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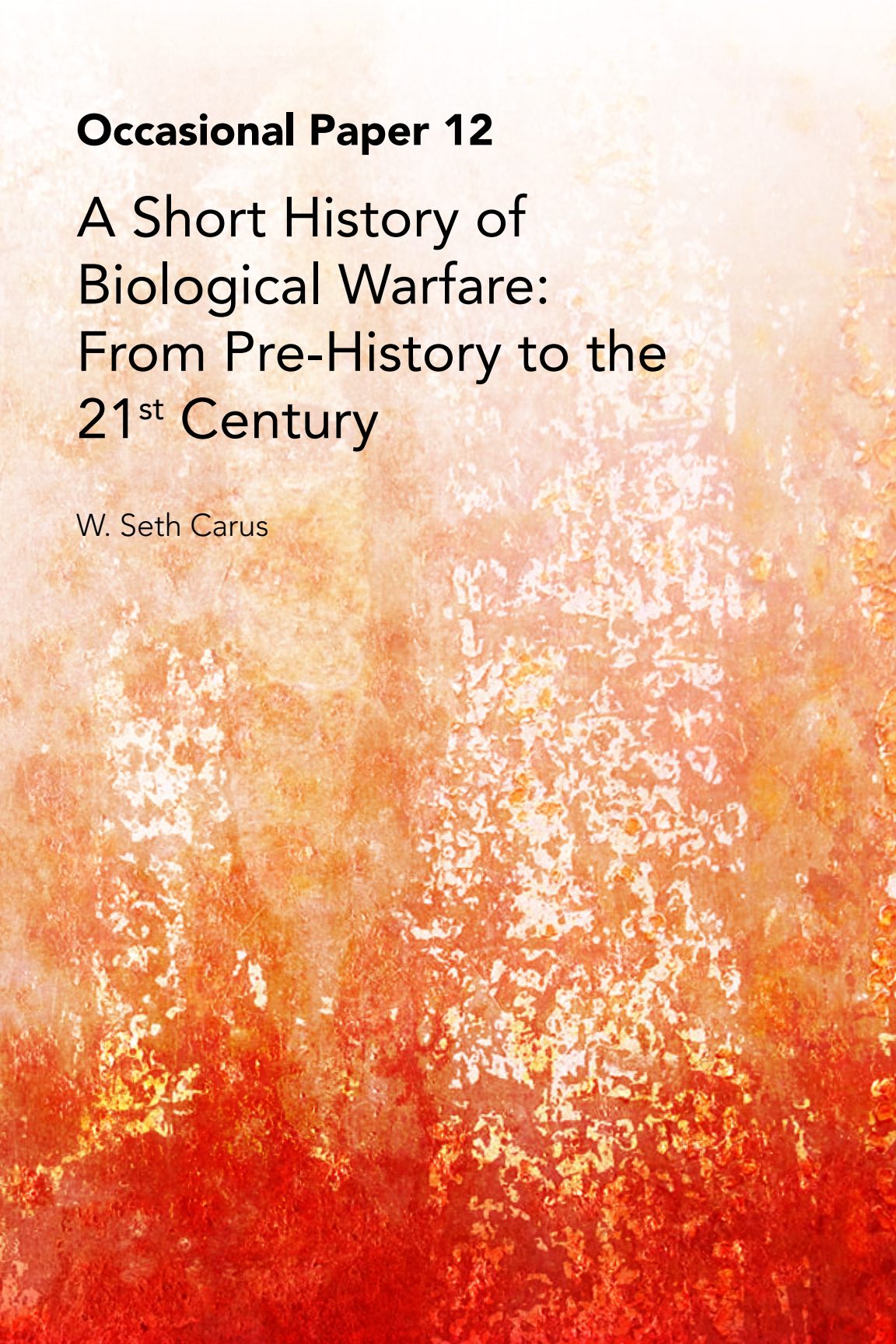
A Short History of Biological Warfare: From Pre-History to the 21st Century

W. Seth Carus



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Introduction

This short monograph reviews the history of biological warfare (BW) from prehistory to the present. It covers what we know about the practice of BW and briefly describes the programs that developed BW weapons based on the best available research. To the extent possible, it primarily draws on the work of historians who used primary sources, relying where possible on studies specifically focused on BW. By broadening our knowledge of BW, such studies have enabled us to write about the topic with more accuracy and detail than could have been done even a few years ago.

This is an overview, not a definitive history. Much about BW remains unknown, either because it is unknowable (due in some cases to the deliberate destruction of records) or because it is knowable only to some people (such as those who might have access to classified information) or because of the absence of academic research.[1]

This survey breaks the history of BW into three periods. The first section examines prehistory to 1900—the period before scientific advances proved that microorganisms were the cause of many diseases. Despite many claims to the contrary, resort to BW was exceedingly rare during this era. Readers interested only in BW's modern history can skip this section.

The second section looks at the years from 1900 through 1945. This period saw the emergence of state BW programs, the employment of biological weapons in both world wars, and the use of biological agents by nonstate actors, including criminals. This period witnessed the most significant resort to BW. It included the first organized state campaign to wage BW—sabotage operations organized by the German government during World War I. It also saw the most extensive use—the Japanese attacks in China. Almost all the known victims of BW were Chinese, mostly civilians, who were killed in these operations. This period also saw the initial efforts to control BW in the 1925 Geneva Protocol, which essentially prohibited the first use of BW agents.

Finally, the third section, covering the period from 1945 to the present, focuses mostly on developments during the Cold War, including descriptions of

state BW programs as well as known uses of biological agents by states, terrorists, and criminals. Despite the development of highly sophisticated techniques for dissemination of biological agents by the United States and the Soviet Union during the Cold War (the two countries with the largest and most advanced BW programs ever organized), most of the known programs were small and possessed only crude dissemination capabilities. The known uses were unsophisticated as well, essentially no more advanced than what the Germans did during World War I. This era also saw the negotiation of the 1972 Biological and Toxin Weapons Convention (BWC).

This history focuses on those agents covered by the BWC, which prohibited weapons disseminating biological agents or toxins. Biological agents are replicating biological entities, such as bacteria. Toxins, poisons of biological origin, are similar to chemical warfare agents and also have been banned by the Chemical Weapons Convention. Definitional matters are discussed in more detail in appendix 2.

Biological agents are referred to by their scientific name. Following scientific practice, the name is abbreviated after the first mention. Thus, *Bacillus anthracis* (commonly, but incorrectly, called anthrax), which causes several diseases (including cutaneous anthrax, inhalational anthrax, and gastrointestinal anthrax), is hereafter called *B. anthracis*. Those seeking additional information about specific diseases should refer to specialist works that describe them in more detail.[2]

Readers wishing more detailed information should look at the references cited in the notes. Appendix 1 also provides suggested readings.

Early Use (through 1900)

Biological warfare, as we understand it today, is a modern invention. It was not until the middle of the 19th century that the pioneering scientific research of Louis Pasteur in France and Robert Koch in Germany demonstrated that microorganisms could cause disease. Before then, people had a limited understanding of disease causation, and what they thought they knew was often wrong. Many people ascribed diseases to supernatural causes. It is thus not surprising that the Romans used the same word, *veneficium*, for both "poisoning" and "practicing sorcery."[3] Even after

the emergence of scientific explanations for disease causation, there were many competing theories, generally partly or wholly wrong. Some emphasized environmental factors, such as the miasma theories that focused on the harmful effects of rotting organic matter, while others focused on supposed imbalances in the body as the likely cause of specific diseases.[4]

Further complicating matters, medical diagnosis was often poor. Before the widespread use of autopsies to support clinical research and the development of modern diagnostic techniques, medical practitioners often had difficulty differentiating between diseases with similar symptoms. For example, the symptoms of some diseases caused by poison can mimic those of diseases caused by microorganisms. Thus, it was difficult to differentiate between the effects of strychnine, a common arrow poison obtained from certain species of Strychnos plants found in sub-Saharan Africa, and tetanus, which is caused by the pathogen *Clostridium tetani*.[5] Similarly, many physicians could not distinguish between different fever-causing diseases. It was not until 1837 that an American doctor described the differences between typhoid and typhus fevers.[6] Even in the late 19th century, most doctors could not distinguish typhoid fever from malaria.[7]

Nonetheless, there is evidence that some people in past eras deliberately tried to spread diseases that we now know are spread by pathogens, and that those actions plausibly could have caused disease transmission. This occurred with both plague and smallpox, which some people thought could be transmitted by fomites (contaminated materials, such as bedding or clothes). Smallpox can be spread through such exposure, although the risk of transmission is relatively small.[8] In contrast, plague is not transmitted by contaminated material; only in the late 19th century was the flea proved to be the vector for the *Yersinia pestis*, the organism that causes plague.[9]

Prehistoric Biological Warfare

Biological warfare may have originated in prehistory, although that is not certain. Archeologists believe that poisons were used widely for fishing, hunting, and warfare by nomadic and primitive tribal societies, although direct evidence is scanty for the prehistoric period. The poisons were toxins obtained from readily

available plants or animals.[10] In some cases, however, primitive peoples contaminated arrows in ways that seemed likely to introduce pathogens. Such techniques were employed by tribes located in North America, South America, sub-Saharan Africa, and Southeast Asia.[11]

The methods used varied widely. Sometimes, the methods were quite simple, as when Melanesian tribesmen in what is now Vanuatu covered arrows with the contents of crab burrows and thus contaminated them with *Clostridium tetani* (the organism causing tetanus).[12] Other methods were quite elaborate. The Scythians, a nomadic tribe that inhabited what is now Ukraine, during the era of Classical Greece, used an elaborate technique to produce an arrow poison that almost certainly contained some pathogens. One ancient account reports that the Scythians killed young vipers and allowed them to rot. At the same time, they took human blood, put it into a small vessel, and allowed it to decompose. They then mixed the liquid from the rotten vipers and the sediments from the decomposed blood and put it on arrowheads.[13]

Primitive tribes have used such methods even in the modern era. These techniques, reportedly only used in warfare and not for hunting, would have produced uneven results, dependent as they were on the vagaries of nature to inoculate their concoctions with a dangerous pathogen. Unfortunately, only a handful of scientific studies have been conducted on poisoned arrows to look for the presence of pathogens, and those are dated (some to the 1890s).[14] For that reason, we do not know the extent of these practices, the likely viability of the organisms, or their possible effectiveness.

Ancient BW (500 BCE to 1000 AD)

Some authors assert that BW was practiced widely in the ancient world.[15] Such claims should be viewed skeptically, because most of the alleged incidents almost certainly never occurred. Indeed, there is no reliable evidence for BW in the ancient world, apart from contaminated arrows such as those made by the Scythians.[16] What is undeniable, however, is that some people did fear the intentional spread of disease. We are told, for example, that some Athenians initially but falsely thought that the Spartans poisoned their water, thus causing

the devastating 430 BCE "plague" outbreak in Athens during the Peloponnesian War (431–404 BCE).[17]

The absence of BW is surprising, given the apparent ubiquity of poisoned arrows among hunter-gatherer communities. The use of arrow poisons mostly disappeared in the civilizations that arose in the Mediterranean world, the Tigris-Euphrates river valleys, the Indian subcontinent, China, and elsewhere. What seems clear is that most early civilizations developed an antipathy toward the use of poison in warfare. This was most explicit in ancient India, where Brahmins were forbidden the use of poisoned weapons. However, an Indian manual of statecraft from the same era, the *Kautiliya Arthasastra*, advised rulers on the clandestine use of poisons, suggesting that the prohibition may have been more theoretical than real.[18] Some sources also claim that the Greeks of the classical world believed only barbarians used poisons to fight wars, but the supporting evidence is thin, and the topic merits more serious study.[19]

Unfortunately, there is no historical record to help understand why the transition from hunter-gatherer bands to ancient civilizations resulted in the abandonment of poison as a common weapon of organized violence. It may have something to do with transformed social structures or with changes in the character of warfare. Hunter-gatherer warfare bears little resemblance to that practiced by larger, settled societies. Hunter-gatherers rely on ambushes, typically finding and killing isolated members of other bands, or on formalistic "line battles," ritualistic displays of aggression that usually resulted in few deaths.[20] Whatever the cause, the propensity to use poison in warfare largely disappeared.

