

In Press: M.I. Chevrier, K. Chomiczewski, M.R. Dando, H. Garrigue, G. Granasztai and G.S. Pearson, editors. *The Implementation of Legally Binding Measures to Strengthen the Biological and Toxin Weapons Convention*. ISO Press Amsterdam

A SHORT HISTORY OF BIOLOGICAL WARFARE AND WEAPONS

Mark Wheelis
University of California, Davis, California, USA

Introduction

Biological weapons have the potential to kill or incapacitate very large numbers of people, or to do crippling economic damage by killing crop plants or domestic animals. Historically, the diseases that accompanied the armies of expanding empires have been more effective tools of expansion than the armies themselves (1). Given the proven effectiveness of the inadvertent spread of disease and the potential effectiveness of deliberate use, it is surprising that biological weapons (BW) have not been more commonly used. Such use has occurred only a handful of times. A number of additional allegations, some more plausible than others, suggest that they may have been used somewhat more frequently than can be documented. Nevertheless, their use has clearly been quite rare relative to other categories of warfare.

Despite the rarity of actual use of bioweapons, a number of nations have had active programs of bioweapon development during the past century, and some may continue today (2). The probable existence of covert bioweapon programs in a highly unstable world is alarming; certainly the historical reluctance to use them provides scant basis for complacency.

Use Of Biological Weapons

In this section I discuss those instances in which the use of bioweapons by states is known or highly probable. In the subsequent section I deal with allegations that are unproven, or which appear false but remain politically important. I do not include the practice of contaminating wells with human or animal cadavers as instances of BW; most such instances are more likely to have been intended to prevent opponents from using the water, than to transmit disease. For a discussion of the ancient roots of biological weapons, see Mayor (3).

Hurling of biological material in siege warfare—Europe, 14th-15th centuries

Sporadic instances are recorded of the use of biological ammunition in medieval siege warfare (4). At Thun L'Eveque in Hainault (now northern France) in 1340, the material was dead horses and other animals. At Caffa in the Crimea in 1346 it was human plague cadavers. And at Karlstein in Bohemia in 1422 it was human battle casualties and waste of some kind—probably human and animal manure. The purpose was almost certainly to transmit disease. In medieval medical theory the stench of rotting organic material was thought to be a potent cause of disease. And in two of the three written records we have of these events, the victims interpreted the stench resulting from biological aggression as the cause of subsequent disease.

At least two of the biological attacks appear to have been tactically successful. At Thun L'Eveque the defenders reported that “the stink and air was so abominable, that they considered how that finally they could not long endure” and they negotiated a truce (and somewhat later abandoned the castle). And at Caffa a large number of the defenders came down with plague, and in fleeing Caffa helped transmit the disease around the Mediterranean basin initiating the Black Death. The Black Death would have spread from the Crimea throughout Mediterranean Europe in any case, given the great importance of maritime trade; but certainly plague-infected refugees from Caffa contributed.

BW at Karolstein appears to have been unsuccessful. An outbreak of disease was attributed to the biological attack, but was more likely scurvy or another deficiency disease. Nevertheless, the castle stood, and the siege was abandoned after five months.

None of the three events mentioned here is documented beyond any doubt. Nevertheless, three independent accounts attest to the medieval capacity to conceive of an effective biological weaponry, and it is likely that this form of BW was occasionally employed.

Biological attack on Native Americans—North America, 18th to 20th centuries

It was a matter of frequent observation on the American frontier that disease outbreaks, particularly of smallpox, were devastating to Native Americans. Some of these outbreaks might have been deliberately instigated. There are sporadic records of attempts to do so over 300 years of nearly continuous frontier warfare (4, 5).

The best documented event was at Fort Pitt on the Pennsylvania frontier in 1763. At the height of the Pontiac rebellion, Fort Pitt was besieged by a large force of Delaware. During a parlay, the British gave as a gift some blankets and handkerchiefs that were taken from smallpox patients in the infirmary. This event is established beyond any doubt; the fort commander entered in his ledger the cost of replacement of two blankets and two handkerchiefs “taken from people in the Hospital to Convey the Smallpox to the Indians.” At approximately the same time, smallpox broke out among the Native Americans, but the records are insufficiently reliable or detailed to establish a definite connection. There are sporadic other accounts from North and South America, but they are poorly documented and

sparsely detailed. It is hard to determine how frequent the practice was, but it appears to have been rare.

The last known incidents occurred from 1957 to 1965, when land speculators and corrupt agents of the Brazilian Indian Protective Service introduced smallpox, measles, influenza, and tuberculosis into the Native Americans of the Amazonian basin. For smallpox they used fomites, as had been done for centuries; however, for the other diseases they had ill whites make contact with the tribes.

