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BIOLOGICAL TERRORISM

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By

Ryan Clarke

Andrew Frankenthal

Peter Johansen

William Woerter

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Approved:

Professor Jeanine D. Plummer, Major Advisor

1. Biological terrorism
2. Feasibility
3. Response

Professor Michelle Ephraim, Co-Advisor

ABSTRACT

This project discusses the feasibility of and response to a large-scale covert bio-terrorist attack on the United States. Necessary background information was compiled, including historical incidents, likely bio-agents, and the roles of individual government agencies. We conclude that terrorist groups need state sponsorship in order to launch a successful large-scale attack. Flaws in the current response plans for the medical community and the government, as well as flaws of current bio-detection equipment, demonstrate the need for increased training and funding.

EXECUTIVE SUMMARY

There are numerous groups throughout the world that can be categorized as terrorist organizations. Traditionally, terrorist acts are committed with conventional weapons, but recently there has been an increasing threat of a biological terrorist attack. This new threat is our primary focus.

Biological agents were originally used as an instrument of war. In the 14th century, Tatar forces besieged the city of Kaffa. There was a sudden outbreak of plague among the Tatar troops. The corpses of these troops were then catapulted over the city walls of Kaffa in an attempt to infect the populace of the city. This strategy was successful and the Tatars ultimately conquered the city. In time, understanding of biological agents increased and as a result their effectiveness as a weapon was improved. In the first and second World Wars, biological agents were used by both the German and the Japanese forces. German troops infected enemy livestock thereby disrupting their enemies' ability to wage war. Japanese forces used a variety of delivery devices to infect Chinese troops, including rats infected with plague and contaminated handkerchiefs.

In the early 1980's a precedent was set; a new role for biological agents emerged. In 1984, in The Dalles area of Oregon, ten salad bars throughout the region were intentionally contaminated with *Salmonella*. The party responsible for this was the Rajneeshee cult, motivated by their desire to disrupt local elections. In October 2001, there was a sudden rash of anthrax outbreaks in media and government organizations throughout the United States. Anthrax in its powdered form had been mailed to these offices accompanied by anti-American messages.

All of the attacks throughout history have been small-scale attacks; casualties have not been on the scale of tens or hundreds of thousands of people. The most recent small scale attacks, the anthrax incidents, have raised concerns about the possibility of a large-scale attack. This project focuses on the feasibility of a large-scale biological terrorist attack and the response mechanisms in place.

In order to establish feasibility, it is important to identify which nations may sponsor a terrorist group. According to information from the U.S. Department of State, Iran, Iraq, and North Korea are possible sponsors of bio-terrorism against the United States. These nations have the technology and resources to produce biological weapons, have supported terrorist organizations in the past, and are hostile to the United States. The U.S. Department of State also reports on terrorist organizations that could orchestrate a bio-terrorist attack. Groups such as al Qaeda, Hizballah, and the Fatah Revolutionary Council have claimed responsibility for terrorist attacks on U.S. Embassies and U.S. military forces, such as the USS Cole. The cooperation of sponsor nations and terrorist groups creates a strong possibility of a large-scale bio-terrorist attack on the United States.

Once a terrorist group has planned a bio-terrorist attack, the next obstacle is the production of the biological weapon. There are several difficulties encountered in processing a dangerous pathogen into a weapon system. This process requires some level of experience with microbiology, which could be gained through college-level courses. The chosen agent must be grown into a sufficient quantity and then processed for transmission. Smallpox may be carried on minute water droplets and inhaled, while anthrax may be desiccated into spores and dispersed as a dry aerosol. In either case, large fermenters are required to grow the vast quantities of the agent. Such fermenters are expensive and their purchase is currently being monitored by U.S. intelligence organizations. Small, concealed bio-weapons facilities are still feasible, especially if the terrorists are receiving financial support from a foreign power.

In the event of a bio-terrorist attack, an early warning is the best hope of containing casualties. Bio-detection is one of the first lines of response against bio-terrorism. With this technology, dangerous pathogens can be identified both before and after people have been exposed to them. Two of the key techniques in bio-detection are polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay (ELISA). The Bio-Threat-Alert strip from Tetracore, Inc. and the Smart Cycler from Cepheid are currently two of the best tools, however, each of them has their shortcomings. The Bio-Threat-Alert strip is

not sensitive to small quantities of agents and is only effective against a specific agent. The Smart Cycler, on the other hand, may be too sensitive, producing many false-positive results as a result of environmental contamination. Technology still has need of advancement before equipment can be produced that can quickly and reliably be used for bio-detection in the field.

Once the presence of a biological agent has been detected, the next step is the quick response of the medical community and the government. The medical community, led by the Centers for Disease Control, responds with supplies of antibiotics and vaccines from government stockpiles. However, there is the problem of local hospitals being overwhelmed by a sudden demand for treatment caused by a large-scale attack. Few doctors and nurses have experience treating the relatively rare pathogens that would be involved in a bio-terrorist attack. The medical community needs to develop a plan to respond to a sudden demand for treatment of casualties.

Federal agencies, such as the Federal Emergency Management Agency (FEMA), mobilize and organize response teams. The Federal government is responsible for managing containment and decontamination of the site of attack. The Federal Bureau of Investigation (FBI) would be the overall director of federal forces in the event of a bio-terrorist attack. FEMA will be given control of resource management in order to protect the public. State and local governments would provide support when needed. Quarantine is a possible course of action, but only as a last resort. While this plan sounds practical, it has not been adequately rehearsed. The exercise *Dark Winter*, a training scenario conducted in June of 2001, showed severe tension between State and Federal leaders. Logistical problems slowed the speed of the response. The Federal government must practice working with State governments in order to better protect and rescue the public from bio-terrorist attacks.

Some of the current methods in place to respond to a biological terrorist attack are inadequate. Cooperation between various government response teams needs to be better organized so that in the event of a large-scale attack these various groups will be prepared

to work together. Response teams need to practice more, in order to prepare for an actual attack. In the case of medical response, more hospital beds are needed and better training is required for doctors to properly diagnose the likely agents of a bio-terrorist attack. In order to prepare for a possible outbreak, a more adequate government stockpile of vaccines and antibiotics needs to be built up. As a country, the United States is not prepared for a biological attack and such an attack would be devastating as a whole.

AUTHORSHIP

Executive Summary

Mr. Frankenthal and Mr. Johansen are responsible for this section.

Introduction

Mr. Clarke, Mr. Frankenthal, and Mr. Woerter are responsible for this section.

Background

- Mr. Clarke – Government Agencies
- Mr. Frankenthal - History
- Mr. Johansen – Biological Agents
- Mr. Woerter - Legislation

Methods

- Mr. Clarke – Government Documents
- Mr. Frankenthal – Interview With Dr. Calvin Chue
- Mr. Johansen – Medical Journals and Professional Organizations

Results and Analysis

- Mr. Clarke – Potentially Sponsoring Countries, Government Response, and Quarantine
- Mr. Frankenthal – Potentially Sponsoring Countries, Terrorist Groups
- Mr. Johansen – Potentially Sponsoring Countries, Weaponization, Medical Response
- Mr. Woerter – Potentially Sponsoring Countries, Bio-Detection

Conclusions and Recommendations

Mr. Clarke, Mr. Johansen, and Mr. Woerter are responsible for this section.

Interview With Dr. Calvin Chue

Mr. Frankenthal and Mr. Woerter are responsible for the interview.

LIST OF ACRONYMS

- BW – Biological Weapons
- BWATA – Biological Weapons Anti-Terrorism Act
- BWC – Biological Weapons Convention
- CDC – Centers for Disease Control and Prevention
- CIA – Central Intelligence Agency
- CSIS – Canadian Security Intelligence Service
- DOD – Department of Defense
- ELISA - Enzyme-Linked ImmunoSorbant Assay
- EPA – Environmental Protection Agency
- FAS – Federation of American Scientists
- FBI – Federal Bureau of Investigation
- FEMA – Federal Emergency Management Agency
- GIA – Armed Islamic Group
- IDPH – Illinois Department of Public Health
- JAMA – Journal of the American Medical Association
- MMRS – Metropolitan Medical Response Strike Team
- NBC – Nuclear/Biological/Chemical
- NKAG – North Korea Advisory Group
- PCR - Polymerase Chain Reaction
- PLO – Palestinian Liberation Organization
- SBCCOM – Soldier and Biological Chemical Command
- UN – United Nations
- UNSCOM – United Nations Special Commission
- USAMRIID – US Army Medical Research Institute of Infectious Diseases
- USDOHHS – US Department of Health and Human Services
- USDOS – US Department of State
- USHOR – US House of Representatives
- WHO – World Health Organization
- WMD – Weapons of Mass Destruction

TABLE OF CONTENTS

1. INTRODUCTION

The FBI defines terrorism as "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives" (The Terrorism Research Center, 2002). There are numerous groups throughout the world that have committed acts that meet the criteria of this definition. In Asia, between 1993 and 1998, there were 158 acts of terrorism. Asian terrorist groups like the Liberation Tigers of Tamil Eelam, Abu Sayyaf Group, Aum Shinrikyo, the Harakat ul-Ansar, and the Japanese Red Army have perpetrated terrorist acts that resulted in 8,331 dead or wounded in the aforementioned timeframe. There have also been acts of terrorism in the newly independent Russian states. In late summer and early fall of 1999, Russia endured an apartment-bombing campaign perpetrated by Chechen resistance that resulted in a retaliatory war intended to end terrorism in the south. In the Middle East, between 1993 and 1998, there were 2,524 people killed or injured. These facts show that terrorism is a global phenomenon that is on the rise in many parts of the world.

Terrorist acts have traditionally been committed with conventional weapons, firearms and explosives. Conventional attacks have occurred throughout the world and the response infrastructure has plans in place to respond effectively in terms of manpower and resources. More recently, terrorist groups have begun to use chemical and biological weapons to attack civilian populations. A biological attack raises new problems with new challenges to be faced. For example, some biological agents may spread through a civilian population undetected over a matter of months, while a conventional terrorist attack has an immediate impact.

The September 11th, 2001, attacks on the World Trade Center in New York City and the Pentagon in Washington, D.C. have, for most people in the United States, brought the reality of foreign terrorism to bear. While there have been domestic groups responsible for attacks inside the United States, there has never been such a massive scale attack executed on domestic soil by a foreign group prior to September 11, 2001. Along with

these more conventional terror attacks, there have been letters containing anthrax, sent through the U.S. Postal System to various politicians and newspersons in New York City, Washington D.C., and Boca Raton, FL. However, despite their large geographic scope, the number of casualties was very low (22) and the number of deaths even lower (4).

The recent anthrax attacks have been of small scale. Because of this, we chose to look at the feasibility and effects of a large-scale biological attack, one that would cause thousands of casualties and put immense pressure on the medical community. Evidence indicating that terrorist groups are trying to acquire existing biological weapons also suggests that terrorist groups could launch such an attack.

One of the goals of this project is to establish a link between countries capable of producing Class A biological agents for a large scale attack and their willingness to support terrorist groups. We also determined whether the state sponsors have the necessary equipment and knowledge to weaponize the Class A biological agents. Lastly, we determined if the government agencies and medical community are collaborating effectively with each other to cope with a biological attack.

In the second chapter of the project, we familiarize the reader with the background information pertaining to biological terrorism. Topics included are a brief history of biological weapons, legislation regarding biological warfare and terrorism, various government agencies, and a section on the biology involved in biological terrorism. The next chapter describes the methods used to do our research, including using a variety of different types of sources, and conducting an interview. The results chapter starts with a discussion of the feasibility of a biological attack on the United States. The discussion on feasibility includes information on various nations that could potentially sponsor a biological terrorist attack. Various terrorist groups and their capabilities were also analyzed, as well as the possibility of weaponizing a biological agent. We then discuss the response capabilities of the medical community, including bio-detection equipment, and the combined response of Federal and State/Local governments. The conclusion chapter highlights the key findings made and includes our final thoughts and comments

on the subject of the feasibility of a large-scale biological attack on the United States, as well as our response capabilities to such an attack.

2. BACKGROUND

The purpose of this chapter is to supply the reader with background information on the subject of bio-terrorism. Included is information on the history of biological attacks, legislation relevant to bio-terrorism, an overview of responding government agencies, and a primer on biological agents.

2.1 History of Biological Attacks

Throughout history there have been many incidences of death or injury that have been caused by the intentional use of biological agents in an adversarial manner. A problem that occurs when examining the historical record is that it is not always clear what the source of infection is. It is difficult to determine if a casualty occurred as a result of intentional infection or as a result of a naturally occurring biological agent.

One of the earliest recorded instances of a biological attack occurred in the 14th century. It took place during the siege of the city of Kaffa, now known as Fedossia, Ukraine. The attacking Tatar force suddenly experienced an epidemic of plague. This could have led to a Tatar withdrawal, but instead the Tatars decided to capitalize on their misfortune by catapulting their dead over the outer walls of Kaffa and into the city. The result was a plague outbreak within Kaffa and the subsequent surrender of the defending force. One of the problems that historians face is determining exactly how many cases of plague occurred as a result of accidental exposure and how many cases were induced by Tatar "ingenuity." The exact numbers are not clear, but what is clear is the fact that Tatars were using biological agents as weapons (Derbes, 1966).

Another incident with similar ambiguities occurred in the 18th century. During the French and Indian War (1754-1767), Sir Jeffrey Amherst, commander of British forces at the time, saw to it that blankets and handkerchiefs that had been exposed to smallpox virus were distributed to Native Americans in the area. This was done because the British wanted to clear certain areas and make them "Indian free." The British obtained their virulent blankets from smallpox outbreaks of their own, one of them occurring at Fort

Pitt. Again, it is difficult to differentiate the source of the smallpox in every case but it is known that people were intentionally infected (Parkman, 1901).

At the time of the First World War, the use of biological agents was documented more carefully and evidence of intentional infection, as opposed to accidental infection, is more abundant. During the First World War the Germans developed a substantial biological warfare program intended to have a wide-ranging effect on both humans and animals. German saboteurs took advantage of this and infected the livestock of their enemies with *Bacillus anthracis* and as a result thousands of mules and horses died. This is important because at the time beasts of burden played a vital role in military endeavors (Hugh-Jones, 1992).