Medieval and Early Modern BW (1000 AD to 1750 AD)

Although there are numerous allegations of BW during the medieval and early modern eras, the evidence supporting all but one of them is weak or nonexistent.[21] The most plausible instance of BW occurred in 1346 during the Mongol siege of Caffa, a Genoese city located in modern Crimea. Our knowledge of this incident is based on one source, a Genoese chronicle written by Gabriele de' Mussi. Although not an eyewitness, de' Mussi wrote soon after the events, clearly had access to people who had been present, and is considered highly credible. He reported that the

Mongols, then in control of the territory around Caffa, besieged the town in 1345 but were forced to retreat in 1346 when their army suffered a plague outbreak. Before abandoning the siege, the Mongols catapulted "what seemed like mountains of dead" into Caffa, which de' Mussi says caused an outbreak in the city. Although the Genoese clearly suffered heavily, they were not forced to abandon Caffa. Some of the survivors carried the disease with them when they left Caffa, and de' Mussi attributes the further spread of the plague to the return of these people to their homes. This view is no longer accepted; we now know that the plague entered Western Europe through multiple routes. Nevertheless, his description of events is consistent with our modern understanding of *Yersinia pestis*, the organism that causes plague.[22]

The siege of Caffa is mentioned in several medieval accounts, but de' Mussi's is the only one to mention the plague outbreak. Moreover, none of our accounts comes from Mongol sources. Thus, even if the events occurred as described, we do not know for certain that the Mongols intended to spread disease. None of the modern accounts discuss Mongol concepts of disease causation, so we do not know if the Mongols believed that the bodies of dead plague victims might spread the plague. It also is unclear whether the Mongols would have had time to gain an empirical understanding of how *Y. pestis* spread. Although "plagues" were common in the ancient world, most were caused by other pathogens, and the last major plague outbreak tied to *Y. pestis* (the Plague of Justinian) occurred around 800 years earlier. The medieval Black Death would have been something altogether new to the Mongols.[23] Finally, fleas living on rats are the primary vectors for spreading the plague, not dead bodies, and they leave a corpse as the body cools down. Hence, unless the catapulted bodies were recently dead, it is unlikely that they would have been infested with fleas.[24]

There were few if any other examples of BW during these years, although some people considered using disease as a weapon. Documents in the Venetian archives suggest that they discussed the possibility when attempting (1649–1651) to break the Turkish siege of a town in Crete.[25] Many people also feared intentional disease, although armies invariably lost more soldiers to disease from natural causes than from enemy weapons prior to the 20th century. Some Venetians believed the

Byzantines were responsible for an 1171 "plague" outbreak that erupted while their fleet was wintering on the island of Chios, but this seems doubtful. There was no explanation for how the Byzantines might have caused the outbreak.[26] Perhaps the best-documented examples are the scapegoating that occurred during the European plague from 1348 to 1351, which was widely blamed on foreigners, Jews, and beggars. Scapegoating appeared again during plague outbreaks in the late 16th and early 17th centuries. The tendency to blame disease outbreaks on intentional acts has varied over time.[27]

Late Modern BW (1750 AD to 1900 AD)

During the late 18th and early 19th centuries, several documented attempts were made to deliberately spread biological agents, although there were no significant advances in medicine or the biological sciences to enhance the effectiveness of BW. Antonie Philips van Leeuwenhoek discovered the existence of microorganisms in the 1670s, but it was not until the 1860s and 1870s that the pioneering research of Louis Pasteur and Robert Koch proved that microorganisms could cause disease in humans and animals. The first identified human pathogen was *B. anthracis*, the organism that causes anthrax, which Koch demonstrated could cause disease in a series of experiments he described in an 1876 article. Proof of the germ theory provided the scientific underpinnings for the use of biological agents as weapons, but it took decades for scientists to associate specific pathogens to specific diseases, as well as to isolate and cultivate them.[28] None of the attempted instances of BW prior to 1900 was based on a modern scientific understanding of infectious disease.

The first well-documented case of BW was by the British against Native Americans in 1763. That year, a confederation of Native American tribes launched what is now called Pontiac's Rebellion. The Indians, dissatisfied with the results of the French and Indian War, which ceded control of Canada to the British and thus led to British domination of the Great Lakes region, launched a series of attacks on forts and settlements along the western frontier of the northern tier of Britain's American colonies. From around June 22 through August 20, the Delaware loosely besieged Fort Pitt, a British fortification on the site of modern

Pittsburgh. On June 24, a group of Delaware parlayed with the fort's leaders and tried to convince the British to abandon their post. At the end of the parlay, the British gave the departing Indian chiefs food and goods. Among the gifts were blankets and a handkerchief taken from the fort's smallpox hospital, provided with the hope that they would cause a smallpox outbreak.[29]

This incident often is attributed to the commander of British forces in North America at the time, Sir Jeffery Amherst, because letters survive showing that he also advocated spreading smallpox among the hostile Indians. However, those letters were written in July, weeks after the contaminated material was given to the Delaware, and there is no evidence to suggest that Amherst's suggestion led to any follow-on actions.[30]

Less clear are the consequences of the attack. Some recent accounts incorrectly assert that large numbers of Indians were killed due to the activities of those at Fort Pitt and that the outbreak broke the siege. The record does not support such claims. One historian argues that documentary evidence shows that only about 100 Indians died during this smallpox outbreak. Moreover, at least some historians believe that the epidemic started well before the late June encounter at Fort Pitt.[31] Given that smallpox was circulating already among many of these same tribes during the French and Indian War (1756–1763), it would be surprising to discover that there were large numbers of people susceptible to the disease by the time of the Fort Pitt incident.[32]

Nor is there necessarily an association between the smallpox victims of 1763 and what happened at Fort Pitt. There were many other contacts between Europeans and Indians during this period, and it is far more likely that the smallpox outbreak resulted from those interactions than from the transmission caused by the Fort Pitt material.[33] Although exposure to material contaminated with smallpox virus can lead to infection, it is a relatively low probability route of transmission. Smallpox virus degrades in the environment, and over time the virus particles on the contaminated material would have lost infectivity and virulence.[34] Hence, it is perhaps unsurprising that Indians identified by name as having been associated with the Fort Pitt incident never became sick and are known to have survived.[35]

What is incontestable, however, is that some British soldiers deliberately tried to spread smallpox, that the idea of disseminating the disease was discussed at the highest levels of command in British North America, and that senior officers condoned the action. However, not all were convinced of the strategy. Many British troops and colonials were not immune, given that there was no routine smallpox vaccination at the time. Indeed, even some senior British officers were vulnerable and thus less than enthusiastic about deliberately spreading the disease.[36]

There are a handful of other episodes of attempted deliberate disease transmission. Although there are claims that whites routinely introduced disease into Native American populations during the 19th century, this was not true.[37] The only credible allegation was made by Isaac McCoy, a prominent Baptist missionary who also worked for the U.S. Government as an Indian agent. He claimed to have obtained a firsthand account of an attempt to deliberately spread smallpox among the Pawnee in 1831. McCoy's source told him that the men in charge of a trade caravan traveling from St. Louis to Santa Fe, angry at previous harassment by the Pawnee, planned to transmit smallpox to the Indians by using tobacco mixed with smallpox (probably from scabs) or smallpox-contaminated clothing. Allegedly, the attempt succeeded and caused a subsequent disease outbreak among the Pawnee, killing thousands. The smallpox epidemic is well documented, but no documents have surfaced that might confirm McCoy's allegation.[38] Even if true, it also is impossible to prove that the outbreak resulted from the contaminated material. As previously noted, there were many interactions between whites and Native American communities, and the disease could have been spread through other contacts.

Some historians argue that the first smallpox outbreak in Australia, which occurred in early 1789, just over a year after the establishment of the first British colony, may have been deliberate. The colony, comprising transported convicts, arrived in January 1788 and quickly faced numerous difficulties, including increasingly hostile relations with the nearby Aboriginal peoples. In April 1789, the British authorities discovered that a smallpox outbreak had erupted in the Aboriginal population. The outbreak devastated the population, and some people credited it with allowing the colony to survive in the face of growing Aborigine hostility. The origins of this outbreak mystified the British at the time, because the new colony

was demonstrably free of smallpox, and there was no evidence of smallpox among the Aborigines prior to the arrival of the colonists. For that reason, it was impossible for the disease to have spread from the white settlers by natural causes.[39]

Several theories have been suggested to account for this mysterious outbreak, but two alternatives currently are favored. One theory is that the disease might have been introduced by Macassar fishermen from the Indonesian island of Sulawesi (once called Celebes). These fishermen regularly visited Australia's northern shore to harvest sea slugs, and it is believed that they were subjected to periodic outbreaks of smallpox by the late 1700s. For this to have happened, smallpox would have had to spread from one small group of Aborigines to another, traveling the 2,000-mile distance from the northern coast to the area around the new colony.[40]

Some dissenting historians claim that the smallpox outbreak resulted from a deliberate introduction.[41] They reject the theory that Macassar fisherman introduced the disease, arguing that it would have been difficult to sustain the chain of transmission such a long distance through such a sparsely inhabited area. They argue that the colonists had the motive and capability to use smallpox as a weapon against the Aborigines. At least one of the Royal Marine officers tasked to protect the colony had served in North America at the time of the Fort Pitt episode and plausibly may have known of that attack. The only known smallpox in the whole area was in the possession of a British physician who brought the smallpox material to inoculate the colonists should the need arise.[42] This involved a technique called variolation to immunize people against smallpox by exposing them to material taken from smallpox victims.[43] At best, this is a highly circumstantial case, so in the absence of new evidence, there is no way to ascertain how the smallpox was introduced.

It also is possible that there were deliberate introductions of smallpox by Portuguese settlers into the indigenous population of Brazil. Claude Lévi-Strauss, the famed anthropologist, heard these reports and considered them credible. These accounts dated the practice to as far back as the 16th century and suggested that it continued into the 19th century.[44] In contrast, there is no reason to believe allegations that the Spanish did the same.[45]

There also were incidents of failed attempts to spread biological agents. During a 1784–1785 plague outbreak in Tunis, there was considerable tension between the local Muslims and the European Christians residing there. The Europeans isolated themselves from the rest of the city, and in reaction, some Muslims buried plague victims near the European enclave and tossed cloth soaked in the pus from plague buboes into the European sector.[46] This incident is misrepresented in some sources that incorrectly claim that a besieging Muslim army catapulted contaminated clothing.[47]

Better documented is an incident during the American Civil War in which a Confederate physician tried to spread yellow fever in Northern cities and among Union troops. Although he successfully obtained clothing and bedclothes contaminated by yellow fever victims and distributed some of it in Washington, DC, the action produced no results. The plot probably was not authorized by the Confederate government in Richmond, but it was abetted by Confederate officials in Canada.[48] We now know that the plan could not have worked. In the 1860s, many physicians believed that yellow fever could be spread through contact with contaminated materials, as was true for smallpox. It was not until 1900, however, that scientific studies demonstrated that yellow fever was spread by mosquitoes and could not be transmitted using contaminated material.[49]

Interestingly, some people claimed during and after the Civil War that the other side was responsible for deliberately spreading disease. Thus, on one occasion, the North repatriated some Southern prisoners of war who were sick with smallpox, which led some Southerners to claim that the Northerners deliberately sought to spread the disease. On another occasion, Southerners alleged that the North deliberately inoculated prisoners of war with syphilis-contaminated smallpox vaccine. Some Northerners claimed that prisoners of war in the notorious Andersonville Prison were similarly inoculated with contaminated vaccine. There is no evidence to support any of these allegations.[50]

Summation

Although fears of intentional disease existed before 1900, and some people thought about spreading disease, such intentions were rarely acted upon. It is also

evident that such actions usually had little effect. The most catastrophic uses of biological agents would have targeted indigenous populations, such as the alleged deliberate introduction of smallpox in Australia.

