sipri Stockholm International Peace Research Institute

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BIOTECHNOLOGY AND THE FUTURE OF THE BIOLOGICAL AND TOXIN WEAPONS CONVENTION

Introduction

The spectre of the deliberate use of disease in war has long haunted humankind. The biological warfare threat became more realistic after the terrorist attacks against New York and Washington on 11 September 2001. Not only did the terrorists demonstrate that they were prepared to murder large numbers of people indiscriminately, they also exposed the vulnerability of many societies. The sense of vulnerability was increased by attacks in the United States with letters containing anthrax bacteria, which killed several people and infected many more. Against this background the Fifth Review Conference of the States Parties to the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (BTWC) convened in Geneva on 19 November 2001. One of its main tasks was to evaluate the functioning of the treaty in the light of scientific and technological developments. Biotechnology has expanded rapidly in the past three decades—offering the prospect of a better quality of life—but it can be applied to design new types of biological weapons (BW). This raises concern as to whether the BTWC is sufficiently comprehensive to cover these developments.

Biological warfare is the intentional use of disease-causing micro-organisms or other entities that can replicate themselves (e.g., viruses, infectious nucleic acids and prions) against humans, animals or plants for hostile purposes. It may also involve the use of toxins: poisonous substances produced by living organisms, including micro-organisms (e.g., botulinum toxin), plants (e.g., ricin derived from castor beans) and animals (e.g., snake venom). If they are utilized for warfare purpose, the synthetically manufactured counterparts of these toxins are biological weapons.

Biological agents have the potential to cause mass casualties: on any given day over 2 billion people may be seriously ill as the result of exposure to such agents. One-quarter of all deaths worldwide and about 50 per cent of all deaths in developing countries are attributed to infectious diseases. The lengthening of the human lifespan is largely due to the effective combating of infectious diseases.

BW may thus cause casualties of the order of magnitude of a nuclear weapon, although they will not destroy infrastructure, and the number of casualties depends on various factors. Through evolution humans have developed physiological defences against disease or have acquired immunity. War, famine, drought or natural disasters can weaken natural defences, increasing susceptibility to certain diseases, which can become epidemic. For example, Spanish Flu broke out in 1918, at the end of World War I, and ultimately caused more fatalities than the entire war effort.

Currently, the principal tool against biological warfare is the BTWC. Since its entry into force in 1975 there have been confirmed cases of material breaches as well as allegations of biological warfare. This has increased interest in adding verification and enforcement instruments to the BTWC. So far, efforts to strengthen it by adding a supplementary legally binding protocol have failed.

In addition to its intrinsic weakness the BTWC is challenged by developments in biotechnology and genetic engineering. It contains a comprehensive ban on the development, production and possession of BW, and its parties have reaffirmed the prohibition at periodic review conferences. Biotechnology and genetic engineering hold the promise of improving the quality of life, but such knowledge can easily be converted to hostile purposes—to improve the stability and virulence of existing warfare agents or to create new agents based on components of an organism. This fact sheet explores the impact of technological development on the BTWC and the opportunities for verifying the convention.

It was prepared by Dr Jean Pascal Zanders, Head of the SIPRI Chemical and Biological Warfare Project; John Hart, SIPRI Researcher; and Frida Kuhlau, SIPRI Intern. It was edited by Jetta Gilligan Borg.

Adam Daniel Rotfeld
Director of SIPRI

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A brief history of biological warfare

Early biological warfare

Biological warfare may be almost as old as civilization. Until the end of the 19th century BW, as thought of today, were inconceivable because the propagation of disease was not understood. Consequently, there were no carriers (vectors) to manipulate. In antiquity, it was believed that epidemics were caused by bad odours emanating from the soil. This understanding of disease may have afforded military advantage by drawing the enemy into areas known to be particularly infectious in certain seasons.

Thucydides, for example, relates how the Athenians were forced to break their siege of Syracuse on Sicily after having suffered virulent epidemics during two consecutive summers. The Syracusians had reportedly succeeded in drawing the Athenians into the nearby disease-ridden marshes during the summer and autumn using the ruse of negotiating their surrender. Since it is likely that the defenders knew when they had to avoid the marshes, they may have exploited the inherent properties of living organisms to their military advantage. This suggests that a civilization will exploit nature to its advantage consistent with the way it understands it.

Until the early 20th century armies habitually lost more personnel to disease than to combat. The knowledge that disease can ravage even strong armed forces led to the practice of dumping animal carcasses in water supplies and the catapulting of corpses into besieged cities. These practices were fairly widespread during antiquity, the Middle Ages and the Renaissance. It has been suggested that the 14th century plague epidemic in Europe was caused in this way.

In 1346 Mongol forces allegedly catapulted plague-infested cadavers into the Genoese city of Caffa (now Feodosia) in the Crimea. No first-hand accounts of events inside Caffa exist, but the fleeing inhabitants carried the disease westward from one trading post to another to the Mediterranean. (The disease may also have been caused naturally by the transfer of the bacteria by fleas from rodents to the weakened inhabitants of Caffa.) During the 1861–65 US Civil War dead animals were used to pollute drinking water.

