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Biological toxin warfare: threat, proliferation, and the effects of neutron energy on BTW agents

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THESIS

**BIOLOGICAL TOXIN WARFARE:
THREAT, PROLIFERATION, AND THE EFFECTS
OF NEUTRON ENERGY ON BTW AGENTS**

by

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September 1995

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The threat of biological weapons presents a special military challenge. Biological toxin warfare (BTW) agents are more potent than chemical warfare agents. Depending on the yield of the nuclear weapon, a biological weapon also can have a higher lethality than nuclear weapons. This thesis examines existing international restrictions on the proliferation of BTW technology and identifies their shortcomings. These loopholes contribute to the easy availability of the technology necessary to develop biological weapons programs. As efforts to curb BTW proliferation continue with little avail, it is necessary to examine military means for neutralizing or destroying biological pathogens and toxins in both the production and weaponization phases. One such method, enhanced radiation weaponry, is examined in this thesis and is shown to be a viable means of neutralizing pathogens and toxins.

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BIOLOGICAL TOXIN WARFARE: THREAT, PROLIFERATION, AND THE EFFECTS OF NEUTRON ENERGY ON BTW AGENTS

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ABSTRACT

The threat of biological weapons presents a special military challenge. Biological toxin warfare (BTW) agents are more potent than chemical warfare agents. Depending on the yield of the nuclear weapon, a biological weapon also can have a higher lethality than nuclear weapons. This thesis examines existing international restrictions on the proliferation of BTW technology and identifies their shortcomings. These loopholes contribute to the easy availability of the technology necessary to develop biological weapons programs. As efforts to curb BTW proliferation continue with little avail, it is necessary to examine military means for neutralizing or destroying biological pathogens and toxins in both the production and weaponization phases. One such method, enhanced radiation weaponry, is examined in this thesis and is shown to be a viable means of neutralizing pathogens and toxins.

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I. INTRODUCTION

> Unlike most other types of weapons, biological weapons can be used either overtly or covertly. In the case of overt use, a military target might be hit with a highly infectious, fast-acting pathogen that would either weaken or kill its victims. Biological weapons would probably be used as a first strike that might go undetected, followed by a conventional attack. Alternatively, biological weapons could be used covertly, with no follow-up attack or other activity that might identify the user.[1]

A. BACKGROUND

As the preceding passage illustrates, the threat of biological weapons poses a special challenge that, until now, United States Armed Forces have not encountered. Unlike any other weapon, they can be used overtly or covertly, and can yield similar results, in terms of fatalities, as nuclear weapons. There is no guarantee that U.S. forces will not encounter them on future battlefields. The 1972 Biological Weapons Convention cannot ensure a halt to the production and use of biological agents for warfare. A combination of new security threats and an absence of old security sources has led many states to initiate or accelerate biological weapons programs. Due to the strength of the Nuclear Nonproliferation Treaty, most states are prevented from producing nuclear weapons and have turned to the cheaper alternative of biological and chemical toxins.[2] Whether biological weapons will be used remains to be seen, but as an increasing number of countries appear determined to acquire these weapons, the United States needs to develop countermeasures to neutralize or destroy them.[3]

It is the problem of destroying them before they are used that this thesis theoretically examines. In order to conduct this analysis, I examine the potential military threat posed by biological warfare capability, and survey the means with which countries

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[1] Kathleen C. Bailey, *Doomsday Weapons in the Hands of Many* (Chicago: University of Illinois Press, 1991), 83-84.

[2] Estimated costs for various programs are: (1) for producing nuclear weapons $2-10 billion, (2) chemical weapons tens of millions, and (3) biological arms less than ten million dollars.

[3] John M. Deutch, Office of the Deputy Secretary of Defense, "Report on Nonproliferation and Counterproliferation Activities and Programs," (US. Department of Defense, May 1994).

are able to circumvent the international system to procure biological weapon programs. Ultimately, this thesis determines whether enhanced energy (i.e., the neutron bomb), in other words, generating tremendous amounts of neutron radiation, can be an effective physical means of destroying or neutralizing biological weapons stockpiles and/or production facilities of countries who are signatories to, but are not in compliance with the 1972 Biological Weapons Convention (see Appendix D and E).

B. METHODOLOGY AND ORGANIZATION OF THESIS

The following four sections are a synopsis of what will be examined in this thesis. The key issue illustrated in this thesis is the need for a response, either retaliatory or preemptive, to the use or potential use of biological toxin warfare (BTW) agents. This thesis examines the effect of neutron energy on biological agents. Other options that could be pursued but that are not explored here include destruction through heat (perhaps a dual penetrating weapon with a heat source piggybacked on the weapon), conventional weapons, and some other newly developing technologies. While tactical nuclear weapons are no longer a component in the strategy of the U.S. Armed Forces and the political will does not currently exist to use nuclear weapons, the problems created by the spread of biological technology warrant an examination of the effectiveness of neutron energy in neutralizing BTW agents.

1. Chapter II: BTW Background

Prior to surveying the reasons contributing to the proliferation of BTW agents, I examine what makes BTW such an attractive option for countries pursuing a weapon of mass destruction. Initially an introduction of general scientific information regarding toxins and pathogens will be presented. It is these agents when combined with a delivery mechanism that comprise biological weapons. Then the distinction will be made between BTW agents and chemical warfare agents as these are sometimes erroneously grouped together. The final part of this chapter allows the reader to examine specific effects of some biological pathogen and toxin agents.

Due to the capability of toxins to reproduce rapidly within a host and the extreme lethality of toxins and pathogens, very small amounts of a particular biological agent are required to cause tremendous amounts of casualties (presuming proper deployment and favorable winds and atmospheric conditions). The insidious results wrought by these weapons makes understanding their capabilities tantamount, and places the need to study possible military responses to their uses in the forefront of technological research.

2. Chapter III: Factors Contributing to BTW Agent Proliferation

Following the explanation of the capability and potential destruction caused by these weapons, it seems natural to survey the international system and the technology that makes acquisition of a BTW capability relatively simple. This thesis does not examine in detail reasons for the proliferation of biological weapons. Instead three key factors that contribute to a growing number of countries acquiring biological weapons programs are examined to highlight the military problem created by the spread of the technology underlying biological weapons.

The first factor in highlighting the emergence of the increasing biological weapons threat is the inherent weakness of the 1972 Biological Weapons Convention. Specifically, Articles One, Three, Four, Nine, and Ten are examined. These are the articles that are intended to stop the spread of biological pathogens and toxins for other than peaceful purposes, but as this chapter will illustrate, the convention does not appear to have a viable enforcement organization to support the provisions of the aricles. The importance of such an enforcement agency is paramount as was witnessed with the North Korean nuclear situation in 1994.

These weaknesses ultimately contribute to the ease of acquiring a BTW capability. Taking the increasingly easy availability of technology and equipment into account, I examine the eight steps, from the research phase (step one) to the weaponization process (step eight), required to build a biological weapons program. Due to a lack of constraints to prevent the spread of technology that is necessary to establish

biological weapons programs, the relatively low cost of developing such a program, and strict enforcement of the Nuclear Nonproliferation Treaty, the majority of biological weapons programs appear destined for lesser developed countries. To further cut costs and ensure relatively quick success in establishing a program, these countries are likely to choose toxins and pathogens that have been weaponized in the past. Research into exotic agents that have never been weaponized drives the price of the program higher and requires a greater level of expertise that lesser developed countries are not likely to possess.

The last contributing factor examined is one that is not unique to the BTW arena -- the dual use issue. Summarized briefly, much of the technology that is required for a biological weapons program may also have every day uses in the biotechnical industry, medical research, and in commercial fermentation. Iraq, despite being a signatory to the convention, purchased and was able to hide seventeen tons of anthrax cultures from the international community.[4] While seventeen pounds would be an easily acceptable quantity for legitimate medical research, it appears as though the seventeen tons were intended to be used for offensive purposes -- a violation of the convention. There arises the major concern regarding dual use technology, and that is identifying whether a nation actually is engaging in legitimate activities or is establishing an offensive biological capability.

3. Chapter IV: Effects of Neutron Energy on BTW Agents

With the establishment of the problem that biological pathogen and toxin proliferation creates, the task at hand is to answer the hypothesis posed at the beginning of this introduction. Is enhanced energy, or neutron radiation from a source such as a neutron bomb, theoretically capable of neutralizing or destroying pathogens and toxins?

Neutrons are chargeless particles. Because of this property, they can penetrate through significant thicknesses of concrete, earth, and other materials. This is the

[4] Rolf Ekeus, "Monitoring Iraq," *New Perspectives* 12, no. 3 (Summer 1995), summary of article was downloaded from *New Perspectives* archive on the Internet.

primary reason that neutron energy was chosen for this thesis, because the ability to penetrate a structure is likely a requirement in targeting a BTW agent production/ stockpile facility. Another property is that most all of the neutrons are emitted as prompt neutrons -- simultaneously with the explosion. This is significant because it allows a high neutron flux to be imparted on the target in a very short amount of time.[5]

The effectiveness of enhanced radiation in neutralizing BTW agents is determined using two methods. The first method determines whether it is technically possible to impart enough neutron fluence on a generic agent to neutralize that agent. The neutron fluence is the number of neutrons per unit area (in this case, neutrons per square centimeter).[6] High neutron fluences are required due to the microscopic size targets that this thesis considers. The second method determines whether a neutron weapon is feasible to raise the specific heat of an agent enough to destroy that agent.

For this thesis it is assumed that BTW agents are being stored in their liquid form which is the most unstable and should be the easiest to neutralize. The reasoning behind this assumption is that if a technically possible level of neutron fluence is not attainable to neutralize the agents in their most unstable form, by deduction, it is highly unlikely that an enhanced energy weapon would be a logical choice for an agent stabilized by one of the other methods described in Chapter III. If either of these methods is theoretically successful, the final step is determining the required effective yield of the neutron weapon.

4. Chapter V: Conclusion

The conclusion summarizes the analysis. The purpose is not to encourage the use of nuclear weapons. This thesis is instead intended to provide policy makers and

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[5] Samuel Glasstone and Philip J. Dolan ed., *The Effects of Nuclear Weapons* (Washington, DC.: US Government Printing Office, 1977), 343. Peak energy neutron levels per neutron are approximately 14 Massive electron Volts (MeV). 1 MeV (is equal to one million electron volts) = 1.6×10^{-6} erg.

[6] Flux is the product of the neutron density and the particle velocity. The flux is expressed as particles per square centimeter per second and is related to the absorbed dose rate.

operational planners an option to consider and to use these insights when making difficult decisions regarding the use of force against potential WMD targets.

II. BTW BACKGROUND

A. INTRODUCTION

Before examining the three primary reasons that contribute to the proliferation of BTW agents (Chapter III), it is necessary to introduce some of the general scientific information regarding these agents which when weaponized constitute the biological weapon or munition. Initially a brief section familiarizes the reader with the difference between BTW agents and chemical agents. This is followed by a generic description of BTW agent characteristics. Finally, a specific analysis of the classifications of pathogens and toxins ensues, including potential hosts and effects of agents. The intent is to provide insight into what makes this weapon of mass destruction so attractive to nations pursuing this capability.

B. BACKGROUND

From the effects of "Black Death" in England in 1349 and 1665, which each time reportedly reduced the population by half, to the Ebola virus of 1995 in Zaire, civilization has learned about the drastic effects of diseases on unsuspecting populations. It is this mass destruction that is intended to be inflicted by countries currently in possession of biological toxins and pathogens for offensive purposes -- a blatant violation of the 1972 Biological Weapons Convention. Prior to examining the military means of neutralizing these insidious weapons, it is necessary to have a basic understanding of the science concerning BTW agents.