The Origins of Modern BW (1900–1945)

The first decades of the 20th century saw the creation of several BW programs, mostly small and unsophisticated. The Germans organized the first documented state program at the start of World War I (probably in late 1914 or early 1915). They also were the first to employ biological weapons and the first to embark on a BW *campaign*, attempting to use biological agents in multiple countries over the course of several years. During the period between the two world wars, it appears that France, Hungary, Italy, Japan, Poland, and the Soviet Union all had BW programs, although they varied substantially in scope. The Japanese program was by far the largest, possibly with more people and resources than all the others combined.

Views of BW varied considerably. During World War I, the Germans undertook what have been called biological sabotage operations, deliberately targeting animals and not people. Others thought that BW could be employed to create tactical effects on the battlefield or even mass casualties to achieve a strategic impact. Many people were skeptical of the utility of BW and considered its use unsavory or immoral, resulting in resistance to its employment.

Biological weapons were used during World War II, primarily by the Japanese. Their operations mostly were large-scale biological sabotage, although they did make some attacks involving aircraft release of fleas infected with the plague-causing organism. Resistance groups in Eastern Europe also employed biological agents against the occupying Germans, also relying on crude dissemination means. This experience demonstrated the limitations of BW at that time.

World War I (1915–1918)

The origins of the German BW program are obscure. By 1915, however, the Germans began producing several animal pathogens, particularly *B. anthracis* and *Pseudomonas mallei* (the agent that causes glanders).[51] Most armies at the time

depended on horses and mules to move supplies, and so the German BW efforts focused primarily on such animals. The Germans operated globally and are known to have attempted to spread disease in Argentina, Finland (then a part of Russia), France, and the United States, and possibly other countries as well.[52] For example, stocks of Germany's biological agents were discovered in Romania, but it is not known if they were used there.[53] There is some evidence that the French also mounted biological sabotage operations in 1916.[54]

A great deal is known about German BW operations in the United States. These activities, which occurred while the United States was still a neutral country, were part of a larger sabotage effort. The Germans targeted the munitions that U.S. industry was manufacturing for the Allies, including attacks on factories, storage facilities, and ships. These attacks, which caused considerable loss of life, were controlled by the staff of the German embassy in Washington, DC.[55] The Germans' biological sabotage campaign initially relied on pathogens shipped to the United States through covert channels, but it proved difficult to ensure that their agents received viable organisms in this way. Accordingly, they established a small laboratory in the basement of a Silver Spring, Maryland, house to grow their biological agents. The Germans organized a network of operatives in several port cities to disseminate the pathogens.[56]

The effectiveness of these attacks is uncertain. The most careful review of the evidence suggests that they caused only minor results.[57] The virulence of the cultures used in these attacks is unknown. Not much is known about how the attacks were conducted, but reliance on unskilled dockworkers raises questions about the frequency of the attacks and whether they were carried out in ways likely to result in disease.

Mark Wheelis, who conducted the most careful study of the German BW program, argues that it was significant in several respects. It was the first organized state BW program; it was the first BW program that relied on a scientific understanding of disease, based on the microbiological discoveries of the previous decades; it was one of only two BW campaigns mounted in wartime (the other was Japan's during World War II); and it was the only substantial BW campaign undertaken by clandestine state agents.[58]

BW Arms Control: The 1925 Geneva Protocol

Some legal experts have argued that BW was prohibited under customary international law prior to 1925, while others have contended that it was banned by the prohibition against the use of poisons in the 1907 Hague Convention. However, the 1925 Geneva Protocol was the first explicit ban on the use of biological agents as weapons of war.[59] The extensive employment of chemical weapons (CW) during World War I led to efforts—both by military leaders who opposed them for practical reasons and by others who had moral objections— to prevent their future use. While the focus of the agreement negotiated, the Geneva Protocol, was on chemical weapons, it also prohibited "the use of bacteriological methods of warfare." This proscription, which was introduced at the request of the Polish government, subsequently was taken to cover the employment of any microorganisms, not just bacteria (viruses had not yet been discovered at the time).[60] It appears that the Poles requested the inclusion of bacteriological agents due to their concerns that the Soviet Union had initiated a BW program.[61]

The scope of the protocol was limited. It only applied to conflicts between countries adhering to the agreement, meaning it posed no binding constraints on employment in internal conflicts or for use against countries that were not signatories. Nor did it prohibit possession of biological weapons. Many nations added reservations to their adherence asserting a continued right to retaliate in kind should they be attacked by chemical or biological agents, which transformed the protocol into a "no first use" agreement. Most of the major powers ratified the Geneva Protocol, including France, Germany, Italy, and the Soviet Union, but China did not do so until 1952, Japan until 1970, and the United States until 1971.[62]

These legal prohibitions failed to prevent further use of chemical and biological weapons. The Italians, who were a party to the protocol, extensively employed chemical agents during their 1935 invasion of Ethiopia, arguing that atrocities (unrelated to CW use) committed by their enemies justified retaliatory CW employment. The Italians were not sanctioned by the international community. The Japanese, who did not yet adhere to the protocol, extensively employed chemical and biological agents in China during World War II. Other countries did not

use chemical or biological weapons, probably because their military and political leaders were skeptical about the utility of such weapons or because they feared enemy retaliation. In those cases, legal restrictions accentuated other tendencies that militated against the employment of chemical and biological weapons.[63]

Japanese BW (1939–1945)

The Japanese BW program is significant for several reasons. First, the Japanese used their agents in China in the most extensively known employment of biological weapons, probably killing tens of thousands of Chinese, mostly civilians. Second, the Japanese program was one of the largest ever organized, exceeded in size only by the Cold War programs of the Soviet Union and possibly the United States.

The origins of the Japanese program date to 1925, during the negotiation of the Geneva Protocol. At that time, Ishii Shiro, an Imperial Japanese army physician, became convinced that Japan needed to develop biological weapons, believing that BW must be an effective form of warfare if the Western powers wanted to ban it. It was not until 1932, however, that the first biological weapons research facility was established at the army's medical school in Tokyo. Another facility, apparently intended for human experimentation, was created the next year in Japanese-occupied Manchuria. The program was further expanded in 1936 with the organization of Unit 731 (known as the Kwantung Army Epidemic Prevention Division), along with the Kwantung Army Military Horse Epidemic Prevention Workshop, later known as Unit 100.[64]

The program was quite primitive in many ways ("amateurish" in the view of one BW expert).[65] The Japanese developed methods for disseminating fleas infected with *Y. pestis*, the organism responsible for plague, from aircraft, as well as bombs that could be filled with agent slurries that would explode and generate infectious droplets. Although they experimented with an aircraft sprayer to spread biological aerosols, they abandoned the effort after only a few tests. They also appear to have dropped contaminated food from planes and used soldiers to pour pathogen slurries into water supplies.[66]

The Japanese program is most notorious for its research activities, which included extensive human experimentation. People were exposed to different biological agents, and the course of their disease was studied. In some cases, the victims were dissected while still alive. It is known that thousands of people died in those experiments, possibly as many as 10,000.[67]

The Japanese employed their BW capabilities against the Soviets and Chinese on multiple occasions, although there is some uncertainty about the scope of their activities. A Chinese researcher has identified about 161 such operations during the late 1930s and 1940s, but that estimate may be too high. In any case, it includes many small-scale attacks in addition to a few large campaigns that involved extensive dissemination of biological agents. A Western historian identified seven operations from 1939 to 1942, but that list included only the most significant attacks.[68] What seems clear is that the major attacks ended in 1942.

The Japanese tried to use biological agents during the so-called Nomonhan (Kahalkin-Gol) Incident, a border war fought with the Soviet Union from May to September 1939. The Japanese made several attempts to spread biological agents but did so in a crude fashion unlikely to cause casualties. According to accounts given many years later by soldiers who participated in the operation, the Japanese poured *Salmonella typhi*, the organism responsible for typhoid, into a river upstream of Soviet forces. There is no evidence that any Soviet personnel were infected (the organisms probably did not survive once in the water), but at least some of the Japanese soldiers involved in the operation became sick and died.[69]

Japanese dissemination methods could cause epidemics, but effective medical and public health response could limit the danger. Some of the earliest attacks against the Chinese occurred in Zhejiang Province. On October 27, 1940, Japanese aircraft dropped packages of rice and wheat containing fleas infected with *Y. pestis* on the Chinese port city of Ningbo. The first victim died on October 30. Local officials only recognized the presence of plague on November 4, although laboratory confirmation took until November 8. A coordinated local response was undertaken, which included measures to treat victims and other measures to limit further spread. Those who might have been exposed were isolated, contacts of patients were tracked, the area where the attack occurred was quarantined, steps

were taken to bury the dead safely, and a rat eradication campaign was organized to prevent further spread and to ensure the disease did not become endemic. These measures were supported by an effective public communications campaign. The outbreak was brought under control by December 1 at the cost of 106 lives.[70]

In contrast, an attack on October 4 on the river town of Quzhou using the same techniques resulted in more deaths. The outbreak emerged far more slowly than the one in Ningbo. The first known case was identified 38 days after the attack. Even after 8 weeks, there were only 22 known cases (21 of the victims died). The outbreak extended into 1941, killing another 275 people. Effective public health responses probably could have reduced the number of deaths to a handful. The problem was an uncoordinated and slow response, poor leadership by government officials and local elites, and inept laboratories and public health organizations.[71]

Unfortunately, refugees took the plague with them to surrounding rural areas and spread the disease. More than 600 died in Yin County, which surrounded Ningbo. In the counties around Quzhou, it appears that another 2,000 died.[72] Thus, approximately 3,000 people were killed during the outbreak. Most of these deaths could have been prevented through effective public health interventions.

The largest Japanese employment of biological weapons occurred during the Zhe-Gan (Zhejiang-Jiangxi) campaign. This operation was a response to the April 18, 1942, Doolittle Raid, which was the first U.S. air attack on the Japanese homeland. The B-25 bombers used in the Doolittle Raid flew to Zhejiang Province, the only coastal area still under Chinese control. The raid alarmed the Japanese military because its leaders feared that the United States would use newly improved airfields in Zhejiang to mount additional air attacks on the Japanese islands. Accordingly, the Japanese organized a massive incursion into Zhejiang intended to destroy infrastructure that could be used to support bombing raids.[73]

The Zhe-Gan campaign (May to September 1942) was one of the largest offensives mounted by the Japanese against the Chinese in the last 4 years of the war. The Japanese assigned 8 divisions and 3 separate brigades to the attack, a significant portion of the 22 divisions belonging to its China Expeditionary Army. The

175,000 Japanese troops confronted about 260,000 poorly equipped and trained Chinese troops and easily overwhelmed them.[74]

Spreading biological agents was an integral part of the Zhe-Gan campaign. In May 1942, the Japanese spread *Y. pestis* and other pathogens by aircraft, focusing on the Zhenjiang-Jiangxi Railway. As the Japanese began their withdrawal in August 1942 from the areas they had occupied, they contaminated water supplies with the organisms responsible for causing cholera, typhoid, and paratyphoid. They also spread *B. anthracis* in rice fields, released fleas infected with *Y. pestis*, and gave the Chinese cakes contaminated with unspecified pathogens. These activities were conducted under the direct control of Ishii.[75] At the end of the operation, the Japanese reportedly infected 3,000 Chinese prisoners of war by giving them food contaminated with the organisms responsible for typhoid and paratyphoid. The prisoners were then freed to spread the disease further.[76]

The Japanese claimed that they lost only 1,000 dead and another 10,000 wounded or sick from all causes while in turn causing 30,000 Chinese military losses.[77] In addition, the Japanese killed large numbers of civilians, especially in communities that had assisted the U.S. Airmen involved in the Doolittle Raid. A senior U.S. military officer estimated that as many as 250,000 Chinese died as a result of the Japanese campaign.[78]

Spreading biological agents caused many people to become ill. A Chinese account claims that the BW attacks caused 1 million people to become sick, killing a "few" tens of thousands.[79] It is impossible to verify this estimate; the actual numbers might have been far lower. The Japanese also managed to infect many of their own troops during the operation, causing 10,000 to become sick and killing 1,700, according to one account.[80]

What were the Japanese trying to accomplish? The leaders of the BW program apparently viewed the operations as field experiments, as a test of the potential effectiveness of biological weapons. Martin Furmanski, a U.S. expert who has studied the action, suggests that the actions also may have been intended to support the campaign's broader strategic objectives by spreading biological agents to prevent the Chinese from establishing airbases for U.S. strategic bombers. For

that reason, this may have been the most significant BW campaign ever conducted because it was undertaken to achieve strategic and operational objectives.[81]

Some accounts suggest that Japan's military leaders were unhappy with the number of their own soldiers who became infected during the operation.[82] For this reason, it appears that they refused to authorize additional large-scale biological weapons employment, and there were no more major BW attacks.

