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The Human and Environmental Effects of CBRN Weapons

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"For the Angel of Death spread his wings on the blast,
And breathed in the face of the foe as he passed;
And the eyes of the sleepers waxed deadly and chill,
And their hearts but once heaved, and forever grew still!"

- Lord Byron, "The Destruction of Sennacherib"

Abstract

Since the first use of modern weapons of mass destruction during the First World War, the World has lived in fear of these horrifying instruments of death. Gripped by this fear, countries around the world have continued to research, develop, and test these weapons in the spirit of mutually assured destruction. Over the years, science and warfare have continually refined their methods of human extermination, bringing forth some of the most terrifyingly effective weapon systems ever devised. However, the testing and use of these weapons is often a step into the unknown. The repercussions of deploying these weapons are sometimes not known until after they have been used. Thus, large portions of land have been contaminated in the quest for the ultimate weapon. This thesis explores the effects of CBRN (Chemical, Biological, Radiological, and Nuclear) weapons on the environment. This encompasses the effects on organic life (both the intended targets of weapon deployment and other organisms caught in the effected area) as well as the long-term effects to the areas contaminated. Each element of CBRN is discussed individually with a combination of historical deployment, testing data, and current threat level and prevention. These are followed by an analysis of the current threat of CBRN weapon use and the steps the international community is taking to prevent it. In conclusion, a recommendation is given for implementing policy to prevent CBRN weapon use as well as store or dispose of these weapons to prevent future use.

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Introduction:

In 1942 on a small island off the northwest coast of Scotland, military scientists from Great Britain's Porton Down chemical warfare facility prepared to test a new type of biological weapon. A 25-pound chemical bomb, 18 inches high and 6 inches wide was filled with a slurry of concentrated Anthrax spores and primed to detonate. After retreating to a safe distance, the bomb was detonated. Billions of Anthrax spores were thrown into the air, settling over the sheep inhabiting the island, the island, and the sea. The sheep continued to graze, undisturbed. A day later, they began to die. The number of sheep carcasses on the island grew and grew, proving to the scientists that germs could be manufactured and weaponized. Tests continued on Guinard Island until 1943, when Anthrax spores caused outbreaks on the mainland. The same scientists attempted to decontaminate the island, but the Anthrax spores proved to be more resilient then expected. The spores had found shelter deep in the soil of the island and continued to reproduce without limit. With all attempts to decontaminate the island ending in failure, the government of Great Britain sealed off the island. Warning signs ringed the island stating, "Guinard Island: This island is government property under experiment. The ground is contaminated with Anthrax and dangerous. Landing is prohibited." The island remained sealed off for forty years until in the 1980s the government moved to decontaminate the island once again. It took six years of work to rid the island of Anthrax. Topsoil was removed and stored in sealed containers, subsoil was soaked in seawater and formaldehyde, and sheep were placed on the island to graze until it was deemed safe. Finally in 1990, Guinard Island was once again safe for humans to land on.[1]

[1] Harris, Robert, and Jeremy Paxman. *A Higher Form of Killing: The Secret History of Chemical and Biological*

From the darkness of the First World War came a new breed of warfare that generated new forms of killing on a massive scale. CBRN (Chemical, Biological, Radiological, and Nuclear) Warfare was born from the first use of Chlorine gas by the Germans during the First World War and still lurks in the shadows of modern conflict. These chemical and nuclear weapons have been proven to be extremely effective in their task of eradicating the enemy, but their use also results in extreme damage to all organic life in the area affected. Mustard Gas contaminates the soil and can remain highly toxic for years after its initial deployment. Radiation from nuclear weapon detonation blankets the blast zone for decades and fallout can travel huge distances through the air, propelled by the wind. Thus, their killing potential is not limited to those unfortunate enough to be caught in the initial attack, but can continue to be lethal to organic life for much longer. Due to the killing potential of these weapons, their creation and use is highly regulated by international coalitions. However, many of these weapons have already caused lasting damage to the environment from their testing and wartime use. In this thesis, I first examine the history of CBRN weapons since their first large-scale military use in the First World War. Next, I examine each of the major weapon systems, explain how they function, and discuss their potential to damage the effected area. Then I explore the current policies and efforts of the global community to regulate these weapons, both their storage and their use. Finally, I will make policy recommendations based on this research about the current threat of CBRN weapons and what steps the international community could be taking to limit or restrict their use.

Chapter I: The Roots of Modern CBRN Warfare

When most of us think of weapons of mass destruction, we tend to immediately think of modern warfare. The first thing on most people's minds would be the use of the atom bomb at Nagasaki and Hiroshima by the United States against the Empire of Japan in World War II, perhaps maybe the nuclear arms race of the Cold War between the United States and Russia or the gases that clouded in the trenches of World War I. While it is true that the most notable and extensive use of chemical, biological, and nuclear weapons has been in the last century, the roots of this way of war were anchored in much earlier conflicts. Even in the ancient world, warriors recognized the power of the elements to weaken or kill their enemies. Through ancient history poisoning or disabling combatants, their livestock, and their food and water supplies has been accomplished using chemical and biological weapons. In ancient Europe, India, and China, observers of battles noted the use of poisonous or noxious smokes that were designed to incapacitate the enemy and deny the use of defensive positions, such as the use of sulfur-based irritant used by the Peloponnesians against the town of Plataea in the fifth century BC.[2] Armies of the Byzantine Empire were also known to deploy a type of incendiary weapon known as "Greek Fire" against land and naval targets. The substance is believed to possibly be a petroleum-based solution that has been thickened with resins, allowing it to stick to targets and remain burning for longer periods of time.[3] Insect-based bombs were also used to counter sappers and in defense of walled cities. There were also many poisons that were used in the ancient world to both add to the lethality of bladed weapons as well as pollute food and water sources to damage enemies who may have been holding out during a siege. One instance of this type of chemical warfare was the use of the poisonous hellebore by the Athenians against the city

[2] Spiers, Edward M. *A History of Chemical and Biological Weapons*. London: Reaktion, 2010. Print. (28)
[3] Spiers, (28)

of Kirrha. The Athenians dumped cartloads of hellebore into the river that fed into the city. The polluted water caused many of the inhabitants of Kirrha to develop violent diarrhea, which effectively incapacitated them and allowed the Athenians to take the city.[4] Ancient armies also used poisoned arrows, darts, and spears when their resources allowed for it. However, more developed nations of Europe condemned the use of poisons in conflict between civilized nations.

In addition to these early chemical weapons, the ancients were aware of the ability of disease to destroy or inhibit enemy forces. Biological weapons have been implemented in war farther back then has been recorded. The most common use of biological warfare was the spread of disease. Ancient armies could infect the enemy with disease like smallpox or the plague by means such as infiltration with infected individuals, catapulting infected cadavers into besieged cites, infecting agricultural fields and water supplies, or spreading clothes or food that had been exposed to disease. These methods were often extremely effective. One such attack took place in 1346 in the Genoese seaport of Caffa. The Mongol army surrounding the city used a form of catapult to fling cadavers infected with plague over the walls of the city, causing a plague outbreak and resulting in those not infected fleeing the city by boat.[5] Another infamous technique that was implemented by ancient armies across the globe was the simple act of tossing bodies into wells and other water sources to pollute the water and spread disease to anyone who accessed these sources. This type of warfare continued to exist, even with the "refinement" of warfare as nations became more developed and civilized. Many of these nations did not use such weapons against each other, but had no problem using them on the indigenous people who inhabited lands that had been colonized. One of the most famous examples of biological warfare in this respect was the use of smallpox-infected blankets against the Native Americans in the

[4] Spiers, (28)
[5] Spiers, (28)

British colonies. The subsequent spread of disease decimated the native populations of the Delaware, Shawnee, and Mingo Indians.[6]