We are as ignorant of the consequences of frontier BW as we are of its frequency. However, given the great susceptibility of Native Americans with little exposure to Eurasian diseases, it is likely that acts of biological aggression would often have been successful and have had significant effect.

Use of inoculation to transmit smallpox by the British during the American Revolutionary War

During the American Revolutionary War Britain apparently used smallpox as a biological weapon, possibly on several occasions (6). In the northern colonies, they are suspected on several occasions of inoculating civilians with smallpox with the intent that they would transmit the disease to the Continental Army. Deliberate inoculation with material from a smallpox pustule was a well-known protective measure; it gave the recipient a mild case of smallpox, with lower chance of death than natural transmission, and led to life-long immunity. However, the induced disease was as contagious as natural smallpox, and inoculated people were commonly quarantined until their symptoms abated.

At Boston, and perhaps Quebec, the British are thought to have used inoculation offensively—to intentionally produce disease. They routinely inoculated their own troops as a protective measure, but this was apparently extended to forced inoculation of civilians intending to leave the besieged cities. At Boston the attempt apparently failed; quarantine of refugees from the city contained smallpox before it infected troops. However, if the same thing was done at Quebec, it may have been quite successful; the combination of smallpox and winter weather forced the Continental Army to abandon the siege and retreat.

In the south, British forces had the strategy of repatriating escaped slaves with smallpox to rebel plantations. Whether this had any effect is not known.

German biological sabotage in WWI

From 1915 through 1918, Germany waged an ambitious campaign of covert biological attack on animals being shipped from neutral countries to the Allies (7). The program used the diseases glanders and anthrax, and employed secret agents to administer the bacterial cultures to animals penned for shipment. The cultures were sometimes injected using needles dipped into the cultures, sometimes poured onto feed, or (later in the war) contained in capillary tubes embedded in lumps of sugar that were fed to the animals. Horses and mules were the main targets, but in some cases sheep and cattle appear to have been targeted as well.

The programs were initiated nearly simultaneously in Romania and the United States. The Romanian campaign was administered by Major Nodolny of the German

General Staff, through his Military Attaché in Bucharest. The agents disseminating the cultures were Bulgarian, run by the Bulgarian embassy. Cultures were shipped from Berlin. The program lasted until the August 1916 Romanian declaration of war against Austro-Hungary, and the expulsion of German diplomats.

The US campaign was operated by a US-born, German-raised, physician, Anton Dilger. Dr. Dilger brought seed cultures with him to the United States in 1915, and set up a culture facility in the suburban Washington DC home that he rented. He supplied cultures to the German merchant-ship captain Hinsch, stranded in the United States by the British naval blockade, who ran the agents, largely stevedores. Dr. Dilger returned to Germany in early 1916, and the campaign came to a halt a few months later.

There also appear to have been campaigns in Spain and in Argentina, but the details are sketchy. We know little of the program in Spain other than its existence. The Argentinean campaign was operated by a German agent, Dr. Hermann Wuppermann, code-named 'Arnold,' from 1916 or 1917 through 1918. Cultures (by now in capillaries inside sugar cubes) were shipped, probably by train from Berlin to Croatia, by U-boat to neutral Spain, then by commercial steamer to Buenos Aires.

In Norway, German agents attempted to attack reindeer and horses used in the transport of materiel across the north to Russia. The perpetrators were arrested and deported, and it appears that the program was of very short duration. How many attacks occurred, if any, is not documented.

The effectiveness of these attacks is not clear. German agents involved in the Western hemisphere campaigns, Hinsch in the US and Arnold in Argentina, claimed significant successes. However, those claims have not been confirmed by scholars, and it is doubtful that they had any long-term strategic effects. There is no evidence bearing on the effectiveness of the Spanish, Romanian, or Norwegian programs, but it seems most likely that these too were ineffectual.

Japanese biological warfare in WWII

Although most major post-WWI powers thought that the next war would see extensive use of chemical and biological weapons, in fact only Japan made significant use of BW (8, 9, 10). Japan's program was probably due in large part to the persistent enthusiasm of one Japanese army officer, Shiro Ishii. Ishii first became convinced of the potential of bioweapons in the late 1920s while a Lieutenant and surgeon in the Japanese army in Tokyo. His persistent lobbying eventually led to him being assigned to investigate biological weapons. First in Tokyo, then in several locations in occupied Manchuria, Ishii conducted both offensive and defensive research, using human research subjects. The use of human subjects was probably only sporadic when the program was located in Tokyo, but expanded to a massive scale once the operation moved to Manchuria, where oversight was minimal and prisoners, indigent Chinese, and later, prisoners of war were in ample supply. It has been estimated that more than 10,000 people were killed or allowed to die after deliberate infection. in this program.

