

THE HISTORY OF BIOLOGICAL WEAPONS USE: WHAT WE KNOW AND WHAT WE DON'T

W. Seth Carus

This article critically reviews the literature on the history of biological warfare, bioterrorism, and biocrimes. The first serious effort to review this entire history, made in 1969, had numerous limitations. In recent decades, several authors have filled many of the gaps in our understanding of the past use of biological agents (including both pathogens and toxins), making it possible to reconstruct that history with greater fidelity than previously possible. Nevertheless, there are numerous remaining gaps, and closer inspection indicates that some supposed uses of biological weapons never took place or are poorly substantiated. Topics requiring additional research are identified.

THERE IS NO COMPREHENSIVE, authoritative history of biological warfare (BW). Indeed, as is argued here, it is probably impossible to write such an account at this time because of the many gaps in our knowledge of that history.

Why should we care about the history of BW? After all, almost all of that history involves incidents employing long obsolete science and technology. And given the pace with which our understanding of biological processes is advancing, future employment of BW could look far different from what happened even in the recent past. Moreover, as is evident to anyone with more than a passing interest in the subject, there have been very few BW incidents and what has occurred has had, with perhaps one significant exception, remarkably little impact.

Nonetheless, there are several reasons that we should properly understand BW's history. It allows us to put into some perspective concerns about the threat posed by BW, even if the past is not prologue. Illuminating past challenges assists in addressing contemporary and future responses. Although there has been little BW, its history provides insight into attitudes about intentionally caused disease, including the motivation of those who might want to engage in BW and the character of the anxieties of those who

fear it. Reviewing past allegations of BW also may help better understand how to attribute use of biological weapons in the future.

Unfortunately, existing surveys of past BW are replete with misinformation and gaps, including this author's own work. Events that almost certainly never happened are widely reported as fact, while events that certainly did happen are poorly described. As a result, it is as important to dispose of false allegations that have made their way into the literature as it is to identify and characterize actual uses of biological weapons.

What follows is a review of the literature on the history of the use of biological weapons. It does not purport to be a comprehensive history, but rather is intended to assess the current state of that literature and to suggest topics meriting additional research. It concentrates on use, rather than on BW programs.

THE STATE OF THE LITERATURE

Although mankind probably has employed biological weapons since before the dawn of recorded history, our

W. Seth Carus, PhD, is Distinguished Research Fellow, Center for the Study of WMD, National Defense University, Ft. McNair, Washington, DC.

understanding of that history is recent. Writing in 1960, the eminent biologist Theodor Rosebury, who knew more than a little about biological weapons, asserted that "... although allegations are many, not a single one can be called fully authenticated."¹

It was not until a decade later that Milton Leitenberg published the first systematic survey of alleged biological agent use in *The Rise of CB Weapons*, the first of the 6-volume 1969 Stockholm International Peace Research Institute (SIPRI) study, *The Problem of Chemical and Biological Warfare; A Study of the Historical, Technical, Military, Legal and Political Aspects of CBW, and Possible Disarmament Measures*.² In 17 pages, supplemented by a 5-page appendix, Leitenberg reviewed claims of BW during the post-1914 era, although he mentioned some earlier allegations as well. As such, his work provides a baseline for assessing how much we have learned about the history of BW during the past 45 years.²

Leitenberg described 18 allegations (although the exact count depends on how they are categorized), but carefully avoided giving definitive conclusions about their validity. At least some claims, such as Japanese use of biological weapons during World War II, were supported by considerable evidence, suggesting that Leitenberg found them credible. However, the final chapter of the SIPRI volume includes a section, written by Julian Perry Robinson, titled, "The non-use of biological weapons," suggesting others did not agree.²

Today, however, there is a substantial literature on the history of BW, including many short surveys that purport to cover the entire history,³⁻¹⁸ and scores of books and articles written about some aspect of the topic. As a result, many incidents unknown, or just barely known, a few decades ago are now well characterized, even if we sometimes await the appearance of definitive accounts. Unfortunately, this literature also reports on a number of claimed instances of BW that almost certainly never occurred. As a result, sorting through the allegations to obtain an accurate picture remains difficult.

This essay reviews the existing literature, highlighting what appears to be the best writing on any given topic. It identifies gaps in that literature and suggests areas needing additional research. Finally, it flags incidents that appear in some accounts, but that clearly never occurred or should be treated with skepticism.

METHODOLOGY

This essay focuses explicitly on books and articles that describe alleged instances of biological agent *use*, rather than on BW *programs*. While understanding programs—how countries and nonstate groups attempted to produce biological weapons—is important, this essay focuses on what is known about incidents involving the employment of biological agents. Hence, Japanese BW during World War II and allegations that the United States resorted to BW

during the Korean War are reviewed, but not histories of the Japanese or US offensive biological weapons programs. Similarly, while some histories of the Soviet offensive biological weapons program are mentioned, the focus is on claims of their actual use. A systematic review of studies focusing on programs requires its own lengthy survey.

For purposes of this essay, a *biological weapon* is defined as the combination of a biological agent with a means of delivery. The delivery system can be quite complex, as is the case with bomblets in a ballistic missile, or extremely simple, as with a powder in an envelope or a liquid in a test tube. The definition of *biological agent* used here is consistent with the coverage of the Biological and Toxin Weapons Convention (BWC): pathogenic microorganisms or toxins (toxins are poisons produced by living matter).¹⁹ This contrasts with the perfectly reasonable preference of some authorities to limit biological agents only to pathogenic microorganisms.

Use of higher order animals, such as insects or poisonous snakes, as weapons is not considered. BW normally refers to the employment of biological agents in the context of wars, armed conflicts between states, but in this essay it is taken to include all uses of biological agents to cause harm, such as by terrorists ("bioterrorism"), criminals ("biocrimes"), and clandestine state operatives during peacetime.

Some activities occasionally treated as BW, such as polluting water supplies with dead animals or waste, are not considered here. This essay follows the example of 2 respected experts in the history of BW, Milton Leitenberg and Mark Wheelis.^{2,20} This approach also follows the example of the jurist Hugo Grotius, who helped create modern international law. While Grotius condemned the use of poison in warfare, he accepted that the pollution of water was equivalent to the cutting off of water supplies by destroying aqueducts or diverting water in rivers and streams.²¹ While it is possible that water contaminations were meant to spread disease, it is clear that in most cases such acts were intended simply to make water sources unavailable to opposing armies. This was, according to some historians, a common practice.²²

Insects also are excluded as weapons, unless used as a vector to spread a pathogen. Thus, the Japanese reliance on fleas to spread *Yersinia pestis*, the causative agent of plague, is mentioned, but not the many false allegations that the Germans and Allies spread Colorado potato beetles during World War II.²³ Nor do I discuss similar claims by the Soviet bloc that the United States at various times dispersed insects to attack agriculture.²⁴ There is a small literature on the use of insects as weapons, including a book-length study by Jeffrey Lockwood.²⁵ Unfortunately, that book must be used with caution because of the author's unfamiliarity with the complexities of diplomacy and international law associated with biological warfare, the uneven research, and an unwillingness to forthrightly declare that many of the alleged intentional releases of insects were fabricated for political reasons.

Toxins are included in this survey. There are important differences between toxins, which are poisons of biological origin, and chemical warfare agents. Chemical warfare agents are all man-made, while toxins are natural products. Toxins are not volatile, in contrast to almost all chemical warfare agents. Almost all toxins are not dermally active, while most chemical warfare agents can penetrate the skin. Toxins operate through a wide variety of biochemical pathways, while chemical warfare agents operate through a small range of toxic effects. For such reasons, some experts prefer to view toxins as a category of substances different from either biological or chemical warfare agents.²⁶ Purists would argue, perhaps correctly, that what is described in this article is really biological and toxin warfare.

Some authors, such as Mark Wheelis, prefer to disregard toxins and focus just on infectious diseases.²⁰ This is defensible, given the modern understanding of the role of pathogens in disease etiology. Toxins are much closer to chemical poisons than to replicating entities, whether pathogens or infectious proteins (such as prions). Thus, it is not surprising to learn that toxins were part of the Soviet chemical weapons program, not its BW effort, with the significant exception of botulinum toxin.²⁴ In contrast, toxins were part of the US biological weapons program, probably because the expertise in biological production processes resided there and not with the chemical experts.²⁷

Ignoring toxins, however, leads to an anachronistic perspective. Evidence for the germ theory only emerged in the last third of the 19th century. It is impossible to discuss intentional spread of pathogens, as opposed to the intentional spread of disease, prior to that. Interest in the motivations for resorting to BW and reactions to intentional disease, for example, make it desirable to look well before the modern era. As will be evident, fears of intentional disease, and the desire to use disease agents as weapons, are quite ancient. Understanding the sociocultural context of BW militates against too narrow a perspective, and requires that we broaden our understanding of BW beyond a definition limited strictly to infectious disease.

Moreover, until the study of infectious disease emerged as a scientific discipline in the late 19th century, it sometimes was difficult to differentiate between toxin poisoning and pathogen infection. Thomas Heazel Parke, a British Army physician, thought that poison arrows actually containing strychnine (from a species of *Strychnos* plant) were causing tetanus.²⁸ The confusion is not surprising, since strychnine and tetanus cause similar symptoms.²⁹⁻³¹

This essay divides the history of BW into 3 main eras: (1) prior to the germ theory (through the late 19th century); (2) the emergence of microbiology from the late 19th century through 1945; and (3) the modern era (1945 to the present). This differs from the breakdown suggested by other writers, such as Gregory Koblenz, who also would consider the invention of genetic engineering as the transition to a new era.³² For purposes of this essay, such an additional division is not helpful, given the few instances of BW in the

modern era and the total absence of known BW incidents employing the techniques of advanced biotechnology.

One critical question requires further elaboration: What constitutes “proof” of the use of a biological agent? Rosebury apparently thought evidence needed to be overwhelmingly compelling when he argued that there had been no “fully authenticated” uses of BW: “In other words, no government, and no responsible government official who was free from duress at the time, has ever admitted waging offensive biological warfare. No other evidence could be fully acceptable to all concerned.”^{31(p228)} This standard is clearly unworkable. Indeed, few criminal cases adjudicated in the most scrupulous judicial settings could satisfy this criterion, given that most perpetrators never admit guilt.

What other evidence is acceptable for establishing intent? Admissions of guilt are unlikely, as perpetrators are unlikely to confess their misdeeds and governments are likely to obfuscate their activities. Document destruction is one method to hide culpability, as demonstrated by the Germans after World War I, the Japanese at the end of World War II, the white Rhodesians after they abandoned their bid for an independent state, and the Bulgarians with documents related to the Georgi Markov assassination. The problems are even more difficult when we consider alleged uses in the pre-modern era. Even if employment of BW was documented—a doubtful prospect—survival of that supporting evidence is even more unlikely. Nor can allegations of BW by the supposed victims be accepted uncritically. There is a long modern history of false claims of BW. Misguided individuals who thought that they were reporting a credible claim advanced some allegations, while other claims were disseminated as deliberate misinformation.

Attribution of biological attacks has begun to receive serious analytic attention.³³ The focus often has been on the emerging science of bioforensics.^{34,35} Unfortunately, many of the tools available to the bioforensics analyst may be useless for the exploration of past BW events. In some cases, however, should there be surviving biological samples, it might be possible to reconstruct events using techniques unavailable even a few years ago. Recent studies have demonstrated that it is possible to identify infectious agents from bone fragments and teeth from people who died thousands of years ago, resulting in the emergence of paleomicrobiology as a new field of study.^{36,37} In particular, paleomicrobiologists may be able to answer questions about the causative agent of an outbreak, which could provide telling evidence useful in reconstructing the historical event.

Paleomicrobiology and bioforensics, however, cannot determine whether an outbreak was natural or intentional. Far more important are the answers to medical and public health questions, which often are unavailable for past incidents. Is the claim consistent with what we know about the natural ecology and etiology of the disease and with the epidemiology of a natural outbreak? Is there reason to believe that the disease could be spread in the manner claimed? Did the perpetrators, whether state or nonstate,

have the scientific and technical capabilities to undertake the claimed activities? Does an outbreak have a plausible natural explanation?³⁸⁻⁴¹

Attribution is not just a technical matter, determined solely by scientific or forensic evidence. Rather, it requires the integration of all sources of information, including those that would be collected in the case of incidents not related to BW. In essence, such a review requires an assessment of all the available sources specific to the alleged use in the broader historical context. From that perspective, the evaluation is no different from any reconstruction of any past event. Many of the studies cited below meet that criterion, even if they may not definitively settle the question of whether a particular event occurred.

BIOLOGICAL WARFARE BEFORE THE GERM THEORY

Some caution is needed when discussing BW prior to the emergence of the germ theory in the late 19th century. The cause of many diseases was unclear, and what we now know to be infectious diseases caused by pathogens often were attributed to chemicals, environmental factors, host pathologies, or supernatural causes. Many doctors could not distinguish between “fevers” associated with such diseases as malaria, yellow fever, typhoid, and typhus. Only during the 19th century did medicine learn to differentiate between these diseases, aided by the growing use of autopsies to discern their differing pathologies. Even when it became possible to more reliably distinguish between different diseases, which only happened in the early 19th century in the United States, the etiology of diseases was rarely understood.^{13,42}

Only a few diseases, such as smallpox, were understood sufficiently to enable a reasonably accurate theory of disease transmission. A classic example is provided by yellow fever, which was the source of much dispute during the 19th century.⁴³ Even in the early 20th century, after Walter Reed and his team performed their experiments in Cuba, some authorities doubted that mosquitos were associated with yellow fever.⁴⁴ It is often forgotten that Walter Reed experimented to see if yellow fever could be transmitted by fomites (objects, such as blankets or clothing, contaminated with pathogens) soiled with the fluids of yellow fever victims at the same time he and his colleagues undertook their more famous mosquito experiment.⁴⁵

Infectious diseases often were inexplicable even to experts prior to scientific demonstration of the germ theory, which occurred primarily through the microbiological work of Louis Pasteur and Robert Koch and the epidemiologic studies of John Snow. Pasteur and Koch proved that microorganisms could cause disease and that certain diseases resulted from infection with specific microorganisms. Snow demonstrated that it was possible to understand routes of transmission even when the specific cause of the disease

remained unidentified. Thus, Snow tied cholera outbreaks to contaminated water supplies decades before Koch demonstrated that *Vibrio cholerae* was responsible.⁴⁶

As a result, it is perhaps not surprising that theories of disease causation in most cultures over much of human history were heavily imbued with magical thinking. Theories of disease etiology often had little if any scientific plausibility. While this may suggest that such societies lacked the tools essential to cause intentional disease, shamans and their equivalents often had special “knowledge” that supposedly allowed them to inflict illness. Sometimes the shamans employed toxins capable of causing disease. Occasionally, empirical observation led to theories of disease causation consistent with modern medicine, perhaps most evident with smallpox. It is probably true, however, that people more commonly relied on theories with no empiric validity.⁴⁷

An intriguing perspective on primitive concepts of disease, relevant to the discussion here, is one offered a century ago by the British ethnographer W. H. R. Rivers:

If we examine the beliefs of mankind in general concerning the causation of disease, we find that the causes may be grouped in three chief classes: (1) human agency, in which it is believed that disease is directly due to action on the part of some human being; (2) the action of some spiritual or supernatural being, or, more exactly, the action of some agent who is not human, but is yet more or less definitely personified; and (3) what we ordinarily call natural causes.^{48(p7)}

As Rivers noted then, and as many have confirmed since then, it is common in indigenous societies to believe that some illness results from maleficent human intervention.⁴⁹ The following account will suggest that such fears are not limited to so-called primitive societies.

