBM) reporting requirements (including biodefence and high containment facilities),[32] as well as facilities working with advanced biological science or undertaking 'experiments of concern'.[33] We would also see benefits if these facilities were required to report their progress in developing/adapting their workplace codes to the government agency responsible for compiling BWC-relevant information for the BWC CBM return.

Practical Considerations in the development of Codes of Conduct

The various layers of codes (universal, scientific society and workplace) have been recognised as complementary and mutually reinforcing, and will be most effective as a package.[34] The various scientific institutions and workplaces are much more likely to accept, and take seriously, a Workplace Code related to BWC issues if they fully understand the reasons for the code and if they have a sense of ownership of the code. To win the 'hearts and minds' of the relevant scientific communities, the best approach may be for the BWC States Parties to use a set of elements or themes that the scientific institutes / workplaces can then craft into appropriate language as either a new code or to add to their existing codes. Implementation of this process would effectively be through a 'bottom-up' approach. Such a code could become a formal part of a workplace agreement.

Following the intersessional BWC meetings in 2005, there have been several initiatives by international governmental agencies, professional organisations and associations, and academic institutions to provide guidance in the development of BWC-relevant codes of conduct.[35] The

[30] This document, which was originally provided to participants at the BWC Regional Workshop in Bali in February 2006, was based on the elements of a Workplace Code which had been developed by scientists at Australia's Defence Science and Technology Organisation (DSTO) Biodefence facility in Melbourne.

[31] R.J. Mathews, 'Codes of Conduct for Scientists', op.cit.

[32] United Nations, Final Declaration of the Third Review Conference of the BWC, *Document BWC/CONF.III.23*, (Geneva: United Nations, 9-27 September 1991), pp. 15-16. Available at: http://www.opbw.org

[33] These include experiments that would: demonstrate how to render a vaccine ineffective; confer resistance to therapeutically useful antibiotics or antiviral agents; enhance the virulence of a pathogen or render a non-pathogen virulent; increase the transmissibility of a pathogen; alter the host range of a pathogen; enable the evasion of diagnostic/detection modalities; and enable the weaponization of a biological agent or toxin. See: National Research Council, 'Biotechnology Research in an Age of Terrorism', op. cit.

[34] R.J. Mathews and J.M. Webb, 'Codes of Conduct for Scientists: Considerations during a BWC Regional Workshop and Subsequent Reflections', op.cit.

[35] For a summary report of some of the recent developments in codes of conduct, see United Nations, Background Paper: Developments in Codes of Conduct since 2005, *Document BWC/MSP/2008/MX//INF.2* (Geneva: United Nations, 26 June 2008). Available at: http://www.opbw.org

intersessional meeting in 2008 recognised that such codes can complement national legislation, regulatory and oversight frameworks and help guide science so that it is not misused for prohibited purposes.[36] As with the other topics covered in the BWC intersessional programme of work, participants recognised that 'No one size fits all'. Rather, participants considered that the best approach may be a range of regional, national, societal and workplace codes.

There has been increasing recognition that there are already many existing codes of conduct which are relevant to the biological sciences, including codes of conduct which have been developed by a number of scientific societies, as well as many workplaces (universities, research institutes, government agencies, biotechnology industry). Based on our discussions with representatives from a number of scientific societies and workplaces, there is a strong preference among some to add elements to an existing code, rather than developing a brand new code specific to BWC issues. For example, Australia's Biotechnology Organisation ('AusBiotech') has developed a 'Code of Conduct' which includes the following element:

> *We oppose the use of biotechnology to make any weapons and will not develop or produce biological weapons.*[37]

The Australian Society for Microbiology has developed a 'Code of Ethics'[38] which includes the following element:

> *The Society requires each member to not engage knowingly in research for the production or promotion of biological warfare agents.*[39]

A BWC-relevant element has been included in the American Society of Microbiology (ASM) code which requires that members of the society call to the attention of either the public or law enforcement people or other authorities any misuse of microbiology or information obtained from microbiology for hostile purposes.[40]

Concluding Comments

While the initial expectations of the BWC intersessional programme of work in Geneva were generally fairly modest, this process has proved to be a significant innovation, and resulted in States Parties becoming substantially more focused on the practical aspects of effective national

[36] United Nations, Report of the Meeting of States Parties to the BWC, *Document BWC/MSP/2008/5* (Geneva: United Nations, 12 December 2008). Available at: http://www.opbw.org

[37] AusBiotech also has a number of 'Members Commitments' which include 'Members will ensure that staff and colleagues are made aware of this Code of Conduct and other standards, guidelines and laws relevant to the safe and ethical conduct of biotechnology activities'. For more information, see http://www.ausbiotech.org.

[38] These two examples also illustrate how different scientific societies name their society codes: 'Code of Conduct', in the case of AusBiotech, and 'Code of Ethics', in the case of the Australian Society for Microbiology. This variation in nomenclature can cause confusion, which is why we chose to call this type of code a 'Scientific Society Code'.

[39] For more information on the Australian Society for Microbiology Code of Ethics, see http://www.theasm.com.au.

[40] This element states: ASM members are obligated to discourage any use of microbiology contrary to the welfare of humankind, including the use of microbes as biological weapons. Bioterrorism violates the fundamental principles upon which the Society was founded and is abhorrent to the ASM and its members. ASM members will call to the attention of the public or the appropriate authorities' misuses of microbiology or of information derived from microbiology. For more information on this code, see http://www.asm.org/Policy/index.asp?bid=35983

implementation of their BWC obligations through their agreement in 2002 to '*discuss* and *develop common understandings* and *promote effective action'* on the various national implementation measures. [41]

With respect to oversight, education, awareness-raising initiatives, and the development of codes of conduct, there have been very useful *discussions* at the meetings in Geneva and at a number of national and regional workshops. As a result there are now *common understandings* among those who have participated in the various meetings and workshops of the importance of this set of activities. And the critical link between effective national implementation of the BWC and effective oversight, education, awareness-raising strategies, including the development of codes of conduct for scientists, is now better understood.

With respect to *promoting effective action*, there have been substantial efforts in some States Parties by a number of government agencies, academics and NGOs to translate these common understandings into effective action, including the preparation of teaching modules, and development of new codes of conduct, as well as drafting elements that could be adapted and incorporated into existing codes. But a major effort will be required to ensure that all relevant scientific communities are aware of the provisions of the BWC and the potential dual-use aspects of their work, have the necessary codes of conduct enacted, and have developed the necessary culture of responsibility within their workplaces to ensure the prevention of misuse in the context of advances in bio-science and bio-technology research.