Even with the use of chemical and biological weapons in history before the 19th century, the German Army initiated the first instance of large-scale CBRN warfare during the First World War. The idea to use gas in warfare was not a novel concept as the Germans had previously used tear-gas and other irritants in shells against the French and Russians. However, a German scientist named Professor Fritz Haber brought the idea to use a cloud-gas attack to breach the Allied lines. The attack would utilize chlorine gas launched from cylinders and borne by the wind towards the Allied trenches. On the 22nd of April 1915 near the town of Ypres, Belgium, the German Army released 5,730 cylinders of chlorine along 6 kilometers of the front.[7] 160 tons of chlorine was released into the air and was pushed towards the French trenches in a 5 foot tall cloud by the wind. Within a minute, the cloud had enveloped thousands of French soldiers in thick, green smoke. The French succumbed to chlorine poisoning in seconds, gasping for air as the chemical caused them to drown in fluid from their own bronchial tubes and lungs. Those who tried to escape the cloud by running only worsened their poisoning with increased inhalation. The Germans soon came through the French lines wearing crude respirators, capturing some 50 guns, 2,000 prisoners, and a large amount of the French line.[89] Thus had begun the modern era of CBRN Warfare. The attack at Ypres kicked off a chemical arms race between the Allies and the Central Powers. Chlorine was the first lethal chemical weapon used, but both sides soon developed methods of protecting themselves against exposure. Soon phosgene was developed, which was harder to detect then chlorine but worked in a similar fashion. Both sides of the

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[6] Spiers, (29)
[7] Spiers, (30)
[8] Spiers, (30-31)
[9] Harris, Robert, and Jeremy Paxman. *A Higher Form of Killing: The Secret History of Chemical and Biological Warfare*. New York: Random House Trade Paperbacks, 2002. Print. (3-4)

conflict began to search for an alternative chemical that could bypass the opposition's protective masks. Thus the blistering agents Sulfer Mustard and Lewisite were developed. These chemicals caused large blisters to form on exposed organic tissue. In this way, they could effect the enemy through skin exposure. Sulfur Mustard was used extensively through the remainder of World War I by both sides. By the end of the war in 1918, both sides were weary of the use of gas in warfare. Hundreds of thousands of chemical rounds had been manufactured and fired during the duration of the war. Large areas of land had been contaminated by the use of chemical weapons; both through deployed ordinance and through unexploded shells that had been stored underground or failed to detonate when they impacted their targets. At the end of the war, both through the use of chemical weapons and through the defensive tactics used to guard the lines against chemical weapons, the French countryside and farmland had been devastated. Thousands of acres of farmland that had once been fertile were now barren and scarred with trenches and shell holes. Soil remained polluted from chemical ordinance and continued to be polluted from shells leaking in their underground resting places. This paved the way for the signing of the Geneva Protocol on 17th of June 1925. This treaty signed by 38 nations who had fought in the First World War as well as other countries around the world prohibited the use of asphyxiating, poisonous, or other gases as well as bacteriological weapons in international conflicts. The treaty states,

> *Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilized world; and Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations; Declare: That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend*

this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.[10]

While this treaty did put the agreement between these nations on the record, distrust remained deeply rooted between the former opponents. Many of the major nations like Germany, the United Kingdom, and the United States felt that their former opponents would be likely to resort to the use of chemical and biological weapons in the future. As a result these nations accepted the conditions of the Geneva Protocol on two conditions: the agreement was only binding if both aggressors had signed the treaty and the signing nations reserved the right to retaliate in kind in the event that they were attacked using the prohibited weapons.[11] Thus, in the years between the First World War and the Second World War, these countries continued to research, develop, and refine their chemical and biological weapons. In England, the Porton Down chemical warfare installation continued to research variants of mustard gas and other chemical weapons as well as biological weapons such as Anthrax. The installation covers 7,000 acres of land in Salisbury Plain and features extensive laboratories and facilities that were used to conduct research on animal, agricultural, and human targets. [12] Other countries had similar facilities; Italy established the Servizio Chemico Militaire in northern Italy, the French used the Atelier de Pyrotechnie du Bouchet near Paris, The Japanese Navy and Army began chemical and biological weapons research in 1923 and 1925 respectfully, Germany continued limited research at the Kaiser Wilhelm Institute which would later lay the framework of their offensive operation under the Third Reich, and finally the Soviet Union established the Military-Chemical

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[10] *Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases, and of Bacteriological Methods of Warfare*, 17 JUN 1925, L.N.T.S. Vol. 94., Registration Number 2138
[11] Harris & Paxman, (48)
[12] Harris & Paxman, (39-45)

Administration of the Red Army in 1924.[13] These facilities, behind a veil of secrecy, continued to develop, refine, and test these weapons of mass destruction. For the most part, the former Allied powers continued to refine and develop already existing chemical and biological weapons and delivery systems. However, two other nations began to develop weapons that exceeded the deadly effects of the weapons of World War I.

The Empire of Japan, feeling that it had to bolster its arsenal in the advent of conflict with the Soviet Union began to conduct deep research into biological weapons. Under the leadership of General Shiro Ishii, the Japanese Army established a biological testing and research facility in Pingfang, China. The facility was codenamed "Unit 731" and conducted extensive development and testing of biological weapons on human subjects. Among the diseases, germs, and bio-agents researched at the facility were syphilis, gonorrhea, plague, cholera, anthrax, smallpox, botulism, typhoid, dysentery, gangrene, tuberculosis, and other diseases. This facility operated from 1935 to 1945, performing tests on human subjects including exposure to disease through injection, rape, mutilation, explosive ordinance, and other means as well as testing of burns, frostbite, animal blood transfusions, live vivisection without anesthesia, and other morally deplorable conditions. This facility developed and implemented the only successful modern large-scale biological attack against the Chinese city of Changde in 1941 and 1942, where Japanese bombers dropped ordinance containing plague fleas, anthrax, typhoid, dysentery, and cholera onto the population of the city as well as food and water supplies. These diseases took hold in the fields and water sources of the cities and continued to infect both humans and livestock for years after their introduction. After the conclusion of World War II, the members of Unit 731 were

[13] Harris & Paxman, (45)

pardoned of war crimes in exchange for turning over their human testing data to the United States. [14]

At the same time in Germany, under the leadership of Adolf Hitler, the Third Reich had discovered and produced in secret a whole new breed of poison gas known as nerve gas. These gases were not like the asphyxiating and blister agents of the First World War. Instead, they worked by causing the victim to loose control of their nervous system, causing them to die in convulsions and suffocation. These gases were especially dangerous because of their high toxicity, where only a few milligrams constituted a lethal dose to humans. The first nerve gas to be discovered was called Tabun. It was discovered by a German scientist named Gerhard Schrader in 1936[15], while he was attempting to develop a more effective pesticide for use in agriculture. According to the law in the Reich, any discovery of potential military use was to be reported to the Wehrmacht. The German Army recognized the value of Tabun as a chemical weapon and immediately began constructing a secret facility in Dyhernfurth to begin creating the weapon. The facility was commissioned in 1939 but would not begin production until April of 1942. Schrader was convinced to continue research on nerve gases by the German Army and discovered a more lethal variant of Tabun named Sarin in 1938.[16] The facility to create Sarin was not commissioned until 1942 and would not be able to begin production until March of 1945.

Even with these developments in chemical and biological warfare from Germany and Japan, the Second World War passed with very little to no use of chemical or biological weapons. The main reason for this was deterrence through the prospect of retaliation and the lack of preparation on both sides to effectively engage in effective CBRN combat. The Germans were convinced that the Allies knew about their stockpiles of nerve gas and believed that the Allies

[14] Harris & Paxman, (77-83)
[15] Spiers, (53)
[16] Spiers, (53)

had developed nerve gases of their own. The reality was that the Allies had no idea about the German gases and would have been completely unprepared if Hitler had chosen to deploy them. The Axis also lacked the logistical capability to deploy their gas stocks effectively to the extent that they would have needed. On the other side, the Allies were still working on more effective delivery systems for World War I era gases and biological weapons. In addition, the Allies did not want to engage in chemical or biological weapons because they were afraid that the Germans would retaliate in kind. Both sides however were doing their best to create and stockpile as much chemical reserves as they could produce in preparation for retaliatory action against the other. By the end of the war, Britain had 35,000 tons of gas and Germany had 78,000 tons of chemical weapons. The Soviet Union was producing in the neighborhood of 35,000 tons per year during the war but lost much of their chemical weapon deployment ability during the German offensive. The United States amassed the largest stockpile of chemical weapons, estimated over 135,000 tons by 1945.[17] However, the relatively small number of discharges of chemical and biological weapons were shadowed by the extensive use of chemical agents to help clear the way for Allied forces to advance through rough terrain such as the jungles of the Pacific islands. The U.S. Army Chemical Corps developed more effective flamethrowers and herbicides to help clear the way through the jungle. The resulting deforestation caused the death of entire ecosystems and continues to affect the islands to this day. However, these issues were overlooked as a means of continuing to push towards Tokyo and end the war. The war would indeed end, but not through the continued push through the jungle, but instead by the development and deployment of the atomic bomb, which ushered in a new era of weapons of mass destruction.