“Primitive” Warfare

Biological warfare probably originated in prehistory. Careful study of indigenous societies during and after their contact with explorers and researchers suggests that toxins and even pathogens were used in prehistoric warfare. Émile Perrot’s 1913 book, *Poisons de flèches et poisons d’épreuve*, which is an excellent survey, gives evidence of extensive poison arrow use everywhere except Central America and Australia.⁵⁰ H. D. Neuwinger, a toxicologist, more recently has argued that only the peoples of Australia and New Zealand did not use poisons.⁵¹ This perspective is supported by David Jones, who in his monograph, *Poison Arrows: North American Indian Hunting and Warfare*, identifies 80 tribes that used poison arrows.⁵² The available evidence suggests that many, perhaps most, indigenous societies used poison for hunting, fishing, and warfare, but there is too little information available to provide a more precise estimate of the prevalence of such usage.

Numerous articles and books, usually penned by anthropologists or ethnopharmacologists, explore some aspect of poison use in primitive societies, but the only

comprehensive surveys are badly dated. Perrot's compendium appeared in 1913, while Louis Lewin's *Die Pfeilgifte* was published in 1923.^{50,53} Perrot's volume is uneven, providing excellent accounts for some parts of the world and cursory summaries for others (such as North America). I have been unable to review Lewin's study, but Neuwinger found it more satisfactory than Perrot's, perhaps because it gave more emphasis to the toxicology.⁵¹ In contrast, the American microbiologist Ivan C. Hall found Perrot more useful in his studies of poisoned arrows, perhaps because Perrot recognized that some of the "poisons" might have relied on pathogens to achieve their fatal effect. There is no comparable English review, although Neuwinger wrote a book-length study of African ethnobiology, which appears to be both comprehensive and up-to-date, although focused more on the biology and toxicology than on military or sociocultural issues. Jones's book on North American poison arrows provides a short "World Survey of Arrow Poisoning." He apparently was unaware of the studies by Perrot, Lewin, or Neuwinger, which undermines the value of his review.⁵²

The claim that poison arrows were the norm in primitive societies, not the exception, contrasts sharply with one offered by Leonard Cole, who studied the use of poison weapons in preparing an interesting study of the "poison taboo" and concluded that "most tribal groups did not use them."⁵⁴(pp123-124) His conclusion came from negative evidence: There were few mentions of poisoned weapons in an anthropological bibliography of warfare or in the *Encyclopedia of World Cultures*,^{55,56} and the anthropological studies that he consulted rarely mentioned poisons. His conclusion was clearly misguided, telling more about the interests of anthropologists than the history of poison use. As Jones noted in particular reference to the study of poison arrows among North American Indians, most scholars have preferred to ignore or denigrate the subject.⁵²

Why was poison so widely employed? According to one theory, early bows and arrows were insufficiently powerful to reliably kill prey, especially large animals, unless they were poison-tipped. Using the right poisons, however, hunters could use even wooden arrows to kill large game—even elephants and whales.^{57,58} From this perspective, the spread of the bow and arrow was made possible only by the concomitant reliance on toxins.⁵⁹ However, use of poison arrows did not necessarily disappear with the development of more effective combinations of bows and arrows, and there is documented use of iron arrowheads coated with poison.⁶⁰

Jones offers an interesting perspective on the use of poison arrows that is particularly germane to this study in his monograph *Poison Arrows*. He suggests that poison arrows relying on animal poisons were used in warfare, while hunting relied on plant toxins. Moreover, animal poisons typically were allowed to putrefy before use, and they "probably exert their principal effect by inducing gas-gangrene, tetanus, and other severe infections."⁵²(p64-65)

Scattered accounts suggest that it may have been relatively common for indigenous peoples to use "poisons" that apparently rely on the effects of pathogens, although the evidence is admittedly scattered. We have several descriptions of such poisons. A band of the Yavapai, a group indigenous to Arizona, reportedly prepared their war poison in the following way:

Arrow poison was made by stuffing a piece of deer's liver with spiders, tarantulas, and a rattlesnake's head. It was then wrapped with yucca fiber, buried in the ground, and fire maintained over it. When rotten, it was exhumed, tied with a string, and hung from the limb of a tree. Because of stench it was hung well away from camp. There it dried for several days, and shrunk to only a fraction of its original size. Next, a part of it was rubbed down with a stone on a flat rock, a little water being added to make a paste. The unused portion was rehung. The paste was applied to the arrow points with a stick. One took care not to get the paste under his nails, lest he be poisoned. Arrows thus treated were dried far from camp. The arrows were placed in a special quiver.⁶¹(p224)

Other Native Americans apparently used a similar technique, which clearly was not intended to kill immediately because the "septic effect of such a preparation is likely to have been much greater than the toxic."⁶²(p417) According to Jones, a common preparation involved getting rattlesnakes to bite into a liver, allowing the liver to rot, and then making a paste that was spread on arrowheads.⁵² However, at least one contemporary observer was skeptical of the efficacy of this preparation.⁶³ It might be interesting to undertake a test to determine whether there was an empirical logic to these practices and, if so, the nature of the "poison" generated.

Similar practices are widely reported. Cole, despite his general skepticism, cites anthropological studies of 2 New Guinea tribes who used rotting material in their arrow poisons.⁵⁴ Little is known of their practices, but in the case of the Kiwai Papuans, they used a "poison" consisting of little more than contaminating arrow heads with rotting flesh.⁶⁴ Others have identified similar practices in East Africa.^{65,66} Perrot's survey suggests that poisons prepared using decomposing flesh were found globally, although not every group using toxins also used biological materials.⁵⁰

There have been several published experiments to test poison arrows for the presence of pathogens. The most recent identified by this author are 2 studies undertaken by Professor Hall. A 1927 test of 6 Bushman arrows revealed that only 3 were coated with a toxin, while *Bacillus histolyticus* was present in 5 of 6 arrows tested. *Bacillus welchii* and *Bacillus novyi* also appeared, but only on a single arrow for each of those pathogens. Tests confirmed that a solution of the poison removed from the arrows was toxic, at least to guinea pigs.⁶⁷ Hall subsequently examined 2 Malayan blowgun darts and found no evidence of any known pathogen, although there were some otherwise unknown

organisms cultured that appeared to have mild pathogenic effects in inoculated guinea pigs.⁶⁸

Similar studies were undertaken at about the same time by a team of Swedish researchers. In 1921, the ethnographer Gustaf Bolinger returned to Sweden with poison arrows obtained from the Guajiros, an indigenous people located in Columbia and Venezuela. Reputedly, the poison was a product of the “decomposing cadavers of animals, snakes, toads, and such poisonous creatures.”^{69(p153)} Five years later, animal testing of the poison found that it produced tetanus-like symptoms. A Swedish team consisting of a bacteriologist, Gottfrid Thorell, and a toxinologist, C. G. Santesson, determined that the “poison” coating contained virulent *Clostridium tetanus* organisms.⁶⁹ This study, which this author has not reviewed, was published in 1927.⁷⁰

Finally, a French microbiologist, Félix Le Dantec, found that arrows obtained from New Hebrides were contaminated with *bacille de Nicolaïer*, the name then used by the French for the organism causing tetanus, *Clostridium tetani*. According to Le Dantec, the New Hebridians made their poison arrows by dipping the tip into soil obtained from crab burrows found in mangrove swamps. He found a slight effect from very old arrows, but 6-month old arrows prepared in this way quickly produced lethal results in laboratory animals.^{71,72}

Early Civilizations

There are claims that some ancient societies deliberately spread infectious diseases, but the evidence is scanty and generally unconvincing. It is always difficult to definitively determine the etiologic agent responsible for a disease outbreak by relying only on written sources, often written by people with limited medical background. However, even when it is possible to link a disease to an event, claims that certain outbreaks were spread deliberately are poorly substantiated.

A ubiquitous source of information on poisons in the ancient world, whether chemical or biological in origin, is an often-cited book by Adrienne Mayor, *Greek Fire, Poison Arrows, and Scorpion Bombs*.⁷³ This work received mixed reviews,⁷⁴⁻⁷⁷ but it should be used with caution, even though it presents a wide body of original research. Mayor’s real expertise is folklore, and she rarely assesses the accounts with the critical eye of either the scientist or the trained historian. It is best used as a sourcebook for further research, not as a definitive text.

These problems are evident in Mayor’s claim that the Hittites waged biological warfare.⁷³ The first edition of her work based this on a reference to a scapegoating ritual found in Hittite religious documents. In the second edition, she also cited the research of Siro Iginio Trevisanato, who expanded on Mayor’s claim by identifying the disease transmitted as *Francisella tularensis*. According to Trevisanato, the Hittites infected their Anatolian enemies, the Arzawans, with *F. tularensis* during the late 13th century

BCE, and the Arzawans retaliated in kind.⁷⁸ This derives in part from his earlier arguments that a “plague” outbreak affecting the entire region was caused by *F. tularensis*.^{79,80} While there is agreement that such an outbreak occurred, some scholars had speculated that the outbreak was bubonic plague or bacillary dysentery, although still others argue that there is insufficient information in the ancient source to support any diagnosis.⁸¹

Unfortunately, the evidence to support deliberate spread of disease by the Hittites is nonexistent. The only “proof” of possible use of biological agents comes from descriptions of a scapegoat ritual practiced by the Hittites. Trevisanato relies on a study by Professor O. R. Gurney, a noted authority on that ancient society, while Mayor references the similar work by Christopher Faraone, which refers to Gurney’s study but actually focuses on Greek practices. Such rituals, widely practiced in the ancient world, sought to induce a divine being to end an epidemic, perhaps by transmitting it to their enemies. Gurney does not directly associate that ritual with the so-called “Hittite plague” studied by Trevisanato, nor does he claim that the practice had anything but symbolic significance.^{82,83} These scapegoating rituals do not suggest actual transmission of disease. The ritual is symbolic, not physical, and the rituals are best understood not as BW but rather as a mystical understanding of disease causation (disease resulting from the acts of a god) and as a desire to convince friendly deities both to lift the disease and to inflict it on enemy societies.⁸²⁻⁸⁵ Hence, there is simply no evidence to suggest that the Hittites waged biological warfare. Nonetheless, numerous publications have reported that the Hittites had engaged in biological warfare.^{14,86-89}

A second allegation of possible BW has arisen in the context of the Peloponnesian War, fought between Athens and Sparta and their allies. Recently, a team of Greek researchers, led by Manolis J. Papagrigrakis, suggested that the famous “Plague of Athens,” which reportedly killed one-third of the population during Sparta’s 4-year siege of Athens, resulted from deliberate introduction of the organism responsible for typhoid into the water supply.⁹⁰ The causes of that outbreak have been intensely debated. In recent years, it has been attributed to diseases as varied as smallpox, typhus, measles, bubonic plague, Ebola virus, influenza combined with toxigenic staphylococci, and Rift Valley fever, among the 30 odd theories advanced over the years.⁹¹⁻⁹³

What is the evidence to support the theory of intentional contamination? Papagrigrakis and his colleagues have scientific evidence to support the involvement of a biological agent in the outbreak. Genomic analysis of recovered DNA from a burial pit of plague victims thought to have died during the siege revealed the presence of *Salmonella enterica* serovar Typhi organisms in the skeletal remains of outbreak victims.⁹⁴ The organism identified may have been an ancestral version of the modern strain.⁹⁵ According to Thucydides, the Athenians suspected that the

Peloponnesians deliberately poisoned the city's water supply, which led Papagrigorakis to suggest that spies introduced the pathogen.

Others are more skeptical. Some worry that the genomic evidence is not sufficiently strong to support the identification of *Salmonella enterica* serovar Typhi. The techniques to reconstruct DNA at the time Papagrigorakis and his team undertook their work have been heavily criticized, and only the subsequent development of methods that can reconstruct genomes from smaller fragments of DNA have started to silence the critics.⁹⁶ Moreover, it is generally agreed that Athens was probably suffering from outbreaks of multiple diseases, and there is no proof that typhoid fever was the disease associated with the "plague" outbreak.^{97,98} Pathogens evolve, as does host response, and other critics argue that the epidemiology of the epidemic is inconsistent with typhoid fever,⁹⁹ although possible differences between the ancient and modern strains of the pathogen might make it hard to rely too much on analogies to modern epidemiologic patterns.

The major problem, however, is the absence of any reliable evidence that the Peloponnesians either contaminated the water supply or that such a contamination would have been effective or that anyone knew how to spread the disease intentionally. The only reason to believe the outbreak was intentional comes from a comment by Thucydides, who described the outbreak in detail: "The disease ... suddenly fell upon the city of Athens, and attacked first the inhabitants of the Piraeus, so that the people there even said that the Peloponnesians had put poison in their cisterns; for there were as yet no public fountains there."^{100(p343)} The fact that some Athenians thought the water had been deliberately contaminated is meaningless; we know how often such allegations are made with no supporting evidence. Moreover, it is not evident that Thucydides believed the allegation even as he reported it.¹⁰¹ In the end, the hypothesis advanced by Papagrigorakis and his colleagues is not supportable with the evidence that they provide.

A more plausible form of biological warfare involved Scythian arrow poison. The Scythians were a nomadic people who lived in what is now Ukraine and were famed archers during the period of Classical Greece. Renata Rolle, an expert on Scythia, hypothesized that the poison probably was contaminated with organisms capable of causing gangrene and tetanus.¹⁰² This interpretation is plausible, based on the method for producing the poison. The fullest description of their arrow poison appeared in a work wrongly attributed to Aristotle (hence, sometimes known as Pseudo-Aristotle).

They say that the Scythian poison, in which that people dips its arrows, is procured from the viper. The Scythians, it would appear, watch those that are just bringing forth young, and take them, and allow them to putrefy for some days. But when the whole mass appears to them to have become sufficiently rotten, they pour human blood into a little pot, and, after covering it with a lid, bury it in a dung-hill. And when

this likewise has putrefied, they mix the sediment, which is of a watery nature, with the corrupted blood of the viper, and thus make it a deadly poison.^{103(p1294)}

Similarly, a Roman author, Pliny, states, "In Scythia the natives poison their arrows with vipers' venom and human blood; this nefarious practice makes a wound incurable—by a light touch it causes instant death."^{104(pp97-98)} A third source, Aelian, who relied at least in part on a lost work by Theophrastus of Eresus, noted that "the Scythians are even said to mix serum from the human body with the poison that they smear upon their arrows to drug them. This serum somehow floats on the surface of the blood [and they know a means of separating it]."^{105(p235)} Unfortunately, the part of the text in brackets was corrupted, so the exact meaning is uncertain.¹⁰⁵

Mayor attempts to reconstruct the production method using these accounts, but it is unclear if she fully understands her sources. Her reconstruction of the recipe from multiple accounts cannot be accepted without further justification. For example, she claimed that the Scythians had a method of separating plasma from blood, while the accounts make clear that they drew on a component of decomposed blood. Similarly, she asserts that the arrow poison included decomposed dung, even though the account by Pseudo-Aristotle states only that the container of the decomposing material was buried in a dung-hill.⁷³

More plausible are claims that toxins were used in warfare during this period. Arrow poison was used during the time of classical Greece and Rome, but apparently only by "barbarians."

