



Research Journal of
**Environmental
Toxicology**

ISSN 1819-3420



Academic
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www.academicjournals.com

Biological Weapons-agents for Life and Environmental Destruction

Onyenekenwa Cyprian Eneh

Institute for Development Studies, Enugu Campus, University of Nigeria, Nsukka, Nigeria

ABSTRACT

The world is harbouring stockpiles of biological weapon materials, with the potential for military use to destroy life and the environment that supports it. Science has potential for creating even more effective and horrific biological weapons. In response to the palpable public concern over the situation, this review updates and harmonises available resources on what biological weapons are, their function and characteristics, categories, production and delivery, as well as historical development of biological warfare; biological warfare institutions, programmes, projects and sites by country; the ethnic bomb and treaties. Stepping up awareness on the nature of the problem of biological weapon was recommended.

Key words: Biological weapons, warfare, ethnic bomb, toxin, toxic material

INTRODUCTION

Biological Weapons (BWs) are micro-organisms that infect and grow in the target host, producing a clinical disease that kills or incapacitates him. Such microbes may be natural, wild-type strains or may be the result of genetically engineered organisms. They include any organism (such as bacteria, viruses or fungi) or toxin found in nature that can be used to kill or injure people. Toxins are poisonous compounds produced by organisms (Dire *et al.*, 2011).

BWs are toxic materials produced from pathogenic organisms (usually microbes) or artificially manufactured toxic substances that are used to intentionally interfere with the biological processes of a host. They may be used to target living organisms, such as humans, animals or vegetation. They may also be used to contaminate non-living substances, such as air, water and soil (Bailey, 2011).

Biologically Derived Bioactive Substances (BDBS) are products of metabolism (usually but not always, of microbial origin) that kill or incapacitate the targeted host. These include biological toxins, as well as substances that interfere with normal behavior, such as hormones, neuropeptides and cytokines.

Artificially Designed Biological-mimicking Substances (ADBMS) are designed and manufactured substances that mimic the action of biologics. Nerve gases and their close relatives (pesticides) are made to act by binding specifically to receptors of targeted organisms of a particular cell-type (e.g., people with blond hair and blue eyes).

A Chemical Weapon (CW) is a device that uses chemicals produced in a chemical plant to inflict death or harm on human beings, e.g., the nerve gas sarin. It uses the toxic, rather than the explosive, properties of chemical substances to inflict physical or physiological effects on an enemy. It is man-made agent (in gas or liquid form) which attacks the body organs, leading to symptoms and/or death (Eneh, 2012). On the other hand, a Biological Chemical Weapon (BCW) is produced by cultivating an organism and extracting from it or its spent medium the toxic material, e.g., botulism toxin (botox).

However, with improving technology (Eneh, 2010a) these definitions will blur as we learn to chemically and genetically manipulate biological toxins so as to improve their efficacy and yield. For example, botox is unstable but if it could be chemically modified or genetically manipulated, such as mutating its gene or fusing it to another molecule, so as to stabilize it, while maintaining its lethality, it would be a much more effective weapon.

Biological warfare also known as germ warfare is an act of war that involves the use of bacteria, viruses, fungi or biological toxins to kill or incapacitate humans, animals or plants. Biological weapons (often termed "bio-weapons" or "bio-agents") are living organisms or replicating entities (viruses) that reproduce or replicate within their host victims. Entomological (insect) warfare is also considered a type of biological warfare (Wheelis *et al.*, 2006).

There is an overlap between biological warfare and chemical warfare, as the use of toxins produced by living organisms is considered under the provisions of both the Biological Weapons Convention (BWC) and the Chemical Weapons Convention (CWC). Toxins and psychochemical weapons are often referred to as mid-spectrum agents. Unlike bioweapons, they do not reproduce in their host and are typically characterized by shorter incubation periods (Gray, 2007).

Despite the untold harm occasioned on human life and environment (Eneh, 2011a-e; Eneh and Agbazue, 2011; Eneh and Agunwamba, 2011), resources on biological weapons are unharmonised and dated. The aim of this review paper was to address this gap.

THE FUNCTION AND CHARACTERISTICS OF BWs

BWs deliver toxins and microorganisms, such as viruses and bacteria, so as to deliberately inflict disease among people, animals and agriculture. Biological attacks can result in destruction of crops, temporarily discomforting a small community, killing large numbers of people or other outcomes (FAS, 2011).

To qualify as a biological weapon, the material must be:

- Highly infectious; requiring only a few organisms to cause the desired effect (e.g., smallpox) or highly effective; requiring a small quantity of material to cause the desired effect (e.g., botox)
- Efficiently dispersible, usually in the air; contagious or effective on contact
- Readily grown and produced in large quantities
- Stable in storage; preferably in a ready-to-deliver state
- Resistant enough to environmental conditions, so as to remain infectious or operational long enough to affect the majority of the target but not so persistent as to affect the occupying army
- Resistant to treatment; e.g. antibiotics, antibodies, pharmaceutical drugs, etc

BWs can be differentiated from other weapons of mass destruction (like nuclear and chemical weapons), as follows (FAS, 2011):

- The release of an agent is not immediately detectable; most of the systems that detect biological agents have a delay between acquiring the agent and identifying it
- The effects of an attack are not immediately detectable, since the infection to cause illness in people exposed to an agent soon after its release requires the incubation period of the micro-organism. Thus, one of the first indicators of a BW attack could be disease outbreaks

- The effect of BWs disease can continue after its release. If a transmissible agent, such as the smallpox or Ebola virus, infects a person at the site of its release, that person could travel and spread the agent to others. This would result in secondary infections at areas far from initial release and unprepared for the disease

Categories of BWs: Biological weapons are categorized by (1) their target system, (2) the nature of the biological weapon and (3) whether they are natural or genetic engineering products (increasing difficult to decide). However, "Natural BW" may be defined as one obtained from wild type strains or from selected mutants randomly induced spontaneously or by classical mutagenic procedures (e.g., exposure to UV or X-ray irradiation, chemical mutagenesis etc.). Therefore a "genetically engineered BW" may be defined as one constructed by the nonrandom modification of a gene (Appel, 2009).

Targeted hosts of biological weapons are humans, commercial animals, commercial plants and environmental systems. A list of proven and potential BWs has been supplied (Bailey, 2011).

The advantages of using BWs include:

- By reproducing in the host, a single microbial bioweapon can theoretically produce the desired detrimental outcome. A single smallpox virus or plague bacillus deposited in the right place in the host can grow and produce a disease. In practice, it usually takes more than a single organism to establish an infection
- Biological toxins are among the most toxic agents known
- Most bioweapon grade microbes are relatively easy and inexpensive to grow
- Large quantities of biological weapons can, in most cases, be produced in a short period (a few days to a few weeks)

The disadvantages of using BWs are:

- Difficulty of protecting the workers at all stages of production, transportation, loading of delivery systems and final delivery
- Difficulty in maintaining quality control and sufficient containment during growth and harvesting of agents
- **Effective delivery problems:** Most biological materials, including spores, are destroyed by exposure to ultraviolet (UV) light and drying. Agents released in the air may disperse in unexpected ways due to the vagaries of wind patterns. Dispersal patterns may be ineffectual. Rain may wash the agents out of the air before they reach their target
- **Poor storage survival:** Many biological weapons must be stored under special conditions to maintain efficacy. Further, they are often difficult to maintain in a weapons-delivery state (e.g., loaded and ready to be fired in a rocket). This means that the warheads must be taken from storage and attached to the rocket engine, during which time they are exposed to attack
- Once released, BW is difficult to control. One's own troops may be infected under the chaos of a war. In theory, it may be possible to protect one's own population by vaccination or the prophylactic administration of antibiotics against a BW one plans to use. But, the chance that the enemy will discover what one is doing is high

BW production: BW production can be divided into several, general stages (FAS, 2011):

- Choosing and acquiring a biological agent. For toxins, the production method must be acquired
- Growing and multiplying to sufficient quantities, noting that various selection and modification procedures can alter certain traits and characteristics of the microorganism
- Preparation of agent for delivery

Choosing an agent requires matching the desired results of an attack with an agent's characteristics. Those characteristics may include: how much of an agent can cause disease (pathogenicity); time between exposure and illness (incubation period); how debilitating the resulting disease is (virulence); its lethality and how readily the disease spreads to others (transmissibility). Countermeasures to the disease, such as treatment and vaccination, are also considered (FAS, 2011).