Ultimately the BW program was centered in Ping Fan, and carried the designation Unit 731. Other units were involved as well, most notably Unit 100,

located near Changchun, in occupied China. Unit 100 focused on plant and animal diseases, but used human subjects in their investigations of several zoonoses.

In 1939, Ishii obtained permission to do field tests with biological weapons. For the next three years Units 731 and 100 carried out periodic biological attacks on military and civilian targets. The methods were primitive; all efforts to develop reliable and effective biological munitions failed. Most attacks relied on saboteurs contaminating wells with intestinal pathogens, distribution of microbe-laced foods, air drops of plague-infected fleas, and probably aerial spraying of microbial cultures. Their effectiveness is very hard to evaluate. However, Chinese civilian casualties are thought to have been extremely high; several hundred thousand killed is generally considered likely. As a comparison, the United States armed services sustained slightly more than four hundred thousand fatalities in all of World War II.

The use of biological weapons in China by Japan not only showed their strategic potential, even when conducted by primitive means, but also demonstrated their danger to the user. In the Chekiang campaign in the summer of 1942, during a Japanese retreat, agents of Unit 731 poisoned wells with microbial cultures, sprayed the ground with cultures, and left infected foodstuffs for the advancing Chinese army to encounter. Chinese casualties were apparently high, but so were those among the Japanese. When the Japanese army advanced again into contaminated territory, an outbreak of intestinal disease caused up to 10,000 casualties, with perhaps 1700 deaths.

After the war, Unit 731 and 100 facilities were destroyed, records burned, X-rays and pathology specimens destroyed or hidden. Most of the leadership escaped to Japan just ahead of the Soviet army, but a dozen officers fell into Soviet hands. They were put on trial in Khabarovsk, Siberia, convicted, and given remarkably lenient sentences (2-25 years of hard labor), given the magnitude of the war crimes to which they confessed.

The leaders of the BW program fell into US hands in Tokyo, and over months of interrogation the outlines of the program were gradually revealed. This led to a negotiated deal, in which the US granted immunity from war crimes prosecution to the leaders of the program in exchange for full disclosure. The reasons are complex. They certainly included eagerness to see the results of biological attacks and of human experiments, since the US had a large BW program. However, the principal reason was probably concern that any information that came out during war crimes prosecution would have had to be shared with the Soviet Union, co-prosecutors, along with the United States and Australia, in the Tokyo War Crimes Tribunal.

Allegations of Biological Weapons Use

Increased incidence of infectious disease always accompanies war and civil disruption. Since these are also times of heightened suspicion and ideological fervor, some of these outbreaks are bound to stimulate speculation about possible unnatural etiology. Most allegations based on political suspicions alone are probably baseless, and most are ignored here. In this section I discuss briefly a few allegations that are important for one reason or another; either they are supported by some evidence, or they are politically important, or natural means have been shown to be the cause.

Allegation of Soviet use of tularemia against Germany in 1942

Alibek recounts his study of a 1942 outbreak of Tularemia that began in German troops and then spread to Soviet troops in the Volga basin in southern Russia (11). His analysis indicated that the outbreak was unique in its magnitude and in its epidemiology. Evidence suggests approximately 10,000 cases and Alibek concluded that 70% of early cases were pneumonic.

Whether the Soviet Union was prepared to use BW in 1942 is not clear. The only history of the Soviet BW program of this era (12) concluded that the available documentation is insufficient to answer the question. Croddy, in a recent study of the Russian-language literature on the outbreak has concluded that it was natural (13). It thus remains unclear whether Alibek is correct about the origin of this outbreak of tularemia.

Allegations of US use of biological agents against North Korea and China, 1952

In 1952 the North Korean government alleged that US pilots were dropping a variety of fomites and live insects contaminated with disease agents over the territory of North Korea (14). The Chinese government (PRC) joined North Korea, and expanded the charges to include a number of alleged BW attacks in Chinese territory. The charges were debated intensely within the United Nations, and several approaches to investigating the charges were proposed. The General Assembly approved a UN Commission to investigate; the US government proposed an International Committee of the Red Cross investigation; and the Secretary General proposed that the World Health Organization investigate. North Korea and the PRC rejected all proposals, questioning the objectivity of the three bodies. Instead, two non-governmental organizations put together investigating bodies that traveled to North Korea and examined evidence presented to them by the North Korean government. The first was the International Association of Democratic Lawyers, and the second was the World Peace Council. The latter's team, the International Scientific Commission (ISC), was genuinely international and included a number of prominent scientists.