In this activity, the importance of cooperative efforts: internationally; regionally; between relevant domestic government agencies; and between government and relevant educational, scientific and industrial communities in this context has been well recognised. Clearly, for oversight, education, awareness-raising, and codes of conduct to be effective, this cooperation will need to extend to international agencies, government officials, scientific societies, educators, scientific researchers and industry representatives who have not traditionally been involved with BWC-related activities.

It would be useful, as these cooperative activities proceed, for States Parties to include progress reports of these activities in their annual CBM reports.[42] Likewise, we would see real benefits if all States Parties could be encouraged to provide to a written summary report to the Seventh BWC Review Conference in 2011 of their progress in the implementation of their oversight, education, awareness-raising strategies, including the development of codes of conduct for scientists, especially if such reports included a measure of the effectiveness of the various activities.

As a final comment, it must be emphasised that the oversight, education, awareness-raising, and codes of conduct activities discussed in this article will need to be a continuing process because of the changing players and changing technologies in the various biological sectors. Clearly, a State Party cannot simply 'do it once' and then put a 'tick in the box'.

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[41] United Nations, Final Declaration of the Fifth Review Conference of the BWC, *Document BWC/CONF.V/17*, (Geneva: United Nations, 19 November-7 December 2001 and 11-22 November 2002). Available at: www.opbw.org (Italics added by authors).

[42] For example, a report on this activity could be included under 'Other Measures' in CBM Measure E. CBM Measure E is the 'Declaration of legislation, regulations and other measures' undertaken by States Parties to ensure effective national implementation of the BWC.

Appendix – Draft / Elements for a Workplace Code

The **[Name of Institution]** Workplace Code is the following a set of requirements developed to ensure that scientists employed by **[Name of Institution]** comply with all obligations, legislation, Regulations and oversight mechanisms, and to prevent activities by **[Name of Institution]** scientists which would deliberately or inadvertently assist in the development of biological weapons.

1) Awareness of international obligations under the Biological and Toxin Weapons Convention (BWC) (see Annex 1).

2) Awareness of national legislation and associated regulations related to **[the State Party's]** obligations under the BWC (see Annex 2).

3) Awareness of the various BWC-related regulatory and oversight mechanisms applicable to the **[Name of Institution]** research programme, including the **[Name of Institution]** Research Oversight process / Advisory Committee, the Institutional Biosafety Committee (IBC), and the Office of the Gene Technology Regulator (see Annex 3).

4) A personal commitment by all scientists employed by **[Name of Institution]** Workplace Code to fully comply with all international obligations, national legislation and related regulations, and the various regulatory and oversight mechanisms applicable to the **[Name of Institution]** research programme.

5) Awareness of the dual-use nature of biological materials, equipment and 'know-how', and a personal commitment by all scientists employed by **[Name of Institution]** to not deliberately or inadvertently assist anyone in any biological weapons-proliferation or bio-terrorism activity.

6) A personal commitment by all scientists employed by **[Name of Institution]** to report to Senior Manager, **[Name of Institution]** any issue or activity that they consider may be relevant to compliance with BWC obligations, **[the State Party's]** national legislation and associated regulations, or **[Name of Institution]** regulations and oversight mechanisms.

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N.B. These elements could be used in the development of a new Workplace Code specific to the BWC, or the elements could be added to an existing Workplace Code.

Annexes 1, 2 and 3 are respectively: brief summaries in the form of PowerPoint presentations of the international obligations under the BWC; the national legislation and associated regulations related to **[the State Party's]** obligations under the BWC; and the various BWC-related regulatory and oversight mechanisms applicable to the Institution's research programme.

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Factsheet: Bioterrorism

Iris Hunger

Bioterrorism has received a lot of attention recently, in particular after the anthrax letter attacks in autumn 2001 in the USA. Bioterrorism is the deliberate introduction of disease by non-state actors in order to reach political, ideological or religious aims. Note that terrorism is perpetrated by non-state actors such as terrorist organisations or individuals; if bioweapons are used by states we talk of biological warfare. Note also, that terrorism has political motivations; if non-state actors are using bioweapons for non-political reasons, e.g. to gain financial advantages or to murder someone, we talk about criminal acts, not terrorism.

There is a growing worldwide assumption that advances in the life sciences are leading to an increasing threat of bioterrorist attacks. This assumption needs to be challenged on two grounds: historical evidence and likely capabilities. Historically, there is little evidence of terrorist use of biological weapons. The two examples of "successful" bioterrorist attacks that do exist occurred in 1984 and 2001. In 1984 members of the Rajneeshee sect used salmonella bacteria to contaminate salad bars in ten restaurants in the town The Dalles in Oregon, USA. 751 people suffered from food poisoning; all of them recovered. The aim of the sect had been to make people too sick to vote in order to influence the results of local elections in their favour. In 2001, letters containing high-quality dry-powder anthrax spores were sent to politicians and media people in the USA. 11 people contracted pulmonary anthrax, five of them died. Up to 11 more people (seven confirmed, four uncertain) contracted the less dangerous form of cutaneous anthrax. After years of investigation it now seems from the evidence available that the perpetrator came out of the biodefence establishment in the USA. It is important to note that mass killing was not the aim in both cases.

Two other events merit attention. These are the bioweapon development efforts by the terrorist organisations Aum Shinrikyo and Al Qaeda. Aum tried to produce anthrax bacteria between 1990 and 1995 and dispersed the product at different times in and around Tokyo. These attacks did not claim any victims, most likely because the wrong type of anthrax – a harmless vaccine strain – was used. Al Qaeda was and likely still is dedicated to obtain weapons of mass destruction including bioweapons. Documents were found in November 2001, when US and British military forces occupied Afghanistan, indicating that Al Qaeda had been trying to obtain anthrax. There is no publicly available information on the current state of Al Qaeda's bioweapon efforts.

The scarcity of historical examples of terrorist bioweapon efforts and use indicates that the intention to use bioweapons is no habitual characteristic of terrorist organisations. But even if the intention is there, technological capabilities to develop, produce and use bioweapons seem to remain a severe limiting factor.