A pathogen can be obtained from two major sources: its natural environment and a microbiology laboratory or bank. When acquired from environmental sources, such as soil, water or infected animals, enough of the microorganism would have to be obtained to allow purification and testing of its characteristics. The difficulty in acquiring agents stored in laboratories and banks, such as the American type culture collection, depends on accessibility to the pathogens, security for the facility or security measures for the bank's ordering process. These agents are purified and of a known quality (FAS, 2011).

An alternative to acquiring agents is creating them. Toxins can be produced by adding the DNA coding for its production to bacteria. Also, advances in biotechnology have made it possible to synthesize certain viruses based on their genome or an organism's genetic instructions and using basic materials, such as DNA. Dr. Eckard Wimmer first demonstrated this by re-creating the poliovirus in 2001 which was followed by Dr. Craig Venter's synthesis of the bacteriophage phiX174 in 2003 and the 2005 re-creation of the 1918 flu virus by Dr. Jeffrey Taubenberger and Dr. Terrence Tumpey (FAS, 2011).

Growing micro-organisms requires providing optimal conditions. Living cells are required for the replication of viruses and some bacteria. Fungi, most bacteria and other micro-organisms can be grown in petri dishes or fermentation vats. Although, growing large amounts of an agent is possible, it can be limited by factors, such as equipment, space and safety concerns, that arise from handling dangerous germs without appropriate safeguards. However, large amounts of an agent may not be necessary if the target population is small (FAS, 2011).

Modification of micro-organisms through selection techniques and advances in genetic engineering could alter an agent so it will function in a particular manner. Agents modified for increased pathogenicity and a shorter incubation period could result in a more severe, fast-acting disease. Micro-organisms that do not infect potential targets under normal circumstances could be modified to do so. Other changes could make treatments, vaccines or the body's immune system useless (FAS, 2011).

Ideal characteristics of a biological agent to be used as a weapon against humans are high infectivity, high virulence, non-availability of vaccines and availability of an effective and efficient delivery system. Stability of the weaponized agent (ability of the agent to retain its infectivity and virulence after a prolonged period of storage) may also be desirable, particularly for military applications. The primary difficulty is not the production of the biological agent, as many biological agents used in weapons can often be manufactured relatively quickly, cheaply and easily. Rather,

it is the weaponization, storage and delivery in an effective vehicle to a vulnerable target that pose significant problems. For example, *Bacillus anthracis* is considered an effective agent for several reasons. First, it forms hardy spore, perfect for dispersal aerosols. Second, this organism is not considered transmissible from person to person and thus rarely if ever causes secondary infections. A pulmonary anthrax infection starts with ordinary influenza-like symptoms and progresses to a lethal haemorrhagic mediastinitis within 3-7 days, with a fatality rate that is 90% or higher in untreated patients. Finally, friendly personnel can be protected with suitable antibiotics (FAS, 2011).

A large-scale attack using anthrax would require the creation of aerosol particles of 1.5-5 micron. Too large and the particles would not reach the lower respiratory tract. Too small and the particles would be exhaled back out into the atmosphere. At this size, conductive powders tend to aggregate because of electrostatic charges, hindering dispersion. So the material must be treated to insulate and neutralize the charges. The weaponized agent must be resistant to degradation by rain and ultraviolet radiation from sunlight, while retaining the ability to efficiently infect the human lung. There are other technological difficulties as well, chiefly relating to storage of the weaponized agent (FAS, 2011).

Agents considered for weaponization or known to be weaponized, include bacteria, such as *Bacillus anthracis*, *Brucella* spp., *Burkholderia mallei*, *Burkholderia pseudomallei*, *Chlamydophila psittaci*, *Coxiella burnetii*, *Francisella tularensis*, some of the Rickettsiaceae (especially *Rickettsia prowazekii* and *Rickettsia rickettsii*), *Shigella* spp., *Vibrio cholerae* and *Yersinia pestis*. Many viral agents have been studied and/or weaponized, including some of the Bunyaviridae (especially Rift Valley fever virus), Ebola virus, many of the flaviviridae (especially Japanese encephalitis virus), Machupo virus, Marburg virus, Variola virus and Yellow fever virus. Fungal agents that have been studied include *Coccidioides* spp.

Toxins that can be used as weapons include ricin, staphylococcal enterotoxin B, botulinum toxin, saxitoxin and many mycotoxins. These toxins and the organisms that produce them are sometimes referred to as select agents. In the United States, their possession, use and transfer are regulated by the Center for Disease Control and Prevention's Select Agent Programme (FAS, 2011).

BW delivery: The way that a biological weapon is used depends on several factors, including the agent itself, its preparation, its durability in the environment and route of infection. Some agents can be disbursed as an aerosol which can be inhaled or can infect a susceptible spot on the skin, like a cut or wound. Attackers can also contaminate food or water with some agents (FAS, 2011).

Delivering an agent requires preparing it to remain effective when outside of its optimal growing conditions. Exposure to environmental stresses such as temperature, ultraviolet radiation and drying can reduce the agent's activity. Some pathogens, like the anthrax bacteria, can encapsulate itself into a hardy, long-lasting spore not easily susceptible to those conditions (FAS, 2011).

Other agents require further processing that minimizes damage to it and allows it to retain its activity when dispersed. These procedures include: direct freeze drying (lyophilization); formulation into a special stabilizing solid, liquid or gaseous solution; deep freezing and powdering and milling. Once stabilized, the pathogens are ready for dispersal (FAS, 2011).

Many of the above manipulations require techniques and procedures that have been published in scientific literature. In addition, the equipment required for most procedures is available since

legitimate researchers require them as well. This represents the "dual-use" problem, where the same knowledge and equipment used for beneficial work could also be used for more malevolent deeds (FAS, 2011).

There are a variety of microorganisms that can be used as biological weapons. Agents are commonly chosen because they are highly toxic, easily obtainable and inexpensive to produce, easily transferable from person to person, can be dispersed in aerosol form or have no known vaccine. While it is possible to develop biological weapons from microbes (typically bacteria), finding a means of distributing the substances is difficult. One possible way is through aerosols. This can be ineffective as the materials often get clogged when spraying. Biological agents distributed by air may also be destroyed by UV light or rain may wash them away. Another method of distribution may be to attach the toxins to a bomb so that they may be released upon explosion. The problem with this is that the microbes will most likely be destroyed by the explosion as well (Bailey, 2011).

The world is concerned about rockets being used to deliver BWs, especially with the recent confrontations with Iraq over its suspected missile capability. However, considering the crude nature of the SCUD missiles, they are probably more useful in a publicity capacity than as a credible military threat. The SCUD missiles have a range of between 400-500 miles. They lack a sophisticated guidance system, so their chances of hitting a target are limited. Further, the warhead must explode at the proper height to create an aerosol capable of dispersing effective quantities of BW agent over a wide area but it appears they lack this capacity as they apparently only explode on contact. The explosion would likely destroy much of the BW. Any BW material that survives the explosion would be dependant on low level air currents to disperse it. If the wind was not blowing, most of the Microbial Weapon (MW) material would settle near the site of impact, severely limiting its efficacy. Finally, it is clearly understood that if the Israelis are the target of such a SCUD attack, Iraq would suffer nuclear retaliation almost certainly designed to forever eliminate an Iraqi threat (Eneh, 2010b).