The Japanese continued to conduct smaller BW operations through the end of the war. Although most of the attacks were aimed at China, the Japanese also tried to cause disease outbreaks in the Soviet Union. They sent infected individuals across the border, hoping that they would infect others. In addition, the Japanese released balloons carrying flasks filled with biological agents, spreading the agent in the area around the point of dissemination.[83] It does not appear that these attempts had any result.

Some Chinese sources claim that the Japanese attacks killed hundreds of thousands of people. One study puts the number at 740,000.[84] A Western expert who has studied the Japanese attacks in some detail, however, concluded, "The Japanese BW program caused a few tens of thousands of deaths overall, almost all Chinese civilians (if you don't count whatever 'blowback' casualties occurred among Japanese troops)."[85] At least some of the casualties probably resulted from epidemics that continued after the initial dissemination. In addition to person-to-person transmission, biological weapon attacks can create new enzootic reservoirs and thus cause outbreaks long after the initial dissemination.[86] Clearly, the victims of such epidemics are as much BW casualties as those infected in the initial attack. Whichever figure is correct, Japan's BW attacks in China were history's most lethal uses of biological weapons.

The Soviet Union held a war crimes trial for Japanese soldiers associated with their BW program. The United States refused to assist in the effort, choosing to view it as a politically motivated propaganda stunt. The United States never prosecuted anyone for their involvement in Japan's BW program, having offered amnesty in return for information about what the Japanese accomplished. It is generally agreed that the Japanese information was incomplete and proved to have little value.[87]

Other State BW Programs

Several other countries had BW programs during the first half of the 20th century. Some were small or poorly organized, while others were large and well-organized. In no case, however, is there evidence of biological weapons employment.

Canada. In 1937, Sir Frederick Banting, who was awarded the Nobel Prize in 1923 for the co-discovery of insulin, began agitating for Canada to organize a BW program. Although his efforts met with considerable opposition, both in Canada and the United Kingdom, exploratory research was under way by mid-1940. During the war, the Canadians investigated several biological warfare agents, including the pathogens responsible for anthrax, brucellosis, and tularemia, and they produced small quantities of *B. anthracis* for munitions testing. Canadian facilities tested several biological weapons, including the British Mark I, a 4-pound bomblet filled with the agents causing brucellosis and tularemia. Botulinum toxin also was a part of the program; the Canadians tested a cluster munition that dispensed darts coated with the poison. The Canadian effort should be seen not as an independent activity but rather as a component of the larger British and U.S. programs. The Canadians developed no operational BW capability.[88]

France. The French had a small BW program during the period between the two world wars. They benefited from the contributions of André Trillat. One of the world's leading experts on dissemination of disease through the air, he published seminal articles on the topic in 1918 and 1920. The program was active from 1921 to 1927 and then went dormant, but efforts resumed in 1935. Trillat remained a part of the program until Germany's occupation of France in 1940 caused its termination.[89] The French program drew on the expertise of the Pasteur Institute, giving it access to some of the world's leading biological scientists.[90]

The French effort had both defensive and offensive elements. On the one hand, the French were trying to understand the potential threat better. They began researching dissemination technologies and techniques, even to the extent of releasing microorganisms in the Paris subway to determine the degree to which they would disperse. They studied botulinum toxin and determined that it could survive the destructive forces of an exploding artillery shell. Similarly, they researched

dissemination of animal diseases. They also tried to implement some defensive measures, including the production of anti-anthrax sera.[91]

In the months before the start of World War II, the French explored several different types of biological weapons, including an aircraft bomb, an artillery shell, and a hand grenade. The French tested some of these devices in early 1940, reportedly with positive results. Interestingly, it appears that the devices disseminated "bovine plague virus," probably a reference to "cattle plague" or rinderpest.[92] Rinderpest is an animal disease and does not affect people, so the objective must have been to attack horses used by military units (most German army units relied on horses for transport).

The French program ended with their military defeat in 1940. The French destroyed most of their records and hid others.[93] The Germans discovered some of their work, which affected German thinking about both BW and biodefense.[94]

Hungary. The Hungarians organized a small BW program. Although authorized in 1936, it was not until August 1938 that it became active. Known as the Health Control Station of the Hungarian Royal Defense Forces, the institution was based in a converted artillery warehouse in Budapest. The program reportedly employed only six technicians but supposedly made considerable progress before the facility was destroyed during a bombing raid in April 1944. The Hungarians researched *Bacillus anthracis*, *Clostridium perfringens*, *Salmonella paratyphi*, and *Shigella dysenteriae*. They also explored various dissemination techniques, including glass bombs capable of carrying 1 to 50 kilograms of a biological agent (either wet or dry). The Hungarians thought that these weapons were highly effective, but that claim is questionable. Their munitions probably could not generate effective aerosols.[95]

Italy. The Italians initiated a small BW program in 1934.[96] The program reportedly was based in a military hospital in Rome. Mussolini reportedly suggested in February 1936 that Italy employ biological weapons against hostile forces during the invasion of Abyssinia. At least one of his senior commanders opposed the proposal, fearing that such attacks would undermine support from Ethiopians sympathetic toward the Italians and that any possible operational benefits would not outweigh the negative international repercussions.[97] The Germans never discovered

the existence of this program.[98] It seems likely that the program went moribund in 1940 when its director and chief advocate was given a battlefield assignment.[99]

Poland. The available evidence suggests that the Polish BW program was motivated by concerns that the Soviet Union had initiated work on biological weapons. The Polish program, underway by 1928, was under the authority of the intelligence services and operated from a dedicated military laboratory. Although its personnel drew on the expertise of other Polish scientists, it worked under intense secrecy, and the Poles probably did not interact with other BW programs. Polish BW scientists debated how to use their emerging capabilities best. One of its senior scientific managers told U.S. interrogators that the program's primary military objective was the development of a capacity for conducting biological sabotage operations against a military force occupying Polish territory. Efforts were accelerated in the years immediately before the war. By 1938, 67 people were working in their research institute. Some of the key BW scientists fled Poland ahead of the invading Germans in September 1939 after destroying their military laboratory.[100] As discussed below, the Polish resistance army conducted extensive biological sabotage operations against the Germans, probably drawing on skills developed by their prewar BW program.

The Soviet Union. The Soviet Union opened its first laboratory for conducting BW-related research in 1925, although research may have started earlier. This small facility did research on *B. anthracis* and *C. botulinum* to determine if it were possible to wage biological warfare with them. The results of those early experiments led the Soviet government to commit to the establishment of an organized offensive BW program by 1928.[101]

During the next decade, the Soviets created a substantial infrastructure to support its BW program. They used existing organizations, which included 35 institutes controlled by the Ministry of Health, and created several dedicated BW research centers, initially concentrated around Leningrad and Moscow. In addition, testing facilities were established, which were used to conduct open-air testing of biological agents. The most important was on Vozrozhdenia Island in the Aral Sea. The program benefited from the already formidable talent of Russian biological scientists.[102]

Although the Soviet Union had an extensive BW program by the late 1930s, reportedly comparable in size to the one organized by the Japanese, it was disrupted by the purges of the late 1930s. A considerable number of BW scientists and administrators were accused of sabotage and espionage. Some were executed, while others were sent to prison camps for periods of time. This appears to have significantly hindered Soviet BW activities at that time.[103]

The Soviets researched numerous pathogens for use as BW agents, including *B. anthracis*, *C. botulinum, Francisella tularensis,* and *Y. pestis*. It appears that the elements of the program specifically targeted animals, which were a military target at the time given the dependence of most armies on horses for movement of supplies and transport of artillery. Foot and mouth disease virus was researched, as well as several zoonotic agents, such as the organism that causes glanders. The Soviets tested some weapons during this period, but it is unclear if any reached operational status. The potential effectiveness of the munitions is unknown. Information on Soviet preparedness to employ BW is scanty, but it is unlikely that the Soviets used biological agents except in sabotage operations.[104]

The Soviet military is not known to have used any BW agents during this period, despite claims that a 1942 outbreak of *F. tularensis* among German troops during the Battle of Stalingrad resulted from a deliberate release.[105] Also unconfirmed is an allegation that the Soviets caused a 1943 outbreak of Q fever (caused by *Coxiella burnetti*) in Crimea.[106]

Possible links between the Soviet BW program and partisan use of biological agents in German-occupied areas of the former Soviet Union require further investigation.[107] Recently discovered documents confirm that some Soviet intelligence operatives deliberately spread a biological agent. Reportedly, a sabotage team operating in German-occupied Slavuta (a town in Ukraine) infected Germans (including civilians, government officials, and soldiers) with *Rickettsia prowazekii*, the organism that causes typhus fever. They did this by spreading infected lice. Although some of the infected lice were obtained locally from typhus victims, the origin of the initial batches used by the team is unknown. Unconfirmed claims found in Soviet intelligence files indicate that more than 120 Germans were killed in these operations.[108]

The United Kingdom. The British initiated an offensive BW program in 1940. Prior to the war, press reports suggesting that the Germans had an offensive BW program attracted high-level official attention.[109] This led to some defensive efforts. It was only after the war started, however, that serious investments were made in offensive weapons. This was a relatively modest program, guided by a research laboratory with about 45 personnel.[110] It was, however, staffed with talented scientists, and its director, Paul Gordon Fildes, was one of the world's most respected microbiologists.[111] The program focused primarily on research designed to understand the character of aerosol transmission of pathogens.

The British program explored several biological weapons options but developed only a few. The focus was the Mark I, a modification of the Type F cluster munition originally intended for use with high explosives and chemical agents. Field tests demonstrated that it could disseminate *B. anthracis* from a liquid slurry, although it was highly inefficient in generating aerosols. The British were unable to produce the bulk agent required to fill these munitions and intended to rely on the United States to do so. The planned U.S. facility was not completed before the war ended, and the munitions were never fielded. The British did produce large quantities of cattle cakes impregnated with anthrax for bomber delivery. The intended targets were German cattle herds.[112] Designed for retaliatory attacks should the Germans resort to BW, the effectiveness of such a weapon is unclear; its strategic utility was dubious.