Further reading:

- L.H. Kahn, 'Biosecurity lessons from the Bruce Ivins case', *Bulletin of the Atomic Scientists*, August 8, 2008. Available at http://www.thebulletin.org/node/4006.
- M. Leitenberg, *Assessing the Biological Weapons and Bioterrorism Threat* (Strategic Studies Institute, 2005). Available at http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?PubID=639.
- R. Purver, *Chemical and Biological Terrorism: The Threat According to the Open Literature* (Canadian Security Intelligence Service, 1995). Available at http://www.csis-scrs.gc.ca/pblctns/thr/cbtrrrsm01-eng.asp.
- J.B. Tucker (ed.), *Toxic Terror. Assessing Terrorist Use of Chemical and Biological Weapons*, 2000. Partly available at http://cns.miis.edu/research/cbw/toxterr.htm.

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Factsheet: BWC Implementation

Angela Woodward, Scott Spence and Rocio Escauriaza Leal

What is National Implementation?
National implementation is the process by which a State Party adopts appropriate and effective national measures to carry out and enforce the obligations to which it has committed when ratifying or acceding to a Treaty.

Are States under an obligation to implement the BWC?
Once a State has ratified or acceded to the BWC, it will be bound by its content, and obliged to implement its requirements.

Article IV obliges each State Party, in accordance with its constitutional processes, to take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition or retention of biological weapons in its territory and anywhere under its jurisdiction or control. States Parties have agreed that the prohibition of the use of biological weapons also falls under the scope of the BWC.

In addition, Article III requires all States Parties to refrain from transferring biological weapons to anyone and from assisting, encouraging or inducing anyone to manufacture or acquire them.

What forms of legislation could States Parties consider?

- *Penal measures* criminalizing the development, production, manufacture, stockpiling, acquisition, retention, transfer and use of biological weapons. Preparatory measures to carry out such activities, including assistance, encouragement, or inducement, should also be penalized.
- *Biosafety and biosecurity measures*, such as measures to account for and secure production, use, storage and transport of particularly dangerous pathogens or activities involving humans, plants or animals where infection may pose a risk; related licensing procedures; safety and security measures for laboratories; containment measures; and genetic engineering regulations.
- *Import and export controls* should be adopted. States could consider incorporating control lists into their legislative framework for particularly dangerous pathogens and toxins, and dual-use equipment and technology. Import and export licenses should be required for items on the control lists, and measures should be in place ensuring general oversight over transfers. An official body should be designated to properly enforce these measures.
- *Enforcement measures* should be adopted to facilitate ongoing monitoring of life sciences activities and compliance with the Convention, and to prosecute and punish offenders.
- Other measures may be necessary to facilitate domestic and international cooperation and assistance.

What other additional measures should States adopt?

States Parties adopted additional understandings during the last six Review Conferences of the Convention. These additional understandings call for the adoption of additional measures:

- States should annually submit information on seven *Confidence Building Measures (CBMs)* to the BWC Implementation Support Unit (ISU). In order to receive, prepare and send CBMs to the ISU, States should designate a governmental department or official responsible for these tasks. They should also adopt measures requiring the submission of information to this department or official by affected individuals or laboratories.
- States should designate a *National Point of Contact* whose role would be to communicate with other States Parties and relevant international organizations, coordinate national implementation of the BWC, and prepare and submit the CBMs to the ISU.

What is the role of civil society in BWC implementation?

Civil society can provide the expertise and impartiality that Governments cannot always offer. Often Governments organize consultation committees to make implementation processes more inclusive and/or to obtain the technical knowledge that they don't always have (i.e. scientific knowledge).

Where can State's legislative drafters turn for assistance?

There is no intergovernmental organization overseeing the implementation of the Convention. However, your drafters can turn to a number of assistance providers that offer legislative services.

- *The BWC Implementation Support Unit (ISU)* was established within the United Nations in August 2007 to provide administrative support in relation to the BWC, to receive and distribute Confidence Building Measures (CBMs) among States Parties, to promote the universalization of the BWC, to serve as a focal point for the exchange of information on national implementation measures, and to act as a clearinghouse for assistance requests and offers. For further information contact Dr. Piers Millett, Political Affairs Officer (pmillet@unog.ch or bwc@unog.ch).
- *The Verification Research, Training and Information Centre (VERTIC)* offers assistance with legislative drafting for BWC obligations. VERTIC assesses the comprehensiveness of existing national measures, identifies gaps, and proposes approaches, including on-site drafting assistance and follow-up, to fully implement the BWC. For further information contact VERTIC's Senior Legal Officer Scott Spence (scott.spence@vertic.org) or Legal Officer Rocio Escauriaza (rocio.escauriaza@vertic.org).
- *The Advisory Service of the International Committee of the Red Cross (ICRC)* offers legal and technical assistance in incorporating International Humanitarian Law, including the BWC, into national law. For further information contact the Advisory Service of the International Committee of the red Cross (advisoryservice.gva@icrc.org)
- *The EU* offers assistance with BWC national implementation under its Joint Action on the BTWC. For further information see www.euja-btwc.eu

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Glossary

1925 Geneva Protocol
The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare is a treaty prohibiting the first use of chemical and biological weapons. It was signed at Geneva on June 17, 1925 and was entered into force on February 8, 1928.

Abandoned chemical weapons
Chemical weapons, including old chemical weapons, abandoned by a State after 1 January 1925 on the territory of another State without the consent of the latter.

Ad Hoc Group
The group established by the 1994 Special Conference to negotiate and develop a legally-binding verification regime for the Biological and Toxin Weapons Convention. It held 24 meetings between January 1995 and August 2001. It ultimately failed in this task.

Additional Agreements
The commitments made by States Parties at Review Conferences on how to implement the obligations of the Biological and Toxin Weapons Convention. As they have not been endorsed by a specific act of parliament or Presidential Decree, they are considered to be politically (as opposed to legally) binding. Politically binding obligations are the things States Parties SHOULD do.

Aerosol
Particles that are suspended in air or in liquid droplets.

Allied Forces in World War II
Those countries officially opposed to the Axis powers. They included the British Empire, the Soviet Union and the United States of America, known as "The Big Three", as well as China, Poland, and France.

Anti-animal biological warfare
The deliberate release of disease amongst animals with the aim of causing death or incapacitation of the affected animals, thus disrupting food supplies or means of transportation. Together with anti-crop biological warfare it is considered to be a form of “anti-agricultural biological warfare”.

Anti-crop biological warfare
The deliberate release of disease amongst crops with the aim of killing the crops or rendering them unusable, thus disrupting food supplies. Together with anti-animal biological warfare is considered to be a form of “anti-agricultural biological warfare”.