Some sources claim that during the 6th century BCE the Assyrians contaminated the wells of their enemies with rye ergot (*Claviceps purpurea*), a parasitic fungus that grows on certain grains and grasses and produces hallucinogenic alkaloids. This allegation first appeared in the *Medical Management of Biological Casualties*, a publication of the US Army Medical Research Institute of Infectious Diseases (USAMRIID) in the mid-1990s, and was repeated in the 7th edition of that work released in 2011.^{87,106} Unfortunately, it provides no references, so it is impossible to know where the account originated. This account was subsequently picked up in the popular press,¹⁰⁷ and *Guinness World Records* even anointed it "the first incidence of biological warfare."¹⁰⁸ Recent publications repeat the claim.^{11,109,110}

There is, however, no reason to believe that the Assyrians ever used ergot as a biological weapon. Mayor doubts the story, but cites no sources and provides no supporting rationale.⁷³ Other historical writings by authors associated with USAMRIID do not mention it.^{5,7,14,15} More fundamentally, it is not even certain that the Assyrians suffered from ergotism. According to some students of Assyria, they did not cultivate rye, which is the primary host for outbreaks associated with consumption of *C. purpurea*. The symptoms described in Assyrian texts could be ascribed to other causes besides exposure to ergot.^{111,112} Nor is it clear how the contamination would occur. Would the Assyrians

have carried quantities of infected grain to the territory of their enemies to dump into water supplies? Could such contamination even cause a toxic effect? On balance, it is best to reject this allegation, barring the emergence of far more compelling evidence than now exists.

Mayor reviews the accounts of the claimed poisoning of the water supply of Cirrha during the First Sacred War. The people of Cirrha stood accused of interfering with the famous Oracle of Delphi. An alliance of Greek city-states besieged the city, finally destroying it after a 10-year-long siege ending around 585 BCE. Mayor identified multiple sources supposedly describing this incident, differing in important details, but all agreeing that the water was contaminated with a poison; most identified hellebore as the toxin employed, which led to the incapacitation of the city's defenders and their ultimate defeat.⁷³

There is a rather serious problem, however, which Mayor ignored. In 1978 a classicist, Noel Robertson, argued that the First Sacred War never occurred, pointing out that archeologists have been unable to identify a city that corresponds to Cirrha despite intensive efforts to find it, that all the sources attesting to the incident were written at least 200 years after the supposed event, that some of the sources are problematic for other reasons, and that it may not even be possible to use hellebore to cause a mass poisoning in the way described.¹¹³ While some classicists disagree, others accept Robertson's arguments.¹¹⁴⁻¹¹⁶ This led one recent account to assert, "Whether or not the war took place, it seems clear that many details of the usual account were later elaborations."^{117(p332)} In other words, we should be cautious about accepting stories about the siege, such as the claimed poisoning of the water.

These disputes suggest that Mayor's account is highly problematic. This is reinforced by a closer look at how she uses her sources. For example, Mayor relies on an account attributed to Thessalus, son of the great physician Hippocrates, who ostensibly wrote the earliest account of the siege. His version of the history mentioned the poisoning but did not name the specific poison used.⁷³ As it happens, most classical scholars seem to doubt that Thessalus actually wrote the account, suspecting that it was written much later.¹¹³

In other words, even the best-documented incident of toxin warfare in the classical world may not have happened. Given that most people interested in BW lack the expertise to evaluate the sources and understand the historical context of such incidents, even a well-informed reader of BW history is unlikely to know that there are reasons for caution. For this reason, if no other, Mayor has done the field a grave disservice.

Similar problems emerge with Mayor's claim that Rome suffered 2 intentionally started epidemics, based on references in the history written by Dio Cassius in the early 3rd century CE. According to her account, Dio Cassius claims that "saboteurs" initiated the plagues "to spread chaos and undermine unpopular emperors' authority."^{73(p126)} This happened first in 90-91 CE, and again in 189 CE. In both

cases, the perpetrators allegedly used poisoned needles to kill their victims.⁷³

Even a cursory reading of Dio Cassius shows that Mayor misinterprets his account. First, he does mention the incident (Book 67, Chapter 11), but imputes no political motivation. Nor was it described as a disease outbreak or a "plague." This is what he says about the "epidemic":

During this period some had become accustomed to smear needles with poison and then to prick with them whomsoever they would. Many persons thus attacked died without even knowing the cause, and many of the murderers were informed against and punished. And this went on not only in Rome but over practically the entire civilized world.^{118(Vol8,p343)}

There is nothing in this account to suggest any kind of infection. Rather, it is clear that the reference is to some toxin or mineral poison.

The second passage in Dio Cassius (Book 73, Chapter 14) is more difficult to interpret. He does mention a disease outbreak, which is generally assumed to be a continuation of the Antonine Plague that struck the Roman Empire between 165 and 189 CE.¹¹⁹ However, it is not clear that he attributes its origins to poisoning.

Moreover, a pestilence, as great as any I know, took place, for it should be noted that two thousand persons several times died in Rome on a single day. Many more, not merely in the capital but throughout almost the entire empire, perished by the hands of scoundrels, who smeared some deadly drugs on tiny needles, and, for pay, infected men with the poison by means of these instruments. The same thing had happened before in the reign of Domitian. But the death of these unfortunates was not regarded as of any importance.^{118(Vol9,p101)}

The second sentence does not state that the poisoned needles were the cause of the pestilence. Indeed, the choice of words ("many more ... perished") seems to suggest that these were 2 simultaneous but disconnected events. Reinforcing this view is the reference to drugs and poisons, which suggests use of a toxin or mineral poison.

The need for a new and more systematic account of the use of toxins in early civilizations is evident in discussions of changing perceptions of the legitimacy of poison as a weapon of war. Significantly, it appears that use of poison arrows largely disappeared in the transition from hunter-gatherer to nomadic to settled societies, albeit with a few notable exceptions.

While some authorities assert that the emergence of civilized societies was accompanied by a growing repugnance for the use of poison in warfare,¹²⁰ the evidence for such claims is remarkably thin. Commentators note that the Hindu Laws of Manu decried the use of poison: "When he is engaged in battle, he must never slay his enemies with weapons that are treacherous, barbed or laced with poison

or whose tips are ablaze with fire.”^{121(p101)} A similar injunction appears in yet another Vedic text, the *Dharmasutra of Baudhayana*: “The king should not turn back in battle or strike with barbed or poisoned weapons.”^{122(p159)} The role of such injunctions is not self-evident to the casual reader and has been the subject of considerable learned debate by those expert in this literature.¹²¹

Certainly, the Indian manual of statecraft, Kautiliya’s *Arthashastra*, which seems to date from the same era, is filled with references to the use of poison. It is impossible to identify the various poisons mentioned in it, and we cannot tell whether the “poisons” mentioned are real—that is, are they true toxic substances with identifiable physiological effects, or are they merely magical in character? Whatever the case, it is evident that the most influential ancient Indian guide to statecraft saw poisons as ordinary tools of statecraft. It may be significant that it never mentions poison in the context of battles, but rather confines its use to clandestine uses, such as assassination of political enemies or the secret murder of enemy commanders.¹²³⁻¹²⁵

This is a subject worthy of considerably more attention, given its importance for our modern understanding of the norms and taboos associated with BW. Some prohibition on the use of poison is evident in at least some early civilizations, but the significance is unclear, given indications that poison was still used. Indeed, Richard Price, who examined the norms associated with chemical weapons, argued that the prohibition against the use of poison in warfare dates to the early modern era and particularly to the writings of Grotius. According to Grotius, the ban on poisons reflected the desires of kings, who saw poison as the weapon of the weak and a dangerous threat to their power.¹²⁰ This seems doubtful, given the apparent disappearance of poison weapons from the arsenals of at least some societies thousands of years earlier.

Medieval and Early Modern Warfare

There are few references to BW during the medieval period. Mark Wheelis identified only 4 alleged incidents between 1340 and 1710 in his excellent survey, “Biological Warfare Before 1914.”²⁰ It appears in an indispensable SIPRI publication, *Biological and Toxin Weapons: Research, Development, and Use from the Middle Ages to 1945*, edited by Erhard Geissler and John Ellis van Courtland Moon, which contains a number of excellent studies that are referenced below.¹²⁶

The only alleged use of BW during the medieval period that Wheelis found totally credible occurred during the Mongol siege of the Genoese town of Caffa, a community in Crimea on the site of modern Feodosiya. Wheelis focused on this episode in a separate article likely to remain the definitive account, superseding a 1966 study by Vincent Derbes.^{127,128} The besieging Mongols reportedly catapulted the bodies of plague victims into the city, but our only account is Genoese, and we have nothing from a Mongol source. Hence, while Wheelis makes a strong case

that these actions led to an outbreak among the besieged, the evidence certainly does not come close to meeting Rosebury’s standard of proof and may not even be “beyond a reasonable doubt.” Bubonic plague typically is transmitted through the bites of infected fleas. But fleas quickly leave a dead body as it cools down,¹²⁹ so it is uncertain that the catapulted bodies would have exposed the residents of Caffa through that route.

Ultimately, there are missing elements to the story, if we are to believe that the Mongols deliberately spread the disease. First, we need some evidence that the catapulting of the bodies was linked to a plan to spread disease, but we have no accounts from the Mongol perspective. Second, even if the Mongols intended to spread the disease, we do not know for certain that their actions were responsible for the outbreak, although Wheelis may be correct that the catapulted bodies could have been the cause.

Although Wheelis makes a compelling, but by no means definitive, attribution, his research is a model that others would do well to follow. He carefully researched the known historical sources, providing as rich an account as possible given the limited amount of material available. Equally important, he examined the issue from epidemiological and microbiological perspectives, drawing on what is scientifically known about the spread of *Y. pestis*. He also considered an alternative explanation for the spread of the disease, and carefully caveated his conclusions.

Wheelis makes a similarly careful assessment of 2 other incidents. He reviews the evidence associated with a possible BW attack during the 1340 siege of Thun l’Eveque. According to one account, the besieging French army used their siege engine to hurl dead horses into the castle. It is unclear why they did so; they may have been merely trying to harass the defenders. Complicating matters, this account was written long after the event, while another version of the battle, written by someone who was fighting with the English army in the area at the time, does not mention the catapulted horses.²⁰ These considerations suggest that at most this is a possible instance of BW.

Finally, Wheelis also discusses the claim that the city of Karlstein was subjected to a biological attack in 1422. At the time, the Catholic Church was attempting to suppress the Hussites, which was seen as a heretical movement. Karlstein, the most important Catholic stronghold in Hussite-dominated Bohemia, was besieged by the Hussites for 5 months in 1522. A history of the failed siege, written about 250 years after the event, claims that they catapulted the dead bodies of soldiers into the city, along with 2,000 “barrow-loads of waste.” The objective of these attacks is not given, but Wheelis finds them to be plausible efforts to cause disease. He also admits that an account relying on unnamed sources and written so long after the event cannot be considered very credible.²⁰ Ultimately, it is difficult to consider this a likely example of BW.

There are a few incidents not mentioned by Wheelis. Many accounts repeat the story that Frederick Barbarossa,

the Holy Roman Emperor, employed BW while besieging the Italian city of Tortona in 1155. One source even claims that his capture of the city resulted from the effects of the biological agents.^{3,130} However, a reading of the original accounts indicates that the emperor was attempting to make the town's water supply undrinkable. In addition to dumping the carcasses of dead men and animals into the water, he also contaminated it with sulphur and pitch, hardly the actions of someone who wanted people to drink the water.²²

There also is an alleged incident involving the Venetians and the Byzantines.^{4,8} In 1171, the Venetians became embroiled in a war with the Byzantine Empire. After the Byzantines arrested Venetian subjects and seized their property, the Venetians built a large fleet and mounted a retaliatory strike against the Byzantines. They seized a number of cities along the Adriatic coast that were friendly with the Byzantines, including Ragusa, a quasi-independent city-state. The Venetians then wintered on the island of Chios while trying, unsuccessfully, to negotiate a settlement with the Byzantines. After many of the Venetians became ill due to a "plague" outbreak (which may not have resulted from *Y. pestis* infections), some of the Venetians feared that the Byzantines must have caused the disease by poisoning their water supplies. However, there is no evidence to support that theory.^{131,132} That an army would experience disease outbreaks is scarcely surprising, given that until the 20th century, infectious diseases killed more soldiers than enemy action. Natural causes are the most plausible explanation for the disease.

It is sometimes asserted that medieval European armies commonly catapulted the carcasses of animals that died of disease or even diseased human remains into castles or fortified cities (as allegedly done at Caffa).³ In contrast, Wheelis uncovered only a single incident involving dead animals and only a couple (including Caffa) involving humans in the 500 years before 1914.²⁰ This is a subject that might benefit from some explorations by scholars who study medieval warfare.

Other allegations simply require more investigation. Louis XIV of France supposedly gave an Italian "chemist" a pension to keep the secret of a "bacteriological weapon."⁴ The source of that account is an article in the *Encyclopedia Britannica*, written by a biographer of the French king.¹³³ The article does not source the story, and others claim, more plausibly, that the suppressed weapon was an incendiary device.^{134,135} The event apparently was well known. The French writer Fontenelle wrote a life of Martino Poli, the alleged inventor, mentioning the incident without specifically describing the type of weapon involved.¹³⁶ Without further evidence, there is no reason to accept the claimed existence of a biological weapon.

Numerous accounts now repeat a story that in 1495 the Spanish provided an opposing French army with "wine contaminated with the blood of leprosy patients."^{4(p370)} However, the authors who reported this supposed event

failed to note that their French-language source also asserted, "Le caractère légendaire de cette accusation est évident" ("The legendary nature of this accusation is obvious"). Unfortunately, the source of the original accusation (a 1602 publication) and the rebuttal (a 1740 publication) were both written in Latin and do not seem to have been translated into a modern language.¹³⁷ Thus, the allegation was made more than a century after the alleged event, and no one has bothered to review the original sources for the claim (and the rebuttal), clarify the historical context in which it supposedly occurred, or examine its scientific plausibility. Absent such research, this allegation cannot be accepted as a historical fact.

According to one researcher, in 1650 a Polish artilleryist by the name of Jan Kazimierz Siemienowicz "fired hollow artillery spheres filled with the saliva from rabid dogs at enemy forces."¹⁴ Other sources repeat this claim.^{6,9,16} In contrast, the Robertsons, who first published an English language version of this story, only claim that he designed such a device.⁴ They ascribe the story to an article that appeared in a Norwegian language medical journal, which was not located for this survey.¹³⁸

There is at least some reason to suspect the accuracy of all these accounts. Siemienowicz published a Latin text on artillery, rocketry, and fireworks in 1650, *Artis Magnae Artilleriae pars prima (Great Art of Artillery, the First Part)*, which was translated into English in 1729.¹³⁹ Suspiciously, the alleged year that he supposedly used his weapon corresponds with the publication date of the book, suggesting that the Robertsons are correct in claiming that Siemienowicz described but did not construct such a weapon. More significantly, while Siemienowicz described a poison weapon, it bore no resemblance to any of the accounts offered in the literature. Book 4, Part II, Chapter XI of Siemienowicz's book is devoted to "Poisoned Balls." In it, he describes how to contaminate the surface of artillery shot (not exploding shells) with poison, following a procedure he outlines for making fire-balls. For this purpose, he recommends combining wolf bane with poison extracted from a toad, along with mineral poisons (such as mercury or arsenic), "to which may be added the *Menstrua of Barren Women*, the *Brains of Rats, Cats, Bears*, the *Foam of Mad-Dogs...*," and so on.^{139(pp294-295)} Thus, the slobber of rabid dogs is only one possible ingredient for this poison weapon and by no means an important one. Finally, Siemienowicz makes clear that the use of such weapons is proscribed in warfare, at least against fellow Christians.