[17] Spiers, (57-60)

Even with the terror of gas weapons lingering in the shadows of World War II, the real weapon that defined the conflict was the atomic bomb. Although it was developed by both sides in utter secrecy, it was a race to the finish to see who would be the first to harness the power of the atom for destruction. The Allies became aware of the potential development of an atomic weapon by the Germans through the warning of Albert Einstein to President Roosevelt and the memorandum from two refugee German scientists living in England. Their memo to the British government theorized that just 5 kilograms of uranium would create an explosion equivalent to several thousand tons of dynamite.[18] The Allies concluded that they could develop and create a uranium-based bomb in time to use it against the Axis. In 1942, the Manhattan Engineering District (also known as the Manhattan Project) was launched by the Americans in secret. Hundreds of scientists were brought to Los Alamos, New Mexico in order to develop a nuclear fission weapon. The calculations were relatively easy to understand in theory, but the challenge was refining and enriching uranium to the purity required to sustain a chain fission reaction. Nearly the entire budget of the project was devoted to creating and running the facilities to bring the uranium to the required purity. Once the uranium had been refined and the trigger mechanism had been designed and constructed, the bomb was ready to deploy. The first atomic bomb, codenamed "Little Boy" was shipped off to the pacific front. On the 6th of August 1945, history changed forever when the Enola Gay dropped "Little Boy" over the Japanese city of Hiroshima. "Little Boy" detonated over the city with an explosive force of 15 kilotons.[19] Anything close to ground zero was vaporized, with the exception of several thick structures. The heat of the atomic blast destroyed any life close to explosion site, leaving "shadows" of ash in the places where bodies used to be. Radioactive particles rained down on the city and the neighboring areas,

[18] Cirincione, Joseph. *Bomb Scare: The History and Future of Nuclear Weapons*. New York: Columbia UP, 2007. Print. (1-2)
[19] Cirincione, (12)

polluting the land and the water. For years after the attack, agriculture was crippled and the population suffered from radiation exposure. The 1945 estimates placed the number of casualties at 66,000 from the blast itself and 69.000 injured. The plutonium-based bomb "Fat Man" was dropped two days later on the city of Nagasaki with similar results. Upon threat of a third atomic strike, Japan surrendered. The Second World War had just ended and the world would never be the same.

With the world in awe of the destructive capabilities of the atomic bomb the major powers of the world, namely the United States and the Soviet Union, became locked in a race to develop the most powerful nuclear weapons imaginable. Each country began to create new, more powerful nuclear weapons. They eventually developed a new type of bomb, the Hydrogen bomb. This weapon harnessed more of the explosive potential of fission and dwarfed the outputs of the first bombs. In addition to developing more powerful bombs, the two nations refined delivery systems. Before long, both nations had developed ballistic missile systems capable of delivering a rocket with a nuclear warhead across vast distances to its target. The world held its breath as the U.S. and the U.S.S.R. stood poised at the brink of destruction, with its nuclear weapons poised and aimed at each other in the promise of mutually assured destruction of the highest degree. By 1960, the United States possessed a nuclear arsenal of 20,000 weapons and the Soviet Union an arsenal of 1,600.[20] In 1961, The United States realized the consequences of an endless arms race. President John F. Kennedy and President Lyndon B. Johnson began the de-escalation of the nuclear arms race with the Limited Test Ban Treaty in 1963 and the Non-Proliferation Treaty in 1968, which helped restrict nuclear testing and the global spread of nuclear arms.[21]

[20] Cirincione, (26)
[21] Cirincione, (29)

While these treaties were being forged between the U.S. and the U.S.S.R, there was a brief re-emergence of chemical and biological weapons to the international stage. In the 1950s, a British chemist named Ranajit Ghosh working for the Plant Protection Laboratories of Imperial Chemical Industries discovered the most toxic nerve weapon ever produced. It was initially marketed by ICI as a pesticide called Amiton, but was withdrawn from the market due to it's toxicity. However, the new substance was picked up by the British and American militaries as a new series of chemical weapons called the V-Series. In the mid-1950s, the U.S. Army Chemical Center created about 50 variants of V-Series nerve agents, the most toxic of which was code named "VX".[22] This new weapon was three times more toxic then Sarin when inhaled and one thousand times more toxic when exposed to skin. Less then 10 milligrams of VX is a lethal dose to a human being. 1 Liter of VX is estimated to be enough to kill one million people.[23] VX was turned over to the U.S. Army Chemical Corps for expanded research and development as well as preparation for the large-scale production of VX. The Newport Army Chemical Plant was completed in 1961 and was capable of producing 10 tons of VX per day.[24] The United States continued to stockpile and test VX in the event of chemical warfare with the Soviet Union. The U.S. development of VX stopped in 1969 when the government canceled all its chemical weapons programs and began to disarm its vast stockpile of WMDs. However, chemical warfare was not quite over for the U.S. While engaged in the Vietnam War between 1961 and 1971, the United States tiptoed the line of chemical warfare with the use of chemical defoliants such as napalm and Agent Orange in Operation Ranch Hand and the use of CS gas and Napalm to force the Vietcong into the open. During Operation Ranch hand, the United States sprayed an

[22] Tucker, Jonathan B. *War of Nerves: Chemical Warfare from World War I to Al-Qaeda*. New York: Pantheon, 2006. Print. (158)
[23] Tucker, (158)
[24] Tucker, (166)

estimated 12 million gallons of Agent Orange over the jungles of Vietnam. Agent Orange worked by introducing a potent mix of toxic chemicals (including the highly toxic chemical dioxin) to plant life, causing it to die and also rendering the soil infertile to prevent a resurgence of plant growth. By the end of the war, 3.8 million acres of land was destroyed as well as 13,000 livestock animals due to Agent Orange use. Agent Orange also caused various health problems to both the Vietnamese people exposed to the spray and the U.S. military personnel that handled the chemical. Napalm also constituted a vast amount of environmental destruction in the quest to rob the enemy of their cover and concealment. Napalm is a form of gelled petroleum that burns extremely hot and for long periods of time. It was used extensively to clear forests by burning them to the ground. Many forests ecosystems were destroyed through this burning, including the U Minh forest, which suffered a loss of 75% to 80% of its foliage due to Napalm use. There was significant public outcry over the use of chemical spray in Vietnam. However, the U.S. argued that it did not specifically target humans and was using the chemical to deny cover and concealment to the enemy and was therefore not in violation of the Geneva Protocol. Those who were exposed to Agent Orange and other chemical defoliants during the Vietnam War continue to suffer from related illnesses to this day.

In the wake of the 1960s, the world began to shift in favor of a de-escalation of nuclear, chemical, and biological weapons. The United States and the U.S.S.R. negotiated several treaties that backed the two superpowers down from the brink of nuclear war. Both nations began programs to begin decommissioning WMD stockpiles. However, the threat of nuclear conflict was not gone. Both nations remained wary of the other and it was not until the collapse of the Soviet Union in 1991 that the Cold War finally came to a close. While these two superpowers

began the process of disarming their vast arsenals, there were other nations that were beginning to arm themselves in the hopes of regional expansion of power. One such nation was Iraq.

In the 1960s, Iraq had sent officers of its army for training in CBRN weapons in the Soviet Union.[25] These officers returned to Iraq and formed the basis of the Iraqi Chemical Corps. In the 1970s, Iraq built several laboratories with the assistance of West German companies such as Karl Kolb and its affiliate Pilot Plant. These CBN facilities were developed to train their soldiers in CBN combat and synthesize and develop chemical and biological weapons of their own. By 1983, the Iraqi Army had synthesized about 150 tons of sulfur mustard and by 1984 had a pilot program to develop sarin.[26] To manufacture these gases, Iraq purchased $11 million in chemicals and production machinery from the German firm, Water Engineering Trading (WET). The company continued to sell the mechanisms and precursor chemicals necessary for chemical weapons between 1983 and 1987 despite the efforts of the international community to restrict the ability of Iraq to import such materials.[27]

During the Iran-Iraq War, nerve agents would get their first use during war. While fighting to hold on to seized territory in southern Iran, the Iraqi Army deployed shells filled with riot control agents. When these shells proved to be effective in dispersing the Iranian infantry, the Iraqis began to use more serious chemical weapons such as sulfur mustard via aerial bombardment. However, there was little in the part of international response to the use of chemical agents by the Iraqis. That would change in February of 1984, when the Iraqis deployed a combination of sulfur mustard and tabun against Iranian forces in the Majnoon Islands.[28] The international community responded with a blanket ban on the sale of chemical agents to Iraq.