Anti-materiel biological warfare
The use of microorganisms genetically engineered to produce acids or enzymes with the ability to destroy or degrade a variety of materials and substances including cement, polyurethane, paint, lubricants and fuel.

Artificial viruses
These are non-viral vectors consisting of polymer-based complexes of nanoparticle size containing DNA. They usually consist of DNA compacted into particles with polycationic substances to

enhance their uptake into cells. They are being developed in an attempt to overcome the negative aspects of using viruses to deliver genes.

Avian influenza
A contagious disease of animals caused by viruses that normally infect only birds and, less commonly, pigs. Avian influenza viruses are highly species-specific, but have, on rare occasions, crossed the species barrier to infect humans such as the virus strain known as H5N1. Also commonly known as 'bird flu'.

Axis Powers of World War II
Those countries opposed to the Allies in World War II. The three major Axis countries were Germany, Italy and Japan.

Bacillus anthracis
Bacillus anthracis is a type of aerobic spore-forming bacteria that causes anthrax disease. Livestock may become infected by eating or inhaling anthrax endospores. Humans may develop cutaneous anthrax through skin exposure to infected animals, or inhalational anthrax by breathing in material contaminated with the bacteria or by eating contaminated meat.

Bacteriophage
A virus of bacteria.

Biochemical
A chemical substance produced by living organisms that acts on biological systems.

Biocide
A synthetic or natural substance capable of killing living organisms, usually in a selective manner. Refers to pesticides (e.g. fungicides, herbicides, insecticides etc) as well as antimicrobials (germicides, antibiotics, antibacterials etc.)

Biocontrol
Biological control, in the classical sense, is the deliberate introduction by humankind of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control is an approach that fits into an overall pest management program, and represents an alternative to continued reliance on pesticides.

Biocontrol agent
An organism (or product of an organism) used in the artificial control of pests.

Biocrime
Use of a biological agent for criminal purposes as opposed to political or strategic warfare aims. The vast majority of biological incidents are biocrimes rather than bioterrorism or biowarfare.

Biological agent
Defined here as any material of biological origin that is capable of causing damage, disease or illness.

Biological Weapon
(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.

Biological and Toxin Weapons Convention
The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction opened for signature in 1972 and entered into force in 1975. It was the first multilateral disarmament treaty banning an entire category of weapons. It effectively prohibits the development, production, acquisition, transfer, retention, stockpiling and use of biological and toxin weapons and is a key element in the international community's efforts to address the proliferation of weapons of mass destruction.

Biopreparat
The massive Soviet biological weapons program operating in at least 20 different locations. To give an idea of the capability of the system, a major Biopreparat facility was said to be able to produce two hundred kilograms of weaponized plague agent (*Yersinia pestis*, a contagious agent) material each week. In addition to the well known biological weapons agents such as those causing anthrax, tularemia and glanders, work was done on highly lethal viruses including Ebola virus, Marburg virus and the smallpox virus. Also, genetic engineering was carried out, with attempts to render the plague bacillus resistant to multiple antibiotics and to modify pathogens to overproduce one of the body's chemical signalling molecules in order to disrupt physiological function.

Bioregulators
Defined here as naturally occurring organic compounds that regulate diverse cellular processes in multiple organ systems and are essential for normal homeostatic function. They are diverse in structure and play key roles in many vitally important bodily functions such as respiration, blood pressure, heart rate, body temperature, mood and consciousness, as well as innate and adaptive immune responses.

Bioremediation
The use of biological organisms such as plants or microbes to aid in removing hazardous substances from an area. Bioremediation is the use of organisms to break down and thereby detoxify dangerous chemicals in the environment. The technology can take advantage of a natural mechanism or organisms can be genetically modified to have a particular toxic "appetite".

Biosafety
A combination of measures employed when handling pathogens to avoid infecting oneself, others or the environment. An approach which focuses on the safe use of biological materials and equipment, for example, in the designation of different levels of laboratory design required to perform certain experiments and the official control of certain types of genetic engineering.

Biosecurity
Protection, control and accountability measures implemented to prevent the loss, theft, misuse, diversion or intentional release of biological agents and toxins and related resources as well as unauthorized access to, retention or transfer of such material.

Biotechnology
Modern definition: A collection of technologies that use living cells and/or biological molecules to solve problems and make useful products.

Bioterrorism
The deliberate introduction of disease by non-state actors in order to reach political, ideological or religious aims.

Bovine spongiform encephalitis
Bovine Spongiform Encephalopathy (BSE) is a transmissible, neurodegenerative, fatal brain disease of cattle. The infectious agent is thought to be a protein called a prion.

Burkholderia mallei
Causative agent of glanders. Glanders is primarily a disease affecting horses, but it also affects donkeys and mules and can be naturally contracted by goats, dogs, and cats. Human infection is very rare. The types of infection include localized, pus-forming cutaneous infections, pulmonary infections, and bloodstream infections.

Burkholderia pseudomallei
Causative agent of melioidosis. This is a disease which is mainly found in tropical climates, particularly in Southeast Asia. Humans and animals can become infected by direct contact.
Illness from melioidosis can be categorized as acute or localized infection, acute pulmonary infection, acute bloodstream infection, and chronic suppurative (characterised by pus formation) infection.

Chemical Weapon
Together or separately:
(a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;
(b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;
(c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).

Chemical weapon production facility
(a) Means any equipment, as well as any building housing such equipment, that was designed, constructed or used at any time since 1 January 1946:

    (i) As part of the stage in the production of chemicals ("final technological stage") where the material flows would contain, when the equipment is in operation:

        (1) Any chemical listed in Schedule 1 in the Annex on Chemicals; or

        (2) Any other chemical that has no use, above 1 tonne per year on the territory of a State Party or in any other place under the jurisdiction or control of a State Party, for purposes not prohibited under this Convention, but can be used for chemical weapons purposes; or

    (ii) For filling chemical weapons, including, inter alia, the filling of chemicals listed in Schedule 1 into munitions, devices or bulk storage containers; the filling of chemicals

into containers that form part of assembled binary munitions and devices or into chemical submunitions that form part of assembled unitary munitions and devices, and the loading of the containers and chemical submunitions into the respective munitions and devices;

(b) Does not mean:

(i) Any facility having a production capacity for synthesis of chemicals specified in subparagraph (a) (i) that is less than 1 tonne;

(ii) Any facility in which a chemical specified in subparagraph (a) (i) is or was produced as an unavoidable by-product of activities for purposes not prohibited under this Convention, provided that the chemical does not exceed 3 per cent of the total product and that the facility is subject to declaration and inspection under the Annex on Implementation and Verification (hereinafter referred to as "Verification Annex"); or

(iii) The single small-scale facility for production of chemicals listed in Schedule 1 for purposes not prohibited under this Convention as referred to in Part VI of the Verification Annex.