The emerging understanding of disease

In the 18th century there was growing understanding of disease as an unhealthy condition of the body. The causes of disease and many forms of propagation remained obscure, but the understanding led to the use of disease to attack opposing forces in the knowledge that one's own troops were less likely to suffer the same consequences. The European colonists observed during their exploration and occupation of the Americas that many Indian civilizations were virtually eradicated after their interactions.

There are several reports of the deliberate use of smallpox and other diseases as a means of warfare by all parties (including the British, the French and the Indians) during the wars in North America.

The new understanding of disease enabled its conscious manipulation for warfare purposes. (Biological warfare previously consisted of polluting the environment.) It also contributed significantly to health protection. Disease prevention took an important qualitative step with the development of a smallpox vaccine in 1798 (previously a process of inoculation was used whereby 'matter' from a person suffering a mild smallpox attack was transferred to a healthy person). The dual-use potential of knowledge and information, today an important component of the BW proliferation threat, was thus evident.

Another aspect of the dual-use potential of health research manifested itself during the American War of Independence (1775–83). British troops, who had been vaccinated against smallpox, enjoyed an important strategic advantage for several years until George Washington ordered his troops to be vaccinated. Health protection became a major factor in winning military campaigns.

By 1914 microbiology had advanced considerably: major bacterial diseases had been isolated and cultivated; the existence of viral diseases had been discovered (although the pathogens were not well understood); and parasitic diseases were being studied. There was an improved understanding of disease transmission, which also contributed to better prophylaxis, prevention and countermeasures. The insights and new techniques were applied for hostile purposes in World War I, although the sabotage operations were not directed against humans.

German operatives inoculated horses and livestock destined for the war fronts with anthrax and glanders in the USA. There were several other Allied allegations of German sabotage operations with biological agents, but the evidence is inconclusive.

During the period between the two world wars (1918–39) the first apprehensions about BW programmes were expressed. The better understanding of disease transmission in the 1920s and 1930s and the experience of the Spanish Flu epidemic at the end of World War I increased concern

about biological warfare. Based on faulty intelligence and fear of vulnerability, several countries—including France, Germany and the United Kingdom—began to consider the feasibility of biological warfare and the suitability of certain pathogens for weaponization.

Germany's research and development (R&D) was uncoordinated throughout World War II and did not result in a usable biological weapon. However, Canada, the UK and the USA pooled their resources in what was to become a major BW R&D programme. Apart from a limited British retaliatory capability to infect German cattle with anthrax, the Allies produced no operational offensive BW before the end of the war.

Japan was the only country with a dedicated long-term offensive BW programme. Its R&D of agents and dissemination devices began in the early 1930s and lasted until the end of World War II. Although Japan conducted human experiments and tested BW during military operations in China and against Soviet troops, it made no more progress than the Allies. The USA also granted the head of the Japanese BW programme immunity from prosecution for war crimes in hope of gaining more detailed information.

Developments after World War II

After World War II the Soviet Union and the USA (and, initially, also the UK) were the principal states continuing R&D and production of offensive BW. The USA formally halted its programme in 1969 and proceeded to destroy its existing BW stockpiles. This helped to pave the way for the 1972 BTWC. The USSR did not reciprocate and accelerated its BW armament programme despite the fact that it is one of the three co-depositaries of the BTWC (with the UK and the USA). The programme survived the 1991 breakup of the Soviet Union. Despite assurances by the Russian leadership, there remains considerable doubt as to whether Russia has terminated all of the activities prohibited under the BTWC.

After World War II most second-tier powers in Europe gradually abandoned their offensive BW programmes as they joined military alliances—the North Atlantic Treaty Organization (NATO) and the Warsaw Treaty Organization (WTO)—and relied on the respective nuclear deterrents for their security. Nevertheless, many of these countries continue to work on biological defence, protection and prophylaxis. These activities are expressly permitted by the BTWC.

Few countries other than those that had begun BW-related investigations during the inter-war years are known to have started new biological warfare programmes, but several of these countries are located in the highly volatile Middle East region. Concerns about such activities were significantly heightened in the 1990s. After the 1991 Persian Gulf War, international inspections by the United Nations Special Commission on Iraq (UNSCOM) revealed the advanced and extensive nature of Iraq's BW programmes. Iraq continues its efforts to retain its biological warfare capability, which has resulted in the loss of billions of dollars in oil revenue under UN-imposed sanctions as a consequence.

The list of countries with a chemical or biological warfare programme changes continuously, and it is difficult to make firm statements about which countries possess such weapons. Claims of proliferation may refer to a past programme or an allegation of use made decades ago.

Nevertheless, there is a degree of consensus about the identity of the chemical and biological weapon (CBW) proliferators. There is greater uncertainty about whether the programmes are offensive or defensive and about their level of sophistication. It is also unclear at what point a country should be considered a CBW state. The criteria to be considered include: if it has the scientific, technological and industrial base to support a CBW programme; if it has an R&D programme; if it produces or stockpiles CW and BW; if its armed forces possess deployable CW and BW; or if there is clear evidence that such weapons have been assimilated into military doctrine. The criteria by which a state is judged may differ from country to country. A country which has an antagonistic relationship with the state making the intelligence assessment is at greater risk of being deemed a proliferator than one which enjoys a friendly relationship. The perceived intent of a state is a major subjective component of threat assessment.