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[25] Spiers, (102)
[26] Spiers, (103)
[27] Spiers, (104)
[28] Spiers, (105)

However, this would not curtail the Iraqi use of chemical weapons. They continued to develop and improve their weapon systems and by the late 1980s were able to deploy chemical weapons effectively along their entire front. The most notable attack by the Iraqis occurred on August 25th 1988, when the Iraqis used sulfur mustard against the Kurdish insurgency in five locations via aerial bombardment, resulting in mass casualties and exodus of the Kurds from their contaminated settlements in Kurdistan. Overall in the Iran-Iraq War, the Iraqis deployed about 1,800 tons of sulfur mustard, 140 tons of tabun, and 600 tons of sarin.[29] Iraqi estimates put the number of Iranian fatalities at about 30,000 from chemical attacks. Since that war, chemical weapons have not been used in a large-scale military conflict.

Even with the reduction of arsenals around the world today, there still remains the threat of the use of chemical, biological, and nuclear weapons by rogue states and terrorist groups. Countries such as Iran and North Korea vigorously work to gain nuclear capability, states engaged in civil war such as Syria have deployed chemical weapons against rebels, and terrorist groups such as ISIS and the Aum Cult have used chemical weapons like chlorine and sarin to attack civilians. While the use of chemical, biological, and nuclear weapons is strictly forbidden in the eyes of the international community, it does not change the fact that these weapons exist and may find their way into the hands of those who are willing to use them for their own nefarious purposes.

[29] Spiers, (109)

Chapter II: The Science of Mass Killing

The acronym CBRN (or shortened to CBN) is comprised of four parts; Chemical, Biological, Radiological, and Nuclear. In this chapter, data that explains the composition and destructive capabilities of each weapon is presented.

Chemical Weapons. The first category is chemical weapons. The definition of a chemical weapon as given by the Organization for the Prohibition of Chemical Weapons is,

> (a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;
>
> (b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;
>
> (c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).[30]

Chemical weapons can be broken down into four categories: blister agents, nerve agents, blood agents, and choking agents. For use in this thesis, the discussion every variant of each will not be used, only the chemicals that have been used in war or prepared exclusively for wartime use.

Blister agents that are used in chemical weapons are Lewisite (L), Sulfur Mustard (HD), and Nitrogen Mustard (HN). These agents were designed to contaminate victims through dermal contact and inhalation. Common effects of blister agents are erythema and blistering, pharyngitis, cough, dyspnea, conjunctivitis, burns, nausea, and vomiting.[31]

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[30] "Article II. Definitions and Criteria." *Article II. Definitions and Criteria*. Organization for the Prohibition of Chemical Weapons, n.d. Web. 20 Apr. 2015.

[31] "Vesicant/Blister Agent Poisoning." *CDC || Toxic Syndrome Description:*. Centers for Disease Control and Prevention, n.d. Web. 20 Apr. 2015.

Lewisite (L)[32]: Lewisite, also known as Chlorovinylarsine dichloride, is an extremely toxic vesicant containing arsenic. Its most common physical form is an oily liquid ranging in color from colorless to brownish amber. It is famous for having the odor of geraniums. Contamination can occur from inhalation of liquid spray or vapor as well as dermal contact. Upon contact with a victim's skin, Lewisite causes severe chemical burns, resulting in rash, swelling, and large fluid-filled blisters. When inhaled, Lewisite causes burning pain, sneezing, and coughing. Ingestion causes severe pain, nausea, vomiting, and damage to internal body tissue. Sufficient absorption (3.9 mg/m3) of Lewisite can cause respiratory failure, liver failure, and death. Lewisite can be dispersed as an aerosol spray as liquid vapor, in liquid form can contaminate water and food, and can contaminate agricultural products if dispersed as a liquid spray. Areas contaminated with Lewisite can be decontaminated using a solution of detergent and water with a pH value between 8 and 10.5. Lewisite also hydrolyses in water to form hydrochloric acid.

Sulfur Mustard (HD)[33]: Sulfur Mustard, also known as Mustard Gas or Dichlorodiethyl sulfide, is a vesicant causes severe burns to the eyes, skin, and respiratory tract of it's victims. It is an oily liquid that ranges from colorless to yellow or brown. It is named after it's famous odor of mustard. Symptoms of HD exposure are often not immediate. During a period of 24 hours after exposure to HD, victims will experience itching and skin irritation which develops into large, fluid-filled blisters. Exposure to the eyes causes conjunctivitis and temporary blindness. Inhalation causes bleeding and blistering within the respiratory system, which can result in pulmonary edema and death. It can be released as a liquid spray or a vapor. Like Lewisite, it can

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[32] "LEWISITE (L) : Blister Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[33] "SULFUR MUSTARD : Blister Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

contaminate food, water, and agricultural products in liquid spray form. HD evaporates slowly and thus can remain hazardous for an extended period of time after the initial contamination of an area. Areas contaminated with HD can be decontaminated using a solution of water and detergent with a pH between 8 and 10.5.

Nitrogen Mustard (HN-1)[34] Nitrogen Mustard, also known as Bis(2-chloroethyl)ethylamine, is a vesicant causes severe burns to the eyes, skin, and respiratory tract of it's victims. It is an oily liquid that ranges from colorless to pale yellow. It has a fishy or musty odor. Symptoms of HN exposure are more immediate then HD. After exposure to HN, victims will experience itching and skin irritation which develops into large, fluid-filled blisters. Exposure to the eyes causes conjunctivitis and temporary blindness. Inhalation causes bleeding and blistering within the respiratory system, which can result in pulmonary edema and death. In concentrations of 2.2 mg/m3, it is lethal in 10 minutes. It can be released as a liquid spray or a vapor. Like Lewisite, it can contaminate food, water, and agricultural products in liquid spray form. HN evaporates slowly and thus can remain hazardous for an extended period of time after the initial contamination of an area. Areas contaminated with HN can be decontaminated using a solution of water and detergent with a pH between 8 and 10.5.

These blister agents are some of the most well known chemical weapons due to their extensive role in modern warfare from World War I to ongoing conflicts. HD and HN are especially notable due to their role as an area denial weapon. Since HD and HN evaporate slowly, land contaminated with these chemicals can remain contaminated for an extended period of time depending on the concentration. This is not limited to the land only, as HD and HN can also remain in water for an extended amount of time before being dispersed.

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[34] "NITROGEN MUSTARD HN-1 : Blister Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

The next series of chemical weapons are referred to as nerve agents. Nerve agents receive their name from their effects on the nervous system of humans. They disrupt the enzyme acetylcholinesterase, which destroys acetylcholine and causes the body to loose control of its muscles. These weapons are the most toxic chemical agents ever devised for warfare. They are Tabun (GA), Sarin (GB), Soman (GD), and VX.

Tabun (GA)[35]: Tabun, also known as Ethyl dimethylamidocyanophosphate, is the first of the nerve agents. It is a clear, colorless to amber liquid with an odor similar to bitter almonds. It is extremely toxic and can cause death in minutes after exposure. An amount of between 1 to 10 mL in contact with skin can be fatal. Eye exposure causes pinpoint pupils, redness of the membrane, pain and irritation of the eye, blurred vision, nausea and vomiting. Ingestion results in nausea, vomiting, diarrhea, abdominal pain, and cramping. Inhalation causes pinpoint pupils, runny nose, narrowing of the airways, pulmonary edema. Skin exposure causes profuse sweating and muscular twitching, nausea, vomiting, diarrhea, and weakness. Severe exposure results in loss of consciousness, seizure, muscular twitching, flaccid paralysis, fluid build up in the airways and digestive tract, cessation of breathing, and death. Tabun can be dispersed as a liquid spray or a vapor. It can contaminated the air, water, food, and agricultural products as a liquid spray. Tabun can be dispersed using water spray.