Thirty-five years later, during World War II, evidence exists that the Japanese used biological weapons against their enemies. Research began in Manchuria under the direction of Shiro Ishii and Kitano Misaji, who named their biological warfare facility Unit 731. Under their direction, 10,000 prisoners of Japan were intentionally infected with agents such as anthrax and cholera. Furthermore, when the Soviet Union captured some Japanese personnel who were involved in biological research, they discovered through lengthy interrogations that the Japanese had launched biological attacks on eleven Chinese cities. Their methods for distributing the agents were varied. Water supplies were directly infected with cholera, anthrax and meningitis. Sometimes the cultures themselves were simply thrown into homes. The Japanese were also able to create living plague weapons by gathering rats infected with plague and allowing fleas to feed on them, becoming infected themselves. The fleas were then dropped on Chinese cities from airplanes (Harris, 1992).

Aside from actual attacks there have also been accidental outbreaks. Although not intentional, these events were still significant. Between September 1950 and February 1951 there was an outbreak of *S. marcescens* in the San Francisco area. The U.S. Biological Weapons program had been covertly dispersing aerosolized forms of this organism, which they thought was harmless, over major cities. These "simulants" were

released to study the effects of solar radiation and climactic conditions on the viability of these organisms. At or around the same time these experiments were taking place, people began checking into Stanford University Hospital with urinary tract infections and two people eventually died. It was thought that the increased use of antibiotics in American society was what caused people to die from an agent that was thought to be harmless. An article on this story appeared in the *Washington Post* in 1976, along with data suggesting that instances of pneumonia were higher in areas where simulant testing was being conducted. A public outcry followed and a ban on simulant testing was introduced in 1977. Many scientists still believe that simulant testing is vital if we are to understand the ways in which biological agents behave in the atmosphere. Historical incidents like the one in San Francisco often have psychological effects that can linger for decades (U.S. Congress, 1977).

One of the most famous accidental outbreaks in recent history occurred in Sverdlosk, Russia in 1979. Sixty-four people that lived in a narrow stretch of land between a military installation and the southern city limit of Sverdlosk died. The military installation stored and produced anthrax. The wind was blowing in the proper direction in the days before the outbreak to facilitate a large-scale infection of anthrax that was delivered in an aerosolized form. Soviet officials claimed that the infections were a result of people eating infected meat. Due to the victims' proximity to the military installation and the favorable wind conditions it was concluded that their official position is false (Meseson *et al.*, 1999).

There have also been acts of domestic and foreign biological terrorism in the United States. In 1984, 751 people were infected with *Salmonella typhimurium* in the small community of The Dalles, Oregon (Bjerklie, 2001). It was determined that all the victims dined at ten local area restaurants that had salad bars. The responsible party was a local cult known as the Rajneeshees. The goal of their attack was to disrupt local elections. Fortunately for the 751 victims, salmonellosis is not fatal and only results in gastroenteritis (Torok, 1997).

On September 11, 2001 the World Trade Center was destroyed in a terrorist attack. In the weeks that followed the attack, major news organizations and government offices began receiving packages that contained spores of anthrax in a powdered form. The attacks began on October 2, 2001. Robert Stevenson, an editor at American Media Inc. in Boca Raton, Florida, was admitted to the hospital with a rash and a high fever. He died of inhalational anthrax three days later. Over the course of the next month, letters with anthrax spores were mailed to several other locations, including the three major network news organizations in New York (NBC, CBS, ABC), the office of the Governor of New York, the Supreme Court and the State Department. These attacks inexplicably stopped on October 21st (ABC News, 2002).

2.2 Legislation

Prior to the September 11, 2001, attacks on the United States of America, the threat of biological terrorism had been realized and some legislation had been put into place. The legislation that existed prior to the September 11 attacks was mainly intended to prevent biological weapons from being produced so they could not be used in warfare or proliferated to terrorist organizations. However, it was realized after the September 11 attacks and the subsequent anthrax scare that more legislation was needed to strengthen the United States' defense against all possible terrorist attacks.

2.2.1 World Legislation Prior to September 11, 2001

On June 17, 1925, one hundred forty five countries throughout the world signed the *Geneva Protocol for the Prohibition of the use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods Warfare* (USDOS, 1925), which limited the use and production of biological agents as a weapon. The Geneva protocol of 1925 was drawn up in response to certain countries experimentation with deadly biological agents during World War I. Key signing countries of this protocol were Afghanistan, The United Kingdom, France, the Union of Soviet Socialist Republics, and the United States of America. The protocol is specifically targeted towards "prohibition to the use of

bacteriological methods of warfare" since there already existed some legislation concerning the other types of agents and chemical warfare. The signing countries agreed not to develop biological weapons or use them for warfare.

The Geneva Protocol of 1925 had many flaws. Nowhere within did it mention the stockpiling and production of the agents that it explicitly references. The Geneva Protocol of 1925 made no attempt to define which agents were to be outlawed, or how the laws were to be enforced. In 1971 the Soviets and their allies introduced a draft for a new biological weapons convention. To supplement the Geneva Protocol, the *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction* (USDOS, 1972), otherwise known as the Biological Weapons Convention, was available for signing in 1972 and came into action in 1975. In signing this convention all 162 participating countries, many of whom signed the Geneva Protocol of 1925, agreed to a number of details. In the first article of the convention they agreed not to "develop, produce, stockpile or otherwise acquire or retain" biological weapons. The participants also agreed to destroy or convert their biological weapons and facilities into resources intended for peaceful purposes, such as anti-terrorism research facilities or medicines. Another key aspect of the convention was to prohibit the countries from transferring agents, weapons, or knowledge to any other countries or organizations. The convention put into each of the countries hands the responsibility to generate, under their own constitution, a set of laws to regulate and prohibit the use and production of biological weapons. This helped solve the problem of enforcing the regulations that were agreed upon in the Geneva Protocol of 1925. The convention laid down the groundwork for cooperation between the countries of the United Nations to work together in the prevention and destruction of biological weapons. One of the most significant aspects of the Biological Weapons Convention is that it is considered the first disarmament treaty to altogether ban an entire category of weapon.

2.2.2 National Legislation Prior to September 11, 2001

In order to fulfill the requirement of the 1972 Biological Weapons Convention (BWC) that each signing country develop a set of laws under its own constitution governing the production, handling and use of biological weapons, and deadly biological agents, the Biological Weapons Anti-Terrorism Act (BWATA) of 1989 was brought into action. The intent of BWATA is to "implement the Biological Weapons Convention" and to "protect the United States against the threat of biological terrorism" without restraining or restricting "peaceful scientific research or development" (U.S. Congress, 1989). Section 175 entitled *Prohibitions with respect to biological weapons* makes it illegal to develop, produce, stockpile, transfer, acquire or retain "any biological agent, toxin or delivery system for use as a weapon" (U.S. Congress, 1989). It also states that anyone who gets caught doing so will face a fine or imprisonment up to and including a life sentence. This section, however, specifically excludes those that are using the biological agents, toxins, or delivery systems for vaccines or other prophylactic use and any other peaceful scientific use of them. Section 176, entitled *Seizure, forfeiture, and destruction*, provides the means for any biological agent, toxin, or delivery system that is not for prophylactic, protective, or other peaceful purposes, to be seized and destroyed with an obtained warrant. Section 176 also allows for a seizure to take place without a warrant in extenuating circumstances (U.S. Congress, 1989). While this could be interpreted as an infringement upon the 4th Amendment of the Bill of Rights, it may be a very necessary step to ensure the safety of Americans against an internal biological terrorist attack. The only allowable defense against the hearing to follow such seizures is if the materials seized were for a legitimate prophylactic, protective, or otherwise peaceful purpose, and if the said materials are reasonable for such use (U.S. Congress, 1989).

2.2.3 Legislation After September 11, 2001

Since the September 11 attacks on the United States there have been a number of proposed and implemented legislations regarding terrorism and biological terrorism. President George W. Bush's administration is backing a 3.25 billion dollar senate bill intended to increase the United States' capability to response to a biological attack on the

populace. The proposed bill would allocate 1.1 billion dollars to increase the United State's stockpiles of vaccines, 1 billon for improving the public health system's response capabilities to a biological attack, and 1.1 billion dollars for improving food borne detection capabilities (Garrett, 2001). Another bill being developed by Senator Dianne Feinstein of California would tighten the restriction on the use and transfer of deadly biological agents. One of the key elements of this bill are the proposed certification processes for labs and individuals that would be handling and researching the biological agents and a significant fine for anyone transferring agents to an uncertified lab or for the use of the agents without proper certification. The bill would require periodic inspections of any areas using the agents for research, and it would introduce specific rules for handling different classes of the agents. It would also call for a review of the current list of deadly agents maintained by the CDC (Wright, 2001).

2.3 Government Agencies

In order to give the reader a better understanding of the material presented dealing with the prevention and response to a biological terrorist attack, some background information on the major government agencies and organizations that are involved is necessary. While there are many organizations involved in a response to a biological attack, only the few very large organizations that would be involved are mentioned here. Military, law enforcement, research organizations, the medical community, and civilians could be called upon for assistance in the event of a major attack.

2.3.1 Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) is the largest emergency management agency in the United States of America. Reporting directly to the President, it is tasked with responding to, planning for, recovering from, and mitigating against disaster. FEMA can trace its origins to the Congressional Act of 1803, which provided assistance to a New Hampshire town that was devastated by an extensive fire. Since then, the Federal government has become increasingly involved in disasters, including those involving nuclear materials. It was these nuclear disasters that prompted President

Carter's 1979 executive order merging many of the separate disaster-related responsibilities into the Federal Emergency Management Agency. Since the end of the Cold War, FEMA has focused less on civil defense and more on disaster relief, recovery, and mitigation programs. These included responding to 43 major disasters declared by former President Clinton, and implementing Project Impact, a program designed to create disaster resistant communities. In the event of a biological terrorist attack, FEMA would ultimately be responsible "for Federal consequence management and public safety" (FEMA, 2001).

2.3.2 Centers for Disease Control and Prevention

The Centers for Disease Control and Prevention (CDC), originally titled the Communicable Disease Center, was formed in 1946 to fight against malaria, typhus, and other communicable diseases. Since then, the CDC has been directly involved with the preventive health of not only the United States, but also the world. Gaining control of polio, helping to fight AIDS, and eradicating smallpox, the CDC has been a valuable asset in history. They also offer numerous published resources for information on the country's and world's state of health (CDC, 2001a). During an actual biological attack, the CDC would be notified as early as possible and "although they will not likely be able to mobilize in a timely fashion," a communications link between the CDC and the attack site would be formed for information exchange and consultations (USDOHHS, 1998).

2.3.3 Department of Defense

The United States military, most notably the U.S. Army and National Guard, are also important contributors in the response to a biological attack. Although primarily a fighting force, the military is also very knowledgeable in the response of a Nuclear/Biological/Chemical (NBC) attack, something they trained for far before their civilian counterparts started doing so. There are two large organizations under the U.S. Army and National Guard that would be involved in a response to a biological attack on a civilian population.

2.3.3.1 United States Army Medical Research Institute of Infectious Diseases

The United States Army Medical Research Institute of Infectious Diseases (USAMRIID) is ultimately responsible for the research of strategies, products, information, procedures, and training programs for medical defense against biological threats. USAMRIID also houses the only maximum containment biological laboratory at the Department of Defense's (DOD) disposal. Although their primary purpose is to protect the military from biological warfare, they also research and develop vaccines and treatment methods, which could be used to treat the effects of a massive attack on the civilian population of the United States. USAMRIID and the CDC also coordinate together, along with the World Health Organization (WHO), to help diagnose and treat unusual diseases wherever they occur. Due to the potentially catastrophic consequences of a biological terrorist attack, USAMRIID may also be called upon for assistance to the civilian sector (USAMRIID, 2001).

2.3.3.2 United States Army Soldier and Biological Chemical Command

The United States Army Soldier and Biological Chemical Command (SBCCOM) provides support for emergency preparedness and response. An important element of SBCCOM is their Army Technical Escort Unit. This unit is globally deployable and highly trained in explosive and chemical/biological response, the likes of which they have been safely dealing with for more than 50 years. SBCCOM also leads the Domestic Preparedness Program, which is designed to enhance the capability of Local, State, and Federal emergency response to NBC incidents. This program includes numerous training exercises designed to test the response of our current infrastructure and to help improve it where it falls short. In the event of a massive attack on the United States, they could be called into action to assist those presently engaged and responding (SBCCOM, 2001).

2.3.4 Federal Bureau of Investigation

The Federal Bureau of Investigation (FBI), although not directly responsible for action in the casualty response of a biological attack, is responsible for the prevention of and also the legal response to such an attack. Being the largest counter-terrorist organization in the country, the FBI would be ultimately responsible for prevention and warning of such an attack. After a biological attack has occurred, the FBI would also be responsible for the legal and criminal issues of such an attack, and would be involved in the apprehension of the suspects involved. The FBI is also given command over the scene of attack once the area is stabilized. Although they would not be an immediate responder to the treatment of casualties, they would still play a role in such a response (USDOHHS, 1998).

2.3.5 Environmental Protection Agency

The Environmental Protection Agency (EPA) is the primary government agency for the response to a hazardous materials situation. The EPA's role would be to provide coordinated Federal response to a hazardous material release. If an NBC-type attack occurred, specifically a biological attack, the EPA would be ultimately responsible for the long-term consequences of such an attack. The EPA would be in control of remediation and decontamination of the attack site, working in coordination with other state and Federal agencies such as FEMA (USDOHHS, 1998).

2.4 Biological Agents

There are a variety of options available to a terrorist choosing to use biological weapons. While there are two basic categories of biological agents, bacteria and viruses, the possibilities within each category are extensive. However, we will only focus on the most virulent possible agents.

2.4.1 Bacteria

Bacterial infections come in three major types: cutaneous, pneumonic, and gastro-intestinal. A cutaneous infection occurs when bacteria enter the body through a cut in the skin and infects the dermis. This is the most common type of infection and also the easiest to treat with antibiotics. This is because the bacteria do not typically migrate from the site of infection (Harley, 1999).

Pneumonic infections are caused by the inhalation of aerosolized bacteria or bacterial spores. The infection takes up residence in the bronchial tubes or the lung tissue itself. Pneumonic infections are far more serious than other infections due to the difficulty of treating the delicate lung cells with antibiotics and the body's limited ability to send white blood cells to the infected tissue (Harley, 1999).

Gastro-intestinal infections are caused by ingestion of contaminated food or water. The bacteria in these types of infections attack the stomach or intestines. Gastro-intestinal infections can cause a variety of digestive problems as the body tries to purge the bacteria from the system (Harley, 1999).