Use of toxin weapons also appears rare during this period. A 1947 article by a Chinese scholar, Wang Ling, reports that the Chinese of the Song and Yuan dynasties used what were called "poison-drug smoke balls," which included mixtures of gunpowder and a number of poisonous materials, including plant toxins (aconite, croton oil, *langtu*). One incorporated several toxins, as well as metallic poisons, another "dried, powdered and sieved" human feces. The feces could not have spread an infectious

disease, because the “balls” were boiled during their preparation. Ling also reports that the Mongols who tried to invade Japan in the 13th century were armed with poison arrows, although we are not told what poisons were used.¹⁴⁰

Norman Grainger Bisset, a pharmacologist, identified numerous instances of such use of poison arrows, even though he denies having made a comprehensive survey of the topic. The Chinese military continued to use poisoned arrows until relatively modern times, although apparently in relatively limited quantities and for specialized purposes. A Chinese law from 1546 required the production of about 2 kilograms of an aconite-based poison, which Bisset thought sufficient to coat 30,000 arrows. Indigenous peoples continued to use poisoned arrows and crossbow bolts until at least the 18th century. When the Chinese defeated the Miao in 1726, they captured 30,000 poison arrows.¹⁴¹

In any case, it is evident that in medieval Europe, and perhaps elsewhere at the same time, the use of poison in warfare was rare. One intriguing explanation deserving greater attention is suggested by the ethnographic studies mentioned earlier. If poisons were essential to make the early bow and arrow a viable weapon, then what happens when the bow and arrow became a highly efficient killing machine? By the medieval period, technological advances made archers, often available in large numbers, highly effective in battle, even against armored opponents. Indeed, a medieval longbow arrow could penetrate steel plate; the British kings ordered hundreds of thousands of these arrows in preparation for their French campaigns. In a 1360 campaign, the English supplied their army with 23,600 sheaves, each containing 24 arrows, or 566,400 arrows in all.¹⁴² How necessary or useful were poisoned weapons in such a setting? How easy would it have been to poison so many arrows?

At least one archeologist argues that poison arrows were used by Slavs in parts of Poland into the 14th century CE, but that poison was abandoned in response to the requirement for arrows able to penetrate the improved armor adopted by soldiers in the late medieval era.¹⁴³

Indigenous Peoples: Native Americans and Aborigines

The most credible allegations of BW reviewed by Wheelis involved use of the smallpox virus against Native Americans. Indigenous peoples can be highly susceptible to infectious diseases because they often are immunologically naïve and rarely have needed medical or public health practices to combat them.¹⁴⁴ Often they ascribed human agency to disease outbreaks. Accordingly, it is not a surprise either that Native Americans might have been the target of BW or that they would fear infectious disease. Nevertheless, Wheelis, almost certainly correctly, considers almost all of the allegations doubtful, although oral traditions among Native Americans suggest that they were subjected rou-

tinely to biological attacks.²⁰ His account is better than an earlier essay by Adrienne Mayor, who reviewed many such allegations, but she was more interested in the transmission of legends than in authenticity of the stories.¹⁴⁵ At best, her research shows how often people have suspected malicious intent as the cause of disease outbreaks.

Wheelis mentions claims that indigenous peoples in the Brazilian Amazon were infected with smallpox during this period, but he was unable to research Portuguese language sources to confirm the reports.²⁰ However, he pointed to a published account by Claude Lévi-Strauss that suggests that Brazilian elite oral tradition holds that such attempts dated as far back as the 16th century.¹⁴⁶ Lévi-Strauss also told Wheelis in an interview that he heard from Brazilians that such methods were employed in the 19th century as well.²⁰

In any case, reports of BW were rare in South America. One account is almost certainly false. The latest edition of *Medical Management of Biological Casualties* produced by USAMRIID claims that the Spanish conquistador Pizarro gave the Incas smallpox-contaminated clothing.⁸⁷ While it is true that disease outbreaks devastated the Incas, the smallpox epidemics occurred well before the Spanish attacked in 1532 (probably sometime before 1530). Some historians also doubt that smallpox was the disease.¹⁴⁷ Noble David Cook, who extensively studied the causes of disease in colonial America prior to 1650, argues that there is no evidence that the Spanish ever intentionally tried to spread disease in the Americas.¹⁴⁸

The best documented incident, and the only one from this era confirmed “beyond the shadow of a doubt,” was a 1763 British plot to spread disease through the transfer of smallpox-contaminated fomites to Native Americans during Pontiac’s War. Often attributed to Lord Amherst, the British commander in North America who advocated spreading smallpox among hostile Indians, the evidence suggests that the actual “attack” originated with and was executed by the men defending the loosely besieged Fort Pitt. It appears that by the time Amherst wrote in support of the plan, it had already been executed. Unlike most other incidents, we do not need to infer culpability, because the historian can refer to original documents describing what the British did and why they did it. Fortunately, we have some excellent histories, especially the recent writings of Elizabeth Fenn,¹⁴⁹⁻¹⁵¹ who built on earlier scholarship apparently unknown to the BW community.^{152,153} More recently, Erica Charters has tried to understand how the British at the time understood the ethical implications of intentional disease introduction, concluding that they recognized that it was outside the bounds of conventional rules of warfare.¹⁵⁴

The 1763 incident thus constitutes the first well-documented instance of deliberate spread of an infectious disease. While we know the intent and the action (giving contaminated material to the Native Americans), we do not know the result. It is possible that the smallpox outbreaks among the Indians resulted from other interactions, and

Wheelis provides several plausible alternative routes of transmission.²⁰

There is another alleged incident involving Native Americans that has in recent years received more attention than all the others combined. Wheelis mentions an allegation that an 1837 smallpox outbreak among the Mandans resulted from the deliberate introduction of the disease, only to dismiss it.²⁰ He does not refer to the writings of Ward Churchill, a prolific author who wrote several accounts of the outbreak, not all consistent with one another, claiming that the US Army deliberately provided smallpox virus-contaminated blankets to the Mandans in 1837, causing a major outbreak that killed possibly as many as 100,000 Indians.¹⁵⁵ Subsequently, Churchill seems to indicate that the number of victims might have been 400,000.¹⁵⁶

Reviews of Churchill's work demonstrate that his accounts of the outbreak are unsupported.¹⁵⁷⁻¹⁵⁹ If they had been true, the 1837 smallpox outbreak would have constituted history's single most significant instance of BW. While some contended that the critiques of Churchill's scholarship were highly politicized (because the University of Colorado launched its investigation in response to his attacks on US policy following the 9/11 attacks), there seems little doubt but that his conclusions related to BW had no merit.¹⁶⁰

There is at least one other incident that deserves more attention, although it may not be possible to learn more about it. Wheelis mentions that Isaac McCoy, a respected Baptist missionary and Indian agent, reported that he had evidence showing that in 1831 certain members of a wagon train carrying trade goods from St. Louis to Santa Fe deliberately spread smallpox among the Pawnee Indians, causing thousands of deaths. Unfortunately, all we have is the single account in McCoy's memoirs. An affidavit he mentions does not appear to have survived.^{20,161} This is the only credible 19th century claim of a deliberate attempt to spread smallpox among Native Americans, and it deserves closer examination.

While actual attacks were rare, there were numerous instances in which someone, usually a white man but occasionally a Native American, threatened to deliberately spread disease, usually smallpox.^{149,158} Wheelis describes one such incident, involving a fur trader in the Pacific Northwest in 1812, but there were others as well.¹⁶² Perhaps also relevant to this discussion is the so-called Whitman Massacre, an 1847 Indian attack on a white settlement that was sparked by belief among the Cayuse in the Pacific Northwest that deliberate "poisoning" by Dr. Marcus Whitman caused a measles epidemic that devastated the tribe.¹⁶³

There also is one claimed use of biological agents against Aborigines in Australia. The first white settlers, convicts transported by the so-called First Fleet, arrived at Botany Bay in January 1788. In April 1789, British authorities discovered a smallpox outbreak among the nearby Aborigines.

This outbreak quickly spread widely through the Aboriginal population in southeast Australia. So devastating was the impact that some modern historians believe that it made possible European settlement of Australia in the face of Aboriginal hostility. The cause of the outbreak has been a mystery, because the First Fleet was free of smallpox.¹⁶⁴⁻¹⁶⁷

Several theories have been offered to explain the unexpected emergence of smallpox at that time. Some historians believe its appearance might have resulted from infections originating on Australia's northern coast due to transmission from Macassan fishermen known to visit there. Critics of this theory argue that it is unlikely that an unbroken chain of transmission could have been maintained for such a distance.¹⁶⁶ Another theory, that it might have been introduced by a French exploration that visited Botany Bay in early 1788, has not been explored in any detail. However, the French apparently made no mention of smallpox, which the British certainly would have recalled when trying to understand the unexpected appearance of the disease.^{164,167} While the French ships were wrecked before returning to Europe, they left behind records of their activities in the months before visiting Botany Bay.¹⁶⁸

The prevailing theory, however, is that the British almost certainly introduced the disease. It is known that the First Fleet's physician had some bottled smallpox material, as an account of the expedition reported, "Our surgeons had brought out variolous matter in bottles."^{164(p2)} There was considerable conflict between the whites and the Aborigines, resulting in the death of both settlers and members of the marine contingent protecting them. Moreover, the marines were woefully unprepared for their responsibilities, being too few to protect the area being colonized and having neglected to bring sufficient stocks of ammunition and repair equipment.^{166,167}

Advocates that the introduction was intentional also refer back to the 1763 incident at Fort Pitt.^{166,167} This is more problematic than they would suggest, given that it is unclear how many people were aware of the incident at the time. It is unclear that anyone knew about this incident until 1870, when the historian Francis Parkman described the episode in the 6th edition of *The Conspiracy of Pontiac and the Indian War After the Conquest of Canada*.¹⁶⁹ Equally important, advocates point to Fenn's argument that the prevailing moral standards in British society did not forbid genocidal practices against primitive peoples.^{149,167} Fenn's views, however, are contested, so they cannot be taken as the last word on the subject.¹⁵⁴

Ultimately, we have a strong circumstantial case supporting the theory that someone deliberately introduced smallpox in the Aboriginal population. The strength of the case depends heavily on the exclusion of alternative explanations, and advocates have done yeoman's work undermining those alternatives. Some of the arguments made by some advocates go well beyond the available evidence. Nevertheless, the extensive research into the disease, the

careful exclusion of alternative explanations, and the attention to counterarguments make this a model exploration of a possible instance of BW.

18th and 19th Century Wars

There are several claims that biological agents were employed during 18th and 19th century wars. Most of these allegations are simply not credible.

Some sources claim that the Russians hurled the bodies of plague victims into the city of Reval (now known as Tallinn) during a 1710 siege, causing a plague outbreak.^{2,4} The reality appears to have been somewhat different. In 1710, the Russians were seizing Swedish-held territory on the Baltic coast. As part of that campaign, a 5,000-man Russian army camped outside Reval in mid-August and cut the city off from surrounding areas on August 22. However, the presence of plague was detected on August 10 and was in full force by the time the Russians approached the city. About three-quarters of the 20,000 people in the city had died by the time the epidemic ended. Although the Russians never assaulted Reval, they contaminated a stream that flowed into the city with the corpses of their dead (not necessarily plague victims). It is not clear whether this was to cause disease, to make the water undrinkable, or was merely a convenient way to dispose of the bodies. A Swedish army officer who was present blamed the plague outbreak on the contaminated water, but that is highly unlikely.¹⁷⁰

What is clear, however, is that the claim that the Russians catapulted dead bodies into the city is completely wrong. All these accounts appear to have originated with a report issued by a Swedish defense agency. There has been a considerable amount of work done on the plague outbreaks that occurred at that time in Eastern Europe and the Baltic area, including some studies focused specifically on Reval. Unfortunately, most of those accounts are in German or Estonian, so they have not been consulted for this study. Wheelis, who examined the evidence he could find, found the allegation dubious.²⁰

Another dubious allegation asserts that Napoleon Bonaparte tried to use malaria to break the resistance during the siege of an Austrian army at Mantua in 1797.¹⁶ However, campaign histories do not support the claim. If anything, the risk of malaria posed as much of a danger to the besieging French as to the Austrians. The Austrians surrendered in February 1797 after an 8-month siege. During the final months of the siege, typhus, dysentery, scurvy, and starvation were the main causes of illness.¹⁷¹ More plausible are allegations that Napoleon ordered his commanders to break dikes in the Netherlands in 1810 to promote the spread of malaria among British troops, although it is unclear how much of the resulting illness resulted from preexisting conditions and how much from the claimed French actions.¹⁷² It is possible, however, that the dikes were destroyed to obstruct the movement of enemy armies, not to create conditions conducive to the spread of

certain infectious diseases. As a result, better evidence is needed before concluding that the actions were intended to cause disease.

Fenn reviews claims that the British tried to spread smallpox during the American Revolution. While many Americans at the time clearly believed rumors of British efforts to spread smallpox, there generally is no supporting evidence. On several occasions, the British sent people suffering from smallpox into areas held by the rebels, or allowed smallpox-infected people to be captured by the Americans. However, we do not know why the British acted in that way. While it is possible that they were trying to spread disease, it is also possible that they were trying to rid themselves of the burden of dealing with smallpox patients. In only one instance did Fenn locate supporting evidence that the British considered deliberate spread of the disease: a letter sent to General Charles Cornwallis a few months before his defeat at Yorktown in 1781.¹⁴⁹ For that reason, there are grounds for skepticism. Philip Ranlet, who examined these claims in some detail, is skeptical, and correctly points out that fears of intentional smallpox are not matched by evidence to support them.¹⁷³ Leitenberg in his original study mentioned a claim that the Americans also used smallpox against the British during the Revolutionary War.² The source was a 1969 comment by the Chief Counsel to the House Armed Services Committee during a hearing. The basis for his assertion is not given.¹⁷⁴ Similarly, it does not appear that anyone has researched the validity of allegations, circulating in Canada in 1865, that the United States tried to infect British-allied Indians with smallpox during the War of 1812.^{175,176}

A French source (not located for this survey) apparently reported that in 1785 a Tunisian army sent clothes contaminated with plague to their enemy.^{4,177} This may be a misrepresentation of what actually happened. There was a major plague epidemic in Tunis during 1784-85, causing much loss of life. The small European community isolated itself from the rest of the city and suffered far less. According to one account, "By burying their dead near the walls and throwing rags dipped in suppurating buboes over the walls, the Muslims tried to introduce the disease among the Christians, indicating their belief in contagion and their resentment of the European presence."^{178(p30)}

We have considerably more information about plots and suspicions of plots during the American Civil War. The first effort to review this topic was Paul Steiner's *Disease in the Civil War: Natural Biological Warfare in 1861-1865*, a medical history.¹⁷⁹ On several occasions, Southern officers believed that Northerners tried to spread smallpox among their forces, although there is no confirmation.¹⁷⁹ Some Southerners also believed that the North deliberately inoculated Southern prisoners of war with smallpox vaccine contaminated in some fashion with syphilis. That particular claim was investigated by the US Army, which denied that it occurred but suspected that there may have been side effects resulting from the poor health of the prisoners.¹⁸⁰

Steiner, for one, was confident that no one considered BW during the Civil War: “no evidence is found for the deliberate use of disease as an offensive weapon by either side.”^{179(p43)}

In fact, there was a plot to employ BW. Although the episode received considerable attention at the time, it was largely forgotten until uncovered by historians researching related topics. Thus, Nancy Disher Baird, an archivist, uncovered reports about this plot while writing a biography of Luke Pryor Blackburn, who was a governor of Kentucky.^{181,182} Additional details were uncovered by a student of the Lincoln assassination, Edward Steers, who mentioned the incident in his pioneering research.^{183,184} Jane Singer provides probably the best single account of the story in her works on Confederate covert operations, but she adds nothing to what was already known.^{185,186}

Northern officials collected considerable evidence to support allegations that Blackburn had collected clothing and bedding from yellow fever victims, intending to use it to cause outbreaks in Northern cities and among Union forces. At the time, many physicians and sanitarians believed that yellow fever could be spread by fomites, but we now know it could never have worked. More plausibly, Blackburn also hoped to infect Abraham Lincoln with smallpox, but we now know that Lincoln probably had a mild case of smallpox in late 1863 and so would have had immunity.¹⁸⁷

A Research Agenda

The following is a list of topics from the period before the development of germ theory that could benefit from additional research.