BWs lend themselves to the far greater danger as terrorist's weapons attack on a large population area. For example, a light plane equipped with crop spraying equipment could spray BWs downwind from the target of an evening without attracting much notice, particularly since the plume of the aerosol probably could not even be seen (i.e., just a student pilot practicing turns). Alternatively, a motor vehicle as small as a car could cruise the streets of a city while emitting a fine spray of BW-aerosol through a fake tailpipe or other small vent; after all car or truck trailing a plume "smoke or steam" is a common sight. The only equipment needed would be a hand-pumped sprayer like those used to spray insecticide on one's garden (Eneh, 2010c).

The Japanese terrorists used small exploding devices to disperse sarin in the subway. Although, their devices proved to be inefficient, their choice of a subway was malignantly inspired; a subway, particularly crowded with people at rush hour, insures the maximum exposure in the smallest area. Further, the subway's air exchange system would likely carry the BW agent rapidly out into the general environment, usually a crowded city. An individual carrying a large suitcase or backpack could disperse BW material while walking the streets. Even more fearsome is the possible use of better remote-control devices than those used in Japan. In this case the suspension of BW material could be placed in a container attached to an aerosol-producing pump (such as used to spray insecticide on trees) that could be turned on by remote control or with a timer. Such a unit could even be set to release material periodically over several days depending on the direction of the wind (Bailey, 2011).

Robotic delivery offers another likely possibility. Satellite-controlled robotic delivery is possible with today's technology. Such robots would be small enough to be camouflaged as pieces of wood

or rocks and could be programmed to bury themselves under ground until activated. They could even be solar-powered so they could function independently for long periods (Eneh, 2010a).

A version of a robotic delivery method involved brainwashed young women. These nubile young ladies had been brainwashed to return to their countries of origin with the biological-crop-destroying-agent and, on command, to go to an assigned location and release it unless the Evil scientist was paid a humongous amount of boodle (Eneh, 2010a).

HISTORICAL DEVELOPMENT OF BIOLOGICAL WARFARE

Biological warfare can be said to be in genes because most living organisms engage in biological warfare against their enemies or competitors. The use of biological toxins extracted from plants and animals on arrow heads or poison darts to kill game and human enemies certainly predates recorded history. This technology is still used by some South American Indians and Africans to slay game and to down the human enemy. Attacking an enemy with arrows previously dipped in faecal material or decaying meat led to debilitating infection of the opponent. Faecal matter usually harbours the gas gangrene bacterium, *Clostridium perfringens* and often the tetanus bacillus, *Clostridium tetani*. The poisoning of enemy water supply by dumping dead bodies or faecal material into wells and other confined water sources is an ancient war strategy still in use today (Maskiell and Mayor, 2001; Mayor *et al.*, 2009; Rozsa, 2009).

The wars of the middle ages witnessed catapulting the bodies of victims of highly contagious diseases, such as smallpox or bubonic plague, into enemy camps. Europeans traded the American Indians blankets on which men had died of smallpox or measles, two viral diseases that decimated these peoples. The Japanese used germ warfare in World War II. In the practice of "indirect biological warfare", starvation and disease were used to force the inhabitants to surrender. The Nazis forced the Jews in the concentration camps to live under conditions that led to the outbreak and spread of virulent diseases among a cold, starving and stressed population. Both sides in the first and second World War recognized that the indiscriminate bombing of large civilian populations would have the consequence of inducing disease outbreaks among the weakened and injured survivors. Embargoes were used to prevent food and medicine from reaching civilian populations.

In 1969, when the biological weapons programme was terminated by President Nixon in the United States of America (USA), two lethal biological agents, *Bacillus anthrax* and *Francisella tularensis* (tularemia) and three incapacitating biological agents, *Brucella suis* (brucellosis), *Coxiella burnetii* (Q fever) and Venezuelan Equine Encephalitis (VEE) virus had been standardized and weaponized. In addition, they had also weaponized one lethal toxin, botox and an incapacitating toxin, staphylococcal enterotoxin B. The USA had also stockpiled several other biological agents and toxins.

According to FAS (2011), BWs have a long history of use. In 1346, the invading Tartar army catapulted the bodies of plague victims into the Crimean Peninsula city of Kaffa and infected its citizens. In 1763, British troops under General Jeffrey Amherst gave the Delaware Indians blankets used by people with smallpox, possibly infecting the susceptible native population. Japan contaminated food and released plague-infected ticks during their conflict with China during World War II. The 2001 anthrax letter attacks in the United States infected 22 people and killed five.

Dire *et al.* (2011) submitted that the use of biological agents is not a new concept and that history is filled with examples of their use. Ancient time usages include:

- Scythian archers infected their arrows by dipping them in decomposing bodies or in blood mixed with manure as far back as 400 BC. Persian, Greek and Roman literature from 300 BC quotes

examples of dead animals used to contaminate wells and other sources of water. In the Battle of Eurymedon in 190 BC, Hannibal won a naval victory over King Eumenes II of Pergamon by firing earthen vessels full of venomous snakes into the enemy ships

- During the battle of Tortona in the 12th century AD, Barbarossa used the bodies of dead and decomposing soldiers to poison wells. During the siege of Kaffa in the 14th century AD, the attacking Tatar forces hurled plague-infected corpses into the city in an attempt to cause an epidemic within enemy forces. This was repeated in 1710, when the Russians besieging Swedish forces at Reval in Estonia catapulted bodies of people who had died from plague
- During the French and Indian War in the 18th century AD, British forces under the direction of Sir Jeffrey Amherst gave blankets that had been used by smallpox victims to the Native Americans in a plan to spread the disease
- Allegations were made during the American Civil War by both sides but especially against the Confederate Army, of the attempted use of smallpox to cause disease among enemy forces

Dire *et al.* (2011) also stated that biological warfare in modern times reached sophistication during the 1900s, including:

- During World War I, the German Army developed anthrax, glanders, cholera and a wheat fungus specifically for use as biological weapons. They allegedly spread plague in St. Petersburg, Russia, infected mules with glanders in Mesopotamia and attempted to do the same with the horses of the French Cavalry
- The Geneva Protocol of 1925 was signed by 108 nations. This was the first multilateral agreement that extended prohibition of chemical agents to biological agents. Unfortunately, no method for verification of compliance was addressed
- During World War II, Japanese forces operated a secret biological warfare research facility (Unit 731) in Manchuria that carried out human experiments on prisoners. They exposed more than 3000 victims to plague, anthrax, syphilis and other agents in an attempt to develop and observe the disease. Some victims were executed or died from their infections. Autopsies were also performed for greater understanding of the effects on the human body
- In 1942, the United States formed the War Research Service. Anthrax and botulinum toxin initially were investigated for use as weapons. Sufficient quantities of botulinum toxin and anthrax were stockpiled by June 1944 to allow unlimited retaliation if the German forces first used biological agents. The British also tested anthrax bombs on Gruinard Island off the northwest coast of Scotland in 1942 and 1943 and then prepared and stockpiled anthrax-laced cattle cakes for the same reason
- The United States continued research on various offensive biological weapons during the 1950s and 1960s. From 1951-1954, harmless organisms were released off both coasts of the United States to demonstrate the vulnerability of American cities to biological attacks. This weakness was tested again in 1966 when a test substance was released in the New York City subway system
- During the Vietnam War, Viet Cong guerrillas used needle-sharp punji sticks dipped in faeces to cause severe infections after an enemy soldier had been stabbed
- In 1979, an accidental release of anthrax from a weapons facility in Sverdlovsk, USSR, killed at least 66 people. The Russian government claimed these deaths were due to infected meat and maintained this position until 1992, when Russian President Boris Yeltsin finally admitted to the accident

Dire *et al.* (2011) also reported on bioterrorism and biowarfare of today. The act of bioterrorism can range from a simple hoax to the actual use of biological weapons, also referred to as agents. A number of nations have or are seeking to acquire biological warfare agents and there are concerned that terrorist groups or individuals may acquire the technologies and expertise to use these destructive agents. Biological agents may be used for an isolated assassination, as well as to cause incapacitation or death to thousands. If the environment is contaminated, a long-term threat to the population could be created.