Antibiotics are the standard treatment for a bacterial infection. Antibiotics are a class of chemical compounds that attack bacteria, inhibiting their growth and destroying the infection. An unfortunate side affect of such treatment is that when a bacterium is killed, any remaining toxins that it carries are subsequently released into the host's system (Harley, 1999).

2.4.2 Viruses

A virus is a microscopic particle consisting of either RNA or DNA coated in a protein capsule. It has no metabolism of its own, so it must rely on a host cell to replicate itself. Once a virus attaches to a host cell, it injects its genome into the cell. The viral genome is taken up by the host and the viral DNA is incorporated into the cell's own DNA, while the viral RNA goes directly to the cell's ribosomes to synthesize new proteins. In both

cases, the end result is the same: the virus takes control of the cell's metabolic processes to replicate itself. The viral DNA replaces key portions of the host's DNA and uses the cell's own metabolism to translate the viral DNA into more viral proteins. The new proteins are assembled into viruses and placed together with a copy of the viral genome. Eventually, the cell begins to secrete the newly made copies of the virus, or the cell bursts and disperses the new copies into the host to infect anew (Harley, 1999).

There is no simple treatment for a viral infection, only bed rest and nursing. The subject's immune system must learn to recognize infected cells and treat them on their own. Vaccines are created in this way: the subject receives an infusion of viral proteins and the body creates antibodies to combat them. When a viable virus arrives, the subject can mount an immunological response much quicker, preventing infection (Harley, 1999).

2.4.3 Class A Biological Agents

The CDC classifies biological diseases into three categories: A, B, and C. Class A biological agents are the highest priority agents recognized by the CDC. The CDC has placed these pathogens on this list due to their high lethality, difficulty of treatment, and the possibility of contagion. Class B diseases are less lethal than Class A, but still require special attention to contain and treat. Class C diseases, while still dangerous, are difficult to acquire or disseminate. As such, they may not be effective bio-terrorist weapons. Since Class A agents are considered to be the most lethal available and have the highest terrorist potential, we will concern ourselves solely with the discussion of diseases from this group (CDC, 2001b).

2.4.3.1 Anthrax

Bacillus anthracis is a bacterium capable of infecting almost any human tissue. It is commonly found in grazing animals, which consume the bacteria's spores while grazing. Farmers and herders occasionally contract the bacteria from working with infected animals that carry the spores in their fur or fleece.

B. anthracis secretes three types of proteins. The first is an 'Edema factor' which attacks and destroys surrounding cells, causing ulcerated lesions and edema in blood vessels. The second toxin is a 'Lethal factor', a potent cellular poison that kills the infected host by toxaemia. The third secreted protein is a protective antigen, which binds to the edema and lethal factors, concealing them from the host's immune cells (Abravoma *et al.*, 1993).

The overwhelming majority of naturally occurring anthrax infections are the cutaneous type, which are easily distinguished from other bacterial infections by the appearance of a large, blackened lesion around the infected site. Headache and fever are also major symptoms of infection. In severe cases, the patient may also contract meningitis as the bacteria migrates through the lymphatic system and enters the brain. Fortunately, cutaneous anthrax is easily diagnosed and treated with antibiotics. If treated quickly, the infection is easily cured (CDC, 2002a).

When spores of *B. anthracis* are aerosolized and inhaled, the resulting infection is much more dangerous. The spores germinate in the lung tissue and begin to cause flu-like symptoms, such as fever and a severe, non-productive cough. If undiagnosed, the infection spreads into the lymphatic system where it can attack other tissues, making it exceptionally lethal. In many cases, diagnosis and treatment come too late, since the only way to detect the presence of the bacillus is by direct microscopic analysis of the infected tissue, followed by culturation. An inhaled infection of *B. anthracis* can become lethal in as little as 2-3 days (CDC, 2002a).

Gastrointestinal infections of *B. anthracis* are similar to respiratory infections. In this case, the spore germinates in the intestinal tract. Edema occurs quickly, and the infection can rapidly spread into the blood stream. Death by toxic shock occurs soon after, in 2-3 days. This type of infection manifests as a severe abdominal pain, accompanied by bloody vomiting. Again, quick diagnosis and response are the best defense, but by the time a reliable diagnosis can be made, it may be too late to start treatment (CDC, 2002a).

Preventative measures are often taken when someone is suspected of having an anthrax infection. The patient is usually started on an antibiotic regimen immediately, usually penicillin or tetracycline. Even with antibiotic treatment, fatalities of inhaled and gastrointestinal infections are very high, 75% and 25%-60%, respectively (Abravoma *et al.,* 1993).

2.4.3.2 Botulism

Botulism is a nerve-paralyzing disease caused by *Clostridium botulinum*, a rod-shaped bacteria which secretes a dangerous neurotoxin. The most common source of infection is consumption of food contaminated with *C. botulinum* or its toxin. The bacterium infects the small intestine, where it can produce more of its lethal toxin.

The toxin secreted by *C. botulinum* binds to the neuro-muscular joints, specifically the nerve endings. The toxin interferes with the release of acetylcholine, a key neurotransmitter. The resulting nerve damage causes muscle weakness that slowly sweeps though the body, starting with the shoulders and descending downward. If the toxin interferes with breathing muscles, it causes a person to stop breathing and asphyxiate (Lederberg, 2000).

Infections of *C. botulinum* are treated with antibiotics; however, this does not halt the activity of the toxin. The CDC maintains a supply of antitoxin, which can ease the symptoms of botulism. The antitoxin does not remove the effects of the toxin, rather, it binds to any toxin that may still be in the patient's system and neutralizes it. Only the patient's own immune system can remove the damage caused by the toxin (Clark and Minton, 1989). In extreme cases where the patient is having respiratory difficulty, the patient can be placed in an iron lung until his system cleans out the toxin. Full recovery takes weeks or months of support (CDC, 2002b).

Bio-terrorist use of *C. botulinum* or its toxin is limited. Introducing the bacteria into a water supply would certainly cause some contamination. However, many reservoirs are so vast that massive amounts of bacteria are needed to cause a detrimental effect, and water treatment processes may effectively remove or inactivate the bacteria.

2.4.3.3 Plague

Yersinia pestis, otherwise known as "bubonic plague", is still present in the world today. Earning its reputation as the "black death" in the middle ages, bubonic plague is transmitted by a bite from an infected flea or rat. The bacteria then multiplies and spreads quickly to the blood and lymphatic system, where it can infect the entire body. *Y. pestis* is even able to survive inside of white blood cells and continue to spread, similar to the Human Immunodeficiency Virus. The infection of *Y. pestis* causes high fever and swelling of the lymph nodes, which are called buboes, hence the name 'bubonic plague'. Hemorrhages below the skin causes blackened area over the body, which is where the name 'black death' comes from (CDC, 2002c).

A secondary infection of *Y. pestis* is possible if the bacteria invades the lungs. These infections are caused by inhalation of the bacteria, possibly by close proximity with someone who is already infected with bubonic plague. The bacteria are carried on microscopic droplets when the patient sneezes or coughs. Such a secondary infection is called pneumonic plague, named for its pneumonia-like symptoms and infection path. Symptoms of pneumonic plague include fever, weakness, and a bloody, watery cough (Perry and Fetherson, 1997).

Pneumonic plague kills quickly, in as little as 2-4 days. Quick diagnosis and treatment are again the best response, but *Y. pestis* replicates so quickly that the infection may become lethal in as little as 24 hours. There is currently a vaccine for bubonic plague, but its effects on pneumonic plague are unknown. Antibiotics are still the best post-infection treatment (Titball and Williamson, 2001).

2.4.3.4 Smallpox

Smallpox is caused by the poxvirus *variola*. Once one of the most feared and devastating illness in human history, it has now been eliminated in the natural environment.

Variola typically first enters the body by inhalation. Incubation of smallpox is slow, taking about 2 weeks. During this time, the virus migrates from the mucous membranes to the lymphatic system, spleen, and bone marrow, interfering with the patient's immune system. From there, the virus localizes in the dermis.

High fever and fatigue are the first symptoms. Soon after, a rash develops, most prominently on the head and limbs. Within 2-3 days after the first symptoms, the rash is fully developed, and forms the lesions and pustules that are characteristic of *variola* infection. The lesions fill with pus, then slowly drain and crust over during the following weeks. The pustules eventually turn into scabs, which flake off as the disease runs its course. This process often causes severe scarring or even blindness. Death occurs in about 1 in 3 cases, with children and the elderly suffering disproportionally higher fatality rates. Smallpox is very contagious, especially from the fluid that fills the lesions. Typical contagion is caused by inhalation of saliva droplets that are aerosolized by coughing (Lederberg, 2000).

In 1967, the World Health Organization began a global vaccination campaign to eradicate smallpox from the natural environment. Surveillance teams monitored areas of potential outbreaks and vaccinated the family and friends of those who became infected. This protocol was effective and within ten years the virus had disappeared (WHO, 2002). However, the CDC and Russia kept small samples of the virus for further study. Intelligence communities fear that Russian scientists who had defected to hostile nations took samples of the virus with them (CDC, 2001c).

The CDC has a stockpile of smallpox vaccine on hand, but not nearly enough to vaccinate the entire country. After September 11, 2001, public fear of a possible bio-terrorist attack has prompted vaccine production to begin again. The CDC has contracted Oravax of Cambridge, Massachusetts to produce an additional 40 million doses of the vaccine. The completion of the first batches of the new vaccine is projected for 2004 (Johns Hopkins, 2002b).

2.4.3.5 Tularemia

Tularemia is a flu-like illness caused by the bacteria *Francisella tularensis*. This disease was first discovered in rodents in 1911, but its potential to infect humans was quickly seen in the 1930s and 1940s in Eastern Europe and the United States. Outbreaks of tularemia sporadically occurred in areas of poor sanitation. Contaminated drinking water is thought to be the source of the outbreaks.

F. tularensis can be found in a variety of places, including contaminated water, soil, and vegetation. Many rodents, including mice and rats, may also be carriers of the bacteria. Tularemia can also be contracted by bites from infected mosquitoes and ticks. The bacteria may also be inhaled from exposure to contaminated areas. The bacteria infects its host quickly; symptoms may develop within 48 hours of infection. Symptoms of inhalation tularemia are acute fever, fatigue, and similar flu-like symptoms. Some patients may develop pneumonia or bronchitis as a secondary infection. The bacteria may also migrate into the lymphatic system, where they can attack other organs, including the liver, spleen, and kidneys. When the lymph nodes are infected, the accumulation of fluid may cause the tissue to swell, producing a visible bulge in the skin (IDPH, 2002).

Tetracycline and similar antibiotics are the best treatment for tularemia. When untreated, the patient can develop more secondary infections, including meningitis. Untreated infections of tularemia have a mortality rate as high as 30-60%. When treated with antibiotics, the mortality rate is only 2% (Johns Hopkins, 2002c).

Since tularemia outbreaks are typically isolated, a sudden, large outbreak of many people would hint strongly at a biological terrorist attack. *F. tularensis* is relatively easy to aerosolize, or it can be placed into a public water supply. However, due to modern water treatment methods now in place, this may have a minimal effect (Dennis *et al.*, 2001).

2.4.3.6 Viral Hemorrhagic Fever

Hemorrhagic fevers are a class of RNA viruses. These viruses cause disease when humans come into contact with infected hosts or their bodily fluids, causing sudden and sporadic outbreaks. Ebola and Hantavirus are the two more widely known types of hemorrhagic fevers.

Ebola is a virus that is found in primates in central Africa. The virus can also be spread from infected humans through contact with blood or other secretions. Symptoms vary greatly from patient to patient, but almost all patients suffer from high fever and muscle aches, and many suffer from shock and death within a week of infection. The first documented outbreak of Ebola occurred in 1976 in Zaire and Sudan. Approximately 700 people were infected with the virus, many of them doctors and nurses. Over two-thirds of those infected died (CDC, 2002d).

Hantavirus pulmonary syndrome is a cardiopulmonary infection. The droppings of rodents, which contain virus particles, are one source that may cause this disease. Humans contract the virus when they inhale aerosolized particles that contain the virus. The first outbreak of Hantavirus pulmonary syndrome occurred in the four-corners regions of the United States in the summer of 1993. El Nino weather patterns caused a surplus of rain, which in turn led to an explosion in the deer mouse population. Since the outbreak, isolated cases of the virus have appeared in almost every state. Hantavirus pulmonary syndrome attacks the lungs, causing shortness of breath, shock, and heart attacks. Approximately 50-75% of all cases are fatal (CDC, 2002e).

3. METHODS

In order to determine the feasibility of a biological terrorist attack and to identify the weaknesses in the response of such an attack, research for this project was focused on four basic sources: government documents, an interview with a professional in the bio-detection field, medical journals, and professional organizations. With millions of dollars worth of research already expended in the field of bio-detection and organizing reaction plans to an attack, we were given the opportunity to determine whether the current technology and plans meet their goals of preventing or minimizing a biological attack. Also, analyzing current intelligence sources, we made a determination of whether or not the threat of an attack actually exists.

3.1 Government Documents

Researching government documents is vital due to the large role that governments play in the event of an attack. It is necessary to study the history of biological weapons controls as well as how the current infrastructure will respond to a biological attack.

3.1.1 Legislation

Researching legislation is instrumental for understanding the controls emplaced on biological agents and weapons of mass destruction. This information is then used to determine the ease of obtaining these potentially deadly weapons. Research is conducted on current laws and on laws that are currently being proposed. A large part of the international legislation came from the United Nations website and some of the Geneva conventions, one of specific importance being the 1972 *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction.* Much of the legislation and treaties were found on the Internet, along with bill proposals and ongoing debates on new legislative ideas. Websites such as CNN's homepage provided information on new proposed legislations and other current international issues in biological weapons controls.

3.1.2 Operations Manuals

Operations Manuals from government agencies were critical to understanding the response methods of the government, both Federal and State/Local. Manuals such as *The Metropolitan Medical Response System's Field Operations Guide* were highly valuable as they are official guides and procedures for catastrophic events such as a biological attack and contained very specific response information for government employees associated with responding to such an attack. Other documents included field information guides published by the United States Army that would be given to soldiers and first responders in the event of an attack. These guides would be used to identify the agent and treat the resulting casualties. The use of these documents allowed us to better understand and analyze the response procedures to a biological terrorist attack.

3.1.3 Agency Websites

Each government agency website typically had certain sections designed to inform the public about the current state of biological weapons and terrorism, or current issues related to the field of disease control and new discoveries. The Internet was extremely effective when information was needed on these government agencies. Each agency, such as the CDC and FEMA, has its own website that provided information on its purpose and function. Agency websites also provided information for intelligence on countries that pose a potential threat for sponsoring an attack. Agencies such as the Central Intelligence Agency, State Department, and the Canadian Security Intelligence Service provided unclassified information on biological weapons programs conducted by these countries.