The ISC issued its findings in 1952, consisting of a report of less than 50 pages and over 600 pages of evidence summaries (15). The report makes a compelling case for BW, with one serious flaw—the ISC did not itself observe any attacks, nor collect any evidence itself. All the evidence it examined was presented to it by the Chinese. This appears to have been a fatal lapse of forensic practice; documents published by Leitenberg make it clear that evidence was fabricated (including deliberate infection of prisoners), and that the charges were fabrications from the beginning (16).

Allegations of US use of biological agents against Cuba, 1960s and 1970s

Cuba has suggested periodically that some disease outbreaks were deliberately introduced into the island by the US. Most of these allegations have been in domestic speeches by Castro. No evidence is available to support most of them, and only one of

them has been subject to a formal process of international consultation. Following a thorough review of the allegations, Zilinskas has recently concluded that they are all false (17). Nevertheless, two of them are supported by some evidence, and one of them led to a consultative process under Article V of the Biological and Toxin Weapons Convention (BTWC).

US investigative journalists have provided some evidence for two instances of covert biological attack. A Canadian poultry expert who visited Cuba told the press that in 1962 the US CIA had paid him \$5000 to infect Cuban turkeys with Newcastle Disease virus. He claimed to have accepted the money but discarded the viral cultures. Newcastle disease did break out shortly after he visited. There is no corroborating evidence.

The second allegation with supporting evidence was that in 1971 African Swine Fever (ASF) was deliberately introduced by expatriate Cuban operatives who picked up the virus at Fort Gulick, a US base in Panama, and took it to the southeast coast of Cuba. What is alleged to have happened thereafter is not clear, but a month later there was a large outbreak of ASF in Havana Province (at the northwest end of the island). The story is based on the testimony of alleged participants, but their reliability is questionable.

A third case has garnered international attention. In 1996 a Cuban pilot observed a US aircraft, which was legally overflying Cuba, release some material. The plane was an agricultural spray plane on the way to Columbia to participate in drug interdiction efforts. Two months later an infestation of the insect *Thrips palmi* was detected in the area where the release had been observed, allegedly the first time the pest had been detected in the country. In 1997 Cuba requested a formal consultation under procedures agreed upon to implement Article V of the Biological and Toxin Weapons Convention (BTWC). In its request Cuba alleged that the US plane had released thrips and was the cause of the outbreak; the US responded that the plane had routinely released smoke to ensure that Cuban pilots saw it. The Cuban charges, and the US response, were circulated among BTWC States Parties with an invitation to comment. About 20 countries commented, almost all of them agreeing that there was no significant evidence supporting the charge, and that a natural introduction was plausible.

Allegations of anthrax use during the Zimbabwean civil war

The worst outbreak of human anthrax ever recorded occurred in 1979-80 in Rhodesia (now Zimbabwe) during its war for majority rule. The outbreak was largely confined to the Black-held Tribal Trust Lands, and caused over 10,700 human cases and 182 deaths from anthrax—mostly cutaneous, with some intestinal. The human cases were incidental to an outbreak in cattle, whose magnitude is not documented but which was clearly huge. For the previous half century anthrax had been rare in Rhodesia. The magnitude of the outbreak, its unusual geography (widespread, but confined to Tribal Trust Lands), and investigative reporting on the role of Selous Scouts in the war suggested to Nass that this was a deliberately instigated outbreak (18, 19, 20).

However, it now seems unlikely that this was the case. Most anthrax and veterinary experts think that the breakdown of vaccination practices in the Tribal

lands is a sufficient explanation, and the lack of detailed documentation since the collapse of White minority governments in Rhodesia and South Africa undermines the case for deliberate instigation. In order to deliberately create such a large and widespread outbreak, many separate attacks, using large amounts of materiel distributed over large areas, would have been necessary. It seems unlikely that a program of such a magnitude would not have been better documented by now. There are some indications that the Selous Scouts made several attempts to spread disease (including cholera, and maybe anthrax), but there is no hint of a program of the required magnitude.

Allegations of Soviet/Vietnamese use of mycotoxins; the “yellow rain” story

In 1981 the US government charged that the Soviet Union had provided toxin weapons to Vietnamese troops operating in Laos and Cambodia (21, 22). The charges were based on interviews with Hmong refugees, and on a positive chemical test for tricothecene mycotoxins in a few samples provided by refugees. Most samples consisted of small yellow spots on leaves, bark, and the like; they quickly became known as “yellow rain.”

However, the yellow spots consisted largely of digested pollen, and turned out to be natural spots of honeybee feces. Many bees, including ones in the area where yellow rain was alleged, conduct collective purging flights, in which hundreds of thousands of bees leave the hive and defecate. These flights are too high for the swarm to be seen, and can cover an acre or more with hundreds or thousands of yellow spots.