Sarin (GB)[36]: Sarin, also known as Trilone, is a more potent nerve agent developed after Tabun. It is colorless, odorless, and tasteless. It is extremely toxic, with a dose of 0.064 ppm causing death in 10 minutes or less. Sarin shares the same health effects as Tabun. Like Tabun, it

[35] "TABUN (GA) : Nerve Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[36] "SARIN (GB) : Nerve Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

can be deployed in the form of a liquid spray or a vapor. It can contaminate food, water, and agricultural products in liquid spray form. It can be dispersed using water spray.

Soman (GD)[37]: Soman, also known as Pinacolyl methylfluorophosphonate, is a third nerve agent developed alongside Sarin. When synthesized it is colorless, although it becomes dark brown with aging. It has an odor of rotting fruit. It is more toxic then Sarin, with a dose of 0.049 ppm causing death in 10 minutes or less. Soman shares the same health effects as Tabun and Sarin. Like Sarin, it can be deployed in the form of a liquid spray or a vapor. It can contaminate food, water, and agricultural products in liquid spray form. It can be dispersed using water spray.

VX[38]: VX, also known as Methylphosphonothioic acid, is the deadliest nerve agent ever developed. It is a clear, oily liquid with an amber coloration. It is tasteless and odorless. It is so toxic that a single drop is lethal. A dose of 0.0027 ppm will kill a human in less then 10 minutes. It shares the same health effects as the other nerve agents. It can be deployed as a vapor or a liquid spray. It can contaminate air, water, food, and agricultural products in liquid spray form. It can be dispersed using water spray.

The nerve agents are truly the most terrifying of the chemical weapons due to their incredible toxicity. Only a few drops on exposed skin are more than enough to kill a human. A single liter of VX has the theoretical potential to kill 1 million people.[39] Among them, Soman and VX are especially dangerous because of their slow decomposition in water. These chemicals can remain in water for extended periods of time depending on the extent of contamination. VX can also break down into other toxic substances in water.

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[37] "SOMAN (GD) : Nerve Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[38] "VX : Nerve Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[39] Tucker, (158)

The next category of chemical agents are referred to as blood agents. A blood agent is affects the body by absorption into the blood. Due to the fast-paced circulatory action of the body, blood agents can be fast acting and lethal. The two blood agents implemented or proposed for use in chemical weapons are Cyanogen Chloride (CK) and Hydrogen Cyanide (AC).

Cyanogen Chloride (CK)[40] Cyanogen Chloride, also known as Chlorcyan or Chlorine cyanide, is a highly volatile and toxic chemical asphyxiant. It is a colorless liquid below 55 degrees Fahrenheit and a gas above the same temperature. Eye exposure results in severe blinking, tear production and temporary blindness. Ingestion exposure results in a burning taste with constriction or numbness of the throat, nausea, and vomiting. Inhalation causes the most drastic symptoms, including headache, confusion, dizziness, and loss of consciousness. Once the toxin has entered the bloodstream, heart palpitations, difficulty breathing, and hyperpnea will occur. Severe doses will result in coma, seizure, shock, critically low blood pressure, pulmonary edema, and cardiac arrest. CK can be deployed as a liquid spray or a vapor. It can contaminate air, food, water, and agricultural products in spray form. Decontamination can be accomplished using a water and detergent solution with a pH between 8 and 10.5.

Hydrogen Cyanide (AC)[41]**:** Hydrogen Cyanide, also known as Prussic acid or Hydrocyanic acid, is one of most infamous chemical agents ever used due to its use during the Holocaust by the Nazi SS. It is more lethal then CK with a dose of 27 ppm causing death in 10 minutes or less. It is colorless or a pale blue liquid below 78 degrees Fahrenheit and a colorless gas above the same temperature. It has a distinctive bitter almond odor, however a large proportion of people are unable to detect it by odor. It shares health effects with CK. AC can be

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[40] "CYANOGEN CHLORIDE (CK) : Systemic Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[41] "HYDROGEN CYANIDE (AC) : Systemic Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

deployed as a liquid spray or as a gas. It can contaminate water, food, and agricultural products in liquid spray form. Decontamination can be achieved through use of a water and detergent solution with a pH between 8 and 10.5.

Blood agents were used in World War I by the Allies against the Central Powers and by the Nazi regime in World War II in the extermination camps. However, their toxicity was easily outmatched by more powerful agents and thus did not see combat deployment in any large-scale conflicts after World War II.

The final category of chemical agent is choking agents. Choking agents are designed to inhibit the victim's ability to breath. Exposure to choking agents likely results in severe burns to the skin, blurred vision, and pulmonary edema. Choking agents were the first chemical weapons used in large-scale modern conflict.

Chloropicrin (PS)[42] Chloropicrin, also known as Trichloronitromethane, is an irritating chemical with properties similar to tear gas. It was used extensively in World War I as a troop dispersal agent. It is a faint, yellow oily liquid with a severely irritating odor. Eye exposure results in irritation and tear production. Ingestion results in burns in the mouth, esophagus, and stomach as well as vomiting, nausea, and difficulty breathing. Inhalation results in severe irritation with coughing, choking, and shortness of breath. Inhalation also causes tightness in the chest, pulmonary edema, nausea, vomiting, headache, and dizziness. Skin exposure can cause severe irritation developing into blisters, headache, and shortness of breath. PS can be deployed as a liquid spray. It can contaminate water, food, and agricultural products in liquid spray form. Decontamination can be achieved through use of a water and detergent solution with a pH between 8 and 10.5.

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[42] "CHLOROPICRIN (PS) : Lung Damaging Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

Phosgene and Diphosgene (CG and DP)[43]**:** Phosgene, also known as Carbonic Dichloride, is a pulmonary agent that was extensively used during World War I. It is a colorless gas above 47 degrees Fahrenheit and a colorless liquid below the same temperature. In gas form, it appears like a white cloud. It has an odor of mown hay or green corn. Eye exposure results in tear production, blood accumulation, inflammation, and clouding of the cornea. After mild or moderate inhalation exposure, symptoms will not manifest after up to 24 hours after exposure. The symptoms include irritation of the upper airway, burning of the throat, choking, difficulty breathing and spasmodic narrowing of the large airways. Severe exposure though inhalation causes rapid pulmonary edema, severe coughing, and upper airway closure. This causes death suddenly and unexpectedly and helped this weapon earn notoriety. Phosgene is only deployed in gaseous form. It is unable to contaminate water, food, or agricultural products. Decontamination can be achieved with a through use of a water and detergent solution with a pH between 8 and 10.5.

Chlorine (CI)[44]**:** Chlorine, also known as Molecular chlorine, is a corrosive toxic gas. It is one of the few gases used for chemical warfare that is also widely used in industry to this day. It is a greenish-yellow gas at room temperature and a clear amber-colored liquid under pressure. It shares health effects with PS, however it can be fatal in large doses. Chlorine can be deployed in a gaseous state. It can contaminate the air and water, but is unlikely to contaminate food or agricultural products. Decontamination can be reached by use of a water and detergent solution with a pH between 8 and 10.5.

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[43] "PHOSGENE (CG) : Lung Damaging Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.
[44] "CHLORINE : Lung Damaging Agent." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 20 Nov. 2014. Web. 20 Apr. 2015.

While choking agents have been overshadowed by more potent toxins such as nerve agents and blister agents, they remain the most available for use by terrorist organizations due to their common use in industry. Therefore, the potential for the use of choking agents as a chemical weapon is more likely then the use of a highly toxic chemical such as VX.

Biological Weapons. The second category is biological weapons. Biological agents are defined as bacterium, virus, protozoan, parasite, or fungus that can be used as a weapon in biological warfare. Since these agents are the manipulation of natural diseases and organisms for the purpose of war, they can be especially damaging to both their intended human targets as well as other living organisms caught in the contaminated area. More then 1,200 different potential agents have been explored for the purpose of weaponization. However only few have become weaponized. In this section I will list the known weaponized biological agents and briefly describe them.

Bacterial Biological Agents

Bacillus anthracis[45]: the etiologic agent of anthrax. Anthrax is a common disease of livestock and can infect humans who come in contact with it. The agent forms a spore which can lie dormant until conditions allow it to grow. Spores are resistant to heat, dryness, and most disinfectants. Therefore, areas exposed to anthrax can remain contaminated for years after initial exposure, rendering land unusable and highly dangerous to any human or animal inhabitants.