3.2 Interview With Dr. Calvin Chue

Bio-detection is an important factor in determining the potential success of a biological terrorist attack. If hazardous biological agents are detected, either before or after they have been implemented, casualties can be greatly reduced. When the project began in early September 2001, the importance of bio-detection was not clear to members of the

group. Unfortunately, the importance of bio-detection was brought to bear in October 2001 when government offices and media organizations began to receive letters contaminated with Anthrax spores. There was an abundance of information suddenly available on bio-detection through media broadcasts. However, an interview with an expert in the field of bio-detection was arranged to better ascertain what role bio-detection has in preventing or inhibiting a biological attack. The Johns Hopkins Center for Civilian Bio-Defense is a renowned institution and has many experts in many fields. An appointment was made for October 25, 2001 to conduct an hour long interview with Dr. Calvin Chue, a research scientist and an expert in bio-detection. Over the course of an hour, a wide range of topics was discussed and the material obtained during the interview is referenced at various points in our project. A transcript of the interview has also been appended to the project.

Dr. Calvin Chue
Research Scientist
The Johns Hopkins Center for Civilian Bio-Defense
615 North Wolfe Street
Baltimore, MD. 21205
(410) 223-1667

3.3 Medical Journals

In order to better understand the arsenal of a biological terrorist, we researched the potential agents that may be used in a biological terrorist attack. To do this, we consulted medical journals such as the *Journal of the American Medical Association* (*JAMA*). *JAMA* and the journal *Science* had many articles on historical incidents of biological attacks and accidental outbreaks, such as the Sverdlovsk, Russia outbreak of anthrax in 1979. Bibliographies from papers that dealt with the history of attacks in a broad sense were used to find additional papers that had more in-depth information. Research articles were also very useful in uncovering in-depth information about how each of the agents work and what makes them such a threat.

3.4 Professional Organizations

Our group also investigated research centers such as the Centers for Disease Control (CDC) and the Johns Hopkins Center for Civil Biodefense Studies. These organizations routinely publish information and journals relating to biological defense research and government preparedness to a biological terrorist attack. Research groups, most noticeably the CDC, were consulted for biological background information and medical community response procedures. These groups are at the pinnacle of biological defense research and development, making their information and insight valuable to our project. Information pertaining to biological weapons programs and terrorist groups was obtained from the Federation of American Scientists and the Canadian Security Intelligence Service, in conjunction with other government agencies such as CIA.

4. RESULTS AND ANALYSIS

The information in this section was gathered in order to determine the feasibility of a large-scale biological terrorist attack as well as the response capabilities of the United States. Establishing a link between terrorist groups and countries with Class A biological weapons is necessary to establish feasibility. Also included is a description of the response plans that are now in place in the United States as well as current issues with bio-detection equipment.

4.1 Feasibility

On October 5, 2001, Robert Stevens, an employee of the American Media company in Boca Raton, Florida, died as a result of exposure to anthrax. It was the first anthrax death in the United States in 25 years. In the weeks that followed, letters that contained anthrax spores were mailed to several media organizations as well as government offices, and four people were killed as a result of exposure. There have been other biological terrorist attacks on American soil with less fatal results such as the contamination of ten salad bars with *Salmonella* in The Dalles, Oregon in 1984. These two incidences set a historical precedent for small scale attacks. It is entirely feasible for a terrorist to use some form of bio-agent to harm another human being. Therefore, the purpose of this project is to investigate the feasibility of a large-scale attack that can result in the death of tens or hundreds of thousands of people.

4.1.1 Potentially Sponsoring Countries

In order for a large-scale biological terrorist attack to be successful, it is necessary to have vast resources of capital, scientists, and hardware. This requires the support of a nation that is belligerent to the target, in our case the United States. The nations that we selected all have a historical precedent of (a) being belligerent to the United States, (b) supporting or hosting terrorist groups, and (c) having a biological weapons program or striving to develop one. President George W. Bush's State of the Union address on January 29, 2002, reinforces our decisions on some of our selected nations. During this

address, President Bush listed Iraq, Iran, and North Korea as members of the "axis of evil" that threatens to disrupt the peace of the world (Bush, 2002).

4.1.1.1 Iran

Ever since the overthrow of the ruling shah in 1979 and the subsequent overthrow of the U.S. Embassy in Tehran, Iran has been a belligerent nation to the U.S. Iran also has an unfriendly relationship with at least two of its neighbors, Iraq and Afghanistan. During the 1980s, Iran was engaged in a decade long territorial war with Iraq during which it became evident that both sides used chemical weapons on each other. The war was devastating to both countries. Although diplomatic relations were restored in 1990, written agreements are still being negotiated (CIA, 2000).

Iran was believed to have begun its biological weapons (BW) program in the early 1980s during the Iran-Iraq War. They were conducting research on toxins and organisms with applications in bio-weapons; they had the capability to produce many of the agents used in a bio-weapon, and in 1996 they were pursing complete plants that could be converted to create agents for bio-weapons. Major universities and research organizations in Iran were also linked to the BW program (CSIS, 2001). In 1997, the Pentagon projected that within 10 years the Iranian military could have the capability to deliver bio-weapons in an efficient and effective manner. In a 1998 report from the U.S. Arms Control and Disarmament Agency, it was stated that the Iranian BW program has been integrated into their pharmaceutical and biotechnology industries as a cover for their real activities (USDOS, 1998b). The Iranian military has also used the pharmaceutical and biotechnology industries as a procurement, research, and production channel for bio-weapons. According to a 1998 public announcement from the CIA, Iran's BW program is largely in the research and development stage. However, the CIA also believed that Iran could possess the ability to weaponize certain agents for use in artillery and aerial bombs, and were researching warheads for ballistic missiles (CIA, 1998). According to the Canadian Security Intelligence Service, Israel also confirmed that Iran maintained a stockpile of anthrax and botulism, was able to reproduce them in quantity at a quick rate,

and was already capable of delivering them via attack aircraft and Scud missiles (CSIS, 2001). John Lauder, the Assistant to the U.S. Director of Central Intelligence for Nonproliferation, testified in 1999 that "Tehran...continues to seek dual-use biotechnological equipment from Russia and other countries, ostensibly for civilian uses...and it may have some limited capability for BW deployment" (USIS, 2002).

It is believed by the Federation of American Scientists (FAS) that Iranian efforts to develop a BW program could have intensified in 1995 due to revelations of the extent of the Iraqi bio-weapon program during the Gulf War. Iran's scientists are highly qualified with considerable expertise in pharmaceuticals. Although most of their scientists are native to Iran, there are reports that Iran has received some outside help from bio-weapon scientists from Russia. It is also reported that Iran has staged a BW facility next to their chemical weapons facility in Damghan (FAS, 2002a).

Irregardless of the fact that Iran has denounced the terrorist attacks on the United States of America on September 11, 2001, and has offered assistance to any American pilot that ejects from their aircraft over Iranian territory, Iran still poses a threat as a terrorist sponsor. Iran has mainly sponsored terrorist groups that are opposed to Israel and any of their supporters, including the United States. Supreme Leader Khamenei has repeatedly referred to Israel as a "cancerous tumor" that must be removed. Iran has repeatedly offered assistance to Palestinian resistance groups, Lebanese Hizballah, Hamas, Palestine Islamic Jihad, and many others. Assistance comes in different forms, usually funding, safe haven, training, and weapons. Iran has also funded other groups in the Middle East, Africa, Turkey, and Central Asia on a lower level (USDOS, 2001).

4.1.1.2 Libya

In 1969 a military coup led by Colonel Muammar al-Qadaffi effectively ended the existing monarchy in Libya. In its place Qaddafi created the Libyan Arab Republic. Qaddafi is a socialist and his manifesto took the form of a "Green Book." In it Qaddafi talks about "the final solution" to the problems of government. Qaddafi quickly gets to

the core of his political philosophy. In the first chapter he writes that a 51 percent margin of victory is unfair; the other 49 percent of the populace has not been represented. In his own words a "dictatorship is established under the cover of false democracy" (Qadaffi, 2002). His solution is to form "peoples committees" or "popular congresses." The Green Book shows his distaste of western political ideas and this has led to a number of conflicts with the West. Libya has supported terrorism in the past and the United States retaliated in 1981 by shooting down two Libyan aircraft fighters and in 1986 with U.S. air attacks. The UN has banned all arm sales to Libya as a direct result of the refusal of the Libyans to turn over the suspected masterminds of the bombing of Pan Am flight 103 over Lockerbie, Scotland (Arabnet, 2001).

Over the past five years there have been numerous reports on the Libyan pursuit of biological weapons capability. In 1996 the Pentagon reported that Libya was pursuing a biological weapons program but that "technical shortcomings" would prevent them from producing a militarily effective product (CSIS, 2001). One year later the situation changed slightly. The Pentagon reported that the Libyans "may be able to produce laboratory quantities of agent." This was an advance on their part but it is still far from weaponized biological agents. Intelligence sources reported that in 1995, Libya was trying to recruit biological weapons experts from South Africa. The following year they were collaborating with the Romanians on BW production and development. In 1998, the situation intensified. The U.S. Arms Control and Disarmament Agency reported that Libya had acquired the capability to manufacture a limited amount of equipment used to create biological weapons and that Libya was looking to begin a BW program in earnest. The British press issued the most alarming report of all, in which "western intelligence sources" asserted that a team of Iraqi scientists had been moved to Libya in order to help them advance their program (CSIS, 2001).

4.1.1.3 Algeria

Algeria's recent history has been marred by long years of internal conflict. Since breaking away from French colonization in 1962, Algeria has been subject to cultural

infighting between the government and radical Islamic groups. As Islam resurged in the early 1980's, Islamic leaders began to demand the overthrow of the secular government and a return to a religious way of life. By 1988, resentment of the socialist government peaked, and Algeria erupted into rioting. The government became less authoritarian with its populace, allowing more civil liberties and the creation of opposing political parties. In 1990 and 1991, the new Islamic Salvation Front won an overwhelming majority in the popular elections.

The Islamic Salvation Front's main goal was to remove the old socialist government in favor of a new Islamic state. Unfortunately, the new regime began to terrorize its people by targeting secularists and intellectuals. These sporadic clashes with the fundamentalist government cost thousands of lives. In 1994, opposition groups had grown too numerous and the government was forced to open negotiations. The result was the elections of 1995, which were won by the democratic reformist Liamine Zeroual. As Zeroual slowly made the move from fundamentalism to democracy, conflicts with militant Islamic groups grew in both number and violence. Acts of terrorism and other atrocities raged for the later part of the 1990s, with an estimated 80,000 to 100,000 people killed, most of them civilians (Arabnet, 2001).

The war between the government and Islamic militants continues to this day. The most infamous of these groups is Armed Islamic Group (GIA, from the French name). A GIA member, Abdelmajid Dahoumane, was indicted in 2000 for conspiring to smuggle explosives into the U.S. in order to carry out a millennial bomb attack on U.S. soil. He was taken into custody in December of 2000 in Algeria by the Algerian government. The GIA and other radical militant groups do not appear to be associated with each other, although intelligence sources say there may be collusion between the groups. Dahoumane had received training from terrorist mastermind Osama Bin Laden in Afghanistan prior to 2000, and some members of Bin Laden's Al-Queda organization are ethnic Algerians (Eggen and Vise, 2000).

A united radical front is a major threat to the Algerian government, as well as many other nations. Small, poorly organized groups of terrorists do not have the resources or organization to carry out a large-scale terrorist or bio-terrorist attack. If the groups were able to pool their resources and unite under a skilled strategist, much larger operations could be launched. If the Algerian government were to be overthrown, there is a very strong indication that radical forces would attempt to spread their forces to attack enemy nations. It is unknown whether any of the militant groups have access to biological weapons. No outbreaks have been reported so far, but the possibility of a bio-terrorist attack remains. If Algerian militias have had contact with bin Laden or other terrorist groups, the possibility of terrorist strikes on the U.S. from these groups is increased dramatically (USDOS, 1998a).

4.1.1.4 Iraq

When the United Nations Special Commission on Iraq (UNSCOM) was in-country to inspect their weapons of mass destruction, they found that the biological weapons program was the most secretive of all their programs. Iraq repeatedly misled inspectors and deported them many times (CIA, 2001). Because of this, Iraq has been very closely watched. Along with demonstrating their will to use weapons of mass destruction bombing their own people with chemical weapons and using them in the Iran-Iraq war, Iraq has also demonstrated ambitions for using them in other situations. They threatened the Israelis and Coalition Forces with weapons of mass destruction during the Gulf War, causing a very fragile situation that could have resulted in nuclear exchange (FAS, 2002b).

In 1974, the Iraqi government developed a policy of procuring biological weapons and in 1975, research and development programs were initiated at the Al Hazen Ibn Haytham Institute in Al Salman. Work was poorly directed, and a lack of appropriate facilities and equipment forced it to close in 1978. For several years after the closing of the Institute, there were no alleged biological weapon programs or research being conducted. However, in 1985, as a result of the ongoing Iran-Iraq War, the Muthanna State

Establishment (Iraq's main facility for chemical weapons research and production) recommended a biological weapons program be started. Throughout 1985, staff was recruited, a 150-liter fermenter was purchased and research had begun (FAS, 2002b).

By 1987, the biological weapons program was moved back to Al Salman, new equipment was purchased, and progress was being made. In early 1988, effects on large animals inside of inhalation chambers were tested, along with field experiments. Studies were also started to boost the production of botulinum toxin and anthrax. By the end of 1988, a new facility at Al Hakam was built with the same design as the chemical weapons plants and the equipment was transferred from Al Salman. New pursuits also included agents that affect foods such as aflatoxin and wheat cover smut. Viruses, however, were not researched until 1990, with the introduction of haemorrhagic conjunctivitis virus, a rotavirus and camel pox virus (FAS, 2002b).

During the Iraqi invasion of Kuwait on August 2, 1990, biological weapons programs were intensified greatly. Emphasis was now placed on weaponization of biological agents, including foot and mouth disease. Vaccine fermenters were converted to agent production use and by January 15, 1991, the beginning of the Allied Coalition attack against Iraq, 5400-liters of botulinum toxin was produced. In December of 1990, a spray tank prototype was designed to be attached to an aircraft that could spray anthrax or another agent over a large area. However, the tests failed and the equipment was destroyed by Coalition bombing during Operation Desert Storm. Also in December, weaponization began on a large scale and active weapons were eventually deployed into four locations before the war, including aerial bombs, artillery shells, and missile warheads (FAS, 2002b).