The United States. The United States initiated a BW program in 1942, after the attack on Pearl Harbor brought the Nation into World War II, although serious work did not begin until the spring of 1943. By that time, it was known that the Japanese were using biological agents in China, although it is unclear whether defense planners in Washington fully understood this. President Franklin D. Roosevelt, fearing that the Germans or Japanese might employ biological weapons against the United States, considered the BW program as a deterrent. The U.S. Army organized a substantial effort, ultimately spending roughly $60 million (about $800 million in 2016 dollars) and employing approximately 4,000 personnel.[113] This was far larger than the British program. By comparison, the

United States spent about $1.9 billion (over $25 billion in 2016 dollars) on the Manhattan Project to produce the atomic bomb.[114]

The research efforts were highly successful, demonstrating that it was possible to transmit certain pathogens through the air in aerosol clouds. At least 18 different biological agents were studied, including some intended for use against crops and animals. The primary focus was on *B. anthracis* and botulinum toxin as antipersonnel agents.[115] The program made much less progress in the development of biological weapons and in the mass production of biological agents. A few munitions were tested and adopted for service, although they were marginally effective at best. Given the perceived need to have a deterrent capability, the U.S. military was willing to accept weapons with known flaws. For this purpose, a modified version of the British Mark I cluster munition was adopted. The United States made little progress in the large-scale production of biological agents. Construction was started on a large-scale biological agent production facility intended to provide *B. anthracis*, but it was not completed before the end of the war. Technical challenges were never overcome, and the military abandoned the facility, which never produced any BW agent.[116]

The United States ended the war with no employable BW capability but had a research effort, undertaken in close collaboration with the British and Canadians, that transformed BW science and laid the foundation for future U.S. efforts during the Cold War. In particular, the United States learned enough about the transmission of disease through the air to reshape the understanding of infectious disease transmission in natural settings and to create conceptions of aerosol transmission for biological warfare.[117]

Nonstate Use (1900–1945)

The early 20th century saw efforts by criminals and terrorists to exploit pathogens for use as weapons. Some attempts to use biological agents are well documented, others less so. Documented incidents occurred in countries around the world, including in France, Germany, India, Japan, and the United States.

In France, Henri Girard used *S. typhi* to commit insurance fraud on several occasions starting in 1910. He would open an insurance policy in the name of

a victim, making either himself or a confederate the beneficiary. He killed one person using the pathogen but failed in several other attempts. He was caught but died before he was tried.[118]

In January 1914, a German court sentenced Karl Hopf to death for the murder of his first wife and the attempted murder of other family members, including his third wife. While most of his victims were given arsenic, he reportedly laced food given to his third wife with the organisms responsible for cholera and typhoid. It was the first case tried in Germany involving the use of pathogens to attempt murder.[119]

In 1916, a resident of New York, Arthur Warren Waite, tried to kill his in-laws by infecting them with several pathogens, but with no success. He ultimately murdered his father-in-law using arsenic.[120] In 1935, Benoyendra Chandra Pandey and Dr. Taranath Bhatacharya conspired to kill 20-year-old Amarendra Pandey, Benoyendra's half-brother, by infecting him with a lethal dose of *Y. pestis*.[121]

Some resistance groups, primarily in Eastern Europe, employed biological agents against the Germans during World War II. There are numerous reports of such activity, but no comprehensive historical review has been made. The Germans reported 25 such incidents in 1943, mostly associated with the Polish and Soviet resistance.[122] One incident investigated by the Germans involved the contamination of coffee with *Salmonella typhi* by a Czech saboteur. The investigation identified 60 examples of contamination.[123] In contrast, the Germans concluded that a typhoid outbreak in France resulted from natural causes.[124] Polish resistance forces made extensive use of chemical and biological agents after the Germans occupied their country in 1939. Prior to the war, the Polish intelligence service devised a program to attack enemy personnel with poisons and infectious diseases in the event that their country was occupied. According to Polish records, they executed thousands of such attacks, mainly targeting individuals, but most involved poisons and not pathogens. Although these attacks are known to have killed or harmed some Germans, the claimed results usually cannot be confirmed. The Germans may not have realized that some disease outbreaks resulted from deliberate attacks, but it is also evident that the Poles had no way to assess the effectiveness of their

activities. Apparently, the Poles found it hard to culture the biological agents and keep them viable until used.[125]

Claude Lévi-Strauss, the eminent anthropologist, reported that indigenous peoples in Brazil were exposed to smallpox virus by landowners from 1918 to 1935, apparently to facilitate expropriation of land for farming. These landowners spread the disease by taking clothing from smallpox victims and leaving it on trails frequented by the natives. Unfortunately, there is no other corroboration of this allegation.[126]

Summation

The first half of the 20th century saw the emergence of crude efforts to exploit the biological sciences to create weapons of war. The initial steps were hesitant. During World War I, the Germans focused their efforts on animals and rejected plans to use disease against people. In contrast, the Japanese were quite willing to use disease against people, mostly against noncombatants. However, the amount of effort Japan devoted to BW was not matched by its results. Ultimately, inadequate scientific and engineering foundations limited the effectiveness of the Japanese program. Although many countries organized BW programs during this period, it was the Western allies—the United States, the United Kingdom, and Canada—that undertook the research suggesting that it would be possible to employ BW in ways that could rival the atomic bomb in lethality.

The Cold War and Beyond (1945–Present)

The period since 1945 has been characterized by several key trends. First, massive investments by the superpowers (the Soviet Union and the United States) in BW science and technology converted a technique useful mostly for sabotage operations into one capable of inflicting mass casualties potentially equaling the lethality of thermonuclear weapons.[127] This resulted largely from the development of methods for the effective and efficient aerosol dissemination of biological agents.[128] Both the United States and the Soviet Union had programs that exploited these advances. Second, while other countries also had BW programs, most appear to have been small, and none approached the capabilities of the two

superpowers. Indeed, many seem to have had capabilities little more complex than those developed prior to World War II. Third, biological arms control and disarmament became a serious topic of discussion in the international community, resulting in the BWC prohibiting the possession of biological weapons.

Most remarkably, despite the growing lethality of biological weapons and the investments in BW by many countries, there was no significant resort to BW. Instead, biological agent use was confined primarily to terrorists and criminals. The few cases of state use were limited to relatively simple, small-scale attacks.

State BW Programs

It is difficult to definitively determine the extent of biological weapons proliferation during the Cold War era. Although several dozen countries have been accused of having a BW program since 1945, the supporting evidence is weak or even nonexistent in many cases. Some countries appear to have considered the acquisition of biological weapons but never organized an effective research and development program. In other cases, research and development programs never produced results, either because of poor quality research or the low priority assigned the effort.[129]

Open-source information, admittedly of uneven reliability, suggests that fewer than 20 countries had or attempted to organize programs to develop BW capabilities (including weapons utilizing pathogens, toxins, or both) at any time between 1945 and 2015. The number active in any given year was small, probably no more than five to eight.[130]

These programs differed radically in size and sophistication. The largest (organized by the Soviet Union) may have employed 60,000 scientists, engineers, technicians, and other personnel. The smallest (Rhodesia) had no more than six technically trained people (although not all may have worked on biological as opposed to chemical agents). Some programs relied on crude dissemination techniques, such as contamination of food and water (Israel in 1948, Rhodesia in the 1970s, South Africa in the 1980s). Only the United States and the Soviet Union are known to have developed operational capabilities to disseminate biological agents over large areas using sophisticated aircraft and missile delivery systems.[131]

Some of these programs were initiated before or during World War II (Canada, France, the former Soviet Union, the United Kingdom, and the United States). Several programs were terminated before the final negotiation of the BWC (Canada, France, the United Kingdom, and the United States). In some countries, biological weapons competed poorly with nuclear weapons. Nuclear weapons were given priority, and resources devoted to BW development were transferred to nuclear weapons programs deemed strategically far more important (France and the United Kingdom). With a few exceptions, these programs operated independently with no intentional transfers of technology from one BW program to another. The sole known exception was the close collaboration starting in the 1940s between the United States and the United Kingdom, supported by the much smaller Canadian effort.[132] The United States remains concerned that Russia never dismantled all the components of the former Soviet BW program.

Canada. The Canadian BW program, tied closely to the efforts of the United States and the United Kingdom, was centered on a small but high-quality research establishment. Canada abandoned its own offensive program in 1958 but continued to support U.S. activities through the 1960s.[133]

China. Little is known about the Chinese BW program. The United States believed that it started in the 1950s and was still active after the Chinese acceded to the BWC in 1984.[134] Practically nothing else is known.[135]

Egypt. In early 1972, Egyptian President Anwar Sadat stated, "Briefly, we have the instruments of biological warfare in the refrigerator and we will not use them unless they [the Israelis] begin to use them." This assertion was repeated by another Egyptian official a few months later.[136] Other reports suggest that the Egyptians initiated their program in the 1960s. In the late 1990s, the U.S. Government thought that the Egyptians retained a capability to employ BW but has not repeated that claim since then. In 2015, the U.S. State Department once again mentioned Egypt in its annual arms control compliance report but stated that "available information did not indicate that Egypt was engaged in activities prohibited to States Parties of the BWC."[137] Egypt is a signatory to the BWC but has never ratified it and thus has "an obligation under international law to refrain from acts that would defeat the object and purpose of the treaty."[138]

France. The resumption of BW research, building on the work of the prewar program, was authorized by the French in early 1947. This effort continued until 1956 when funding diminished as the priority shifted to the development of nuclear weapons. Although technically sophisticated, the BW program remained a research activity and did not build facilities for large-scale production of BW agents or conduct open-air testing. The program was smaller and less advanced than the British or U.S. programs.[139]

Iran. Although the United States and others have asserted that Iran initiated a BW program in the 1980s, possibly in response to Iraqi activities during their 1981–1988 war, almost nothing is known about it.[140] Much of the open-source reporting refers to dual-use items not necessarily associated with BW activities.[141] There is insufficient information to assess the likely size or sophistication of the Iranian BW program.

Iraq. Despite many gaps in the available information, much is known about Iraq's efforts to develop BW capabilities due primarily to the efforts of United Nations (UN) inspectors after the 1991 Gulf War and the investigations of the U.S. Government after 2003.[142]

A small program was initiated in 1974 but was disbanded in 1979 due to lack of progress. Its staff was dispersed, including some assigned to an intelligence activity. In the following years, the Iraqis continued to develop dual-use capabilities needed for a BW program but undertook little substantive work. In 1983, Saddam Hussein decided to restart the BW program. Over the next 3 years, a bureaucratic structure was put into place, and the new program was given the budget, personnel, and leadership to create biological weapons capabilities. In 1986, a 5-year plan for weapons development was adopted. One senior Iraqi military official told UN inspectors in 1998 that Iraq's leaders organized their BW program to provide a strategic weapons capability until they had nuclear weapons.[143] According to a UN assessment, the program had about 100 dedicated staff, including 25 key technical personnel.[144]

The program researched many biological agents, focusing especially on *B. anthracis* and *Clostridium perfringens*, a pathogen typically associated with food poisoning but also responsible for wound gangrene. At various times, their pro-

gram investigated viral agents, including three apparently intended for use as incapacitants: camelpox virus, Enterovirus 70, and rotavirus. An anti-plant agent, wheat cover smut, also was researched. The greatest attention, however, was given to toxin agents, including aflatoxin, botulinum toxin, and ricin.[145]

Iraq attempted to develop a number of biological munitions, including artillery rockets, aircraft bombs, and missile warheads, typically chemical munitions modified to carry biological agents. The Iraqis also worked on aerial sprayers, including modification of existing drop tanks for use with their French-made Mirage F1 fighters and a helicopter system using an adapted agricultural sprayer. None of these sprayer systems was operational at the time of the Gulf War.[146]

By early 1991, when the Gulf War started, the Iraqis had a small arsenal of biological weapons. They had produced and weaponized *B. anthracis*, aflatoxin, and botulinum toxin.[147] The Iraqis intended to fill 200 R-400A aircraft bombs and 25 Al Hussein missile warheads with these agents. Ultimately, lack of agent allowed them to field only some of these munitions. According to the Iraqis, they had filled 157 of the aircraft bombs (100 with *B. anthracis*, 50 with botulinum toxin, and 7 with aflatoxin) and 25 Al Hussein warheads (16 with botulinum toxin, 5 with *B. anthracis*, and 4 with aflatoxin), but both UN and U.S. investigators were unable to confirm these numbers. The missile warheads were never tested. They were fitted with fuses that detonated on impact, meaning that the agent would be disseminated when the warhead hit the ground.[148]

Iraq never employed its biological munitions; their effectiveness was dubious. At least some senior Iraqi military officers were skeptical of their weapons' military effectiveness, hoping instead that the psychological effect of a biological attack would have a strategic impact:

> *The Iraqis were well aware of the shortcomings of the Al Husayn missile and the R-400. Lt. Gen. Hazim, commander of the surface-to-surface missile forces, openly admitted that the Al Husayn, with a BW agent filled warhead, would fulfill its purpose if after impact in an enemy country sufficient material survived to enable its detection as a BW agent. It was a weapon of terror.*[149]

It is unlikely that they could have caused mass casualties and may have been no more dangerous than conventional munitions.