Recent US proliferation analyses have listed 20 to 25 countries that have or may be developing nuclear, biological, or chemical (NBC) weapons or their missile delivery systems. As the figures now usually comprise four categories of weapons, it has become more difficult to isolate the CBW component. The 1997 edition of the US Department of Defense publication ***Proliferation: Threat and Response*** listed seven countries as having a BW programme: China, India, Iran, Iraq, North Korea, Pakistan and Russia. Several countries are conspicuously absent from these lists. Egypt, Israel, South Korea and Taiwan were not included although they were named in the August 1993 Office of Technology Assessment report ***Proliferation of***

Weapons of Mass Destruction: Assessing the Risks.

In the opening plenary session of the Fifth Review Conference of the BTWC, on 19 November 2001, the USA publicly accused Iran, Iraq, North Korea, Libya, Sudan and Syria of having offensive BW programmes. It also stated that there were several other proliferators but refused to name them.

The Biological and Toxin Weapons Convention

The first international agreement to focus on BW was the 1925 Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (Geneva Protocol). It does not address the issue of BW development, production and storage nor does it contain a verification mechanism. In the 1930s disarmament negotiations under the auspices of the League of Nations failed, and the subject of BW disarmament remained dormant until the late 1960s, when the extensive use of anti-plant and riot-control agents in the Viet Nam War prompted the UN General Assembly to take up the question of CBW disarmament.

The current regime against BW consists of several legal instruments. At the heart of this regime is the BTWC. The Geneva Protocol remains relevant, since the BTWC does not explicitly prohibit the ***use*** of BW in armed conflict. Since the entry into force of the BTWC in 1975 the understanding that BW cannot be used under any circumstances has gained strength as many states have withdrawn their reservations to the Geneva Protocol with respect to the use of BW.

The continued relevance of the Geneva Protocol to the BW regime was also enhanced by UN General Assembly Resolution A/RES/42/37 of 30 November 1987. It empowers the Secretary-General 'to carry out investigations in response to reports that may be brought to his attention by any Member State concerning the possible use of chemical and bacteriological (biological) or toxin weapons that may constitute a violation of the 1925 Geneva Protocol or other relevant rules of customary international law in order to ascertain the facts of the matter, and to report promptly the results of any such investigation to all Member States'. The resolution was adopted in the light of the many allegations of chemical warfare in the 1980–88 Iraq–Iran War and the perceived need for the UN Secretary-General to authorize the investigation of these allegations without formal backing by the Security Council.

Toxin weapons are also covered by the 1993 Chemical Weapons Convention (CWC), which entered into force on 29 April 1997. The CWC contains extensive verification provisions and restrictions on the transfer of such agents.

The strengths and weaknesses of the BTWC

The BTWC was opened for signature on 10 April 1972 and entered into force on 26 March 1975. As of November 2001, 144 states have ratified or acceded to the BTWC, and another 18 states have signed but not ratified the convention.

The BTWC is a weak treaty because it lacks verification and enforcement mechanisms. A transparency mechanism establishing a monitoring regime was rejected by the USA in the summer of 2001 because it would negatively affect US national interests.

Despite this inherent weakness the BTWC encompasses a comprehensive prohibition on preparation for biological warfare. At the heart of the BTWC regime lies the obligation of Article I, which specifies that states parties cannot acquire or retain BW under any circumstances. The Fourth Review Conference of States Parties, held in 1996, formally expanded the interpretation of this article to cover BW use. The negative security guarantee is reinforced by the requirement in Article II to destroy or divert all BW to peaceful uses and by the non-proliferation provision of Article III. The value of these guarantees is limited by the absence of verification instruments.

The BTWC contains tools to deal with compliance concerns. Under Article V parties may consult and cooperate with each other to resolve an issue or may undertake to resolve the concern through appropriate international procedures within the framework of the UN and in accordance with its Charter. The Third Review Conference of the BTWC (1991) adopted a procedure to strengthen Article V.

Another cornerstone of the BTWC is Article X. It gives the parties the right to participate in the fullest possible exchange of equipment, materials, and scientific and technological information of relevance to the convention for peaceful purposes and encourages the parties to facilitate such exchanges. Article X also orders the parties to implement the BTWC so that the economic or technological development of the parties is not hampered. The implementation of Article X has become more contentious because biotechnology plays an increasingly dominant role in economic and societal development but may also make it easier for a state to acquire an offensive biological warfare capability or to

develop novel types of agents. The export controls imposed by a number of industrialized states to prevent BW proliferation are viewed by some developing countries as discriminatory and a violation of the obligation not to hamper their economic or technological development.

Despite its intrinsic weaknesses the BTWC has been able to retain its relevance through the periodic review conferences, at which the parties interpret the treaty provisions in the light of political and technological developments or try to devise mechanisms to enhance confidence in the treaty.