1. A global perspective on arrow poisons: There has never been a comprehensive, global study of arrow poisons in English. The last such survey of arrow poisons is now approaching a century old, so it is perhaps time for an updated study to supplant the studies of Lewin and Perrot.
2. The cultural and scientific context of biological agent use by primitive societies: Most studies of poison use by primitive societies focus on what they did, rather than on why they chose to use poisons or the moral implications of such use. There is opportunity for studies from an anthropological perspective.
3. An assessment of the contaminants used by tribal societies allegedly capable of causing infection: There are widespread claims that indigenous peoples created arrow poisons, apparently for warfare, intended to cause infection. This topic would benefit from both a comprehensive survey of such reports and an assessment of their scientific plausibility.
4. Exploring possible use of toxins among early civilizations, especially non-Western: There has been little or no exploration of possible use of toxins by armies,

starting with early civilizations and continuing through the medieval era. In some cases, we know that more can be learned. In other cases, it is unclear whether the absence of information results from lack of research or from the lack of material to be researched.

5. The growth of the taboo against poisons in civilized societies, especially the evident decline in the use of poisonous substances in warfare: It is widely argued that norms developed against the use of poisons in war. However, we know little about the use of poisons or about attitudes toward them in the transition from primitive to more modern societies. Accordingly, it is difficult to understand how and when such a shift may have occurred.
6. Threatened use of pathogens against or by Native Americans: It is possible that there is little more useful to be said about this topic, but it would be worth the effort to ensure that was the case. Where did the British come up with the idea of disseminating smallpox-contaminated materials? Is there a possible linkage between the incident at Fort Pitt and the alleged use in Australia? Is it possible to say more about the incident described by Isaac McCoy?
7. Attempts to employ biological agents during the American Civil War.

THE EMERGENCE OF SCIENTIFIC BW: 1880-1945

It is sometimes assumed that the dramatic advances in microbiology during the late 19th century and first years of the 20th century opened the way for BW. Certainly, biologists understood that microorganisms could cause disease in humans, animals, and plants. Bacteria and rickettsia were known at the time, although knowledge of viruses lagged. Yet, it is misleading to say, “Modes of transmission were well understood for many agents.”^{188(p35)} In reality, the understanding of disease transmission was hampered by the prevailing view, certainly held by most scientists and health professionals in the Anglo-American world, that infectious diseases were transmitted primarily through contact exposure, and that the airborne route was of “minor importance.”¹⁸⁹ This perspective on the issue of disease transmission through the air is reflected in the writings of an icon of American public health, Alexander Langmuir. According to his accounts, only a 1934 study by William F. Wells began to erode this dogma.¹⁹⁰⁻¹⁹³

Studies conducted by the World War II biological weapons programs of the United States and Great Britain definitively demonstrated the importance of the airborne route and, even more significantly, the importance of biological aerosols. Most of this knowledge, however, was gained too late and affected the conduct of BW programs only during the early Cold War. When it was assimilated, the result was a “theory of biological warfare,” to use

Langmuir's phrase,¹⁹⁰ that changed the potential impact of a BW attack as much as the invention of the atomic bomb changed the potential effect of explosive devices. From this perspective, the BW threat was far more limited before 1945 than is commonly realized.

It is unclear to what extent this perspective was shared elsewhere. Anglo-American researchers appeared largely unaware of the research performed by André Trillat, a French military scientist who did pioneering work on airborne transmission of disease during the 1920s and 1930s that anticipated the later work done in British and American laboratories.¹⁹⁴ To what extent Trillat understood the physics and biology of aerosol infection, as opposed to droplet transmission, is unclear from the secondary literature, so his publications merit further investigation by someone with expertise in aerobiology. There is little evidence to demonstrate that other BW programs were equally sophisticated. Neither the German, Japanese, nor Soviet programs seem to have fully understood the implications of pathogen aerosolization prior to World War II. According to Zilinskas and Leitenberg, the Soviets began to understand the role of aerosols only after studying the tularemia outbreaks during the siege of Stalingrad.²⁴ The only effort to undertake a cross-country analysis of this topic is a monograph by Neil Davison.¹⁹⁵ It is a subject that merits additional research.

Before 1914

The use of toxins for assassinations and criminal activities has a long, if not well documented, history. Unfortunately, most studies tend to be sensationalistic. It is a topic worthy of more serious study, including, perhaps, an exploration into the reasons why it appears that the poisons of choice transitioned over time from toxins to metallic poisons.

Some 19th century anarchist theoreticians, such as Karl Heinzen and Johann Most, expressed interest in biological agents, although they clearly had no understanding of the science.¹⁹⁶⁻¹⁹⁹ These ideas never found an audience, although we do not know why. However, a British journal claimed that some anarchists did resort to bioterrorism. In 1894, *Tit-Bits* (a popular British magazine of the era) reported that anarchists imported yellow fever–contaminated materials into England in the early 1890s, killing several customs officials.^{200,201} Since we know that fever is not transmitted through fomites, the story cannot possibly be true. We are also told that Johann Most contemplated spreading cholera and yellow fever “for the purpose of exterminating mankind, rather than suffer the present condition of society to perpetuate itself,” certainly another canard.^{202(p244)}

We thus find 2 interesting developments. Terrorist theoreticians discussed the use of pathogens for bioterrorism, but their views generated little or no interest in terrorist practitioners. At the same time, some members of the press, drafted into the cause of combating anarchism, found it useful to raise accusations of bioterrorism. Whether there is

more to be said about these matters is unknown, but it is also a topic that has never attracted the attention of someone potentially familiar with the appropriate source material.

Of particular interest for this essay is another topic that until recently received little scholarly attention: the criminal use of pathogens and bacterial toxins as weapons. There were a number of rather dramatic cases during the first years of the 20th century, including incidents in Germany, France, and possibly the United States. Equally significant was a Russian incident involving the use of diphtheria toxin, making use of the new discoveries in microbiology to access a toxin previously unavailable. These incidents are reviewed in a survey of terrorism and criminal cases examined by me, relying almost exclusively on English language sources.²⁰³ Such incidents appear to have been rare, but, given the lack of serious attention to the topic of biocrimes, it is impossible to determine how rare they were. It deserves more attention by scholars able to work with non-English language sources.

One additional episode may merit attention. In 1901 and 1902, rumors suggested that the Boers had infected horses, purchased in the United States by the British for shipment to South Africa, with the pathogens causing glanders and anthrax. It is not known what steps, if any, were taken to investigate these allegations.²⁰⁴⁻²⁰⁶ While it seems highly unlikely that the Boers actually used biological agents, the persistence of such rumors is intriguing. As with many such allegations, the subject has not been scrutinized in the secondary literature.

World War I

The German military was the first to rely on biology to create a new form of warfare. During World War I, the German general staff mounted a substantial effort to use biological agents against the Allies, targeting mostly horses and livestock. The French reciprocated, but on a much smaller scale. The best summary of these activities appears in another essay by Mark Wheelis, “Biological Sabotage in World War I.”¹⁸⁸ His account superseded early studies,^{207,208} and has not been overtaken by more recent histories. It has been supplemented by a biography of one of the German saboteurs, Anton Dilger, which provides much new information about his operations in the United States. Unfortunately, as with other recent books describing German BW in the United States, it is a journalistic account without a standard scholarly apparatus. All we are given is a list of sources for each chapter.²⁰⁹ This same weakness mars another recent account of these activities, told from the perspective of the New York Police Department detective who played a central role in uncovering the German activities in the United States.²¹⁰

Efforts to reconstruct what happened have been limited by the destruction of relevant German archives. It is clear that the German military organized and implemented a global campaign to spread infectious diseases in animals,

relying on anthrax and glanders, operating in Finland, the United States, Spain, Argentina, Romania, and elsewhere. The best-documented parts of the German program are their operations in the United States and Romania. The US government collected a considerable amount of material to support its claims against Germany for its violations of US neutrality. In addition, the United States was involved in the seizure of sabotage supplies from the grounds of the former German embassy in Bucharest, which included vials containing cultures of *Bacillus anthracis*.¹⁸⁸

The Germans, we are told, had no interest in causing human casualties. Rather, their efforts were directed against horses and mules supporting the Allied war effort. World War I armies depended largely on horses to move equipment and supplies, and the rigors of war meant that they needed a steady supply of new animals to replace those lost in combat. Operations in the United States, Spain, and Argentina apparently focused on horses and mules purchased by the Allies. The pathogens causing anthrax and glanders were the agents of choice, usually shipped clandestinely from Germany, although small labs were established in Spain and the United States as well.¹⁸⁸

There remain a number of unanswered questions about German BW activities in the United States. One of the more interesting arises from a reference in an early account, Henry Landau's *The Enemy Within*. According to Landau, papers found in the possession of a German embassy official included reference to the expenditure, through November 30, 1915, of \$82,109.08 to acquire tetanus germs.²⁰⁸ To this must be added 2 other interesting facts. First, Dilger had some familiarity with tetanus from his work as a military surgeon during the Second Balkan War.²⁰⁹ Second, public health laboratories in 1917 found court plaster, a predecessor to the adhesive bandage, contaminated with *Clostridium tetani*. US officials doubted that the contamination was intentional, but it is not clear that they had any basis for reaching such a conclusion.²¹¹ It is possible, perhaps likely, that the skepticism was warranted. However, the matter deserves more attention.

It is generally believed that the Germans stopped using biological weapons in the United States after the US declaration of war. This conclusion may be an artifact of the peculiar nature of the primary records used to research German BW activities in the United States. Most researchers have relied heavily on the records of the Mixed Claims Commission, which was established to litigate US claims that Germany violated its neutrality. The commission had no interest in German activities that occurred while the 2 countries were at war.

In any case, there was widespread popular suspicion that the Germans were responsible for anthrax outbreaks on ranches and in dairies throughout the United States and its territories. There is no evidence to link any of these outbreaks to German saboteurs, but the epidemiology of some of the incidents led responsible government officials to suspect human involvement.²¹² The existing histories make little or no mention of these allegations, so we do not know if they were

ever investigated or if they were scrutinized and dismissed because there was no corroborating evidence. Irrespective of the merits of the allegations, this apparent widespread fear of German BW merits more attention by today's researchers.

That there is more to learn about German activities is evident from the research of Jamie Bisher, who located additional material about the activities of Baron Otto Carl Robert von Rosen, a Swedish national working for German intelligence in Finland, using Norway as a base of operations. At the time, Finland was part of Russia, but many Finns sought independence and worked for the Germans during the war. Relying on material found in the US National Archives and in extracts from a Norwegian police officer's autobiography, Bisher found that the primary target of the anthrax was not reindeer, as commonly reported, but horses used by Russian army units. In addition, Baron von Rosen's diary mentioned providing Finnish separatists with pathogens that caused both anthrax and typhus (the Germans also relied on locals to spread disease among horses in the United States). When the baron was arrested in early 1917, the Norwegians found boxes in his belongings filled with sugar cubes, each containing a small glass vial filled with *B. anthracis*, and a glass jar with "toxic bacteria bullion." Reportedly, the Smithsonian Institution possessed some of those vials but destroyed them in the 1960s.^{213,214} It remains an interesting question as to how those vials ended up in Washington. In any case, someone able to read German, Norwegian, Swedish, and Finnish probably could undertake research that would reveal more about this episode.

German BW during World War I presents a final conundrum. According to Wheelis, German officials associated with the program certainly believed it was effective, but he could find limited evidence to support that view. It is an interesting question whether the Germans deluded themselves, which is the prevailing consensus, or if the Allies were unaware of the consequences of the BW operations.¹⁸⁸ Martin Furmanski researched British veterinary records and presented his conclusions at a 2004 conference. Based on these records, he concluded that the impact "was militarily insignificant."²¹⁵ Unfortunately, Furmanski has not published his research.²¹⁶

France was the only other country that dabbled in BW during World War I, according to Wheelis. Thus, the French reportedly infected horses in Switzerland that were being shipped to Germany with *Burkholderia mallei* and may have provided unidentified pathogens to prisoners of war inside Germany to employ in sabotage operations. However, he suggests that additional research needs to be done in French archives to understand the scope of those activities.¹⁸⁸

Between the Two Wars

In November 1920, the British raided an Irish Republican Army safe house and captured a trove of documents, including one attributed to Michael Collins, the IRA's commander-in-chief, proposing use of biological weapons.²¹⁷

While supporters of the IRA claimed that it was either a forgery or a plant, historians generally accept the British government claims.²¹⁸ If real, this memorandum is unique: It appears to be one of the few discussions of biological agent use written by someone in a position of responsibility in a terrorist or guerilla organization. Unfortunately, there has been no satisfactory history written of this incident, so we do not fully understand its provenance, the context in which the plan was written, or its broader significance. The Germans recruited agents of Irish origin during their activities in the United States, and it would be interesting to know if the IRA's leadership knew of that experience.¹⁸⁸

Vahakn Dadrian, a respected historian of the Armenian genocide, has reported allegations that some Turks deliberately inoculated Armenians with "typhus." He describes 2 separate incidents in which Turkish physicians injected Armenians with blood from "typhus" patients under the guise of developing or providing prophylactic protection. For one of these episodes, he draws primarily from the outraged descriptions provided by Turkish physicians not complicit in the alleged events, while the other relied on the observations of an Armenian physician.²¹⁹

Typhus epidemics had a tremendous impact on the conduct of World War I. At the time, the only treatment available for typhus patients was supportive therapy, although there was hope of developing both a vaccine and a "serum-therapy," presumably meaning antibodies obtained from the blood of an infected animal.²²⁰ This was the approach successfully used to treat other infectious diseases at the time, such as anthrax.²²¹ There is one difficulty with this account that requires some further exploration. Furmanski notes that during this period the Germans, and those trained by the Germans, used the term "typhus" to refer to the disease now called typhoid. The Germans referred to what is now called typhus as "exanthemous typhus" or "spotted fever."²¹⁶ Hence, it is unclear if this account is about the disease caused by *Salmonella typhi* or the one caused by *Rickettsia prowazekii*.

Another author suggested that this incident constituted "the initial, scientifically-informed use of biological agents."^{222(p222)} Such a claim is clearly not sustainable, even if the incidents involved deliberate attempts to spread disease. The author was unaware of the well-documented use of biological agents by the Germans during World War I.

The episodes described by Dadrian merit further research, and his account suggests that there is additional information available about both incidents. He indicates that records associated with one of the incidents were believed to exist in an archive in Soviet Armenia (Dadrian wrote his account before the collapse of the Soviet Union). The physician involved in the other incident published a medical journal article about his work, which Dadrian apparently did not locate, but which should be obtainable.

That these activities were documented suggests they might have been highly unethical research coupled with

extremely poor science. Given the controversies surrounding the Armenian genocide, and the intense emotions it engenders, a cautious approach must be taken to accepting or rejecting the possibility of intent to deliberately spread typhus. Some authors have called into question the quality of Dadrian's research, suggesting that he made selective use of material and quoted original sources out of context.^{223,224} Such criticisms were not aimed specifically at this allegation, so they are not a reason to reject Dadrian's research out of hand. In any case, it would be useful to have the technical documents associated with the incident reviewed by someone with appropriate scientific training.