After Iraq's defeat in the 1991 Gulf War, the UN Security Council required it to accede to the BWC and account for its past BW activity. Iraq destroyed most of its BW agent and associated munitions in the months after the war but attempted to keep the program a secret. Until 1995, the Iraqis apparently hoped to revive their previous activity and tried to prevent UN inspectors from identifying BW-related facilities. Even after Iraq finally admitted to having had a program in 1995 and began providing information to UN inspectors, it continued to hide information and sustained its denial and deception activities. Subsequently, some Iraqi BW scientists were assigned to laboratories run by the Iraqi intelligence, and may have been helping develop poisons and toxins for use in assassinations.[150] Based on statements made by Saddam Hussein, U.S. investigators concluded that he hoped to create the impression that Iraq retained some weapons capability as a deterrent against regional neighbors, especially Iran.[151] So far as is known, the Iraqis never employed their biological weapons.

Israel. The Israeli BW program was initiated in the months before the establishment of the state in May 1948 and the subsequent outbreak of hostilities with neighboring Arab countries. As discussed below, biological agents were employed with limited success during 1948 against the British (who had legal authority over Mandatory Palestine) and the invading Arab armies. Following the end of hostilities, the Israelis created a BW program within their new Ministry of Defense. Although Israel created a world-class biological research establishment, it is not known what kinds of BW capabilities resulted.[152] Given the advanced state of Israeli biology and the competence of its military industry, it is reasonable to assume that it could have created highly effective BW capabilities.[153] However, there is no publicly available evidence to support such a conjecture.

North Korea. Although there is a substantial body of literature on North Korea's BW program, hard facts are rare, and most open-source information comes from South Korean sources of uncertain reliability. This makes it difficult to assess the size, sophistication, or intended role of North Korea's program, or even if the program remains active.[154]

The U.S. Government believes that the program originated in the 1960s, and a 1993 Russian government report claims that the North Koreans were testing biological weapons on an offshore island. The Russians also mentioned that North Korea held stocks of smallpox, which it was supposed to have destroyed after the eradication of that disease.[155] Other sources claim that the North Koreans have a large infrastructure devoted to BW activity and that they are working on numerous BW agents. It is unclear if such reports differentiate legitimate research from a covert BW program, especially since the allegations often refer to diseases endemic to the Korean Peninsula.[156]

Most analysts believe that North Korea is most likely to rely on covert dissemination of BW agents. North Korea operates a substantial force of special operations units and is thought to give particular emphasis to their use. Some sources doubt that they have BW missile delivery systems but speculate that they might have aircraft sprayers.[157]

Rhodesia (now Zimbabwe). The white Rhodesian regime operated a small BW program in the 1970s run by a professor of anatomy at the University of Rhodesia. It appears that the Rhodesians tried to culture the organisms responsible for cholera and anthrax. They had no specialized dissemination capabilities and allegedly poured out a liquid slurry of the biological agents when they mounted an attack. The Rhodesians apparently experimented with cigarettes laced with *B. anthracis*. The Rhodesians probably were assisted by the South Africans, but the surviving evidence is limited.[158] Rhodesia probably used biological agents, as discussed in the next section.

South Africa. South Africa developed a chemical and biological weapons program in the 1980s, possibly benefiting from knowledge from Rhodesia's experience.[159] The BW program operated out of a front company, Roodeplaat Research Laboratories, to hide its ties with the government. Much of its work was focused on the development of toxins intended for assassinations. In addition, the South Africans created small stocks of biological agents for use against regime opponents, including *B. anthracis* (which causes various forms of anthrax), botulinum toxin, *Brucella melitensis* (which causes brucellosis), *Salmonella typhimurium*

(which causes food poisoning), and *Vibrio cholerae* (which causes cholera). All this work was in violation of South Africa's obligations as a BWC signatory.[160]

The South African program appears schizophrenic to the outside observer. Like the Rhodesian practice, the South Africans developed only rudimentary biological agent dissemination capabilities. On the other hand, the South Africans created Roodeplaat Research Laboratories as their primary BW research institution. It had well-equipped biological research laboratories staffed with skilled personnel. Nearly a fifth of the laboratories' activities were focused on antifertility drugs intended for use against the country's black population. That project never produced any concrete results. The program also was supported by another organization, Delta-G, which primarily focused on chemical agents but also developed and manufactured biochemical products. Ultimately, it also produced a considerable quantity of several types of street drugs.[161]

The Soviet Union and Russia. The Soviet Union operated a BW program during the entire Cold War. The best available evidence (admittedly scanty) suggests that it made relatively little progress from the end of World War II until the early 1970s. However, the program was then reorganized and rejuvenated, even though the Soviet Union joined the BWC after playing a leading role in negotiating that treaty. The new effort exploited the possibilities offered by advances in biology and resulted in the largest and most sophisticated BW program ever organized. This account is based largely on the best description of Soviet BW activities, a study by Milton Leitenberg and Ray Zilinskas, *The Soviet Biological Weapons Program*.[162]

A great deal is known about the scientific underpinnings of the program; much less is known of its military dimensions. In addition, there are whole aspects of Soviet BW development that remain largely unknown, including the anti-agriculture activities of the Ministry of Agriculture and the clandestine operations capabilities of the Soviet intelligence services, especially the KGB. The Soviets worked on biological agents for attacking both crops and animals, including organisms that infect wheat, rye, and rice plants and numerous viruses that affect agricultural animals.[163] We do know that the KGB viewed pathogens as possible weapons for targeted killing. Documents uncovered after the collapse of the Soviet Union reveal that Joseph Stalin instigated a plot to assassinate Josip Broz Tito and that one of the options

was to infect him with *Yersinia pestis*, the organism that causes plague. Stalin died before the assassination plot was finalized, and it was abandoned.[164]

Little is known of Soviet BW efforts from 1945 until the early 1970s. The Soviet military continued BW research and development, but it is unclear that the program ever fielded militarily significant capabilities. Part of the problem was scientific. During the 1930s, Soviet biology was tainted by the views of Trofim Lysenko, an agricultural scientist who rejected Mendelian genetics and instead advocated an alternative holding that traits acquired through environmental exposures could be transmitted to offspring. Consequently, Soviet biology lagged the West. Another part of the problem was bureaucratic. The Soviet military establishment was unable to support the type of creative scientific research needed to advance the program.[165]

Convinced that the Soviet Union needed a robust BW program, the country's leaders were open to the persuasions of its scientific elite. It appears that leading Soviet scientists successfully lobbied for the organization of a new BW research and development organization, Biopreparat, separate from the existing military laboratories. The Politburo provided generous funding to Biopreparat, also accepting Western biology and repudiating Lysenko's views.

During the 1970s and 1980s, the Soviet program made enormous strides, and by the time the Soviet Union collapsed in 1991, the scientific underpinnings of its BW program went far beyond anything accomplished by others. Although the research program was highly inefficient, its sheer size more than made up for the usual deficiencies that compromised Soviet productivity by the end of the Cold War.

The Soviet BW program always was kept secret, but the intensity of its activities increased after negotiation of the BWC. The Soviets designed their new program knowing that it was in violation of the treaty, and hence they had to protect the mere fact of its existence. Some of its facilities were located in closed cities, communities in remote areas accessible only with special permission. Some of these closed cities also were unacknowledged, not even appearing on maps.[166] The scope of the program is evident in a listing of facilities associated with just the civilian components of the program: 10 research and development institutes,

14 production and mobilization plants, and 8 special weapons and facility design units.[167] There were additional military installations, including test sites that conducted open-air testing of munitions with a live agent.[168] The military and civilian production sites had the capacity to produce hundreds of tons of biological agent per year.[169]

The research facilities engaged in a wide range of activity, both offensive and defensive. Some work was devoted to enhancing traditional biological agents, but the Soviets also were interested in adopting emerging pathogens and creating novel biological agents. Biopreparat was organized mainly to develop enhanced pathogens resistant to antibiotics and able to evade vaccine protection. The Soviets explored certain emerging infectious diseases as potential BW agents, including the Ebola and Marburg viruses. They eventually selected Marburg virus and developed formulations that would enable its use in weapons. Finally, the Soviets were attempting to develop so-called chimeras, biological agents that incorporated genetic components from different pathogens to create an organism with unique characteristics. None of the novel agents were ready for service when the Soviet Union collapsed in 1991. Among the agents being developed was a strain of vaccinia, the virus used in the smallpox vaccine, incorporating genes from the Ebola virus. Another variant added genes that produce certain bioregulators (chemicals naturally present in the body) with the intent of disrupting the immune system.[170]

Most of the biological agents adopted by the Soviet Union were like those used in other BW programs, such as the smallpox virus, *B. anthracis*, *Coxiella burnetii*, and *Y. pestis*, all weaponized by the early 1970s. The only new agent added to the program by the beginning of the 1990s was the Marburg virus, but it seems likely that new strains of older agents replaced those previously in use.[171]

Because little is known about Soviet biological weapons design, concepts of operation, or the intended strategic role of their BW program, it is impossible to assess its likely effectiveness. However, the Soviets developed standardized techniques for large-scale production of pathogens and associated formulations to enhance dissemination and virulence. They certainly viewed their weapons as having both strategic and operational utility.[172] The Soviet Union built a huge complex for the production of biological weapons. A former Soviet BW scientist claimed

that the Soviet Union maintained a stockpile of 20 tons of smallpox virus, grown in eggs and constantly replenished as old stocks lost viability. It also built 3 plants with an annual wartime production capacity of 1,800 tons of *B. anthracis*.[173]

It is unclear whether the Russians have entirely terminated the former Soviet BW development program. In 1992, Russian president Boris Yeltsin admitted that the Soviet Union had operated a BW program in contravention of its BWC obligations and promised to terminate it. Yeltsin encountered considerable opposition to his efforts, and it is unclear that all elements of the program were shut down. The Russian government officially admitted to some of its past activities in a report to the United Nations in 1992 (a document submitted as a BWC confidence-building measure), but by 1994 it had backed away from that admission.[174]

Since then, the U.S. Government has regularly expressed concerns about the lack of transparency. In 2005, for example, the U.S. State Department declared, "The United States judges based on all available evidence that Russia continues to maintain an offensive BW program in violation of the [Biological and Toxin Weapons] Convention."[175] The Barack Obama administration did not repeat the allegation that the Russians kept a BW program, but in 2016 it still reported that the Russians "have not satisfactorily documented whether this program was completely destroyed or diverted to peaceful purposes."[176]

In 2012, Vladimir Putin called for the development of "weapons systems based on new principles," including genetics.[177] Subsequently, the Russian minister of defense reportedly initiated planning to implement this agenda.[178] Acquisition and use of such a "genetic weapon," whether based on new or old principles, is illegal under international law. As far as is known, the Soviet Union never employed its biological weapons during the Cold War.