Review conferences

The BTWC, which is of unlimited duration, specifies in Article XII that a review conference of the states parties was to be held within five years after entry into force. The First Review Conference took place in 1980. The Second Review Conference was held in 1986, and since then review conferences have been held at five-year intervals. The parties review the operation of the treaty in order to ensure that the purposes of the treaty are being realized, taking into account relevant new scientific and technological developments.

The review process has reaffirmed the applicability of the core prohibition of Article I to the rapid developments and discoveries in the field of biotechnology. A major breakthrough in genetic engineering was reported shortly after the conclusion of the negotiation of the BTWC; since then biotechnological products, applications and processes have multiplied exponentially. Concern has grown that the new techniques could be applied for non-peaceful purposes. The information about the genetic manipulation of pathogens that was revealed by some senior scientists in the BW programme of the former Soviet Union who defected to the West underscores the need to continuously revisit and maintain the effectiveness of the core prohibition of the BTWC.

The absence of verification measures was highlighted in 1979 by the outbreak of anthrax near Sverdlovsk (now Yekaterinburg), which the West attributed to a prohibited Soviet military programme, as well as by US claims that Soviet client states were waging biological warfare in South-East Asia. In 1992 President Boris Yeltsin all but acknowledged that the former Soviet Union, despite the fact that it is a co-depositary of the BTWC, had continued an offensive BW programme. Serious concern continues to exist about Russia's compliance with the convention. The trilateral investigation exercises, which were agreed by the three co-depositaries of the BTWC, have ceased, thus leaving unresolved suspicion of Russian non-compliance. After the Gulf War, UNSCOM uncovered an extensive Iraqi offensive BW programme. These findings proved the reality of BW proliferation. The March 1995 nerve agent attacks in the Tokyo underground and the subsequent realization that the religious sect responsible for them was also seeking to acquire BW have heightened awareness of proliferation to sub-state actors.

The review conferences have attempted to increase the transparency of activities relevant to the BTWC on a voluntary basis. During the Second Review Conference the states parties agreed on annual data exchanges to serve as confidence-building measures (CBMs). However, participation in these politically binding CBMs and transparency-building measures has been limited and in most cases is not systematic.

VEREX

The demonstrated inadequacy of the voluntary CBMs prompted the 1991 Third Review Conference to create the Ad Hoc Group of Governmental Experts to Identify and Examine Potential Verification Measures from a Scientific and Technical Standpoint (VEREX). The group met four times between March 1992 and September 1993. Its final report listed 21 measures, intended to provide the basis for promoting compliance with the BTWC.

In September 1994 a special conference of parties to the BTWC was held to consider the final VEREX report. The special conference decided that an Ad Hoc Group (AHG) of states parties should further develop such measures and consider the possibility of a legally binding instrument to strengthen the BTWC.

The Ad Hoc Group

Between January 1995 and August 2001, the AHG met in regular session 24 times and elaborated a draft protocol text which eventually contained over 200 pages. Initially, the AHG was mandated only to further develop the potential verification measures identified by VEREX and to explore the possibility of creating a legally binding instrument to strengthen the BTWC. After the Fourth Review Conference, in 1996, the AHG received a mandate to negotiate the legally binding instrument (the BTWC protocol) and was requested to complete its work before the Fifth Review Conference (19 November to 7 December 2001). In the summer of 2001, the USA formally rejected the draft protocol. Its principal objections were that the verification provisions were weak, the measures to protect

confidential business information and other sensitive information were inadequate, and the implementation of national export controls and informal export control arrangements (e.g., the Australia Group) could be hindered by participation in the BTWC protocol. As a consequence of the US action, it is unlikely that agreement on a protocol will be reached in the near future.

The BTWC protocol, as envisaged by the AHG, would have been implemented by an Organization for the Prohibition of Biological Weapons (OPBW). Confidence in compliance would have been generated by means of declarations, visits and investigations. The parties to the BTWC protocol would have been required to submit both an initial and annual declarations on their BW programmes. In the initial declaration, parties would have had to provide information on past offensive and defensive BW programmes. Annual declarations were to have included information on:

- national biological defence programme(s) and/or activities against bacteriological (biological) and toxin weapons conducted in the previous year;
- certain maximum-biological, high-biological and plant-pathogen containment facilities that work with pathogens or toxins listed in the protocol; and
- certain production facilities.

Since biological agents can usually be grown quickly over a short period of time using small initial quantities, basing declarations on quantitative thresholds is of limited value. Partly for this reason the protocol was structured with a view to ascertaining the capabilities of a party, as opposed to quantitative declaration thresholds.