Eventually Iraq declared that they produced 19,000-liters of botulinum toxin, 8500-liters of anthrax, and 2200-liters of aflatoxin. After the Gulf War, Iraq claimed that they destroyed all of their biological weapons. The order for destruction was supposedly given verbally. However, no senior official to this day can recall when the destruction took place. In late August of 1995, an UNSCOM team was shown the location of the site

where Iraq had destroyed its weapons. Afterwards, the Iraqi regime reversed its position and could no longer recall the exact location of the supposed destruction (USDOS, 1998b).

Currently Iraq has medical, veterinary, and university facilities where research and production can occur. The Federation of American Scientists believes that "it is very likely that these places are staffed by former members of the Iraqi biological weapons program" (FAS, 2002b). Most of the equipment used in these facilities is labeled as "dual use," where it can be used for both peaceful and offensive activities. Iraq retains the equipment, knowledge, and raw materials necessary for bulk production of biological weapons and a means of delivery of these weapons (CIA, 2001). According to Iraq's own estimates, 350-liters of weapons grade anthrax could be produced per week with their current equipment (FAS, 2002b).

4.1.1.5 North Korea

Despite North Korea's claim that they have no involvement in terrorist activities, there is much evidence to suggest otherwise. North Korea has had a history of involvement in terrorism, and has been on the U.S. Department of State's list of terrorist states since 1988 (Hwang, 2001). North Korea was added to this list due to its involvement in the 1987 bombing of a Korean passenger plane, which killed all 115 passengers and crew. The leader of North Korea, Kim Chong-il, also continues to provide sanctuary for five of the nine hijackers of a Japan Airlines flight to North Korea in 1970. One of the hijackers was arrested in 1996 by Cambodian authorities carrying 1,238 counterfeit U.S. hundred dollar bills and a North Korean diplomatic passport (USHOR, 2002). This arrest supports the belief that North Korea sponsors terrorist activities. Top government officials in the Philippines also claim that terrorist groups there have bought weapons from North Korea with funds from the Middle East (USDOS, 2000).

North Korea has a significant weapons of mass destruction program, which poses a major threat to the U.S. and its allies (USHOR, 2002). Some of their recent efforts have

included efforts to obtain uranium enrichment technologies and nuclear related high explosive testing. Not only does North Korea develop their own missiles, they export them to other terrorist supporting states such as Iran. They are the "largest proliferator of missiles and enabling technology in the world" and their largest markets are the Middle East and South Asia (USHOR, 2002). North Korea has made it obvious through their actions that they are willing to provide weapons to other states hostile towards the U.S.

North Korea is suspected to have begun their biological weapons program in the 1960's. Traditionally North Korea was believed to have an inferior biotechnology field. However, recently a Hepatitis-B vaccine was developed in North Korea, indicating that they possess the capability to develop sophisticated biological technologies. It is believed that the biological weapons program in North Korea focuses on "the traditional agents: plague, typhoid, cholera, anthrax, smallpox, yellow fever, botulinum toxin, and hemorrhagic fevers" (USHOR, 2002).

4.1.1.6 Analysis

Large, regionally powerful nations such as Iran, Iraq, and North Korea have the skill and desire to create biological weapons that are a threat to the United States. Iraq, one of the only nations to not offer any condolences for the September 11 terrorist attacks, is very blatant with its hostility towards America. Iraq's known ability to manufacture biological weapons and the deployment of them in Operation Desert Storm, and its support of terrorist groups makes them a possible sponsor nation. Iran is also a country that should be watched closely. Their ambitions to develop biological weapons as well as their history with the United States and support of terrorist groups makes them as much as a threat as Iraq when dealing with terror group support.

North Korea also poses a threat as a sponsor of biological terrorism against the United States. They have a history of supporting terrorism and developing weapons of mass destruction, including biological weapons. By combining their missile technology with

their biological expertise they could easily develop a weapon that could be used to support a large-scale biological attack on the United States or its allies.

Nations like Libya and Algeria should not be overlooked. They are hostile to the United States, they support terror groups, and they strive to develop biological weapons. Although their abilities are not comparable to Iraq and Iran, they should not be dismissed. It is only a matter of capital and knowledge, both of which can be obtained without much difficulty, which would allow them to make significant advances in their biological weapons programs.

If a terrorist group were to consult with and receive the aid of a nation such as Iran or Iraq, it is very feasible for them to develop a biological weapon that could be used to effect a large population of people. A terrorist group that has vast amounts of financial resources could even assist a host nation such as Libya in the creation of biological weapons.

4.1.2 Terrorist Groups

There are many terrorist groups, both foreign and domestic, that have ideological conflicts with the United States. If these groups wish to launch a biological attack on the people of the United States they would need the support of a like-minded government. Therefore, to establish feasibility it is important to link a terrorist group to a foreign government, thereby giving them the means to launch a successful attack.

4.1.2.1 Objectives of Terrorist Groups

Not long after the destruction of the World Trade Center in New York City, it was discovered that the responsible party was the al Qaeda terrorist network, an organization with the now infamous mastermind, Osama bin Laden. We can gain some insight into the motivation behind this atrocity if we take notice of a statement issued by al Qaeda urging a "Jihad against Jews and Crusaders" in February 1998. In this statement the order was given to all Muslims that "to kill the Americans and their allies -- civilians and military --

is an individual duty for every Muslim who can do it in any country in which it is possible to do it." Al Qaeda goes on to say:

> if the Americans' aims behind these wars are religious and economic, the aim is also to serve the Jews' petty state and divert attention from its occupation of Jerusalem and murder of Muslims there. The best proof of this is their eagerness to destroy Iraq, the strongest neighboring Arab state, and their endeavor to fragment all the states of the region such as Iraq, Saudi Arabia, Egypt, and Sudan into paper statelets and through their disunion and weakness to guarantee Israel's survival and the continuation of the brutal crusade occupation of the Peninsula (Terrorism Research Center, 2002).

Al Qaeda views the U.S. as antagonistic, conflating the United States' presence in the Middle East with that of the Crusades of ancient times. When Saddam Hussein invaded Kuwait in 1991, American military forces were invited into Saudi Arabia and allowed to establish bases throughout the country. It was at this time that al Qaeda took up its more aggressive posture against the United States. Al Qaeda felt that the idea of a foreign power with no particular allegiance to the Muslim faith residing in the lands of some of their holiest sites was an unforgivable crime. Up until the time of the Gulf War the primary consideration of the al Qaeda network was the perceived influence of the United States on the Egyptian and Saudi governments and these governments shift away from Islamic law (Time, 2002). This shift in al Qaeda's priorities clearly demonstrates the importance of the religious sites. A brief discussion of the establishment of the holy sites and the reasons for their holiness is worth exploring.

The prophet Muhammad was born in the year 570 A.D., in Mecca, Saudi Arabia. He was a spiritual man who meditated often. It says in the *Quran* that he ascended Mount Hira where he was visited by the angel Jibreel who revealed to him that he had been chosen as a prophet. The word of God was dictated to him and Muhammad began to preach the monotheistic faith to a largely polytheistic society. The people of Mecca found his ideas attractive and he began to amass a large group of followers. The powers that controlled Mecca at the time were threatened by Muhammad, so in fear of his life he fled to Medina. In Medina his followers swelled in number and Muhammad returned to Mecca as a

conqueror. It is for this reason that both Mecca and Medina are two out of the three holiest cities of the Muslim faith (BBCi, 2002).

When Muhammad died in 632 A.D. the era of the Caliphates began, a Caliph being a leader of the Muslim community. Under the leadership of the Caliph, the Muslims conquered Damascus, Jerusalem, Cairo, and Alexandria as well as other ancient cities. In the year 691 A.D. the Dome of the Rock was completed in Jerusalem on a site that Muslims believe marks the location that Muhammad ascended to heaven. This is a very important religious site, ranked third in importance in the Muslim World (BBCi, 2002).

At this time the state of Israel, a Jewish state, is in control of the Holy Land. Terrorist organizations aggressively challenge Israel's control over the region. These groups believe holy sites should be under Muslim control. They also dislike the idea of Americans taking hold in Arab lands, a phenomenon they believe is taking place now and must be stopped at all costs. Terrorist groups have formed in the Middle East that are linked by their intense resentment of what they believe to be the Jewish occupation of the Holy Land and a strong urge to convert the populace of the world to Islam. The United States of America has historically been a strong supporter of the state of Israel for many complex reasons, one of them being that it is the only democratic country in the region. Terrorist groups believe that this support cannot go unpunished and conflate both countries as a common enemy.

4.1.2.2 Descriptions of Terrorist Groups

All of the groups discussed below were chosen because of their strong ties to foreign governments that have the capability—or actively seek the capability—to produce weapons grade biological agents.

Al Qaeda (The Group for the Preservation of the Holy Sites) was established in 1990 by Osama bin Laden to bring together Arabs that fought against the Soviets in Afghanistan. One of their goals is to "establish the Muslim state" throughout the entire world

(USDOS, 1999). Al Qaeda is responsible for the bombings of U.S. embassies in Nairobi, Kenya and Dar Es Salamm, Tanzania. They also claim to have shot down U.S. helicopters and killed U.S. serviceman in Somalia (USDOS, 1999). In recent years they have bombed the USS Cole and the World Trade Center. After September 11 the Pentagon set up a secret unit to help find the links between Iraq and al Qaeda (Woodward, 2002).

A different group with similar ideologies is Hamas, formed in 1987 with the express goal of destroying the state of Israel and erecting an Islamic Palestinian state in its place. This is a primarily clandestine organization, though they sometimes operate openly in mosques to recruit members and raise money. They are responsible for numerous attacks on Israeli civilian and military targets and in the past they have received funding from Iran and Saudi Arabia (USDOS, 1999).

Hizballah (Party of God) was formed with the intention of creating an Iranian style Islamic republic in Lebanon and hopes to expel all non-Islamic influences in the Middle East. This group is responsible for many anti-U.S. attacks, including the bombing of the U.S. Embassy and U.S. Marine barracks in Beirut in 1993. Western hostages have also been taken by elements of Hizballah. They have received aid in the past form Iran and Syria (USDOS, 1999).

The Fatah Revolutionary Council came into being as a result of a split with the Palestinian Liberation Organization (PLO). They have committed acts of terrorism in over twenty countries including the United States, Britain, and Israel. They are responsible for killing or injuring over 900 people. Among their crimes is the hijacking of Pan Am flight 73 in Karachi in 1986 and the City of Poros day-excursion ship attack in Greece in 1988. They have also killed major figures in the PLO. They have received aid in the past from Iraq, Libya and Syria (USDOS, 1999).

4.1.2.3 Analysis

It has been shown that control of holy sites is one of the primary motivations for terrorist activity. Furthermore, terrorist groups have the backing of large governments, so it is entirely possible that we will see a shift in the scale of terrorist attacks.

Al Qaeda has already shown that it has the ability to kill thousands of Americans. If they had the proper resources they would be capable of perpetrating an attack on an even larger scale than the World Trade Center attacks. At the very least we know that they are capable of planning an operation of a certain logistical complexity. That planning ability can be used to new and more severe ends.

Hamas has not shown as keen an interest in the United States as has Hizballah. Hizballah has attacked American targets in the past and their allegiances with Iran and Syria could give them the capability to attack the United States on a larger scale.

Fatah's link to Iraq gives them access to the enormous amount of resources of the Iraqi government. An antagonistic relationship has existed between the United States and Iraq ever since the Gulf War and Iraq has demonstrated its willingness to support terrorist groups.

4.1.3 Weaponization

Although weaponization has many facets, the complexities of which are beyond the scope of this project, our focus is on the particular aspect of growing microbes. In order for a pathogen to be used as an instrument of terrorism, it must first be modified into a suitable form so that it may be used as a weapon. Proper equipment and expertise are necessary to mass-produce the pathogen for large-scale operations.

4.1.3.1 Preparation

The first step in the creation of a biological weapon is to acquire a sample of the agent. In some cases, this is fairly simple. *B. anthracis* can be gathered from sheep's wool, and

F. tularensis can be isolated from sewage. Once gathered, however, it is necessary to refine the microbe for more potency in order for it to be an effective weapon. Other agents are considerably more dangerous to work with. Ebola, for example, requires extremely careful handling. The virus is most abundantly found in the blood of people who have contracted the disease. However, even the slightest contact with contaminated blood or other bodily fluids is sufficient to cause an infection. Early outbreaks of the disease in Africa were spread by the sharing of needles and the failure of hospital workers to use gloves. Isolation of Ebola requires great care to avoid accidental spread of the disease (Perry and Fetherston, 1997).

Smallpox presents its own special difficulties. Since the World Health Organization's vaccination initiative eliminated smallpox from the natural environment in 1978, the only place it can be found is in government laboratories. In 1972, immediately after signing the Geneva treaty prohibiting biological warfare, Russia violated the treaty and began an aggressive covert research and production program to build massive stockpiles of biological weapons, including smallpox. When the Soviet Union collapsed in the early 1990's, many scientists defected to other nations as their programs were disbanded. According to members of the Soviet biological arms program, security around the production laboratories was very poor due to the poor economic conditions in the country. Whether or not any samples have been acquired by terrorist organizations is unknown (Otterholm and Schwatz, 2000).

Once a sample of the agent has been acquired, the next step is the mass production of the agent. This requires a great deal of large equipment, as well as space to store the equipment. Large vats, such as those used in breweries, are ideal for growing large quantities. Other equipment for preparation of the agent, such as desiccators to dry the bacteria and form them into spores, centrifuges for cell separation, and other laboratory essentials, are easily available through companies that deal in laboratory supplies. Since September 11, many governments are monitoring the sale of equipment for large-scale bacteria production. Old, second-hand equipment is also a viable option (Siegrist, 1999).

4.1.3.2 Implementation

The next step is the preparation of a delivery vector: a way to infect the victim with the agent. There are various methods of accomplishing this; we focus on aerosolizing, a process that enables the agent to be carried through the air on minute water particles and inhaled. Aerosols are the preferred vector of biological attack because they lead to infections of the lungs, which are difficult to treat. Assuming that the agent is still alive and viable, it will be delivered into the delicate lung tissue, where the body cannot easily resist infection. The particles must be very small, between one and five microns in order to be inhaled (Cieslak and Eitzen, 1999).