Clostridium botulinum
The name of a group of bacteria commonly found in soil that produce botulinum toxins of biological warfare relevance. These rod-shaped organisms grow best under low oxygen conditions. Clostridia form highly resistant endospores which allow them to survive in a dormant state until exposed to conditions that can support their growth. There are seven types of botulinum toxin that cause a muscle-paralysing disease called botulism. These toxins are designated by the letters A through G; only types A, B, E and F cause illness in humans. Treatment includes intensive supportive care, and there are anti-toxins available that are helpful if administered early.

Common Understandings
Elements agreed upon at the annual Meeting of States Parties that might be useful when addressing the politically or legally binding commitments under the Biological and Toxin Weapons Convention. They are shared national positions on mechanisms that might strengthen implementation – or the things States Parties COULD do.

Compendiums of National Activities
Descriptive datasets of how legislative and regulatory measures to implement the Biological and Toxin Weapons Convention are operationalized (who is in charge, what bodies are involved, how do they interact, etc.). They are taken from the statements, presentations and documents as well as other contributions made at meetings of the BWC.

Conference of the States Parties of the Organisation for the Prohibition of Chemical Weapons
The Conference of the States Parties is the principal organ of the Organization for the Prohibition of Chemical Weapons. It considers any questions, matters or issues within the scope of the Chemical Weapons Convention, may make recommendations and take decisions on any questions, matters or issues related to that Convention raised by a State Party or brought to its attention by the Executive Council.
The Conference oversees the implementation of the CWC, and acts in order to promote its object and purpose. The Conference reviews compliance with the CWC, and also oversees the activities of the Executive Council and the Technical Secretariat and may issue guidelines to either of them in the exercise of their functions.

Confidence-Building Measures (CBMs)
They are annual exchanges of information "in order to prevent or reduce the occurrence of ambiguities, doubts and suspicions and in order to improve international co-operation in the field of peaceful biological activities". The CBMs were elaborated at a meeting of scientific and technical experts in 1987, and were modified and considerably expanded by the Third Review Conference in 1991. The CBMs include:

CBM A	Part 1: Exchange of data on research centres and laboratories; Part 2: Exchange of information on national biological defence research and development Programmes.
CBM B	Exchange of information on outbreaks of infectious diseases and similar occurrences caused by toxins.
CBM C	Encouragement of publication of results and promotion of use of knowledge.
CBM D	Active promotion of contacts.
CBM E	Declaration of legislation, regulations and other measures.
CBM F	Declaration of past activities in offensive and/or defensive biological research and development programmes.
CBM G	Declaration of vaccine production facilities.

The CBMs have not been modified since, although the Sixth Review Conference in 2006 agreed on various improvements to the mechanisms for submission and distribution.

Contagious infection
An infection that can spread from individual to individual by means of a contagious microorganism. Some potential biological weapons are not contagious agents, such as the causative agents of anthrax and tularemia, while others such as the causative agents of smallpox and plague are highly contagious.

Discrete organic chemical (DOC)
Any chemical belonging to the class of chemical compounds consisting of all compounds of carbon except for its oxides, sulfides and metal carbonates, identifiable by chemical name, by structural formula, if known, and by Chemical Abstracts Service registry number, if assigned. The term does not extend to metal carbides, oligomers or polymers. As a sub-category, the CWC has provisions that specifically apply to chemical plants producing so-called "PSF chemicals"; these are DOCs that contain one or more atoms of either phosphorous, sulphur or fluorine.

Dual-use
Refers to agents, activities, technology or equipment that can be used for peaceful purposes, but can also be misused to threaten public health or national security.

Ecosystem diversity
The broad differences between ecosystem types, and the diversity of habitats and ecological processes occurring within each ecosystem type. It is an essential element of total biodiversity. Ecosystem services provide food, fresh water, lumber, pharmaceuticals, bio-chemicals, and genetic material. Our natural ecosystems also generate soil, recycle and store nutrients, pollinate plants, maintain the water cycle, and control pests and diseases. Ecosystem functions regulate climate and build resiliency to climate change, clean the atmosphere and water, sequester carbon, treat waste and control erosion and flooding.

Endospore
A differentiated cell formed within the cells of certain bacteria (for example, *Bacillus anthracis and Clostridium botulinum*). It is formed in response to limited nutrients and is extremely resistant to heat, dessication (drying out) as well as to other harmful substances. By example, it is much more resistant than the spores formed by fungi. Bacterial endospores may survive quite extraordinary extremes of temperature, dehydration or chemical insult.

Environment
The external surroundings including all of the living and non-living factors that surround and affect the survival and development of an organism or population.

Executive Council of the Organisation for the Prohibition of Chemical Weapons
The Executive Council of the Organisation for the Prohibition of Chemical Weapons is the executive organ of the Organisation. It is responsible to the Conference of the States Parties. The Executive Council carries out the powers and functions entrusted to it under the Chemical Weapons Convention, as well as those functions delegated to it by the Conference. In so doing, it acts in conformity with the recommendations, decisions and guidelines of the Conference and assure their proper and continuous implementation.
The Executive Council promotes the effective implementation of, and compliance with, the Convention. It supervises the activities of the Technical Secretariat, cooperates with the National Authority of each State Party and facilitates consultations and cooperation among States Parties at their request.

Final Declaration
The substantive section of the Final Documents of review conferences of the Biological and Toxin Weapons Convention; they include a Solemn Declaration where States Parties recommit themselves to the aims and objectives of the treaty as well as an article-by-article review which examines how the treaty is functioning and addresses additional agreements.

Food security
The most commonly accepted definition of food security is that of a sustained access at all times, in socially acceptable ways, to food adequate in quantity and quality to maintain a healthy life. This definition can be operationalized at the individual and household level, and with minor modification can be applied to whole populations. The definition incorporates several concepts: Access (economic and social); sustainability or security of access; availability of food supply, both quantitative and qualitative; and, quality of food supply to include nutritional adequacy and safety. Defined in this way, food insecurity applies to a wide spectrum of phenomena ranging from famine to periodic hunger to worry about safety or security of food.