"Biological and toxin warfare (BTW) has been termed 'public health in reverse' because it involves the deliberate use of disease and natural poisons to incapacitate or kill people."[7] Perhaps the best description of the nature of biological warfare is provided in *Plagues and Peoples* -- "macro-parasites of which-or-of whom enlist the help of micro-

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[7] US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, D.C.: U.S. Government Printing Office, December 1993), 71.

parasites in their predation."[8] Included among BTW agents that could be used in warfare are fungi, viruses, rickettsiae, and bacteria. These are also referred to as pathogens. The other aspect of biological warfare is the use of toxins which are nonliving chemicals produced by animals, plants, bacteria, and fungi.

The goal of all of these is to cause infection that results in eventual death or incapacitation. The difference between the two is the time for which it takes them to yield an effect. Pathogens can require a period of incubation from about one day to six weeks, while toxins cannot reproduce within the host and yield relatively quick results -- as short as minutes or hours.[9] One common factor regarding their virility or toxicity is that it decreases with time as the agent disperses, although there are some exceptions (anthrax).[10]

Even though biological warfare arouses repugnance, and has never been used on a broad scale in modern warfare, agents were stockpiled during the Second World War and are the poor nation's current answer to the elusive nuclear weapon. In fact, biological weapons are sometimes referred to as "the poor man's atomic bomb."[11] To examine the lure that biological toxins and pathogens have to potential possessor states, one need only consider that the accidental spread of contagious diseases during war causes more fatalities than armed combat.[12] So by intentionally introducing disease to the battlefield, an aggressor gains an indescribable advantage over his opponent.

While it currently appears that biological weapons cannot be used as effective tactical weapons, a small non-nuclear country may still use them in a regional conflict (such as the war between Iran and Iraq), or when threatened by a nuclear state or

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[8] Nicholas A. Sims, *The Diplomacy of Biological Disarmament* (New York: St. Martins Press, 1988).
[9] Ibid.
[10] The use of anthrax on the British Isle of Gruinard, off the coast of Scotland, from 1941-43 plagued the island with the presence of anthrax spores until 1990.
[11] OTA, *Technologies Underlying Weapons of Mass Destruction,* 71.
[12] John P. Heggers, "Microbial Invasion-The Major Ally of War (Natural Biological Warfare)," *Military Medicine*, vol. 143, No. 6 June 1978: 390-94.

coalition as Iraq was in the Gulf War. The major technical hurdle is the establishment of reliable means of delivery due to the unpredictable behavior of the agents.

1. Toxins and Pathogens[13]

Biological and toxin agents are sometimes referred to as chemical agents, but there are some key differences. The confusion sometimes arises because some toxins possess many of the same characteristics of chemical agents. CW agents are nonliving, manmade or manufactured poisons. BTW agents are either pathogens, living microorganisms that are capable of reproducing within a host, or toxins which are poisonous chemicals produced by living organisms (sometimes pathogens). When comparing the individual lethalities or effectiveness, it is important to note that BTW agents are much more potent than CW agents, and, depending on the yield of the nuclear weapon, also can have a higher lethality than the nuclear weapon.

Additionally, unlike the production of CW agents which requires certain precursor chemicals that can be tracked, there are no such indicators in the production of BTW agents, thus the issue which often arises is whether someone is producing offensive capabilities or defensive vaccines. This is virtually impossible to discern since both applications utilize the same technology and techniques during the research and development stage. It appears logical though that the more secretive the program, the more likely it is to be offensive in nature, while openness likely indicates the legitimate commercial or defensive intentions of a country's program.

To clarify the issue, it should be stated that presently the use of BTW agents for peaceful purposes are very few in number and are primarily limited to producing vaccines, treating neurological disorders, and experimental cancer treatment (see Appendix H). These applications however are not normally found in third world countries and are instead limited to highly sophisticated biomedical facilities. Thus most

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[13] Much of the information contained in the following sections was taken from the following source: OTA, *Technologies Underlying Weapons of Mass Destruction,* 73-80.

programs involving any biotechnical related issues in lesser developed countries that are not openly announced should be reviewed with the utmost skepticism.

2. Description of Typical BTW Agents

This section provides more details about BTW agents. A brief description of the classification of pathogens ensues. It includes bacteria, rickettsiae, viruses, and fungi, and is followed by a similar analysis for the two classifications of toxins -- protein and nonprotein. But before delving into the specifics, it is necessary to provide some insight into the characteristics of these agents that make them so attractive as warfare agents. Some of the more desirable characteristics of ideal biological agents that make them viable military options include the following:

- the ability to infect reliably in small doses.
- high virulence which is the ability to inflict acute illness or fatality without the loss of potency during production, storage, and transport.
- short incubation periods which yield quick results from infection until the onset of clinical symptoms.
- minimal contagiousness from one host to another to limit the accidental infection of the user nation's population.
- no widespread immunity either synthetically produced or naturally available to to the country that the user intends to attack.
- insusceptibility to common medical treatments (i.e., common antibiotics).
- suitability for economic production from readily available materials in quantities significant for military use.
- ease of transport and stability under wartime conditions of storage and delivery.
- ease of dissemination (i.e., as an aerosol cloud via the atmosphere).
- ability to survive environmental stresses while used on the battlefield -- in other words, agents must be able to survive long enough to infect.

- availability of protection for the attacking troops (i.e., vaccines, antibiotics, protective gear, and breathing devices).

a. Pathogens

Bacteria are single-cell organisms that are causative agents of anthrax, brucellosis, tularemia, plague, and many other diseases. The level of infectiousness and lethality varies with each. As an example, tularemia is extremely infectious. Inhalation of only ten organisms will cause disease after an incubation of three to five days resulting in fatal pneumonia for thirty to sixty percent of those infected within one month. On the other hand, brucellosis, which is also a bacterial disease, has a very high infectious rate in inflicting injury, but has a lethality rate of only two percent. However, results of brucellosis are still enough to incapacitate the host (which is a goal of BTW) by inflicting high fever and chills, headaches, appetite loss, depression, extraordinary fatigue, body aches, and sweating.

Perhaps the most common agent and that which has received the most attention publicly is anthrax. When exposed to certain atmospheric conditions, anthrax can mutate itself into extremely resilient spores that are much less susceptible to normal atmospheric conditions of temperature, pressure, and moisture content. One gram of anthrax spores contains more than 10^{11} particles; since the lethal dose by inhalation is estimated to be between 10^3 and 10^4 spores, a gram of anthrax theoretically contains some ten million lethal doses.

Rickettsiae, another subset of pathogens, are microorganisms resembling bacteria in form and structure. The major distinction is that rickettsiae can only reproduce inside the cells of animals. Rickettsiae diseases most likely to be used in BW are typhus, Rocky Mountain spotted fever, Tsutsugamuchi disease, and Q fever. They have a variety of natural hosts including mammals and arthropods like ticks, fleas, and lice. The most likely means of dissemination if used in war would be through the air as an aerosol.

Viruses are intracellular parasites approximately 100 times smaller than bacteria, and are capable of infecting humans, crops, and domestic animals. They are comprised of a strand of genetic material, either DNA or RNA, which is surrounded by a safeguarding coat that assists the transmission of the virus between the host's cells. Some highly lethal viruses include Ebola and Lassa which kill approximately seventy percent of the hosts infected. On the other side of the spectrum is Venezuelan Equine Encephalitis (VEE) virus which is extremely infectious but does not kill very often. Its mortality rate is estimated to be less than one percent.

Fungi are not normally capable of causing disease in healthy humans, but the fungus Aspergillus, which enters the host by inhalation, can cause serious injuries to those with weakened immune systems. While they are not usually considered a direct threat to humans, they are however extremely devastating to crops. Despite their low toxicity toward humans, an effective attack on the food supply of another country or that of deployed troops could result in hunger and severe sickness in both circumstances and severe economic problems in the former situation.

b. Toxins

Toxins, as a reminder, are poisonous substances produced by living organisms, or are manufactured copies of naturally existing poisonous substances. Some sources of toxins include bacteria, fungi, marine organisms, plants, insects, spiders and animals. Toxins may enter the system by one of three different methods -- injection, ingestion, or inhalation. Their potency derives from their high specificity for cellular targets. A majority of toxins attach themselves to key nerve membranes, thus affecting the transmission of nerve impulses and cause fatal respiratory paralysis.
In chemistry there exist two different classifications of toxins. Those are protein and nonprotein toxins.

Protein toxins like those associated with cholera, tetanus, diphtheria, and botulism are normally large proteins. Strains of the toxin *Staphylococcus aureus* (SEB),

which is a major bacterial pathogen, are capable of secreting protein toxins that can induce nausea, vomiting, and diarrhea for several days. SEB was originally developed as an agent of warfare by the US during the 1960s . A freeze-dried compound of SEB when disseminated through the air as an aerosol is capable of causing a chemical pneumonia reaction that is more potent than the gastrointestinal effects which are normally associated with toxins when ingested. It is capable of neutralizing troops within a matter of hours and requires a six to ten day recovery period for those inflicted.

The most poisonous substance known to mankind, botulinal toxin is a byproduct of the soil bacterium *Clostridium botulinum*. The fatal dosage for this toxin, either by inhalation or injection, is one nanogram per kilogram or seventy nanograms for a seventy kilogram adult. The other advantage that it has for the user is that it is a very fast acting agent and like many toxins can cause death between one to three days after exposure in eighty percent of the victims. UN inspections of Iraqi facilities yielded evidence that the microbiological research facility at Salman Pak was involved in developmental work to produce botulinum toxin as a warfare agent.

Had the Iraqis been able to continue their program and solve what has been the greatest challenge throughout the history of the BTW, the effective weaponization of agents, the scope of warfare in the Middle East could have changed dramatically, as could have the Gulf War. But more importantly, the result of the Gulf War could have been more devastating in that the number of lives lost by the coalition could have increased significantly.

Ricin, another protein toxin, has a lethal dosage of ten micrograms. It is a byproduct of castor beans and affects the victims by permanently blocking cellular protein synthesis. The problem concerning this toxin is that castor beans are cultivated to produce castor oil legitimately -- the dual use issue. It is the remaining paste that contains about five percent ricin which is then extracted by biochemical means. It has been used or developed in the past as a chemical-warfare agent. The British developed a

ricin weapon known as the "W bomb" during the Second World War which was never used. Additionally, in 1978 with the assistance of the KGB, the Bulgarian secret police assassinated an exiled dissident with a tiny metal ball filled with ricin.[14] Published reports also claim that Iran has imported 120 tons of castor beans to purify ricin in pharmaceutical plants.[15]

Nonprotein toxins are small organic molecules that are very often comprised of extremely complex chemical structures. These include tetrodotoxin which is produced by the puffer fish, saxitoxin produced by dinoflagellates (a class of marine algae), ciguatoxin and microcystin which are synthesized by microscopic algae, palytoxin which is a product of soft red Hawaiian coral, and batrachotoxin which is secreted by poisonous frogs primarily indigenous to western Colombia. Some distinguishing characteristics of nonprotein toxins are a very high toxicity, a lack of antidotes, heat resistance, resistance to other environmental factors, and speed at which they effect the host.

Saxitoxin, to cite one example, yields initial symptoms in as little as thirty seconds after exposure/ingestion resulting in difficulty breathing. The next phase of the infection is paralysis which sometimes occurs in as little as twelve minutes. There is no known treatment or therapy and the lethal dose in half of those exposed is about fifty micrograms. It is estimated to be approximately 1000 times more potent than the chemical nerve agent VX.[16]

Trichothecene mycotoxins are another family of nonprotein toxins. The family consists of approximately 100 poisonous compounds that are considered to be relatively easy to culture. They are a product of certain strains of the *Fusarium* mold that

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[14] Robert Harris and Jeremy Paxman, *A Higher Form of Killing: The Secret Story of Gas and Germ Warfare* (London: Chatto & Windus, 1982), 197-198; David Wise, "Was Oswald a Spy, and Other Cold War Mysteries," *New York Times Magazine* (December 6, 1992): 44.