A number of countries have continued offensive biological weapons research and use. Additionally, since the 1980s, terrorist organizations have become users of biological agents. Usually, these cases amount only to hoaxes. However, the following exceptions have been noted (Dire *et al.*, 2011):

- In 1985, Iraq began an offensive biological weapons programme producing anthrax, botulinum toxin and aflatoxin. During Operation Desert Storm, the coalition of allied forces faced the threat of chemical and biological agents. Following the Persian Gulf War, Iraq disclosed that it had bombs, Scud missiles, 122 mm rockets and artillery shells armed with botulinum toxin, anthrax and aflatoxin. They also had spray tanks fitted to aircraft that could distribute agents over a specific target
- In September and October of 1984, 751 people were intentionally infected with Salmonella, an agent that causes food poisoning, when followers of the Bhagwan Shree Rajneesh contaminated restaurant salad bars in Oregon
- In 1994, a Japanese sect of the Aum Shinrikyo cult attempted an aerosolized (sprayed into the air) release of anthrax from the tops of buildings in Tokyo
- In 1995, 2 members of a Minnesota militia group were convicted of possession of ricin which they had produced themselves for use in retaliation against local government officials
- In 1996, an Ohio man attempted to obtain bubonic plague cultures through the mail
- In 2001, anthrax was delivered by mail to US media and government offices. There were 4 deaths
- In December 2002, 6 terrorist suspects were arrested in Manchester, England; their apartment was serving as a "ricin laboratory". Among them was a 27 year old chemist who was producing the toxin. Later, on January 5, 2003, British police raided 2 residences around London and found traces of ricin, which led to an investigation of a possible Chechen separatist plan to attack the Russian embassy with the toxin; several arrests were made
- On February 3, 2004, 3 US Senate office buildings were closed after the toxin, ricin, was found in mailroom that serves Senate Majority Leader Bill Frist's office

Dire *et al.* (2011) opined that the threat that biological agents will be used on both military forces and civilian populations is now more likely than it was at any other point in history.

Wheelis *et al.* (2006) reported that BWs may be employed in various ways to gain a strategic or tactical advantage over an adversary, either by threat or by actual deployment. Like some of the chemical weapons, biological weapons may also be useful as area denial weapons. These agents may be lethal or non-lethal and may be targeted against a single individual, a group of people or even an entire population. They may be developed, acquired, stockpiled or deployed by nation states or by non-national groups. In the latter case or if a nation-state uses it clandestinely, it may also be considered bioterrorism.

Mayor (2003) noted that offensive biological warfare, including mass production, stockpiling and use of biological weapons, was outlawed by the 1972 Biological Weapons Convention (BWC). The rationale behind this treaty which has been ratified or acceded to by 163 countries as of 2009, is to prevent a biological attack which could conceivably result in large numbers of civilian fatalities and cause severe disruption to economic and societal infrastructure. Many countries, including signatories of the BWC, currently pursue research into the defense or protection against BW which is not prohibited by the BWC.

A nation or group that can pose a credible threat of mass casualty has the ability to alter the terms on which other nations or groups interact with it. Biological weapons allow for the potential to create a level of destruction and loss of life far in excess of nuclear, chemical or conventional weapons, relative to their mass and cost of development and storage. Therefore, biological agents may be useful as strategic deterrents in addition to their utility as offensive weapons on the battlefield (Mayor, 2003).

As a tactical weapon for military use, a significant problem with a BW attack is that it would take days to be effective and therefore might not immediately stop an opposing force. Some biological agents (especially smallpox, plague and tularemia) have the capability of person-to-person transmission via aerosolized respiratory droplets. This feature can be undesirable, as the agent(s) may be transmitted by this mechanism to unintended populations, including neutral or even friendly forces. While containment of BW transmission is less of a concern for certain criminal or terrorist organizations, it remains a significant concern for the military and civilian populations of virtually all nations (Mayor, 2003).

Biological warfare has been practiced repeatedly throughout history. Before the 20th century, the use of biological agents took three major forms (Mayor, 2003):

- Deliberate poisoning of food and water with infectious material
- Use of microorganisms, toxins or animals, living or dead, in a weapon system
- Use of biologically inoculated fabrics

Mayor (2003) also reported that the earliest documented incident of the intention to use biological weapons is recorded in Hittite texts of 1500-1200 B.C., in which victims of plague were driven into enemy lands. Although, the Assyrians knew of ergot, a parasitic fungus of rye which produces ergotism when ingested, there is no evidence that they poisoned enemy wells with the fungus, as has been claimed.

According to Homer's epic poems about the legendary Trojan War, the *Iliad* and the *Odyssey*, spears and arrows were tipped with poison. During the First Sacred War in Greece, in about 590 BC, Athens and the Amphictionic League poisoned the water supply of the besieged town of Kirrha (near Delphi) with the toxic plant hellebore. The Roman commander Manius Aquillus poisoned the wells of besieged enemy cities in about 130 BC (Mayor, 2003).

During the 4th century BC, Scythian archers tipped their arrow tips with snake venom, human blood and animal faeces to cause wounds to become infected. There are numerous other instances of the use of plant toxins, venoms and other poisonous substances to create biological weapons in antiquity (Mayor, 2003).

In 184 B.C., Hannibal of Carthage had clay pots filled with venomous snakes and instructed his soldiers to throw the pots onto the decks of Pergamene ships. In about AD 198, the Parthian city of Hatra (near Mosul, Iraq) repulsed the Roman army led by Septimius Severus by hurling clay pots filled with live scorpions at them.

Hobbes (2003), Wheelis (2002) and Lederberg (2001) and eMedicineHealth (online) reported on biological warfare in the Middle ages. Through the most mobile army ever seen the Mongol Empire established commercial and political connections between the Eastern and Western areas of the world. Being the most rapidly moving travelers who had ever moved between the steppes of East Asia (where bubonic plague was and remains endemic among small rodents), the armies managed to keep the chain of infection without a break until they reached and infected peoples and rodents who had never encountered it. The ensuing Black Death may have killed almost half of the population of Europe in the next decades, changing the course of Asian and European history (Wheelis, 2002).

Victims of the bubonic plague were used for biological attacks, often by flinging fomites, such as infected corpses and excrement over castle walls using catapults. In 1346, during the siege of Kafa (now Feodosia Ukraine) the attacking Tartar Forces which were subjugated by the Mongol empire under Genghis Khan, used the bodies of Mongol warriors of the Golden Horde who had died of plague, as weapons. An outbreak of plague followed and the defending forces retreated, followed by the conquest of the city by the Mongol army. It has been speculated that this operation may have been responsible for the advent of the Black Death in Europe. At the time, the attackers thought that the stench was enough to kill them, though it was the disease that was deadly (Lederberg, 2001).

At the siege of Thun-l'Eveque in 1340, during the Hundred Years' War, the attackers catapulted decomposing animals into the besieged area (Wheelis, 2002). In 1422, during the siege of Karlstejn Castle in Bohemia, Hussite attackers used catapults to throw dead (but not plague-infected) bodies and 2000 carriage-loads of dung over the walls (Hobbes, 2003). The last known incident of using plague corpses for biological warfare occurred in 1710, when Russian forces attacked the Swedes by flinging plague-infected corpses over the city walls of Reval (Tallinn) (EMedicineHealth, online). However, during the 1785 siege of La Calle, Tunisian forces flung diseased clothing into the city. English longbowmen usually did not draw their arrows from a quiver. They rather stuck their arrows into the ground in front of them. This made nocking the arrows to the bow faster and the dirt and soil was likely to stick the arrowheads and thus, making the wounds that it made much more likely to infect (Hobbes, 2003).