Foot and Mouth Disease (FMD)
Foot and mouth disease is an infectious disease affecting cloven-hoofed animals, in particular cattle, sheep, pigs, goats and deer. Other ruminants including deer and some zoo animals, camelids (camels, llamas, alpacas, guanaco and vicuña) and elephants can also be affected. The disease is serious for animal health and for the economics of the livestock industry. While FMD is not normally fatal to adult animals, it is debilitating and causes significant loss of productivity; for example milk yields may drop or the animals may become lame. In young animals it can be fatal on a large scale.

Formal Consultative Process
The mechanism through which States Parties to the Biological and Toxin Weapons Convention consult one another and cooperate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, the Convention. The current procedures for a Formal Consultative Process were created at the Second Review Conference in 1986 and developed by the Third Review Conference in 1991.

Francisella tularensis
The causative agent of tularemia, a disease of wild animals that can also cause disease in humans, particularly those in contact with wild animals. The bacterium is one of the most infectious microorganisms known. As little as 10 bacteria can cause an infection through inoculation or inhalation of aerosols. Although the agent is highly infective, it is not contagious. That is, the disease is not transmitted from person to person. For these reasons, but also because the organism remains relatively stable during production, storage and deployment, it is considered to have particular relevance as a potential biological weapon. Symptoms vary based on mode of infection, but generally include fever, chills, joint and muscle pain, headache, weakness, and sometimes pneumonia. Individuals who develop pneumonic tularemia experience chest pain, bloody sputum, and difficultly breathing. The disease is easily cured by antibiotic treatment. A vaccine is currently under review by the US Food and Drug Administration.

Fungicide
A chemical or organic agent that destroys fungi.

General purpose criterion
Shorthand for a concept built into the definitions of chemical as well as biological weapons, as well as into the provisions related to the implementation of the two Conventions, whereby the intent of using the toxic properties of a chemical, or the intent of using a biological agent, for hostile purposes renders the chemical/agent into a prohibited weapon. That is irrespective of whether the chemical/agent was listed on any control list or Schedule.

Gene sequencing
The identification of the order of the nucleotides which make up genetic information allowing the individual genes of an organism to be identified.

Gene silencing
A general term describing a process of gene regulation. The term gene silencing is generally used to describe the "switching off" of a gene by a mechanism other than genetic modification. That is, a gene which would be expressed (turned on) under normal circumstances is switched off by machinery in the cell.

Gene synthesis
The process of synthesizing an artificially designed gene into a physical DNA sequence.

Genetic diversity
Genetic diversity has been called the “fundamental currency of diversity” - it refers to genetic variation among individuals, populations and species. The interactions between the individual organisms (e.g., reproductive behaviour, predation, parasitism) of a population or community, and their specialisations for their environment (including ways in which they might modify the

environment itself) are important functional aspects of biodiversity. These functional aspects can determine the diversity of different communities and ecosystems.

Genetic engineering
Techniques by which functional genes are artificially moved even between different species, for example, the use of recombinant DNA technology to put the genes for insulin into a bacterium in order to grow large quantities of the hormone artificially.

Genetic weapon
A biological weapon capable of targeting a specific group of human beings with common genetic characteristics, as may be the case with certain ethnic groups.

Genome
The entire complement of genetic material of an organism. It is the hereditary information encoded in DNA (or, for some viruses, RNA). The genome includes both the genes and the non-coding sequences of the DNA.

Genomics
Genome analyses that are concerned with the determination (identification) of the nucleotide base sequence of the genomic (chromosomal) deoxyribonucleic acid (DNA) of organisms. In its widest application, genomics includes efforts to determine the functions of the genes delineated through the sequence analyses.

Gruinard Island
A small island located off the North West Scottish coast used as an anthrax field testing site by the UK government in the 1940s, which was quarantined for 48 years before decontamination attempts were eventually successful.

Health-for-All
Health paradigm defined in the Alma Ata declaration in 1978, which expressed the need for urgent action by all governments, all health and development workers, and the world community to protect and promote the health of all the people of the world.

Health Security
Measures which aim to provide a degree of protection against disease or any factor which impacts negatively on the health of an individual.

Host
Defined here as an organism which harbours another organism, often a parasite such as a bacterium or virus that causes an infection in humans, plants or animals.

Implementation Support Unit
The institutional support for the Biological and Toxin Weapons Convention was created by the Sixth Review Conference in 2006. The unit provides administrative support and assistance, national implementation support and assistance, support and assistance for Confidence-Building Measures, as well as support and assistance for obtaining universality. It currently has three members and in based in the United Nations Office for Disarmament Affairs in Geneva, Switzerland.

Infectious agent
A microorganism that is capable of causing an infection. It may or may not be contagious.

Infectivity
The characteristic of a disease agent that embodies capability of entering, surviving in, and multiplying in a susceptible host.

Insecticide
Chemical substances capable of killing insects, used by humans against insects considered as pests.

Intersessional Process
They are annual meetings of the Biological and Toxin Weapons Convention between the Review Conferences. The last two Intersessional Processes (2003 to 2005 and 2007 to 2010) have focused on discussing, and promoting common understandings and effective action on specific topics to strengthen the implementation of the Convention.

Legally-binding Obligations
The provisions and prohibitions of the Biological and Toxin Weapons Convention which states bind themselves to when they ratify or accede to the treaty. They can be considered the things that States Parties MUST do.

Meeting of Experts
These are the first of the two sets of meetings held on an annual basis under the current Intersessional Process of the Biological and Toxin Weapons Convention. Held during the middle of the year, they are an information gathering and exchange opportunity. They benefit from attracting as many relevant experts as possible and focus on one or two specific topics determined by the preceding Review Conference.

Meeting of States Parties
The second of the two sets of meetings held on an annual basis under the current Intersessional Process of the Biological and Toxin Weapons Convention. Held at the end of the year, they consider how the data gathered at the Meeting of Experts relates to the Convention, what the implications are and for identifying common understandings on what action is needed as a result. They are held at a high diplomatic level and focus on one or two specific topics determined by the preceding Review Conference.

Microbe
A microscopic organism, such as a bacterium, a fungus, a protozoon or a virus.

Mitigation (of disease)
Action undertaken to lessen the severity and impact of a disease. Usually considered together with prevention and response with as part of a comprehensive strategy

Molecular biology
This is the study of biology on a molecular level. It encompasses such study areas as biochemistry and genetics and concerns itself with understanding the interactions between the various systems of a cell, in particular the regulation of the interactions between RNA, DNA and proteins.