Brucella abortus, melitensis, suis[46]: Brucella bacteria can spread to humans through contaminated animals, usually through consumption of contaminated food, direct contact, or

[45] "Anthrax." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 22 July 2014. Web. 21 Apr. 2015.
[46] "Humans and Brucella Species." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 12 Nov. 2012. Web. 21 Apr. 2015.

inhalation of aerosols. The bacteria can infect any organ or organ system and can cause weakness, mental fatigue, and endocarditis.

Vibrio cholerae[47]: the bacteria that causes the disease Cholera. Cholera is an infection of the intestine. It can be spread through contaminated water and food. Symptoms include large amounts of watery diarrhea, vomiting, and muscle cramps, resulting in dehydration and electrolyte imbalance in victims. Cholera can continue to contaminate water sources for extended periods of time until the water source is decontaminated.

Corynebacterium diphtheriae[48]: the pathogenic bacterium that causes the disease diphtheria. Diphtheria can be spread between humans through direct contact or through the air. Symptoms include sore throat, fever, barking cough, and extreme swelling of the neck. In severe cases, Diphtheria can result in abnormal heart rate or paralysis.

Shigella dysenteriae[49]: a species of the bacterial genus *Shigella* which can cause shigellosis. Shigellosis is spread through contaminated water and food. in can cause cramps, diarrhea, dehydration, rectal bleeding, and mucosal ulceration. Shigella dysenteriae is a resilient bacterium and is difficult to remove from water sources.

Burkholderia mallei[50]: an aerobic bacterium that can cause Glanders in humans and animals. Spreads through infected food and water as well as bodily fluids of contaminated victims. Causes coughing, fever, and death within several days of infection.

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[47] "Cholera." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 27 Oct. 2014. Web. 21 Apr. 2015.
[48] "Diphtheria." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 13 May 2013. Web. 21 Apr. 2015.
[49] "Shigella." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 02 Apr. 2015. Web. 21 Apr. 2015.
[50] "Glanders." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 15 June 2011. Web. 21 Apr. 2015.

Listeria monocytogenes[51]**:** Bacterium that causes listeriosis. One of the most virulent food-borne pathogens. The bacteria survives and reproduces in the host, causing infections of the central nervous system and in some cases death.

Burkholderia pseudomallei[52]**:** an aerobic bacterium that causes the disease melioidosis. It can infect humans, animals, and plants. It can be found in the soil and water and causes pain in the chest, bones, or joints. It also causes cough, skin infections, and pneumonia.

Yersinia Pestis[53]**:** a facultative anaerobic bacterium that causes Plague. Infection in humans causes swollen lymph nodes, acral gangrene, seizures, and pain. Plague is lethal to most infected humans within four days. It is typically carried by fleas and passed to humans through bites.

Francisella tularensis[54]**:** a pathogenic species of bacteria causes tularemia. Tularemia can infect both humans and animals. Effects of Tularemia include fever, lethargy, loss of appetite, and in some cases death.

Chlamydial Biological Agents

Chlamydophila psittaci[55]**:** a lethal intracellular bacterial bacteria that causes epizootic outbreaks in animals and respiratory psittacosis in humans. symptoms include joint pain, diarrhea, conjunctivitis, nose-bleeds, and coma.

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[51] "Listeria." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Mar. 2015. Web. 21 Apr. 2015.
[52] "Melioidosis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 26 Jan. 2012. Web. 21 Apr. 2015.
[53] "Plague." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 03 Mar. 2015. Web. 21 Apr. 2015.
[54] "Tularemia." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 11 Jan. 2011. Web. 21 Apr. 2015.
[55] "Psittacosis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 07 Feb. 2014. Web. 21 Apr. 2015.

Rickettsial Biological Agents

Coxiella burnetii[56]**:** a bacterial pathogen which causes Q Fever. Q Fever can infect humans and animals. Infection is spread through inhalation of spores as well as contact with bodily fluids of infected humans or animals. Symptoms are flu-like, developing into atypical pneumonia and can lead to death.

Rickettsia rickettsii[57]**: a** unicellular bacteria that causes Rocky Mountain spotted fever. The disease is transferred from an infected animal to a human through a tick bite. Symptoms include, fever, nausea, muscle pain, and vomiting in early stages. In later stages, victims can develop maculopapular rash, petechial rash, abdominal and joint pain, and memory loss. The disease is potentially fatal as some victims die from infection.

Rickettsia prowazekii[58]**:** a species of parasitic, intracellular aerobic bacterium that causes epidemic typhus. It is transferred through the feces of lice to humans. Symptoms include a high fever, cough, rash, muscle pain, falling blood pressure, stupor, delirium, and death.

Rickettsia typhi[59]**:** A species of bacterium similar to Rickettsia prowazekii. It causes Murine typhus. Transferred through the bites of rat fleas on humans. Symptoms include Symptoms include a high fever, cough, rash, muscle pain, falling blood pressure, stupor, delirium, and death.

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[56] "Q Fever." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Mar. 2015. Web. 21 Apr. 2015.
[57] "Rocky Mountain Spotted Fever." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 21 Nov. 2013. Web. 21 Apr. 2015.
[58] "Chapter 3 Infectious Diseases Related To Travel." *Rickettsial (Spotted & Typhus Fevers) & Related Infections (Anaplasmosis & Ehrlichiosis)*. Centers for Disease Control and Prevention, n.d. Web. 21 Apr. 2015.
[59] "Chapter 3 Infectious Diseases Related To Travel." *Rickettsial (Spotted & Typhus Fevers) & Related Infections (Anaplasmosis & Ehrlichiosis)*. Centers for Disease Control and Prevention, n.d. Web. 21 Apr. 2015.

Viral Biological Agents

Eastern equine encephalitis virus[60]: a zoonotic alphavirus and arbovirus that causes encephalitic illness. Symptoms include high fever, muscle pain, altered mental state, photophobia and seizures.

Venezuelan Equine Encephalomyelitis virus[61]: a mosquito-born viral pathogen that causes Venezuelan Equine Encephalomyelitis. Symptoms include flu-like conditions as well as a weakened immune system. Many victims become severely ill or die from the disease.

Western equine encephalitis virus[62]: a mosquito-born viral pathogen that mimics Eastern equine encephalitis virus.

Japanese encephalitis virus[63]: a mosquito-born viral pathogen that causes encephalitis. Symptoms include neck rigidity, cachexia, hemiparesis, convulsions and coma.

Rift Valley fever virus[64]: a Phlebovirus type virus that infects the blood and milk of infected animals. Disease is spread through touching infected blood, inhaling the virus from infected blood, drinking raw milk from an infected animal, or the bite of infected mosquitoes.

Variola virus[65]: the Variola virus is an airborne virus that causes smallpox in humans. Transmission of smallpox is done through inhalation of droplets of infected mucus of infected humans.

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[60] "Eastern Equine Encephalitis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015
[61] "Venezuelan Equine Encephalitis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015
[62] "Western Equine Encephalitis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015
[63] "Japanese Equine Encephalitis." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015
[64] "Rift Valley Fever." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015
[65] "Smallpox." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015

Yellow fever virus[66]: an RNA virus that causes the disease yellow fever. It is transmitted to humans through mosquito bite. Yellow fever victims experience two phases of infection. During the first phase they experience fever, chills, fatigue, loss of appetite, muscle pain, nausea, and vomiting. Most victims will recover after the first phase but some will experience the more serious second phase. In the second phase, victims experience liver damage, abdominal pain, bleeding in the eyes, mouth, and gastrointestinal tract, and in 50% of cases death.

Mycotic Biological Agents

Coccidioides immitis[67]: a pathogenic fungus that generates spores that cause Coccidioidomycosis (also called valley fever). Valley fever causes symptoms similar to bronchitis or pneumonia. More advanced stages causes lethargy, fever, cough, rash, and infections of the lungs and body tissues.

As the data indicates in many of these biological agents, these weapons are incredibly effective due to their ability to survive. These organisms can infect plants, water supplies, and livestock, which make them especially concerning in the area of environmental damage. Many of these organisms will reproduce and further infect environments that they have been released into. Livestock, agriculture, and water sources that have been infected with some of these agents is extremely hard to decontaminate and can render these resources unusable for extended periods of time or even permanently. Thus, the creation and handling of these weapons is highly restricted and regulated. However, many of these agents have never been used in modern conflict, and thus the damage done from their use in warfare is extremely small or nonexistent. This does not mean that the possibility of their use is not a concern. Should any of these weapons be used on a large

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[66] "Yellow Fever." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015

[67] "Valley Fever (Coccidiodomycosis)." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Aug. 2010. Web. 21 Apr. 2015

scale in conflict, the resulting damage to human health as well as natural resources and ecosystems could be far-reaching.