The story continued to collapse as attempts to repeat the chemical identification of mycotoxins failed, and as carefully conducted repeat interview with refugees failed to support the previous reports. Thus by the mid-1980s it was clear that the evidence for toxin warfare in Southeast Asia was very weak.

Allegations of Soviet use of mycotoxins and glanders in Afghanistan

As part of the yellow rain accusations, the US claimed to have detected tricothecene mycotoxins on a gas mask smuggled out of Afghanistan, where the Soviet Union was embroiled in a long civil war. As with the other positive results for mycotoxins, repeated testing failed to confirm the contamination of this gas mask.

Another allegation claims that the Soviet Union used glanders against both the horses and soldiers of the mujahedeen (11). Alibek claims to have been told by a senior Army officer that at least once, and possibly several times, Soviet Ilyushin-28 bombers based in southern Russia attacked mujahedeen with biological munitions (presumably bombs or spray tanks) containing glanders. Effects, if any, are not reported.

Allegations of use of biological weapons by Myanmar against the separatist Karen

The State Law and Order Reconciliation Council (SLORC) government of Myanmar (Burma) has been fighting insurgent ethnic groups in several areas of the country for many years (23). The Karen are among the most tenacious of the groups, and their countryside is mountainous and remote. The Karen Human Rights Group

recounted a series of outbreaks of fatal intestinal disease shortly after SLORC planes had dropped odd devices. Some of these putative delivery devices were recovered. The devices consisted of a parachute, a small weather balloon, and a meteorological radiosonde. It was hypothesized that the balloons contained liquid cultures of bacteria and were dropped by parachute. The radiosondes presumably ruptured the balloons at a preset altitude, spraying their contents over the land below. One recovered device was tested for intestinal pathogens at Porton Down in the UK with negative results, perhaps due to the long time between use and analysis, including considerable time exposed to the weather.

Terrorist Bioweapon Use

A number of instances of terrorist or criminal attempts to acquire or use chemical or biological weapons are known (24); three instances involving biological agents are particularly important.

Use of Salmonella by the Rajneesh Sect, USA, 1984

In 1984 followers of the Bagwan Shree Rajneesh living on a ranch in rural Oregon tested a crude bioweapon in The Dalles, Oregon (25). Cultures of *S. typhimurium* were grown in the infirmary on the ranch, then sprinkled on food in restaurants, principally at salad bars. The result was more than 750 cases of salmonellosis, 45 of which required hospitalization. There were no deaths.

The intent of the attack was to determine the feasibility of keeping voters from the polls in an upcoming election, with the hope that the Rajneeshis could win a majority in the county government, allowing them to make changes to zoning and land-use policies that the existing government had turned down. Although the attack was quite successful, the perpetrators apparently decided that their political goal was out of reach; in any event, the attack was not repeated at election time.

Despite considerable epidemiological evidence that the outbreak was deliberately initiated, the investigating team did not recognize it as unnatural. It was only after an independent police investigation of illegal activities at the Rajneesh ranch that the attack became known.

Allegations of attacks by the Aum Shunrikyo sect with botulinum toxin and Bacillus anthracis spores, Japan, 1990-95

The apocalyptic Aum Shunrikyo sect in Japan was very well funded, had PhD-level expertise in many fields, and was paranoid and violent. Among their many weapons programs were ones dedicated to chemical, toxin, and biological agents (26). All three agents were alleged to have been developed and used. The most famous incident is the 1995 Tokyo subway sarin gas attack, which killed 12 and injured many others. They cult is also alleged to have attempted as many as 10 different biological and toxin attacks—six of aerosolized botulinum toxin and four of aerosolized *B anthracis* spores. None of the attacks had any apparent consequences. The reason is unclear; indications are that they were using an avirulent strain of *B anthracis*, and the

nozzles on the spraying devices may have clogged or delivered a grossly inappropriate particle size.

Use of Bacillus anthracis spores in letters, USA, 2001

In September and October, 2001, several letters (probably 5-6) containing *Bacillus anthracis spores* were mailed from Trenton, New Jersey to several media representatives and two senatorial offices. As these envelopes were processed through automatic sorting machines they contaminated thousands of postal workers, and upon opening, they contaminated hundreds more people in the receiving premises. A total of 22 cases of anthrax are thought to have resulted (a few more are possible). Eleven of these were cutaneous, none fatal; the other eleven were pulmonary, and five were fatal. Many additional cases were undoubtedly prevented by widespread use of prophylactic antibiotic treatment of thousands of exposed persons. There was widespread and extensive disruption of federal government activities. The perpetrator(s) remain unidentified, but is widely thought to be a current or former employee of the US biodefense program or of a private contractor to it.