Potential BTWC verification measures

Off-site measures

- Information monitoring: surveillance of publications and legislation; data on transfers and transfer requests and on production; multilateral information sharing; and exchange visits
- Data exchange: declarations, including notifications, data on transfers and transfer requests and on production
- Remote sensing: surveillance by satellite and aircraft; and ground-based surveillance
- Inspections: sampling and identification; observation; and auditing

On-site measures

- Exchange visits: international agreements
- Inspections: interviewing; visual inspections, including observation and surveillance by aircraft; identification of key equipment; auditing; sampling and identification; and medical examination
- Continuous monitoring: By instruments, including ground-based surveillance; and by personnel

The text envisaged three types of visit by inspectors to protocol-relevant sites: randomly selected transparency visits, voluntary assistance visits and declaration clarification procedures. The main purpose of these on-site visits was to ensure the completeness and correctness of the submitted declarations, and hence to generate confidence in the compliance of the other parties. Under the AHG chairman's composite text the OPBW would have conducted a maximum of 120 randomly selected transparency visits each year with a maximum of 7 visits per country. The draft protocol also provided for two types of investigation to address cases of suspected non-compliance: field and facility investigations. Investigation-related provisions dealing with the timing, degree of access and procedures for the Executive Council of the OPBW to allow or disallow an investigation were complicated and never fully resolved. The tension between the non-proliferation obligation in Article III of the BTWC and the right to technology transfers under Article X was constantly present during the negotiation of the projected protocol.

Each party would have been required to provide the Technical Secretariat of the OPBW with information on its domestic implementing legislation and other regulations governing the transfer of agents, toxins, equipment and technologies relevant to Article III of the BTWC. The transfer guidelines would have been essentially voluntary. They would have required end-user certificates, written commitments by receiving parties not to retransfer the specified items, and information on the receiving party's laws and regulations. The guidelines would also have been restricted to certain types of equipment, such as 'fermentors or bioreactors designed to prevent the release of aerosols with a total internal volume of 100 litres or more' or 'aerosol analytical equipment designed to determine the size of aerosol particles up to 20 microns in diameter that contain micro-organisms or toxins'. In addition

to transfer guidelines, Article VII contained provisions for voluntary notifications among parties of aggregate data on certain exports or authorizations for export of selected equipment for prophylactic, protective or other peaceful purposes in order to promote transparency and act as a CBM among parties.

With respect to scientific and technological exchange for peaceful purposes and technical cooperation, parties would have been required to promote and support a list of activities.

In order to avoid hampering economic and technological development, parties to the protocol would have had to ensure that, individually or collectively, they did not take discriminatory measures that are incompatible with the obligations of the BTWC. The draft protocol envisaged the establishment of a cooperation committee within the OPBW to oversee the implementation of Article X of the BTWC. This initiative was highly controversial.

The protocol was negotiated as a confidence-building regime designed to enhance transparency, not as a verification regime. This was done for a number of reasons, including a desire by many delegations to protect confidential business information, doubts that compliance could be definitively and consistently demonstrated by a single on-site inspection, and the dual-use nature of many of the treaty-relevant technologies that can, in principle, be used for both peaceful and non-peaceful purposes.

Issues in biotechnology

Biotechnology may be broadly defined as any technique that uses living organisms (or parts of organisms) to make or modify products, improve plants or animals, or develop micro-organisms for specific uses. In the narrow sense of the industrial use of recombinant deoxyribonucleic acid (rDNA), cell fusion and novel bioprocessing techniques, its history goes back less than three decades.

In 1973 the first gene was cloned; three years later Genentech, the first company to exploit technology based on rDNA, was founded in the USA. In a move that would prove to have a major impact on the creation of a verification regime for the BTWC, the US Supreme Court ruled in 1980 that micro-organisms may be patented. The same year the first patent for the construction of rDNA was awarded to Genentech. The Federal Republic of Germany and the UK targeted biotechnology for R&D in 1980, followed by Japan in 1981. By the end of 1981, more than 80 biotechnology companies had been established worldwide.

In 1982 the first animal vaccine and pharmaceutical product (human insulin) based on rDNA technology was approved for use in Europe and the USA. Since then, the number of companies and the range of technologies being explored and applied has increased dramatically.

Examples of biotechnology

Enabling technologies

- Automated sequencing
- Bioinformatics: storage and analysis
- Combinational chemistry and high throughput screening
- DNA/protein chips

Technological application

- Medicine: vaccines and treatment such as gene therapy
- Agriculture: biocontrol and plant innoculants
- Bioremediation
- Industrial production
- Defence: protection and detection

The biotechnology revolution has continued along two main lines: genomics and proteomics. Rapid DNA sequencing technology laid the foundation for genomics. The genome is the total genetic material possessed by an individual organism. Each cell contains a complete copy of the genome, which consists of chromosomes that, in turn, contain genes. Genomic information can be extracted from the cells of organisms and then analysed and catalogued.

Proteomics is the systematic analysis of the protein expression of healthy and diseased tissues. The proteome is the complete profile of proteins expressed in a given tissue, cell or biological system at a given time. Proteins are any of a very large group of complex combinations of amino acids. They are basic constituents of living organisms and are necessary for the chemical processes carried out by them.

Genome sequencing projects are providing insight into amino acid sequences, although full knowledge of their structure and processes is required to understand the biological role of proteins. This will, in turn, improve the understanding of disease. Protein therapy will probably play

an important part in the future treatment of disease. Because protein therapy can specifically target diseased cells or tissue, the destruction of healthy cells or tissue can be prevented.