Radiological and Nuclear Weapons. The third and final category of CBRN is radiological and nuclear weapons. Both types of weapons utilize unstable isotopes of heavy elements to cause damage. The difference is that a nuclear weapon uses a forced nuclear fission or fusion chain reaction to release energy while a radiological weapon disperses radioactive material in fallout to induce radiation poisoning of an intended target. Radiological weapons have never been constructed for any conventional Army, only theorized about. However, governments of modern nations take precautions to guard against the possible event of radiological weapon use. Nuclear weapons on the other hand have been used on two occasions in warfare (Hiroshima and Nagasaki) and have been extensively tested during the Cold War.

Radiological Weapons[68]: There are two types of theoretical radiological weapons. The first is the "Dirty Bomb" and the second is the "Salted Bomb". The "Dirty Bomb", also known as a radiological dispersal device (RDD), works by using conventional explosives to discharge radioactive material in the immediate area of the detonation. Radioactive material can be any unstable isotopes that emit alpha, beta, or gamma radiation. Victims that entered the area effected with an alpha or beta type weapon would only experience major effects if they inhaled radioactive particles. However, a dirty bomb using gamma radiation would have a more lethal effect on anyone who entered the contaminated area. However, this is simply not practical due to the degree of radiation protection needed to construct and transport a gamma weapon. The purpose of radiological weapons for large-scale military conflict would be area denial, which would prevent or deter enemy combatants from entering areas contaminated by radioactive materials. Due to the impracticality of implementing a gamma weapon and the relatively low

[68] "Radiological Threats | NTI." *NTI: Nuclear Threat Initiative*. N.p., n.d. Web. 21 Apr. 2015.

effect of alpha and beta weapons, most militaries view dirty bombs as having low military value compared to other methods of area denial. The other use of a dirty bomb is theorized to be as a terror weapon. However, the same drawbacks apply to terrorist organizations. The feasibility of creating and transporting a gamma type radiological weapon is just too unrealistic to be practical. Alpha and beta radiological weapons would not have the desired destructive power and thus would not be attractive either. A "Salted Bomb" on the other hand would be a much more destructive radiological weapon. A salted bomb is a nuclear weapon that has been designed to create a much larger amount of radioactive fallout then conventional nuclear weapons. This weapon would not only destroy a large area with its blast force and massive heat, but also would render the effected area uninhabitable for years after the attack due to the large amount of radiation. However, such a weapon has never been created or tested (as far as we know). Radiological weapons are extremely terrifying to think about due to the long lasting environmental effects of extended radiation contamination, but fortunately the ability to construct and deploy such weapons is severely limited.

Nuclear Weapons[69]: Nuclear weapons are explosive devices that utilize nuclear fission or fusion to discharge extremely large amounts of energy. There are two types of nuclear weapons. There are fission bombs and fission/fusion bombs. Fission bombs create explosive energy solely from nuclear fission while fission/fusion bombs use nuclear fission to induce nuclear fusion.

Fission Weapons: Fission weapons work by using a mass of fissile material assembled in a supercritical mass. This is done in two different methods, the gun-type assembly or an implosion-type assembly. In the gun-type assembly, a piece of sub-critical material is fired into

[69] Glasstone, Samuel, and Philip J. Dolan. *The Effects of Nuclear Weapons*. Washington: U.S. Dept. of Defense, 1977. Print.

another sub-critical mass, causing the material to enter supercritical mass and begin a runaway fission chain reaction. The implosion-type assembly works by explosive lenses of sub-critical material and compressing them using chemical explosives to reach supercritical mass. While both create a huge amount of explosive energy (from 1 to 500,000 tons of TNT), they are not efficient as much of the fission material is expended in the initial fission reactions and is consumed before the actual explosion. Both types of weapon emit fission products, which are the remains of atomic nuclei split by fission. These particles are highly radioactive and make up what is known as nuclear fallout. These products can render effected areas highly contaminated with radiation if not properly contained.

Fusion Weapons: Fusion weapons are a more refined version of fission weapons. They work by using an initial nuclear fission reaction to compress and heat fusion fuel. The explosion causes the fission fuel to compress and heat to thermonuclear levels. This results in a large number of high-speed neutrons to be released, which induces fission in materials that are not prone to fission such as depleted uranium. This is referred to as a "stage". Several designs feature multiple stages, which compounds the explosive force of the weapon. These weapons have a higher explosive yield then fission weapons with no fission products created (up to 50 million tons of TNT). This means that there is a reduced amount of nuclear fallout. However, fallout is created during the final fission stage of fusion weapons. However, a variant of thermonuclear weapon known as a neutron bomb can yield a much smaller explosion but a massive amount of neutron radiation. This is called a salted bomb.

As the information in this chapter indicates, CBRN weapons have a massive potential for destructive power. That destructive power is not limited solely to an explosion or a splash of liquid, but can expand beyond its human targets and effect animals and the natural resources of

effected areas. Many of these effects are not quickly fixed and can remain extremely dangerous to humans and other organisms in those areas. Therefore, we must do what we can to limit the use of these weapons, whether that use is testing or wartime use. Luckily, most of the weapons discussed in this chapter have rarely been used in large-scale conflict, if at all. As a result, there has not been a large extent of human and environmental damage when compared to the potential of these weapons to destroy and the stockpiles that were created. However, just because many of these weapons have never seen wartime use in a modern conflict does not mean that they are any less threatening. The potential of these weapons to permanently destroy or completely erase ecosystems is unparalleled by any other technology we have developed.

Chapter III: Depleting Stockpiles and Stopping the Spread of CBRN Weapons

Amid the ongoing conflict of the Cold War, the world began to realize the immense destructive power that was being collected in the major nations of the world. Fueled by the outcries of the public against the use of such weapons and the fears of an incident that would plunge the world into a nuclear war, the nations that wielded these super weapons came together and began the process of scaling back their arsenals and disposing of their accumulated WMDs. The U.S.S.R. and the United States began to negotiate bilateral agreements concerning the use of nuclear weapons, known as the Strategic Arms Limitation Agreement Talks (SALT 1)[70]. In the same spirit, these superpowers began agreements to limit the use of biological weapons. The Biological and Toxin Weapons Convention (BWTC) of the 10th of April, 1972 banned the development, production, and stockpiling of biological and toxin weapons. However, the agreement permitted the continued research of these weapons for defense purposes. The

[70] Spiers, (62)

agreement went into effect on the 26th of March 1975. As of 2007, 155 states have signed and ratified it.[71]

The U.S.S.R. and the United States would not reach an agreement on chemical weapons until the 1st of June, 1990, when both nations signed an agreement to stop the production of chemical agents and accept monitoring of their declared stockpiles as well as accelerate their destruction of their chemical programs.[72] In 1993, the Chemical Weapons Convention was opened for signature in Paris. The document bans the development, production, use, transfer, retention, or stockpiling of chemical weapons. It also requires the signing parties to destroy all production facilities and chemical weapons within a period of ten years. The Organization for the Prohibition of Chemical Weapons (OPCW) was also established to oversee the the inspection of declared stockpiles and the destruction of production facilities and stockpiles. The convention was put into force after it was ratified by 65 countries in 1997.[73] However, the CWC is not a airtight ban on chemical weapons. The treaty does not cover terrorist groups or sub-states that may possess or are in the process of manufacturing chemical weapons. It also only focuses on chemicals that have been previously used in warfare, leaving the door open for new weapons to be synthesized and weaponized. Finally, the inspections that were meant to deter the manufacturing of chemical weapons are not extensive enough to detect small amounts of chemical weapons being developed. This allows terrorists or sub-state actors the ability to develop their weapons undetected. To this day, there has been very few requests by states to inspect other states for evidence of chemical weapons manufacture. Therefore, there still is a lot of uncertainty as to whether or not many of the signing parties have abided by the agreement.