Foley (2001) reported on biological warfare in the 18th century North America. The Native American population was devastated after contact with the Old World due to the introduction of many different fatal diseases. There are two documented cases of alleged and attempted germ warfare. The first, during a parley at Fort Pitt on June 24, 1763, Ecuyer gave representatives of the besieging Delawares two blankets and a handkerchief that had been exposed to smallpox, hoping to spread the disease to the Natives in order to end the siege. William Trent, the militia commander, left records that clearly indicated that the purpose of giving the blankets was "to Convey the Smallpox to the Indians" (Foley, 2001).

British commander Lord Jeffrey Amherst and Swiss-British officer Colonel Henry Bouquet certainly discussed this, in the course of Pontiac's Rebellion; there still exists correspondence referencing the idea of giving smallpox-infected blankets to enemy Indians. Historian Francis Parkman verifies four letters from June 29, July 13, 16 and 26th, 1763. Excerpts: Commander Lord Jeffrey Amherst writes July 16, 1763, "P.S. You will Do well to try to inoculate the Indians by means of blankets, as well as to try every other method that can serve to Extirpate this Execrable Race. I should be very glad your Scheme for Hunting them Down by Dogs could take Effect,"

Colonel Henry Bouquet replies July 26, 1763, "I received yesterday your excellency's letters of 16th with their Inclosures. The signal for Indian Messengers and all your directions will be observed" (Foley, 2001).

While the intent of carrying out biological warfare is clear, there is debate among historians as to whether this actually took place despite Bouquet's affirmative reply to Amherst and the continuing correspondence on the point. Smallpox is highly infectious and does not require contaminated blankets to spread uncontrollably and together with measles, influenza, chickenpox and so on. had been doing so since the arrival of Europeans and their animals. Historians have been unable to establish whether or not the Amherst plan was implemented, particularly in light of the fact that smallpox was already present in the region and that scientific knowledge of disease at that time had yet to develop an understanding of infection vectors, nor in the case of smallpox a full acknowledgment of the protective effect of a cowpox infection.

Regardless of whether the plan was carried out, trade and combat provided ample opportunity for transmission of the disease. The diseases that struck indigenous Americans can be traced to Eurasia where people had long lived with them and developed some immunological ability to survive their presence. Without similarly long ancestral exposure, indigenous Americans were immunologically naive and extremely vulnerable.

Finzsch (2008), Mear (2008), Warren (2007) and Lambert (2000) reported on biological warfare in the 18th century New South Wales. Australian aborigines (Kooris) have always maintained that the British deliberately spread smallpox in 1789 but this fact has only been apparent to historians from the 1980s when it was suggested; "there are some possibilities that disease could have been used deliberately as an exterminating agent". In 1997, it was claimed there "remains considerable circumstantial evidence to suggest that officers other than Philip or perhaps convicts or soldiers ... deliberately spread smallpox among aborigines" and in 2000. It was argued that "strong circumstantial evidence suggests the smallpox epidemic which ravaged Aborigines in 1789, may have resulted from deliberate infection" (Lambert, 2000; Warren, 2007).

These claims were controversial as it was argued that any smallpox virus brought to New South Wales would have been sterilised during the voyage of the First Fleet from England and incapable of biological warfare. However, in 2007, it was demonstrated conclusively that the British smallpox was still viable. Since then most scholars have recognized that the British committed biological warfare in 1789 near their new convict settlement at Port Jackson (Finzsch, 2008; Mear, 2008). Some earlier writers, misunderstanding that British stocks of virus had been sterilised, proposed that the 1789 outbreak was caused by a hypothetical transmission from Macassar in Sulawesi. However the available records for smallpox in Macassar only show an outbreak in 1789, too late and inconvenient to be associated with the First Fleet outbreak.

In 1834, Massachusetts diarist Richard Henry Dana visited San Francisco on a merchant ship. His ship traded many items including blankets with Mexicans and Russians who had established outposts on the northern side of the San Francisco Bay. Local histories document that the California plague epidemic began at the Russian fort soon after they left. It is possible that the blankets were the source of the contamination (hidden fleas or rats, perhaps) but another possible source was a Chinese ship making port in San Francisco at the same time. Plague became established in California and has since become endemic throughout much of the North American West. Native rodents have suffered a severe population decline, only partly due to human eradication action.

During the American Civil War, General Sherman reported that Confederate forces shot farm animals in ponds upon which the Union troops depended for drinking water. This would have made the water unpleasant to drink, though perhaps the death caused might not have been that desired. A Confederate doctor planned and may have carried out a bacteriological attack on Northern populations across the Canadian border. A punitive European expedition to a South Pacific island described deliberately exposing the Polynesian population to measles, of which many of them died. While much of the material for London's *South Sea Tales* is derived from his personal experience in the region, it is not known whether this particular incident is historical.

During the First World War, the Empire of Germany pursued an ambitious biological warfare program. Using diplomatic pouches and couriers, the German General Staff supplied small teams of saboteurs in the Russian Duchy of Finland and in the then neutral countries of Romania, the United States and Argentina. In Finland, saboteurs mounted on reindeer placed ampoules of anthrax in stables of Russian horses in 1916. Anthrax was also supplied to the German military attaché in Bucharest, as was glanders which was employed against livestock destined for Allied service. German intelligence officer and US citizen Dr. Anton Casimir Dilger established a secret lab in the basement of his sister's home in Chevy Chase, that produced glanders which was used to infect livestock in ports and inland collection points including, at least, Newport News, Norfolk, Baltimore and New York and probably St. Louis and Covington. In Argentina, German agents also employed glanders in the port of Buenos Aires and also tried to ruin wheat harvests with a destructive fungus.

The Geneva Protocol of 1925 prohibited the use of chemical weapons and biological weapons but said nothing about experimentation, production, storage or transfer; later treaties did cover these aspects. Twentieth-century advances in microbiology enabled the first pure-culture biological agents to be developed by World War II. The interwar period was a period of development by many nations, most notably the Empire of Japan. Secret Imperial Japanese Army Unit 731, based primarily at Pingfan in Manchuria commanded by Lieutenant General Shirô Ishii, did research on BW, conducted often fatal human experiment on prisoners and produced biological weapons for combat use during the Second Sino-Japanese War. Biological experiments, often using twins with one subject to the procedure and the other as a control, were carried out by Nazi Germany on concentration camp inmates, particularly by Joseph Mengele.

Evans (2009) and Barenblatt (2004) wrote on biological warfare of 1937-1945. During the Sino-Japanese War (1937-1945 and World War II, the Imperial Japanese Army made use of biological weapons against both Chinese soldiers and civilians in several military campaigns. Three veterans of Unit 731 testified, in a 1989 interview to the *Asahi Shimbun*, that they were part of a mission to contaminate the Horustein river with typhoid near the Soviet troops during the Battle of Khalkhim Gol. In 1940, the Imperial Japanese Army Air Force bombed Ningbo with ceramic bombs full of fleas carrying the bubonic plague. A film showing this operation was seen by the imperial princes Tsuneyoshi Takeda and Takahito Mikasa during a screening made by mastermind Shiro Ishii. During the Khabarovsk War Crime Trials the accused, such as Major General Kiyashi Kawashima, testified that as early as 1941 some 40 members of Unit 731 air-dropped plague-contaminated fleas on Changde. These operations caused epidemic plague outbreaks.