Syria. The first references to a Syrian BW program appeared in 1990, but it is not known when the program started. The Syrians admitted to producing ricin toxin for use in weapons.[179] In contrast, no evidence has emerged to support claims that Syria also was exploring biological agents, including *B. anthracis*, or that it developed and deployed missile warheads for their delivery.[180]

The United Kingdom. The efforts of the United Kingdom built on the country's World War II experiences. Initially, efforts to develop BW capabilities had

a priority equal to that assigned to the atomic bomb program. The Air Ministry drafted a requirement for the development and procurement of air-delivered cluster munitions for use against Soviet industrial centers. In other words, civilians would be the primary target. Support infrastructure was improved, including construction of a small production facility to produce quantities of biological agent. Open-air biological agent releases, intended initially to test biological munitions, were conducted in the Caribbean and off the coast of England. Among the agents tested were *B. anthracis*, *Brucella suis*, *Brucella arbortus*, and *Francisella tularensis*.[181]

The program produced little. The weapons tests were disappointing, as the existing bomblets proved highly inefficient. In 1952, a new British military strategy downplayed the importance of the BW program, assigning greater importance to nuclear weapons, and the requirement for a near-term biological weapons capability was eliminated. Over time, even the long-term need for a biological munition disappeared, and by 1957 all offensive development activity had ended.[182] Although the British retained considerable expertise in BW science and technology, supporting a technically sophisticated biodefense effort, they never had an operational capability to employ biological weapons.

Paul Gordon Fildes, who had led the program during World War II, ultimately concluded in 1955, "It was becoming clear that the hazards of biological warfare, as distinct from sabotage, were not as great as has been thought."[183] While British military planners accepted that North Atlantic Treaty Organization countries might need BW capabilities, they also concluded that the United Kingdom did not. They believed BW was not useful as a deterrent and could not identify a useful operational military role for it. British policy never changed, even after the United States demonstrated a strategic BW capability in the 1960s.

The United States. The United States almost certainly had the world's most accomplished BW program during the Cold War, at least until it was canceled in 1969. Support for the program waxed and waned, and levels of funding fluctuated accordingly. However, the quality of the science that supported it was excellent, and program leaders persistently worked to solve the many technical obstacles to a fully realized BW capability. In the end, the program failed because the U.S. national security establishment found no strategic rationale for BW.[184]

U.S. BW scientists understood the implications of agent aerosolization and focused efforts on the complex task of identifying agents, formulations, and dissemination systems optimized for that purpose.[185] Through a series of elaborate field trials, the United States eventually demonstrated an ability to disseminate lethal biological agents over large areas. By the mid-1960s, the U.S. Air Force had a bomblet delivery system that allowed a single B-52 bomber sortie to affect 10,000 square miles as well as spray tank systems for use on fighter-bombers affecting 25,000 to 50,000 square miles. It also sought to develop agents with differing characteristics, including a focus on supposedly nonlethal agents that could be used in limited wars. Indeed, in the late 1950s, the program invested far more on so-called incapacitating agents than acknowledged lethal agents.[186]

Considerable effort was devoted during the 1950s to develop anticrop munitions. The intended target was the agriculture of the Soviet Union and China. The U.S. Army acquired biological agents and associated delivery systems for use against rice, rye, and wheat. The requirement apparently derived from a need to undermine the ability of the Communist countries to fight a protracted war.[187] The utility of these weapons was dubious in the strategic environment that emerged during the Cold War. The technical effectiveness of these programs also was unclear.

Despite claims that the United States employed biological weapons during the Korean War, the reality is that it had no capability to use biological agents in a militarily significant way at that time.[188] There is little evidence to support claims that the United States used biological weapons during that conflict and considerable evidence that the allegation was not true.[189]

The U.S. program was terminated unilaterally in 1969 by President Richard M. Nixon (toxin work was not stopped until later), who concluded that biological weapons added little to U.S. security even as they complicated arms control negotiations with the Soviet Union.[190]

Biological Arms Control and Disarmament

Negotiations to prohibit biological weapons became part of the agenda of the international community with the organization of the United Nations. Initial

discussions focused on a treaty aimed at both chemical and biological weapons, but little progress was made until the mid-1960s. At the insistence of the British, negotiators began to focus on a treaty limited solely to biological weapons. The result was the 1972 BWC, which prohibited possession of any biological and toxin weapons. Although the treaty does not define what constitutes a biological weapon, subsequent deliberations made clear that the agreement proscribes the possession of any weapon that incorporates any pathogenic microorganism or poison of biological origin, including those developed using science that did not exist at the time the treaty was negotiated.[191]

The Soviet Union never intended to respect the treaty. Its efforts to develop biological weapons accelerated after the BWC entered into force. Because the BWC lacks verification procedures, the treaty's signatories tried to negotiate a protocol to provide them during the 1990s. The attempt failed. While the United States is often blamed, Russia and the members of the Non-Aligned Movement also undermined the negotiations. U.S. opposition reflected widely held views in Washington that the proposed agreement was fatally flawed, unlikely to uncover treaty violations or otherwise enhance confidence in treaty compliance.[192]

Despite the treaty's flaws, it plays a central role in the delegitimization of BW. Review conferences, held every 5 years since the treaty entered into force, provide an opportunity for the international community to reaffirm its continued importance. At those meetings, the states' parties have also concurred that the agreement comprehensively applies to new scientific developments. As the 2006 conference reported, the treaty "applies to all scientific and technological developments in the life sciences and in other fields of science relevant to the Convention."[193] The failure of the 2016 Review Conference to reach agreement has generated concerns about the treaty's future.[194]

Preventing countries from acquiring biological weapons capabilities also is a part of the BW nonproliferation regime. The Australia Group, created as a response to Iraq's use of chemical warfare agents during its war with Iran in the 1980s, strives to harmonize export regulations among a like-minded group of countries. It covers biological warfare agents and equipment need to produce biological agents and weapons.[195] In addition, United Nations Security Council

Resolution 1540, originally adopted in 2004, requires all UN member states to prevent terrorists from obtaining access to weapons of mass destruction, including BW capabilities. In 2010, the resolution's mandate was extended to 2021.[196] More recently, scientific organizations supported by national governments have created codes of conduct to establish norms against the use of biology as a weapon.[197]

State Use

A few countries, including Israel, Rhodesia, and South Africa, made limited, small-scale use of biological agents. These activities were little more than biological sabotage, not too dissimilar from German BW operations during World War I, and had nothing in common with the sophisticated aerosol delivery techniques mastered by the United States and the Soviet Union.

Israel employed biological agents on several occasions during 1948 by contaminating water supplies. Some Israeli operatives attempting to spread infectious agents were captured by the Egyptian army in Gaza. Allegedly, the Israelis also tried to attack Syrian forces. In addition, there is evidence that the Israelis targeted Palestinian settlements, apparently to prevent refugees from returning to their former homes.[198] There also were allegations that a British military unit was attacked.[199] These were crude attacks, less sophisticated than the ones launched by the Germans decades earlier.

The Rhodesian government employed biological and chemical agents during its struggle against African nationalists in the 1970s. It made extensive use of chemicals, usually by contaminating clothing with deadly pesticides, probably killing hundreds of guerrillas. Some reports allege that it also made a failed attempt to disseminate the pathogen responsible for cholera and experimented with other agents as well. Claims that the Rhodesians were responsible for a massive anthrax outbreak among cattle that led to a substantial number of cases of gastrointestinal anthrax, including many deaths, have never been proved.[200]

The South Africans admitted to mounting a few small biological attacks. Reportedly, they tried to spread cholera in a guerrilla camp, but the water treatment system killed the pathogens. One account claims that they also distributed sugar

contaminated with *B. typhimurium* at a meeting of the African National Congress. It is doubtful that these attacks were effective.[201]

It also appears that officials working for the Brazilian government's Indian Protective Service deliberately introduced pathogens into the aboriginal population. Mestizos, people of mixed blood, sick with smallpox, influenza, tuberculosis, and measles, were sent to interact with aboriginal peoples between 1957 and 1963. Investigators could not confirm reports that some Indians were infected with the smallpox virus. There is no evidence to suggest that these actions were officially sanctioned by the country's leaders.[202]

Although there are numerous additional allegations of employing biological weapons during the Cold War era, most are untrue. The Soviet Union and its allies were responsible for spreading many of them, including false claims that the United States spread biological agents during the Korean War, that HIV originated in U.S. BW laboratories, and that the United States mounted numerous biological attacks on Cuba.[203]

Nonstate Use

During the Cold War, there was limited terrorist interest in BW.[204] The only significant act of bioterrorism during that period was committed by a cult group, the Rajneeshees, in 1984. Having come into conflict with the local community, the leaders of the cult decided to take over the county government by suppressing voter turnout. This was to be accomplished by making voters too sick to cast their ballots on election day. They experimented with their biological agents in August and September by contaminating food at restaurants in the town of The Dalles, Oregon, with a common foodborne pathogen, *Salmonella typhimurium.* These attacks ultimately caused 751 people to become ill, including several dozens who had to be hospitalized. The plot was uncovered when internal conflicts led the cult's leaders to accuse former members of conducting the biological attack.[205]

The Aum Shinrikyo, a Japanese cult group, created both chemical and biological weapons programs, attempting to produce both botulinum toxin and *Bacillus anthracis*. There is no evidence that the cult ever acquired strains of *C. botulinum* capable of producing the toxin or the virulent *B. anthracis*. Recent evidence suggests

that the group deliberately obtained a vaccine strain of *B. anthracis*, believing that it could employ newly developed techniques to insert the toxin-producing plasmids that are missing from the vaccine strain. Aum produced quantities of this supposedly lethal strain and tried to disseminate it but to no effect. In addition to lacking a deadly strain of the pathogen, their dissemination device was totally ineffective.[206]

Al Qaeda created a BW program in the late 1990s. Some evidence suggests that it was motivated at least in part by growing commentary in the United States about the dangers of bioterrorism. In any case, the program was still in the formative stage in September 2001. Although the group had made progress in constructing a laboratory in Afghanistan, there is no evidence that it ever obtained any biological agents. The available evidence suggests that its activities were disrupted by the U.S. invasion of Afghanistan, and the program was never reconstituted.[207] Other jihadi groups also have expressed interest in BW but generally seem to focus on capabilities easier to acquire but less likely to inflict catastrophic casualties.[208]

The last major bioterrorism event (although it might better be classified as a biocrime) was the anthrax letter attacks that occurred in September and October 2001. The letters targeted three news outlets and two U.S. Senators. The *B. anthracis* in the last two letters sent was highly refined. While not weaponized in a military sense, the agent readily spread through the air when the envelopes were opened. The Federal Bureau of Investigation (FBI) ultimately identified the perpetrator of the attacks as Bruce Ivins, an anthrax expert at the U.S. Army Research Institute of Infectious Disease. Although critics have cast doubt on the FBI's case, an independent psychological evaluation suggests that Ivins was capable of having committed the crimes.[209]

Finally, there were several biocrimes committed using pathogens during the last half of the twentieth century. Most were relatively minor. A notable case was the deliberate infection in the early 1990s of a woman by a Louisiana doctor with HIV-infected blood. In that case, the prosecutors used newly developed genetic tests to demonstrate that the HIV in the victim was consistent with the HIV in samples held by the suspect. This was the first courtroom test of the new science and demonstrated that judges were willing to accept such forensic evidence. The

accused physician was convicted, and appellate courts upheld the use of the biological forensics.[210]

In another notable case that occurred in the late 1990s, public health investigators linked a hospital technician to an unusual outbreak of Shigella associated with the eating of pastries. This was the first time that law enforcement officials employed epidemiology as an investigative tool to support the prosecution of the suspect. The suspect was convicted.[211]

Summary

Since the end of World War II, BW science and technology has developed in ways that could make effectively disseminated biological weapons as deadly as thermonuclear weapons.[212] At the same time, globalization and the widespread adoption of so-called dual-use technologies—those with legitimate uses for commerce, science, or medicine—have made many of the underlying scientific and technical capabilities required for BW programs accessible even to small groups and individuals.[213]

The growth in BW's lethality was not matched by increased use. Indeed, there is no evidence of widespread use of biological agents since 1945. There were small-scale attacks, amounting to biological sabotage, but none of those exploited the new dissemination technologies developed by the United States and the Soviet Union. There was some terrorist interest in BW and a few instances of actual use. These attacks either failed or caused sickness but no deaths. The deadliest biological attacks have been attributed to criminals. Why has there been so little resort to BW since 1945? There is no clear answer to that question, but it is likely to have resulted from some combination of a lack of interest, countermeasures that reduce the attractiveness of BW for those inclined toward exploring its utility, and at least some good luck.[214]

Biological Warfare's Future

What is the future of BW? Will there be a resurgence of BW proliferation? Will nonstate actors resort to bioterrorism? Will any countries or states employ biological agents to inflict catastrophic casualties?