Genomics and proteomics are powerful experimental and modelling techniques that enable the modification of living organisms and their products in precise and predictable ways. They also enable small molecules to be designed to interact in specific ways with proteins in order to predictably alter their functioning.

The potential application of biotechnology for biological warfare

The core of the future biological warfare threat will probably not consist of large weapon stockpiles. It will more likely be the capability to produce warfare agents (and their antidotes or prophylaxis) on a large scale in a short time frame or in a crisis. Biotechnology may improve biological warfare capabilities through product and process improvements. Product improvements may involve the genetic modification of pathogens or the creation of novel agents and vectors, as well as the development of new equipment for analysis and production. Process improvements relate to the way in which the agents are manufactured. Optimization of production processes could lead to the manufacture of larger batches in a shorter period of time or to the use of smaller, less conspicuous equipment (such as fermentors), which would make it easier to hide a BW programme in legitimate installations and activities. Examples of activities include:

- Existing pathogens could be modified by genetic engineering to make them more virulent or more resistant to known drugs, vaccines and therapies; to make their effects more predictable and controllable; or to render them more resistant to environmental stresses (e.g., ultraviolet radiation, meteorological conditions, explosive shock of the munition) after their release into the atmosphere.
- The large-scale production of certain agents (especially toxins) that were previously difficult to acquire would be possible. In particular, micro-organisms could be genetically altered to produce toxins or bioregulators.
- Modification of antigenic properties could impede the immune defence mechanism of an organism. This could also make detection and identification of the agent by immunological diagnostic tests more difficult, if not impossible.
- Genomic information could be exploited to specifically target certain genetic properties of an organism using, for example, the techniques of gene therapy.

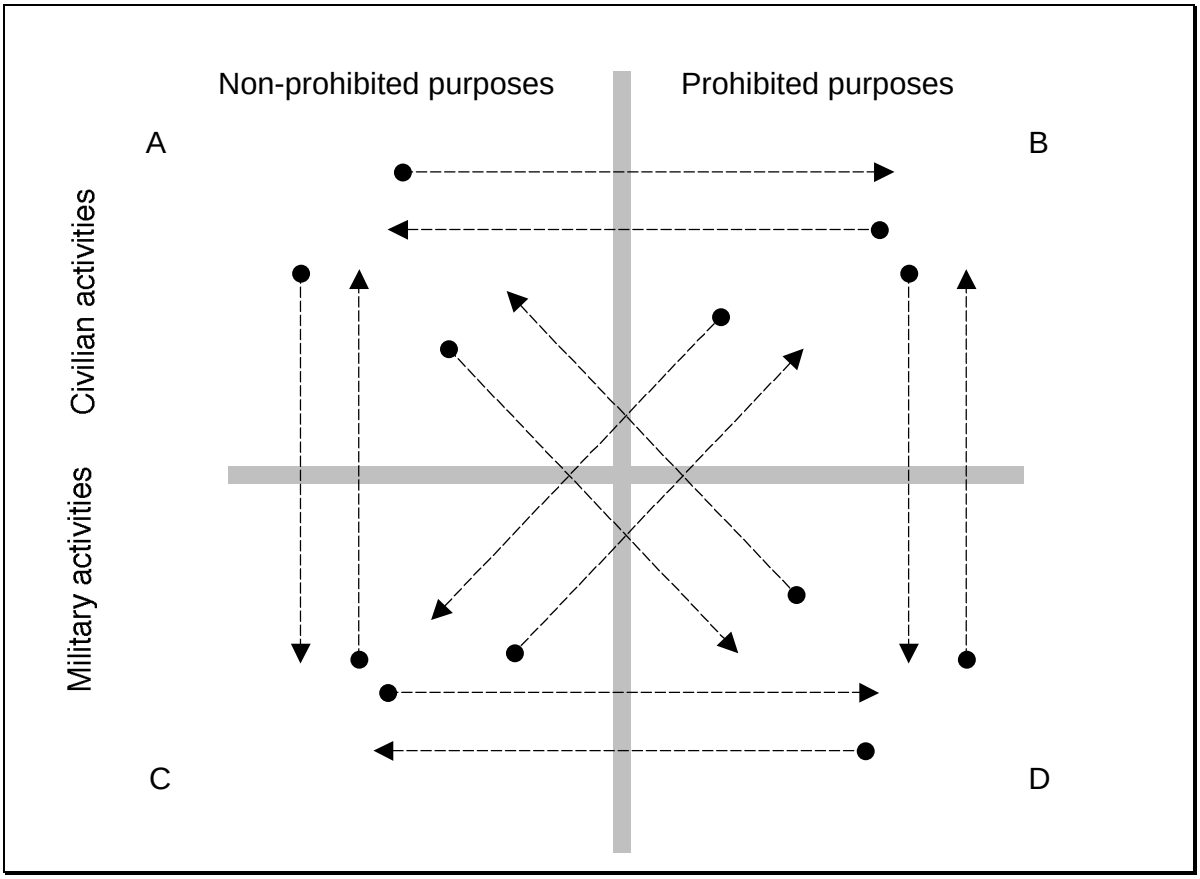
R&D in biotechnology leads to many ‘enabling technologies’, which lay the foundation for future process and product improvements. Of particular importance today are the automation of sequencing in genome projects; bioinformatics, which contributes greatly to the storage and analysis of research data; and the advances in combinational chemistry and high throughput screening of compounds.