Anthrax spores are an ideal bio-terrorist weapon. When *B. anthracis* is deprived of nutrients, the cell surrounds itself with a protective coating and shuts down its metabolism. These spores are highly resilient to heat, dryness, and even radiation. More importantly, the spores cannot be digested by macrophage white blood cells. The spores use the macrophages as carriers to enter the lymphatic system (CDC, 2002a).

Once the spore detects a sufficient amount of nutrients, the spore germinates and resumes growing. Spores of anthrax are light and small, and can be easily dispersed. Crop dusting planes could be used to drop the spores over a high-density population area. On a calm night, 100 kilograms of anthrax spores dropped on a city could kill between one and three million people (Pike, 2002). The cloud of spores would linger in the area until a strong enough breeze blows them away, eventually dispersing the cloud (Kortepeter and Parker, 1999).

4.1.3.3 Analysis

Biological weapons are exceptionally dangerous, yet relatively easy to produce, compared to other weapons of mass destruction. A small facility with a minimal staff can produce biological weapons. The knowledge required to process and reproduce pathogens is taught in some college-level microbiology programs. This information could

then be expanded and adapted to weaponizing particular biological agents. The possibility that a terrorist group could be in possession of a biological weapon or have the means to produce it is very high.

The best defense against biological weapons is to prevent them from being deployed or developed. In order to protect national security, we must be aware of the possibility of a bio-terrorist attack. The Federal government, especially the FBI, is currently tracking all purchases and transfers of laboratory equipment that could be used to produce biological weapons. However, this is only effective in the United States. Other nations would have to participate in the same program for it to be effective worldwide. Unfortunately, countries such as Iraq and Iran will either not participate or they cannot be trusted. Intelligence on hostile nations and their capacity to produce biological weapons is also essential.

4.2 Response

In the event of a biological terrorist attack on the United States, the government would bear the weight of the initial response. They would be tasked with gaining control over the situation, search and rescue of casualties, and law enforcement. The medical community is tasked with providing treatment for casualties.

4.2.1 Bio-Detection

One way to counter biological terrorism is the development of bio-detection equipment. Bio-detection equipment is used to detect biological agents of any type in the field or in the laboratory. Because the equipment used covers a very broad range of agents and applications, it must be a diverse set, or one advanced piece of equipment which can detect all agents at various levels in the environment.

For field use there are primarily two types of bio-detection devices used: Real-time Polymerase chain reaction (PCR) devices and Enzyme-Linked ImmunoSorbant Assay (ELISA) devices. PCR devices are the more sensitive of the two and can identify an agent

with as little as one to ten organisms. The ELISA devices are slightly less sensitive and are primarily used for detecting proteins. They can generally identify an agent with more than a hundred organisms (Chue, 2001).

ELISA is a test to detect the presence of a specific protein. It is used to detect the presence of a pathogen in a patient's body after exposure by assaying for the presence of antibodies against the pathogen. If a patient is producing the target antibody, then he has been exposed to the pathogen. ELISA can be used to confirm a diagnosis of a specific disease (University of Arizona, 2002). An ELISA consists of a grid of 96 well plates that have been coated with a protein that binds to the target antibody. Blood serum containing antibodies are then added to the wells. The antibodies bind to the protein coating, adhering to the bottom of the wells. After an incubation period, the wells are washed with a buffer solution to remove any weakly bound antibodies. To detect the bound antibodies, the wells are treated with a second antibody, which contains an enzyme. The wells are washed again, and finally treated with an enzyme substrate. When the substrate reacts with the enzyme bound to the second antibody, it produces a yellow color. The plate is then read for optical density to analytically determine the concentration of the primary antibody (Davidson College, 2002).

PCR is a procedure used to amplify a small sample of DNA. The initial sample of DNA is treated with primers, short sequences of DNA that are complimentary to the sample DNA. A heat-resistant DNA polymerase enzyme called *Taq* polymerase is then added. Finally, DNA bases, deoxyribose, and phosphate ions are added to the solution (Cooper, 1997).

The solution is heated to 95 degrees Celsius to separate the two strands of DNA. The solution is then cooled rapidly down to 55 degrees Celsius. After cooling, the primers bind to the separated strands, and *Taq* polymerase builds a complimentary strand from the available DNA components in the solution. The DNA sample is amplified exponentially over a period of about thirty cycles. Even a single DNA molecule can multiply into over one billion during a thirty cycle PCR. PCR is a key bio-detection

assay because it can pick up even the slightest traces of dangerous agents and amplify them (Herington, 2002).

There are currently many different companies manufacturing bio-detection equipment, some with more success than others. One of the more successful companies is Cepheid, based in Sunnyvale, CA. They manufacture a device called the Smart Cycler, which is a real-time PCR device. Cepheid claims that "[real-time PCR] is more sensitive and specific than other analytical methods, and can provide results in under 30 minutes" (Cepheid, 2002). Another company that manufactures various pieces of bio-detection equipment is Tetracore, Inc. One of the devices that they manufacture is called the Bio-Threat-Alert test strip. A specific test strip is made for each of the agents that they are designed to detect. Test strips are available for Anthrax, Plague, Botulinum toxin, Tularemia, Ricin toxin, and Staphococcal entertoxin. According to Tetracore, the Bio-Threat-Alert test strip for Anthrax is the "first antibody-based anthrax test demonstrated anywhere in the world that does not cross-react with commonly-available bacterial strains." The Bio-Threat-Alert test strip provides "visual results in 1-15 minutes" (Alexeter, 2002) which means that almost instantly the results for the test are going to be available. The Bio-Threat-Alert test strip can also be used in conjunction with a device called the BioCapture Air Sampler, from Mesosystems. The BioCapture Air Sampler is a "high-efficiency aerosol collector/concentrator with the capability to automatically add sampled particles directly to a Bio Threat Alert Test Strip" (Alexeter, 2002). According to Dr. Calvin Chue of the John Hopkins Center for Civilian Bio-Defense, despite these companies' claims of near perfect accuracy, none of them can claim that their devices are going to be one hundred percent accurate all the time.

Different strains of anthrax exist naturally in the environment, at different levels of potency, almost everywhere in the world. One of the problems with bio-detection equipment is the degree of sensitivity. If a device designed to be used in the field is too sensitive, then naturally existing environmental contaminants can cause false-positive results. However, this is not the primary concern. The real problem are agents that are at a lethal level which yield false-negative results (Chue, 2001).

The recognition of specific strains of agents in the field is not really an issue, as long as there is prior knowledge that a specific agent is in the area. Once an agent has been detected, the samples can be taken to a lab and the specific strains can be determined. Recognizing specific strains is important in order to identify who has launched an attack, or at least the source of the agent. Comparing the strain from the attack with a list of known strains throughout the world, as well as with strains that have been used in previous attacks, can help identify the source of the attack. The most accurate way to identify the strains is to do genomic comparisons (Chue, 2001). Currently there are laboratories in the U.S. that do these specific genomic comparisons, primarily the Los Alamos National Laboratory and Martin Hugh Jones Laboratory at Louisiana State University.

4.2.1.1 Analysis

The field of bio-detection has become very important to the safety of our country. Bio-detection equipment plays a key role in quickly identifying possible agents in the most accurate and precise ways possible. While some great advances in bio-detection have been made in the past few years, field equipment is still technologically deficient. Some of the devices that can quickly recognize agents, such as the Bio-Threat-Alert test strip, require relatively large amounts of biological material to give a correct result. They are highly specific to the agent that they are designed to recognize. While the Smart Cycler from Cepheid is a versatile device, they cannot claim 100% accuracy on the results.

4.2.2 Medical Response

The first problem in medical response to a bio-terrorist attack is diagnosis. The first few people to show symptoms of many of the agents discussed in this paper are likely to believe that they have the flu. Hospital workers who are untrained in detection of agents such as anthrax and smallpox would likely arrive at similar conclusions. This is the first sign of a bio-terrorist attack: a sudden, localized surge of people with severe, flu-like symptoms (CDC, 2001a).

Once a patient is suspected of having a bacterial infection, antibiotic treatment is the next line of defense. Other people in the same area of the outbreak are also given antibiotics as a precaution, in order to prevent them from developing a full-blown infection. This practice is called prophylaxis. While this treatment may prevent some people from developing symptoms, it also creates the possibility of the bacteria developing a resistance to the antibiotic. This occurs as a result of mutations in the bacteria's genome. Mutations are rare, occurring about once in every million base pairs. Mutations are essentially random in nature, many of them of no consequence. However, bacteria multiply so quickly, about 20 minutes a generation, that there is a chance of a bacteria developing a beneficial mutation. The antibiotic-resistance gene can then be shared with other bacteria and the new strain continues to spread. In order to curb the spread of antibiotic-resistant bacteria, it is necessary to use antibiotics responsibly (Levy, 1998).

Viruses are a different challenge. There is no practical treatment for a viral infection besides bed rest and supportive nursing care. Anyone who has been infected with a highly infectious virus such as smallpox would need to be isolated. People who have come in contact with the patient would have to be quarantined, details of which will be discussed in a subsequent section.

In the event of a large-scale bio-terrorist attack, the resulting surge on hospitals would be overwhelming. To project the impact of a bio-terrorist attack on hospital capacity, we examined Boston, the nearest major city in our area. Boston claims the sixth highest population density in the country: 11,398 people per square mile (Microsoft Encarta, 2002). Like most cities, Boston is a major commercial center, populated with skyscrapers such as the John Hancock Tower, the State Street Bank, and the Prudential Center. The FleetCenter and Fenway Park, home to three of the region's professional sports teams, also reside in the city. Boston is very well known for its medical community. The following is a list of hospitals in the city of Boston that have general infirmary care available and the number of beds for each hospital (Massachusetts Medical Society, 2000).

Beth Israel Deaconess	1406
Boston Medical	800
Brigam & Women's	702
Children's Hospital	325
Mass General	832
New England Baptist	141
New England Medical Center	429
Total	4635

There are a total of 4,635 beds for the city of Boston, which has approximately 600,000 people. If only one percent of the population of Boston were to be infected, they would overwhelm the local hospitals. An attack on an area of high population density, such as a mall or a stadium, could reach this number (Massachusetts Medical Society, 2000).

Few doctors and nurses have any experience treating the Class A diseases discussed in this paper. Even fewer could make an accurate diagnosis if they saw them. The main reason for this is not lack of skill, but a lack of preparation. Class A diseases are rare, most doctors do not consider them when making a diagnosis (CDC, 2001a).

Vaccines are another possible defense against disease. A vaccine is a solution of viral or bacterial proteins or DNA that is injected into the patient. The patient's macrophage leukocytes, also known as white blood cells, consume and digest the proteins. The macrophages then produce killer-T leukocytes, a specialized type of immune cell that are programmed to recognize the virus or bacteria that produces those proteins, and neutralize them. The CDC currently has a stockpile of about 15 million doses of smallpox vaccine. In the year 2000, the CDC contracted pharmaceutical companies to resume production of the vaccine in order to build the stockpile. There are also plans to produce another round of vaccinations to protect the current generation from smallpox. However, a small percentage of the population would be at risk. In approximately 1 out of 300,000 cases, the vaccine causes encephalitis, an infection of the brain. About one-

fourth of these cases are fatal. It is projected that about 300 people would die as a result of such vaccine complications if the entire population of the U.S. were to receive the vaccine (Medical Society of New Jersey, 2002). Due to the large time frame required to produce vaccines for the entire population, as well as the uncertainty of whether a terrorist group actually possesses smallpox, it may be advisable to reserve the vaccines for an actual attack.

4.2.2.1 Analysis

The CDC's National Pharmaceutical Stockpile is the nation's best hope for early containment and treatment of an outbreak. It is imperative for the United States to continue to build its stockpile of antibiotics and vaccines, and to develop a feasible plan for the delivery of these medicines into infected areas.

While the current medical infrastructure is sufficient to respond to a small, localized outbreak, a large-scale bio-terrorist attack would be devastating to the medical community and its resources. All major cities must be prepared in the event of a bio-terrorist attack. Each city should have a plan to deal with the masses of infected citizens so they do not overwhelm the local hospitals. Hospitals need to develop a surge capacity in the event of a sudden mass outbreak of infections caused by a large-scale bio-terrorist attack.

4.2.3 Government Response

The United States Public Health Service, Office of Emergency Preparedness (USPHS/OEP) has developed a locally available Nuclear/Biological/Chemical incident (NBC) response team that can be mobilized and integrated into the Federal and State/Local governments in the event of a NBC terrorist attack. This team, called the Metropolitan Medical Response Strike Team will work with the on-scene Incident Commander to coordinate efforts in dealing with a NBC terrorist attack (USDOHHS, 1998).

4.2.3.1 Integration with Federal Government

In the event of a NBC terrorist attack, the supreme authority is the Federal Bureau of Investigation (FBI). However, during the response and rescue phases the FBI will work in a unified command structure with the Incident Commander and Metropolitan Medical Response Strike Team. After all treatable victims have been removed from the scene, the FBI's selected Special Agent in Charge on the scene will then take responsibility and all local responders will operate under their command (USDOHHS, 1998).

Any Department of Defense assets that can be utilized in a NBC attack, such as the Chemical/Biological Incident Response Force and anti-terrorist units within the military, can only be activated by another Federal agency. Due to the preparation time required for these teams, they will need to be activated early in the event so that they can respond in a reasonable amount of time (USDOHHS, 1998).

During the response of an attack, once the Attorney General has determined that law enforcement goals have been met and objectives have been set, the Federal Emergency Management Agency (FEMA) will be given control for consequence management and public safety responsibilities. FEMA will have control of Federal resource management and also the responsibility to activate urban search and rescue when indicated (USDOHHS, 1998).

The Centers for Disease Control and Prevention (CDC) is a major factor in the response to a biological attack. Due to their superior knowledge of diseases and biologics, the CDC would be notified as early as possible in the event of an attack. Communication links would be established immediately for rapid medical consultation and transfer of information. The CDC will be able to consult on decontamination, medical intervention, vaccines, and antibiotics, and they also have a response team that could be sent to the site in some time (USDOHHS, 1998).

The Environmental Protection Agency would also have a role in a responding to a biological attack. The EPA primarily deals with the long-term remediation and decontamination of the attack site, which would be coordinated with other Federal and State agencies (USDOHHS, 1998).