Mycotoxins
A group of fungal toxins. They can cause illness or death upon ingestion, skin contact or inhalation. They exhibit great stability and heat resistance. Mycotoxins are difficult to detect, identify, and decontaminate.

Nanoparticles
Particles having a size between 0.1 nanometre (single atom) and 100 nanometres (large molecule).

Nanotechnology
A world-wide scientific and industrial enterprise which can be defined as dealing with structures of sizes between 0.1 nanometre (single atom) and 100 nanometres (large molecule). 1 nanometre (nm) = 10^{-9} metre (m) or one billionth of a metre.

National Authority to the Organisation for the Prohibition of Chemical Weapons
A body designated by each State Party to the Chemical Weapons Convention, under Article VII(4), which serves as the national focal point for effective liaison with the Organisation and other States Parties. In practice, National Authorities have become national focal points for the implementation of the Convention, and often have been given statutory powers to coordinate the implementation processes between different government agencies and ministries as well as the private sector.

National Implementation Measures
The mechanisms put in place by States Parties to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery within its territory, under its jurisdiction or under its control anywhere. They include relevant legislative, regulatory and administrative frameworks and methods for their enforcement.

National Implementation Database
The catalogue of national implementation measures for the Biological and Toxin Weapons Convention, maintained by the Implementation Support Unit and freely available on its website: www.unog.ch/bwc/NID.

Non-State actor
An individual or entity, not acting under the lawful authority of any State in conducting its activities. The term can be applied, for example, to terrorists, terrorist organisations, or criminals.

Nucleotide
A compound made up of three components: a sugar (either ribose or deoxyribose), phosphate, and a nitrogen-containing base. Many nucleotides linked together in a chain form nucleic acids (DNA or RNA). The nucleotide base sequence is characteristic for specific nucleic acid molecules.

Old chemical weapon
(a) Chemical weapons which were produced before 1925; or
(b) Chemical weapons produced in the period between 1925 and 1946 that have deteriorated to such extent that they can no longer be used as chemical weapons.

Pathogenicity
The ability of a parasite to inflict damage on the host.

Pesticide
A substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. The term pesticide applies to insecticides, herbicides, fungicides, and various other substances used to control pests. A pesticide is also often considered to be any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Pro-inflammatory cytokines
Biochemical substances produced by the body that can cause inflammatory reactions. Three main examples include interleukin 1 beta, tumour necrosis factor alpha and interleukin 6.

Pseudotyping
The packaging of the genome of one virus in the envelope or the outer covering capsid protein of another virus. This can change the tropism or host range of the virus (the type of cells it can infect).

Q fever
A disease caused by infection with the bacterium *Coxiella brunettes* (related to the rickettsia), which affects both humans and animals. The infection results from inhalation of contaminated particles in the air rather than by insect bites, as is usual for the rickettsia. It is considered the most infectious disease in the world, as a human being can be infected by a single bacterium. The infection has a very low mortality rate (1%-2%); most infected individuals recover even without treatment, but several antibiotics are effective. It is, however, a very debilitating pneumonia-like disease, and that plus its high infectivity have made it a potential biological weapon.

Rickettsia
Obligate intracellular parasites that belong to the bacteria but must be grown in living cells like viruses. They cause such diseases as typhus (*R. prowazekii*), transmitted to humans primarily by lice, and Rocky Mountain spotted fever (*R. rickettsii*), transmitted to humans by various ticks. Symptoms include severe headache, fever and general body malaise. Characteristic is the appearance of a rash in both cases. Untreated, the mortality rate of typhus ranges from 6%-30%. Untreated typhus can involve damage to the central nervous system, lungs, kidneys and heart. Severe manifestations of Rocky Mountain spotted fever may involve the respiratory system, the central nervous system and the kidneys. Both diseases can be effectively treated with antibiotics, but in the case of Rocky Mountain spotted fever, even treated patients suffer a mortality rate of about 5%. Untreated there is a 30% mortality rate.

Risk communication
Risk communication is the process of providing society, or certain sectors of society, with information that serves to reduce anxiety and fear as well as provide suggestions for planning that will assist the public in responding appropriately to some crisis (or impending crisis) situation. It often involves multiple messages about the nature of risk or expressing concerns, opinions, or reactions to risk messages, or to legal and institutional arrangements for management. Typically the crisis situation has the potential to impact large groups of people

Retrovirus
A class of RNA viruses that can form double-stranded DNA copies of their genomes; the double-stranded DNA formed can integrate into chromosomal sites of an infected cell.

Review Conference
The large international meetings held on a five yearly basis to review the operation of the Biological and Toxin Weapons Convention, with a view to assuring that the purposes of its preamble and its provisions are being realised. Such reviews also take into account any new scientific and technological developments relevant to the Convention and help to ensure that it remains relevant and effective in an evolving world.

Review Conference Final Document
The substantive and procedural output of review conferences of the Biological and Toxin Weapons Convention are recorded in its Final Document. Traditionally, they are made up of a procedural report and a Final Declaration, which reflects relevant Additional Agreements. The Final Document of the Sixth Review Conference in 2006 also included a section on Decisions and Recommendations which, amongst other things, revised the mechanism for submitting Confidence-Building Measures, created the Implementation Support Unit and adopted a plan of action to increase the membership of the treaty.

Scheduled chemical
A chemical in one of three lists of toxic chemicals and their precursors annexed to the Chemical Weapons Convention. For the purpose of implementing the Convention, the three Schedules identify chemicals for the application of verification measures according to the provisions of the Verification Annex.

Severe Acute Respiratory Syndrome (SARS)
The syndrome caused by a coronavirus which provoked great concern when a disease outbreak spread rapidly around the world and required drastic coordinated international measures to bring it under control.

Signatory State
A country which has signed an international treaty or convention but not yet ratified it.

Smallpox
Disease caused by the virus *Variola major*, characterized by fever, headache, malaise, severe aching pains, and prostration with the manifestation of a pustular rash that leaves scars. In contrast to anthrax, smallpox can be spread readily from person to person through droplets or aerosols. Transmission by direct contact is also known. The mortality rate from the disease is about 30%. The vaccine against smallpox, vaccinia virus, is very effective. Even when administered within three to four days after exposure, the vaccine can prevent or significantly lessen the severity of smallpox symptoms. Viruses are not susceptible to antibiotics and at present time there are no anti-viral drugs currently approved for therapeutic treatment of smallpox. Variola major has been developed as a biological weapon in the past, but its potential for use as a biowarfare agent is considered low, because the disease has been eradicated since 1977 and the only known stocks are kept under tight security in just two facilities, the Centers for Disease Control and Prevention in the US, and at Vector in Russia. Nevertheless, some fear that there is a possibility for terrorists or military forces to obtain the virus, so it is still high on the list of potential biological weapons.