Many of these products and processes are being researched and developed for civilian application in medicine, pharmaceuticals and agriculture as well as for purposes that are deemed legitimate under the BTWC (i.e., defence, detection, protection and prophylaxis). However, their investigation also generates considerable knowledge about the potential offensive use of certain substances to interfere with the biological processes in humans, animals and plants. In certain cases, the offensive properties of known or potential biological warfare agents are being actively investigated in order to develop adequate defensive technologies and procedures. Such activities raise the question whether they are permissible under the BTWC. The answer depends on the intention of the state conducting an R&D programme. Transparency may be the key. Secrecy will arouse suspicion about the nature of such programmes.

The dual-use potential of technology

The dual-use potential of most of the technology involved in the R&D and the production of BW complicates the verification of activities relevant to the BTWC. Biotechnology is applied commercially every day. In arms control and disarmament studies ‘dual use’ means that technology intended for civilian application can also be used for military purposes (spin-on) or vice versa (spin-off). However, the development of a verification and control regime for dual-use technology requires a fuller understanding of the concept.

Technology involves more than products; it also encompasses the means to conceptualize and produce the products in response to a particular technical problem and the ability to use them in an effective way to solve the problem. Technology can be defined as comprising ‘the ability to recognize technical problems, the ability to develop new concepts and tangible solutions to technical problems, the concepts and tangibles developed to solve technical problems, and the ability to exploit the concepts and tangibles in an effective way’. It involves not only materials and objects,



but also capital, knowledge and skills as well as principles, techniques and systems for the management of R&D and production processes.

Dual-use technology is technology that 'has current or potential military and civilian applications'. A dual-use transfer occurs whenever a technology is used for a civilian or military purpose that differs from the purpose which was originally envisaged. This transfer may take place inside an economic unit (e.g., a research institute or a company) or between economic units (e.g., after a sale).

Most of the technologies required for the manufacture of BW have important legitimate civilian applications. The convention uses the 'general purpose criterion' (GPC) to distinguish between the legitimate and prohibited application of technology: parties to the BTWC can never under any circumstances develop, produce, stockpile or otherwise acquire or retain biological agents ***for purposes other than prophylaxis, protection or other peaceful uses***. The convention also orders the destruction of existing biological warfare agents, delivery systems and other equipment or their diversion to peaceful purposes, and prohibits the transfer of BW-relevant technologies to any recipient if they are intended for purposes prohibited by the convention. In other words, the purposes for which they may be applied are prohibited, not the technologies themselves. The BTWC identifies certain purposes that are exempt from the ban on BW. Consequently, dual-use transfers are only permitted for uses not prohibited by it.

The dual-use concept is often understood in the context of spin-on and spin-off effects. Under the BTWC, however, the differentiation between prohibited and non-prohibited purposes does not equal the distinction between civilian and military activities regarding dual-use technology transfers. In the light of the fact that many of the civilian and most of the military permitted purposes are related to BW defence, protection and prophylaxis, the issue of technology transfer becomes two-dimensional (see figure).

The BTWC prohibits all technology transfers from the left to the right side of the figure and between quadrants B and D under all circumstances. Technology transfers from B and D to either A or C are permitted only

once: for the conversion of BW-related technologies and installations to non-prohibited purposes. The 'window of opportunity' is limited: according to Article II of the BTWC such conversion should take place as soon as possible, but not later than nine months after entry into force of the convention. Because the BTWC does not make a formal distinction between civilian and military activities, it does not constrain technology transfers between quadrants A and C as they serve the specified non-prohibited purposes. The dual-use potential of the technologies in these civilian and military activities may be exploited to the fullest. Advances in the civilian sector can benefit the goal of improved defence, protection and prophylaxis, while some of the research and products from the military sector can serve society as a whole.

The real challenge for a future BTWC verification and monitoring regime lies in the fact that many beneficial technologies developed in quadrants A and C can be directly applied in offensive BW programmes or involve the study of the offensive aspects of biological warfare. While this realization of the dual-use potential of the relevant technologies may not be realized currently, the resort to 'off-the-shelf' technology to quickly acquire BW in a future conflict is not unthinkable.

Furthermore, as was noted in the historical example of the American War of Independence, dominance in BW defence may grant a military force significant advantages over its opponents. Because such a force will be less deterred by natural or deliberate disease, a unilateral advance in BW defence might increase the likelihood of armed intervention in order to resolve political conflicts. The growing importance of BW defence may also lead to an arms competition in this field, which would decrease the willingness of states to participate in a future BW verification regime or share their technologies with other countries.

Preventing the misuse of biotechnology

Technology developments relevant to the BTWC pose a significant challenge to both the convention and its future verification and monitoring regime. In the post-cold war era, with its increased attention on proliferation, the concept of verification needs to be expanded or reconsidered. Depending on the type of treaty, verification mechanisms are traditionally tailored to certify the absence or presence of treaty-controlled items and their destruction, if required. Verification mechanisms can be included to monitor the use or consumption of goods that may pose a threat to the treaty objectives.