4.2.3.2 Integration with State/Local Government

Because the severity a biological terrorist attack poses to a population and the country, the Federal government would have ultimate control in such an event. The State/Local governments would be more or less supporting the Federal response and offering services that the Federal government needs assistance with. After an attack has occurred and the local responders have requested a Metropolitan Medical Response Strike Team, State services will then be notified via 911 or a local emergency management agency. State/Local law enforcement will be tasked to assist the Strike Team Commander in order to accomplish the objectives set by the team and to help with on-site enforcement. The medical community in the state will also assist the Response Strike Team and will be under the guidance of the Federal government (USDOHHS, 1998).

4.2.3.3 Analysis

As evidenced by the exercise *Dark Winter*, conducted by Johns Hopkins Center for Civilian Bio-defense Studies, there are many issues that need to be addressed before an actual event occurs. In *Dark Winter*, conducted on June 22nd and 23rd, 2001, on Andrew's Air Force Base, the United States is subject to a simulated biological terrorist attack. The exercise was conducted in three segments: segment one consisted of Iraq mobilizing its biological weapons program and taking offensive positions along the Kuwaiti border, along with 20 smallpox cases in Oklahoma. Segment two, six days in the future, featured 2000 cases in 15 states, along with cases in Canada, Mexico, and the United Kingdom. Borders were closed, vaccine supplies dwindled, and some racial violence occurred against Arab-Americans. Segment three, the last segment seven days later, had 16,000 cases in 25 states with 1000 deaths, predictions of 300,000 victims with a 33% death rate, vaccines completely diminished, and the nation plunged into an emergency situation. The

participants learned in *Dark Winter* that Federal and State/Local authorities quickly develop tension between each other. State leaders and Federal officials were constantly at odds with each other over how to control the situation (i.e. shutting down borders). In this scenario, the leaders in states that had massive smallpox casualties requested vaccines for all their citizens, however, the Federal government needed to balance the vaccines amongst other federal priorities. The issue of federalizing the National Guard was also struggled with between State and Federal leaders (Johns Hopkins, 2002a). It is widely known that logistics wins a war; the same applies in this situation. If the State and Federal authorities and leaders cannot cooperate and act as one cohesive unit, then when a large-scale attack does occur there will be many casualties that did not need to happen.

4.3 Quarantine

Quarantining a population can be a very volatile situation. To quarantine a group of people not only requires isolating those that are currently sick, but it also requires sequestering those who may have been exposed. Businesses will be required to shut down, armed guards will be deployed to patrol the streets, and people will not be allowed to leave their homes. Anyone violating the quarantine will be sent to jail and in the extreme case where a quarantined person is resisting or escaping they may be taken with deadly force. Due to the current attacks on the United States with anthrax and the possibility of an attack using smallpox, the use of quarantine in response to a potential attack has begun to be considered. A relatively famous outbreak of smallpox resulted in a quarantine of the town of Muncie, Indiana in 1893. Many neighborhoods were essentially shut down, with residents confined to their homes and armed patrols in the streets. Some people resisted and unfortunately several people were shot (Tanner, 2001).

In addition, quarantine also poses the danger of exposing those that are not infected. This could create more casualties that would overwhelm the medical system. In order for the quarantine to work it would be necessary to ensure that the area is kept clean and safe and that adequate care and support is received (Barbera, 2001). Many doctors and public health experts recommend against quarantine except in the direst situation, one of their

arguments being that smallpox is infectious before any symptoms are shown. This would mean that infected people could have traveled in the time it took for them to have symptoms and for the quarantine to be put in place. This would continue to spread the smallpox and therefore nullify the quarantine. History is also used to show that quarantines have been destructive to people and economies. In 1900, plague broke out in San Francisco, quarantine was imposed on a Chinese neighborhood, and subsequently thriving businesses were hurt or destroyed (Tanner, 2001).

4.3.1 Analysis

Instead of quarantine, selective isolation may be a better strategy. Isolation would take only those that are infected or have a high possibility of being infected and remove them from the population for observation and treatment. This would help curb the effects of quarantine and hopefully not damage the economy and spirit of the people as much as a full quarantine would. A full quarantine should only be used in a massive casualty situation where isolation would have no effect. There are dire consequences to this route, but it may be necessary to prevent further mass casualties.

5. CONCLUSIONS AND RECOMMENDATIONS

The threat of bio-terrorism is real in America today. We have examined the history, feasibility, and response to a large-scale bio-terrorist attack. While the best defense against bio-terrorism is to prevent attacks before they happen, this is not always possible. The United States must be prepared for a bio-terrorist attack, and in order to save lives there must be swift reactions and smart decisions.

There are a number of countries throughout the world that are potential sponsors of biological terrorism. Countries of significance are Iran, Iraq, and North Korea. Iraq was one of the only nations that did not express sympathy to the United States after the September 11th, 2001 attacks. Iran and Iraq have a history of supporting terrorism and groups hostile to the United States. Iraq possesses the technology to manufacture and deploy large-scale biological weapons, while Iran is progressing. North Korea also has a history of belligerence with the United States, as well as a history of sponsoring terrorism. Because their biological weapons programs are in the early stages of development or are non-existent, countries such as Libya and Algeria do not pose as high of a threat.

Several terrorist groups throughout the world are known to be hostile towards the United States. One of the main sources of anger towards the U.S. by these terrorist organizations is the control of their holy lands. The al Qaeda terrorist network is hostile to the United States. As the perpetrator of the September 11th attacks, al Qaeda is a threat that has to be taken very seriously. With the support of a state willing to sponsor terrorism, al Qaeda could become a greater threat. The terrorist group Hizballah has attacked American targets in the past with the goal of expelling all non-Muslim influences in the Middle East. Their links to Iran could give them the capability to launch a biological attack against Americans.

Biological weapons can be manufactured with greater ease than other weapons of mass destruction. The costs, space, and level of expertise is relatively low when compared to nuclear or chemical weapons. Biological weapons are being developed by potentially

hostile nations and these weapons may be used for terrorist purposes. The best prevention against bio-terrorist attacks is a proactive intelligence program to track the production of biological weapons and the equipment used to produce them.

It is necessary to gather information on nations and organizations that have access to biological weapons and have demonstrated a willingness to inflict harm on Americans or to support groups that are willing to do so themselves. Human intelligence is a very important asset that was cut severely after the end of the Cold War. Infiltrating terrorist groups and hostile governments can provide enormous amounts of information. As demonstrated by the ousting of the UNSCOM teams from Iraq, current diplomatic methods have not worked. It may be necessary in the future, if there is sufficient intelligence, to preemptively strike facilities or terrorist groups that are being readied for an attack on the United States. However, this is not always possible as intelligence operations are not always successful. If intelligence operations are unsuccessful, the problem is no longer one of preventing an attack, but of responding to one.

In the event of an attack, bio-detection is important to response. Equipment has been developed that can recognize biological agents in the field in less than fifteen minutes. Current devices can lead to quick recognition of the agents used in an attack, however, no technologies exist to preemptively detect such an attack. Field bio-detection equipment has greatly improved since many of the technologies were first used in the Gulf War. Before the equipment can be considered reliable, more time and capital needs to be put into research in this area.

In the event of a bio-terrorist attack, a quick response can save lives. Currently, the Federal government and most State/Local governments have response plans for a biological attack. Federal agencies must effectively coordinate their plans with other response teams, such as the FBI, EPA, and local police forces in order to mount an effective containment plan. However, collaboration between response teams is flawed, as evidenced by the exercise *Dark Winter*; there needs to be better organization in the event that a large-scale attack does occur.

The medical community is currently not prepared for a large-scale bio-terrorist attack. Hospitals will be overwhelmed with a surge of patients from a large-scale attack, however, smaller hospitals surrounding large cities could be used to lessen the impact. Quick diagnosis and treatment can save lives. Doctors must be aware of the possibility of bio-terrorism and know how to recognize the signs. Smallpox is the most glaring example of the medical community's lack of preparedness. Few doctors are trained to recognize the rash caused by the initial stage of smallpox infection, and even fewer medical schools teach their students these symptoms. Smallpox is considered to be extinct in civilization, however, there are still samples of the virus in existence.

The CDC's National Pharmaceutical Stockpile program is a proactive measure for bio-terrorism preparedness. A government stockpile of antibiotics, vaccines, and medical supplies spread through out the country in strategic locations, in order to minimize response time to an outbreak, is crucial to reducing the fatalities of a bio-terrorist attack. There is no way to predict where a bio-terrorist will strike. The National Pharmaceutical Stockpile can move supplies to areas of a bio-terrorist attack quickly in order to re-supply or supplement local reserves of medicines. This plan has the potential to save lives due to the unpredictability of a bio-terrorist attack. It is necessary to continue to build our stockpile of antibiotics and vaccines to ensure a fast response.

The best-made plans of defense and security are only plans until they are put into action. Dealing with deadly biohazards can be very demanding, both physically and psychologically. Task forces that will be exposed to the areas of a bio-terrorist attack must continue to be trained to handle these deadly pathogens. Our forces must run more practice trials to make sure that they are equipped to handle these situations.

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APPENDIX – Dr. Calvin Chue Interview Transcript

An interview was conducted with Dr. Calvin Chue, a research scientist at the Johns Hopkins Center for Civilian Biodefense in Baltimore, Maryland on October 25, 2001. The following is a transcript of a taped interview.

AF = Andrew Frankenthal
CC = Calvin Chue
WW = William Woerter

AF: OK First of all, we want to know are you more interested in field biodetection or lab biodetection, what do you primarily deal with.

CC: Primarily I deal with the field detection equipment, real time detection on site.

AF: Real time detection on site

CC: Prior to coming here at Hopkins I was working for the DOD as a consultant and we would develop the assays for real-time PCR, ELISA's, we developed recombinant anti-bodies, things that go into the field tests, we would also go to field trials and evaluate the military devices from other institutions to see how they were effective. The Gulf War didn't actually have any effective equipment, it wasn't until after the Gulf War that we began developing much more effective equipment, cause we saw what the limitations were and began trying to compensate for those.

AF: What were those limitations?

CC: Well there wasn't anything that was specific or sensitive enough, so there weren't good environmental studies, because a lot of the assays back then, and still now, would cross react with a lot of normal environmental bacterium. Bacillus anthraces is one of the biggest problems of course, members of the Bacillus genus are all pretty homogenous. I think, uh, in the seria subgroup (?) alone they are about 98% homologous, or, even identical in most of their proteins, and so all of the tests that we do now do have some level of cross reactivity, especially for the anti-body based tests. When they went to the Gulf, a lot of the test just kept coming up anthrax positive all the time, and there was a normal environmental Bacillus, Bacillus therogensis (garbled) strain that was found there that kept giving these false positives, so, when it came back from the Gulf War, it was decided that new tests had to be developed, and that was when the small hand held assays were developed by the US Navy under the command, uh, of Jim Buerens, he developed those first because he saw a need for a rapid, small, similar to a home pregnancy test kit. But we knew that would be a strong limitation in that they're not very sensitive, they are only designed for detecting large amounts of biological development material, so we had to come up with compensatory mechanisms to back up that data that would be just as fast, so real time PCR was developed, we partnered with Alan Northrop at the, he was then, at the Lawrence Livermore National Laboratories, he now has founded the company Cepheid, that manufactures real time PCR devices, so we did real time PCR with that

device, the Light Cycler, and a machine from Arjen Incorporated called the IGen, much of this was written up in "The Hot Zone", I think, by Richard Preston, these devices that we used in the field, he called it the Felix, uh then, the machine is an IGen machine.

AF: Ok, we were reading an article where you are quoted as saying that there are lots of people making lots of claims about what their devices can do, and it's hard to say who has effective equipment.

CC: The problem is, so after '93, we began conducting joint field trials to test the efficacy of the environmental samplers and field testing. I think they are up to joint field trial 6 now, so it's conducted every year, and the best companies' technology are brought together in a single location and we test them, with simulants and sometimes the real thing to see how effective they are going to be and the other organizations now who are coming out of the woodwork saying that they have these new tests are primarily basing them on their capabilities for clinical lab detection, but the clinical lab detection needs are a little different than military, plus none of them have ever had to deal with the problem of environmental contaminants and so they can't make the claim that they are going to be 100% accurate. Maybe for clinical detection, they might be, but not for in the field detection if you swab a surface of some sort.

AF: When you say joint trial, you mean a trial that...

CC: Joint field trials, they are conducted by all the military organizations that are associated together and they invite people that are contracted through different military organizations to come and work.

AF: Ok. So, you'd say that the largest problem is this whole problem of contaminants when you're in the field.

CC: Contaminants are a big problem, false negatives are a big problem, the sensitivity of the devices they vary. PCR devices are incredibly sensitive we can pick up as little as one to ten organisms. Elisa devices are somewhat a little less sensitive and we are looking primarily at proteins, they may not be able to pick up, eh you know, at around a hundred organisms depending on what we're looking for specifically. False positives are not as big a problem because obviously you may test positive at first, we'll start treating people we'll find out it's negative later ,that's fine, no harm no foul. False negatives however are the huge killer, if you test it, nothing comes up, but it turns out to be the real thing, there is no device that can claim that there is no false positives possible with that particular device and so we're hesitant to say that people start using something until we can prove absolutely that you will never get a false negative.

AF: On a more biological note...how are these...it's critical that they identify what strains...

CC: That's less important for the initial detection, but it is important from a perspective of tracking who might have been responsible for this act.

AF: And how are strains identified in the lab?

CC: Well right now there are a couple of different ways, the most accurate way is to do genomic comparisons and there is a laboratory, two laboratories that I know of that are doing that primarily, Los Alamos national labs , Paul Kaim and Paul Jackson, working together between Arizona State and Los Alamos and Martin Hugh Jones lab at LSU, in New Orleans.

AF: They're both doing genomic?

CC: They both do genomic analysis, they compare sequences and they look at proteins that are conserved within the chromosomal DNA of the bacterium and look for small changes, point mutations that sort of thing. In the normal laboratory the strain typing is done by looking at metabolic changes, so you would grow things out and you would look for metabolic growth , phenotypic changes between different strains. Which is how they were originally identified in the old days, but with these DNA technologies we can identify things down to nucleotide changes which is far more specific.

AF: And is it faster?

CC: Relative...it depends how many things you're trying to compare to, how many sequences you want to do but yes it is somewhat faster than growing things out. Although microbiology technology has caught up a good bit as well. In the old days we would have to plate things out one by one onto different kinds of media, new devices such as the VDL crystal or the Biolog or the Bitech systems managed to put hundreds of metabolic test onto a single plate which allow you then to place one bacterium on them and see how they behave metabolically and a machine reads them all at once, so that takes much less time then the old days plus you need much smaller amounts of bacteria.

AF: When we say in the old days, how long ago are we talking about?