Many operations were ineffective due to inefficient delivery systems, using disease-bearing insects rather than dispersing the agent as an bioaerosol cloud. Nevertheless, some modern Chinese historians estimate that 400,000 Chinese died as a direct result of Japanese field testing and operational use of biological weapons. In 1943, following the Allied invasion at Anzio, German

forces flooded The Pontine Marshes to reintroduce Malaria to the area. Perhaps 100,000 cases of the disease were noted in the region in 1944 and 43,000 in 1945. German forces withheld medical care to the civilian population (Barenblatt, 2004).

In response to biological weapons development in Japan and at the time suspected in Nazi Germany, the United States, United Kingdom and Canada initiated a BW development programs in 1941 that resulted in the weaponization of tularemia, anthrax, brucellosis and botulism toxin. The center for United States military BW research was Fort Detrick, Maryland, where USAMRIID is currently based; the first director was pharmaceutical executive George W. Merk. Some biological and chemical weapons research and testing was also conducted at Dugway Proving Grounds in Utah, at a munition manufacturing complex in Terre Haute, India and at a tract on Horn, Mississippi. Much of the British work was carried out at Porton Down. Field testing carried out in the United Kingdom during World War II left Gruinard island in Scotland contaminated with anthrax for the next 48 years (Evans, 2009).

Ryall (2010) recorded the biological warfare that took place between 1946 and 1972. During the 1948 Israel War of Independence, International Red Cross reports raised suspicion that the Jewish Haganah militia had released *Salmonella typhi* bacteria into the water supply for the city of Acre, causing an outbreak of typhoid among the inhabitants. Egyptian troops later claimed to have captured disguised Haganah soldiers near wells in Gaza, whom they executed for allegedly attempting another attack. Israel denies these allegations.

During the Cold War, the US conscientious objectors were used as consenting test subjects for biological agents in a program known as Operation Whitecoat. There were also many unpublicized tests carried out on the public during the Cold War. E120 biological bomblet, developed before the U.S. signed the Biological and Toxic Weapons Convention. Considerable research on the topic was performed by the United States, the Soviet Union and probably other major nations throughout the Cold War era, though it is generally believed that biological weapons were never used after World War II. This view was challenged by China and North Korea, who accused the United States of germ warfare in the Korean War (1950-1953) (Ryall, 2010).

Cuba has also accused the United States of spreading human and animal disease on their island nation. At the time of the Korean the United States had only weaponized one agent, brucellosis ("Agent US") which is caused by *Brucella suis*. The original weaponized form used the M114 bursting bomblet in M33 cluster bombs. While the specific form of the biological bomb was classified until some years after the Korean War, in the various exhibits of biological weapons that Korea alleged were dropped on their country nothing resembled an M114 bomblet. There were ceramic containers that had some similarity to Japanese weapons used against the Chinese in World War II, developed by Unit 731. Some of the Unit 731 personnel were imprisoned by the Soviets and would have been a potential source of information on Japanese weaponization. The head of Unit 731, Lieutenant General Shiro Ishii, was granted immunity from war crimes prosecution in exchange for providing information to the United States on the Unit's activities (Ryall, 2010).

The Korean War allegations also stressed the use of disease vectors, such as fleas which, again, were probably a legacy of Japanese biological warfare efforts. The United States initiated its weaponization efforts with disease vectors in 1953, focused on Plague-fleas, EEE-mosquitoes and yellow fever-mosquitoes (OJ-AP). However, US medical scientists in occupied Japan undertook extensive research on insect vectors, with the assistance of former Unit 731 staff, as early as 1946. The United States Air Force was not satisfied with the operational qualities

of the M114/US and labeled it an interim item until the United State army chemical corps could deliver a superior weapon. The Air Force also changed its plans and wanted lethal biologicals.

The chemical corps then initiated a crash program to weaponize anthrax (N) in the E61 1/2-lb hour-glass bomblet. Though, the program was successful in meeting its development goals, the lack of validation on the infectivity of anthrax stalled standardization. Around 1950 the chemical corps also initiated a program to weaponize tularemia (UL). Shortly after the E61/N failed to make standardization, tularemia was standardized in the 3.4" M114 bursting spherical bomblet. This was intended for delivery by the MGM-29 Sergeant missile warhead and could produce 50% infection over a 7 mile² (18 km²) area. Unlike anthrax, tularemia had a demonstrated infectivity with human volunteers (Operation Whitecoat). Furthermore, although tularemia is treatable by antibiotics, treatment does not shorten the course of the disease. In addition to the use of bursting bomblets for creating biological aerosols, the chemical corps started investigating aerosol-generating bomblets in the 1950s. The E99 was the first workable design but was too complex to be manufactured. By the late 1950s the 4.5" E120 spraying spherical bomblet was developed; a B-47 bomber with a SUU-24/A dispenser could infect 50% or more of the population of a 16-square-mile (41 km²) area with tularemia with the E120. The E120 was later superseded by dry-type agents.

Dry-type biologicals resemble talcum powder and can be disseminated as aerosols using gas expulsion devices instead of a burster or complex sprayer. The chemical corps developed flettner rotor bomblets and later triangular bomblets for wider coverage due to improved glide angles over magnus-lift spherical bomblets. Weapons of this type were in advanced development by the time the program ended. United States President Richard Nixon signed an executive order on November 1969 which stopped production of biological weapons in the United States and allowed only scientific research of lethal biological agents and defensive measures such as immunization and biosafety. The biological munition stockpiles were destroyed and approximately 2,200 researchers became redundant.

United States special forces and the CIA also had an interest in biological warfare and a series of special munitions was created for their operations. The covert weapons developed for the military (M1, M2, M4, M5 and M32 or Big Five Weapons) were destroyed in accordance with Nixon's executive order to end the offensive program. The CIA maintained its collection of biologicals well into 1975 when it became the subject of the senate Church committee.

In 1972, the United States signed the biological and toxic weapons convention which banned the "development, production and stockpiling of microbes or their poisonous products except in amounts necessary for protective and peaceful research." By 1996, 137 countries had signed the treaty; however it is believed that since the signing of the convention the number of countries capable of producing such weapons has increased. The Soviet Union continued research and production of offensive biological weapons in a program called Biopreparat, despite having signed the convention. The United States was unaware of the program until Dr. Vladimir Pasechnik defected in 1989 and Dr. Kanatjan Alibekov, the first deputy director of Biopreparat defected in 1992.

During the closing stages of the Rhodesian Bush War, the Rhodesian government resorted to biological warfare. Watercourses at several sites close to the Mozambique border were deliberately contaminated with cholera and the toxin sodium coumadin, an anti-coagulant commonly used as the active ingredient in rat poison. Food stocks in the area were contaminated with anthrax spores. These biological attacks had little impact on the fighting capability of ZANLA but caused considerable distress to the local population. Over 10,000 people contracted anthrax in the period

1978 to 1980, of whom 200 died. The facts about this episode became known during the hearings of the South African Truth and Reconciliation Commission during the late 1990s.

After the 1991 Persian Gulf War, Iraq admitted to the United Nations inspection team to having produced 19,000 L of concentrated botulinum toxin, of which approximately 10,000 L were loaded into military weapons; the 19,000 L have never been fully accounted for. This is approximately three times the amount needed to kill the entire current human population by inhalation, although in practice it would be impossible to distribute it so efficiently and, unless it is protected from oxygen, it deteriorates in storage (Rheinhardt, 2007). On September 18, 2001 and for a few days after several letters were received by members of the United States Congress and media outlets containing anthrax spores: the attack killed five people. The identity of the perpetrator remained unknown until 2008, when a primary suspect was named.

Darling and Woods (2005) reported on anti-agriculture biological warfare. According to these scholars, biological warfare can also specifically target plants to destroy crops or defoliate vegetation. The United States and Britain discovered plant growth regulators (i.e., herbicides) during the Second World War and initiated an herbicidal warfare programme that was eventually used in Malaya and Vietnam in counter insurgency. Though, herbicides are chemicals, they are often grouped with biological warfare as bioregulators in a similar manner as biotoxins. Scorched earth tactics or destroying livestock and farmland were carried out in the Vietnam war (cf. Agent Orange) and Eelam War in Sri Lanka.