[15] Douglas Waller, "Sneaking in the Scuds," *Newsweek* (June 22, 1992): 42.

[16] B.J. Benton and F.C.T. Chang, "Reversal of Saxitoxin-Induced Cardio-Respiratory Failure by Burro IgG Antibody and Oxygen Therapy," *Proceedings of the 1991 Medical Defense Bioscience Review* (Fort Detrick, Maryland: U.S. Army Medical Research Institure of Chemical Defense, August 7-8, 1991), 176.

grow on wheat, millet, and barley and their products. In its aerosol form a dose of thirty milligrams per seventy-five kilogram man of the trichothecene mycotoxin T-2 is lethal. An advantage that these toxins offer is their relative simple production and methods of stabilization.

C. THREAT

What is evident from the sections above is that if BTW agents are used, the results would be disastrous. The allure for nations pursuing this capability is the medical effect that agents have on those exposed to them. Pathogens and toxins are capable of inducing drastic illness and/or death as witnessed by the results of the plague in England and the rest of Europe in the middle ages and the more recent outbreak of the Ebola virus in Zaire (see Appendix I). By employing biological weapons, the user can gain an inexplicable advantage before mounting an offensive campaign by inflicting opposing troop formations with whichever agents the user has weaponized. The questions remaining to be answered are: is the proliferation of BTW agents of major concern, and if so, what factors contribute to increasing the threat; how easy is it for a country to obtain the technology to develop a biological weapons program; and how does the dual use issue further cloud the prevention of continuing proliferation?

III. FACTORS CONTRIBUTING TO BTW AGENT PROLIFERATION

A. INTRODUCTION

From the end of the Second World War until 1990 there existed a global balance of power. The two blocs of power, the United States and its allies and the Soviet Union and its allies, both possessed weapons of mass destruction. The collapse of the Soviet Union resulted in the collapse of old security sources and new security threats. Also with the breakdown of law and order in the Soviet successor states, there is concern that either the technical infrastructure or the flow of pathogens and toxins from these states to lesser developed countries will occur.

Accompanying the collapse of the Soviet Empire, there has been an increase in regional conflict. The Gulf War of 1991 illustrated that, even independent of the Arab-Israeli conflict, other Islamic countries are likely to build and use arms against one another. The steady flow of conventional arms into this region and the superiority of one nation over another in order of battle will likely stimulate the quest for equalizer weapons.

The collapse of old security sources and the increase in regional conflict has forced countries to reexamine their security. No longer guaranteed security by the superpowers, countries are looking to other means. For many states, the answer to the security gap appears to be the pursuit of weapons of mass destruction. Due to the strength of the Nuclear Nonproliferation Treaty, most states are prevented from developing nuclear weapons programs. As a result, many nations may pursue a cheaper alternative --biological weapons.

The purpose of this chapter is to highlight three reasons that contribute to proliferation of biological toxins, pathogens, and weapons. The first contributing factor examined is the inherent weakness of the 1972 Biological Weapons Convention in

preventing the spread of technology necessary to establish a BTW program. Specifically Articles One, Three, Four, Nine, and Ten are surveyed.

The second dimension is a result of the shortcomings of the convention. The relatively weak constraints of the convention create a situation in which the required materials and technology are easily available to countries with the money to invest in biological warfare programs. An eight step process to acquire a biological weapons program is examined to illustrate the relative ease of establishing such a program.

Despite this recognized process, uncovering programs is not a simple process. Like the production of nuclear weapons, there is a dual use dilemma that clouds the BTW issue. In short, many of the technologies that have civilian or legitimate defensive applications also have offensive BTW utility, and distinguishing between the two areas is tedious at best.

B. THE BIOLOGICAL WEAPONS CONVENTION

The first attempt at banning biological weapons came in 1925 when the Polish delegate to the League of Nations successfully garnered the support of other delegates to include limitations on biological warfare in the 17 June 1925 Geneva Protocol (see Appendix F and G).[17] The second attempt, which continues to be the primary means of limiting BW, is the 1972 Biological Weapons Convention. The primary issue that arises regarding the effectiveness of the 1972 Convention is whether the international community is successful in enforcing the provisions of the convention. To answer this question it is necessary to survey specific articles of the convention.

There are two parts to the 1972 Convention -- the preamble and the operative sections. Only the operative portion generates actual obligations on the part of signatory sovereignties.[18] The operative part is divided into the substantive and administrative provisions. The substantive provisions are Articles One through Ten, while the

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[17] Nicholas A. Sims, *The Diplomacy of Biological Disarmament* , 5.
[18] Ibid, 15.

administrative provisions are Articles Eleven through Fifteen. This thesis will concentrate only on the substantive provisions.

The wording of Article One prohibits each party to the convention from taking part in the development, production, stockpiling or acquisition to retain microbial or other biological pathogens or toxins that do not have a justifiably peaceful purpose. Additionally, it prohibits the development, production, stockpiling or acquisition of equipment required for hostile delivery of said biological agents.[19] While this is a major advantage compared to the 1925 attempt at simply banning biological weapons in war, the wording does not explicitly prohibit research or actual use of such agents. The ramification is that there are no security guarantees that even a signatory nation will not engage in one of these two areas. In fact there is speculation that Iraq, a signatory since 1972, may have used biological/toxin weapons during the war with Iran in the 1980s and against the Kurdish population in the northern part of Iraq.

Article Three is sometimes referred to as the "non-dissemination clause". It prohibits states from transferring, assisting, encouraging or inducing any international actor in acquiring or to acquire those BTW agents prohibited in Article One.[20] This Article unlike Article One is very specific in its goal of preventing proliferation for hostile intentions. The major problem in enforcing this article is the dual use issue of biological products as well as technology and is discussed in depth later in this chapter. Basically, a transfer of such technology could be deemed as a peaceful, scientific transfer and any evidence to the contrary could likely be hidden easily by noncompliant signatory nations.

Article Four's intention is to place the responsibility of initiating the necessary measures to prevent the development, production, stockpiling, acquisition, or retention of agents, toxins, weapons, or means of delivery outlined in Article One upon each

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[19] Ibid, 324.
[20] Ibid, 20-21.

signatory nation.[21] In effect, this creates a situation similar to trusting an unsupervised child in a candy store. By placing the responsibility of examining existing legislation or creating new legislation to effect internal control over the Convention and its prohibitions on each nation, the drafters created a situation in which a country that wishes to circumvent the Convention could easily do so. One needs only to examine the secret program that was uncovered by the United Nations inspection teams in Iraq following the Gulf War and the program that existed in the former Soviet Union for many years. Both were either signatories to the convention and/or the Geneva Protocol but still pursued offensive capabilities.

The next pertinent article, Article Nine, can be described as the "good faith clause". It is effectively a reproduction of the Nuclear Nonproliferation Treaty's Article VI and the Seabed Test Treaty's Article V. It provides that each signatory to the convention recognizes the objective of the agreement, and will in good faith satisfy the agreement regarding the prohibitions described specifically in Articles One and Three.[22] This should legally commit a signatory to the convention's prohibitions. However as observed in the case of Iraq, for some sovereign nations, the convention is only as good as the paper it is written on, and without an enforcement agency to support it, the convention cannot be effective. The direct result of this noncompliance is the endangerment of troops deployed abroad to regions where countries posses offensive BTW capabilities, and is one of the issues that prompted this thesis.

Article Ten contributes further to cloud the issue of technological transfer and the dual-use dilemma. It authorizes states to exchange equipment , materials and scientific and technological information for peaceful uses of biological pathogens and toxins. The article is specifically intended to further the prevention of disease through developments and applications of scientific discoveries in biology.[23] Effectively, this provides a cover

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[21] Ibid, 21.
[22] Ibid, 25.
[23] Ibid, 25-26.

for nations to hide behind regarding the illegal transfer of either BTW agents or technology contributing to the massive proliferation of agents. A later section illuminates how readily available the technology is to initiate a production program capable of harvesting militarily significant quantities of BTW agents.

Another inherent problem is the means by which the convention was drafted. Instead of identifying the biological threat as a unique threat, the convention was drawn primarily from the Nuclear Nonproliferation Treaty and the Seabed Test Treaty. This may have resulted in mirror-imaging the biological paradigm with that which the other treaties were established to answer, and resulted in the use of ready made phrases drawn from the aforementioned treaties.

The inherent weaknesses of the 1972 Biological Weapons Convention make the enforcement of its provisions nearly impossible. Furthermore, loopholes allow technology to be transferred in manners that appear to be for peaceful purposes. This easy availability of technology and equipment exacerbates the military dilemma already existing by making the means available to whoever can pay for it.

C. EASY AVAILABILITY

There are eight steps to the process of acquiring a BTW capability. The first is establishing one or more production facilities and determining personnel who can be considered trusted agents to carry out the necessary work in secret. The next seven steps may be grouped in one large category - research, development, and weaponization. The research phase involves studying the pathogens and toxins. In the initial production phase, small amounts of agents are produced either in flasks and/or small fermenter systems. The next step is a military assessment of the agent. This assessment involves determining its stability, infectivity, course of infection, dosage to achieve the desired results, and feasibility of employment as an aerosol. Following the military assessment stage the procurement or research, design, development and testing of munitions (or other delivery means) associated with the agents occurs. Almost simultaneously, one could

expect an increase in the production line of the agents. The next phase is stabilizing the agents and weaponizing them. Finally, the eighth step is the stockpiling of loaded or unloaded munitions and delivery methods. This last step may in some countries be combined with exercises involving troops to develop doctrine to protect them on the battlefield when biological agents are employed.[24] These steps are all summarized in Table 1.

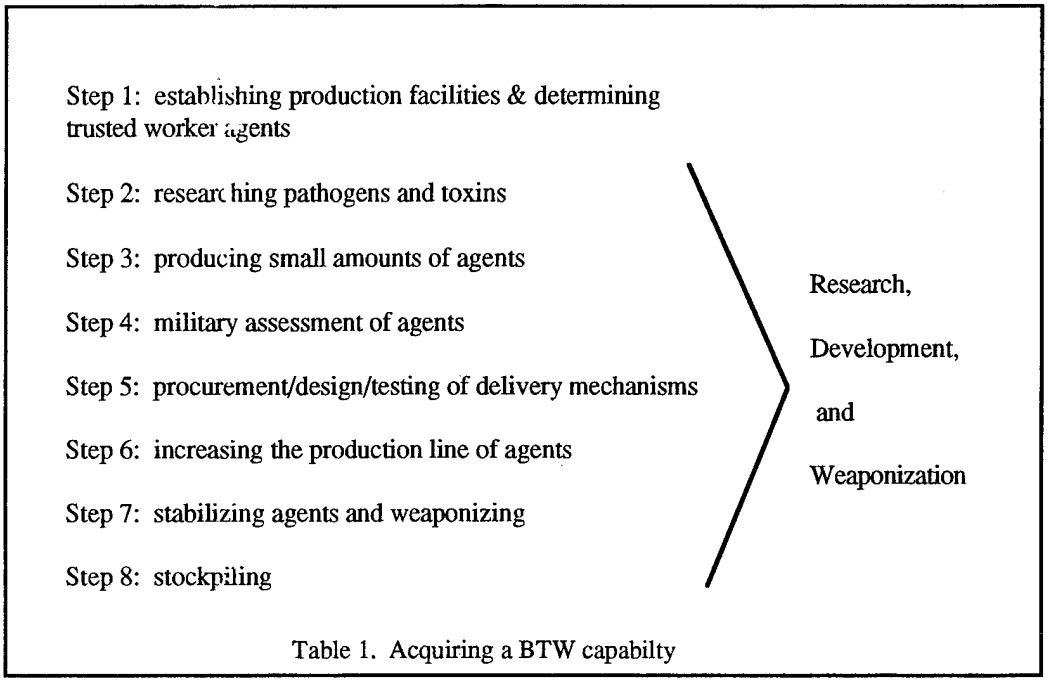

Table 1. Acquiring a BTW capabilty

The next sections will examine each of these steps in more detail.