Spanish influenza 1918
The influenza outbreak that spread worldwide at the end of the First World War causing many millions of deaths.

Special Conference
A meeting held in 1994 at the request of States Parties to the Biological and Toxin Weapons Convention. It considered the work of the VEREX group and concluded that it might be possible (from a technical perspective) to verify the treaty. It created the Ad Hoc Group to negotiate a political framework for these verification measures.

Species diversity
The variety of species. The species level is generally regarded as the most appropriate way to consider the diversity among organisms.

States Parties
A country which has either deposited an instrument of ratification or an instrument of accession.

Synthetic Biology
This is a new science discipline combining the biological sciences and engineering order to design and assemble interacting genes into circuits in order to direct cells to perform new (for them uncharacteristic) tasks. It refers to both the design and fabrication of biological components and systems that do not already exist in the natural world, and the re-design and fabrication of existing biological systems.

Systems Biology
A relatively new field in biology that looks at interacting physiological systems in organisms and seeks to understand how all these different systems operate as a whole. It is an emerging field that is characterised by the application of quantitative theoretical methods and the tendency to take a global view of problems in biology.

Toxin
Non-living, poisonous substance produced by many types of living beings, including animals, plants and bacteria. Toxins cannot reproduce, and therefore cannot produce transmissible diseases; they only affect those individuals that have been directly exposed to them.

Transmissibility
The characteristic of being able to be transmitted or to spread from one person or place to another.

Tularaemia
A disease of wild animals caused by the bacterium *Francisella tularensis*. It can also cause disease in humans, particularly those in contact with wild animals. Symptoms vary based on mode of infection, but generally include fever, chills, joint and muscle pain, headache, weakness, and sometimes pneumonia. Individuals who develop pneumonic tularemia experience chest pain, bloody sputum, and difficultly breathing. The disease is easily cured by antibiotic treatment. A vaccine is currently under review by the US Food and Drug Administration.

United Nations Office for Disarmament Affairs
The part of the secretariat of the United Nations dedicated to dealing with disarmament and non-proliferation issues. Prior to the creation of the Implementation Support Unit in 2006, this office provided support for the Biological and Toxin Weapons Convention. The Geneva Branch of UN-ODA continues to house the Implementation Support Unit.

United Nations Security Council Resolution 1540
A unanimous resolution, adopted on 28 April 2004, under Chapter VII of the United Nations Charter, obliging States, *inter alia*, to refrain from supporting by any means non-State actors from developing, acquiring, manufacturing, possessing, transporting, transferring or using nuclear, chemical or biological weapons and their delivery systems.

Vector
An entity that acts as a ferry or vehicle to carry and deliver foreign genes to (cells of) organisms. Vectors in this sense may be viruses, bacteria or also artificial viruses. The term vector is also used to describe biting insects such as mosquitoes, fleas and ticks that carry and deliver infectious microorganisms to humans and animals.

VEREX
The Ad Hoc Group of Governmental Experts to identify and examine potential verification measures from a scientific and technical standpoint. It was created by the Third Review Conference of the Biological and Toxin Weapons Convention in 1991. It held four meetings between March 1992 and September 1993. The group concluded that it might be possible (from a technical perspective) to verify the treaty. It findings prompted States Parties to hold the 1994 Special Conference.

Viral haemorrhagic fever (VHF)
Viral haemorrhagic fever is actually a diverse group of human and animal illnesses caused by different groups of viruses. Examples of these viruses include Lassa fever virus (Arenaviridae); Crimean Congo haemorrhagic fever (CCHF) virus, Rift Valley fever (RVF) virus, the Hantavirus strain HFRS causing haemorrhagic fever with renal syndrome (all Bunyaviridae); Ebola and Marburg viruses (Filoviridae); and the dengue and yellow fever viruses (Flaviviridae). All of the viruses named here can cause severe, life threatening diseases characterized by fever and bleeding disorders, for which intensive supportive care may be required. At present either very limited or essentially no approved prophylactic or therapeutic measures such as vaccines and anti-viral drugs are available. Ribavirin, an anti-viral drug listed by the US Food and Drug Administration as an investigational new drug may be useful for treating Lassa fever, RVF, CCHF and HFRS. There is an effective vaccine against infection with the yellow fever virus. Approved, effective vaccines for other VHFs are not available, although some are in the experimental stage of development.

Yersina pestis
Causative agent of plague. The bacterial infection can manifest itself in three forms: bubonic, pneumonic and septicemic. The bubonic form is transmitted by the bite of a flea and travels to the lymphatics. Without treatment the mortality rate is about 50%. Several classes of antibiotics are effective in treating the infection. A vaccine is no longer available in the US. The pneumonic form is the most virulent and least common form, and is typically due to a secondary spread from advanced infection of an initial bubonic form. Primary pneumonic plague results from inhalation of aerosolized infective droplets and can be transmitted from human to human without involvement of fleas or animals. Untreated pneumonic plague has a very high case-fatality ratio.

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Contributors

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Ralf Trapp is a chemist and toxicologist by training. Between 1978 and 1992, he worked with the German Democratic Republic (GDR) Academy of Sciences, the Stockholm International Peace Research Institute (SIPRI), the Stiftung Wissenschaft und Politik Ebenhausen. He served as technical adviser on chemical weapons control for the GDR delegation and later for the German delegation to the Conference on Disarmament. Between 1993 and 2006, he held different senior positions at the Organisation for the Prohibition of Chemical Weapons (OPCW). Since 2006 he is an independent consultant on chemical and biological arms control, including legal coordinator of the European Union Joint Action on the BWC.

John M. Webb is Deputy Director and Professor, Australia India Institute, University of Melbourne. While Professor of Chemistry at Murdoch University in Perth, he taught and researched on aspects of non-proliferation of chemical weapons. From 2005 to early 2008, Professor Webb was based at the Australian High Commission in New Delhi as Counsellor (Education, Science and Training) with responsibilities that also included Nepal and Pakistan.
He holds postgraduate qualifications in science (Ph.D., California Institute of Technology and B.Sc. Hons., University of Sydney) and education (Diploma of Education, Murdoch University). In 1996 he was awarded the Medal of the Order of Australia for establishing collaborative research networks in Asia and for his research achievements in chemistry.

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