Under a future BTWC regime verification will have to focus on keeping technology transfers as transparent as possible, thereby building confidence. Intangible technologies—data collection and processing, knowledge, techniques and skills—are central to the biotechnological revolution. Only minute amounts of pathogens, genetic materials or other cell components are needed to start R&D and production of BW. Therefore, it is unlikely that a material-balance accounting mechanism, like the one used under the nuclear safeguards system, can be adapted to monitor BTWC-relevant transfers. (The model has proven problematic under the CWC.)

Proliferation studies focus principally on the patterns of transfer of tangible objects, such as agents and equipment, and the threat of the immediate realization of the dual-use potential of these objects (i.e., the acquisition by recipient countries or sub-state actors of technology developed for civilian use and its application for the purpose of acquiring BW).

Biotechnology produces enabling technologies for many civilian applications that contribute to information accumulation and improvement of products and processes. Information influences the society in which the development takes place, but it also spreads across national borders. While lateral proliferation processes are undeniably taking place, the greatest challenge to the future BTWC regime may come from massive application of civilian biotechnology for the purpose of acquiring a biological warfare capability by a state facing a security threat.

If future verification or monitoring tools to the BTWC are to remain relevant, it will require mechanisms to deal with such a possibility. In addition to verification and monitoring of the destruction and non-production of BW in states parties, a future verification regime will have to incorporate an understanding of biotechnology and technology transfer processes that goes beyond products. Technology transfers between economic units within a state and between economic units across national boundaries must become transparent. All economic units involved in a transaction will share the responsibility of ensuring that the dual-use potential of the technologies is not realized, and such a commitment will become a key component for granting transfer licences.

The principle also applies to scientific and student exchanges as in-depth background knowledge will enhance the transparency of the activities of insti-

tutes and individuals. The national authorities and international organization which will be necessary under any future verification and transparency mechanism will monitor the transparency of relevant technology transfers. This mechanism of shared responsibilities between suppliers and recipients can facilitate assistance to countries because confidence in compliance will grow, while making it harder for countries or terrorist organizations to acquire BW-relevant technologies.

This set of tools will have to be supplemented with extensive positive security guarantees in order to reduce the disproportionate military advantage a party might gain by 'defecting' from the treaty. Such guarantees do not solely entail the right of access to assistance and protection (subject to the transparency conditions outlined above), but also involve dynamic decision-making procedures in order to be able to respond swiftly and decisively to a rapidly developing crisis. If adequately implemented, the mechanisms to enhance the transparency of technology transfers may provide sufficient warning of an impending massive transfer of civilian technology for prohibited purposes.

The greatest challenge to the BTWC may nevertheless come from the novel conceptualization of disease offered by biotechnology. The historical overview in this fact sheet illustrates how humankind has been able to exploit nature to its advantage in ways that are consistent with its conception of nature. The use of disease moved from luring an opponent into a diseased area to the pollution of the environment. Once it was understood that it was a physiological condition, disease was deliberately transferred using vectors (e.g., blankets that had been in contact with a diseased person). After the causative agents had been identified, bacteria and viruses became possible weapons of war. This pathogen-based understanding of disease forms the foundation of the way in which the norm against biological warfare was formulated in the 20th century. The notion of bacterial warfare in the Geneva Protocol (viruses were still not well understood in 1925) was expanded to biological and toxin warfare in the BTWC (which also covers fungi, rickettsia, etc.). The novel conceptualization of disease follows from the focus of biotechnology on chemical and genetic actions and other processes on the sub-cell level. Future warfare agents may not just be pathogens that were genetically or chemically modified to enhance virulence, stability or resistance to environmental stress after release, but also parts of genetic code or biochemical materials that are directed to interfere with specific biological processes inside a cell. Some agents may also be designed to degrade the immunological defences of an organism rather than to cause disease directly. Combined with new vectoring technologies that can accurately deliver the warfare agent to the correct part of the cell biological warfare may become too attractive for states to resist.

In order to take account of biotechnological developments, the various review conferences have expanded the understanding of the core prohibition in Article I of the BTWC to address new products and processes. However, biotechnology is expanding rapidly and moving into associated fields (such as combinational chemistry and informatics), and soon the addition of new technologies and processes to the understanding of the norm will not suffice. Biotechnological innovation is currently advancing so quickly that the five-year interval between the review conferences is too long a period to keep the key prohibition sufficiently updated. In this way, the biotechnological revolution may create loopholes in the ban on BW and provide opportunities for novel weapon developments. As a consequence, if humankind is to be prevented from exploiting this new conceptualization of disease for hostile purposes the need may soon arise to reformulate the core prohibition of the BTWC in order to keep it relevant in the coming decades.

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Stockholm International Peace Research Institute
Signalistgatan 9, SE-169 70 Solna, Sweden
Telephone +46 8/655 97 00 Telefax +46 8/655 97 33
Email: sipri@sipri.org
Internet URL: http://www.sipri.org