The United States developed an anti-crop capability during the Cold War that used plant diseases (bioherbicides or mycoherbicides) for destroying enemy agriculture. It was believed that destruction of enemy agriculture on a strategic scale could thwart Sino-Soviet aggression in a general war. Diseases such as wheat blast and rice blast were weaponized in aerial spray tanks and cluster bombs for delivery to enemy watersheds in agricultural regions to initiate epiphytotics (epidemics among plants). When the United States renounced its offensive biological warfare program in 1969 and 1970, the vast majority of its biological arsenal was composed of these plant diseases. Biological weapons also target fisheries as well as water-based vegetation, as well as livestock (Darling and Woods, 2005).

In the 1980s, Soviet Ministry of Agriculture successfully developed variants of foot-and-mouth disease and rinderpest against cows, African swine fever for pigs and psittacosis to kill chicken. These agents were prepared to spray them down from tanks attached to airplanes over hundreds of miles. The secret program was code-named "Ecology".

Attacking animals is another area of biological warfare intended to eliminate animal resources for transportation and food. In the First World War, German agents were arrested attempting to inoculate draft animals with anthrax and they were believed to be responsible for outbreaks of glanders in horses and mules. The British tainted small feed cakes with anthrax in the Second World War as a potential means of attacking German cattle for food denial but never employed the weapon. In the 1950s, the United States had a field trial with hog cholera. During the Mau Mau Uprising in 1952, the poisonous latex of the African milk bush was used to kill cattle.

Unconnected with inter-human wars, humans have deliberately introduced the rabbit disease Myxomatosis originating in South America, to Australia and Europe, with the intention of reducing the rabbit population - which had devastating but temporary results, with wild rabbit populations reduced to a fraction of their former size but survivors developing immunity and increasing again (Dembek, 2007).

Entomological Warfare (EW) is a type of biological warfare that uses insects to attack the enemy. The concept has existed for centuries and research and development have continued into the modern era. EW has been used in battle by Japan and several other nations have developed and been accused of using an entomological warfare program. EW may employ insects in a direct attack or as vectors to deliver a biological agent, such as plague or cholera. Essentially, EW exists in three varieties. One type of EW involves infecting insects with a pathogen and then dispersing the insects over target areas (Sunshine Project, 2002). The insects then act as a vector, infecting any person or animal they might bite. Another type of EW is a direct insect attack against crops; the insect may not be infected with any pathogen but instead represents a threat to agriculture. The final method uses uninfected insects, such as bees, to directly attack the enemy (Lockwood, 2009).

Recent research in genetics, specifically, expanding the set of bases found in DNA (A, C, G, T) and RNA (A, C, G, U) from four; expanding the set of codons (due to the expanded base set, as well as 3-base codons, to 4 and 5-base codons) and expanding the set of amino acids incorporated into polypeptides, extends the new field of synthetic biology to synthetic biological warfare.

It is important to note that all of the classical and modern biological weapons organisms are animal diseases, the only exception being smallpox. Thus, in any use of biological weapons, it is highly likely that animals will become ill either simultaneously with or perhaps earlier than humans. Indeed, in the largest biological weapons accident known - the anthrax outbreak in Sverdlovsk (now Yekaterinburg) in the Soviet Union in 1979 sheep became ill with anthrax as far as 200 km from the release point of the organism from a military facility in the southeastern portion of the city (known as Compound 19 and still off limits to visitors today).

Thus, a robust surveillance system involving human clinicians and veterinarians may identify a bioweapons attack early in the course of an epidemic, permitting the prophylaxis of disease in the vast majority of people (and/or animals) exposed but not yet ill. For example in the case of anthrax, it is likely that by 24-36 h after an attack, some small percentage of individuals (those with compromised immune system or who had received a large dose of the organism due to proximity to the release point) will become ill with classical symptoms and signs (including a virtually unique chest X-ray finding, often recognized by public health officials if they receive timely reports). By making these data available to local public health officials in real time, most models of anthrax epidemics indicate that more than 80% of an exposed population can receive antibiotic treatment before becoming symptomatic and thus avoid the moderately high mortality of the disease.

The goal of biodefense is to integrate the sustained efforts of the national and homeland security, medical, public health, intelligence, diplomatic and law enforcement communities. Health care providers and public health officers are among the first lines of defense. In some countries private, local and provincial (state) capabilities are being augmented by and coordinated with federal assets, to provide layered defenses against biological weapons attacks. During the first Gulf War the United Nations activated a biological and chemical response team, Task Force Scorpio, to respond to any potential use of weapons of mass destruction on civilians.

The traditional approach toward protecting agriculture, food and water: focusing on the natural or unintentional introduction of a disease is being strengthened by focused efforts to address current and anticipated future biological weapons threats that may be deliberate, multiple and repetitive.

The growing threat of biowarfare agents and bioterrorism has led to the development of specific field tools that perform on-the-spot analysis and identification of encountered suspect materials.

One such technology, being developed by researchers from the Lawrence Livermore National Laboratory (LLNL), employs a "sandwich immunoassay", in which fluorescent dye-labeled antibodies aimed at specific pathogen are attached to silver and gold nanowires (Orent, 2004; Preston, 2002).

In the Netherlands, the company TNO has designed bioaerosol single particle recognition equipment (BiosparQ). This system would be implemented into the national response plan for bioweapons attacks in the Netherlands.

Researchers at Ben Gurion University in Israel are developing a different device called the BioPen, essentially a "Lab-in-a-Pen" which can detect known biological agents in under 20 min using an adaptation of the ELISA, a similar widely employed immunological technique, that in this case incorporates fiber optics.

Microbes that are composed of synthetic or artificial components, such as DNA or RNA or codons or amino acids can be tailored for use as biological warfare agents. As examples, if DNA used xDNA were to be coupled with synthetic codons, with synthetic anti-codons, etc., then such microbes used as biological warfare agents would be synthetic biological warfare agents.

BIOLOGICAL WARFARE INSTITUTIONS, PROGRAMMES, PROJECTS AND SITES BY COUNTRY

According to the United States Office of Technology Assessment, since disbanded, 17 countries were believed to possess biological weapons in 1995: Libya, North Korea, South Korea, Iraq, Taiwan, Syria, Israel, Iran, China, Egypt, Vietnam, Laos, Cuba, Bulgaria, India, South Africa and Russia. In the Fort Detrick, Maryland in the United States of America, there was the U.S. Army Biological Warfare Laboratories from 1943 to 1969 which had 470 buildings, one-million-litre test sphere and undertook Operation Whitecoat from 1954 to 1973. There are also U.S. Army Medical Unit from 1956 to 1960; U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) since 1969; U.S. Entomological Warfare Programme which undertakes Operation Big Itch, Operation Big Buzz, Operation Drop Kick and Operation May Day; as well as National Biodefense Analysis and Countermeasures Centre (NBACC) projected 2008 which undertakes Project Bacchus, Project Clear Vision, Project SHAD, Project 112, Horn Island Testing Station, Fort Terry and Granite Peak Installation.

In the United Kingdom, there are the United Kingdom and Weapons of Mass Destruction and Biological Weapons which undertakes Porton Down, Gruinard Island, Nancekuke, Operation Cauldron and Operation Vegetarian. In the Soviet Union, there are the Biopreparat (18 laboratories and production centres); Stepnagorsk Scientific and Technical Institute for Microbiology, Stepnorgorsk, northern Kazakhstan; Institute of Ultra Pure Biochemical Preparations, Leningrad, a weaponized plague centre; Vector State Research Centre of Virology and Biotechnology (VECTOR), a weaponized smallpox centre; Institute of Applied Biochemistry, Facility, Kirov, Kirov Oblast; Zagorsk Smallpox Production Facility, Zagorsk; Berdsk Bioweapons Production Facility, Berdsk; Bioweapons Research Facility, Obolensk; Sverdlovsk Bioweapons Production Facility (Military Compound 19), Sverdlovsk, a weaponized anthrax centre; Institute of Virus Preparations; Poison Laboratory of the Soviet Secret Services; Vozrozhdeniya; Project Bonfire and Project Factor.