1. Step One: Establishing Production Facilities

Only the establishment of the production facilities will be examined in this section as the selection of trusted agents is an internal manner and would likely involve strict background investigations on the part of the country developing a BTW program. Due to the hazardous working environment created by working with pathogenic microorganisms, distinct measures must be taken to protect plant workers and surrounding population bases in the event of catastrophes.

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[24] OTA, "Technical Aspects of Biological Weapon Proliferation," 83-84.

Microorganisms are usually produced in special biohazard vault-like areas which are kept at negative pressures. (lower than ambient pressure of 14.7 pounds per square inch). This allows any air to flow into the work area vice from it. If this measure were to fail, secondary measures such as highly efficient air filters and the incineration of exhaust would be some secondary measures in place.[25] Viral particles on the other hand, because of their smaller size when compared to bacteria, are more difficult to contain with the aforementioned secondary measures, so they require separate facilities.[26]

A developing nation would, however, likely use less efficient methods. One such method was uncovered during United Nations inspections of Iraq following the Gulf War. Standard procedure involved vaccinating laboratory tehcnicians against the infectious agents that they were working with, and the wearing of hoods, while ignoring masks and protective clothing.[27] This observation is significant because one can expect other lesser developed countries to employ similar techniques, thus making easier the destruction of the agents via the proposed options -- the fewer the safeguards, the more susceptible the agents will be to neutralization.

2. Research, Development, and Weaponization

a. Steps Two and Three

Most countries desiring to create a capability will likely choose agents that have been previously weaponized. Generally speaking those trying to attain BTW capabilities are lesser developed countries that lack the technological infrastructure and the monetary to develop the more exotic agents. Among those previously weaponized agents are anthrax (refer to Iraq's program), tularemia, and botulinum toxin. Rudimentary pathogenic organisms are easily available in many countries. These organisms can be cultured from the following: infected wild animals (plague in rodents), remains of or

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[25] Department of the Army, U.S. Army Medical Research and Development Command, *Final Programmatic Environmental Impact Statement: Biological Defense Research Program*, RCS DD-M (AR) 1327 (Fort Detrick, Maryland: USAMRDC, 1989), 7-15.
[26] OTA, *Technical Aspects of Biological Weapon Proliferation*, 92.
[27] Ibid.

living domestic animals (Q fever in sheep and anthrax in cattle), soil in infected areas (could contain traces of anthrax bacteria as well as other pathogens).[28]

It is also common practice for certain biological supply labs to ship microbial pathogens to scientists worldwide. One example is the American Type Culture Collection (ATCC), which is a nonprofit organization that ships about 130,000 weakened pathogen cultures to sixty nations.[29] While these weakened cultures are difficult, but not impossible, to be converted into useful warfare agents by lesser developed countries, they could be used to study the genetic structure of the microorganism or toxin, thus contributing useful information for future harvesting.[30]

Open scientific literature further creates difficulties by publishing methods for both culturing organisms and inducing spore formation. Further complicating the issue is that once a proliferating nation acquires agents, it can genetically alter them using many of the standard microbiological procedures described in open literature (selection techniques) to increase their viral effects and potency. One such technique would be to incubate pathogens with standard antibiotics which can result in drug resistant strains. These strains can then be mass-produced for weaponization by subculturing them.[31]

b. Steps Four and Five

As stated previously, the military assessment portion involves determining the stability, infectivity, course of infection, dosage to achieve the desired result, and the feasibility of weaponization. Due to the technological level of most of the countries, according to the criteria mentioned earlier (i.e., poor, lesser developed nations), it is not likely that a great deal of resources will be dedicated to new areas of research. Information is readily available for these countries to examine in open sources regarding

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[28] Ibid, 84.
[29] Eric Nadler and Robert Windrew, "Deadly Contagion," *The New Republic* , vol. 204, No. 5 (February 4, 1991): 18.
[30] OTA, *Technical Aspects of Biological Weapon Proliferation*, 84.
[31] Ibid.

this step, and it is very likely that they will chose agents that have been weaponized in the past by countries like the United States and former Soviet Union.

c. Step Six

In contrast to the production of chemical-warfare agents, BTW agents, perhaps with the exception of nonprotein toxins, do not require specialized precursor materials. They require only a small supply of a disease producing organism. Therefore it is estimated that any nation with a modestly sophisticated pharmaceutical or fermentation facility should be able to take a small supply of one of the more common agents and mass produce pure cultures.

The production of bacterial agents requires a biological warfare production facility containing fermenters and a procedure for sterilizing and disposing hazardous biological waste products on a grand scale. Fermentation is achieved either on a batch basis or in a continuous culture whereby the organisms are continuously removed while replacing them with an equal volume of new culture medium.[32] As an example, "a small vial of freeze-dried seed culture, grown in a fermenter in a nutrient medium kept at constant temperature can result in kilograms of product (e.g., anthrax bacteria) in as little as 96 hours.[33] Continuous culture increases productivity for each fermenter because turnaround time is significantly less than in a batch basis scheme. In fact, if proper care is taken, a continuous culture can exceed production on a batch basis by a factor of approximately ten due to exponential multiplication of the agent.[34] Despite this, batch culture has been the preferred method in the past because of the sophisticated technology required to maintain continuous cultures while not losing potency.

Within the past decade certain technological improvements were made that increased production of BTW agents. These advances have made it possible to

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[32] Ibid, 87.

[33] Testimony by Barry J. Erlick, Biological Weapons Analyst, Department of the Army, in U.S. Senate, Committee on Governmental Affairs, *Global Spread of Chemical and Biological Weapons: Assessing Challenges and Responses* , 101st Cong., 1st sess., February 9, 1989 (Washington, DC: U. S. Government Printing Office, 1990), 32.

[34] OTA, *Technical Aspects of Biological Weapon Proliferation*, 88.

reduce the size of fermenters, increase production, and ensure better quality products.[35] This further obscures attempts to control or gain information regarding a nation's attempts to gain BTW capabilities because the technology has greatly reduced the number of personnel required to operate the larger, less concealable equipment. Because of the advanced fermentation techniques it becomes increasingly more important to identify production facilities because the need to stockpile militarily significant quantities is reduced by the capability to produce a significant amount of BTW agents within a matter of days. Furthermore, a country may not even require special equipment. It is entirely possible that a nation could produce a small amount of toxin or pathogen without purchasing any of the high-technology equipment.[36]

Pathogenic viruses and rickettsiae can either be produced or grown in intact living tissue or isolated cells in a tissue culture. Although technically simpler, the latter cannot be used to cultivate all types of viruses.[37] Fermentation is considered to be the most effective method of producing bacterial toxins. Botulinal toxin, to use a previous example, is a byproduct of the culture *Clostridium botulinum* bacteria. If grown under the correct conditions (temperature controlled, acidity, and absence of oxygen), it takes approximately three days to grow a culture that could expel botulinal toxin into the culture medium. The next step would be to freeze-dry the toxin into a "solid cake" which could then be pulverized and disseminated through the air.[38]

Nonprotein toxins are today still more difficult to produce in militarily useful quantities. The major hurdles are the cost of the large amount of biological material from which they must be extracted as well as the extremely laborious

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35 Government of Australia, "Impact of Recent Advances in Science and Technology on the Biological Weapons Convention," *Background Document on New Scientific and Technological Developments Relevant to the Convention on the Prohibition of the development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction*, Third Review Conference of the BWC (Geneva, Switzerland), Document No. BWC/CONF. III/4, August 26, 1991, 3.
36 OTA, *Technical Aspects of Biological Weapon Proliferation*, 89.
37 Ibid.
38 Ibid, 90.

purification methods. To cite another previous example, 270 kilograms of toxin-containing clam siphons will yield fewer than five grams of saxitoxin.[39] If more synthetic means are attempted, such as chemical synthesis in a test tube using a multistep procedure, the overall yield decreases even more significantly (to only 0.1 percent), thus the likelihood of a militarily significant quantity of toxin produced via this method is small.[40]

d. ***Step Seven: Stabilization and Weaponization***

(1) Stabilization: One of the most important factors regarding the effectiveness of toxin and pathogen agents is their stability which determines how long they can remain "poisonous". The stability factor of these agents is what will be exploited by the military options considered in the next chapter. In the case of microbial pathogens, stability is achieved by slowing or stopping the metabolism of the specific pathogen. Anthrax, to serve as a spore-forming microorganism example, is able to survive for decades in a dormant spore form. Most toxins and nonspore forming microorganisms tend to be very susceptible to the effects of the environment and break down rapidly if not properly protected -- hopefully this can be exploited. Obviously, due to the previous fact, it is paramount that most agents be used relatively close in time to the production phase. However since this is not always a feasible option, it became necessary to develop the following stabilization and containment measures.[41]

Freeze drying is a procedure also known as *lyophilization.* It involves rapid freezing followed by dehydration in a vacuum. The procedure employs a lyophilizer, which is a common instrument in the pharmaceutical industry, that can convert a bacterial solution with a sugar stabilizer into a small cake-like dehydrated

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[39] Ibid, 88.
[40] Manuel L. Sanches et al., *Chemical Weapons Convention (CWC) Signatures Analysis* (Arlington, Virginia: System Planning Corp, Final Technical Report No. 1396, August 1991), 89.
[41] OTA, *Technical Aspects of Biological Weapon Proliferation*, 93.

material. The final step is the pulverization of the cake into the desired granular composition.

Lyophilization eliminates the need to transport these dangerous substances in their highly volatile liquid form. But most importantly for the possessor, the agent becomes more dangerous because it can be ingested directly by the victim via inhalation. This method is effective for both toxins and pathogens. The cold storage process allows the possessor state to store the pathogen or toxin for longer periods of time; they will still deteriorate over a period of time though. In fact, for those agents that are capable of being stored for one to five years, the virility of the agents decays from ten to one hundred times from the original strength.[42]

Chemical additives are another technique vital to increasing the stability of microbial aerosols. The stability of an agent is enhanced by combining the additive with a spray compound. One such additive, colloidal silica, is used to prevent freeze-dried, pulverized microbial agents and toxins from clumping.[43] Most research in this area involves the stabilization of biological pesticides for agricultural purposes. However, the applications apply scientifically to BTW agents in a similar manner. Specifically, new longer living strains of *Bacillus thuringiensis* , an insect-killing bacterium, have been developed using ultraviolet protectants and other additives The protectants and additives stabilize the BTW agents so their degeneration is retarded as they are dispensed.[44]

Microencapsulation is a procedure performed either by physical or chemical means, and is effective on both toxins and pathogens. The process mimics the formation of natural spores by using a thin coat of gelatin, sodium alginate, cellulose, or

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[42] Ibid, 93.

[43] Robert J. Goodlow and Frederick A. Leonard, "Viability and Infectivity of Microorganisms in Experimental Airborne Infection," *Bacteriological Reviews*, Vol. 25. 1961, 185.

[44] Government of the United Kingdom, "General Developments Relevant to the BWC," in *Background Document on New Scientific and Technological Developments Relevant to the Convention on teh Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction*, Third Review Conference of the BWC (Geneva, Switzerland), Document No. BWC/CONF. III/4, August 26, 1991, 25.

another protectant to cover droplets of pathogen and/or particles of toxin. A common example of the process is the creation of carbonless carbon paper where ink droplets are microencapsulated.[45]

In the process, the coating serves to protect the BTW agents from environmental stresses, mechanical dissemination stress, and allows cold-storage of pathogens for several months. When the encapsulated pathogen or toxin enters the lungs of the host exposed to the agent, the coating breaks down and releases the agent.[46] This process can also be combined with others. The microcapsules can be electrically charged to reduce the clumping that was mentioned while discussing the chemical additive stabilization process. Additionally, chemical additives, such as ultraviolet-light blocking pigments, can be combined with the microorganisms to reduce their sensitivity to sunlight.