Offensive Biological Weapons Programs

Although BW has been rarely used, a number of countries have mounted ambitious programs to develop and produce biological weapons that they did not ultimately ever use (27). Most of these programs began in the 1920s or 30s, and were responsive to a growing conviction among military theorists and arms experts that the next great European war would involve extensive use of chemical and biological weapons. despite the recent entry into force of the Geneva Protocol—see below.

Substantial programs were initiated by the UK, France, US, Canada, Soviet Union, and Japan. Hitler's direct order prohibited Germany from exploring offensive BW, but some of his subordinates implemented modest offensive programs anyway. Only the British and the Japanese succeeded in weaponizing any agents by the end of the war, although the US was close. These early bioweapons were crude: airdropping of plague-infected fleas or saboteurs poisoning wells with cholera or typhoid fever agents in the case of the Japanese; and anthrax-laced cattle cakes stockpiled by the British for use against German cattle if needed for retaliation. Only the Japanese actually used their bioweapons.

These early programs were terminated by defeat and occupation in the case of France (1940), and Japan and Germany (1945). However, the other programs continued after the war. The British and Canadian offensive programs eventually withered, but the US and Soviet programs, newly energized by the cold war, invested considerable resources in their bioweapons programs and developed substantial strategic stockpiles of biological agents and munitions.

The US ended its offensive biological weapons program in 1969 by Nixon's executive order, and ordered all stockpiles destroyed. A similar destruction order for toxin weapons came the following year. The Soviet Union, in contrast, continued its program (10). In 1972 the USSR increased substantially the scale of the program, as the BTWC was signed (this violation of the Convention is discussed below),

ultimately stockpiling dozens of metric tons of agent, ready to be loaded into ICBM warheads or long-range bombers. After the dissolution of the Soviet Union the program Yeltsin issued a Presidential Decree purportedly discontinuing the program. Nevertheless, a continued lack of transparency makes it impossible to be sure that all offensive activities have been discontinued.

Sverdlovsk, USSR, 1979

A 1979 outbreak of anthrax in the city of Sverdlovsk (now Ekaterinberg) in the Ural mountains killed nearly 70 people, and raised immediate suspicions that it was an accidental aerosol escape from an Army laboratory located there. The Soviet Union claimed that the outbreak was of intestinal anthrax due to improperly inspected meat. In the absence of unclassified evidence, the US accusations could not be substantiated. However, after the break-up of the Soviet Union, Russia allowed a US team to visit Sverdlovsk and interview people there about the outbreak. The result was a conclusive demonstration that the outbreak was the result of an emission from the military laboratory (28, 29).

The South African program

In 1981 (six years after ratifying the BTWC) the South African government of P. W. Botha began a covert offensive program, code-named "Project Coast," to develop both chemical and biological weapons. The CW program was the most extensive, but small quantities of some biological agents were produced, including anthrax spores, cholera, *Salmonella*, and botulinum toxin. A number of biochemical agents that, as analogs of natural bioregulators, fall under the prohibitions of the BTWC were also produced, some of them in militarily significant quantities. These agents were largely designed, and apparently used on many occasions, as weapons for disruption, assassination and execution. The program was ended in the mid 1990s, as the African National Congress took over from the White minority government. The head of Project Coast, Wouter Basson, was charged with over 60 counts of fraud, conspiracy, assault, murder, and the like. The trial lasted four years, and ended with the acquittal of Basson on all counts (30, 31).

The Iraqi program

Iraq began serious work on its biological weapons program in about 1985. It was at that time a signatory to the BTWC, but had not yet ratified (ratification came under duress after the cease-fire that ended the Gulf War). By the end of the Gulf War in 1991, they had weaponized several agents (anthrax spores, botulinum toxin, and aflatoxin) and had a number of others under development (32, 33). The program also included a modest stockpile of filled munitions, including missile warheads, bombs, and spray tanks. This capability was assiduously hidden from UN Special Commission (UNSCOM) inspectors. Nevertheless, through a combination of some luck and a great deal of careful effort, UNSCOM was able to piece together the outlines of the program, although many details remain unclear. At the time of writing, a second team of inspectors, the UN Monitoring, Verification and Inspection

Commission (UNMOVIC) is resuming the work of UNSCOM, but so far has obtained little additional information.

Current proliferation concerns

Intelligence agencies of several western nations have periodically released unclassified summaries of classified intelligence indicating the dangers of biological weapons proliferation (34). The number of countries judged to be attempting to develop bioweapons varies, as does their identity—when they are named (often such reports do not name individual countries). The reliability of this intelligence is impossible to determine without access to the classified sources; much of it is likely to be weak. Nevertheless, it is quite possible that somewhere around 5-10 countries are covertly pursuing a BW capability.