In Japan, there are Unit 731, Zhongma Fortress, Unit 100, Unit 2646, Unit 8604 and Unit 1644 projects. Iraq has the Iraqi Biological weapons Programme and Iraq Weapons of Mass Destruction (passim) which undertake Al Hakum, Salman Pak Facility and Al Manal Facility projects.

South Africa has the South Africa and weapons of mass destruction and biological and chemical weapons which undertake project coast, Delta G Scientific Company, Roodeplaat Research Laboratories and Protechnik projects.

The literature (Maksel, 2007; Maddrell, 2005; Chauhan, 2004) has names of people associated with biological warfare. The include bioweaponeers: Anton Dilger, Iran Baldwin, Joshua Lederberg, Paul Fildes, Rihab Rashid Taha, William C. Patrick III, Kanatjan Alibekov (known as Ken Alibek), Vladimir Pasechnik, Segei Popov, Kurt Blome, Eugen von Haagen, Kurt Gutzeit, Erich Traub, Shiro Ishii and Arthur Galston (unwittingly). Others are writers and activists: Michael Crichton ("Andromeda Strain", book and film), Matthew Meselson, Jeane Guillemin, Sheldon H. Harris, Richard Preston, Arthur Galston and David William.

Treaties: Two treaties have placed restrictions on biological weapons. The 1925 Geneva Protocol prohibits the use of chemical and biological weapons in warfare. Some signing countries declared that they would not honor it if their enemies or the allies of their enemies, did not adhere to its prohibitions. The United States ratified the Protocol in 1975 after President Richard Nixon renounced the use of biological weapons in 1969 (FAS, 2011).

The 1972 biological and toxin weapons convention restricts countries from developing, producing, stockpiling or acquiring biological agents, weapons and equipment outside of peaceful purposes. However, some signatory countries may be continuing weapons development, as the former Soviet Union did before its massive program was discontinued in 1992 (FAS, 2011).

Although, developing and using biological weapons once required support by nations, recent advances in biotechnology have made it easier to develop dangerous viruses, bacteria and toxins with fewer resources. This has increased concerns that individuals and groups could resort to bioterrorism to attack a population (FAS, 2011).

The biological and toxin weapons convention (BTWC): The BTWC was opened for signature on April 10, 1972. It entered into force on March 26, 1975 and was ratified by the US on March 26, 1975.

The signatories to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, the BWC or the BTWC, agree not to develop, produce, stockpile or acquire biological agents outside of peaceful purposes and weapons and equipment designed to use biological agents for hostile reasons.

Original US interpretation of the BTWC: Recently, the US interpretation of the BWC has come to reflect the point of view that Article I which forbids the development or production of biological agents except under certain circumstances, does not apply to non-lethal biological weapons. This position is at odds with original US interpretation of the convention. From the perspective of this original interpretation, current non-lethal weapons research clearly exceeds the limits of acceptability defined by Article I. However, the current US stance breaks with historical precedent.

Debate about the national biodefense analysis and countermeasures center: The National Biodefense Analysis and Countermeasures Center (NBACC) is a federally funded research and development center affiliated with the Department of Homeland Security (DHS). NBACC is managed by Battelle National Biodefense Institute (BNBI), a subsidiary of the R and D contractor Battelle Memorial Institute. According to a Department of Homeland Security factsheet, "The

programs conducted at NBACC will provide knowledge of infectious properties of biological agents, effectiveness of countermeasures, decontamination procedures and forensics analyses to support policy makers and responders' development of policies, programs and technologies."

Some of the research programmes outlined by DHS have generated controversy. Specifically, some have complained that its functions possibly violate tenets of the Biological and Toxin Weapons Convention (BWC). According to the treaty, signatory states are not "to develop, produce, stockpile or otherwise acquire or retain microbial or biological agents or toxins, that have no justification for prophylactic, protective or other peaceful purposes." However, part of the NBACC threat assessment includes acquiring, growing, modifying, storing, stabilizing, packaging and dispersing BTA to determine various properties and capabilities, according to a February 2004 presentation by Army Lt. Colonel George W. Korch, Jr, Ph.D. (Zelicoff and Bellomo, 2005).

The ethnic bomb: The White South African government reportedly ordered a programme in 1998 to develop a genetic engineered biological weapon that would specifically kill blacks. The English press also rumoured recently that Israel was working on a BW to specifically harm Arabs carrying certain genes.

A virus or toxin-synthesizing gene in a bacterium can be genetically engineered which is "activated or induced or regulated" by the product of a gene or by binding to a specific receptor that determines an "ethnic" characteristic, e.g., pigment formation for skin or eye color or some other characteristic that is a single-gene characteristic (e.g., ear lob attachment, hitchhiker's thumb etc.).

People have already thought of such a weapon which might be viewed in the same perspective as the "Neutron Bomb" touted in the days of the Cold War as having the dubious 'benefit' of neatly killing all life forms in a given area without destroying the infrastructure (e.g., buildings, roads etc.). So the users of this horror could have come in after a few weeks, cleaned up the unsightly skeletons (or to be efficient, turned them into phosphate fertilizer) and moved into to a virtually undamaged area. Presumably an ethnic biological weapon would achieve roughly the same ends. However, once such a Pandora's Box is opened, it could be applied to all sorts of things, like cleansing the earth of left-handers, brown-eyed people, the Irish, among others.

Poor man's weapons of mass destruction: The modern weapons of war, like the atom bomb, supersonic airplanes, atomic submarines and aircraft carriers, are all horrendously expensive, technologically complex and require a large and sophisticated industrial capacity, as well as a host of highly skilled scientists and engineers to produce and maintain. In contrast biological (and chemical) weapons production is relatively cheap, uses readily available commercial equipment and materials and can be managed by modestly trained scientists and technicians. Hence, biological (and chemical) weapons are regarded as the poor man's weapon of mass destruction.

RECOMMENDATIONS

It is worth considering what can be done about the possibility of BW use. Biodefense and public health and disease surveillance have been helpful. But, awareness on the nature of the problem of BW needs to be stepped up. Ignorance leads only to misunderstandings, panic, chaos and fatal mistakes and always makes a bad situation catastrophic. A careful analysis of the situation probably cannot prevent BWs from being used but can lead to actions that minimize the possibility and lessen the death and destruction it occasions. To diminish the problem:

- Develop full international co-operation in dealing with BW problems, especially with the United Nations (UN)

- Educate likely target populations as to what precautions and protective actions to take in case of an BW attack
- Co-ordinate the monitoring of the potential producers and users of BW as closely as possible
- Continue to improve on BW monitoring techniques and apparatus; making them smaller, faster, more sensitive and more accurate so as to detect BWs rapidly, so as to take action to minimize losses and disruption. New detection systems using biochips will soon make it possible to deploy small, automated monitoring stations at appropriate locations as early warning detectors of a BW attack. Air quality in cities throughout the world is routinely monitored using similar automated equipment. Police cars, buses and other vehicles that travel daily throughout an area could be equipped with detection units to routinely monitor an area
- Stockpile BW-fighting supplies, particularly medical ones, throughout the world so that they could be transported quickly to areas of BW use. It might be reasonable to have these supplies stored in transport aircraft ready to take off in a few minutes. After all, this was the situation during the Cold War when military planes were kept at the ends of the runways with their engines running and pilots in their cockpits ready to go

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