Lévi-Strauss, who heard reports of smallpox virus dissemination in colonial Brazil by the Portuguese, also reported hearing of similar tales in the modern era. Indeed, he seems to claim that similar methods were used between 1918 and 1935 by Brazilian landowners to eliminate the Indian population of the Brazilian state of São Paulo. He describes what happened as follows:

Their favourite pastime [referring to the Brazilian upper class] had been to call at the hospital for the clothes left behind by those who had died of small-pox: these they would then strew, together with other presents, along the lanes still used by the natives. This brought about the following brilliant result: that whereas in 1918 two-thirds of the State of Sao Paulo (as big as France, by the way) was marked on the map as 'unexplored territory, inhabited only by Indians', not one single native was left by the time of my arrival in 1935—with the exception of a few isolated families on the coast who sold 'curiosities' every Sunday on the beaches of Santos.^{146(p51)}

I have done a thorough review of criminal use of pathogens during this period, identifying a number of cases in the United States, Japan, and India.²⁰³ The Japanese cases received additional attention by a Japanese researcher, Masaaki Sugishima.²²⁵ However, I have also mentioned other cases, listed as "probable or possible," in Hungary (alleged pathogen involvement) and Germany (involving a toxin), but was unable to further investigate them.²⁰³ The use of pathogens as a murder weapon appears rare, but it is unclear whether more such cases would emerge from exploration of materials in languages other than English.

According to documents uncovered by an Italian researcher, Alberto Sbacchi, Benito Mussolini suggested in February 1936 that his troops employ bacteriological weapons in Ethiopia, but that one of his field commanders, Marshall Pietro Badoglio, objected for political reasons. According to the documents reviewed by Sbacchi, the marshal worried that the main victims would be pro-Italian Tigreans and that any operational benefit would be outweighed by negative international reaction. Sbacchi also suggests that the Italians would have used BW if their chemical weapons had proven less effective earlier in the war, although it is unclear if this is his personal opinion or if the documents state this directly.²²⁶

Japanese BW During World War II

Japan's use of biological weapons constitutes the single most important instance of BW and represents the only known concerted effort to employ biological agents in the context of combat operations during a war. Appropriately, the Japanese program has been the subject of numerous accounts of uneven quality. Most authors focus on the horrors of Japan's use of human subjects to study the clinical effects of infectious diseases. Thousands of people were murdered in these experiments, perhaps as many as 10,000 according to some accounts, which equaled or even exceeded the horrors of German concentration camp medical experimentation.²²⁷⁻²³⁴ Much less attention has been devoted to Japanese military use of biological weapons.

The English language literature on Japan's use of biological weapons is unsatisfactory. Despite its importance, historians and others have focused far more attention on the program itself, and especially on the medical experimentation. Sheldon Harris wrote a chapter in the volume edited by Geissler and Moon that provided an excellent English language summary of the military operations²³⁵—better than the one that appears in his book-length study of the Japanese program.²³³ However, it is not free of flaws, such as the unsubstantiated claim that the Japanese biological attacks killed “several hundred thousand” Chinese.²³⁵

Much of the literature on the Japanese BW program is from Japan and China. There is a substantial Japanese literature on their BW program, based on a cursory review of books held by the Library of Congress. Its catalog reports holdings of 26 Japanese-language books catalogued under the subject “Sino-Japanese War, 1937-1945—Biological warfare,” published between 1981 and 2009. The Library also catalogs 26 Chinese-language publications with the same subject heading, published between 1989 and 2011. These studies were not reviewed for this survey. Their quality is unknown, although review of some translated materials suggests that at least some of it is very good.

An essay by Tsuneishi Keiichi, translated from the Japanese, gives a more recent survey of the program and its employment of biological weapons and deserves greater attention.²³⁶ Considerably more detail appears in a number of Chinese publications providing English translations of some or all of their text.^{228,231,232} This Chinese literature provides a rich lode of original material, based on surviving documents, interviews with survivors of attacks and their perpetrators, and physical evidence collected by participants and researchers.

A cursory review of this literature suggests that it may now be possible to piece together a more detailed view of Japan's wartime employment of BW, even if significant gaps remain. One Chinese researcher has identified 161 different incidents involving the use of biological agents.²²⁸ In contrast, Harris lists only 7 major operations through 1942, presumably excluding the many smaller attacks.²³⁵

In any case, the literature suggests that the scope of Japanese operations declined after 1942 for unexplained reasons.

Examples of what can be accomplished using the available sources is illustrated by 2 important studies. A chapter in a book by R. Keith Schoppa provides an account of the impact of the 1940 biological attacks on 2 Chinese cities, Quzhou and Ningbo, focusing on the nature of the responses by the local governments. He demonstrates that the consequences were far more severe in Quzhou due to the inefficiency of the local government. While Quzhou ultimately suffered 2,000 deaths, the government and people of Ningbo organized a highly effective response and managed to limit the number of fatalities to 107. According to Schoppa's research, many of the victims died as the disease spread because of the movement of those originally infected to apparently unaffected areas.²³⁷ The richness and detail that Schoppa provides, drawing heavily on local newspapers, is strongly suggestive that it should be possible to better document other attacks.

Martin Furmanski wrote an interesting study of Japan's 1942 Zhejiang BW operations. The Zhejiang campaign was mounted in response to the Doolittle raid on the Japanese homeland, because of a false belief that the bombers had operated from Chinese territory. Furmanski argues that the BW attacks were part of a larger operation intended to prevent future aircraft raids from that area.²³⁸ He believes that this may have been the most important BW campaign ever conducted, because it was undertaken to achieve strategic and operational objectives.²¹⁶

A different kind of study by John Walker reviews what was known by one country (the United Kingdom) about a specific instance of claimed Japanese BW employment in November 1941.²³⁹ It also usefully highlights the complexities of bioattribution.

Despite the clear importance of some of the translated Chinese writings to an understanding of Japan's employment of BW, they also pose a problem for the serious student of biological warfare. Consider, for example, the study by James Yin, *The Rape of Biological Warfare*, produced with the assistance of the “Japanese Biological Warfare Crimes Investigation Committee.”²²⁸ The author and his collaborators took advantage of surviving material to present a book-length account that provides extensive information on what the Japanese did with their biological weapons. This is a welcome contrast to most Western writers who focus largely on Japanese biological weapons research facilities. While the production value of Yin's book is poor—it is filled with misspellings and what are clearly poor translations—the more significant problem is the inadequate analytic rigor. It is unclear to what extent the author and his collaborators really understood the science and technology of BW or the epidemiology of disease spread.

Yin convincingly documents that the Japanese resorted to BW far more extensively than generally believed, but he fails to make a convincing case for the magnitude of the impact. He claims that nearly 750,000 deaths resulted from the attacks. This includes nearly 110,000 people who died

after the war from outbreaks that he associates with the earlier Japanese BW operations. His totals derive from a tabulation of the deaths associated with around 130 attacks, as well as those murdered in the research facilities. This is several times more than the highest estimate for the number of deaths from the atomic bombings of Hiroshima and Nagasaki.

Are such allegations credible? An old adage suggests that an extraordinary claim requires extraordinary proof. While Yin makes extraordinary claims, he does not provide extraordinary proof. Given that some of the diseases employed by the Japanese often appear in war zones or socially disrupted areas, the causal linkage between alleged attacks and claimed outbreaks requires careful scrutiny. Yin reports, for example, evidence that the Japanese spread cholera in August 1943 in western Shandong, and that 200,000 people died as a result. This is documented in 1 page of text and 6 pages of supporting graphics and mentions only 2 sources. There simply is not enough evidence to justify the claim.

Martin Furmanski, who has looked carefully into these accounts, is unwilling to accept such expansive claims and concluded that “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).”²⁴⁰

These criticisms are not meant to denigrate the hard work that activists have undertaken to document an often-ignored history. Yin correctly identifies an issue most researchers ignore (although the leaders of the US BW program understood it well).²⁴¹ Biological warfare can cause new enzootic reservoirs and thus cause outbreaks long after an attack. Clearly, the victims of such epidemics are as much BW casualties as those infected in the original attack, but only if the subsequent outbreaks would not have occurred except for the original biological attack. Nevertheless, the problem remains that we need much better accounts of what happened in China.

World War II Resistance Movements and BW

The Germans believed, apparently correctly, that operatives associated with the Soviets and Poles employed biological agents against their personnel. These allegations are discussed in Geissler’s essay on the German BW program as well as in another essay on the Soviet BW program in the same volume co-authored by Geissler.²⁴² During 1943, the Germans apparently identified 25 incidents. In one incident, more than 3,800 people were infected with typhus.^{242,243} Unfortunately, neither article provides much detail, relying primarily on German documents that report on the results of their investigations into suspected biological attacks. In some cases, as with the incident involving a Czech who contaminated coffee with the organism

causing typhoid fever, it is unclear whether the perpetrator was acting alone, as part of an independent partisan group, as an agent for the Soviet Union, or as an agent of some other government. However, the Germans claimed to have found at least one Soviet document ordering partisans to use biological agents against the Germans.²⁴³ This last allegation comes from the writings of David Irving, whose known Nazi sympathies make many skeptical of his research. He also provides no references for this particular assertion, although checking his claims should be easy, because his account is based on captured German documents.²⁴⁴ Although both of Geissler’s essays seem to treat all the attacks identified by the Germans as related, the political differences between the Soviet Union and the Poles make any connection unlikely.

There are enough hints about the Polish activities to warrant further exploration. Geissler and Moon included an essay on Poland in their volume, which unfortunately ignores these allegations. However, there are multiple sources that confirm Polish biological agent use. The Germans believed that the Poles were engaged in bioterrorism, investigating many such incidents. Indeed, the Germans reported finding a makeshift microbiology lab to support such operations. The Polish resistance also told the British that they were using biological agents against the Germans. The Polish account reports that the German casualties resulted from “typhoid fever microbes and typhoid fever lice,” presumably referring to the causative agents of typhoid and typhus.^{244,245} This terminology, which is confusing to those schooled in modern microbiology, apparently reflects German usage of the era.²¹⁶

We even have an account of one incident described by Jan Nowak, a prominent member of the Polish underground, who claimed to have heard it from the perpetrators. According to Nowak, the Polish resistance, alarmed that fellow Poles were taking vengeance on other Poles by making accusations in letters sent to the Gestapo, decided to end the practice by contaminating letters with *Bacillus anthracis*. The result was an outbreak of cutaneous anthrax that caused the Gestapo to stop opening such letters.²⁴⁶ Geissler, who has studied the German records closely, accepts that the Poles used biological agents against the Germans on numerous occasions, but unfortunately provides few details.^{242,243}

It is disappointing that we know so little about these operations. If the reported German assessments are correct, they represent one of history’s most significant uses of BW, affecting thousands of people. It also makes the German lack of interest in BW even more puzzling. In the chemical arena, Germany’s leadership felt the need for a sophisticated retaliatory capability and invested considerable resources to develop what became the world’s most advanced chemical warfare capability.²⁴⁷ The apparent indifference to BW despite their belief that they were being attacked suggests the potential value of a comparative study of Hitler’s attitudes toward chemical and biological weapons, perhaps

drawing on some of the excellent studies of chemical weapons in that period.²⁴⁸

Non-Use and Allegations of BW

Although other countries researched biological weapons, including Canada, France, Germany, Great Britain, the Soviet Union, and the United States, it was only the Japanese military that used them.^{24,194,242,243,249-252} There are numerous allegations of BW use, but most of them are unverified and are probably not true. Some of these allegations are reviewed here.

Ken Alibek, who had senior management positions in the former Soviet biological weapons program, claimed that the Soviet Union may have used BW during World War II. According to Alibek, a major tularemia outbreak near Stalingrad resulted from the deliberate dissemination of *Francisella tularensis*.²⁵³ His arguments have not convinced Western experts. The German military clearly did not believe that they had been attacked at the time with biological agents, attributing the outbreak of tularemia among their forces during the battle of Stalingrad to transmission from Russian civilians.^{24,254,255}

Robert Harris and Jeremy Paxman report, apparently relying on American reports based on interrogations of former members of the Japanese BW program, that Japanese police captured 5 Russian spies in 1935 and found that they were carrying the organisms responsible for anthrax, cholera, and typhoid. Allegedly, 6,000 Japanese soldiers died of cholera and 2,000 horses died of anthrax from infections.²⁴⁵ This story cannot be taken seriously, if only because of the source. It is just as likely that the story was invented to justify Japanese BW activities. Harris and Paxman claim that Ishii used the story to gain support for his activities, but it is unclear if there was any substantiation for that assertion either. Without additional evidence, this allegation cannot be accepted.

Harris and Paxman also are responsible for a widely cited claim that the British gave weapons contaminated with botulinum toxin to Czech resistance fighters for use in the assassination of Reinhard Heydrich. There is no documentation to support this allegation, which apparently is based solely on the recollections of scientists who heard the story from Paul Fildes, the microbiologist who directed British BW research during World War II.²⁴⁵ Several BW experts have cast doubt on the accuracy of the account. For example, G. B. Carter points out that not only is there no documentation to support the claim, but that the British only initiated their research program in botulinum toxin after the assassination.²⁵⁶⁻²⁵⁸ More recently, Czech researchers have discovered the autopsy report performed on Heydrich. There were no indications of botulinum toxin intoxication, and the available evidence suggests that Heydrich almost certainly died of sepsis.^{259,260}

Despite Germany's use of biological weapons in World War I, it did not do so during World War II. Indeed, it appears that the Nazi regime never authorized an offensive

BW program, although some BW-related research was conducted. There are book-length German-language accounts of the BW activities of the Germans after World War I,²⁶¹⁻²⁶³ which this author has not reviewed. The only serious account available in English is an essay by Erhard Geissler.²⁴² Even though the Germans pioneered the use of BW, Geissler persuasively argues that Hitler refused to support an offensive program, even for retaliatory strikes, and limited research to biological defense. The reasons for Hitler's opposition are not known. BW advocates in Germany conducted research on offensive capabilities by pretending it was permitted defensive research. Geissler believes, however, that it was disorganized and of uneven quality and that there is no evidence that the Germans ever used even the limited capabilities at their disposal.

Nevertheless, the British worried that the Germans were continuing their BW activities before the outbreak of World War II, as documented in an important study by Martin Hugh-Jones. According to a British journalist, Wickham Steed, the Germans performed tests using biological surrogates of biological attacks, including in the Paris subway. The accuracy of those claims is doubtful.^{242,264}

Frank Snowden, a historian with expertise in Italian history and the history of medicine, has claimed that in 1943 the Germans deliberately flooded the Pontine Marshes near Rome to spread malaria in a desperate attempt to stop the advancing Allied armies.²⁶⁵⁻²⁶⁷ Although this allegation has appeared in subsequent accounts of the Italian campaign, Geissler and Guillemin examined the evidence and found it unconvincing.²⁶⁸ An Italian author, Annibale Folchi, an expert on the Pontine Marshes, also reached a similar conclusion after investigating Snowden's allegations.²⁶⁹ Unfortunately, her study appears to be unavailable in the United States and was not examined by this reviewer. However, her conclusions have been summarized in a more accessible Italian language article.²⁷⁰

A Research Agenda

The following is a list of topics from 1914 to 1945 that merit additional research.

1. Japanese use of biological weapons in China and Manchuria: The most significant gap in our understanding of BW is the absence of a comprehensive study of Japanese use of biological agents against the Soviets in Manchuria and against the Chinese. There is considerable material in Japanese and Chinese that has not been exploited, suggesting that a serious effort to study Japanese BW operations will require one or more people with knowledge of both Chinese and Japanese and an understanding of the technical aspects of BW.
2. German non-use of BW in World War II: How do we explain the contrast between Germany's activities in the 2 world wars? Wilhelminian Germany had an organized BW program in World War I, directed by its general staff and involving operations on at least 3

continents. In contrast, Nazi Germany did not engage in BW, and Adolph Hitler appears to have rejected attempts to even develop a capability for retaliatory reasons. Understanding this contrast might provide important insights into the motivations that lead states to pursue or reject BW. It is unclear if there is more to say than is evident from Geissler's study, but he clearly did not feel he had answered this important question.