(2) Weaponization: The weaponization process is a continuation of step four and also involves a thorough analysis of the military effectiveness of the agent including the determination of its stability, infective capability, course of infection, and dosage rates to achieve the desired results. Past experience suggests that such testing would either be carried out in a sealed aerosol laboratory chamber or at a remote test range.[47] On-site inspections performed by United Nations Inspectors in Iraq discovered an aerosol chamber usable for testing BTW agents.[48]

The two most common processes of weaponizing BTW agents are line-source tanks and point-source bomblets. A line-source tank is most often an oblong tank, similar to extra fuel stores carried by fighter aircraft, that is designed to distribute liquids or dry powders. The tanks can be attached to a variety of delivery mechanisms -- wheeled vehicles, aircraft (both fixed wing and helicopter), and ships. Dissemination is

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[45] OTA, *Technical Aspects of Biological Weapon Proliferation*, 94.
[46] Ibid.
[47] Ibid, 84.
[48] Kathleen C. Bailey, ed., *Director's Series on Proliferation* , UCRL-LR-114070-4 (Livermore, California: Lawrence Livermore National Laboratory, 23 May 1994), 12-13.

achieved through a variety of methods. One method is using compressed gasses to force the agents through nozzles usually located on the aft portion of the tank. Another method is simply releasing the agent into the jet stream of an aircraft traveling at 450 knots or more. The agent volume equivalent of these tanks ranges from 120-390 liters (50-200 gallons).[49]

Point-source bomblets are usually cylindrically or spherically shaped. The fuse can be impact or preset to a specific altitude (usually fifteen to sixty meters above ground level), and is armed after take-off. Each bomblet has an agent volume of approximately 50-200 cubic centimeters, and can be delivered to the target through a variety of delivery vehicles. The most obvious mechanisms are missiles and aircraft.

e. Step Eight

Upon successful completion of the required testing, it is estimated that a country will begin the stockpiling of agents and weapons -- a violation of the 1972 Biological Weapons Convention. Despite these recognized steps in developing a BTW program, identification of an offensive program is very challenging while the acquisition of one remains relatively simple. A major aid that contributes to the ability of a country to hide a program is dual use technology.

D. THE DUAL USE DILEMMA

An obstacle in justifying action against any potential proliferating nation is that much of the technology and applications of this technology have legitimate applications both in commercial fermentation and in the biotechnical industry. The global expansion of the biotechnical industry in conjunction with an increasing number of microbiologists trained in the West continues to contribute to a growing number of countries with the technical expertise to develop BTW agents. There now exist sophisticated laboratories

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[49] Ibid, 3-4.

intended for commercial use, but capable of having military applications by producing BTW agents, for a fraction of the cost of a weapons grade Uranium plant.[50]

It is estimated that greater than one hundred countries currently have the capability, but not necessarily the intent to develop, at the very least, rudimentary weapons of both microbial pathogens and toxin agents.[51] As these countries continue to develop their biological expertiese, the chances increase that some will be tempted to research the military potential of toxin and pathogen warfare. Out of those one hundred or so countries with the technology, it is currently estimated that between nine and eleven have active BTW programs. Among these countries are Syria, Iran, and North Korea. The dilemma remains, however, that there is very little concrete evidence to substantiate these estimates, and the number of nations with active BTW programs might actually be higher.[52]

The difficulty in substantiating these claims can be illustrated by discussing a previously mentioned toxin, botulinal toxin. Botulinal toxin, like many other toxins, has legitimate uses in the medical therapy and biomedical research areas, but its also a highly toxic BTW agent (see Appendix H for a list of some diseases treated with toxins). Specifically, in medicine botulinal toxin is used to treat abnormal muscle spasms, or dystonias, by paralyzing the spastic muscles selectively. Additionally it has been applied cosmetically to smooth wrinkles of the skin.[53] Ricin, to cite another example, has shown promise in cancer research as a possible anticancer therapy, but is also a highly virile protein toxin.[54]

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[50] Ibid, 85.
[51] Ibid.
[52] Article downloaded from Internet Newsgroup, "U.S. Targets New Biological Weapons Threats."
[53] Anna Evangeli, "Botulism Gives Faces New Lease of Life," *New Scientist*, vol. 137, No. 1859 (February 6, 1993): 18; and Tom Waters, "The Fine Art of Making Poison," *Discover*, vol. 13, No. 8 (August1992): 32.
[54] Lee H. Pai and Ira Pastan, "Immunotoxin Therapy for Cancer," *Journal of the American Medical Association* , vol. 269, No. 1 (January 6, 1993).

Another ambiguous area concerning dual use is that the same technology base is employed in the development of a defense against BTW attack as is used for an offensive program. In contrast to producing BTW agents for offensive purposes, a program that is defensive in nature is explicitly authorized by the 1972 Convention. Sometimes to test defensive measures against BTW agents it is necessary to subject the measures to the said agents. Production of BTW agents for the aforementioned purpose creates a situation in which the production and development of a viable offensive BTW capability can be masked.[55] With the ambiguity created by the dual use issue it is extremely difficult to prevent research in areas that could lead to the production of BTW agents, thus the need to develope other measures to neutralize security threats created by the presence of these agents increases.

E. IMPACT

The environment created by the inherent weaknesses of the 1972 Biological Weapons Convention, the relative ease with which a nation desiring to create a BTW capability is able to do so, and the ambiguity of dual use of these technologies creates a unique challenge. That challenge is how to militarily counter or neutralize, if deemed necessary by the United Nations or the United States Government, weapons stockpiles or production facilities if a signatory to the convention is determined to be in violation of its provisions and to be in possession of BTW weapons. One such possibility, enhanced energy weapons, is examined in the next chapter.

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55 Susan Wright and Stuart Ketcham, "The Problem of Interpreting the U.S. Biological Defense Research Program," Susan Wright, ed., *Preventing a Biological Arms Race* (Cambridge, Massachusetts: MIT Press, 1990), 167-196.

IV. EFFECT OF NEUTRON ENERGY ON BTW AGENTS

A. INTRODUCTION

The question that is investigated in this chapter is whether an enhanced energy weapon (neutron bomb) is a physically feasible option to neutralize biological toxins and pathogens. Prior to answering this question, it is necessary to understand the characteristics of nuclear detonations. Specifically the prompt radiation characteristics of a neutron bomb will be examined. After discussing these characteristics, the majority of this chapter will be devoted to the calculations required to neutralize biological agents.

B. INTRODUCTION TO ENHANCED RADIATION WEAPONS (ERW) OR THE NEUTRON BOMB

Enhanced radiation weapons have been the subject of debate for many years. The ER concept came into prominence in the mid-1970s. Faced with the prospect of overwhelming Soviet superiority on the ground in the event of an invasion of Western Europe, the NATO countries, led by the United States, sought a means of effective defense. A desire to minimize the loss of lives and property of the invaded countries, while repelling the enemy from their soil, made a neutron warhead on a short-range missile or in an artillery shell seem an appropriate battlefield weapon, especially for use against tanks. U.S. President Jimmy Carter argued that in the event of war more people would die from the use of the 7,000 tactical nuclear warheads then deployed in Europe than from the use of neutron warheads; because the ER weapons, which cause less collateral damage, could be used with less hesitation, they were seen as a more credible deterrent to Soviet aggression. Carter approved (in 1978) the production of ER components, but protests by peace groups and by European political leaders in the countries where the weapons would have been based persuaded him to call a halt to their assembly.[56]

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[56] Downloaded from New Groliers Encylopedia on the Internet, 15 August 1995.

As recent as the 1980s there were plans to incorporate these weapons in United States/NATO defenses with the Reagan administration announcing the production of ER warheads for the 8-inch (203mm) howitzer and the Lance tactical ballistic missile (IRBM).[57] The intent of producing these weapons was presumably to thwart the western advance of Soviet armored vehicles while minimizing collateral damage to both structures and civilian personnel. The latter is what makes ERW weapons viable physical options in neutralizing biological toxins and pathogens whether already weaponized or stored by one of the previously mentioned techniques from Chapter III.

Before calculating the effectiveness of enhanced radiation, it is necessary to understand the physical effects of a nuclear detonation. The basic effects of a nuclear explosion are depicted in Figure 1. The primary area of concern is the prompt or initial nuclear radiation. When discussing the initial or prompt effects of nuclear detonations, one considers emanations within milliseconds of the explosion taking place, and the effects of these emanations.

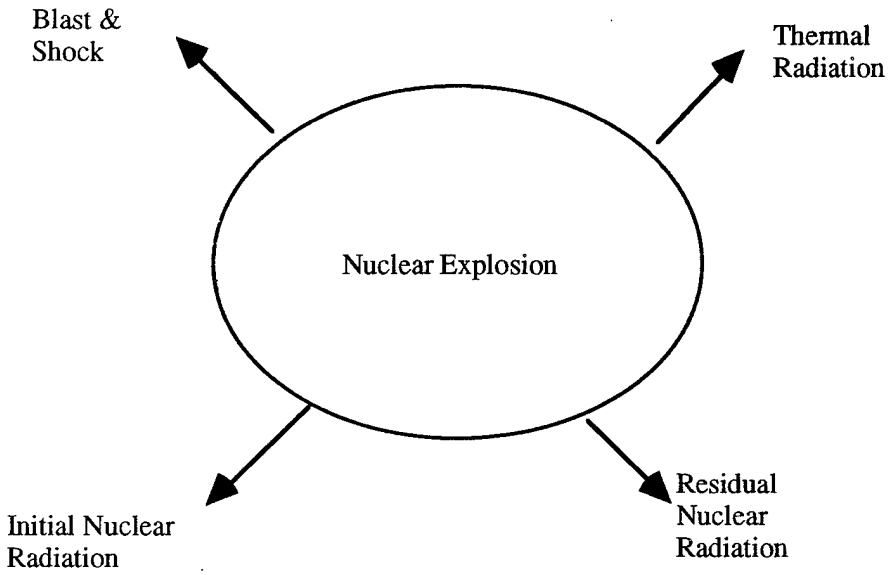

Figure 1. Effects of Nuclear Explosion

[57] Kent F. Wisner, "Military Aspects of Enhanced Radiation Weapons," Survival, XXIII, no. 6 (November/December 1981): 246.

1. Distribution of Energy From a Nuclear Detonation

The distribution of energy from a surface burst in the air, be it fission or fusion, is basically the same with thirty-five percent of the explosive energy contributing to thermal radiation, fifty percent contributing to air shock, and the final fifteen percent consisting of the various nuclear radiations. Of the nuclear radiation, it is estimated that approximately five percent of that is prompt radiation. About half of the five percent is neutron radiation, while the other half is gamma radiation. In comparison, an ERW weapon releases up to ten times the number of neutrons than a standard fission weapon .[58]

2. How Does an ERW Weapon Work?

Enhanced radiation weapons utilize fission triggers to generate fusion reactions. The fusion reaction fuses two heavy elements of hydrogen together and creates helium and neutrons.

$$D + T \text{ ---> } He^4 \quad + \quad n$$

$$(3 \text{ MeV}) \qquad (14 \text{ MeV})$$

In a fusion or thermonuclear (H-bomb) device, some of these neutrons would be contained and employed to create a boost in fission chain reactions. In an ERW, the number of neutrons emitted is six to ten times as great as in a conventional nuclear weapon of the same explosive yield, and those neutrons are released.[59] These fusion neutrons have an energy of 14 MeV compared to 1-2 MeV for ordinary fission neutrons. This serves to enhance the prompt radiation effects while requiring less total yield which in turn decreases the amount of collateral damage. ERWs were chosen for that particular reason -- to minimize the unnecessary loss of civilian lives in the event of a strike against a BTW production/stockpile facility. The following three sections will examine the feasibility of employing ERWs to neutralize BTW agents.