As this study illustrates, biological warfare has been rare. So far as is known, the only significant use resulting in substantial loss of life was by Japan against the Chinese during the 1940s. Despite advances in BW science, the only subsequent uses have been sabotage operations resulting in few casualties. Why it has been so rare is unclear, because the simpler forms of biological sabotage have been accessible for more than 100 years.

Some argue that continuing advances in the biological sciences, the globalization of biological skills and technology, and the growing accessibility of enabling technology will inevitably result in more, and more deadly, use of biological weapons. Capabilities once limited to the Soviet Union and the United States might be accessible even to nonstate actors in the future. Indeed, given the pace of new scientific discovery, capabilities not available to even the superpowers during the Cold War might be accessible to lone actors.[215]

In contrast, others are more skeptical, arguing that biological weapons are harder to develop and employ than many have claimed. These skeptics also contend that technical considerations may not be the most significant constraint. Tacit knowledge, which is undocumented information essential for the exploitation of science and technology required to make biological weapons, is known to practitioners of BW (an ever-smaller group) but not to others expert in the biological sciences. Additionally, there is limited evidence that states or nonstate actors will be attracted to BW because they or their supporters might find the use of biological weapons morally or politically repugnant.[216] Some argue that ultimately there are strong norms against BW and that the few attempts to use it represent outliers unlikely to be often repeated.[217]

If the use of biological weapons increases in the future, it will be because some past constraint has disappeared. Although technological and scientific advances might facilitate that trend, it is most likely to result from fundamental changes in attitudes toward the use of disease as a weapon.

Appendix 1. Additional Reading

Readers unfamiliar with BW should start with a topical overview. Useful starting points are books by Jeanne Guillemin, Greg Koblentz, and Milton Leitenberg.[218] All approach the subject in different ways, so they are not interchangeable, and each has its strengths. Dated, but still relevant, is the multivolume SIPRI study of chemical and biological weapons, *The Problem of Chemical and Biological Weapons*, and the BW section of an Office of Technology Assessment report, *Technologies Underlying Weapons of Mass Destruction*.[219] For a more technical treatment of biological warfare agents, the reader should review the chapters in *Medical Aspects of Biological Warfare*.[220]

There is a growing literature on the history of BW. For those interested in exploring in detail, one possible starting point is this author's review of writings on the history of biological agent employment.[221] Readers also should look at the sources used in that survey. The best starting point on pre-1945 history is the collection of essays in *Biological and Toxin Weapons: Research, Development, and Use from the Middle Ages to 1945*, edited by Erhard Geissler and John van Courtland Moon.[222] A companion volume, *Deadly Cultures: Biological Weapons since 1945*, while also essential, is more uneven, reflecting the difficulties in studying more recent BW activities.[223]

Mark Wheelis has an excellent survey of the pre-1914 era, as well as the best review of World War I biological sabotage operations.[224] Wheelis also wrote the best account of the alleged Mongol dissemination of plague in the 14th century.[225] Essays by Elizabeth Fenn and Philip Ranlet supersede Wheelis's review of the 1763 Fort Pitt smallpox attack.[226]

There is a substantial literature on the Japanese BW program. The best overview is probably an essay by Tsuneishi Keiichi.[227] The work by Sheldon Harris also is essential, although he was more interested in documenting the horrors of Japan's laboratory research than in documenting the development, acquisition, and use of biological weapons.[228]

For French and German BW activities, the best sources are the essays by Olivier Lepick and Erhard Geissler in the Geissler and Moon volume.[229] There

are no good English-language studies of the Italian program. Recent research by Robert Petersen has confirmed the extensive use of biological agents and poisons by the Polish resistance during World War II.[230] His work supplants the earlier research in Geissler's study of German BW.[231]

Soviet BW activities are the subject of an outstanding book by Milton Leitenberg and Raymond Zilinskas.[232] It provides the best single source on this important topic, although it is admittedly not comprehensive. Leitenberg and Zilinskas give a detailed reading of the program's scientific underpinnings, as well as a host of specialized topics, such as Soviet biological arms control policies and BW disinformation activities. Unfortunately, much remains unknown about the Soviet program, including the role of BW in the Soviets' strategic thinking, their biological weapons use doctrine, and their actual weapons.

There is no study of comparable quality and depth of the U.S. biological weapons program, although John van Courtland Moon has published useful essays on the topic.[233] The same volumes containing the Moon articles also provide reviews of the programs of both the United Kingdom and Canada, although they have been given longer treatment elsewhere as well.[234]

Other countries are thought to have had BW programs since 1945, but there are no useful histories of most of them. The main exception is Iraq's program, which is extensively documented in UN and U.S. Government documents, as well as numerous essays and books written by researchers associated with the efforts to uncover Iraq's activities.[235] Avner Cohen has written the best studies of Israel's BW program.[236]

Terrorist and criminal interest and use of biological agents are reviewed in *Biocrimes and Bioterrorism* by Seth Carus, while Maasaki Sugishima gives a more detailed account of Japanese biocrimes cases.[237] *Toxic Terror*, a volume edited by the late Jonathan Tucker, contains several essays reviewing the bioterrorism activities of several groups, including the Minnesota Patriot's Council, the Rajneeshees, and R.I.S.E.[238] Aum Shinrikyo's chemical and biological weapons programs are examined by Richard Danzig and his coauthors.[239] A more skeptical view of Aum's activities is offered by Milton Leitenberg.[240]

Appendix 2. Definitions and Methodology

A *biological agent* is a pathogen, a microorganism capable of causing disease in humans, animals, or plants. Conceptually, a biological agent also could be a microorganism capable of degrading materiel, such as bacteria that might attack the silicon on computer chips or tire rubber. Multicellular animals, such as insects, are not biological agents, although they can disseminate biological agents and have been used to deliver pathogens.

Other substances, such as toxins and bioregulators, are sometimes treated as biological agents but are more like chemical warfare agents. *Toxins*, poisons of biological origin, are produced by poisonous plants and animals, but most now can be made synthetically. Similarly, bioregulators, chemicals that control normal bodily processes, also are not considered BW agents.[241] There is a third category of substance, prions, which are infectious proteins that can replicate in their victim. They are chemicals, but their ability to replicate in a host gives them some similarities to pathogens. There are only two prions known to infect humans, but no BW program is known to have developed or employed infectious proteins, so they are not mentioned in this account.[242]

Potential biological warfare agents are not limited to some short list of pathogens but rather include all microorganisms pathogenic to humans, plants, and animals, as well as those that could be used to attack materials. According to a 2007 survey, there were more than 1,400 human pathogens, including 541 bacteria, 189 viruses, and 57 protozoa (the rest were parasites, such as ringworm, and fungi).[243] A more recent study identified 219 pathogenic viruses and estimated that 3 to 4 more are identified every year.[244] While many of the diseases are rare and may cause only mild illness, nearly 350 are considered clinically significant.[245]

Pathogens aimed at agricultural targets, both plants and animals, also were adopted by several state biological weapons programs.[246] There is no comprehensive list of plant and animal pathogens, although one survey identified 616 pathogens of livestock (which included cattle, sheep, goats, pigs, and horses).[247] Many of these also affect humans: 76 percent of viruses and half of bacteria dangerous to humans also affect animals, usually other mammals.[248] Anti-material agents have

been explored for their BW potential, but there is no evidence of their incorporation into any BW program.[249]

State biological weapons programs have valued certain desired characteristics for their anti-personnel BW agents, often related to lethality, producibility, and suitability for dissemination.[250] For that reason, they have focused on a relatively small number of pathogens naturally possessing those traits. Such technically demanding selection criteria are probably not applicable to terrorists or criminals, who may value different criteria, such as ease of access, which can lead to the selection of organisms considered useless by a state weapons program.[251]

A *biological weapon* consists of a biological agent packaged so that the microorganism can do harm, whether to a person, animal, plant, or materiel. It consists of the agent and some delivery mechanism. Biological weapons can be extremely complex, such as a bomblet carrying a ballistic missile warhead or a cruise missile with spray devices. In such cases, the agent might be formulated to incorporate additives that enhance its survivability once released into the environment or that make it easier to disseminate. Biological weapons also can be extremely simple, such as a vial containing a fluid consisting of a biological agent and growth media or an envelope with a dry powdered spore. Much of the art and science of BW is associated with techniques intended to enhance agent dissemination and survivability.[252] Some biological agents can be transmitted through contact with *fomites*, materials contaminated by exposure to a pathogen, such as clothing, bedding, or other items that were in direct contact with someone who had the disease.[253]

Biological weapons are treated as weapons of mass destruction (WMD) by the international community. This is sometimes a source of confusion. While biological weapons can cause mass casualties, they are not destructive (except for hypothetical anti-materiel agents). Moreover, while biological weapons can infect indiscriminately, as when aerosol clouds of a biological agent are released into the air, they also can be highly discriminate, as when a single individual is infected using a needle. It is for this reason that some WMD definitions exclude uses of biological agents that do not result in mass casualties.[254]

Biological warfare (BW) is the term traditionally used to refer to the employment of biological weapons. It originated at a time when the focus was on state use

of biological weapons. However, three different kinds of actor have used biological weapons: states, terrorist groups, and criminals.[255] When states employ biological weapons against other countries or in insurgencies, they engage in biological warfare or biowarfare. In contrast, biological terrorism, or bioterrorism, involves the terrorist use of biological weapons against any type of adversary. Finally, biological crimes, or biocrimes, are the employment of biological weapons by criminals for financial gain, revenge, or pathological reasons. These are distinctly different uses, which led one scholar to adopt the term "biological violence" to encompass all of them.[256] However, that term has not become common.

The most difficult obstacle to writing the history of BW is separating what is true, or probably true, from what is undoubtedly or probably false. Published accounts of BW programs are relatively rare. Some programs have never been described, and critical information gaps remain for even the best-documented programs.

There are many allegations of biological weapons use that, on closer inspection, are either demonstrably false or substantiated only by flimsy evidence. Indeed, a monograph several times longer than this history could be written just to debunk the many false allegations of BW use. Readers interested in learning more about such false claims can find a discussion of them elsewhere.[257] These false allegations arise for multiple reasons. Some come from outbreak victims who misinterpret natural events or who seek scapegoats for an outbreak that resulted from natural causes. Some allegations, however, are deliberate fabrications. The Soviet Union routinely spread false claims in orchestrated disinformation campaigns, such as the allegations that the United States generated HIV in supposed biological warfare laboratories and deliberately spread the virus.[258] Finally, some claims result from misinterpretation of the historical record by modern authors.

Notes

[1] For an assessment of the gaps in our understanding of the history of biological agent use, see W. Seth Carus, "The History of Biological Warfare: What We Know and What We Don't," *Health Security* 13, no. 4 (August 2015), 219–255.

[2] A good survey of human disease organisms is Zygmunt F. Dembek, ed., *Medical Aspects of Biological Warfare* (Washington, DC: Office of the Surgeon General, U.S. Army, 2007), available at <www.cs.amedd.army.mil/Portlet.aspx?ID=66cffe45-c1b8-4453-91e0-9275007fd157>.

[3] David B. Kaufman, "Poisons and Poisoning among the Romans," *Classical Philology* 27, no. 2 (April 1932), 156–167.

[4] Phyllis Allen, "Etiological Theory in America Prior to the Civil War," *Journal of the History of Medicine and Allied Sciences* II, no. 4 (1947), 489–520.

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