3. Use of biological agents against the Germans by the Polish resistance: The evidence for terrorist attacks by the Polish resistance seems strong, but little is known about it. Researching this episode would require someone with fluency in Polish and German.
4. Use of biological agents by Soviet-associated partisans: There seem to be credible claims that partisans associated with the Soviet Union used biological agents. However, only one scholar has looked into them, and there is little in English about them.
5. The Italian biological weapons program and the Abyssinia War: What were the bacteriological weapons discussed by Mussolini and Badoglio in 1936? Is there more to be learned about this instance of non-use of BW?
6. Alleged Irish Republican Army interest in BW: Although no BW is associated with this incident, it is important simply because it is the only concept of use originating with a nonstate actor known to exist. It also would be worth knowing if there were linkages back to the German World War I activities, which certainly involved Irish-origin longshoremen in the United States.
7. The emergence of biocrimes in the early 20th century: The story of biocrimes in the first half of the 20th century remains largely unwritten. The only accounts draw primarily on English and Japanese language sources. It seems clear that research by scholars familiar with other languages will uncover additional examples. Ultimately, it would be useful to get a holistic sense as to why biocrimes emerged, apparently largely disappearing in the years after World War II.
8. Anarchist reactions to ideas of BW: This is a "dog that didn't bark" story, given that there was interest in BW by 19th century anarchists, but no use. It would be helpful to understand better why the idea of biological terrorism would interest anarchist theoreticians, and why those ideas apparently had no practical impact.

THE LATE 20TH AND EARLY 21ST CENTURIES (1946-2014)

Writing histories of post-World War II BW is problematic. First, there has been relatively little use of biological weapons: a few by governments, some instances of bioterrorism, and a number of attempted and successful criminal cases. Second, it is often difficult to obtain detailed

descriptions of particular incidents or allegations, due in part to the continued classification of official documents. Original documentation often is unavailable, and even when some material becomes available it rarely tells the whole story. Thus, the Chinese and North Koreans have not released documents related to their allegations of US BW during the Korean War, only a handful of Soviet documents have surfaced, and some extant American material remains classified.^{271,272}

Nowhere is the problem more evident than in trying to document the history of the programs. Since the end of the Cold War, the full scope and sophistication of the Soviet biological weapons program has become increasingly evident. Of special importance is a book by Milton Leitenberg and Raymond Zilinskas, *The Soviet Biological Weapons Program*.²⁴ This volume is the most comprehensive effort to study the history of the Soviet efforts to develop biological weapons capabilities, and it is an indispensable resource for anyone interested in BW. Two books, coauthored by former participants in the program, Ken Alibek and Igor Domaradskii, provide personal perspectives.^{253,273} Although Leitenberg and Zilinskas have researched and written an impressive history, by their own admission it tells only part of the story. The secrecy that continues to surround Soviet activity explains why they had to largely ignore the roles of the Ministry of Agriculture, the Ministry of Health, the intelligence services, and offensive activities of the Ministry of Defense.

While there is much more information available on the former US biological weapons program, some portion of the information remains classified and a substantial amount of material was destroyed. Thus, the CIA had destroyed the documents related to its clandestine program for developing biological agents, as documented by the Church Committee in the 1970s, while the US Army also destroyed many of its most sensitive documents. A significant amount of material remains classified, or unclassified but releasable only within the government, due to concerns that the release of technical details related to biological weapons development might be useful to others trying to create an offensive BW program.²⁷⁴

What is clear, however, is that scientific and technical advances made by the United States and the Soviet Union revolutionized BW. Although the foundations of this work were laid during the early 1940s, it was not until the 1950s and 1960s that the theoretical potential of BW became a frightening reality. As the United States demonstrated in its Large Area Coverage (LAC) exercises, biological agents properly prepared and disseminated could have effects that matched or exceeded those of thermonuclear weapons. Small amounts of lethal agent could cover thousands of square kilometers with overwhelming doses.^{241,275}

Yet, the period since 1945 has seen no verified use of biological agents during an inter-state war. In contrast, they have been used primarily by nonstate actors, but only in ways akin to the German WWI biological sabotage

operations. Despite its theoretical capabilities, or perhaps because of them, no country has attempted large-scale BW, just as no country has employed nuclear weapons since 1945. Rather, the period 1946 to present has seen false accusations, a few credible clandestine operations by state intelligence services, minor cases of bioterrorism, and a spate of biocrimes.

State Use of BW

There are several documented instances of BW use by states, although none employed the new technology developed by the United States and the Soviet Union. In fact, all used techniques not dissimilar from those that were available at the beginning of the 20th century.

The Rhodesian military employed chemical and biological agents during the war that country's white minority fought to maintain control over what is now Zimbabwe. The use of chemicals, primarily organophosphate pesticides, to contaminate clothing that was given to guerrillas is well documented.^{276,277} Less well documented is the use of biological agents. It seems widely agreed that the Rhodesians dispensed *V. cholerae* on at least 2 occasions into rivers near guerrilla camps, "attacks" that were unlikely to have caused any harm. These operations are discussed in several accounts, but a complete summary of the available information appears in a study of the South African chemical and biological weapons program authored by Chandré Gould and Peter Folb.²⁷⁸

Of more consequence, the Rhodesians have been accused of causing a well-documented outbreak of anthrax, which started among cattle belonging to blacks and then spread to the human population starting in November 1978 and continuing through at least October 1980.²⁷⁹⁻²⁸⁸ According to an account by Meryl Nass, drawing on official Rhodesian statistics, around 10,000 people were affected and 189 died, making it the world's largest recorded anthrax outbreak. Nass, who was the first to argue that it was intentionally caused, outlined evidence supporting her views in 2 articles, both heavily researched but neither published in a peer-reviewed scientific publication.^{289,290} Other accounts largely repeat what Nass described, although Tom Mangold and Jeff Goldberg did add a few additional details in a chapter of their book, *Plague Wars*.^{291,292}

Nass offered several sensible suggestions for follow-on studies that might prove or disprove her thesis. It is unclear why the government of Zimbabwe chose not to investigate her claims. Dr. Timothy Stamps, while serving as that country's Minister of Health, claimed to have launched an investigation into the incident, but it does not appear that any report was issued. This being the case, it cannot be determined if his investigators followed any of Nass's advice. Dr. Stamps also linked outbreaks from Ebola virus, Marburg virus, and *Y. pestis* in Zimbabwe to intentional introductions. He also claimed that South Africa must have been responsible for those outbreaks, because the Rhodesians

lacked the requisite scientific expertise, and that unnamed outside forces (the United States?) may have provided the South Africans with the biological agents to test them. In the end, however, he had to admit that he had no concrete evidence for any of his allegations.²⁹³

A 2007 doctoral thesis on the Rhodesian BW program written by Glenn Cross was never released publicly.²⁹⁴ Since then, Cross has obtained new material and hopes to publish a book on the topic in 2016. This promises to provide considerable new information on Rhodesian activities and to clarify many of the remaining uncertainties.

The South Africans also are known to have employed biological agents during the apartheid period. There are several good accounts of the South African effort to develop biological weapons, but accounts of actual use of such weapons are less useful. A South African researcher, Chandré Gould, has authored or co-authored the best of these studies,^{278,295-297} which are more carefully researched than those by other authors.^{292,298,299} Unfortunately, we know relatively little about the actual employment of their biological agents. These are reviewed in the book by Gould and Peter Folb, which lists the reported agents stocked by the South Africans (*Bacillus anthracis*, botulinum toxin, *Salmonella typhimurium*, *Vibrio cholerae*, and *Brucella melitensis*) and what little is known of their use. Reportedly, the South Africans used 1 of 32 containers of *V. cholerae* to infect the water supply of a guerrilla camp, but to no avail because chlorination killed the microbes. Sugar contaminated with *S. typhimurium* was provided to an ANC meeting, which may or may not have caused illness among the participants. Unfortunately, the South African government has refused to clarify this past use, even to the extent of falsely reporting that their country never had an offensive biological weapons programs.²⁷⁸ Yet, if they only used biological agents on these 2 occasions with little to no consequence, their effort would have constituted one of the least cost-effective BW programs in modern history. Some as yet unsubstantiated claims contend that surplus Rhodesian materials—largely organophosphate-contaminated clothing and poisoned foodstuffs—were used by South African units against SWAPO in Namibia.

Avner Cohen, best known for his studies of the Israeli nuclear weapons program, convincingly shows that the Israeli military used biological agents during the 1948 Arab-Israeli War. Less clear is the impact of the attacks, as there is no evidence that BW operations, which focused on water contamination, caused any disease outbreaks.^{300,301} According to a declassified 1949 CIA report, *Quarterly Review of Biological Warfare Intelligence*, "There is some evidence that deliberate contamination by Jewish forces of the water supply at Acre, Palestine, was responsible for the typhoid fever epidemic among British Troops during April-May, 1948."^{302(pp3-4)}

A number of countries allegedly employed or tried to employ pathogens or toxins in assassinations, including Israel, Rhodesia, Russia, South Africa, the Soviet Union,

and the United States. Generally, such assassinations relied on chemicals, but poisons of biological origin also have been used. Only on occasion have pathogens been employed. Shlomo Shpiro attempted to comprehensively review the use of biological and chemical agents by intelligence organizations, but he relies totally on a selective use of secondary sources and, as a result, sometimes gives inaccurate accounts of particular incidents.³⁰³ The Soviet Union often employed poisons but also used or considered use of pathogens. According to a report translated by the Wilson Center's Cold War International History Project, in 1953 the Soviets planned to assassinate Tito through the dissemination of *Yersinia pestis*. The plot was cancelled after Stalin's death.³⁰⁴

The most famous incident was the murder of the Bulgarian Georgi Markov. Although it is often asserted that ricin was used, the forensics examination could not identify the poison used. Rather, the pathologists guessed that the poison involved was ricin, based on clinical symptoms.³⁰⁵ Most recently, a Bulgarian journalist has obtained access to archives of the Communist-era Bulgarian State Security Service and published 2 books based on that information. Unfortunately, it appears that key operational documents were destroyed, so we know little more about how the operation was conducted than before.^{306,307} This suggests that aspects of this case, and others like it, may never be known.

One of the most disturbing allegations of the modern era is a report that Brazilian officials with its Indian Protection Service deliberately infected Amazonian tribes with the pathogens causing smallpox, influenza, tuberculosis, and measles.³⁰⁸⁻³¹⁰ Little has been written about the subject, perhaps because the Brazilian government deliberately suppressed a report documenting these allegations.³¹¹ Wheelis and Sugishima correctly argue that this case is "of considerable importance," but that it "has yet to receive the scholarly study that it deserves."^{312(p286)} Although they categorize this incident as terrorism, the actions were undertaken by or with the direct connivance of Brazilian government officials. However, not enough is known about what happened to clearly identify the responsible parties.

Nonstate Use

There is an enormous literature covering almost all aspects of bioterrorism during the period since 1945, but little is focused on its history and even less makes original contributions. This reflects the reality that there have been few documented instances of terrorist interest in biological agents and even fewer documented cases of bioterrorism.

The first serious studies of actual cases of bioterrorism were the articles that appeared in *Toxic Terror*, edited by the late Jonathan Tucker, which examined allegations concerning the activities of 7 BW incidents.³¹³ Several of the case studies cast doubt on the reality of some of the allegations, while other studies demonstrate the reality of others. As a result, this is an essential resource for anyone interested in BW history. The essays on R.I.S.E. and the

Minnesota Patriots Council describe real incidents that did not amount to very much.^{314,315} Jessica Stern has provided what is probably the definitive account of the antics of Larry Wayne Harris, the white supremacist fascinated by biological weapons.³¹⁶ John Parachini convincingly demolishes claims that the Weather Underground, a left-wing radical group, was interested in BW.³¹⁷

The only essay superseded by subsequent scholarship is on Aum Shinrikyo.³¹⁸ Milton Leitenberg argued that the whole matter was overblown and distorted,³¹⁹ while Richard Danzig and his coauthors more recently provide a nuanced study that demonstrates both the grand ambitions and the considerable incompetence of those responsible for the cult's biological weapons program.³²⁰ The Danzig et al essay is particularly valuable because of its analytic framework, providing some convincing insights into the organizational and cultural obstacles facing terrorist organizations, even when well-funded, that seek to develop biological weapons. It would be interesting to see if those insights might apply to other groups, especially the Rajneeshees and al Qaida.

At least 2 of the subjects of essays in the Tucker volume merit additional attention, if only because they illustrate the problems confronting those trying to write contemporary history. Terence Taylor and Tim Trevan, both respected BW experts, failed to definitively demolish claims that French authorities discovered that the Red Army Faction was trying to produce botulinum toxin during a 1980 raid on a Red Army Faction safe house. The authors mention that a German prosecutor publicly supported the allegation at the time, but they never explain why he did so if the allegation was false.³²¹ However, it turns out that all of the alleged perpetrators appear to have broken with the Red Army Faction in 1980 and were living in East Germany under the protection of the Stasi. All currently live in Germany, and one would assume they could be interviewed about the supposed plot.³²² Because the claimed incident occurred in Paris, there should be some French government records related to the incident if it really happened. In the end, Taylor and Trevan almost certainly are right to discredit the story and to conclude that there was no reason to believe that the Red Army Faction had any interest in acquiring a toxin weapon. Nonetheless, the whole story still raises interesting questions about the possible deliberate fabrication of stories intended to denigrate or raise fears about terrorist groups.

A new study of the Rajneeshees also is needed. This is one of the few confirmed bioterrorism incidents and the one that caused the most casualties. The account in my chapter in Tucker's book *Toxic Terror* was derived from official documents and interviews with government officials and journalists.³²³ It should be supplemented by the chapter in *Germes*, coauthored by Judith Miller, Stephen Engelberg, and William Broad, which provides additional details.³²⁴ Both accounts are solid but not definitive. There is certainly additional detail in FBI files. Moreover, none of the authors actually interviewed any of the perpetrators. Finally, as mentioned above, it would be useful to

reexamine the case using the template offered by the Danzig et al study of Aum Shinrikyo.

Toxic Terror also did not address a number of alleged bioterrorism incidents. One of the more interesting is related to claims that Jewish resistance fighters who survived World War II sought biological agents to use against German cities.^{325,326} The only serious look into the activities of one of these groups, a book chapter by terrorism expert Ehud Sprinzak and a colleague about a group known as DIN (the Hebrew acronym for Avenging Israel's Blood), discounts those claims.³²⁷ However, this author found Sprinzak's arguments unconvincing.²⁰³ According to Cohen's study of the Israeli chemical and biological weapons programs, at least 2 of the Israeli scientists contacted by DIN were involved in that country's nascent biological weapons program, a fact not mentioned by Sprinzak.³⁰⁰ Given Israel's subsequent use of BW, this interaction merits more attention.