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[58] Wisner, "Military Aspects of Enhanced Radiation Weapons," 247.
[59] Ibid, 247.

C. NEUTRON FLUENCE REQUIRED FOR DOSAGE OF 750 RAD[60]

The first approach involves imparting a dosage of 750 Rad into the BTW agents. The radiant exposure chosen is based on figures for the survival of living cells exposed to ions or x-rays. At 750 Rad, based upon the criteria just stated, the agent survivability rate is less than one percent ($S/S_0 = 0.01$).[61] The calculation of the total fluence required is shown in Appendix A. The total fluence required (F_0) is determined by the dose required (D), the absorption factor of water (k), and the energy of the neutron (W).

$$F_0 = D/Wk$$

The absorption factor of water is used because the assumption is that the BTW agent in its liquid form will have similar properties as those of water.

The required total fluence is calculated as 3.75×10^{10} neutrons/cm^2. This means that for every one square centimeter area and thickness of one centimeter of BTW agent, 3.75×10^{10} neutrons is required to neutralize the agent in a thin target (target thickness less than twenty centimeters). For simplicity's sake, the fluence is rounded off to 4×10^{10} neutrons/cm^2. This amount of fluence is attainable. A one kiloton standard fission weapon employed in a surface burst could impart that amount of fluence on the target at a slant range of 1000 meters.

Similarly with the boost that occurs with an enhanced radiation weapon, the equivalent to the standard fission weapon is effectively a ten kiloton detonation which at the same slant range subjects the same size target to 4×10^{11} neutrons/cm^2. This is a factor of ten higher, and should decrease the agent survivability to almost zero. Given the initial feasibility of this approach, shielding will be taken into account in a later section to further examine the probability of successful neutralization of the agents.

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[60] The following approaches were developed in discussions with Professor K. E. Wohler, Physics Department, Naval Postgraduate School.

[61] James E. Turner, *Atoms, Radiation, and Radiation Protection* (New York, New York: A. Wheaton and Co. Ltd., 1986), 242.

D. NEUTRON FLUENCE REQUIRED TO HIT EACH DNA COIL OF A BTW AGENT

This approach involves targeting each DNA coil of the BTW agent. Two assumptions are made. The first assumption is that by disrupting the atomic lattice of the DNA molecule, it will be rendered ineffective. The second assumption is that BTW agents have similar dimensions to those of the E-coli bacteria which is used as the generic model in this case. The calculations for this approach can be reviewed in Appendix B.

The net goal of this method is to determine what fluence is required to target each DNA coil. This relies upon determining the volume of the agent's culture (V_L), the length of the storage medium (L), the cross section for hitting vital nucleus in the DNA ($Ó_N$), and the volume of the DNA (V_{DNA}). For this case, the resultant fluence is 5×10^{15} neutrons/cm^2.

Initially when observing the fluence it appears as though this might be an attainable amount based upon the previous approach of imparting 750 Rad on the target. However, when considering the shielding factor for one meter of concrete, one clearly sees that the fluence requirement is not a realistically attainable one. Accounting for shielding, the fluence requirement is increased by a factor of approximately 10^5. The calculation follows and is dependent upon the fluence (F) required to neutralize the BTW agents, the attenutation factor for concrete ($œ = 0.1$ cm^{-1} approximate), and the thickness of the concrete (Δx in cm). For this calculation, the thickness of the concrete shielding is assumed to be one meter thick.

$$F = F_0 e^{-œ \Delta x}$$

$$F_0 = (5 \times 10^{15}/(e^{-(.1)(100)})$$

$$F_0 = 1.1 \times 10^{20} \text{ neutrons/cm}^2$$

This is not an attainable amount as neutron fluences cannot be generated in this range.

E. HEATING OF CELL MATERIAL TO 100° C (PROTEIN DESTRUCTION)

The third approach involves raising the heat content of a BTW agent. This method applies only to protein toxins. In addition to the assumption previously mentioned, that all agents are in their liquid form, one other key assumption is made. The assumption is that by raising the heat content of the cell material through neutron bombardment to about one hundred Celsius degrees, the proteins contained in the agent will be degenerated. The calculations for this approach may be reviewed in Appendix C.

The approach is dependent upon the calculated dosage (D) required to increase the heat content to the desired level. The calculation relies upon determining ΔQ, which is the ratio between the initial heat content of the cell and the final heat content, the density of water, and the volume of one gram of water. The dosage required is 4×10^7 Rad. This dosage does not however correspond with the capabilities of a realistic ERW. Furthermore, considering the previous approaches and the effects of shielding, one can assume that accounting for shielding makes this approach even more unreasonable.

F. EXAMINATION OF PROBABILITY OF SUCCESS WHEN SUBJECTING BTW AGENTS TO 750 RAD

It appears that the most feasible method of employing an enhanced radiation weapon against either a biological production or stockpile facility is by employing the first approach described in this chapter. By attempting to induce a dosage of 750 Rad into BTW agents, a physically feasible amount of fluence was calculated to yield a survivability rate of less than one percent for the generic BTW agent. The calculation is however highly dependent upon the assumption that BTW agents will react in a similar manner when subjected to ions or x-rays as human cells.

As stated previously, one of the reasons that enhanced radiation weapons are suggested in this thesis is that neutron radiation is capable of traveling great distances and penetrating significant thicknesses of intervening material. Since this approach seems possible it is necessary to briefly consider the effects of shielding and what happens to the

fluence. The fluence on the target accounting for shielding is demonstrated below. This scenario could be representative of targeting a production facility in which the agents are either in the production stage or are temporarily being stored in their liquid form.

1. Scenario One

A ten kiloton equivalent ERW detonated at a range of one hundred meters from the target will generate approximately 4×10^{15} neutrons/cm^2. What effect does one meter of concrete shielding have on the fluence if the attenuation factor of concrete equals 0.1 cm^{-1}?[62]

$$F = F_0 e^{-\alpha \Delta x}$$

$$F = (4 \times 10^{15}) (e^{-(.1)(100)})$$

$$F = 1.82 \times 10^{11} \text{ neutrons/cm}^2$$

2. Result

As seen above a one meter shield of concrete will reduce the fluence a great deal (approximately a factor of 10^4). The requirement of 4×10^{10} neutrons/cm^2 is still able to be met by a significant margin. Accounting for the accuracy of modern cruise missiles, it may be possible to increase the unshielded fluence on the target by reducing the slant range at which the weapon detonates from the target, thus increasing the margin and ensuring a higher probability of success.

The neutron fluence of a ten kiloton ERW after one meter shielding is accounted for is seen above. Accounting for the required fluence to theoretically destroy the generic BTW agent, there is a surplus of about 1.4×10^{11} neutrons/cm^2. A very significant amount of fluence is still available and could account either for additional shielding or for other protective measures undertaken by the proliferating nation. It is highly likely that with this amount of fluence remaining that none of the stabilization methods would prevent the neutralization of the targeted BTW agents.

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[62] Glasstone and Dolan, ed., *The Effects of Nuclear Weapons*, 349.

If one were to consider the two weaponization processes, line-source tanks and point-source bomblets, is it likely that the surplus neutron fluence would be significant enough to penetrate both the one meter of concrete and the shell of the tank or bomblet? To answer this question, observe the following calculation. This scenario might be considered representative of the fluence requirement to target stockpile facilities.

3. Scenario Two

A ten kiloton equivalent ERW detonated at a range of one hundred meters from the target will generate approximately 4×10^{15} neutrons/cm^2. The target is located inside of a concrete building. The walls of the building are one meter thick and the BTW agents are stored in iron storage containers and/or bomblets of thickness one centimeter. Is the fluence requirement of 4×10^{10} neutrons/cm^2 for the destruction of BTW agents still able to be met? The attenuation factor for iron is 0.35.[63]

$$F = F_o \, e_{concrete}^{-\alpha \Delta x} \, e_{iron}^{-\alpha \Delta x}$$

$$F = (4 \times 10^{15}) \, (e^{-(.1)(100)}) \, (e^{-(.35)(1)})$$

$$F = 1.28 \times 10^{11} \text{ neutrons/cm}^2$$

4. Result

Based upon the requirements of this scenario, an acceptable level of neutron fluence still remains to destroy the BTW agents. However, certain factors can change the outcome. If the walls of the building storing the weapons are more than one meter thick or are reinforced with heavy elements, or there are multiple walls that the neutrons must penetrate through, or the bomblets and storage containers are greater than one centimeter in thickness, the transmission factor ($e^{\alpha \Delta x}$) will decrease. This decrease results in a lower fluence on the target, and quite possibly a fluence incapable of neutralizing the agents. Similarly, if the storage shelter, bomblets and/or storage containers are constructed of materials with smaller attenuation coefficients, or if the weapons are stored in the open, the transmission factor will experience a significant increase.

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[63] Ibid, 356. Attenuation factor is an average of the linear attenuation coefficients for gamma rays which have similar properties to neutrons.

G. FEASIBILITY

Based upon the previous calculations, it appears as if an enhanced radiation weapon is an effective means of neutralizing BTW agents. The key however lies in the method with which that weapon is used and the target scenario for each case. The following chapter will summarize the impact of biological toxin and pathogen proliferation and draw conclusions regarding the effectiveness of neutralizing agents using the three approaches highlighted in this chapter.

V. CONCLUSION

Perhaps no incident concerning the potential threat of biological warfare is more appropriate to examine than the Sverdlosk incident which occurred in April 1979 in the former Soviet Union. In the days following an explosion that ripped through Military Compound 19 outside of the city, residents of Sverdlosk began to develop high fevers and respiratory problems. Over the next few days there were forty fatalities reported. Autopsies revealed symptoms of toxemia. Doctors in Sverdlosk announced an outbreak of pulmonary anthrax (refer to Appendix I) which the Soviet Ministry of Health refuted.[64] Eventually antibiotics and vaccinations were provided to victims of the explosion. The final death toll counted approximately 200 people and could have been higher had the antibiotics and vaccinations not been administered. The Sverdlosk incident remained a mystery until 1992 when Russian President Boris Yeltsin admitted that the Sverdlosk explosion was an accident involving the release of anthrax spores by researchers attempting to create a biological weapon.

What this case highlights in addition to the potential dangers of BTW is the relative ease with which a country, whether a signatory to the Biological Weapons Convention of 1972 or not, is able to circumvent the provisions of the convention and hide an offensive BTW capability. This fact is reinforced by the existence of the biological weapons program that existed and possibly still does exist to some extent in Iraq despite United Nations inspection and destruction efforts. The easy availability of technology and supplies to create such a program, and the dual use technology issue, which allows proliferating nations to disguise offensive programs as legitimate programs, serves to further exacerbate the issue. What is expected for the near term future is that

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[64] Soviet officials blamed the outbreak on contaminated black market meat from a cow suffering from anthrax. Case fatalities however did not exhibit gastric or skin anthrax which would have resulted from ingesting or handling contaminated beef.

the number of countries that currently maintain suspected offensive biological programs is expected to grow significantly.

The breakup of the Soviet Union, which is generally a concern when discussing nuclear proliferation, also has the potential of contributing greatly to the proliferation of biological warfare. The independent states have the potential of exporting technology vital to establishing offensive programs. They might also choose to establish their own programs with the already existing infrastructure. What seems evident is that the risk of employment of biological weapons in future engagements is quickly becoming a reality.

Despite never having faced biological-toxin weapons on the battlefield, the danger of continued proliferation in this arena increases the odds that U.S. or multinational forces may be exposed to them in the future. If the knowledge regarding the Soviet program and, more recently, the Iraqi program has done nothing else, it has temporarily raised the consciousness of the world regarding the existence of the BTW threat. The risk is however that as during the cold war, the biological-toxin arena again will be overshadowed by the nuclear issue.