Biological Weapons Control Treaties

Two principal treaties limit the legality of bioweapons. The 1925 Geneva Protocol and the 1972 BTWC. In addition, the 1993 Chemical Weapons Convention applies to toxin weapons in addition to more traditional chemical weapons.

The 1925 Geneva Protocol

After WWI the League of Nations convened a Conference on the Control of the International Trade in Arms, Munitions and War Materials, composed of diplomats from over 40 member states. The group was unsuccessful in concluding its primary business, but did propose the text of a treaty prohibiting the use of chemical agents in war (35). At the suggestion of the Polish delegate, bacteriological or biological methods of warfare were added to the proscriptions. The treaty was opened for signature in 1925 as the Protocol Prohibiting the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare. It came into force in 1928. International legal experts generally agree that its provisions are now part of international customary law.

The 1972 BTWC

After the 1969 US renunciation of biological weapons, the momentum for a prohibition on their possession quickly mounted. By 1972 a text was opened for signature, the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, more commonly known as the Biological Weapons Convention (BWC) or the Biological and Toxin Weapons Convention (BTWC). It entered into force in 1975.

The BTWC prohibits the development, production, stockpiling, and transfer of biological and toxin agents “of types and in quantities that have no justification for prophylactic, protective, or other peaceful purposes.” The qualification is necessary to protect peaceful medical and other research. The Convention’s prohibitions also

apply to all delivery devices “designed to use such agents for hostile purposes or in armed conflict.” It also requires parties to facilitate peaceful international collaboration in microbiology.

Although the Convention is clear and unambiguous, and its prohibitions are drafted generally enough that the language remains effective today, after 25 years of advances in molecular biology and microbiology, it has proven to be of limited effectiveness. In addition to the current proliferation concerns, there have been several prominent violations: the Soviet and the Iraq programs. The Soviet program is of particular note because the Soviet Union was a codepositary of the Convention, in addition to being a State Party.* Iraq was a signatory of the BTWC at the time of its active BW program not a State Party; nevertheless Iraq violated even the more limited obligations undertaken by signature of the Convention. These known and suspected violations point to the need for verification provisions such as those implemented in the very similar Chemical Weapons Convention.

Conclusions

Although biological weapons have been used only sporadically throughout human history, and their military effectiveness has never been clearly demonstrated, the impact of natural disease outbreaks continually reminds us that they are potentially very effective weapons. For that reason there has been a continual fascination with them by nations in the last century, a fascination that continues today. Particularly where regional hegemony (or resisting it) may require unconventional weapons, they remain a major threat. The legal regime prohibiting them is clear and in place, but it lacks effective mechanisms to verify compliance and to build confidence in the existing legal regime. Repairing that gap constitutes an urgent agenda for the international community in the next few years.

The urgency is made greater by the rapid scientific progress stimulated by genomics, proteomics, and a host of related research technologies (37). These promise increasingly rapid advances in understanding human physiology and microbial pathogenesis. The scientific advances are matched by rapid changes in biotechnology and the pharmaceutical industries, as they too assimilate the new methods. All of this is likely to bring new military interest in biological weapon, perhaps even in countries not now considered proliferation risks.

* In partial mitigation it should be noted that the US may have been deliberately feeding the Soviet Union misinformation through double and triple agents, including information that the Nixon renunciation of BW was a sham and that the US maintained a substantial covert program (36).

REFERENCES

1. **McNeill, W.** 1976. *Plagues and Peoples*. Garden City, New York, Anchor Press.
2. **Leitenberg, M.** 2001. Biological weapons in the twentieth century: a review and analysis. *Critical Reviews in Microbiology* 27 (4): 267-320.
3. **Mayor, A.,** 1997. Dirty tricks in ancient warfare. *Quarterly Journal of Military History*, Autumn 1997: 32-37.
4. **Wheelis, M.** 1999. Biological warfare before 1914. p. 8-34 in E. Geissler and J. E. v. C. Moon (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
5. **Mayor, A.,** 1995. The Nessus shirt in the new world: smallpox blankets in history and legend. *Journal of American Folklore* 108 (427): 54-77.
6. **Fenn, E. A.** 2000. Biological warfare in eighteenth-century North America: beyond Jeffery Amherst. *Journal of American History* March 2000, 1552-1580.
7. **Wheelis, M.** 1999. Biological sabotage in World War I. p. 35-62 in E. Geissler and J. E. v. C. Moon (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
8. **Harris, S. H.** 1999. The Japanese biological warfare programme: an overview. Biological in World War I. p. 35-62 in E. Geissler and J. E. v. C. Moon (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
9. **Harris, S. H.** 1994. *Factories of Death: Japanese Biological Warfare 1932-45 and the American Cover-Up*. Routledge, London.
10. **Williams, P., and D. Wallace,** 1989. *Unit 731: The Japanese Army's Secret of Secrets* Hodder & Stoughton, London.
11. **Alibek, K., and S. Handelman** 1999. *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World—Told from the Inside by the Man Who Ran It*. Random House, New York
12. **Bojtsov, V., and E. Geissler** 1999. Military biology in the USSR, 1920-45. p. 153-167 in E. Geissler and J. E. v. C. Moon (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
13. **Croddy, E., and S. Krcalova** 2001. Tularemia, biological warfare, and the battle for Stalingrad (1942-1943). *Military Medicine* 166; XXXX.