CC: Five, six years, I mean those devices have made there way into the clinical laboratories for hospital detections, it speed things up tremendously, although many hospitals still do the old laborious process of one plate at a time and different media at a time.

AF: We were reading in the Christian Science monitor that biodetection devices can cost upwards of 50,000 dollars, why is it that they are so costly?

CC: Well mainly it's economy of scale, the government contracted, normally when the government requests a device they put out a proposal or requests for proposals from various companies, the various companies will decide if it's cost effective for them and then send them in. The government doesn't order ten thousand or a hundred thousand units initially, they will order a few prototypes and those prototypes are going to be expensive since most companies make them custom to he government's needs. The

price's will come down if more and more devices will be ordered. The price of a Lightcycler began at around sixty thousand dollars I believe when we first ordered this real-time PCR device and now the price is down to thirty thousand with commercialization of the item.

AF: And has there been an increasing interest in these devices since the attacks on September 11?

CC: Yes, but not necessarily for ordinary detection, I mean laboratories have moved, traditional labs have moved towards real time PCR and other rapid techniques simply because they want to cut time down in the laboratory. PCR in the old days would take two to three hours and then you would analyze the fragments on a gel. With real time PCR you don't even need to do that, you can see amplification of DNA occurring, as it's occurring in real time. SO you can base your experiments on those results much more reliably.

AF: Now, there was an attack in Russia in Sverdlosk, I'm sorry, I mean an accident. Can anthrax be used on a larger scale?

CC: It's difficult to use on a large scale, the Sverdlosk accident released about 100 Kg worth of spores because of a failure of a worker to put a filter in to place and in it washed downwind, and the environmental conditions just happened to be right for that particular day. The winds were good, it managed to carry the spores an effective distance. The one thing that we know is that the Russians never were able to make a grade of anthrax as well as the United States could, but they made a pretty good one, and so even though the estimate of 66 from the original, that was very low by Russian standards. By the experts from today believe that there were hundreds, probably that were likely ill and livestock that were killed as a result of these releases. But doing things on a large scale, this was a bio-production facility, a place that specializes in growing large amounts of bacterium and converting them into spore forms and had the resources of the Russian government behind them. Doing so today on a terrorist scale would be difficult to make 100 Kg of anthrax spores would require a fairly large fermenter, wouldn't be easy to buy initially. You couldn't do it surreptitiously, there would be some clues that an organization or individuals were trying to engage in something unusual, this so called dual use technology.

AF: What is the dual use technology?

CC: Where it has the initial purpose, for example fermenters for making vaccines can also be used for making pathogens and for warfare purposes and so orders for those things have begun to be tracked in he last few years to find out where they're going.

AF: You mentioned the wind speeds. During an outbreak are you monitoring wind speeds?

CC: I'm not involved in that particular aspect of things, but I know of organizations that have been conducting environmental modeling for some years looking at how mostly the release smoke clouds, dust particles and things, to track how they spread in an urban environment and under different weather conditions, if it's foggy, if it's a highly humid day (sound of siren), we need to have accurate models to figure out how biologicals behave. Those models are still only being compiled now. The best evidence we have, the last evidence we have from releases was back in the early 80's when the Army released Seratia Marcessus in the San Francisco area, but after two people inadvertently died, an elderly woman and a child, those were stopped, and we weren't allowed to do environmental releases anymore to simulate how things occur, so it has put, it has made it a little more difficult because we have to use simulants, something like smoke, that doesn't necessarily behave the same way as a pathogen would, or a live biological, even if it was a simulant. So that may need to be readdressed at some point.

AF: So if Anthrax is so difficult to refine, or it's becoming more difficult because we are tracking these orders, what do you think would be a likely agent?

CC: A likely agent for use?

AF: For use in a terrorist attack let's say

CC: Any of the class A bioweapons on the list from the CDC are likely. There is no single organism that's perfect for use as a bioterrorist agent, which is very good for us. There are three major issues when you want to prepare a pathogen. The first is acquiring that pathogen, the second is the propagation or stabilization of that pathogen, and the third is the dissemination. IN the case of anthrax, it's easy to get, it's everywhere the aim strain is ubiquitous to the United States and has been shipped all around the world. The propagation and stabilization is a little more difficult, because you need to grow large amounts of this stuff to purify enough spores in order to try for infection, and you have to have some expertise in the refinement of that material to stabilize it, so that it makes a spore so that it's very stable. But the third part, the dissemination, is very difficult on a wide scale, environmental factors come into play, you need to have a significant dose of spores in order to cause infection. The cutaneous anthrax is not a big danger, cause you can see a lesion, you go to a doctor, that's why it's less than 1% fatal. Inhalation anthrax requires somewhere between 8000 and perhaps up to 50000 spores depending on whose estimates you use and what you're looking at. 8000 is based on animal modeling from the army, 50000 is based on WHO's studies of people who worked in leather tanneries and goat hair factories from around the world. So that's a large amount of spores for a single person to have to breathe into their lungs and the have their alveolar macrophages internalize them and move throughout the body to the peripheral lymph nodes. So you have to get a lot into the air and you have to make sure that people breathe it in , that's really hard to do , that's why Anthrax has it's limitations as a mass weapon, smallpox however, it's really easy to disseminate , respiratory transfer in people can be less than six feet apart and transfer the infectious agent to each other. But the acquisition of that material is difficult, it's basically been eradicated from the world, there are no animal reservoirs for small pox and at the moment we believe there are two repositories for it,

one at the CDC and at Noversebersk in Russia. Some people believe that Russian scientists may have taking vials of the smallpox from Novasobersk when they left during the destabilization of the Soviet Union. We have no firm evidence of that, also would they have transported the material, if the didn't transport it well they might have become unviable when they reached there final destinations and the growth and propagation of smallpox, being that it's a virus, requires that it be grown in living cells, that requires a greater level of complexity and support than growing bacteria on media would be.

AF: You'd need a greater degree of expertise, you'd need somebody who knows a lot about it.

CC: Someone has to know how to do tissue culture, how do to viral infections, how to harvest virus, how to stabilize the virus and the right sort of formulations to release in an aerosol form.

AF: And is that something that is not commonly known, something you can't read in a textbook let's say?

CC: You can read it in a textbook but the execution is a lot different, the practicalities of day to day tissue culture and things like that you have to do in order to know how to accomplish effectively and you also have to do it , not on a huge scale, you can do it on like a medium scale since it is a fairly infectious agent. You would only need to infect a few people to spread initially.

AF: So as of right now we have these PCR assays and these ELISA assays in affect?

CC: They have been in use for the last six or seven years. They are primarily for environmental detection they have not been improved for clinical detection.

AF: So I think one of the problems as far as environmental detection is concerned is that you don't know, let's say if there is a terrorist attack you don't know where it's going to occur so you don't know were to put the device.

CC: Even if you knew were to put a device, for example , if someone were to tell you that a device were to be detonated inn this room were would place your device. If you put it high up in a corner, because the organisms require different amounts to infect an individual, Tularemia for example need only 1 to 10 organisms to infect an individual , Anthrax needs somewhere between 8000 and 50000 spores, smallpox in theory, even a single virus would be sufficient to infect an individual. That machine might not pick it up if it's in the corner and if you put it in the middle of the room, well if they detonated it in the corner then it becomes very complex.

AF: So how do we resolve this?

CC: The best way to resolve this is to prevent it at it's source and to make sure that the individuals that have the right training and background to propagate bioweapons are

ethical people that don't pass the knowledge on to folks who would use that in an unethical manner and also to prevent countries from sponsoring terrorism. Large scale release will be impossible without the resources of a large government, secure testing facilities, animals to do their initial research, you know your basic small terrorist group isn't likely to have that kind of support.

AF: So you don't think there is a technological solution to the detection side of things?

CC: Not environmental detection, it will be a long time before we have a device that is so sensitive that they could pick up any pathogen. The reason is that pathogens are very different and people can't compare this to the chemical side because the chemical side they basically fall into only two categories, your blister agent or your nerve agent, you can't really put your biologicals into that group. Even if you say bacterial versus viral versus toxin producer each organism within that family behaves very differently than the others.

AF: What do you like about the BioThreat Alert Test Strip?

CC: Well it's basically an adaptation, I believe Alex Zeter Technologies manufactures (horn) the TA Guardian and they're doing that in conjunction with Tetracore Incorporated, in Gatorsburg. Tetracore were my colleagues when I was at the Navy, so back in the early 90's when these test strips were developed we developed the first ones. None of those have been approved yet for clinical use, they are primarily for environmental detection, the limitation of them is the amount of anti-body, are you familiar with how the technology works?

AF: That was one of our questions

CC: So, it looks like a small, looks like a home pregnancy test kit, it's a white kind of stick device, it has three chambers on it. One chamber is the S, or Sample Well, which is located 3 to 4 centimeters away from the T & C, test and control Wells, so this is a nitro cellular, or some sort of nylon strip that has been dried, in the test in the control wells there are antibodies that have been dried down and adhere to a single line. In the rest of the strip you have free floating anti-bodies that have been dried down into the strip as well, you hydrate your sample in liquid, you put it into the sample well, and because the rest of the strip is dry it will begin hydrating, moving the liquid upwards. Your free antibodies will begin to combine with any antigens that are in your particular sample, this free antibody has some sort of color metric detector on it, whether it's a florescent molecule or colloidal gold, some other colored bead of some sort. It moves up the strip, and once it reaches the lines in the test and control strips, the antigen is bound in a sandwich. So you have an antibody below that captures one antigen and an antibody above that captures a second antigen and the sandwich is complete and because it's in a line the colors will coalesce or your fluorescent molecules will coalesce as we put it into a device for reading. If that sandwich is not completed, basically meaning there was no antigen to find the two antibodies you don't get a reaction in the test lane, and the control is merely to tell you that the antibodies properly react against each other. It's a different

antibody that binds to your detector antibody so no sandwich is needed for the antigen in that case, and if you have a positive strip it means that you have that antigen present. The problem with this is it's a fixed amount of antibody that's on that strip so it's designed to detect a certain amount of material and only up to that certain amount of material. At the moment it's designed to detect biologically dangerous levels of material, somewhere around the LV50 of a particular organism, so in the case of Anthrax 10,000 spores would probably set off this little hand held device, but 6000 or 7000 spores might not, so depending on how you sample, how you shaken your sample and put it in you may completely miss it. Also cross reactivity is still a problem with these because the antibody base, they may cross react with other environmental bacilli, so that's why no one should rely on that single result alone in order to be able to determine if they've been exposed to Anthrax. They need to back it up with other laboratory testing, either real-time PCR or ELISA or just growing things out on plates to confirm that result. False negatives can be a problem also, it is possible that the antibodies may not react with a particular...you have to have a sandwich form, so if one antibody doesn't react with your antigen your not going to get a sandwich but it still might be dangerous.

AF: Will, do you have any questions?

WW: I don't have anything else, I think you covered everything I had.

CC: They're not the only organization making them, the Alex Zeder technologies, biothreat, guardian, there's also coming on New Horizons, they didn't make a very good device but they've been around for a while and the Navy still produces them.

AF: And these other companies are private companies?

CC: New Horizons is private but of course the US Navy is not, they have a government facility, they just don't have the production capabilities of Tetracorp.

AF: And who do they hope to sell these things to?

CC: They were primarily selling them to the government and to other military organizations around the world, now of course private and commercial companies have begun asking for them. We're hesitant to recommend that private groups or individual citizens use these kind of tests without the expertise to back them up. It would just create more of a fear than there is at the moment, people should leave testing to professionals, if they have something suspicious call in professionals to do the testing.

AF: Well thank you very much for all your time.

CC: Your welcome.

AF: It was nice to finally meet you.

CC: So what are you guys exactly doing, out of curiosity?

AF: Our school, as a degree requirement, we have to do a project.

WW: Well, we actually have to do three projects.

AF: We have to do three projects but this project is a project outside of our major. You see because it's an engineering school they have an idea that we should do something that directly relates to society in a sort of humanitarian way. So bioterrorism is what we chose, I mean prior to September 11.

CC: (Laughs)

WW: Right, we chose this way last year.

CC: Okay, well there are some other technologies at least from an engineering perspective that will be very promising in the near future. We are looking at DNA micro-arrays. Because one of the problems for the kinds of detection we do now is that with PCR obviously you have to have primers that are directly targeted to a template which means you will only look for something very specific so if I get a sample and I have Anthrax primers they will only detect Anthrax in that sample.

WW: Right, because there going to slice the Anthrax genes.

CC: Well they may change Anthrax genes, they may try that but if they put something else in there and I only have Anthrax primers I won't detect it so were trying to come up with ways to develop or identify complete unknowns and one of those ways is with DNA micro-array technology by Affametrix and a couple of other smaller companies. With this they can put the DNA sequences down fro any number of pathogens or they can put down completely random DNA sequences and when you wash the DNA from any group of pathogens or single pathogens onto the chip and the hybridize a certain way a laser can read what's been hybridized and what location and put it into a computer matrix and then determine whether its from a single organism or whether those sequences represent two or three separate organisms and that technology should be coming down the line and should be very effective. Another possibility is using mass spec., well there's a technology called MALDETOF, matrix assisted laser absorption ionization time of flight, we can take a whole pathogen, put it onto a MALDE plate, a laser will ablate everything into fundamental molecules, ionize them and send them down a vacuum tube and they've made those devices very small, you can put them on a table like this now and depending on when the molecules hit the detector plate on the far end, larger molecules hit first, smaller molecules hit later, it creates a trace and that trace can be compared to a known library of actual pathogens and so in that way we can identify some unknowns much faster than we would with these kinds of technologies and we think that those will be available within three years or even faster with the accelerated rate of research and funding that's coming through.

AF: Whose working on this right now?

CC: MALDE is primarily a DARPA project right now, I believe they have collaborators at the advanced physics laboratory in the University of Scranton in Pennsylvania. There is a woman named Joanie Jackman who is the primary person for that project.

AF: What's DARPA?

CC: The Defense Advanced Research Projects Administration it's a pie in the sky group that looks for technologies that may be useful to the military in 15,20,30 years and they fund them initially but a lot of the stuff fails.

AF: (laughs)

CC: But some things pan out every now and then and the DNA microchip arrays folks out in Lawrence Livermore National Labs are out working on that and the company Affimetrix is working on smaller versions of their current device that they sell to Universities like ours , we have a very large Affimetrix device but we're looking for something small and field portable, perhaps something to put on a specialized first responder unit.

AF: O.K., I think that's all.

CC: Great, good luck guys.

AF: Thanks so much.