The degree with which toxins and pathogens can inflict sickness and mortality has not been witnessed in modern warfare, and the Sverdlosk case only provides a small example of BTW's potential. It is therefore a top priority that measures, whether offensive or defensive, be taken to ensure that a certain degree of protection can be afforded military personnel. One such method, the use of enhanced energy weapons, was examined in this thesis. Despite the current environment that does not favor the use of nuclear weapons, retired Joint Chiefs of Staff Chairman Colin Powell revealed in his autobiography that he was directed to engage in strike planning involving nuclear weapons to be targeted against Iraq during the Gulf War of 1991.[65]

While not purporting to suggest that nuclear weapons should be used, this thesis examines whether enhanced energy weapons can generate enough neutron radiation to

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65 CNN Headline News Report, 10 September 1995.

neutralize BTW agents. In one of the three cases, imparting 750 Rad into pathogens and toxins, it was determined feasible even when accounting for shielding and weaponization to a certain degree. The success of this approach is however highly dependent upon a few key factors. Among them are the attenuation coefficient of the shielding material and storage medium as well as the thickness of both. If either of these is changed the results can change dramatically in favor of or against the effectiveness of this approach.

It is very important to note that despite the failure of the other two approaches presented, they may still grant a certain degree of success. The condition stipulated for the second approach was that each DNA coil be targeted. This is a very stringent requirement. It is very possible that this need not be a requirement. By hitting a majority of the DNA coils, the possibility exists that the BTW agent will be degenerated significantly enough to be rendered ineffective.

The third approach, raising the heat content of protein toxins, is in theory a sound method. In fact, for countries who signed the convention the primary method of destroying stockpiles of biological pathogens and toxins was by incineration. The problem concerning this approach arises from the inability of enhanced radiation weapons to generate a realistic amount of radiation to raise the heat content of a generic protein by one hundred degrees centigrade. One possible alternative to this approach is, instead of employing an ERW, it might be possible to target agents with an alternative heat source. Ideally this could be a dual penetrating weapon with a heat source that is capable of heating the surrounding atmosphere to extreme temperatures for long periods of time piggybacked on the penetrator.

Clearly in researching this subject, the one impression that is implanted is that the proliferation of BTW creates a unique environment. This unique environment requires unique solutions to counter the problems and dangers that result from proliferation. Whether the solution is a nuclear one, conventional, or integrated special operations, it is

of the utmost importance that this issue continue to receive attention and is not pushed aside in favor of concentrating on the dangers posed by nuclear proliferation.

APPENDIX A. FLUENCE REQUIRED (F_0) FOR 99% KILL RATIO

1) Required Radiation Dose D= 750 Rad for $S/S_0 < 0.01$ [65]

(750 Rads = 7.5×10^4 erg/gram material)

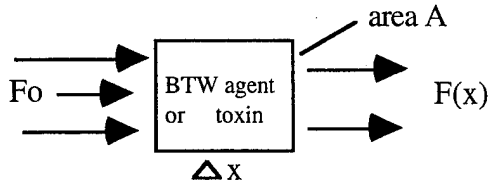

figure (1)

2-1) Fluence (neutrons/cm^2) after penetrating material of thickness Δx, density rho, and absorption coefficient k (cm^2/gr):

$$F(x) = F_0 e^{-k\ rho\ (\Delta x)}$$

For water-like material the attenuation (rho k) is $\approx 0.1\ cm^{-1}$

2-2) Absorbed number of neutrons:

$A [F_0 - F(\Delta x)] = AF_0 (1 - e^{-k\ rho\ (\Delta x)}) \approx A\ \Delta x\ F_0\ k\ rho$ [neutrons]

where the approximation is sufficient for $k\ rho\ \Delta x \ll 1$

(i.e. $\Delta x \ll 1/(k\ rho)$ for $(k\ rho) \approx 0.1\ cm^{-1}$, $\Delta x \ll 10$ cm)

2-3) Absorbed Energy:

$W = 14$ MeV $= 14 \times (1.6 \times 10^{-6}$ erg)

$= 2 \times 10^{-5}$ erg (energy absorbed per fast neutron)

2-4) Q = Total Absorbed Energy = $W\ F_0\ k\ rho\ A\ \Delta x$ [erg]

2-5) D = Dose = absorbed energy per gram material

$= Q/(rho\ A\ \Delta x)$

$= W\ F_0\ k$

2-6) For water-like material rho = 1 gr/cm^3 and k = 0.1 cm^2/gr

so that, $F_0 = D$ [erg/gr]/(W [erg] x k [cm^2/gr]) [neutrons/cm^2]

$F_0 = 7.5 \times 10^4 / [(2 \times 10^{-5}) \times 0.1] =$ **3.75×10^{10} neutrons/cm^2**

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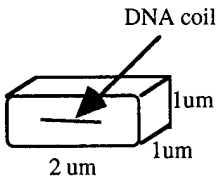
[65] James E. Turner, *Atoms, Radiation, and Radiation Protection* , 242.

APPENDIX B. NEUTRON FLUENCE REQUIRED TO HIT EACH DNA COIL

1) Dimension for E-coli:



1-1) $V_{bact} = (1 \times 10^{-6})^2 (2 \times 10^{-6}) = 2 \times 10^{-18}\ m^3 \approx 2 \times 10^{-12}\ cm^3$

1-2) $V_{dna} = (2 \times 10^{-3})\ (V_{bact}) = 4 \times 10^{-15}\ cm^3$

2) Cross section for hitting vital nucleus in the DNA:

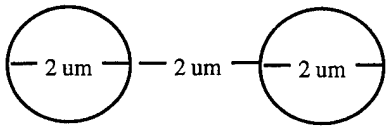
$Ó_n = 10^{-24}\ cm^2$

3) Bacterial Culture:

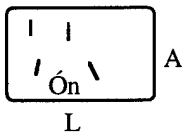
3-1) A single bacterium occupies approximate volume $(2 \times 10^{-4}\ cm)^3 = 8 \times 10^{-12}\ cm^3$

3-2) Allowing one bacterium length separation in the culture,

$V_L \approx (4 \times 10^{-4}\ cm)^3 = 6.4 \times 10^{-11}\ cm^3 \approx 6 \times 10^{-11}\ cm^3$



4) N_T = number of targets = $L\ A/V_L$



5-1) Mass of the DNA = $m_{dna} \approx 4 \times 10^{15}$ gr assuming density $\approx 1\ gr/cm^3$

5-2) Number of atoms in DNA = n_{dna}

$n_{dna} \approx m_{dna}$ [grams]/($m_{hydrogen}$ [grams] x average atomic weight)[66]

$\approx 4 \times 10^{15}/[(1.6 \times 10^{-24}) \times 12]$

$\approx 2 \times 10^{8}$ atoms

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[66] Atomic weight of carbon.

5-3) Probability of Kill = $P_k = N_T\, n_{dna}\, Ó_n/A$

$P_k = L\, A\, n_{dna}\, Ó_n /V_L A$

$P_k = L\, n_{dna}\, Ó_n /V_L$

5-4) Number of bacteria to be killed = N_k

$N_k = F\, A\, P_k$

$N_k = F\, A\, [L\, n_{dna}\, Ó_n /V_L]$

5-5) N_k -----> $N_T = L\, A/V_L$

5-6) $F = 1/n_{dna}\, Ó_n$

$F = 1/[(2 \times 10^8) \times 10^{-24}]$

$F = 5 \times 10^{15}$ neutrons/cm^2

APPENDIX C. HEATING OF CELL MATERIAL TO $T_o + 100^\circ$ C

(PROTEIN DESTRUCTION)

1) Heat Content of the Cell = $Q_o = C_v$ V (density) T_o

(C_v = Specific Heat of water like material T_o = Room Temperature = 291 °K)

(density ≈ 1 gram/m^3 (for water) C_u = 1 calorie/gram °K V = 10^{-12} cm^3)

$Q_o = 2.91 \times 10^{-10}$

2-1) $Q = C_u$ V (density) T

(T = 391 °K $Q_o = 2.91 \times 10^{-10}$)

2-2) $Q/Q_o = T/T_o$

(T = 391 °K T_o = 291 °K)

$Q/Q_o = 1.34 \approx 1.3$

3) $\Delta Q = 0.3\ Q_o$ (to be imparted by neutron absorption generated heat)

$\Delta Q = 0.3\ (2.91 \times 10^{-10})$

$\Delta Q = 8.73 \times 10^{-11}$ calories

$\Delta Q = (8.73 \times 10^{-11})\ (4 \times 10^7)$ erg

$\Delta Q = 3.49 \times 10^{-3}$ erg $\approx 3.5 \times 10^{-3}$ erg

4) $D = \Delta Q$/(density) V

$D = [3.5 \times 10^{-3}/(1 \times 10^{-12})]$ erg/gram

$D = 3.5 \times 10^9$ erg/gram

$D = 3.5 \times 10^7$ Rads[67]

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[67] Based upon conversion of 1 Rad ≈ 100 erg/gram.

APPENDIX D.

CONVENTION ON THE PROHIBITION OF THE DEVELOPMENT, PRODUCTION AND STOCKPILING OF BACTERIOLOGICAL (BIOLOGICAL) AND TOXIN WEAPONS AND ON THEIR DESTRUCTION (1972)

(BIOLOGICAL WEAPONS CONVENTION OF 1972)

ENTRY INTO FORCE: 26 March 1975

The States Parties to this Convention,

Determine to act with a view to achieving effective progress toward general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction, and convinced that the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and their elimination, through effective measures, will facilitate the achievement of general and complete disarmament under strict and effective control,

Recognizing the important significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925, and conscious also of the contribution which the said Protocol has already made and continues to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply strictly with them,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Geneva Protocol of June 17, 1925,

Desiring to contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere,

Desiring also to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Convinced of the importance and urgency of eliminating from the arsenals of States, through effective measures, such dangerous weapons of mass destruction as those using chemical or bacteriological (biological) agents,

Recognizing that an agreement on the prohibition of bacteriological (biological) and toxin weapons represents a first possible step towards the achievement of agreement on effective measures also for the prohibition of the development, production and stockpiling of chemical weapons, and determined to continue negotiations to that end,

Determined, for the sake of all mankind, to exclude completely the possibility of bacteriological (biological) agents and toxins being used as weapons,

Convinced that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimize this risk,

Have agreed as follows:

ARTICLE I

Each State Party to this Convention undertakes never in any circumstance to develop, produce, stockpile or otherwise acquire or retain:

(1) Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;

(2) Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

ARTICLE II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than nine months after the entry into force of the Convention, all agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, which are in its possession or under its jurisdiction or control. In implementing the provisions of this article all necessary safety precautions shall be observed to protect populations and the environment.

ARTICLE III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in article I of the Convention.

ARTICLE IV

Each State Party to this Convention shall, in accordance with its constitutional processes, takes any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition or retention of the agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

ARTICLE V

The States Parties to this Convention undertake to consult one another and to cooperate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, the Convention. Consultation and cooperation pursuant to this article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

ARTICLE VI

(1) Any State Party to this Convention which finds that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council.

(2) Each State Party to this Convention undertakes to cooperate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties to the Convention of the results of the investigation.

ARTICLE VII

Each State Party to this Convention undertakes to provide or support assistance, in accordance with the United Nations Charter, to any Party to the Convention which so requests, if the Security Council decides that such Party has been exposed to danger as a result of violation of the Convention.

ARTICLE VIII

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925.

ARTICLE IX

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

ARTICLE X

(1) The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall also cooperate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of bacteriology (biology) for prevention of disease, or for other peaceful purposes.

(2) This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) agents and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention.

ARTICLE XI

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party on the date of acceptance by it.

ARTICLE XII

Five years after the entry into force of this Convention, or earlier if it is requested by a majority of the Parties to the Convention by submitting a proposal to this effect to the Depositary Governments, a conference of States Parties to the Convention shall be held at Geneva, Switzerland, to review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention, including the provisions concerning negotiations on chemical weapons, are being realized. Such review shall take into account any new scientific and technological developments relevant to the Convention.