14. **Moon, J. E. v. C.**, 1932. Biological warfare allegations: the Korean War case. p. 53-83 in R. A. Zilinskas (ed) *The Microbiologist and Biological Defense research: Ethics, Politics, and International Security*. New York Academy of Sciences, New York.
15. **International Scientific Commission** 1952. *Report of the International Scientific Commission for the Investigation of the Facts Concerning Bacterial Warfare in Korea and China*. Peking. 616 pp.
16. **Leitenberg, M.**, 1998. The Korean biological warfare allegations resolved. Center for Pacific Asia Studies at Stockholm University Occasional Paper 36. May 1998.
17. **Zilinskas, R. A.** 1999. Cuban allegations of biological warfare by the United States: assessing the evidence. *Critical Reviews in Microbiology* 25, 173-227.
18. **Nass, M.**, 1992. Anthrax epizootic in Zimbabwe, 1978-1980: due to deliberate spread? *PSR Quarterly* 2, 198-209.
19. **Nass, M.**, 1992. Zimbabwe's anthrax epizootic. *Covert Action Quarterly* No. 43, 12-18.
20. **Martinez, I.** 2002. The history of the use of bacteriological and chemical agents during Zimbabwe's liberation war of 1965-80 by Rhodesian forces. *Third World Quarterly* 23, 1159-1179.
21. **Seeley, T. D., J. W. Nowicke, M. Meselson, J. Guillemin, and P. Akrotanakul.** 1985 Yellow Rain. *Scientific American* 253, No. 3, 128-137.
22. **Robinson, J., J. Guillemin, and M. Meselson.** 1990. Yellow Rain in Southeast Asia: the story collapses. p. 220-238 in S. Wright (ed) *Preventing a Biological Arms Race*. MIT press, Cambridge.
23. **Selth, A.** 1996. Burma and exotic weapons. *Strategic Analysis* 19, 413-433.
24. **Carus, W. S.** 1999. *Bioterrorism and Biocrimes: The Illicit use of Biological Agents in the 20th Century*. Working paper from the Center for Counterproliferation Research, National Defense University, Washington DC. 215 pp.
25. **Carus, W. S.**, 2000. The Rajneeshees (1984). p. 115-137 in J. B. Tucker (ed). *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*. MIT Press, Cambridge.
26. **Kaplan, D. E.**, 2000. Aum Shinrikyo (1995). p. 207-226 in J. B. Tucker (ed). *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*. MIT Press, Cambridge.

27. **Geissler, E., and J. E. v. C. Moon** (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
28. **Meselson, M., J. Guillemin, M. Hugh-Jones, A. Langmuir, I. Popova, A. Shelekov, and O. Yampolskaya**. 1994. The Sverdlovsk anthrax outbreak of 1979. *Science* 266, 1202-1208.
29. **Guillemin, J.**, 2000. *Anthrax: The Investigation of a Deadly Outbreak*. University of California Press, Berkeley.
30. **Burger, M., and C. Gould**, 2002. *Secrets and Lies: Wouter Basson and South Africa's Chemical and Biological Warfare Programme*. Zebra Press, Cape Town.
31. **Gould, C., and P. I. Folb**, 2003
32. **Zilinskas, R. A.**, 1997. Iraq's biological weapons: the past as future? *JAMA* 278, 418-424.
33. **Trevaan, T.**, 1999. *Saddam's Secrets: The Hunt for Iraq's Hidden Weapons*. HarperCollins, London.
34. **Canadian Security Intelligence Service**, 2000. Biological weapons proliferation. Report # 2000/05. June 9, 2000.
35. **Mierzejewski, J. W., and J. E. v. C. Moon**, 1999. Poland and biological weapons. p. 63-69 in E. Geissler and J. E. v. C. Moon (Eds.) *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945*. Oxford University Press, Oxford.
36. **Garthoff, R. L.**, 2000. Polyakov's run. *Bulletin of the Atomic Scientists* Sept/Oct 2000, 37-40.
37. **Wheelis, M.**, 2002. Biotechnology and biochemical weapons. *Nonproliferation Review* 9 (1): 48-53.