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[71] Spiers, (62)
[72] Spiers, (66)
[73] Spiers, (66)

Unlike chemical and biological weapons, there has been little done in the way of banning the use of nuclear weapons besides the threat of retaliation in kind against aggressors. However, there were two treaties passed in the 1960s that curtailed nuclear testing and restricted the proliferation of nuclear weapons. These were the Limited Nuclear Test Ban Treaty in 1963 and the Non-Proliferation Treaty in 1968. The Limited Nuclear Test Ban Treaty bans the detonation of nuclear weapons underwater, in the atmosphere, or in space. The only place not covered is underground. The Non-Proliferation Treaty is aimed to prevent the proliferation of nuclear weapons, embrace peaceful uses of nuclear technology, and ultimately completely destroy existing nuclear stockpiles. The treaty is signed by almost every nation in the world except for North Korea, India, Israel, Pakistan, and South Sudan. Unfortunately, the treaty has resulted in little action to stop the proliferation of nuclear weapons or disarm currently existing stockpiles.[74]

In addition to the treaties and laws that prohibit the proliferation and use of CBRN weapons, there is a moral code that unites the major powers of the world against the use of CBRN weapons. The moral objection to the use of these weapons lies in the indiscriminate nature of them to kill. They are unlike a gun or a shell in the sense that the gun and shell have a directed military target and can remove that target without collateral damage to civilians and the environment in which they are deployed. CBRN weapons differ because they do not only affect the military target, but anything else that is caught in the area. Thus, CBRN weapons are considered to be indiscriminate killers. One does not circle one single building on the map to be effected by a CBRN weapon, but rather circles an area in which there is a high potential of lethality from the deployment of such a weapon. This is the reason behind the moral aversion of the civilized world concerning the use of CBRN weapons. In certain cases however, the morality of using a CBRN weapon was contrasted with the potential loss of life due to conventional

[74] Cirincione, (30)

armed conflict. In World War I, both sides compared the use of gas to the casualties that would be sustained running across no-man's land into enemy machine gun fire. In World War II, the atomic bomb was weighed against a land invasion of Japan. In Vietnam, Agent Orange and Napalm were thought to be worth the environmental damage to save the lives of troops who would have to hack through an enemy occupied jungle. These were all tough moral dilemmas that commanders were faced with, but in the end decided to use CBRN weapons to mitigate the loss of life. War by its nature is death. The morality of the issue lies in the scope of the death and who or what does the dying. Is it more moral to sacrifice a large amount of soldiers through conventional conflict or sacrifice civilians and the environment of an enemy area by deploying a CBRN weapon? Due to the large scale destruction and lasting effects of chemical, biological, and nuclear weapons, both to combatants and to civilians and nature, it has been accepted by the global community that the use of these weapons in warfare is unacceptable and morally deplorable. However, this may not hinder groups who have a skewed sense of morality. Hence, we cannot depend on the moral compass of human beings to prevent the use of CBRN weapons. Deliberate action, such as treaties and international enforcement and depletion of stockpiles are the only way that we can effectively lower the risk of CBRN weapon use.

Chapter IV: Conclusion

The reason that weapons of mass destruction evoke such strong feelings of fear in our hearts in not simply their ability to kill, it is the efficiency in which they do so. These weapons do not simply kill, they either cause their victims to die extremely painful and inhumane deaths or they completely annihilate anything unfortunate enough to be caught in the target area. Death is not limited to humans, but plants and animals as well. The choice to use these weapons can put

entire ecosystems at risk. Some of these weapons are especially sinister due to their ability to continue their mission of death for long periods of time after deployment. Lethal chemicals, bacterium and viruses, and nuclear fallout can contaminate water, food, and agriculture. In some cases, areas that have been exposed to biological agents that have the capability to survive and reproduce on its own were unable to be decontaminated for decades after exposure. One such example is the case of Gruinard Island in Scotland, mentioned in the introduction. The small island was used extensively to test the biological agent Anthrax in the 1940s and was not safe to enter until it was completely decontaminated in the 1980s after decades of work.[75] Another disaster was the sinking of the *John Harvey*, a U.S. Liberty ship that was sunk in the Italian harbor of Bari by a German air raid. The ship sunk, spilling 2000 containers of sulfur mustard into the harbor. The resulting spill caused nearly 630 individuals to be exposed to harmful concentrations of sulfur mustard.[76] As for nuclear weapons, the survivors of the atomic bomb attacks on Hiroshima and Nagasaki were exposed to contamination from radioactive fallout for years after the attacks. Fallout and radiation rendered land and water sources unusable for agriculture in areas affected by both wartime uses of nuclear weapons as well as from testing of nuclear weapons. In the United States, towns in the vicinity of nuclear test sites were exposed to fallout from nuclear testing that was carried by the wind. Entire islands like the Bikini Atoll in the Pacific were rendered uninhabitable for years due to contamination from nuclear testing. These examples give indications of the unintended consequences of using CBRN weapons and why the global community needs to take a stand on the disarming and destruction of existing stockpiles of CBRN weapons.

[75] Harris & Paxman, 70-76
[76] Harris & Paxman, 121-125

As history has indicated, the matter of disarmament is not an easy fix. There have been multiple treaties between nations to restrict the use of chemical, biological, and nuclear weapons. Some of these treaties have been more successful than others. In the areas of chemical and biological agents, great steps have been taken in the right direction. However there needs to be some fixes to ensure that loopholes in the Chemical Weapons Convention are closed. First, I recommend that nations that have signed the agreement undergo some form of regular inspection by the OPCW as well as random inspections. These inspections need to be more extensive and nations that ratify the agreement must be willing to allow total access by inspectors to chemical facilities. In addition, I think that any newly discovered chemical agents that have the potential to be weaponized or used to create other weaponizable agents should be immediately reported by nations to the OPCW and subject to the same restrictions as currently existing chemical agents. Finally, I think that nations that have large existing chemical stockpiles need to lead the way with disarmament and destruction of those weapons. The main reason many stockpiles continue to exist is through fear of chemical attack from other countries. The larger nations need to set the example and completely destroy any chemical arsenals to show that the civilized nations have no use for such weapons in modern war. Hopefully doing so will convince other nations to destroy their stockpiles as well.

Biological weapons require different situation then chemical agents due to the natural ability of these weapons to exist. I think that many nations have recognized that the intentional spread of disease as a method of war is an underhanded and morally deplorable way to wage war. It not only affects combatants, but also civilians and the land itself. Therefore, I think that nations possessing biological agents need to prioritize the destruction of those weapons.

However, I think that small samples of these agents need to be retained for the purpose of prevention and study. These diseases need to be researched and cures made more available and efficient so as to lower the ability of these weapons to spread infection. As with the CWC, I believe that nations that have signed the BWTC should submit to regular and random inspections to ensure that facilities are not breeding and weaponizing biological agents for use in warfare. Strict penalties should be enforced for nations that are found to be creating biological agents due to the danger to the world's population through infection.

Nuclear weapons are in a grey area. I think that the world needs to evaluate its stockpiles and reduce some of the more ludicrously high ones. However, nuclear weapons currently are the glue that holds the balance of power in place. I think proposing a total disarmament and destruction of nuclear stockpiles would be rash and unwise. However, I think that there must be accurate reporting from all countries that posses nuclear weapons about their current capabilities. Also, any nuclear detonation, whether as a test or as an act of aggression, should be met with absolute and swift punishment from the international community. In addition, all steps that could be taken to prevent the spread of nuclear weapons should be taken. Reserves of fissile materials need to be absolutely controlled and regulated in order to keep rogue groups from attaining nuclear capability. Nations that desire to develop nuclear power plant capabilities must also be closely monitored and not allowed to construct facilities capable of enriching fissile materials to the necessary purity to allow for use in nuclear weapons. Most of all, there needs to be no exceptions to international nuclear policy. Any exceptions open the gates to any nation developing any weapons they want, which is not acceptable.

In conclusion, I believe that we have seen what our destructive capabilities are and now are doing a decent job restraining and limiting these capabilities. Many of these weapons,

although they have been developed or tested, have not been used in modern conflict. Therefore, the damage that has been caused by their use has been limited and not nearly as bad as the potential that these weapons have to destroy. However, we still are accepting negligence and allowing these weapons of mass destruction to spread to places that are not stable enough to be trusted. The international community needs to make the rules concerning these weapons set in stone, with no exceptions. The longer we continue to let these things slip through the cracks, the longer we hold our breath waiting for someone to pull the trigger and plunge our world into darkness.

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