ARTICLE XIII

(1) This Convention shall be of unlimited duration.

(2) Each State Party to this Convention shall in exercising its natural sovereignty have the right to withdraw from the Convention if it decides that extraordinary events, related to the subject matter of the Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to the Convention and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

ARTICLE XIV

(1) This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph (3) of this Article may accede to it at any time.

(2) This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

(3) This Convention shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designated as Depositaries of the Convention.

(4) For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instrument of ratification or accession.

(5) The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of

accession and the date of the entry into force of this Convention, and of the receipt of other notices.

(6) This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XV

This Convention, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of the Convention shall be transmitted by the Depositary Governments of the signatory and acceding States.

APPENDIX E.

BIOLOGICAL WEAPONS CONVENTION OF 1972

LIST OF SIGNATORY STATES AND STATES PARTIES

AS OF FEBRUARY 2, 1994

COUNTRY	YEAR	SPECIAL CONDITIONS
Afghanistan	1975	
Albania	1992	
Argentina	1979	
Australia	1977	
Austria	1973	1
Bahamas	1986	
Bahrain	1988	1
Bangladesh	1985	
Barbados	1973	
Belarus	1975	
Belgium	1979	
Belize	1988	
Benin	1975	
Bhutan	1978	
Bolivia	1975	
Botswana	1992	
Brazil	1973	
Brunei Darussalam	1991	2
Bulgaria	1972	
Burkina Faso	1983	
Cambodia (Kampuchea)	1983	
Canada	1972	
Cape Verde	1977	
Chile	1980	
China, People's Republic of	1984	
Colombia	1983	
Congo	1978	
Costa Rica	1973	
Croatia	1991	
Cuba	1976	
Cyprus	1973	
Czech Republic	1973	
Denmark	1973	
Dominica	1978	2
Dominican Republic	1973	
Ecuador	1975	
Egypt		5
Equatorial Guinea	1989	
Estonia	1993	
Ethiopia	1975	
Fiji	1973	
Finland	1974	

COUNTRY	YEAR	SPECIAL CONDITIONS
France	1984	
Gambia, The	1991	
Germany	1983	
Ghana	1975	
Greece	1975	
Grenada	1986	
Guatemala	1973	
Guinea-Bissau	1976	
Haiti		5
Honduras	1979	
Hungary	1972	
Iceland	1973	
India	1974	
Indonesia	1992	
Iran	1973	
Iraq	1991	
Ireland	1972	
Italy	1975	
Jamaica	1975	
Japan	1982	
Jordan	1975	
Kenya	1978	
Korea, Democratic People's Republic of	1987	
Korea, Republic of	1987	
Kuwait	1972	
Laos	1973	
Lebanon	1975	
Lesotho	1977	
Libya	1982	
Liechtenstein	1991	
Luxembourg	1986	
Malaysia	1991	1
Mali	1993	
Malta	1975	
Mauritius	1972	
Mexico	1972	
Mongolia	1972	
Myanmar (Burma)		s
Nepal		s
Netherlands	1981	3
New Zealand	1972	
Nicaragua	1975	
Niger	1972	
Nigeria	1973	
Norway	1973	
Oman	1992	
Pakistan	1974	
Panama	1974	
Papua New Guinea	1980	
Paraguay	1976	
Peru	1985	

COUNTRY	YEAR	SPECIAL CONDITIONS
Philippines	1973	
Poland	1973	
Portugal	1975	
Qatar	1975	
Romania	1979	
Russia	1975	
Rwanda	1975	
St. Kitts and Nevis	1991	
St. Lucia	1986	
San Marino	1975	
Sao Tome and Principe	1979	
Saudia Arabia	1972	
Senegal	1975	
Seychelles	1979	
Sierra Leone	1976	
Singapore	1975	
Slovenia	1992	
Solomon Islands	1981	2
South Africa	1975	
Spain	1979	
Sri Lanka	1986	
Suriname	1993	
Swaziland	1991	
Sweden	1976	
Switzerland	1976	
Taiwan	1973	4
Thailand	1975	
Togo	1976	
Tonga	1976	
Tunisia	1973	
Turkey	1974	
Uganda	1991	
Ukraine	1975	
United Arab Emiratess		5
United Kingdom	1975	6
United States	1975	
Uruguay	1981	
Vanuatu	1990	
Venezuela	1978	
Vietnam	1980	
Yemen	1979	
Zaire	1977	
Zimbabwe	1990	

NOTES

s Signatory
1 With reservation
2 Based on general declarations concerning Treaty obligations applicable prior to independence.

NOTES (cont.)

3 Applicable to Netherlands Antilles and Aruba.

4 Instruments of Ratification/ Adherence to the Treaty have been deposited in the name of the Republic of China. Effective January 1, 1979, the United States recognized the government of the People's Republic of China.

5 The United Arab Emirates which did not ratify the Convention is listed as one country.

6 Extended to territories under the territorial sovereignty of the United Kingdom. Also extended to New Hebrides; continued application to Vanuatu not determined.

APPENDIX F.

PROTOCOL FOR THE PROHIBITION OF THE USE IN WAR OF ASPHYXIATING, POISONOUS OR OTHER GASES, AND OF BACTERIOLOGICAL METHODS OF WARFARE

(THE GENEVA PROTOCOL OF 1925)

ENTRY INTO FORCE: 8 February 1928

The undersigned Plenipotentiaries, in the name of their respective governments:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilised world; and

Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and

To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations;

Declare:

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other States to accede to the present Protocol. Such accession will be notified to the Government of the French Republic, and by the latter to all signatories and acceding Powers, and will take effect on the date of the notification by the Government of the French Republic.

The present Protocol, of which the English and French texts are both authentic, shall be ratified as soon as possible. It shall bear to-day's date.

The ratifications of the present Protocol shall be addressed to the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instruments of ratification of and accession to the present Protocol will remain deposited in the archives of the Government of the French Republic.

The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and, from that moment, each Power will be bound as regards other Powers which have already deposited their ratifications.

In witness whereof the Plenipotentiaries have signed the present Protocol.

Done at Geneva in a single copy, the seventeenth day of June, One Thousand Nine Hundred and Twenty-Five.

APPENDIX G. SIGNATORIES TO THE GENEVA PROTOCOL OF 1925

COUNTRY	YEAR
Afghanistan	1986
Albania	1989
Algeria	1992
Angola	1990
Antigua and Barbuda	1988
Argentina	1969
Australia	1930
Austria	1928
Bahrain	1988
Bangladesh	1989
Barbados	1976
Belarus	1970
Belgium	1928
Benin	1986
Bhutan	1979
Bolivia	1985
Brazil	1970
Bulgaria	1934
Burkina Faso	1971
Cambodia	1983
Cameroon	1989
Canada	1930
Cape Verde	1991
Central African Republic	1970
Chile	1935
China, People's Republic of	1952
Cote d'Ivoire	1970
Cuba	1966
Cyprus	1966
Czech Republic	1993
Denmark	1930
Dominican Republic	1970
Ecuador	1970
Egypt	1928
El Salvador	Signatory
Equatorial Guinea	1989
Estonia	1931
Ethiopia	1935
Fiji	1973
Finland	1929
France	1926
Gambia	1966
Germany	1929
Ghana	1967
Greece	1931
Grenada	1989
Guatemala	1983

COUNTRY	YEAR
Guinea-Bissau	1989
Holy See	1966
Hungary	1952
Iceland	1967
India	1930
Indonesia	1971
Iran	1929
Iraq	1931
Ireland	1930
Israel	1969
Italy	1928
Jamaica	1970
Japan	1970
Jordan	1977
Kenya	1970
Korea, Democratic People's Republic of	1989
Korea, Republic of	1989
Kuwait	1971
Laos	1989
Latvia	1931
Lebanon	1969
Lesotho	1972
Liberia	1927
Libya	1971
Liechtenstein	1991
Lithuania	1933
Luxembourg	1936
Madagascar	1967
Malawi	1970
Malaysia	1970
Maldives	1966
Malta	1964
Mauritius	1970
Mexico	1932
Monaco	1967
Mongolia	1968
Morocco	1970
Nepal	1969
Netherlands	1930
New Zealand	1930
Nicaragua	1990
Niger	1967
Nigeria	1968
Norway	1932
Pakistan	1960
Panama	1970
Papua New Guinea	1980
Paraguay	1933
Peru	1985
Philippines	1973

COUNTRY	YEAR
Poland	1929
Portugal	1930
Qatar	1976
Romania	1929
Russia	1928
Rwanda	1964
St. Kitts and Nevis	1989
St. Lucia	1988
Saudia Arabia	1971
Senegal	1977
Sierra Leone	1967
Slovakia	1993
Solomon Islands	1981
South Africa	1930
Spain	1929
Sri Lanka	1954
Sudan	1980
Swaziland	1991
Sweden	1930
Switzerland	1932
Syria	1968
Tanzania	1963
Thailand	1931
Togo	1971
Tonga	1971
Trinidad and Tobago	1962
Tunisia	1967
Turkey	1929
Uganda	1965
United Kingdom	1930
United States	1975
Uruguay	1977
Venezuela	1928
Viet Nam	1980
Yemen	1971
Yugoslavia	1929

APPENDIX H. LIST OF SOME DISEASES TREATED WITH TOXINS

Oncologic

Ovarian carcinoma

Small-cell lung carcinoma

Colon carcinoma

Malignant melanoma

Hodgkin's lymphoma

Non-Hodgkin's lymphoma (B & T-cell)

Primary CNS tumors

Bladder carcinoma

Acute and chronic lymphoblastic leukemia

Immunologic

Rheumatoid arthritis

Systemic lupus erythematosus

Transplant rejection

1) Solid organ
2) Bone marrow

Neurologic

Blepharospasm

Dystonias

Cerebral palsy

Hemifacial spasm

Torticollis

Writer's cramp

Stiff-man syndrome

Strabismus

Tremors

Infectious

AIDS

Endocrine

Diabetes mellitus

APPENDIX I. POSSIBLE ANTIPERSONNEL AGENTS

Disease	Agent	Mortality (percent untreated)	Incubation period (days)	Duration of effects (days)
Anthrax (pulmonary)	Bacillus anthracis	99	1-7	1-7
Bacillary dysentery	Shigella dysentriae	2-20	1-3	2-10
Botulism	Clostridium botulinum	60-90	1/2-3	7-35
Brucellosis	Brucella suis	2-3	14-28	30-120
Cholera	Vibrio comma	10-80	1-7	1-30
Coccidiodomycosis	Coccidioides immitis	unknown	7-14	14-90
Dengue fever	Dengue fever	1-15	5-8	3-35
Diphtheria	Corynebacterium diphtheriae	17-20	1-7	4-14
Eastern equine encephalitis	Eastern equine encephalitis	50-80	4-8	varies
Histoplasmosis	Histoplasma capasulatum	unknown		months/ years
Infectious hepatitis	Infectious hepatitis	0-1	15-40	21-60
Influenza	Influenza	0-1	1-2	7-21
Japanese B encephalitis	Japanese B encephalitis	15-60	7-21	21-90
Plague (pneumonic)	Pasteurella pestis	90-100	2-4	14
"Q" fever	Coxiella burnetti	0-4	14-26	6-10
Rocky Mountain	Rickettsia rickettsii	20-80	4-8	14-21
Scrub typhus	Rickettsia tsutsugamushi	1-60	10-12	10-14

APPENDIX I. POSSIBLE ANTIPERSONNEL AGENTS (cont.)

Disease	Agent	Mortality (percent untreated)	Incubation period (days)	Duration of effects (days)
Smallpox	Smallpox	5-40	10-16	6-16
Food poisoning	Staphylococcus aureus	0-5	2-3 hours	hours-days
Tuberculosis	Mycobacterium tuberculosis	7-10	21-56	months-years
Tularemia	Pasteurella tularensis	6-8	2-4	14-30

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