The most lethal use of biological agents by a nonstate actor since 1945 occurred after the publication of *Toxic Terror*. This was the mailing of envelopes containing *Bacillus anthracis* spores to journalists and government officials in the United States in late 2001. The Amerithrax case, the FBI name for its investigation, is without doubt the most thoroughly reported incident of illicit biological agent employment. Attributed by government officials to a biodefense researcher, Dr. Bruce Ivins, it remains controversial. The best single account is probably *American Anthrax*, written by Jeanne Guillemin, which reflects both an understanding of the science and the importance of technical aspects of the case ignored by others.³²⁸ Typical is the discussion of the impact on American officials of the Canadian chamber tests demonstrating the extent to which *B. anthracis* spores in envelopes could aerosolize. It clearly goes well beyond earlier accounts.³²⁹⁻³³⁴ Investigators issued an extensive official report of their findings, which laid out the basis for their identification of Ivins as the perpetrator.³³⁵ The Amerithrax literature is extensive and encompasses scores of technical articles, including clinical descriptions,³³⁶⁻³³⁸ epidemiologic studies,³³⁹⁻³⁴¹ and scientific analyses.^{342,343}

The forensic evidence used in the Amerithrax case has received considerable attention, due in part to the emphasis given it by the investigators. To support their claims, the FBI commissioned a National Research Council review of their microbial forensics. Although generally complimentary, the study did not support FBI assertions that the Amerithrax perpetrator had to have used a specific *B. anthracis* culture prepared by Ivins.³⁴⁴ A subsequent US General Accountability Office review concurred.³⁴⁵ In contrast, a court-authorized Expert Analysis Panel, which analyzed Ivins's mental health records, strongly supported the FBI's conclusions.³⁴⁶ Ultimately, the FBI and Justice Department have not convinced skeptics that they correctly identified the perpetrator.

There are numerous other claimed uses or plans to employ biological agents by terrorists and criminals, some more serious than others. The following examples are taken

from *Bioterrorism and Biocrimes*, the working paper written by this author.²⁰³

The Mau Mau apparently poisoned cattle at a mission station with latex from either *Synadenium grantii* or another plant in the same family. There apparently were other similar incidents. Some involved use of arsenic, but in other instances the poison could not be identified, and it was suspected that a plant toxin was used.³⁴⁷ There should be evidence of this conclusion in archival documents held by the National Archives in Kew, Richmond, Surrey, near London.

My working paper mentions numerous ricin incidents, and there have been other cases as well. A collective account of ricin incidents might be useful. Perhaps more significant is a case that I also mention: "Egyptian gangsters" infected people with typhoid bacteria to obtain their life insurance. Unfortunately, I was unable to follow up on the story, because the original source was an Arabic-language newspaper. This is another instance where access to a foreign language might identify (or perhaps debunk) another intentional use of a pathogen.²⁰³

Since 9/11, US law enforcement authorities have arrested numerous individuals for possessing or attempting to acquire toxins, usually ricin. In some instances, the ricin was found in letters mailed to intended victims. These incidents have received considerable press coverage but much less attention in the analytic literature. The best survey of these incidents, putting them into context, may be a polemical article by George Smith that discounts the significance of ricin as a biological threat.³⁴⁸ His work is usefully supplemented by a Congressional Research Service report and by some thoughtful scientific articles.³⁴⁹⁻³⁵¹ At least one individual attempted to create a business selling toxins, and those poisons were employed in at least one murder plot.³⁵²

False Allegations

A considerable body of BW research during the post-1945 era has focused on 2 episodes of alleged use that almost certainly never happened: Communist bloc claims that the United States employed BW in the Korean War and the US allegation that the Soviet allies used biological agents in Southeast Asia in the late 1970s ("yellow rain"). These are not the only such allegations, only the best known.

The Soviet Union and its allies made numerous claims that the United States has engaged in biological warfare. Leitenberg reviews Soviet allegations of US employment of BW in *The Soviet Biological Weapons Program*. As he demonstrates, the Soviet Union and its allies have made palpably false claims of US BW since the late 1940s.²⁴

A Soviet bloc campaign to link the United States with the origin of HIV has been the subject of several articles. Thomas Boghardt attributes the HIV campaign largely to the East German secret police, the Stasi. In contrast, Erhard Geissler examined Stasi records and discounts the importance of the East German role. Both agree that there was a disinformation campaign, but they disagree about its effectiveness.^{353,354}

The Cubans charged that the United States attacked Cuba with biological agents on multiple occasions; these claims were reviewed and refuted by Raymond Zilinskas and Milton Leitenberg.³⁵⁵⁻³⁵⁷ Charles Calisher gave a first-hand account of a Cuban claim that the United States deliberately introduced the dengue virus into Cuba, putting it into a broader perspective.³⁵⁸ Martin Furmanski and Mark Wheelis take a skeptical view of the Cuban claims in a book chapter reviewing allegations of biological weapons use, but they believe that the Cubans may have had plausible reasons to suspect that the United States was responsible for at least 2 animal epidemics.³⁵⁹

During the Korean War, the Communist bloc countries claimed that the United States employed biological agents against North Korea and China. To prove their claims, the Chinese supported an investigation by sympathetic foreign experts, the International Scientific Commission for the Investigation of the Facts Concerning Bacterial Warfare in Korea and China. Chaired by the noted scholar of Chinese technology, Joseph Needham, the Commission not surprisingly fully supported the allegations. These allegations were reviewed in several SIPRI volumes.^{2,360,361}

Some authors continue to take these allegations seriously; the main Western proponent is Stephen Endicott.^{227,362} Others who have studied the incident, including Leitenberg and Moon, believe that the Chinese and North Koreans fabricated the allegations.³⁶³⁻³⁶⁶ The first major new development was the release of about a dozen documents from Russian archives showing that the Soviets believed the accusations to be false.²⁷² Furmanski and Wheelis argue that the allegations coming from the North Koreans were scientifically implausible, but that at least one set of allegations from the Chinese, involving cases of anthrax, were scientifically valid, even if it is doubtful that the United States was responsible.³⁵⁹

Some Sinologists continue to accept the possibility that the allegations may be true,^{271,367,368} although they tend to distance themselves from the writings of Endicott and Hagerman.³⁶² Similarly, some scientists writing about BW, such as Jeffrey Lockwood in his study of insects as weapons, are remarkably uncritical in reviewing the whole matter.²⁵ In contrast, Reid Kirby, a student of the US chemical and biological warfare programs, argues that the US military arthropod effort began only after the Korean War.³⁶⁹ Recently, a Chinese historical journal published a short account by Wu Zhili, Director of the Chinese People's Volunteer Army Health Division at the time, claiming that the Chinese never had evidence of US biological weapons use.³⁷⁰

During the Reagan Administration, the United States accused the Soviet Union of employing mycotoxins (popularly called "yellow rain") in Southeast Asia and Afghanistan. Most BW experts, including Elisa Harris, Matthew Meselson, and Julian Perry Robinson, either reject the allegation^{359,371-373} or find it open to dispute.³⁷⁴ Rebecca Katz argues that while formerly classified documents support the hypothesis that

some kind of chemical or biological warfare attacks took place, the evidence does not support any conclusion about the agent employed.³⁷⁵⁻³⁷⁷ An article by a former CIA operations officer gives a highly skeptical view of the whole matter from the perspective of someone involved in the search for intelligence supporting the "yellow rain" allegations,³⁷⁸ as does the account of a former Australian intelligence official.³⁷⁹

False allegations were not just the product of the Cold War. For example, the Libyan government claimed foreign medical workers (mostly Bulgarians) deliberately caused an HIV outbreak at a pediatric hospital, causing some 400 cases.^{380,381} The allegation became a cause célèbre in the international scientific community, especially after the Libyans chose to ignore scientific evidence that contradicted their desire to divert blame from the incompetence of their own medical system.³⁸²⁻³⁸⁵

Given the numerous allegations of BW, and the extent to which many of them have been proven false—either fabricated out of whole cloth or based on scientifically untenable evidence—the topic merits greater attention. The best study to date is the book chapter by Furmanski and Wheelis already mentioned, which reviews the Korean War, yellow rain, and the Cuban allegations.³⁵⁹

A Research Agenda

The following is a list of topics for the period since 1945 that would benefit from additional research.

1. Plots to use BW to retaliate against the Germans by Jewish survivors of the Holocaust: There is clearly more to the story of the Avengers, and it would be helpful for someone to dissect the available sources to give an account of what was planned and why it was disrupted.
2. Israeli (and pre-independence Haganah) use of biological agents in 1948: It is unclear how much more can be added to the research of Avner Cohen, but as one of the few examples of BW, it merits at least some attention.
3. The covert BW capabilities of the United States, as developed by the CIA for clandestine operations and the special forces for covert military operations: The destruction of documents in the 1970s may make it impossible to adequately research this topic.
4. Soviet bloc allegations of Western (and especially US) use of BW: As suggested by recent scholarly writing, there is more that can be said about Soviet bloc allegations during the Cold War. Geissler's exploitation of East German archives suggests that there may be more information in Warsaw Pact country intelligence archives that are now available to researchers.
5. History of Rhodesian BW: A definitive review of the available evidence would be extremely helpful in clarifying this obscure aspect of the history of BW.
6. Additional studies of false allegations of BW: Much more could be said about the many false claims of biological weapons use since the end of World War II.

7. Ricin incidents: There have been many instances, especially since the 1990s, of attempted or plotted use of ricin, although it is unclear whether they were successful.

TOPICAL AREAS

Some of the most interesting BW histories address relatively narrow topics. Several topics that merit additional work are highlighted here, although there clearly are others that could be added to the list.

First, fears of intentional disease existed in many primitive societies and recur in more modern societies as well.^{101,386} This topic merits additional attention, because it might help policymakers understand how we should think about contemporary bioterrorism concerns. Only a few studies look into fears of intentional biological agent use. Samuel K. Cohn reviewed reactions to the arrival of the Black Death in 14th century Europe and highlighted the pathological scapegoating that resulted.³⁸⁷ Similarly, Fenn's studies of smallpox outbreaks in pre-Revolutionary and Revolutionary America highlight the fears that the British were trying to deliberately spread smallpox virus into the Continental Army and pro-rebel communities.^{149,150} However, such fears are not inevitable. Cohn also has shown that reactions to epidemics can vary widely and do not inevitably lead communities to seek scapegoats to explain natural outbreaks.³⁸⁸

The utility of such studies is indicated by the research of Furmanski, who has examined fears of hostile BW and shown how unwarranted concerns have led to investments in both biological defenses and offensive biological warfare capabilities.³⁸⁹

Second, many scholars of BW argue that there is a widely accepted taboo against causing intentional disease. Surprisingly, given how often the existence of such a norm is mentioned, the topic has received relatively little serious academic attention. Cole provocatively put the issue in the context of evolutionary biology.⁵⁴ Moon examined the emergence of the taboo against poison through multiple prisms, including references in Western literature and opposition to food contamination and environmental pollution.³⁹⁰ Jessica Stern, focusing on risk assessment, introduced the concept of biological agents as a "dreaded risk."³⁹¹ Erica Charters has examined the ethical implications of the deliberate spread of smallpox to Native Americans during the Seven Years War, arguing that British commanders knew that their actions transgressed acceptable moral boundaries, even when fighting "savages."¹⁵⁴

Michael Mandelbaum, in a book otherwise devoted to nuclear issues, offered some interesting thoughts on attitudes toward poisons, including an attempt to explore the issue through the lens of E. O. Wilson's sociobiology. Unfortunately, like many who have written on the poison taboo, Mandelbaum incorrectly argues, "The poison taboo

recurs through time and across cultures."^{392(p38)} As should be evident from the discussion of the role of poisons in primitive societies, this proposition is certainly debatable. Nevertheless, his effort to make use of the insights offered by evolutionary social sciences hints at the possibilities for a richer set of studies.

Third, relatively little has been written on the evolving role of BW science and technology. Malcolm Dando wrote an article that hints at the possibilities for research in this arena.³⁹³ Dando's study apparently inspired Neil Davison to look into how science and technology shaped the first modern BW programs in the 20th century.¹⁹⁵ While these studies mainly help understand the structure of offensive biological weapons programs, they also contribute to an appreciation of the conduct of BW. Given the hyperbolic language often employed when describing capabilities to employ BW, these studies help put into context the strengths and weaknesses of capabilities.

Fourth, more could be done by exploring in depth specific forms of BW. The potential value of such accounts is evident in the survey of agricultural terrorism undertaken by Haralampos Keremidis and his colleagues.³⁹⁴ Such reviews highlight the need for more focused studies of particular topics. Keremidis et al identified only 4 instances of agricultural bioterrorism; in several of those cases, it should be possible to obtain more information about what happened and why.

Finally, the reasons for the relatively limited resort to BW deserve a serious historical review. Although the technical obstacles to the use of biological agents are not trivial, it is doubtful that these obstacles alone have prevented resort to BW. Other factors, and not just moral and ethical considerations, undoubtedly were important in decisions to develop biological weapons, and then employ them, or the reverse, deliberately deciding not to use them. Putting these decisions into a historical perspective might be difficult, given the gaps in our existing knowledge, but would contribute to an understanding of the real dangers posed by BW.

A Research Agenda

What follows are some suggested topics that merit additional research.

1. Fears of intentional disease: There is a long history in the United States of intentional spread of biological agents, dating to at least the time of the American Revolution. Such fears arose episodically in both the Native American and European populations. While it seems doubtful that such fears were limited to North Americans, there are no studies for other parts of the world.
2. Development of norms against BW: Given the widespread belief that a taboo against intentional infection is a major barrier against the use of biological weapons, it would be helpful to obtain a better understanding of the emergence of such views.

In some ways, this would be a complementary study to one focusing on fears of intentional disease.

3. The role of science and technology in the evolution of BW: The potentialities of BW are defined by scientific and technological possibilities. The uses and failed uses of BW require some understanding of those possibilities.
4. Reasons for the use or nonuse of biological weapons: It is striking how relatively little BW there has been, despite the growing mastery of biological sciences that have made biological weapons increasingly accessible. Yet, some people have sought to employ them. Getting a better understanding of the conditions under which barriers to BW can erode would be useful in strengthening norms against BW.

CONCLUSIONS

Thanks to the efforts of scholars and journalists during the past 45 years, we know a great deal more about BW today than when Leitenberg undertook his survey in 1969. BW has occurred, although few of the allegations are provable using Rosebury's high standard of evidence. In most instances, the evidence is sufficiently compelling to satisfy the more reasonable standard of "beyond a reasonable doubt."

Two problems hamper our understanding of BW's history. First, the available lists of actual and alleged instances of BW are unsatisfactory. They often include events that never took place, or for which the supporting evidence is limited or unpersuasive. Conversely, BW specialists and historians often are unaware of past use or attempted use of biological agents.

Second, often we have limited knowledge of past incidents, so we cannot accurately assess motivations or consequences. It is particularly disturbing that the largest effort to employ BW, the Japanese use of biological agents against the Chinese, has never been subjected to a comprehensive, scholarly review in an English-language study.

What we can say is that incidence of illicit biological agent use is greater than many people realize. Equally important, we also know that the effect of these attacks has been limited. In some cases, we know that the ambitions of those seeking to perpetrate the attacks far exceeded their actual accomplishments. We also can document that fears of intentional disease are not new. The implications of these observations are beyond the scope of this literature review.

In closing, it is worth noting that while numerous articles attempt to survey the history of BW, it is evident, after reviewing this literature, that all should be used cautiously. None is complete, and some contain serious inaccuracies. For those seeking a short history of BW, however, the best are probably an article by Stephen A. Morse,¹³ which covers all forms of biological warfare (despite its title), and a book chapter by James W. Martin and his coauthors.¹⁵ There does not appear to be a book-length history of BW. Given

the gaps in our knowledge highlighted above, however, it probably is premature for anyone to write one.

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Address correspondence to:
W. Seth Carus, PhD
Center for the Study of WMD
National Defense University
Lincoln Hall (Building 64), Room 2421
Ft. McNair
Washington, DC 20319-6000
E-mail: seth.carus@gc.ndu.edu